The politics of transitions in electricity: Contested retail market designs and their significance for demand-side energy resources



Thesis submitted in partial fulfilment of the requirements for the Doctor of Philosophy in Geography and the Environment

Laura Charlotte Brinker
Hertford College
University of Oxford

Michaelmas Term 2019

Word count: 98, 594

Acknowledgements

First and foremost, I would like to thank all my interviewees for their generosity and trust. Many, many thanks! Your valuable insights and time made this research possible. Your kindness, patience, and openness made it enjoyable! Any errors of course remain my own.

Great thanks go to my supervisor Prof Nick Eyre. Thanks especially for your immense generosity with your time, ideas, for an open door, guidance, patience, trust, for laughs, ongoing encouragement, and motivation. Thank you also to Dr Matthew Lockwood for very helpful advice on early chapter drafts. I also thank Dr Tina Fawcett and Dr Jake Barnes for feedback and constructive conversations.

Many thanks to all those who gave me advice and kindly introduced me to interviewees. Especially Joe Eto, Charles Goldman, Dr Ryan Wiser, Dr Brenda Boardman, Christian Noll and Martin Bornholdt, Marie-Luise Arlt, Sean Murphy, Dr Juan Pablo Carvallo, Dr Jan Rosenow, Dr Fereidoon Sioshansi, David Havyatt, David Green, Steve Nadel, and Irene Maffini. Thanks also to all UKERC colleagues.

Thank you also to those who spoke to me at conferences, as well as to the organisers who generously allowed me to attend.

Tremendous thanks go to the Electricity Markets and Policy Group at LBNL for their generosity in hosting and helping me with the research. Thanks to all of you for such a warm welcome, reading tips, and very insightful discussions. Special thanks to Andy Satchwell!

Thank you to all my colleagues at the Energy Programme for inspiration, interested questions, and helpful discussions. For moral support and long chats, Dr Yingqi Liu, Dr Sam Hampton, Dr Scott McDonald, Dr Aven Satre Meloy, and Miriam Zachau Walker. Thanks also to Dr Nico Raab, Dr Jose Luis Ramirez Mendiola, Dr Johanna Köhler, Freya Stanley-Price, and others in Geography.

I thank also my colleagues at Ofgem in the Innovation Link and other teams.

Thanks to my funders, primarily the ESRC and the UK Energy Research Centre Programme. I gratefully acknowledge additional funding from Hertford College, the Environmental Change Institute, and the School of Geography at the University of Oxford.

Great thanks to all my friends. Especially to Christabel for font advice, homecooked lunch, and coworking company at all hours to keep me going and happy. To Dot for coworking, snacks, and apples, and to Nikki, Kathrin, Ranja, and Caroline. Thanks also to Leo for inspiring me to come here in the first place, to Meg and Halea for help with transcription, and to all the others for your nagging questions, cheer, and warm wishes. Thanks also to the Band for musical distraction and flatmates in Berkeley for showing me the ropes. Barnaby who encouraged me to embark on this journey in the first place. Without you I might have quit, several times. Thank you for your encouraging words, listening for hours, giving invaluable advice, and sharing your experience. Thank you for your patience, laughs, distraction, and looking after me when needed. Thank you to my mother, father, and Opa for everything, for your love, and ongoing support. Thank you to Marla, Dylan, and all the little ones too. Special thanks to my mother for some proofreading. With all my love.

Table of Contents

Acknowledgements 2
Table of Contents 3
Abstract 6
Acronyms 8
List of figures 9
List of tables 10

Chapter 1 - Introduction 11
1.1 Topic and problem definition 11
1.2 Empirical focus and research question 15
1.3 Contribution 23
1.4 Outline of the thesis 26

Chapter 2 - Literature Review 29
2.1 Empirical literature 30
2.1.1 Historic evolution of electricity sector institutions and scale 30
2.1.2 The implications of electricity retail competition reforms 44
2.2 Theoretical frameworks to study socio-technical change 58
2.2.1 The multi-level-perspective and coevolutionary processes 59
2.2.2 Institutionalisation of discourses as public policy change 63
2.2.3 Institutionalisation of commercial innovation as business models 68
2.3 Integrating the frameworks to address emerging gaps 74

Chapter 3 – Methodology 85
3.1 Research questions 85
3.2 Research Design 89
3.2.1 Case studies of electricity retail market reform 90
3.2.2 Researching processes of business model evolution 93
3.3 Methods, data, and analysis 96
3.3.1 Methods of data collection and generation 96
3.3.2 Analysis 106
3.4 Limitations 109

Chapter 4 - The evolution of different electricity retail market designs 113
4.1 Electricity retail market designs in Texas, Massachusetts, and California 114
4.2 Changing landscape, regime, and niche-developments 120
4.3 Tracing disagreement: discourse coalitions and storylines 124

4.3.1 Summary of main actors and competing discourse coalitions 125
4.3.2 Debating the costs of the system 129
4.3.3 Innovation as entrepreneurial discovery or managed process of consultation 145
4.3.4 Markets and the 'public interest', or the right to individual choice 148

4.4 Institutionalising the discourses 156

4.4.1 Ideas meet technological change and falling marginal costs of power 156
4.4.2 Friendships, varying ideas, and a shock: The evolution of different electricity retail market designs 165

4.5 Conclusion 172

Chapter 5 – Distributed energy business models challenging centralised electricity regimes 175

5.1 The nature of the regime today: incumbent business models and value pools across the system 176

5.1.1 Incumbent electricity business models 176
5.1.2 Value pools and revenue streams targeted by DER providers 182

5.2 DER activities and capabilities 191

5.3 Customer interface: utility-facing or energy user-facing strategy 199

5.4 Regime resistance: DER newcomers' barriers to building business models 202

5.4.1 Access to and conditions in energy, capacity, and ancillary service markets 203
5.4.2 Tariff design for commodity electricity and network use 211
5.4.3 Network connection 215
5.4.4 Lack of or limited access to data 217

5.5 Conclusion 223

Chapter 6 - Incumbent electricity business models in transition? 227

6.1 Competing incumbents: electricity commodity retailers and gen-tailers 230

6.1.1 Acquisition and investment 230
6.1.2 Public-interest-schemes obligating competing retailers to create revenue for DER 236
6.1.3 Partnerships with DER providers, enabling access to revenues and customers 240
6.1.4 Difficulties 244

6.2 Regulated-franchise incumbents: electricity network operators and network-retail utilities 254

6.2.1 Public-interest-schemes 255
6.2.2 Soft regulatory pressure 259
6.2.3 Difficulties 261

6.3 Conclusion 270

Chapter 7 - Discussion 275

7.1 The contested nature of electricity retail market design 276

7.1.1 Framings of efficiency and welfare 278
7.1.2 Framings of electricity as a special type of service 284
7.1.3 Framings of 'choice' 291

7.2 Electricity retail market design and access to resources and opportunities for DER 296
7.2.1 Similarities in how DER newcomers have accessed resources and opportunities under different market designs: The insignificance of electricity retail market design 298
7.2.2 Differences in how DER providers have been able to access resources and opportunities 314
7.2.3 Summary: Significance of electricity retail market design for DER niche players 341
7.3 Contributions to the study of socio-technical change in electricity systems 344
7.3.1 The role of ideas and frames of meaning in socio-technical change 345
7.3.2 The coevolution of business models and public policy institutions 351

Chapter 8 - Conclusion 357
8.1 Answering the research questions 358
8.1.1 Subsidiary research questions 359
8.1.2 Overarching research question 364
8.2 Implications for public policy 371
8.3 Avenues for further research on demand-side energy transitions 378
8.4 Contribution 381

Bibliography 385
Appendix 1 404
Appendix 2 419
Appendix 3 425
Appendix 4 427

Abstract

In many countries, as part of an attempt to decarbonise, electricity systems are changing to accommodate more distributed energy resources. Distributed energy resources involve a more active role for energy users, when power is generated and stored behind the meter, and demand is reduced or shifted in time. Assuming that rules, firm structures, technologies, and end-user practices co-evolve, public policy and regulation will influence the decisions of firms and end-users, and vice-versa. This thesis asks how a specific set of rules, namely electricity retail market design is related to the wider adoption of distributed energy resources. For decades, electricity firms operated as vertically integrated monopolies with an exclusive license in a region. Since the 1990s, policymakers in several jurisdictions chose to restructure the industry to enable end-users to choose between competing electricity providers separated from distribution networks. In other places, policymakers chose to retain a regional monopoly in electricity retailing or introduced competition without unbundling of distribution networks. Therefore, electricity retail market designs vary across jurisdictions today.

This thesis analyses these differences by asking, "what is the political significance of electricity retail market design institutions for decentralised energy transitions on the demand-side?" The 'political' is defined as the realm of contestation and of varying distribution of resources and opportunities. 'Transition' dynamics are conceptualised through a socio-technical 'multi-level-perspective' lens that focuses on co-evolving realms of public policy, technology, and practices of firms and end-users. The thesis analyses 'transitions' as changes in these various spheres. The focus is on studying decision-making by policymakers, incumbent electricity companies, and innovative 'newcomer' firms. Empirically, the thesis studies electricity transition processes in two phases. First, it examines restructuring reforms in three US states - Massachusetts, California, and Texas - in the early 1990s, where new rules and electricity firm structures were created. Secondly, the thesis analyses business models, to study recent and ongoing processes of innovation that lead to increasing adoption of distributed energy resources behind the meter.

The thesis' methodology is qualitative, and data came primarily from the US, Europe, and Australia. The main sources were publicly available documents; interviews with observers, policymakers, industry experts, company representatives, and other key informants; as well as field notes prepared at industry conferences. The analysis used two different approaches: firstly, the contested and hence political nature of electricity retail market design was explored through discourse analysis. Secondly, the analysis of business model evolution compared processes of building business models in jurisdictions with different electricity retail market designs. This allowed analysing how electricity retail market design influenced the access to resources and opportunities for demand-side resource providers and their customers.

The research finds that there are three main contested assumptions that underlie different electricity retail market designs. Firstly, there is disagreement about the meaning of efficiency and welfare, along with assumptions about what type of institutional arrangement can best achieve these aims. Secondly, there are disagreements between those who frame electricity as a special type of service that requires different rules, and those who believe it should be treated similarly to other products. Thirdly, framings of what constitutes meaningful 'choice' differ between those who privilege individual market choices over collective choice by policymakers.

Depending on these different framings, actors highlight different problems as important and propose varying policies as solutions. These underlying assumptions are reflected in current debates about how institutional frameworks should evolve.

Additionally, the research found that electricity retail market design influenced DER newcomers' access to resources and opportunities in some cases: in jurisdictions without dedicated policy-support, electricity retailers and their customers were able to realise standardised DER projects, such as micro-generation, distributed storage, and simple demand response measures, where market conditions were otherwise favourable. These findings contradict the literature criticising electricity retail competition as hampering the emergence of distributed energy. At the same time, the findings refute literature that suggests competition is important for innovation in energy services. The research found that for many types of distributed energy business models, electricity retail market design does not play a significant role because the business models rely on revenue streams and customer channels independent of electricity retailers. As long as there is adequate policy support for resources behind the meter, electricity retail competition is not a necessary condition for distributed energy service business models to prosper. Different types of DER newcomers and customers can benefit from varying types of electricity retail market design. Competition enables those newcomers and customers with the necessary understanding and capabilities to benefit from a greater range of options in tariffs, contracts, and contestable functions. Retail monopoly reduces the options and thereby the complexity which can be better for newcomers and customers with fewer resources and capabilities.

The study also found that competing retailers have not successfully promoted bespoke, tailored energy services which require more in-depth analysis of a customer's premises, outside of regulatory obligations. This means that competition in retail does not drive these deeper, specially tailored distributed energy projects. This finding supports literature suggesting that on-going policy support is necessary, especially to improve building energy efficiency. Finally, the research did not find evidence to suggest that competition and unbundling of distribution network companies hamper implementation of well-designed policies to promote demand-side resources. Therefore, distributed demand-side transitions can occur under all kinds of electricity retail market designs.

This thesis therefore makes an important contribution to literature on energy services and electricity retail market design. It investigates business model innovation comparatively, after recent technological change and decarbonisation policies have improved the prospects for demand-side energy resources. Moreover, it makes a valuable contribution to policy practice and literature on socio-technical transitions in electricity by analysing the history and politics of retail market design with a focus on discourse and contested assumptions.

Acronyms

AMI: Advanced metering infrastructure

CCA: community choice aggregator

CHP: combined-and-power

CPUC: California Public Utilities Commission

DER: Distributed energy resources

DNO: distribution network operator (distribution network company, British term)

DR: demand response

DSO: distribution system operator (distribution network company, European term)

ERCOT: Electric Reliability Council of Texas

ESCO: energy service company

EU: European Union

GB: Great Britain

IOU: investor owned utility (US regulated-franchise electricity and gas company)

ISO: independent system operator

PG&E: Pacific Gas and Electric Company

PUC: public utilities commission (US regulatory agency)

PV: photovoltaic

RPS: renewable portfolio standard

SCE: Southern California Edison

TSO: transmission system operator

US: United States of America

VPP: virtual power plant

List of figures

1	Traditional electricity supply chain with a passive demand-side under vertically integrated monopoly or competition	19
2	Integrated theoretical framework to research socio-technical change processes	75
3	Socio-technical change through the institutionalisation of new commercial and policy structures to promote DER	76
4	competitive unbundled retail market design, similar to ERCOT	115
5	competitive bundled market design, similar to Massachusetts	116
6	Monopoly bundled market design, similar to California	117
7	Niche, landscape, and regime factors that destabilised the vertically integrated 'natural monopoly' in electricity generation and retail.	120
8	Value pools for DER across the regime	188
9	Access to revenue for DER providers in environments with and without policy support, and the role of retailing incumbents	323

List of tables

1	Methods of data collection and generation to answer subsidiary research questions	97
2	Storylines promoting institutional change in electricity retail in the US in the 1990s	127
3	Storylines promoting institutional continuity in the US in the 1990s	128
4	Incumbent centralised electricity business models	177
5	Summary of value propositions and revenue streams DER business model builders look to offer and capture	184
6	Types of energy contracting offered by energy service companies, plus financing	197
7	Similarities: instances where electricity retail market design has not influenced demand-side access to resources and opportunities	299
8	Differences in access: instances where electricity retail market design has influenced demand-side access to resources and opportunities	316

Chapter 1 - Introduction

1.1 Topic and problem definition

This thesis investigates a set of rules that organise how energy users buy electricity and interface with electricity systems commercially. I define this set of rules as electricity retail market design. Countries around the world have different electricity retail market designs, depending on decisions made by policymakers about how to organise the sector. This thesis focuses on the decisions that determine whether energy users may choose among competing retailers and generators from whom to buy electricity, or whether they are served by a monopoly; and whether electricity network operators are permitted to sell power to energy users.

These rules are important to study because policymakers in many countries are trying to promote investment in more energy saving and load shifting in time; while numerous energy users are interested in generating and storing low-carbon electricity on-site. Electricity retail market design organises how energy users interface with an electricity system, and may therefore play a role for how these demand-side resources 'behind the meter' can become more widely adopted (Eyre and Lockwood 2016). The nature of these rules and specifically, *how* they influence changes in the electricity sector toward a greater role for the demand-side are the subject of this research.

Demand-side energy resources are considered important for de-carbonising energy sectors, an agenda that has gained importance with aims to mitigate anthropogenic climate change (Creutzig et al. 2018). However, there are multiple 'co-benefits' of

saving energy (Fawcett and Killip 2019), of using rooftop-space for generating renewable electricity, and shifting energy demand to times when abundant low-carbon power is available. A more active demand-side offers potential to reduce the cost of low-carbon energy system transitions, improve citizen engagement and support (Bergman and Eyre 2011), reduce dependency on energy imports and environmental impacts of large-scale electricity production, and mitigate fuel poverty (Boardman 2010). Distributed energy resources have also been argued offer potential for local economic development and growth, if players can engage in the energy sector development in their region, where profits under a centralised system accrued to large, in some cases, foreign-owned firms (Hall and Roelich 2016).

For the purpose of this thesis, distributed energy resources (DER) located on the customer-side of the meter are: energy savings, electricity generated by micro-generation systems, stored in storage units on customer premises, or demand shifted in time (demand response). The wider deployment of DER entails a decentralisation of the energy system because when end-users self-generate, reduce or shift demand in time, this can displace power from centralised sources: generated in large, centralised power stations at large distances from and transported through networks to where power is consumed.

Overall, demand-side resources are not new or innovative in the sense that the technologies they rely on have been recently invented. Many large energy users have long since engaged in managing their demand where this was feasible and financially viable. However, the growing importance of DER now comes from wider adoption, new applications, new types of offerings to end-users, and the extension of DER into smaller energy users' premises, including individual households and small businesses. Recently, micro-generation, demand response, and distributed storage have become increasingly commercially viable. Policy ambitions to decarbonise the sector have led

to policies designed to support DER, as they offer decarbonisation benefits in most cases. Moreover, technological innovation in information and computing technology enables electricity companies to automatically control smaller, aggregated power sources and loads (Giordano and Fulli 2011). Digital innovation and developments in analytics capabilities have also promoted energy efficiency services (Bertoldi and Boza-Kiss 2017) because energy savings potential can be assessed remotely. Furthermore, the costs of electricity storage technology and micro-generation behind the meter have reduced (IRENA 2018; Nykvist and Nilsson 2015) offering opportunities for the wider adoption of demand-side energy resources. Demand-side flexibility and storage are also becoming more valuable to electricity systems, as variable renewable energy sources are gaining market share in electricity generation and require balancing. All of these changes have accelerated the adoption of DER in some jurisdictions.

A wider adoption of DER arguably entails a shift in how electricity end-users in buildings engage with the energy system. Energy users with DER can more actively participate through generating, storing, reducing or shifting demand than users who passively buy and use electricity as commodity from centralised power plants received through networks. This active participation could for example be 'co-producing' products and services (Watson 2004a), or exerting more control over decisions on how their energy needs are satisfied (Hannon et al. 2013). This means that electricity decentralisation and greater DER adoption entail not only changes in technologies and infrastructure, but also in end-user practices and the types of offers and services they purchase.

The wider adoption of DER implies changes in technologies and practices, and rules that organise how electricity firms and energy users interact will also have to evolve. It has been shown that rules including contracts, public policies, and regulatory

standards are important elements that 'lock in' energy systems to their established forms, and high-carbon paths (Unruh 2000). When technologies, user practices, and firms' products and strategies change, they don't always neatly fit into the rules and structures that were built in the past around different technologies and user practices. This means that changes to public policy rules that organise market players' interaction are necessary to escape lock-in (Unruh 2002), to enable wider adoption of DER, and to promote a more active electricity demand-side. The problem of electricity sector structures and rules that don't fit novel practices, technologies, and businesses gave the impetus for this thesis to make a timely contribution: by studying in detail the history of rules that organise how the demand-side interfaces with an electricity system, and the significance of these rules for demand-side resources today, the thesis can inform policy reform processes going forward.

Empirically, this thesis starts from the assumption that electricity retail market design influences how the wider adoption of DER, and ultimately the decarbonisation of the energy sector can evolve (Eyre and Lockwood 2016). Electricity retail market design organises the boundary of competition and monopoly on the end-user-side of electricity systems, as well as the associated electricity firms' business activities.

Conceptually, the assumption is that changes in technologies and changes in rules and regulations are interrelated, and 'co-evolve' over time (Foxon 2011; Schot and Geels 2011). Large-scale transformations of socio-technical systems in the past involved interrelated changes in many domains, including skills, technologies, infrastructure, lifestyles, business strategies, science, and regulation (Geels and Schot 2007). Social interaction in all of these realms is structured by rules, referred to as 'institutions'. Change occurs through the creation of new structures (Fuenfschilling and Truffer 2014), that is the institutionalisation of novelties. This thesis focuses in particular on two types of new structures: public policy institutions in the realm of 'regulation', and

commercial structures like firms, contracts, and product offerings in the realm of 'business'. The research investigates the coevolution of specific public policy institutions, namely electricity retail market design, with commercial structures that promote DER.

In order to make a novel contribution, I research the politics of electricity retail, by investigating how retail market design is *politically significant* for distributed energy resources. It takes both an interpretive and a resource-based view of politics. The interpretive perspective (Fischer 2007) defines the political as the realm of contestation. This makes a timely contribution to research on energy transitions because as Schwanen et al. (2017) put it, analysts should *"recognize that disagreement and contestation are central to low-carbon transitions and consider how best to accommodate these conflicts rather than ignore them"* (see also Stirling 2011). The interpretive perspective is linked to a constructivist tradition and suggests researching disagreement and the construction of concepts and ideas. The resource-based view of politics takes a more realist approach. From this perspective, investigating the 'political' implies researching how institutions impact different actors, distribution of resources and opportunities, and inequalities (Lasswell 1936). Both policy analysis traditions inform the definition of the 'political' used in this thesis: domains of contestation and of distributing resources and opportunities.

1.2 Empirical focus and research question

The thesis studies two phases of socio-technical change in the electricity sector on the demand-side. The first phase covers competition reforms in electricity which altered the way energy users commercially interface with the system. The second phase

focuses on the present where the electricity sector is seeing new entry by players who promote demand-side resources on a larger scale.

The first phase of socio-technical change on the demand-side this thesis investigates is aimed at historical processes of *public policy change* that created new rules and firm structures in the electricity sector in the 1990s and early 2000s. These reforms to the structure of electricity companies are commonly referred to as market 'restructuring' or 'deregulation' in the US, and as 'liberalisation' in European literature. The latter term is often used to describe both privatisation and the creation of markets. This thesis focuses on competition reforms and does not consider the history and significance of privatisation policies. Although they are often discussed as closely related and complimentary, privatisation and the introduction of competition in electricity are separate reforms and were implemented independently from one another (Patterson 1999).

Originally, electricity systems evolved into a structure of regional monopolies, where end-users had to buy power from a company that was vertically integrated, operating power plants, networks, and meters. Competition reforms were intended to alter this arrangement so that generators and retailers would compete, and in some cases also involved breaking up the supply chain into separate companies. Creating these new markets and structures meant that policymakers and industry had to construct new rules and institutions (Joskow and Schmalensee 1983).

Market design describes rules through which policymakers influence the places and formats for transaction between buyers and sellers, or between those with resources to distribute, and off-takers (see e.g. Green 2008). The rules and structures that organise from whom customers may buy electricity vary across countries and this means that policymakers with similar aims to promote demand-side resources and

decarbonisation in different jurisdictions have varying starting points. The term 'market design' is not used in neo-classical economic theory which assumes markets are a natural, initial state (Hodgson 2007). However, in policy practice it is acknowledged that there are reasons for policymakers to engage with the design of institutions that govern the allocation of sparse resources. Policymakers are interested in market design mainly in response to reducing 'market failure', and to address political and ethical aims that may arise in relation to these 'allocation mechanisms' (Kominers et al. 2017; Li 2017). The literature on criteria that allocation mechanisms should meet to improve market outcomes has grown especially since auctions had to be designed to assign rights (licenses) to transmit signals over specific bands of the electromagnetic spectrum ('spectrum auctions') (Cramton 1997; Vulkan et al. 2013). In the electricity sector, for analysing and comparing market designs, Belhomme et al. (2016 : 1) recommend identifying essential functions, roles and interactions between roles.

Creating electricity markets entailed moving the boundary of what was considered a 'natural monopoly' and making functions *contestable* that were previously considered most efficiently delivered by a single monopoly company in an area. This meant allowing new entrants to compete, and thereby introducing competition to some functions in electricity.

This thesis focuses on functions considered part of 'electricity retail' at the downstream end of a traditional electricity supply chain: buying power from generation companies and selling it to energy users, billing for power, and in some jurisdictions, metering (see Figure 1). These are 'customer-facing' functions that are organised as monopoly functions in some jurisdictions and are contestable in others; were separated from electricity network operation functions in some jurisdictions and remained integrated with network operation in others.

Competition in generation has been allowed in many jurisdictions around the world. Competition in downstream retail functions is less common and was originally implemented only in Chile, Europe, some US jurisdictions, Australia, and New Zealand, with a few more jurisdictions following suit in later years. Additionally, some jurisdictions implemented *'unbundling'* or 'disaggregation' reforms which forced transmission and distribution companies to divest contestable functions and related company units and assets, or at least operate as commercially separate entities (Meletiou et al. 2018). Unbundling was implemented for instance in Great Britain and Texas (ERCOT[1]). The restructuring of downstream functions is the focus of this thesis, and to illustrate, Figure 1 shows where I draw a boundary around downstream functions, electricity *retail* functions, and retail market design.

[1] The region in Texas under jurisdiction of the Electric Reliability Council of Texas (ERCOT) covers more than 90% of electric load in the state and is referred to by this acronym.

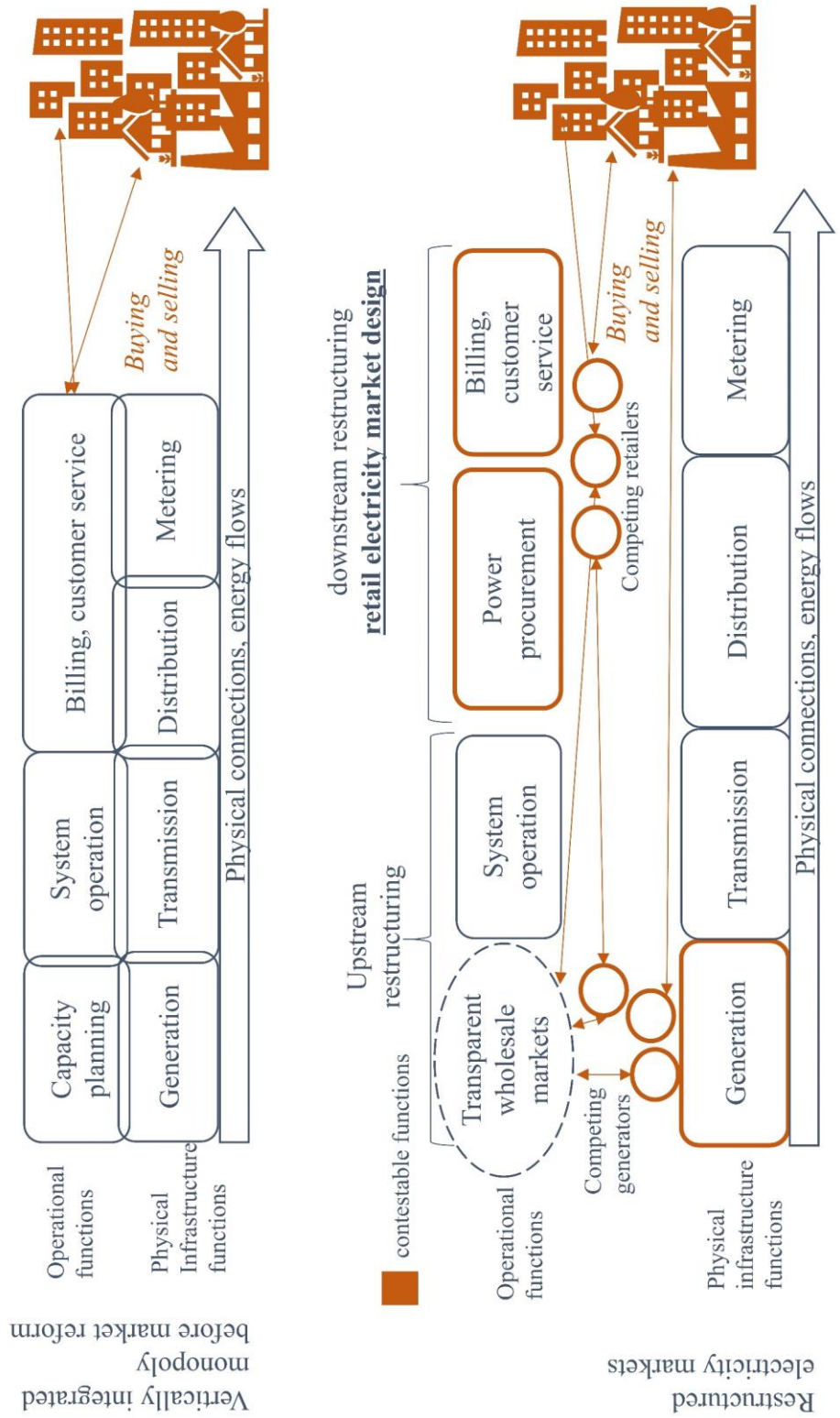


Figure 1: Traditional electricity supply chain with a passive demand-side under vertically integrated monopoly or competition

As outlined in Figure 1, policymakers choosing to make certain electricity functions contestable did not change the physical structure of the sector. The term electricity 'restructuring' refers to institutional change that altered the structure of firms, commercial relationships, interactions, and rules that organise how electricity is bought and sold, and who may use networks to transport power. Different approaches to competition and unbundling of retailing functions today mean that between jurisdictions with different electricity retail market designs, firms providing these functions are organised differently, in terms of their scope of operation, whether they are regulated as monopolies or as competing players, and how they interact with firms providing other functions, and with end-users.

For the purpose of this thesis, competitive *electricity retail market designs* are understood as institutional arrangements that enable customers to buy from generators or retailers, rather than only from one company. By contrast, under a monopoly retail market design an entity whom customers are regionally assigned to procures power on their behalf from competing generators (this has also been called the 'portfolio manager model' (Joskow and Noll 1999)). Here, electricity users are captive until they decide to meet their energy needs through alternative means than electricity transported through the public network. As long as few electricity users have the means or inclination to do so, the companies regulated as monopolies can be very confident about cost recovery through revenues collected from these captive customers. Their activity is licensed for a specified region through a franchise issued by policymakers, and they are referred to as 'regulated-franchise' utilities for the purpose of this thesis. Players without a captive customer base are referred to as 'competing' companies.

Competition reforms brought numerous changes. Firstly, where retail restructuring was implemented, energy procurement was no longer a centralised planning activity,

as under a monopoly system. Instead, generators had to invest in power plants based on market signals[2], given by customers, retailers, or intermediary traders who signal their demand to purchase power. Secondly, competition in electricity retailing required independent access to public electricity networks (Joskow and Noll 1999) owned and operated by regulated-franchise companies (electricity networks on public land). This forced these network companies to make capacity on their networks accessible to competing companies who transport (or 'wheel') power they bought or sold to their contractual partners. These are conventionally generators, retailers, and large customers who buy electricity directly wholesale. Finally, other downstream functions including billing and metering were opened to competition in some, but not all jurisdictions.

The other empirical focus of this thesis is on current processes of socio-technical change that lead to a greater role for *demand-side resources* and thereby a *decentralisation* within electricity systems. In several countries, the importance of smaller units for generating electricity, connected to distribution rather than transmission networks, is growing, investment is happening closer to end-use, and smaller-scale organisations, including energy users themselves, play a more active role in the sector. Demand-side resources 'behind the meter', also known as 'distributed energy resources' (DER) contribute to decentralisation when they displace centralised resources in electricity systems. The research examines changes in firm activities and strategies, and how these processes relate to electricity retail market design.

[2] In some jurisdictions, centralised capacity planning was reintroduced after electricity competition reforms, through 'capacity mechanisms' that provide long-term revenue, based on worries that adequate capacity margins might not be achieved otherwise.

There are a variety of drivers which have contributed to the promotion of DER. Energy savings and electricity generation behind the meter have been invested in by large energy users for many years, driven by their interest in cost reduction and increased reliability of supply, especially in moments and regions where grid-electricity expenses were significant (Kindström and Ottosson 2016). However, policies to explicitly support energy savings and microgeneration have recently driven increased investment, and more specifically in buildings occupied by small businesses and households (Brown and Wang 2015; Watson 2004a). Today, jurisdictions with high penetration of micro-generation are for instance, the UK, Belgium, Denmark, Germany, Greece, California, Hawaii, Arizona (Eid, Codani, et al. 2016), and Australia (Doc-68[3]). Distributed energy storage has been adopted more widely in response to the proliferation of renewable energy technologies and micro-generation, especially solar PV, although levels of adoption are so far lower (Eid, Codani, et al. 2016). Demand response has been established for industrial and large commercial energy users in some jurisdictions for decades, but recently receiving renewed attention in several countries as a low-carbon power resource (Darby and McKenna 2012). Demand response has become more viable recently also on residential energy users' premises because of advances in digital control and communication technology including metering, and wider development of information and communication technology. Load shifting is managed either by energy users themselves in response to signals, for instance time-varying tariffs, or dispatched by energy companies with the authority to directly control appliances (Behrangrad 2015).

The thesis investigates processes of socio-technical change and the role of public policy institutions. Specifically, it examines the political nature of electricity retail

[3] Please see Appendix 1 for a list of primary documents.

market design and demand-side energy transitions. It explores how different institutional designs evolved, and how they influence demand-side energy transitions today. The central research question is:

> *"What is the political significance of electricity retail market design institutions for decentralised energy transitions on the demand-side?"*

There are several subsidiary research questions. These are introduced in Chapter 3 because they are contingent on the explanation of theoretical lenses in Chapter 2.

1.3 Contribution

The research is relevant today because electricity retail market design is currently a live area of policy reform in several countries, and because the literature on the topic has so far not examined the political dimensions of electricity retail market design and their relation to demand-side energy transitions. Therefore, this thesis aims to make contributions to empirical literature and policy debates.

Firstly, this thesis contributes to literature on electricity systems and specifically electricity retail markets. Since their creation, there has been considerable debate about electricity retail markets' performance and the merits of these reforms (see e.g., Brown and Eckert 2018; Cavanagh and Levin 2016; Defeuilley 2009b; Kiesling 2014). With climate change mitigation growing in importance as a policy aim for the energy sector in many jurisdictions, some have suggested that 'liberalisation' reforms in electricity may make it more difficult to decarbonise the energy sector rapidly (Mitchell 2008). Others have praised the potential of competition to engender innovation in energy services and demand-reduction (Marino et al. 2011) and thereby possibly support energy sector decarbonisation. This thesis seeks to contribute to this

debate, by analysing the *history* of electricity retail market creation, and *recent evidence* on how firm strategies and activities have been evolving under different electricity retail market designs. Now that the conditions influencing the potential for the demand-side to participate actively in the system have arguably improved and DER have become more important to decarbonising the sector, this research can make a timely contribution to the literature.

In order to focus on how energy services markets and different types of demand-side resources are affected by electricity *retail* market design, the research excluded jurisdictions with entirely vertically integrated monopoly structures. The data collection focused on jurisdictions where the electricity sector was restructured to allow competition at least upstream in power generation and wholesale electricity markets, but where downstream market designs vary.

Secondly, the thesis makes a valuable contribution because it seeks to politicise debates on electricity retail and demand-side transitions by applying an interpretive policy analysis lens (Fischer 2007) which has not been employed in the study of electricity retail markets before. The focus on *political significance* entails examining in detail differences between market designs and analysing these with respect to ideas; assumptions and meanings underlying varying institutional arrangements; and access to resources and opportunities. It does this first through tracing the historic evolution of electricity retail competition policies in three US states, studying how specific public policy institutions evolved, how they were contested, and which ideas underly them. Then, the thesis compares how processes of change are occurring in jurisdictions with different electricity retail market designs in place today. Analysis of processes in both phases allows to better understand different stakeholders' perception of how public policy institutions affect their access to resources and opportunities; and to analyse how assumptions underlying various proposals are

constructed. This enables informing debates today with the aim to approach reforms more reflexively (Fischer 2007). The research therefore offers important contributions by presenting a *political* analysis of electricity market design, rather than a purely economic or innovation-focused analysis.

This political perspective is valuable also to wider literature on transitions within electricity systems. Since analysts of electricity began studying the evolution of the sector, there have been debates about the relative significance of technological and social factors in driving change. While some have portrayed the development of institutions that structured electricity systems as evolving to accommodate technological change, others have interpreted the history of electricity systems as more socially determined. The research presented in this thesis can help bridge these perspectives through its interpretive approach to politics that pays attention to discourse and ideas, a perspective that has not been applied to coevolutionary electricity sector analyses in this way before.

Thirdly, this research is relevant and timely because reform to electricity retail markets remains or has returned to the regulatory agenda in many countries. This is because the greater opportunities and demand for DER arguably offer new potential for innovation in energy services. Now, new entrants to the electricity sector are challenging the institutional structures constructed when technical and market conditions in the electricity sector were different, often calling for public policy change. Some policymakers in jurisdictions with monopoly in electricity retailing are considering moving to contestable retailing. For example, in California where the number of energy users adopting rooftop solar PV systems is growing, a senior policymaker said, *"advanced metering infrastructure, rooftop solar, increasingly price drops in battery storage, just as examples are allowing customers themselves to invest in systems that allow them to meet needs that were once the sole providence of*

a regulated monopoly utility" (Doc-26-Picker). This means that the established electricity monopolies and the regulatory structures within which they are embedded are being challenged from behind the meter. Like 25 years earlier, when market restructuring reforms were first discussed, policymakers feel that *"the technology is changing fast. (…) And so, going forward, again you're back to the question of which of the functions are still utility functions and which are not, and what are the consequences of that mixture?"* (Doc-26-Weisenmiller).

Electricity retail market design is also being discussed again in some jurisdictions where competition in retailing was implemented already several decades ago. For instance, the British Government and energy regulator since 2017 are considering large-scale reforms to the regulatory regime because *"current retail market arrangements can get in the way of beneficial innovation and competition in a number of ways. (…) Existing arrangements can prevent potential new entrants with disruptive business models from entering the market (…)"* (Doc-69-Ofgem). Therefore, this thesis is contributing to important policy debates around how the public policy institutions that organise energy users' interface with electricity systems can deliver outcomes valued by policymakers, customers, and a variety of stakeholders.

1.4 Outline of the thesis

Chapter 2 first presents a review of literature on the history of the electricity sector in Europe and the US to explain how the structures have changed over time, and technologies, resources, practices, and public policies have co-evolved. Then, Chapter 2 reviews literature on the performance of electricity retail markets in encouraging

innovation, specifically on the demand-side. Next, it explains the thesis' conceptual underpinnings by integrating lenses for the analysis of socio-technical change with frameworks from political science and business studies and explains how these are mobilised to address gaps in the literature. Chapter 3 outlines the methodology. The first phase of socio-technical change in electricity is investigated through case studies of electricity retail market restructuring in three US states. The study of on-going socio-technical changes is based on qualitatively researching processes of building and evolving business models, across several jurisdictions, types of DER, and firms.

The three empirical chapters 4, 5, and 6 present the data on how processes of institutionalising new commercial and public policy institutions have unfolded in detail. Chapter 4 traces the historical evolution of three different electricity retail market designs in California, Massachusetts, and Texas. It outlines changes in technology, public policy, economics, and ideas, and how opposing coalitions of actors argued for different reforms. Chapter 5 explains that the different reform outcomes influenced the structures of electricity utilities, so that in jurisdictions with different market designs, different types of electricity companies operate as incumbents. It then outlines how at present, new entrants to the electricity sector are challenging these established players by promoting decentralised energy resources behind the meter. This covers resources the challengers require, and barriers some have experienced. Chapter 6 shows that in some jurisdictions, established, centralised electricity firms are trying to evolve, how and why some have supported demand-side resources, and which difficulties they have faced.

These processes of socio-technical change are analysed comparatively in Chapter 7 to answer the overarching research question about the political significance of electricity retail market design for distributed energy resources on the demand-side. The Analysis chapter discusses the contested nature of electricity retail market design

institutions, and how they influence access to resources and opportunities in the context of a system with a greater role for demand-side resources. Because electricity retail market design institutions influence the type of electricity firm that is incumbent in any jurisdiction, it also influences how these companies can evolve. The discussion compares how different types of electricity firms, competing companies and regulated-franchise companies, have interacted with DER challengers, and elucidates where electricity retail market design has had significance for access to resources and opportunities. Finally, the chapter draws lessons from the research for the study of socio-technical change in electricity systems. Chapter 8 concludes by answering the research questions, summarising the arguments, outlining the implications for public policy, suggesting avenues for further research, and reviewing the thesis' contribution.

Chapter 2 - Literature Review

The following chapter reviews empirical literature this thesis contributes to, and theoretical literature which guided the research. The thesis is concerned with two main bodies of empirical literature. The history of socio-technical change in electricity is outlined in 2.1.1: initially towards centralisation with electricity production far removed from demand, under a structure of vertically integrated monopoly; later towards a greater role for competition; and most recently with a growing importance for the demand-side. Then, section 2.1.2 reviews literature assessing electricity retail market reform, and the links analysts have drawn to innovation on the demand-side.

The chapter then turns to reviewing theoretical literature which guided the research in section 2.2. Firstly, it outlines the approach to studying socio-technical change in electricity which is based on the multi-level-perspective and coevolutionary theories. Therein, the institutionalisation of new structures has special importance for studying coevolution of technologies, practices, business strategies, and public policies. The section then turns to literature that helps conceptualise institutionalisation processes in different realms: institutional change in public policy through a discourse coalitions lens where important actors are policymakers, interest groups, and citizens. Finally, a lens from business studies to analyse the institutionalisation of new commercial structures is introduced. Here, firms engage in building business models which entails constructing networks with business partners and customers. Section 2.3 outlines how the theoretical lenses are integrated and operationalised to address gaps in the empirical literature this thesis is seeking to address.

2.1 Empirical literature

2.1.1 Historic evolution of electricity sector institutions and scale

Initially, electricity systems began as small-scale, local systems operated by vertically integrated firms. When electricity first emerged as a product, it was marketed by private entrepreneurs who were competing to electrify mainly commercial customers in urban areas, such as office buildings, shops, theatres, and street lighting operations (Hughes 1983). Successful pioneers such as Thomas Edison structured their firms to be 'vertically integrated', meaning they designed, built, and operated the power generators, networks to transport the power, and the lighting technology turning electricity into a useful service (Rudolph and Ridley 1986). Early on, competitor firms such as Brush experimented with selling individual power systems, not connected to a central station, but this model was commercially more challenging to realise (ibid.). Systems to generate power on-site were initially successful in the manufacturing sector: in the US, by 1907, 65 000 plants had isolated power generators (Yakubovich et al. 2005 : 605).

However, over time, electricity systems in the US and Europe centralised through interconnection, first at the urban scale as larger district systems, and shortly thereafter also regionally (Hughes 1983). This meant that larger-scale power plants were interconnected through longer distribution and transmission systems with demand centres at increasingly further distances. Historians and sociologists of electricity have been divided about whether the emergence of large-scale, centralised electricity generation and transmission infrastructure is to be explained primarily through principles of economic and technical rationality which make large-scale systems more

cost-effective, or whether the privileging of large, capital-intensive infrastructure was driven decisively by interest groups seeking to expand their economic and political power.

Early on, the sector developed monopoly structures because firms electrifying city districts often consolidated, and this structure was authorised by some local policymakers by granting exclusive 'licenses' to operate. As networked power systems to electrify lighting for high-paying users were growing in cities in Europe and the US toward the end of the 19th century, some policymakers became increasingly unsatisfied with the visible and cost effects of 'ruinous competition': *"multiple parallel lines and forests of poles"* (Rudolph and Ridley 1986 : 31), lengthy street works, firms going out of business and subsequent consolidation leading to monopoly structures. These conditions led to cities issuing licenses, 'concessions', or 'franchises', giving individual firms exclusive rights to operation in an area (Hughes 1983). This system of monopoly franchising had already been implemented in the gas sector for instance in British cities as early as the 1860s. After ruinous competition had led to the market consolidating into district-level monopolies, these structures were institutionalised in subsequent issuance of concessions (ibid.). Some cities also established municipal monopoly utilities, where policymakers began to worry about the political influence growing private monopolies were gaining (Rudolph and Ridley 1986), both financially, and through their control of a service increasingly important to the economy and citizens.

Technological centralisation involved the average size of power plants growing, and the interconnection of regions through transmission lines capable to transmit power over long distances. These technological changes were institutionalised through company consolidation (Rudolph and Ridley 1986), large utilities buying municipal systems, agreements to exchange power, and through the creation of state- or national-

scale frameworks of rules, such as regulatory agencies in the US (ibid.), or standardisation bodies in Europe (Van der Vleuten and Raven 2006). Where cities did not limit companies' reach, 'system builders' like Edison, his successor Insull, and others in Europe continued to strive *"in a purposeful way to expand the territory of their utilities"*(Hughes 1983 : 463). This created 'empires' of private investor-owned utility (IOU) conglomerates (Patterson 1999), with a few municipal and cooperative enclaves where decision-makers had not given in to the pressure to sell and consolidate.

In several European countries, more cities retained control over electricity supply during the 1920s and 30s than in the US. Their municipal utilities, along with some rural cooperatives, managed to resist consolidation of firms (Hughes 1983), and henceforth operated within in a *"regime of co-existence"* with large, centralised electricity utilities (Van der Vleuten and Raven 2006). In Germany, RWE managed to expand its territory by selling stock to municipal governments who in return agreed to buy power from the big utility (Hughes 1983). This led to a structure of mixed ownership which continues to this day. While the firm structures remained separate, the city-scale utilities were physically interconnected with larger grids and depended on the centralised power plant and network infrastructure to meet electricity demand, and these structures have persisted until today in countries like Germany, the Netherlands, and Denmark. In the US too, municipalities over time, with assistance from the federal Government, aggregated resources to enable buying power from centralised plants and jointly invest in centralised generation and transmission (Carley 2011). Municipal and other small-scale utilities' investments in centralised electricity infrastructure means that, although they operate more locally, these players still benefit financially from energy consumption met by centralised power plants.

Prominent historians of electricity have explained the centralisation of systems as a result of techno-economic superiority of large power plants and transmission infrastructure over the alternatives: decentralised systems and resources behind the meter. Hughes argues,*"expansion was not simply an aggressive drive for undifferentiated size; it was a purposeful move to lower the cost of energy"* (463) because large scale, integrated systems offered techno-economic advantages. First, he argues, technological innovation in turbine technology led to utilities seeking to connect more customers. He proposes that power plant managers chose to introduce the steam engine in power plants in order to replace the less efficient, large reciprocating engines because they took up too much space in urban areas. This *"resulted in the unprecedented and unexpected spread of power systems. (…) The turbines were, in effect, supply in search of demand"* because they had economy-of-scale potential which entrepreneurs sought to fulfil by connecting new load (Hughes 1983 : 363–364). Development in transformer technology in the late 19th century further catalysed centralisation of systems because it improved the viability of long-distance transmission. After power transmitted at high voltage had initially incurred high losses and was unsafe to use in many contexts, transformer technology allowed it be 'stepped up' and 'stepped down' (ibid.) for more uses. After a political battle between those invested in direct current (DC) technology and advocates invested in alternating current (AC), the latter was permitted and institutionalised in standards (ibid.), further improving the economic viability of large, interconnected systems. Following these technological and institutional changes, in the 1910s and 20s, systems grew through interconnection of power plants and demand centres with transmission lines across several hundred kilometres.

Secondly, Hughes contends that engineers understood that they could realise efficiencies from exploiting human and natural geography which required managing

systems across regions. Two key practices established within the power engineering discipline promoted urban and regional interconnection and expansion: the principle of the 'economic mix' of different power plants, and the improvement of load factor through pursuing diversity of demand (Hughes 1983). Interconnecting power plants with different characteristics across regions, such as pumped water, run-of-the-river, soft and hard coal-fired power generation, and dispatching them at different times to achieve an 'economic mix' was practiced by early system builders already in the late 19th century (ibid.). Furthermore, utility managers understood that the human geography could also be beneficially mixed to improve the economic performance of plants. A *"diversity of loads that brought a fuller round-the-clock utilization of generating equipment"* (ibid.: 463) would improve the 'load factor'. Diversity of load they understood was likely found in a greater geographical area, for instance by serving both a chemical plants' night shift and a tram operator's day-time peak.

Other historians and sociologists are critical of the view that the centralised firm structures and large, regional franchises interconnecting vast territories developed by the 1930s were the effect of technically optimal engineering practice. Critics contend that these structures were instead driven by private utilities seeking to extend their power and reach in the face of competition, including from more decentralised municipal utilities and on-site generation. The study of early political strategies employed by private electricity utilities suggests that large power systems developed their techno-economic superiority only after institutions developed that privileged them over smaller-scale systems. Granovetter and McGuire (1998) have shown that private electricity utilities in the US strove to expand territories before the steam engine was introduced in the late 19th century, and thereby before electricity systems could be argued to exhibit significant scale economies. Early on, Edison

> *"saw the growth of the business as dependent on construction of central power stations, each generating and transmitting electric current to hundreds of thousands of customers, all paying operating companies year after year all their lives for a supply of electricity" (Rudolph and Ridley 1986 : 28).*

Critics of the notion that engineering rationale and technology determined how structures in the electricity sector evolved argue that political and institutional structures were built to accommodate this centralised vision.

The early electricity 'system builders'' aggressive search for large energy users to connect is evidence for their active role in driving centralisation and expansion. As manufacturing electrified, especially large industrial energy users found it advantageous to install isolated systems on their own premises initially, but the operators of centralised stations sought to integrate these. For instance in Germany's industrialising West, *"RWE's management persuaded many [industrial plants] to exchange power with RWE or even become completely dependent on its system"* (Hughes 1983 : 409). Similarly, Insull at Chicago Edison, like other station managers, met the challenge that less peaky, 'long-hour' customers installed their own plant by offering them much lower rates than offered to other customers. Offering these *"'special contracts', the most extreme form of price discrimination"* (Yakubovich et al. 2005 : 586) allowed the central station to outcompete self-supply options. Hughes explained this strategy with the engineering principle of promoting an improved 'load factor' to lower the cost of supply because large energy users using electricity over longer periods in a day can improve diversity of demand. Yakubovich et al. by contrast argue that Insull and others were in fact connecting new large customers *at the expense* of balanced load and short-run efficiency. They suggest that managers of central electricity stations *"had major interest in expanding the central station business in the short run at almost any cost. Evidence suggests that the economic motives for this were the fear of competition from gas lighting, not-for profit electric systems and*

isolated generation, and the perceived need to pre-empt the market that these threatening competitors might otherwise serve" (Yakubovich et al. 2005 : 600).

US private central-station managers tried to curb demand-side resources, discouraging large customers from self-generating and managing their demand. Yakubovich et al. (2005) document how they worked to establish standardised pricing systems which would avoid incorporating time-of-use elements, in order not to penalise increased consumption at peak-time. Rather than choosing a pricing system which would have reduced operating costs in the short-term by encouraging users to move consumption to off-peak hours (the 'Barstow system'), utility managers chose to institutionalise the 'Wright' system which would increase their revenues. Yakubovich et al. (2005) argue that the proponents of the "Wright system" and its associated meter mobilised political influence to ensure it triumphed over the alternative. This disadvantaged small-scale power systems, so that they were not seriously competitive again in the US until the 1980s (ibid.).

The vertically integrated monopoly firm structure under exclusive franchise also facilitated the physical and regulatory centralisation of the sector because it institutionalised the electricity entrepreneurs' claim to expand into new territories. The establishment of the regulated-franchise with an exclusive license to operate was promoted very decisively by the industry itself. Some public policymakers did see merit in the concept to reduce the adverse effects of competing wires and street works. But lobbying for exclusive franchise pre-emptively allowed curbing the emergence of municipal utilities and restricting competition from self-generating customers. Some, prominently railroad companies, were at the time also selling power in their vicinity (Yakubovich et al. 2005). In 1898, Samuel Insull presented fellow executives of investor-owned power companies in the US with his idea to lobby for the regulated exclusive franchise (Rudolph and Ridley 1986). The "*frightened leaders of the private*

power companies" subsequently embraced the concept so as not to *"sit idly by as their grip on the future of the industry and the political and economic control attached to it gradually slipped away"* (ibid. : 38). They supported the regulation of rates and standards by Government agencies, to *"reduce 'the necessity or excuse for municipal ownership by securing fair treatment for the public'"* (Insull, cited in ibid. 1986 : 39–40). Public utility commissions (PUCs) were established to ensure protection of the public interest by regulating private monopolies (ibid.). As organisations with jurisdiction across states, their creation further cemented the centralised structure of the industry in the US. Some argue they were used to limit the scope for cities to pursue self-regulated municipal systems (Granovetter and McGuire 1998). Overall, the institutionalisation of the 'natural monopoly' in electricity has been interpreted as one way for private companies to ensure ongoing profits at the expense of captive customers (Granovetter and McGuire 1998; Rudolph and Ridley 1986), hidden in a complex and untransparent regulatory process intended to protect their privileged position (Joskow 2009).

After the steam engine and first transmission lines promoted physical power system centralisation, the technologies employed for power generation grew in scale even further between the 1930s and 1960s. The centralised corporate and regulatory structures remained in place. Where centralised Governments owned and controlled utility companies, power system managers were also not motivated to explore opportunities of decentralised technologies and a role for energy users as co-producers. Russel has shown how in the UK, after the electricity industry had been nationalised in the 1940s, the Government-owned electricity industry repeatedly resisted moves to encourage combined-heat-and power plants and energy conservation, even where politicians tried to encourage it (Russel 1993 : 48). He argues that the history of the electricity sector in Britain shows that *"the dominance*

of producer interests has been maintained"; that they *" sought to consolidate and maintain the structure of the sector"* around *"commodity relations with consumers"*; and *" to minimize users' political influence, so that (...) a limited choice of delivered energy forms"* remained. This meant that the institutions linked to techno-economic principles privileging scale endured, and the system continued relying mainly on centralised power plants far removed from centres of demand to supply commodity electricity. By the 1960s, the *"same technical model and the same guiding premises shaped the thinking of electricity planners everywhere, whatever the institutional context in which they worked. The most economical way to supply electricity to users was to generate it in the largest possible power stations and deliver it through a synchronized AC network covering the largest possible area"* (Patterson 1999 : 59). This idea was reinforced especially once nuclear power was pursued as an important new generation technology (ibid. p. 63). On-site generation and self-supply had become niche practices.

In the last decades of the 20th century, electricity systems became somewhat more decentralised in terms of resources employed to meet demand because investment in demand-side resources, namely combined-heat-and-power-plants (co-generation), demand management, and energy conservation increased. Following the OPEC Oil Embargo to the US and the Netherlands, wider oil price shocks in 1973 and 1979, ensuing petroleum shortages, as well as rising public concerns about the environmental impacts of the power industry, policymakers in many OECD countries began making energy conservation a policy priority (Carley 2011; Eyre and Mallaburn 2014; Russel 1993; Verbong and Geels 2007).

In the US, utility-run programmes to reduce energy consumption were incorporated into power system planning in the 1980s (Isser 2015). The framing of energy demand reduction as 'negawatts' involved acknowledging benefits from energy efficiency

investment and load shifting not simply as improved consumption, but as resources with value to the wider system and to meet energy needs (Rochlin 2016). In some states, 'integrated resource planning' rules required comparing demand-management programmes to investment in new transmission and generation capacity on equal footing. If externalities such as environmental and social impacts of new supply-side resources were included in cost benefit analyses, demand-side programmes often looked favourable (ibid.). In the US, investment in energy efficiency grew (Blumstein et al. 2000), and load shifting provided by large industrial energy users was established as an important part of grid management, especially where electricity demand had large peaks.

European Governments affected by the 'oil crisis' also launched energy saving policies in the 1970s and 80s (Bertoldi et al. 2006; Eyre and Mallaburn 2014). Investment in nuclear power plants also led to promoting investment on the demand-side in some countries. To balance power production from the inflexible nuclear generators over-night, power system planners since the 1980s promoted the installation of appliances which could provide thermal storage by shifting consumption to times of low demand (Boait et al. 2017), and in some cases, electricity tariffs were also designed to encourage night-time demand.

Furthermore, some Governments forced centralised electricity monopolies to connect third parties' power plants and to compensate them for electricity fed into the grid in the aftermath of the oil price shocks (Carley 2011; Verbong and Geels 2007). These laws and the increased availability of natural gas in the 1980s encouraged a growth of decentralised electricity units, including industrial co-generation which grew rapidly in the US and some European countries (Carley, 2011; Verbong and Geels, 2007). At the transmission grid scale, average power plant size also reduced again in the late 1980s. Gas-fired power plants as smaller and more flexibly controllable alternatives

were adopted more widely, following lower gas prices and the development of the combined cycle gas turbine (CCGT), a synthesis of gas and steam turbines following innovation in the aircraft industry (Watson 2004b). This meant that after decades of power plants growing in scale up to several GW capacity with coal and nuclear having been the technologies of choice, smaller, less capital-intensive power-plants became more widespread again.

Towards the end of the 20th century, the institutional framework for the electricity sector based on the vertically integrated monopoly structure was reformed in several jurisdictions. The viability of smaller-scale power plants cast doubt on the notion that electricity systems had to be organised as 'natural monopolies' along the entire supply chain (Carley 2011; Hausman and Neufeld 2011). The policies forcing monopoly utilities to connect and remunerate independents generating power were the first step in a series of regulatory reforms that enabled new players, including self-generating end-users, to compete with the vertically integrated utilities (Carley 2011) using their networks on public land.

In the following years, some jurisdictions introduced further competition reforms (Newbery 2000). Great Britain was perceived world-wide as one of the pioneers of electricity sector competition reforms in the 1980s and 1990s, and several EU and US states tried to learn from its experience (Voss 2007). The British 'standard model' of reform included the creation of transparent spot markets for trading power at the wholesale level and opening electricity retail markets to competition so that end-users could choose from whom to buy power (Voss 2007). Energy networks would continue to be regulated as monopolies under exclusive regional franchise but would have to provide 'third-party-access' to generators, retailers, and end-users. Britain's 'standard model' also included tackling vertical integration, by forcing companies to separate

energy networks and system operation [4], considered 'natural monopoly' activities, from other, newly contestable, functions through 'unbundling' (Newbery 2000). Furthermore, it entailed creating an 'independent regulator' charged with regulating and capping revenues for the monopolies and ensuring network did not discriminate in granting third-party-access to networks (Bolton and Foxon 2013). Where regulatory agencies were already in place, reforms entailed extending their role to overseeing the newly created markets.

In the 1990s and 2000s, electricity market competition reforms were adopted in many countries, including the European Union, some US, Australian, and Canadian states (provinces), and New Zealand. The British 'standard model' was adapted considerably as it travelled, although it had powerful advocates praising the value of the newly developed technocratic approach of 'regulatory science' (Voss 2007). Policymakers in many jurisdictions adopted some of its elements while retaining features of the old system. For instance, price caps and some vertical integration between retailing, generation, and networks remained institutionalised in many jurisdictions, in some cases with aims to phase these out after a phase of transition (Joskow 2008; Voss 2007). Many jurisdictions did not adopt any restructuring beyond allowing independent entry to the power generation market, so that vertically integrated monopoly utilities continue to retail power to users.

The electricity sector in jurisdictions with electricity competition was not 'deregulated', meaning that formal regulation did not decrease as a result of

[4] System operation as a power system function ensures the balancing of supply and demand. It was created as a centralised monopoly function because physical flows of electricity cannot be directed independently by separate economic agents, as common for other products, unless they use a separate private network to connect supply and demand. The physical circumstances of an interconnected electricity system determine which flows of electricity can be accommodated by the networks, not the commercial contracts parties have entered. Electricity systems must be balanced in real-time to ensure high quality of supply (among other parameters, at constant voltage and frequency) (Künneke 2008), and this is the responsibility of parties with 'system operation' functions.

restructuring reforms (Vine et al. 2003; Cavanagh and Levin 2016). Rather, the reforms generated the need for a variety of new institutional arrangements and regulatory proceedings, designed to enable competition by organising the interaction between market players and the oversight of market behaviour. For the restructured firms to interact in markets, contractual arrangements and standards of operation were devised to standardise how network operators, system operators, generators, and retailers would organise their commercial interfaces (Lockwood, Mitchell, et al. 2017). Furthermore, policymakers in many jurisdictions with electricity retail competition introduced special consumer protection measures, licensing, and price regulation, for all or only for default electricity offers (Fraquelli et al. 2005; Levin 2015; Tsai and Tsai 2018). Later, ambitions to decarbonise power sectors also led to competing retailers' activities and investments to become more directed in some jurisdictions. Thereby, elements of centralised energy planning were later reintroduced in some jurisdictions with electricity retail competition (Keay et al. 2013).

Overall, it has been acknowledged by many analysts that, where implemented, electricity market restructuring reforms were key moments within the socio-technical evolution of the sector (Künneke 2008; Bolton and Foxon 2013; Hannon et al. 2013; Carley 2011; Verbong and Geels 2007). Again, there is some disagreement about whether pressures that led to these large-scale organisational shifts were primarily technological or social. Electricity market restructuring reforms have been explained with reference to a variety of drivers, including technology, ideology, and institutional path dependencies.

Some suggest that electricity restructuring was a rational response to technological change which altered the techno-economic realities of the sector such that 'natural

monopoly' conditions no longer applied in generation and retail. For instance, Newberry asserts that in the US, a

> *"mismatch between regulated prices and the cost of new generation in some states, and the development of efficient small-scale generation units has combined to suggest that competition promises benefits to consumers and the prospect of increased efficiency for the industry"* (Newbery 2000 : 259).

In this view, again the design of the institutional structures organising the sector is portrayed as intentionally following the evolution of technology, to enable the most efficient and rational outcomes.

Others argue that restructuring was not everywhere a clearly 'rational' response to technological and economic change. 'Political' pressures (Marino et al. 2019) and a shift in dominant ideology and economic thought about the adequate role of the state have been identified as further important drivers (Bolton and Foxon 2013; Hausman and Neufeld 2011; Mitchell 2008). In this reading, the election to office of leading policymakers with a new set of beliefs about the superiority of competition unencumbered by regulation and state ownership was key, and technological and fuel price changes made implementation of these principles possible (Isser 2015). As a result, regulation setting entry barriers and prices for an authorised monopoly came *"under attack"* (Hausman and Neufeld 2011), following reforms in other sectors like airlines and telephony. In the pioneering UK, prime minister Thatcher had a strong personal interest in Hayekian moral philosophy which privileged individual freedom of choice over state decision-making (Helm 2004 : 59). In the US, economists linked to the Chicago School promoted the idea that markets would better allocate investment than centralised decision-making by public policymakers would (Fourcade and Healy 2007; Isser 2015), and that competition would lead to innovation (Künneke 2008).

Some analysists have argued that path dependencies linked to previously created frameworks also played a role in promoting the spread of competition reforms. For example, in the EU, the Commission's advancement of competition in network industries has been explained as *"a way to strengthen its role vis-à-vis the Member States, justified by its contractual mission to accomplish a European Single Market"* (Voss 2007 : 145; Majone 1996). Although there were and remain some powerful players resisting competition reforms in some European Member States, advocates of reform had a strong ally at EU level who actively promoted and institutionalised public policy change.

Some years after market restructuring, policy ambition to curb anthropogenic climate change especially led to electricity systems in some jurisdictions to decentralise again, in jurisdictions with and without competition. Since the 2000s, policymakers in many states adopted new policies to promote renewable energy and co-generation, supporting investment in generation behind the meter, even at small-business and residential scale (Watson 2004a; Wiser et al. 2011). Policies to encourage energy efficiency investment to reduce costs and greenhouse gas emissions have also led to the demand-side playing a greater role again in electricity systems with climate change mitigation ambitions (Eyre 2013a; Nadel et al. 2017).

2.1.2 The implications of electricity retail competition reforms

Since electricity retail markets were restructured, authors have studied and commented on the implications of these reforms. More recently, some literature has focused also on how they have influenced demand-side resources in particular. This

thesis studies specifically the significance of electricity retail market competition and distribution unbundling.

The implications of electricity retail market reforms discussed in the literature focus on several dimensions:

- how and whether competition motivates or enables market players to develop demand management service offerings;
- whether competition creates incentives and behaviours among energy users which hamper or promote the development of demand-side resources;
- whether electricity retail competition impedes the successful implementation of public policy schemes to promote energy saving;
- how and whether unbundling affects the ability of network operators to promote demand-side resources;
- and how retail market reforms influence the coordination of DER, in terms of locating investments, and dispatching loads and power sources.

Each of these dimensions is discussed in further detail below, alongside a review of more general literature assessing the performance of electricity retail market reforms.

Before and shortly after reform, views of whether electricity retail competition could lead to innovation in demand-side management and associated energy services were mixed. Before reform, some economists predicted that incentives for investment in energy saving and load management would improve because competition would lead to prices for electricity more accurately reflecting marginal costs (Hogan 1994). If demand charges (reflecting peak capacity) were passed through to customers, this was expected to enhance market opportunities for energy service companies (Vine et al. 2003). However, some analysts argued that this effect would not necessarily ensue because energy unit costs might reduce overall, or because customers' bills could shift

toward fixed charges, in both cases reducing demand from customers for energy services (Eyre 1998; Vine et al. 2003)[5].

Furthermore, some believed electricity retail competition could potentially promote innovation in energy services as 'added value': when

> *"price/kWh among competitors is close, retailers may find it profitable to retain or attract customers by offering a package of services as a means of differentiating themselves from competing suppliers"* (Vine et al. 2003 : 411).

This expectation led some to predict that retail electricity competition would create the right market conditions for energy service companies (ESCOs) to emerge more widely (Bertoldi et al. 2006). The literature distinguishes between 'energy service providers' who offer energy services without incurring risk, and 'energy service companies' (ESCOs)[6] who take on commercial risk to guarantee energy savings or performance of an installation. It is believed that ESCOs can increase the uptake of demand-side energy resources and promote decarbonisation more widely (Hannon et al. 2013), because their value proposition is comprehensive and includes financing, thereby addressing some of the commonly cited barriers to cost-effective energy efficiency investment (Vine 2005).

At the same time, demand-side management experts argued that even if tariffs were to create favourable signals, competition would not eliminate other barriers that prevent cost-effective investment in energy saving (Eyre 1998). Literature on

[5] For the purpose of this thesis, the term 'energy services' is defined using a 'commercial' or business model definition. This defines 'energy services' as commercial offerings, not as 'useful work' or the drivers of energy-end use demand such as mobility or light (see Fell 2017 for a conceptual review of different uses of the term).

[6] Bertoldi (2006 : 1821) defines ESCOs as firms who *"accept some degree of risk for the achievement of improved energy efficiency in a user's facility and have their payment for the services delivered based (either in whole or at least in part) on the achievement of those energy efficiency improvements."* Vine defines an ESCO as *"a company that is engaged in developing, installing and financing comprehensive, performance-based projects, typically 5–10 years in duration, centred around improving the energy efficiency or load reduction of facilities owned or operated by customers"*, in other words offers 'energy performance contracts' (Vine 2005 : 691).

'barriers' (Brown 2001; Vine et al. 2003) began to emerge around the time of restructuring that documented how in the absence of policies incentivising or mandating energy efficiency investment, energy markets do not deliver services like light and warmth at least cost (Eyre 1998). Limited information, lack of capital, separation of costs and benefits from energy saving investment, and externalised costs mean that supply-side investments in e.g. new power plants are privileged over demand-side investment by market players and customers (ibid.). It was therefore concluded that, even once competition was introduced, continued policy support would be necessary to create a level playing field for demand-side vis-à-vis supply side investment to meet energy needs (Blumstein et al. 2000; Eyre 1998; Vine et al. 2003).

Since restructuring, several studies have sought to assess electricity retail market reforms' performance in terms of stimulating innovation. Economic theories of innovation suggest different possible effects increasing competition in a sector could have (Marino et al. 2019; Schumpeter 1942; Arrow 1962): on the one hand, firms could be motivated to improve their cost base or service quality to get ahead of their competitors. On the other, too intense competition may mean that the benefits of ambitious innovation are not recoverable quickly enough, so that imitation and incremental improvements are more advantageous strategies.

One empirical study on the effects of competition and unbundling upstream and downstream on the electricity sector investigated how reforms changed firms' processes and strategic orientation. Markard and Truffer (2006) argue that electricity market liberalisation *"transformed the basics of search and innovation processes"* at the firm-level. They suggest that before competition and unbundling reforms, electricity firms' primary concerns were whether innovations contributed to cost reduction, reliability, and technical quality of power supply; innovations'

compatibility with interests of other business units in the vertically integrated firm; and whether innovations could be realized with existing capabilities and resources. They argue that under competition, new questions took centre-stage: whether innovations contribute to cost reduction, appeal to customers, and offer potential for new business and competences; whether competitors are pursuing similar innovations; and whether an innovation has a high or low degree of capital intensity. The firms interviewed explained that under competition they invest under greater uncertainty and therefore shorter time horizons.

Several quantitative studies have investigated relationships between electricity competition reforms and innovation, using research and development (R&D) spending, or patent registrations and applications as proxies for innovation activity. These studies focused on electricity market reform overall, including at the wholesale level in power generation, and they present mixed results. Shortly after restructuring in leading countries, Dooley (1998) found that R&D investments declined and were focused on short-term benefits. Jamasb and Pollitt (2008) confirmed that electricity network companies in restructured, unbundled environments spent fewer resources on innovation. However, recently Cambini et al. (2016) argued that European states where electricity markets are more competitive and network companies are unbundled see more innovation because R&D spending and patent applications are higher. Marino et al. (2019) found that wholly unrestructured and very strongly restructured electricity markets have fewer patents than moderately restructured ones (inverted U-relationship). This suggests that most innovation is expected to occur in the middle ground between strong market power and very highly contested markets. Overall, findings are mixed, but not contradictory. They suggest that restructuring initially led to a decline in innovation investments, but that under the right conditions promoting

R&D, innovation spending can increase again without reverting to a monopoly, vertically integrated market design.

Debates about whether specifically retail competition has led to innovation tend to focus on a range of indicators, including unit prices, numbers of competitors, customers switching, and number and types of tariff offers. Supporters of competition in electricity retail claim that the reforms have led to substantial innovation and benefits to energy users in jurisdictions where vibrant electricity retail markets have emerged, such as in ERCOT (Texas), Australian states, and New Zealand (see e.g. Treadway 2015 : 183; Rai and Zarnikau 2016; Kiesling 2014). They argue this is evidenced by tariff reductions for end-users; several tens or hundreds of companies competing to sell commodity electricity to industrial, commercial, and residential energy users; a range of different tariff options; and high numbers of regular switches between providers (churn).

Critics of the reform however maintain that electricity competition has not resulted in cost reductions, truly differentiated products, or broad engagement (Cavanagh and Levin 2016; Defeuilley 2009a; Thomas 2006). Several authors suggest that retail competition did not bring efficiency gains from innovation or cost reductions. Instead, critics suggest that cost shifts from small to large energy users (see e.g. Thomas 2006 on Britain; Borenstein and Bushnell 2015) and the decline in input costs in the years following reform, specifically of natural gas prices (Borenstein and Bushnell 2015) caused electricity price reductions observed. In Britain, analysts suggest that efficiencies and cost reductions achieved since market restructuring are most likely linked to reforms other than retail competition and unbundling, notably privatisation and upstream competition in generation (Helm 2004; Newbery and Pollitt 1997).

Critical authors point also to the quality of offers as another indicator of poor performance and suggest that homogeneity is evidence of little innovation. Cavanagh and Levin (2016 : 188) assess electricity retail competition in ERCOT and argue that *"a proliferation of retail products is inconsequential by itself. What matters much more is the content of these options and actual customer engagement"*. If the products are based on selling electricity as commodity rather than 'value-added' services and are qualitatively similar, they maintain that electricity retail competition cannot be deemed a success.

Similarly, Defeuilley (2009a) argues that the costs of opening residential electricity retail markets to competition exceeded the benefits. He explains that new electricity retail products are highly reproducible and therefore do not provide a clear and long-term competitive advantage for new entrants. Two main characteristics of electricity make innovation in electricity retail unlikely to emerge, especially supported by new entrants, Defeuilley (2009a : 377) explains: firstly, *"cognitive bias affecting consumer's decisions to switch"* means that many residential and small-business energy users are reluctant or disinterested to engage. This has also been described as 'customer intertia' and means that most remain with their assigned default provider (Hortaçsu et al. 2017). Secondly, electricity retail is characterised by *"few technological and scientific opportunities, but high appropriability and cumulativeness at the firm level"*, Defeuilley (2009a : 384) contends. This technological paradigm means that the innovation process cannot be expected to be driven by new entrants and entrepreneurs, unless *"major technological, knowledge or market discontinuities"* changed this sectoral characterisation of innovative patterns (Breschi et al. 2000; Malerba 2002 cited in Defeuilley 2009a).

Proponents of electricity retail competition assert that where little innovation in electricity retail has occurred, this is because competition and unbundling reforms

have not gone far enough in removing regulation, prescriptions, and barriers to entry. In many US and European jurisdictions, unengaged customers, or specific customer classes such as households, remain protected by price caps (Tsai and Tsai 2018). Moreover, in some jurisdictions, unbundling of distribution networks from retailing was only partially or not implemented at all. Advocates of unfettered competition argue price regulation (Kim 2013; Vallés et al. 2016) and limited unbundling (Fraquelli et al. 2005) hamper innovation in energy services and demand management offers, especially for residential users. Kiesling (2014) argues that price-regulated default supply and lack of unbundling

> *"raises entry costs to suppliers who might otherwise offer differentiated products, product bundles, and new technologies and services that customers might value if competitors had an opportunity to experiment with them by offering them to consumers in competitive markets" (2014 : 242).*

These critics believe regulation should be minimised and competition reforms carried out according to the 'textbook' model, for electricity retail competition reforms to deliver innovation to their full potential (Kiesling 2014; Kim 2013; Vallés et al. 2016; Moran and Sood 2013; Tsai and Tsai 2018).

A few analyses argue that electricity retail restructuring reforms have led to innovation in energy service markets that include energy efficiency, demand response, and micro-generation offers. Marino et al. (2011), in assessing the development of ESCO markets in Europe, claim that competition reforms led to improvement because they resulted in *"sectors with competing market oriented companies, thus creating more room for value-added services and facilitating contractual arrangement"* (Marino et al. 2011 : 6193). One recent US consulting report for the Electric Markets

Research Foundation[7] presents mixed results on the relationship between restructuring and demand-side management. It claims that electricity retail competition in the US *"is extending the market penetration of dynamic pricing programs"* (Morey and Kirsch 2016 : vi). However, it shows that retail competition states lag behind monopoly states in terms of cumulative savings from dispatchable demand response programmes (where the system operator, network operators, or retailers contract with customers to control their load) (ibid. : 26).

Several studies assert that competition in electricity retail has hindered cost-effective investment in demand-side management and generation. The problems authors identify concern a range of dimensions: competing electricity retailers have allegedly focused on selling ever greater volumes of electricity as commodity rather than innovating on the demand-side (Cavanagh and Levin 2016; Hannon et al. 2013). Others argue that retail competition coincides with a limited interest among energy users in long-term energy service contracts (Cappers, MacDonald, et al. 2013) and associated regulatory impediments (Hannon et al. 2013). Finally, it has been suggested that unbundling of network-operation from retailing functions negatively affects the ability of network operators to procure demand response (Hall and Foxon 2014).

Furthermore, critics of electricity retail competition argue that tariffs offered by competitive retailers often do not encourage demand-side management. Hledik and Lazar (2016) are concerned that competitive retailers' pricing strategies may not pass through varying costs of network and wholesale energy use. Cavanagh and Levin (2016) confirm this in reviewing available tariff offers for residential customers in

[7] The study is not peer-reviewed, the think tank EMRF is not transparent about its funding, and the data on demand response programme enrolment are incomplete in many places.

ERCOT. The tariffs available tend to blunt price signals or even encourage greater consumption because average-price-tariffs or even 'all-you-can-eat' rates reward wasteful behaviour. They critically ask, *"retail choice has opened the way for offerings that allow customers to consume as much as they want with a fixed bill, but is that a good thing for our energy system or broader society"* (ibid. : 188)? They call for electricity retail competition reforms to be assessed based on their record in supporting wider societal aims including decarbonisation and energy conservation, rather than the number of offers or competitors in commodity electricity retail markets.

Furthermore, electricity retail competition, it has been proposed, may create a culture of transience among end-users not motivated to enter long-term contracts with service providers, including ESCOs. Vine et al. (2003) suggested that electricity retail competition could reduce energy users' interest in making energy efficiency improvements and contracting with ESCOs because they are confused by offers made to them by many competing retailers. Several studies have shown that players interested in financing DER and recovering capital investment through commodity electricity bills have had difficulties realising this proposition commercially. These studies reported that many customers are not willing to commit to electricity retail contracts for periods long enough to allow service providers investment recovery (Cappers, MacDonald, et al. 2013 on demand response; Hall and Roelich 2016).

Some jurisdictions have put rules in place to prevent energy commodity retailers from locking customers into long-term contracts. These rules are directly related to electricity retail competition and have been shown to create uncertainty for energy service providers trying to realise DER projects. Hannon et al. (2013) explain that regulatory requirements in EU law that force operators of 'private wire' electricity networks to enable third party access create uncertainty for ESCOs. Cost recovery for

an ESCO's distributed generation system linked to the private network becomes uncertain, because customers may choose to buy power from third parties through the private wire (ibid.). Similar uncertainty was created by a rule initially instated to guarantee customers the right to switch retailers within 28 days. This was later abolished in Britain with the aim to promote business models recovering on-site investment through energy bills (Hannon et al. 2013). Hall and Roelich (2016 : 290) argue that the right for individuals to switch at any time has also made it difficult for innovative retailers trying to aggregate loads in one region as demand response because planning *"for aggregated time of use tariffs"* is difficult without a captive customer base.

Unbundling of electricity networks from retailing functions has been argued impedes innovation by distribution-network-operators seeking to invest in demand-side resources as 'non-wires' solutions. For instance, Hall and Foxon (2014) contend that in Britain, not enough load can be aggregated in any one area to help alleviate distribution network constraints because advanced metering is deployed on a geographically ad-hoc basis by retailers rather than regionally by a single entity. Vine et al. (2003) suggest that unbundled network companies may not have *"sufficient relationships with retail customers"* to implement demand-management programmes. Apajalahti (2018), based on a case study, argues that unbundling is one important barrier that prevents a Finnish municipal energy company from successfully launching an energy services business. Reportedly, the utility's *"motivation to develop energy-saving services is strong (…)".* However, *"difficulties"* arose because

> *"energy market liberalisation had created strong boundaries between different operative business units that hindered the common endeavour of developing a model as a joint outcome of different units due to a lack of communication channels, a common development platform and a common budget for developing such a model"(Apajalahti 2018 : 80–81).*

The implicit suggestion is that without unbundling reforms, these electricity companies could have more easily innovated to promote demand-side resources.

Finally, some critics of electricity retail competition argue that policies to promote low-carbon resources are more difficult or costly to implement under competition and unbundling, than under a system with a captive electricity customer base. Under a monopoly retail model, policymakers approve investment to meet demand on behalf of customers and can choose 'preferred resources' on criteria other than cost (Blumstein et al. 2000). Once resource procurement is decentralised under electricity retail competition, policies to promote the demand-side and low-carbon resources must be separated out as discrete public-interest programmes, layered on top of what is otherwise market-led investment (ibid.). Supply- and demand-side resources can no longer be managed in an integrated planning process. Cavanagh and Levin (2016 : 187) argue that having to devise separate policies for the public interest makes decarbonisation of the energy system more complex and costly. Others believe that decarbonising the system is more difficult under competition because decision-making power is ceded from policymakers to private, market-oriented players who have agendas to prevent change. Healy and MacGill (2013 : 633) claim that electricity restructuring in Australia did not deliver innovation in *"energy service retail markets"*, but instead *"created large, powerful industry incumbents interested in protecting the status quo"*. They contend that the restructured electricity companies serving customers are not interested in promoting substantial energy savings because selling less electricity reduces their profitability. Instead, they argue, these incumbents expend great resources on lobbying against decarbonisation policies (ibid.).

Vine et al. (2003) also maintain that competitive generators and retailers have no interest in selling fewer units of electricity (kWh), as demand reduction reduces their revenues. They suggest that competing retailers may therefore be less well-placed

than regulated-franchise players to implement public interest demand-side management policies. They point out that regulated-franchise utilities' incentives can be aligned with the 'public interest' because policymakers can adjust their profit logic. Competing companies can be forced to comply with standards and be incentivised through other policy instruments, but their profit logic cannot be altered as directly through institutional reform (ibid.). This is because regulated-franchise companies' earnings are closely regulated in most jurisdictions, in exchange for the right to collect revenue from a captive customer base. Depending on the regulatory model, revenues or profits are determined through a mix of allowed return on investment, incentives and penalties (Vine et al. 2003; Satchwell et al. 2011; Hall and Foxon 2014). Some regulators have explicitly adjusted electricity utilities' business models to align incentives with promoting demand-side resources through regulatory mechanisms such as 'decoupling' or shareholder incentives. These are designed to ensure that the reduced need for capital investment resulting from energy savings and load shifting does not negatively affect regulated-franchise utilities' earnings (Satchwell et al. 2011). These types of mechanisms cannot be applied to competing companies who independently define their revenue models.

Electricity retail competition and unbundling also affect the options for how electricity and 'flexibility' market designs can evolve in the future, some believe in adverse ways. Eid et al. (2016) consider different organisational models of how dispatchable demand-side resources could be coordinated to provide flexibility across electricity systems. They argue that the European market design of electricity retail competition combined with unbundling is not compatible with a future model in which distribution-network-operators control distributed loads and power sources. Brunekreeft (2015) compares how the coordination of network investments with load and generation investments works in an unbundled environment, with the vertically

integrated situation. Loads and power sources behind the meter can have significant impacts on distribution networks, and these do not always have capacity to accommodate them. Under unbundling, the use of the network would have to be priced adequately on a locational, temporal and capacity basis, so that all costs created by players are internalised, if market designers want to incentivise the demand and supply side to make investments in locations and at capacities that are efficient from a network perspective (and vice-versa). Under vertical integration, this coordination can be achieved internally within a firm (ibid.). Brunekreeft (2015) argues that the price signals and contracts needed in the unbundled environment may be harder (or more costly) to establish than hierarchical coordination within one firm which is incentivised to optimise costs. He therefore suggests that unbundling may increase overall system costs due to ill-coordinated investments. The difficulty and cost of establishing the correct signals may be based on lack of information, e.g. on real-world values of elasticity; politically undesirable distributional effects including regional differences; regulatory and transaction costs of negotiating between parties; different time-horizons for network investments as compared to supply and demand-side investments; and costs of revealing very granular prices on the distribution network (ibid.).

Overall, the literature on electricity retail competition and unbundling of distribution networks from retail functions comes to mixed and, in some cases, contradictory conclusions about these reforms' significance for the development of demand-side energy resources.

2.2 Theoretical frameworks to study socio-technical change

The overarching research question was introduced in Chapter 1: *"What is the political significance of electricity retail market design institutions for decentralised energy transitions on the demand-side?"*

To this end, several concepts need to be defined, and associated theoretical frameworks integrated. Politicising the study of demand-side transitions and electricity retail market design requires a concept of socio-technical change, as well as a set of tools for political analysis. First, section 2.2.1 introduces theories of socio-technical change, specifically the multi-level-perspective. This conceptualises transition processes as consisting of many subsidiary processes of institutionalising novelties as new structures (Schot and Geels 2011). This thesis focuses on two types: the institutionalisation of public policies in the realm of 'regulation' or 'public policy', and secondly the institutionalisation of new firm activities (commercial innovation). Both types of change processes have been conceptualised by theorists in other disciplines, namely political studies and business studies, which this thesis draws on.

Section 2.2.2 explains the 'discourse coalitions' approach used to study change in public policies. Section 2.2.3 outlines a framework to analyse business models as the institutionalisation of new commercial structures, including supply chains, product offerings, and business partnerships. The final section explains how the frameworks and concepts are integrated and mobilised to address the research question and gaps in the literature.

2.2.1 The multi-level-perspective and coevolutionary processes

Theory about sustainability transitions has grown in significance for studying socio-technical systems, including energy systems. This perspective assumes that socio-technical systems are characterised by social and technological lock-in (Unruh 2000). The influential 'multi-level-perspective' (MLP) (Geels 2002) theorises the dominant way of delivering a range of societal functions, for example energy services as a 'regime' that comprises various entrenched practices, technologies, policies, and infrastructure (Smith et al. 2010) (originally based on Nelson and Winter (1977)). Theorists of the MLP assume that the regime may be destabilised and change in response to *"landscape pressures"* at the macro-level and innovations from *"niches"* below or outside the regime, often catalysed by landscape pressures, to eventually effect more than incremental change or a 'transition' (Geels and Schot 2007 : 400). According to Geels (2002), a transition can occur when change happens at the levels of markets and user preferences, industry, science, culture, technology, and policy.

The landscape is conceptualised as comprising pressures from outside the socio-technical regime under analysis, including broader political, international, environmental and cultural factors (Foxon 2013). To break the lock-in, innovation developed outside the regime at the niche-level is important. Niches can succeed when their *"selection environment"* changes (Smith and Raven 2012). When alignment of processes on all levels allows a successful "*breakthrough of novelties*" (Smith et al., 2010, p. 435), a regime can transition.

The multi-level-perspective has taken strong inspiration from evolutionary economics which focuses on populations of economic actors, often firms, evolving. Change processes are conceptualised as 'coevolution':

> *"The focus is on co-evolutionary interactions between ongoing trajectories: developments in one trajectory (e.g. regulations) may hinder or stimulate developments in another trajectory (e.g. technology or markets)"* (Schot and Geels 2011 : 96).

Socio-technical transition analyses investigate very broad units of analysis to take a systems-view. Change *"is multi-dimensional, because it not only involves markets, but also regulations, cultural and social movements, infrastructure and legitimacy"* (Schot and Geels 2011 : 96). Actors at the centre of the regime are considered 'incumbent'. Firms, regulators, Governments, and users, among others, all have a role in stabilising the socio-technical system but can also contribute to enabling change.

Foxon (2011) argues that an evolutionary approach can help multi-level-perspective studies focus on agency and the role of distinct actors within processes of socio-technical change. This can address critiques that MLP inquiries privilege structural accounts of lock-in and pay too little attention to agency (Genus and Coles 2008). Evolutionary perspectives can help illuminate the role of *"individual user choice, the development of business strategies, and the role of governments"* (Foxon 2011 : 2260). Research within evolutionary economics has highlighted technologies, institutions and business strategies as three *"key mutually evolving systems necessary to understand industrial and economic change"* (Foxon, 2011, p.2262). Foxon proposes analysing the coevolution of these sub-systems along with the sub-systems of natural ecosystems and user practices to investigate socio-technical change toward a low-carbon economy (ibid.). Each subsystem is associated with actors and organisations, for instance companies, energy users, regulators, Governments, community groups, and scientists.

To investigate various dimensions ('trajectories' or 'systems'), scholars of socio-technical transitions have drawn on other traditions of social theory. The concepts of 'institutions' and processes of institutionalisation have been used as a way to better

conceptualise socio-technical regimes, and to analyse how agency can break path dependency through the evolution and emergence of new structures ('institutions') in society (Fuenfschilling and Truffer 2014). The regime from this perspective is understood as highly institutionalised, in other words, a realm of strong 'structuration' (ibid.). The regime accounts *"for the stability of an existing socio-technical system. It refers to the semi-coherent set of rules that orient and coordinate the activities of the social groups that reproduce the various elements of socio-technical systems"* (Geels 2011 : 25). Niches are comparatively less structured because practices are less institutionalised and more malleable (Fuenfschilling and Truffer 2014). Transition scholars focusing on institutions have then taken processes of institutionalisation, that is the formation of new rules and structures as key for the process of socio-technical change (Avelino and Rotmans 2011; Fuenfschilling and Truffer 2014). Interaction between niche and regime players is key in this regard (Avelino and Rotmans 2011).

Institutional theory regards 'institutions' as *"rules of the game"* (North 1990) which form a fixed framework for social interaction. They have been studied by political scientists, economists, sociologists, and organisational scholars (Hall and Taylor 1996) who use the term to describe all types of rules and structures: for example, 'public policy' institutions designed by the state including laws and standards applied to citizens and companies; contracts between firms (Williamson 1979); rules internal to organisations, such as formal firm 'policies' and unwritten cultural norms (Zucker 1977), and structures that produce entrenched patterns of policy-making (Thelen 1999), including mental heuristics referred to as 'policy paradigms' (Hall 1993). Institutionalist theory assumes that actors who do not play by the rules can expect in many cases to be sanctioned in formal or informal ways (Ostrom 2007), and that institutions thus constrain the options available to agents, producing path dependency.

Institutionalisation processes can be analysed in detail as subsidiary change processes that can align to form broader transitions within the MLP (Schot and Geels 2011 : 96). They can be studied, either by focusing on variation emerging within populations in an evolutionary manner, or by studying 'event-chains' (ibid.). Investigating populations entails observing how variation happens, how novelties are selected, and then finally institutionalised. In studying *"event-chains"*, the focus is on how

> *"actors a) draw on structural contexts, b) interact with each other, c) aggregate and select outcomes, and d) institutionalize outcomes in new structures (reproduction or change)"* (ibid.).

These explanatory logics to study processes of change are closely related and complementary.

Depending on the trajectories ('sub-systems') analysed, change is thus understood as the production of different types of institutions: for instance, formal public policy institutions created in the realm of regulation, contracts and firm structures created in the realm of business strategies, and informal heuristics, cultural rules, and mental patterns that influence individuals' decision-making.

By focusing on processes of institutionalisation, analysts can focus on instances where distinct players' agency leads to change, for instance by creating new public policies, organisations like firms or community groups, or contracts. Emphasising agency also means being mindful that actors seek to shape outcomes of institutionalisation projects to accomplish their ends, and that the design of an institution is influenced by the relative power of players (DiMaggio 1988). Transition scholars have investigated how niche players can themselves create institutions, or seek to shape their 'selection environment' (Barnes et al. 2018) through promoting change to institutions. Where the power to alter or create these institutions lies primarily with other players, niche players can try to influence these decision-makers (Avelino and Rotmans 2011).

Through institutional change, the selection environment can become more favourable for niche-practices, resources and technologies, for instance through the creation of special spaces of niche-protection (Smith et al. 2005; see Brown and Wang 2015 for examples; Barnes et al. 2018). Often, institutional change happens incrementally, and can then be thought of as "layering" of new institutions over established ones (Kern et al. 2014; Thelen 1999).

However, taking a coevolutionary perspective means viewing agents as operating under uncertainty and with bounded rationality (Foxon 2011). This means that *"change is path dependent and that innovation proceeds by combining the elements at hand in any given situation"* (Foxon 2011 : 2265). Combining institutionalist with coevolutionary approaches enables studying distinct actors' influence on socio-technical change without over-emphasising agency.

2.2.2 Institutionalisation of discourses as public policy change

This section explains the approach to studying socio-technical change in the realm of 'public policy', and the ontological assumptions underpinning the research that are informed by constructivist theories.

For the purpose of this thesis, public policymaking describes decisions intended to organise activities in the 'public interest' by agents acting on a community's, or the 'public's, behalf. Decision-makers are for instance legislators, governmental agencies, and other agents of the state, which can operate at various scales, including locally, regionally, and nationally. Sometimes, public policymaking is also delegated to non-state actors. In all cases, institutional frameworks (in democracies intended to

provide legitimacy) have given policymakers decision-making responsibility. This means that they formally control policymaking processes as 'decision-makers'[8].

The sphere of 'policy' or 'regulation' (Schot and Geels 2011) plays a role in locking-in established socio-technical paths (Bolton and Foxon 2013; Unruh 2000). Because public policy institutions co-evolve with other sub-systems (Foxon 2011), changes to 'public policy' can be prompted by and trigger wider change, including in technologies, firm strategies, and user practices. Kuzemko et al. (2016) argue that differences between jurisdictions in terms of public policy institutions imply differences in power for energy-system incumbents (in this case, firms), diverse articulation of incumbents' interests, and varying degrees of openness of policy and regulatory processes to capture by interest groups.

This thesis studies the phase of electricity retail market creation following a 'discourse coalitions' approach. This conceptualises policy change as the process of institutionalising hegemonic ideas and discourses (Hajer 1995). The focus on ideas and the construction of concepts is rooted in an anti-essentialist ontology, meaning it rejects the existence of a single reality, governed by immutable natural laws (Hajer and Versteeg 2005 : 176). Applying a constructivist perspective to the analysis of public policy institutions has been popularised as 'interpretive policy analysis' (Fischer 2007).

For many years, political science and the study of how public policy institutions evolve was dominated by explanations privileging rational interests, material power,

[8] The realm here analysed as 'public policy', understood as the building of institutions for the furthering of the 'public interest', in socio-technical transition literature is often described as 'governance' (Smith et al. 2005; Kuzemko et al. 2016; Eyre 2013a). This thesis prefers the term 'public policy', because 'governance' describes coordination of social interaction more broadly (e.g., firm-internal institutional frameworks as 'corporate governance' or frameworks external to organisations that coordinate several players, e.g. 'local governance', or 'global governance' etc.).

and path dependencies in political culture and Government processes (Hall and Taylor 1996). Players with agency at the centre of attention were interest groups lobbying for or against policy change, using resources like control over jobs, campaign finance, and investment location. These analyses suggested that mostly, powerful players exert influence to accommodate their material interests, in close alliance with 'captured' policymakers.

However, recently, ideas and discourse became increasingly important units of analysis in political studies (Béland and Cox 2010; Blyth 1997; Schmidt 2008). The discipline began to grapple with large-scale shifts in economic thinking and policy in many Western countries in the latter decades of the 20th century. Moreover, post-structuralist theory became incorporated into the set of analytical tools. Since then, the interplay of ideas, interests, and institutions that create path dependencies has been at the centre of attention for scholars analysing policy change.

Research on low-carbon transitions has documented cases where incumbents linked to centralised, high-carbon energy have mobilised various resources: material spending; personnel (Hess 2014); and structural power through position, authority, and control over key public interest resources including employment (Geels 2014). In only a few cases, ideas and discourse have been analysed as part of low-carbon energy transition dynamics (Kern 2011; Lovell et al. 2009; Rosenbloom et al. 2016).

Hajer's (1995) discourse coalitions approach is one of the best developed frameworks to study the detailed mechanisms through which ideas and discourse influence institutional change. He conceptualised creation of public policy institutions as the result of a struggle for discursive hegemony, in which actors frame issues and events as problems and propose solutions, to argue for institutional change. When ideas

become hegemonic, they can be subsequently institutionalised (ibid.). Previously institutionalised ideas can become destabilised and replaced with new discourses.

The term 'discourse', based on Foucault (2002) has been used to subsume the literature and methodological project of studying acts of framing and reproducing contingent interpretations through argumentation as acts of power. Hajer (1995 : 44) defines discourse as *"an ensemble of ideas, concepts and categories through which meaning is given to social and physical phenomena, and which is produced and reproduced through an identifiable set of practices"*. The concept incorporates different types of ideas (Schmidt 2011): for instance, at the highest level, normative ones about right and wrong, and at more detailed levels 'programmatic ideas' that chart specific courses of policy action. Furthermore, there are ideas agents are aware of and use strategically, and others which are 'invisible' and constrain the view of acceptable options (Campbell 1998 : 393; see also Hall 1993). Discourses are argued to have both enabling and a constraining functions (Hajer 1995)[9]. This means they are *"fundamental both in giving shape to new institutional structures, as a set of ideas about (…) rules, values and practices, and as a resource used by entrepreneurial actors to produce and legitimate those ideas"* (Schmidt and Radaelli 2004 : 192).

Scholars interested in discourse focus on sentient agents' activities within a discursive sphere, for instance constructing and defining categories, problems, and solutions, excluding and including issues, and storytelling (Roe 1994). Methodologically, this means that language itself as the expression of discursive activities becomes the object of analysis. Hajer (1995) suggests identifying prominent 'storylines' and problem-solution-framings allows linking acts of framing to specific agents. Through these

[9] Hajer (1995 : 50–52) shows that although Foucault recognised this dual function, his analysis of modernity focused on the constraining function when analysing discourse as vehicle of domination.

storylines, actors "*try to impose their view of reality on others, suggest certain social positions and practices, and criticize alternative social arrangements"* (Hajer 1993, pg. 47). Agents come together in 'discourse coalitions' around these narratives. Other interpretive scholars have analysed practices of 'framing' (Rein and Schön 1994). The metaphor of the frame describes *"ways of selecting, organizing, interpreting, and making sense of a complex reality so as to provide guideposts for knowing, analyzing, persuading, and acting"* (Rein and Schön 1991). Here too, analysis focuses on the moment of problem definition because *"selecting certain aspects of a worrisome situation for attention is a contingent, political act"* (van Hulst and Yanow 2016). In sum, studying ideas does not involve a psychological exercise of 'what are people really thinking'. Rather, it means investigating how decisions are rationalised (Blyth 2002) and when applying discourse analysis, how realities, norms, and cause-effect relationships are constructed through language (Fischer 2007).

Placing discourse and ideas at the centre of policy analysis does not mean neglecting 'hard' factors in studying decision-making. Interpretive analysts do not reject that *"there is a real world 'out there' [that] (…) is a source of pressures"* (Bevir and Rhodes 2002) – a common criticism of Foucauldian post-structuralist perspectives. Instead, interpretive analysts recognise that these material factors have *"mediated access"* to human behaviour, and that there is not a single way to interpret and react to them (Bevir and Rhodes 2002)[10]. In studying actors' behaviours, attention to discourse and ideas implies recognising that 'interests' cannot be deduced directly from material and institutional position. What is perceived as rational by one member of a given socio-economic group may be different from another's view (Béland 2016). Interests can also not be deduced from actors' actions because there is no reason to

[10] This position has sometimes been described as a dialectical relationship between interests and ideas, meaning that they constitute one another (Hay 2006; Marsh 2009).

believe that actors behave rationally (Blyth 2002). Therefore, as Blyth clarifies, actors' interests must be understood as their *perception* of what is in their interest, especially when operating under great uncertainty (ibid.). This is invariably the case also within socio-technical system change processes.

Nevertheless, to make sense of public policy change it is important to study the context in which actors struggle for discursive hegemony, including differences in actors' access to resources and opportunities (Schmidt 2010). Differences in actors' positions can influence how much their storylines are heard (Hajer 1995), and acted upon. Channels of influence are based also in social relations between actors (Granovetter and McGuire 1998), not only in language. In the energy sector, the capital-intensive nature of infrastructure, including buildings and energy assets, has been argued in some cases materially influences actors' interests in structuring a debate in one direction or another (Lovell et al. 2009). Moreover, the nature of energy as vital to every-day life, economic development, and employment means that players have differing resources through which to exert pressure. Therefore, for energy transition research, material and technological factors remain key focal points in studying policy change.

In summary, concepts and methods of interpretive policy analysis are useful for this thesis, to research processes of public policy reform, and to politicise analyses of socio-technical change through attention to contestation and frames of meaning.

2.2.3 Institutionalisation of commercial innovation as business models

The previous section introduced approaches to studying agency and institution-building in the public policy sphere. This section discusses literature that aids analysis

of institutionalisation in the commercial realm of 'markets' or 'business strategies'. It first explains the 'business-model-framework' this thesis adopts, how this is integrated with the MLP, and the underlying ontological assumptions informed by economic sociology and evolutionary economics that underpin the research on business model innovation.

The 'business model' is one of several concepts employed in business studies to investigate companies' commercial activities, and has been adopted also by transition scholars (see e.g. Boons and Lüdeke-Freund 2013; Bolton and Hannon 2016; Schaltegger et al. 2016; Wainstein and Bumpus 2016). There are different definitions of the term, but generally the business model describes the way an individual firm delivers and captures value (Casadesus-Masanell and Ricart 2010; Osterwalder et al. 2005; Zott and Amit 2010). This thesis adopts a framework popularised by Osterwalder et al. (2005). It includes nine building blocks that together describe the method of value creation and capture as the 'business model': (1) the *value proposition*, meaning a company's bundle of products and services it promises to deliver; (2) the target *customer segments*; (3) *customer channels* through which businesses reach their customers, (4) the *customer relationships* firms establish, incorporating for example the type of transaction and contract; (5) the *value configuration* which includes the core set of activities and resources; (6) the core *competencies*; (7) a network of *key partners*, and finally financial aspects. These are defined by (8) *cost structure*, i.e. all the costs incurred to operate; and (9) *revenue streams* through which the business generates income.

Business models are often analysed as part of wider 'strategy research'. The distinction is that strategies are put in place to devise a high-level plan of what kind of values to deliver and capture, while the business model is a reflection of realised strategy, because the environment shapes how it can be implemented in practice

(Casadesus-Masanell and Ricart 2010). As Grant (2010) outlines, studying business strategies has two elements: articulated strategy can be analysed through company communication, but executed strategies are visible only in the decisions that reallocate resources and implement investments in new acquisitions, products, or ventures. Therefore, studying how strategy and business models evolve requires investigating both what companies say, and what they do (ibid.), in other words, 'talk' and 'walk'. One strategy could also be to run several business models alongside one another (Casadesus-Masanell and Ricart 2010).

To make the business-model-framework useful to system transition research, further theorisation is necessary because it is initially 'firm-centric', meaning it does not focus on the system within which a company operates (Bolton and Hannon 2016). Evolutionary economics offers direction, Schaltegger et al. (2016) suggest. To analyse how business model change can affect systems, they propose investigating the coevolution of incumbent and challenger business models. Evolutionary approaches have theorised change within firm populations as evolving along three main processes: *variation, selection, and retention* (Aldrich 2008; Volberda and Lewin 2003; Foxon 2011; Schaltegger et al. 2016). First, 'variation', entails changes in business model elements within a population of firms. Going further is 'selection', whereby there is some growth in market share for entrepreneurs with qualitatively different business models who succeed in displacing traditional competitors (Schaltegger et al. 2016) (in their case business models with more 'sustainable' propositions). But really transformative, and hence relevant to transitions, they argue, is only the process of 'retention', whereby newcomers and incumbents over a longer time, retain business model elements and thereby achieve continuous growth in market share. To link these coevolutionary processes to interactions between incumbents and newcomers, they present four practical pathways. Novel business

models can scale up through *growth* of a new business model within a single organisation; *replication* by other organisations, often in cooperation with the pioneer; *mimicry* whereby mass-market incumbents copy business model elements introduced by niche players; and *merger and acquisition* (M&A) of newcomers by large incumbents if they lack the capabilities to internally innovate (Schaltegger et al. 2016). These pathways can also be combined.

The implications of individual entrepreneurs' agency for economic systems have also been illuminated by economic sociological perspectives. These emphasise network building and study markets and boundaries between industries as socially constructed (Granovetter and McGuire 1998; Fourcade 2007). Economic sociologists have analysed business models as 'market devices' through which entrepreneurs build innovation networks with financers, business partners, research organisations and others (Doganova and Eyquem-Renault 2009, building on Muniesa et al. 2007 and Callon 1998; see also Boons and Lüdeke-Freund 2013). This is similar to some evolutionary economic accounts of *"sustainable entrepreneurs [as] market cocreators and transformers"* (Schaltegger et al. 2016). Doganova and Eyquem-Renault (2009) argue that the role of the business model is to aid the network building process by acting as a reference point for communication with the different stakeholders through 'narratives' and 'calculations' which entrepreneurs circulate. The business model concept allows describing their venture to other players and allows reflecting on the possible use cases and supply chain configurations, in order to construct a market. Then, further institutionalisation may occur through the development of regulation and public policy (Granovetter 1985), often aimed at aligning private commercial with the wider public interest.

Economic sociological studies have shown that industry boundaries are not only or primarily the result of 'natural' product characteristics or of decisions by 'optimising'

entrepreneurs to maximise value and minimise transaction costs, as the 'theory of the firm' developed by new institutional economists like Williamson (1979) suggests (Granovetter 1985). They argue that instead of *"economic and technical rationality, individual achievement and omniscience"*, it is *"the mobilisation of resources and influence through social networks"* (Granovetter and McGuire 1998 : 167) that fix the structure of an industry, or a market. These boundaries are cemented and institutionalised through processes of standardisation. These usually involve the creation of public policies and regulation which players seek to influence (ibid.).

However, analysis of entrepreneurs as market creators actively changing their selection environment must still take into account path dependencies and uncertainty which are core to socio-technical systems, as evolutionary accounts have stressed (Foxon 2011). Actors are assumed to operate under uncertainty, and this thesis does not analyse strategy, business, and lobbying decisions as rational choices by utility-maximising agents under perfect information. This is commensurate with a more *"limited view of individual deliberative and calculative capacities. Decision-making takes place in the context of complexity and radical uncertainty, limiting the chains of logical reasoning (...)"* (Hodgson 2007 : 16). This evolutionary perspective similarly rejects a view of actors strategically choosing whether to 'make or buy', based on profit-maximising logic and transaction costs, and how to structure the boundaries of their commercial activities, famously articulated by the institutional economist Williamson (1979). Evolutionary economists like economic sociologists are critical of the assumption that *"'in the beginning there was the market', as if markets themselves did not depend on, or are constructed of institutions"* (Hodgson 2007 : 13 in critical reference to Williamson 1981). In other words, the building of institutions, products, and business relations cannot be assumed to result from strategic reasoning, but reflects wider, pre-existing processes and rules. This does not

mean that agents are incapable of identifying a strategic interest to pursue, but only that *"reasoning is impossible without, and inseparable from, its institutional and material context"* (Hodgson 2007 : 13). Not only do agents operate in a state of imperfect information and under 'bounded rationality', the notion of a *"context-dependent, situated rationality"* (Hodgson 2007 : 13) is most useful to accommodate the real-word complexity of business model building and evolution. Economic sociologists would add that this rationality is additionally inseparable from its social context and the decision-maker's social relations.

Organisational literature suggests specific path dependencies that constrain which options and strategies are considered for innovation. At the strategic level, the bounded rationality of decision-makers is visible in the *"very human problem of managers resting on their laurels, or (…) on the technologies that have made them successful"* (Utterback 1994 : 19). Business literature also discusses barriers at operational levels to implementing change directed from above. While operational units can be the source of innovation when new products and improved processes are developed internally, path dependencies often also impede innovation. For example, *"the institutionalized organizational memory consisting of business rules, behavioral norms and success metrics"* can be an 'internal barrier' to the introduction of new business models (Boons and Lüdeke-Freund 2013 : 13 citing Johnson 2010; Johnson et al. 2008). These institutionalised norms are sometimes also discussed as 'organisational culture' (Richardson 2009; Zucker 1977). Management literature outlines similar dimensions of lock-in as MLP literature: *"Established firms (…) carry the burden of large investments in people, equipment, plant, materials, and knowledge, all of which are closely linked to the established technology"* (Utterback 1994 : 19), and change is expected to be especially difficult in large organisations. All

of these factors point to the process of business model evolution being everything but linear, strategic, and rational.

In summary, the business-model-framework can enhance the MLP and sociotechnical change research because the framework allows studying the creation of new commercial structures and the evolution of existing ones. Evolutionary economics and economic sociological perspectives help conceptualise firm's processes of network building and decision-making as 'situatedly' rational and provide insights into how individual business actors' agency can influence wider socio-technical system change.

2.3 Integrating the frameworks to address emerging gaps

The following section first integrates the theoretical frameworks and explains how they complement one another. Then it explains how the theoretical lenses are operationalised to study public policy and business model change within energy transitions on the demand-side. This includes defining the scope of the research. Finally, the section explains how the research addresses gaps in the empirical literature reviewed earlier.

The MLP is useful to conceptualise transitions in the electricity sector because it allows taking a system-wide view of change, recognising the importance of institutions, technologies, firms, and end-user practices. However, because it does not have tools to analyse political dimensions of change and is weak in conceptualising agency, I integrate it with two further frameworks to enable analysing subsidiary change processes in public policy institutions and commercial structures: Hajer's (1995) discourse coalitions approach and Osterwalder et al.'s (2005) business model framework (see Figure 2). Both allow addressing the overarching research question

on the political significance of electricity retail market design for demand-side transitions.

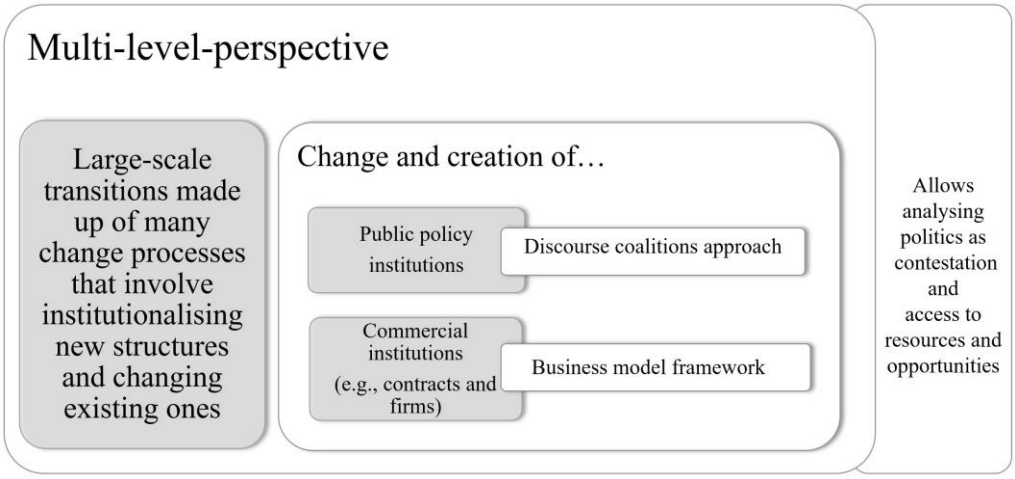


Figure 2: Integrated theoretical framework to research socio-technical change processes

As outlined in Chapter 1, the thesis defines the 'political' from two perspectives well-established within the 'political economy' tradition (Hall 1997): the *construction of ideas and concepts* underlying institutions, and their implications for *access to key resources and opportunities* for different stakeholders. The first is linked to a conception of the 'political' as the realm of contestation; classically articulated by Carl Schmitt (2002; Flinders and Wood 2014), and more recently developed by theorists of radical democracy (see e.g. Mouffe 2005). The resource-based view is linked to a long-established, even colloquial understanding of the meaning of 'politics': as famously expressed by Lasswell (1936) as *"who gets what, when, how"*. This focuses on winners and losers and access to resources and opportunities (see also Avelino and Rotmans 2011). This perspective allows analysing contestation that is not identifiable always in discourse because stakeholders affected by institutional changes do not necessarily participate or are represented in debates.

Figure 3 visualises how a system can change in response to niche and landscape pressures. It has been adapted (in blue) to show how this thesis operationalises the frameworks to investigate regime-level practices and business models; electricity retail market design as structuring the regime; DER niche practices; and change based on institutionalising new public policy and commercial structures.

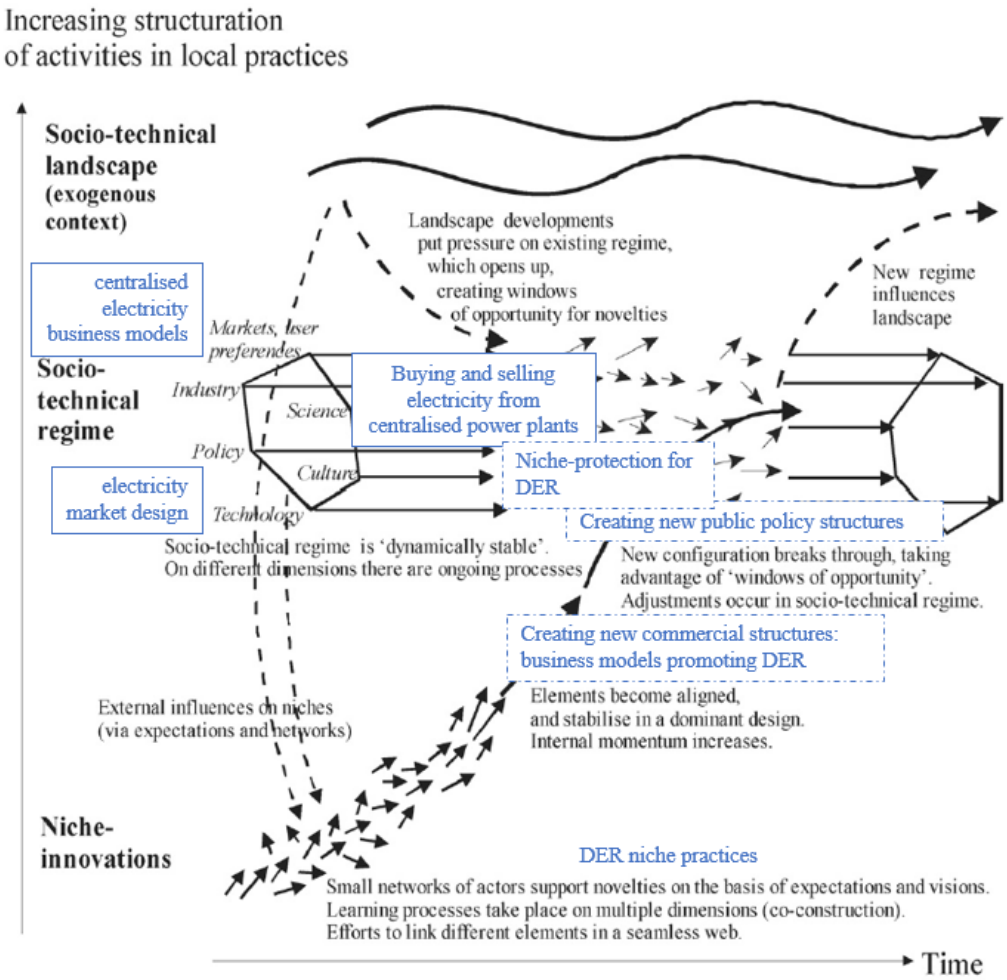


Figure 3: Socio-technical change through the institutionalisation of new commercial and policy structures to promote DER; adapted from Geels and Schot 2007; Geels 2002.

I propose analysing business models as processes of institutionalising new commercial structures. Building a business model implies formalising interaction between players in a supply chain through contracts and partnership agreements. Besides the external structures, internally, rules, routines, roles, and processes are

institutionalised as a business model develops. 'Multi-level-perspective' literature suggests analysing interaction of players at different levels of established and entrenched socio-technical practices (Avelino and Rotmans 2011): the realms of 'regime', 'niche', and 'landscape'.

The process of co-evolving business models and public policies entail business model *change* from the perspective of incumbents, and business model *building* from the perspective of niche-players. Incumbent electricity firms at the regime level have more stable, institutionalised business models than niche players whose business models are considered emerging and not yet fully formed. The niche is a less stable space of lower 'structuration' (Fuenfschilling and Truffer 2014) and the process of building a business model and a network of partners enables growing out of the niche to become institutionalised.

Engaging in debates and relationships to effect or prevent public policy change is important in institutionalising new business models (Bolton and Hannon 2016). This often requires creating institutional space through actively seeking change to the selection environment. The discourse coalitions approach helps analyse the evolution of public policies with attention to the discursive practices of stakeholders and acts of framing. This enables better conceptualising processes of co-evolving technologies, practices, business strategies, and public policy institutions.

Electricity retail market design for this research is investigated as the institutional framework that organises the relationship of electricity end-users with the system (see Chapter 4 for details). Specifically, for the purpose of this thesis, this involves boundaries around functions competing and regulated-franchise companies were assigned or permitted to deliver. The process of market design entailed deciding which new market roles should exist, assigning these to different types of players by creating

licenses to operate or similar entry requirements, and in some cases limiting players' allowable activities. The competition reforms therefore influenced elements of incumbent electricity companies' business models.

Different electricity retail market designs emerged, depending on policymakers' choices, and so the institutional structures of regimes and incumbent business models vary across jurisdictions today. As a result, DER newcomers today face different environments for instance in Europe and most US jurisdictions, where energy users' commercial interface with an electricity system is organised differently. This research is based on the assumption that these differences in regime structure play a role for distributed energy transitions and the business model evolution of incumbents and newcomers (Eyre and Lockwood 2016).

As this thesis focuses on demand-side transitions, business models premised on selling electricity from *centralised resources* are considered *incumbent* and are currently still dominant in the 'regime'. The thesis focuses on centralised *incumbents with a customer-facing role* because their business models are directly influenced by electricity retail market design institutions. This thesis applies the 'business-model-framework' as an analytical lens across both competing and regulated-franchise firms. While the literature on business models evolved from studying internet-based technological innovation (Osterwalder et al. 2005) since the early 2000s, the term 'business model' has also been used to describe the activities, value configurations, regulatory mechanisms, and associated incentives of these companies regulated as monopolies (see e.g. Satchwell et al. 2011; Rochlin 2016). The thesis focuses on two types of incumbent electricity companies: those commercially connected to energy users through selling units of electricity generated in front of the meter, and those physically connected to energy users through electricity distribution networks transporting this power. Energy users who purchase electricity from these centralised

firms are also engaged in regime-level, established practices if they do not promote DER by generating on-site or managing their demand to participate in electricity system management.

The business model is what defines whether a player is considered incumbent or not for this research, rather than the market share of customers or the time of entry. Even if electricity retail entrants have just begun operation, they are considered incumbents if their business model is centralised, traditional, and therefore supporting the stable nature of the regime as centralised. This involves procuring power from centralised power plants, selling electricity commodity, and recovering most costs through unit-charges from customers. As this thesis focuses on decentralised energy transitions, to be considered outside of the incumbency, electricity retailers must be running business models that promote customer-sited DER.

Niche power supply business models include customer offerings and companies who promote *distributed energy resources* as a way to meet energy demand, i.e. energy savings, micro-generation assets, distributed storage, or demand response. The niche also includes the energy users who participate in the system by self-generating and managing demand which is a niche practice as compared to most energy users. Other technologies and practices may simultaneously be challenging the regime from the niche level without promoting the demand-side, e.g., supply-side renewable energy generation technologies in systems that rely primarily on fossil resources, public-sector organisations in systems dominated by private investor-owned utilities, and so forth. These dimensions co-exist at niche and regime-levels but are outside the scope of this thesis, because it focuses on transitions from primarily centralised electricity systems to those where demand is met with significant participation from demand-side resources.

'*Landscape'* influences from the level above the regime, are, following Avelino (2017 : 510), conceptualised as entailing both 'exogenous' processes that have no immediate human involvement (for example climate change or a natural disaster) and macro-trends that are external to the system studied. Because regimes are artificial boundaries drawn around socio-technical systems with individual services at the centre (for instance, energy, food, housing, health), they necessarily overlap and influence one another. Endogenous pressures that can be directly linked to human agency at the landscape level will often derive from these other societal systems outside the core system under study and can either destabilise or reinforce its regime (ibid.).

Defining the regime as associated with centralised electricity supply, and the niche with demand-side provision admittedly departs from the MLP's original focus on 'novelty' and 'innovation'(Geels 2002). Demand-side electricity generation has existed since the invention of electricity, and especially large energy consumers have actively managed their demand to reduce costs. Although these niche activities are not entirely new, adapting the MLP to analyse change from a centralised system toward a system with a greater role for the demand-side is justifiable because demand-side resources today remain niche as compared to resources on the supply-side in the North-American, European, and Australasian electricity systems this thesis focuses on, where electrification of all regions was completed many decades ago. Active involvement in energy supply or 'co-provision' by energy users also remains niche (Watson 2004a; Hannon et al. 2013); most consume electricity passively.

The research investigates only electricity retail market design, rather than all public policy institutions that structure the electricity regime and influence business models. It focuses on incumbents that fulfil electricity retailing and distribution operation functions, rather than on electricity incumbents with other functions because

transmission network operators, regulators, or system operators for instance are considered not directly affected by electricity retail market design. Other public policy institutions that structure the regime and hence matter for DER challengers are, for instance, gas retail market design, wholesale energy market design (Green 2008), energy network operator regulation (Bolton and Foxon 2011; Lockwood 2016), codes and industry licensing governance (Lockwood, Mitchell, et al. 2017), the organisation of energy regulatory processes, in other words, how elected policymakers delegate decision-making and control regulators (see e.g. Mitchell 2008 on Great Britain; Baldwin et al. 2018 on the US), and the design of public-interest programmes such as feed-in tariffs, obligation schemes (ibid.; Wiser et al. 2011; Rosenow et al. 2016), and capacity mechanisms (Liu 2017). Institutions that organise other aspects of company structure and economic activity are also not the focus of this research, for instance, private, public, or 'community' ownership of firms (Berka and Creamer 2018), corporate governance structures internal to firms, or the institutional context of financing (Hall et al. 2016). These institutional realms also structure the electricity regime and hence play a large role in organising how end-users receive electricity but are out of scope for this thesis.

Mobilising the theoretical lenses discussed allows addressing several gaps in the empirical literature on socio-technical change in electricity systems. Firstly, in focusing on electricity *retail* markets, the thesis studies a more detailed subset of decisions within historic electricity market reform processes which has not been investigated in detail. While literature has examined how restructuring unfolded (see e.g., Voss 2007; Isser 2015), this thesis' focus on the differences in reform outcomes between jurisdictions which all implemented competition between generators and unbundling upstream is novel. It is also useful because electricity retail market reforms are currently subject to discussion again in several countries.

Secondly, electricity market design institutions have not been analysed from an interpretive perspective that studies competing discourse coalitions and frames of meaning in the way this thesis does. This interpretive perspective is useful, firstly, because few analyses of electricity system transitions have incorporated discourse as an analytical focus. Attention to ideas has sophisticated the analysis of political behaviour and interests because it is now widely acknowledged that interests are neither pre-given and 'natural', nor fixed. Previous literature on the politics of institutional evolution in electricity put technological change, 'culture', material interests, and relationships at the heart of explaining socio-technical change. Studying how ideas and discourse influence change can advance existing knowledge in this sector, so the thesis makes an important contribution here. Moreover, interpretive analysis can improve policy debates and aid reflexivity within decision-making. As Fischer argues, the interpretive policy analyst's task is to *"improve policy argumentation by illuminating contentious questions"* (2007 : 235). Before this 'argumentative turn', policy analysts aiding decision-makers in evaluating options often took a technocratic approach focused on efficiency and effectiveness, without questioning these concepts (ibid.). This thesis' interpretive approach can enrich current policy debates.

Thirdly, the research contributes to literature on electricity retail and service markets. Here, the advantages and disadvantages of different electricity retail market designs for DER remain disputed. This thesis addresses three gaps within this literature: Firstly, it generates and assesses new evidence, since recent technological, economic, and institutional developments related to climate change mitigation, digitalisation, investment in advanced metering infrastructure, micro-generation and storage technology have promoted demand-side resources at smaller scale. These changes may have altered the opportunities for innovation in electricity retail since these were

investigated (Defeuilley 2009a), so there is now a gap in the literature. Moreover, this thesis' choice of data sources from different jurisdictions (see Chapter 3) makes an important contribution because few qualitative studies have so far taken an explicitly comparative approach. Most studies on the relationship between market design and innovation on the demand-side have been based on evidence from individual jurisdictions or firms. Studies have either looked at one type of incumbent company, or generalised across them, but not investigated the differences between US-style network-retail and European electricity utilities that are unbundled to varying degrees. Therefore, comparing qualitatively processes within different electricity retail market environments is a novel approach and addresses a gap. Finally, focusing on the political dimensions of demand-side transitions and electricity retail market design makes a valuable contribution to the literature. The contested ideas, effects on varying types of DER players, and on their access to resources and opportunities has not been investigated with a special attention to politics.

Chapter 3 – Methodology

This chapter first outlines the overarching and subsidiary research questions this thesis seeks to answer and how they together address the gaps identified in the previous chapter. It then explains the research design: section 3.2.1 describes the approach to researching the evolution of different electricity retail market designs and incumbent electricity business models in the US at the end of the 20th century. Next, section 3.2.2 explains how the research investigated present processes of business model evolution and niche-regime interaction, to analyse which resources and opportunities are important and contested within demand-side transitions today. Section 3.3 explains the methods of data collection and analysis. Section 3.4 reflects on the limitations of the theoretical framework and the methodology.

3.1 Research questions

The overarching research question this thesis seeks to answer is: *What is the political significance of electricity retail market design institutions for decentralised energy transitions on the demand-side?*

Five subsidiary questions guided the research. They served to explore the detailed processes of coevolution of retail market design institutions and business models in electricity and energy services.

To investigate the political significance of a set of institutions, it is useful to first examine their origin. This is important because it allows exploring how these rules

and incumbent business models initially co-evolved with novel technologies and practices, how they were contested at the time, and how market designs vary. The first sub-research question is

I. *How did different electricity retail market designs evolve in California, Massachusetts, and Texas?*

Tracing historically how different market designs evolved through a 'discourse coalitions' lens and comparing the findings in the analysis (Chapter 7) allows analysing the contested nature of different electricity retail market designs. Moreover, it allows exploring how different players strategically sought to bring about institutional change to alter the selection environment within the electricity regime, to create institutional space to capitalise on their capabilities and resources. This approach allows analysing both political dimensions of electricity retail market design: as a controversial set of institutions, and as influencing the distribution of opportunities and resources.

The second question seeks to gather empirical evidence on the strategies of DER niche-players at present:

II. *How are DER niche players today challenging electricity regimes through building business models?*

DER, that is demand reduction, electricity generated, stored on site, or shifted in time, can displace centralised resources, when players build commercial structures that allow these resources to recover value. This is often linked to public policy institutions evolving, so that these new commercial structures can be viable.

The business model lens allows researching which resources and opportunities DER promoters are seeking out. The focus on resources and opportunities is important because it enables analysing interactions with the regime, and the political dimensions

of electricity retail market design. Many of the resources and opportunities required to replicate or scale are controlled by regime-level players because of their privileged role in the system. Barriers are addressed by the third question:

III. *How are DER niche players experiencing incumbent company regime resistance, when trying to access key resources and opportunities?*

Focusing on electricity companies rather than all regime-level players (including energy users or regulators, for instance) is useful because of how incumbent electricity business models vary under different electricity retail market designs. The subsequent analysis can then compare data on niche players' experiences.

The third and fourth questions focus on the business model evolution of the specific incumbent electricity firms who were assigned electricity retailing and distribution network functions: retailers, network operators, and bundled network-retail utilities. These particular incumbents are relevant to the thesis because their business models were initially shaped by retail market design decisions, so that different types of incumbent business models operate in different electricity retail market design environments today. Today, market reform decisions about competition and unbundling influence the allowed scope for these incumbents' activities. Two subsidiary research questions investigate these incumbent electricity firms' business models, strategies, and innovation processes, to complete the evidence base for this thesis on niche-regime interaction around DER.

The fourth question examines how demand-side propositions have been embraced by regime-level players:

IV. *How are electricity retail and distribution network incumbents using their resources and opportunities to promote DER as part of business model evolution?*

Alongside positive instances of incumbents promoting change, barriers invariably remain:

V. *Which difficulties do agents of change promoting DER face within incumbent electricity firms?*

These questions lead the inquiry to focus on the reasons for which incumbents pursue DER, on their successes, and difficulties. The findings on incumbents' business model evolution are then compared in the analysis chapter (7) to investigate how demand-side transitions unfold in different electricity retail market design contexts.

All five questions enable building an understanding of socio-technical change processes in electricity systems, where technologies, business strategies, and institutions co-evolve. As outlined above, they allow collecting data which are then analysed comparatively (see section 3.3.2) to answer the overarching research question.

The questions combine exploratory with comparative inquiry (Gerring 2017). Because they are designed to be exploratory, they focus at a general level on retail electricity market designs, activities of DER-niche players, and on incumbent electricity companies. However, within these categories, there is considerable empirical diversity. Answering the subsidiary research questions to reflect this diversity therefore implies comparison between different types of market designs, DER newcomers, and varying types of incumbent firms. The questions are designed to focus on broad categories of institutions and players, so that the answers can cover the empirical diversity in electricity regimes and ecosystems of niche innovation.

3.2 Research Design

This thesis investigates demand-side transitions in the electricity sector as processes: firstly, processes which institutionalise public policies to form new electricity retail market designs, and secondly processes that institutionalise or change commercial structures to promote demand-side energy resources. Transition theories, and in particular the multi-level-perspective, are process rather than variance theories (Schot and Geels 2011). This means that they rely on explaining the *"unfolding of processes (…) by identifying patterns and underlying mechanisms"* (ibid. : 93). This is different from variance theories that seek to explain *"variation/ change in outcome (dependent variable) as a result of influences from causal factors (independent variables)"* (ibid. 2011 : 93). The transitions in the electricity sector this thesis investigates involve *"complex dynamics, which are difficult to explain as simple cause-and-effect relations"* (ibid., 96). Therefore, narrative explanation that pays attention to sequence of events and agents' interactions, as common in history and sociology (Abbott 2001) is appropriate for this thesis, rather than investigating causal relationships between variables. In analysing these complex dynamics, investigation guided by the MLP focuses on *"co-evolutionary interactions between ongoing trajectories"*, including institutions, technologies, business strategies, and user practices (Schot and Geels 2011 : 96; Foxon 2011).

The multi-level-perspective proposes two explanatory logics to make sense of more detailed processes of socio-technical change which can come together to produce greater system-level transitions: firstly, explanation of *"event-chains"* which follow agents interacting, *"drawing on structural contexts"*, and *"institutionalising outcomes in new structures"* to bring about reproduction or change (Schot and Geels 2011 : 96). *"The second explanation is evolutionary, based on the generation of*

variations within populations and their subsequent selection and institutionalisation; this explanation is especially useful for competition and innovation dynamics in firm populations" (ibid.). This thesis draws on both types of narrative explanation. For analysing the first phase of socio-technical change in electricity retail under investigation, it uses the explanatory logic that looks at event-chains in depth, in three cases of market reform. The on-going processes of business model evolution are analysed using the evolutionary perspective that focuses on how variations occurring in distributed energy niches are being selected by regime-level players in the electricity system, leading to change within these populations of firms. Both approaches are explained in the following.

3.2.1 Case studies of electricity retail market reform

The first transition process the thesis investigates happened in several jurisdictions that introduced 'restructuring' reforms in the 1990s and early 2000s. Extending competition reforms beyond generation of power into energy procurement and other customer-facing functions (downstream) altered the institutional framework through which the demand-side interfaces with an electricity system. I examine this phase of demand-side transition through the analysis of discourse coalitions and institutionalisation of new ideas in three cases of public policy change (Chapter 4).

The three cases examined are Massachusetts, California, and Texas. The chapter explains changes at niche, regime, and landscape level, discourse coalitions and ideas, and similarities and differences between processes of market restructuring. This includes important actor-groups participating in debates in the states and at national level, how storylines were created, resources mobilised, and how material and

technological factors played a role in destabilising a previously hegemonic discourse, so that a new one could become institutionalised.

Case studies are well suited to the tracing of processes (George and Bennett 2005), examination of complex phenomena and their context, and the answering of 'how' questions (Yin 2009). They have been often used for studies of socio-technical change because a small-N methodology allows a detailed, in-depth understanding of complex socio-technical changes to build narrative explanations (Schot and Geels 2011). The aim is to gain an in-depth understanding of the cases themselves, as common in 'case-centric' studies that do not attempt to build a widely generalisable theory (Beach and Pedersen, 2013). Some causal claims are made to explain how institutions, technologies, business strategies, practices, and ideas co-evolved. However, the research is not primarily aimed at making causal inferences about the importance of specific characteristics of the cases (variables) that explain the different outcomes. As such, the case studies presented could be framed as *"descriptive case study research (...) not organized around a central, overarching causal hypothesis or theory"* (Gerring 2017 : 56). This type of case study work still often draws on theoretical lenses and prior knowledge to guide the inquiry, data collection, and analysis (Cloke et al. 2009).

The research design follows a 'diverse' case selection strategy, so states were chosen which adopted different electricity retail market designs. California, Massachusetts, and Texas (ERCOT) all adopted electricity market competition at least upstream with transparent wholesale markets and independent system operators, but on the demand-side, processes of market design resulted in different outcomes. As Gerring explains, *"a descriptive case study may also focus on several cases that, together, are intended to capture the diversity of a subject. In effect, the researcher looks for typical cases of*

each envisioned type" (Gerring 2017 : 58). The cases represent the diversity of electricity retail market reform outcomes in the US, but also internationally.

When initially reviewing electricity retail market designs across jurisdictions (see e.g., Sioshansi 2013), several high-level differences between institutional structures emerged. This thesis focuses on the following:

- whether procuring power from competing generators for retail, billing for power, and metering is contestable or not (direct access and competition);
- how service provision is organised for those customers not exercising affirmative choice (default service);
- and whether distribution network operators would be allowed to provide any contestable retailing functions or not (unbundling).

The three cases represent archetypes of electricity retail market design. Texas is the only state in the US that adopted a *competitive-unbundled* electricity retail market design, similar to the one common in Europe, some Australian states, and New Zealand. Competition in retail allows all customers choice of competitive retailer. Unbundling bans network companies as regulated-franchise entities from engaging in contestable activities such as retailing and marketing energy service offerings.

Massachusetts, with a *competitive-bundled* retail market design allowed all customers to choose independent electricity retailers, but retained a strong role for the network operators, as unbundling of networks from customer-facing activities was not implemented. The regulated-franchise network utilities continue retailing electricity to default customers who don't choose an alternative provider; in practice, most residential and small business energy users. They also retained their role in implementing demand-management programmes. This market design was adopted also in other Northeastern US states.

California initially introduced electricity retail market competition without unbundling, but rescinded competition again in the aftermath of a supply shortage 'electricity crisis' (Sweeney 2002). As competition was not reintroduced on a large scale, the state is classed as representative of a *monopoly* retail market design, meaning customers are served by the franchise network-retail utility and may not choose to buy power from generators or competitive retailers[11].

Case studies of electricity market restructuring processes in these three states allow researching the diverse nature of retail market designs, mechanisms of public policy evolution on the demand-side, and the political dimensions of these institutional frameworks.

3.2.2 Researching processes of business model evolution

The research on the current phase of socio-technical change explores how distributed energy niches including technologies and practices are being selected and change populations of electricity firms and regime-level practices. The research design for analysing these present-day processes of socio-technical change focuses on wider industry trends and variation processes, rather than 'event-chains' and individual cases (Schot and Geels 2011). The data presented allow narrative explanation of how a variety of business models promoting DER emerge in a range of market design contexts.

[11] Some customers have an exceptional permission to buy power directly from generators or retailers. See Chapter 4, pp. 117-118 for details on California's retail electricity market design, including the cap on direct access and community choice aggregation.

'Selection' and 'variation' processes are researched qualitatively, examining experiences of newcomer and incumbent firms, captured in narrative accounts (see section 3.3.1). The investigation is not bounded to a certain geographic jurisdiction. Positive and negative examples of interaction between incumbents and niche-players are referenced but they are not analysed in depth as common with case studies. Instead, they are analysed as examples of wider trends. The aim of this exploratory approach was to capture the gamut of DER business models, and thereby the full breadth of the phenomenon (Gerring 2017) 'demand-side energy transitions'. Cases of individual firms, their supply chains, and processes of trying to influence their selection environment could have been used to investigate certain niches, but this approach would have limited the research to specific types of DER and business models. Instead, I chose to study different DER and approaches to building business models as a variety of demand-side niches. Investigating diverse instances of variation and privileging breadth over depth allows speaking to a wider range of literature because authors have commented on various resources behind the meter and their relationship with retail market design. Furthermore, this approach enables analysing the political implications of market design through studying how it influences the distribution of resources and opportunities between different types of DER niche players.

The research to answer the overarching question relies on comparison of processes through which commercial structures are institutionalised within different market design contexts. Comparison happened in the analysis phase (see section 3.3.2), but also during data collection when research subjects drew direct comparisons. For instance, interviewees and speakers at public industry events recounted how their challenges and opportunities differ across jurisdictions and regulatory contexts.

The qualitative approach that uses narrative explanation and compares processes is best to address the research question. An alternative methodology seeking to explain variance and causal influence of individual variables would not adequately capture the complexity of demand-side transitions investigated here. Some scholars believe that the study of socio-technical transitions should reconceptualise its epistemological foundation as a 'process theory' focused on narrative explanation that privileges richness, and rather try to build *"'mid-range' theories that provide generalisable explanations of patterns of diversity and change"* (Lockwood, Kuzemko, et al. 2017 : 315). These critics propose comparative case studies would enable *"identifying the specific causal mechanisms that drive particular transitions"* (Sorrell 2018 : 1280). A methodology that compared, quantitatively or qualitatively, business model success, DER adoption, and market reforms in different jurisdictions could have been used to approach the question of how electricity retail market designs affect demand-side resources and vice-versa. However, these methodologies necessarily reduce complexity to an extent unfit for large-scale processes that comprise so many factors. Transition processes *"involve many specific mechanisms"* and *"there is no single explanatory silver bullet"* (Schot and Geels 2011 : 96), so the complexity of socio-technical change processes should not be reduced to dependent and independent variables. Therefore, this thesis prefers narrative explanation of transition processes that privileges richness over causality.

Moreover, comparative studies claiming to explain causality within analyses of complex systems are methodologically questionable. As Campbell explains, analysts comparing local and global markets should beware of the

> *"methodological problems associated with comparative studies and drawing conclusions about which institutions are most significant, and for what aspects of firm behaviour, and with what impact on performance outcomes. What is a simple idea can rapidly become swamped by methodological problems*

> *associated with small number samples, with contamination effects (since societies are not self-contained but intricately connected), with historically complex inter-relationships, and with a morass of specific detail that makes broader conclusions extremely difficult to draw"* (Campbell et al. 2010 : 3–4).

Comparing institutional arrangements is useful to identify differences and similarities and thereby improve our understanding of economic organisation (ibid.). Therefore, this thesis' approach of comparing processes in a narrative fashion between jurisdictions with different electricity retail market designs advances the literature.

3.3 Methods, data, and analysis

The following section first describes methods of data collection and generation, including how limitations were mitigated. Then, it explains the analytical approach, using content and discourse analysis of qualitative data to answer the sub-research questions; and comparison of the findings to address the overarching question.

3.3.1 Methods of data collection and generation

A variety of qualitative methods were used to generate and collect data. The three main types of data sources were primary documents such as media reports, archival records, and company publications; qualitative key-informant interviews; and participant observation at public panel-discussion events. Table 1 gives an overview.

Research question: What is the political significance of electricity retail market design institutions for decentralised energy transitions on the demand-side?				
Subsidiary questions	Key-informant interviews	Primary (archival, media, and company) documents	Participant observation at panel discussion events	*Empirical chapter presenting data*
(1) How did different electricity retail market designs evolve in California, Massachusetts, and Texas?	x	x		4
(2) How are DER niche players today challenging the electricity regime through building business models?	x	x	x	5
(3) How are DER niche players experiencing incumbent company regime resistance, when trying to access key resources and opportunities?	x		x	5
(4) How are electricity retail and distribution network incumbents using their resources and opportunities to promote DER as part of business model evolution?	x	x	x	6
(5) Which difficulties do agents of change promoting DER face within incumbent electricity firms?	x	x	x	6

Table 1: Methods of data collection and generation to answer subsidiary research questions

Semi-structured key-informant interviews were important sources of data on both processes of retail electricity market creation and demand-side business model evolution. 122 interviews were conducted between 2016 and 2019 (cited as Int-A or Int-B, see Appendix 2 for a list). Many interviews were conducted face-to-face and audio-recorded. Many were conducted over the telephone which enabled more

interviews and sampling across countries and continents. These were recorded in detailed notes by the researcher.

The research was approved in September 2016 by the *Research Ethics Committee* of the *University of Oxford School of Geography and the Environment*. To ensure compliance with ethical research principles, I provided all interviewees with a participant information sheet detailing the aims of the research, the interview topics, and potential risks of participating, mostly related to the sharing of sensitive information. This enabled me to obtain informed consent from participants, and after the interview I agreed with them a preferred route for citation (by name, affiliation, or anonymised by sector or company type). The data were stored in accordance with the University's ethical research guidelines on a server secured by password only accessible to the researcher.

For researching processes of electricity restructuring reform, interviews covered the contextual changes in technology, markets, and regulation which preceded the reforms; who was involved in debates; which positions different stakeholder groups had taken; which evidence and sources had been consulted by decision-makers; and how participants rationalised the decisions ex-post. By exploring actor groups' lobbying positions, interviews generated insights on how discourse coalitions formed. I also asked about interviewees' hypotheses on why different stakeholders took their respective positions, to investigate how actors believed they and others would be affected by institutional change. Moreover, interviewees' narratives about detailed steps of the process provided accounts of relationships between stakeholders and policymakers, including different actors' influence. These accounts were later triangulated with media reports.

Sampling of interviewees was purposive (Tansey 2007). The key informants were involved in the policy debates in one or several of the three jurisdictions (California, Massachusetts, Texas), either as regulators, legislators, lobbyists (e.g. industry, environmental, and consumer representatives), civil servants, or electricity sector experts. Recruitment used the method of 'snowballing' through referrals from interviewees. Furthermore, archival materials helped identify suitable participants whose names appeared in historic hearing transcripts, media reports, and journal publications. Researching all three states allowed studying a common discursive sphere, or 'national conversation'. Several important interest groups operated at national scale across the US; experts testified across states; decision-makers reviewed some evidence from the same sources; and experiences in other states were key within the discussions.

Interviews with incumbent electricity companies and DER niche players focused on firms' strategies of how to build and evolve their business models. These conversations allowed tracing processes of building networks (Doganova and Eyquem-Renault 2009). The assumption was that entrepreneurs are in search of applications for their solution, value propositions, business partners, and customer channels. Interviews were used to investigate incumbent and niche players' accounts of these activities, and their experiences of barriers, opportunities, differences under varying institutional arrangements, and proposals for regulatory change. Interviews with established firms covered similar areas, including strategies, innovation activities, and difficulties. Interviews with experts in the sector, such as industry associations, charities, and research organisations, focused on identifying trends in how electricity and energy service markets are evolving, within a jurisdiction and internationally. These allowed triangulating accounts from individual companies.

The sampling of company representatives and experts was purposive, to include a wide range of viewpoints, across different business models, target customer segments, company sizes, and jurisdictions. Initial sampling of DER and electricity company interviewees focused on Great Britain (GB), Germany, Texas, California, and Massachusetts. These jurisdictions were identified as having competition in generation (upstream), a variety of electricity retail market designs, and growth in some or all the resources behind the meter considered by this thesis. Many DER players and electricity companies also work in other European, North American, and Australasian regions, and several interviewees spoke about experiences across jurisdictions. This enabled gathering data with a wider geographic reach. It also allowed gaining interviewees' own perspective on whether and how they believed differences between electricity retail market designs had shaped opportunities and barriers. However, speaking to firms about experiences comparatively was not possible for all types of DER. Electricity incumbents, firms in micro-generation, distributed storage, and demand response companies are often active across borders. In energy efficiency on the other hand, the customer-facing end of the supply-chain is largely focused on smaller geographic regions. Exceptions who work across jurisdictions (or internationally) are manufacturers of appliances and building materials, some large ESCOs, and some energy-efficiency-programme-implementation companies. But many energy service providers and installers tend to be smaller and work locally (Int-B-122-DER).

Interviewees from the electricity or DER industries belonged to one or several of the following sectors:

- Residential/ commercial/ industrial demand response
- virtual power plants and aggregation
- (energy consumption) analytics

- solar PV
- micro-CHP
- heat-pumps
- energy efficiency, micro-generation, and building services for medium and large-scale energy users
- energy consultancy
- engineering firms
- electrical infrastructure manufacturing
- energy industry associations and non-governmental organisations
- large, medium, and new entrant energy retailers, including active in Britain, Germany, Australia, the United States, and Canada
- unbundled network operators in Britain, ERCOT, and Germany
- regulated-franchise network-retail utilities in California and Massachusetts
- energy-saving-obligation implementors in Australia, the United States, and Britain

Interviewees held medium to high-level positions; in operations, regulatory affairs, or at board-level.

Sampling relied on recruitment at energy industry conferences with middle to senior and executive-level attendance, and 'snow-balling' through referrals via email contact. I also identified interviewees through publicly available company information and approached participants directly through professional profile websites.

Interviews followed a semi-structured format, whereby the interviewer uses a loose interview guide (see Appendix 4 for examples), but keeps questions open-ended and broad to allow participants' diverse perspectives to emerge (Cloke et al. 2009). First, open questions allowed participants to highlight which aspects of restructuring, business model evolution, policy context, and differences between jurisdictions they found significant. Then, more detailed follow-up questions ensured points most relevant to the study could be covered (ibid.). For interviews on DER innovation,

using the business model framework (Osterwalder et al. 2005) to guide the questions was helpful because it enabled finding a common language with participants. Where interviewees suggested ways in which the regulatory environment or the behaviour of other players influenced their prospects for commercial success, follow-up questions were designed to delve deeper into the mechanisms they proposed were impeding or promoting DER. At the end, prompting interviewees through quotes by other organisations allowed triangulating and uncovering disagreement between participants. This was useful both in researching historic processes of market restructuring and current processes of commercial and policy change.

The semi-structured interview method did not allow data to be sampled representatively. While surveys may have allowed a larger, representative sample of companies, they would not have allowed capturing the range of experiences and complexity of accounts of how supply chains develop needed to answer the exploratory research questions. Moreover, assigning firms to different business model categories to achieve representative samples would have been arbitrary because the complexity and fluidity inherent to building and evolving business models mean that categories overlap and change over time. It was important to allow participants to shape the conversation in ways relevant to the reality of their experiences, and to then in follow-up questions probe how exactly access to resources and opportunities had been impeded or enabled. This enabled investigating whether and how barriers and opportunities mentioned are related to electricity retail market design. Therefore, semi-structured interviews were the best approach to capturing participants' experiences.

A general limitation of data generated through interviews or surveys is that accounts of individuals' experiences can be exaggerated, misrepresented, or in the worst case even deceptive. This is not problematic when individuals' personal views and

perceptions are analysed, but when gathering data about events and other players' behaviours, triangulation is necessary. Interviewees may have misrepresented events in their account of collaboration activities, either because of limited insight into other firms' business operations or because they have a strategic interest in building negative narratives about competitors. Many participants also had implicit ideological assumptions about the topic of competitive or monopoly market structure. This meant that some interviewees interpreted their experiences of challenges and opportunities as linked to market design, given the participant information sheet had informed them that this was the focus of the study, when in fact links were in some cases ambiguous. In following up on how exactly the difference in market design was linked to their experience, most interviewees however were open about their ideological orientations, readily admitted that many other factors played a role, and thus caveated their assessment. Because the interview method yields inherently subjective data coloured by pre-held beliefs and agendas, sampling was purposive to triangulate accounts through insights from a broad range of stakeholders across industry. Also, at the beginning of interviews, participants were asked for an account of their professional background, so that during the analysis I could reflect on the participant's perspective and experience, to improve awareness of biases in representing their own and others' activities.

I discovered another limitation of using interviews to explore emerging business model innovation: many newcomers and established firms prefer not to share details about innovative activities until after they have been launched, and prefer to reflect on the success of building relationships with business partners after the fact. While searching for partners and building a supply chain, many are nervous about sharing details because of non-disclosure agreements, worries about revealing valuable proprietary information, or about jeopardising ongoing negotiations. This problem

was mitigated through anonymisation of names and companies which gave participants more confidence to speak openly. Moreover, questions were developed to speak more generally about strategies observable across the market, including by other companies. Furthermore, researching publicly available information on trials, collaborations, and innovation activities before interviews helped with steering participants to speak about innovation activities already publicly reported in the media or company publications, which in many cases put participants at ease.

Primary documents were also used for all aspects of the research (cited as Doc-A or Doc-B, see Appendix 1). Historic documents from Texas, Massachusetts, and California from the 1990s and 2000s allowed tracing the contested evolution of different electricity retail market designs. The analysis of documents enabled identifying the discourse coalitions and problem-solution framings which actors used to argue for their preferred public policy. The primary documents included media publications, journal articles, working papers, research reports, and regulatory and legislative records from archives. The records allowed analysing stakeholders' statements and written evidence as well as debates with legislators and regulators. They also allowed triangulating the accounts of interviewees on which actors had taken which positions on the issues, and to analyse primary evidence of discourse coalitions' activities of framing problems and solutions. The files contained documents submitted formally by stakeholders as part of the record in regulatory proceedings, but also personal files compiled by decision-makers that include documents like letters and annotated newspaper clippings. As with most archival material, this part of the record was constructed ex-post and includes evidence which the creators believed was significant or wanted to convey was of importance. Where records were digitalised, it was possible to narrow down material for review by searching with key words such as 'choice', 'competition', 'energy procurement',

'billing', 'metering' and 'wires-only'. Material was also selected for review based on interviewees' indication of which sources and hearing dates they believed had been influential.

The archival data sources reflected mainly 'elite' discourse (Schmidt 2011) by policymakers, industry, and stakeholder organisations, as opposed to 'grass-routes' discourse. The sampling focus on official records led to a focus on actors with formal representation in the policymaking process and exclusion of others not represented in archival records or indicated by interviewees as important within the reform process. This focus on 'elite discourse' facilitated by Government makes sense because the records are maintained for public access in archives, making them accessible for historical analysis.

For the research on business model evolution, media reports and company statements in the public domain, primarily online, were important sources. Following literature on how to study strategy (Grant 2010), the focus of data collection was to investigate both how firms publicly communicate their objectives, and to examine implementing decisions, including investments, novel products, and partnerships. Therefore, company documents such as press releases and company websites were analysed. Additionally, media reports, public interviews, and research reports were important to follow market developments and insights into how partnerships between firms are developing.

Publications on public policy reform, by Governments and regulators, companies, and other stakeholders, allowed insights into which public policy changes players call for and how DER players perceive their opportunities to succeed. The sampling of these documents was based on the jurisdictions, companies, and partnerships interviewees

spoke about. Some secondary literature on energy sector decentralisation and system change also provided insights on changing business models and public policies.

Finally, another source of data on the current evolution of demand-side business models was the *participation* in industry conferences and workshops. A total of 13 events were attended in the US, GB, and Germany between 2016 and 2018 (see Appendix 3). My fieldnotes recorded participants' public contributions to panel discussions and presentations. These fieldnotes were insightful because both established and new-entrant firms spoke publicly about their innovation activities, barriers, and proposals for how policies should change. The debates offered ample material for analysing companies' and lobbyists' discursive activities as well as learning about market developments in terms of acquisitions, trials, and partnerships. Often, I would follow up with clarification questions after panel debates with speakers individually. To obtain consent and ensure observation was not covert, I introduced myself and the research, and explained that I was asking questions which would directly feed into results written up as a thesis. In several cases, these conversations led to interviews.

3.3.2 Analysis

Data were analysed in two phases: initially in an exploratory fashion that investigated historic and current processes of creating new commercial and public policy institutions, aimed at answering the subsidiary research questions. Later, analysis at a higher level compared these findings to identify differences and similarities across processes in the context of varying electricity retail market designs to address the overarching research question. Comparison is useful because analysing similarities

and differences helps with understanding the nature of institutional frameworks and how they affect economic activity (Campbell et al. 2010).

Data analysis used two qualitative approaches across both historic and current processes of transition investigated: content and discourse analysis. To investigate acts of framing and discursive activities, discourse analysis techniques were applied to public statements, field notes from conferences, and interview transcripts. While the term qualitative discourse analysis comprises a range of methods, the term is used here to describe textual analysis that looks for underlying assumptions, rhetorical instruments, naturalised relationships and binaries (Dryzek 2005). As a method commonly applied by interpretive policy analysts, the researcher pays particular attention to disagreements; assumptions and definitions taken for granted by the speakers; to how speakers or authors assign causality; and to how problems and categories are constructed (Hajer 1995; Schmidt 2010). This approach was applied to current and historic narratives of business activities, opportunities and difficulties, and to narratives about how public policy structures should be designed. Content analysis takes a more realist approach to the text than discourse analysis (Dixon 2010). It is therefore well suited to investigate who was involved in policy debates at the time of restructuring, how actors perceive strategic interests and activities, and to examine events related to commercial partnerships and firm activities.

Both types of data analysis entailed coding, that is sorting and resorting qualitative data into emerging themes with the help of qualitative analysis software (NVivo). Because the research on current business model evolution was initially exploratory in nature, following Cloke et al. (2009), interviews were analysed during and after the fieldwork. This meant that emerging themes could be used to guide later interviews and textual analysis, and that initial conclusions could be tested and triangulated. The initial analysis during fieldwork phases generated more specific themes to explore in

the interviews that followed (ibid.). Most audio-recorded interviews were transcribed verbatim and coded in text, while others were coded by listening. The telephone-interviews were coded based on the researcher's notes.

Coding was guided by the theoretical frameworks. Data on electricity market restructuring reforms were coded following the MLP and discourse coalitions approach which allowed devising codes to apply to the text. Data were sorted into categories such as problem-solution framings, niche-developments, landscape changes, and actor coalitions. Interviews, documents, and fieldnotes that contained data on on-going coevolutionary processes were coded very openly initially without applying a very granular framework. After several early interviews, the business model framework was adopted which enabled devising a broad range of codes reflecting resources and opportunities. This enabled analysing barriers and opportunities, instances of successful niche-selection, and experiences of limited access to resources. Over time, codes were iterated and merged. Coding enabled building an understanding of how public policy and commercial structures have been institutionalised and are co-evolving in different contexts, and of different actors' narratives about these processes.

The higher-level analysis of these data entailed comparison to answer the overarching research question on the political significance of electricity retail market design for demand-side transitions. Comparison was used to discuss both dimensions of 'politics': the 'political' as the realm of contestation, and as pertaining to distribution of resources and opportunities. These findings are presented in Chapter 7 'Analysis'.

To illuminate contested assumptions, the analysis compared various stakeholders' problem-solution framings and storylines about how the institutional structure should change. Following Fischer (2007), it aimed to trace underlying assumptions otherwise

taken for granted and investigate how information, evidence and concepts presented as objective and universal are socially constructed and contested.

Furthermore, processes of interaction between DER niche players and electricity incumbents today were analysed by comparing access to resources and opportunities in jurisdictions with different electricity retail market designs. There is no clear evidence for better access under either electricity retail market design environment, where DER niche players' and associated energy users' experiences have been similar, and where different types of incumbents have behaved similarly. Where access to resources and opportunities differed and this can be linked to incumbents' direct influence, electricity retail market design arguably has, or will in future have significance. This comparative analysis of frames of meaning and of access to resources and opportunities served to illuminate the political nature and significance of electricity retail market design in the context of demand-side energy transitions.

3.4 Limitations

Firstly, the methodology has some limitations as concerns generalisability of the findings. Although research that takes a process rather than variance-based approach does not intend to build predictive theory, it is useful to reflect on generalisability because the thesis does seek to draw conclusions that can contribute to public policy reform and related literature. The findings from studying electricity market restructuring in three states are case-specific. In other cases of market reform, actor coalitions and contested topics will vary because each transition case is unique. However, case study findings are nonetheless useful to develop knowledge about complex phenomena (see Flyvbjerg 2006) which can inform practice and research on

other places. In this case, the findings on contested concepts and assumptions underlying different electricity retail market designs can be useful to inform debates in other jurisdictions because readers can more reflexively assess debates in their own context with attention to problem-solution framings. This can aid in critically assessing how the assumptions underlying arguments for different institutional arrangements come to be constructed.

The methodology to research processes of selection and variation in electricity systems also means that the generalisations drawn about prospects for successful DER business models must be treated with some caution. The conclusions are based on analysing individual instances of change rather than a representative data set that captures an entire population of firms in transition, or even several populations in different jurisdictions. Chapters 5 and 6 outline instances of successful regime challenge by niche players, and of barriers to building new viable businesses. Chapter 7 links these to electricity retail market design institutions by comparing different types of incumbents' strategies and behaviours. The analysis relies on extrapolation from a small sample to hypothesise which types of firms may be successful in driving forward change, which types of incumbents may be likely to block change, and under which conditions. These findings generate valuable learnings, but viability in some jurisdictions under certain conditions does not mean that these accomplishments can be necessarily replicated in a similar electricity retail market context. Findings about firm behaviour are not widely generalisable because the sample of companies' activities is not representative, because firms differ along many criteria and because ambition varies over time. The insights were strengthened by sampling interviewees broadly; by asking about wider trends; triangulating between interviewees working in different contexts and with different firms; and by asking whether impressions of challenges and opportunities were shared.

Secondly, analytically, the choice of the MLP as a tool to guide the study of socio-technical change has some shortcomings. For instance, there is concern that neatly categorising actors' aims and roles is difficult because their positions, interests, and agendas within the system are not 'naturally' pregiven (Chilvers and Longhurst 2016). Sorting actors into groups such as 'incumbents' or 'innovators' is problematic because in fact actors' roles and identities are continuously shifting or *"co-produced"* (ibid. 2016 : 601), and are hence emergent rather than fixed. This critique is valid and did make the categorisation of players difficult: I discuss all types of retailers who primarily purchase and sell electricity from centralised power plants as incumbent, even if they have entered the market relatively recently, and focus their business model on renewable electricity. This is because incumbency for the purpose of the thesis is focused on *centralised resources* and a *passive demand-side*, and the transition under investigation focuses specifically on *demand-side decentralisation* dynamics. The structural (rather than relational) perspective taken by the MLP is useful for this thesis because of its aim to investigate a core set of institutions which stabilises structures. In this case, market design stabilises the activities and relationships of established electricity firms, and some of the opportunities for challenge by newcomers. Therefore, studying transitions through the multi-level-perspective lens is useful, at a time when DER still play a niche-role in most jurisdictions.

Another critique is that the MLP focuses too much on elite actors, like policymakers and incumbent businesses, and too little on other actors, such as end-users and civil society groups as agents of change (Hargreaves et al. 2013). Furthermore, as Shove and Walker (2010) criticise, while the MLP accounts for technological, infrastructural, and institutional lock-in, it ignores social lock-in in everyday practices which they argue are key to understanding system transitions. The call to pay attention

to everyday practices, activities, and players at the 'base' who are not firms or regulators is relevant, given the thesis' focus on distributed energy where end-users play a crucial role in either adopting actively or at least accepting participation in energy services and public-interest programmes (Eyre and Lockwood 2016).

However, bounding the research to focus on firms, experts, and policymakers is a valid approach to take, again because of how electricity retail markets influence the ecosystem of incumbent companies. Investigating transitions through a business model lens and paying special attention to the interaction of newcomers and regime-level players allows focusing on this core, tangible institutional difference. This way, I aim to improve understanding of how regimes adopt and resist change, and how electricity retail market design affects these processes.

Chapter 4 - The evolution of different electricity retail market designs

For many years, the electricity industry was regarded as a 'natural monopoly' and companies were permitted to operate with regional exclusive franchises, vertically integrated along the supply chain. By the 1990s, the idea that a vertically integrated monopoly was optimal in techno-economic terms was destabilised. In some jurisdictions, a new set of ideas on the superiority of markets was institutionalised when policymakers legislated to introduce competition and separation of functions in the electricity sector.

This chapter traces this phase of socio-technical change in the electricity sector which created markets for competing players to buy and sell power in three cases: California, Texas (ERCOT), and Massachusetts. The ideas about the primacy of markets in electricity were institutionalised differently across the three jurisdictions[12], so that today electricity retail market designs vary.

The chapter traces the processes of institutionalising new public policy and firm structures and addresses the subsidiary research question: *How did different electricity retail market designs evolve in California, Massachusetts, and Texas?*

The first section 4.1 explains the three different archetypal electricity retail market designs that emerged from processes of market restructuring in the US, where

[12] Retail electricity and gas market regulation is under state-level jurisdiction in the US, so that state legislatures, governments, and their regulatory agencies have the authority. Federal policymakers only have jurisdiction over interstate commerce, i.e. electricity that is transported across state borders, and by extension wholesale energy transactions where there is interconnection between states.

wholesale electricity competition was implemented. Section 4.2 outlines changes at landscape and niche-levels which preceded market restructuring in the US. Then, section 4.3 explains the discourse coalitions engaged in the debates about reform, including the storylines actors put forward, how they framed problems and solutions, who the main actor groups were, and why they took their respective positions on the issue. The data are organised along discourses and associated actor coalitions rather than the three cases because the debate in each state was heavily influenced by international and federal debates, and actor alliances across state borders. Section 4.4 explains how storylines were finally institutionalised in new market design and company structures and compares this process across the three cases. Section 4.5 concludes by summarising the findings.

4.1 Electricity retail market designs in Texas, Massachusetts, and California

Electricity retail market design is defined for the purpose of this thesis as the policy framework which determines whether electricity retailing functions are contestable, who has been assigned to serve customers who don't exercise an affirmative choice, and whether network operators are allowed to engage in customer-facing functions or not.

All three case jurisdictions implemented competition upstream in generation and mandated that network companies had to divest (unbundle) most power generation. But downstream the market designs today vary. Figure 4, Figure 5, and Figure 6 show three market design archetypes, based on the models in place in the three case jurisdictions after restructuring processes were complete.

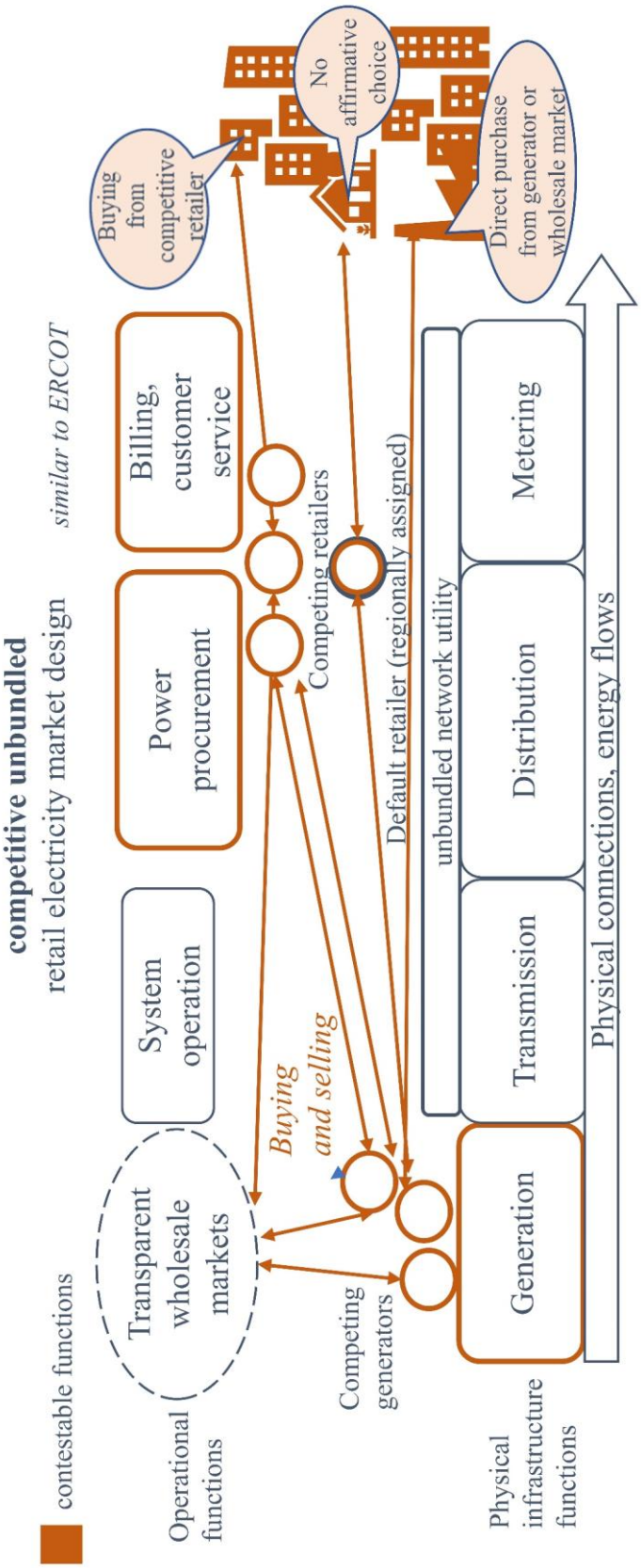


Figure 4: competitive unbundled retail market design, similar to ERCOT

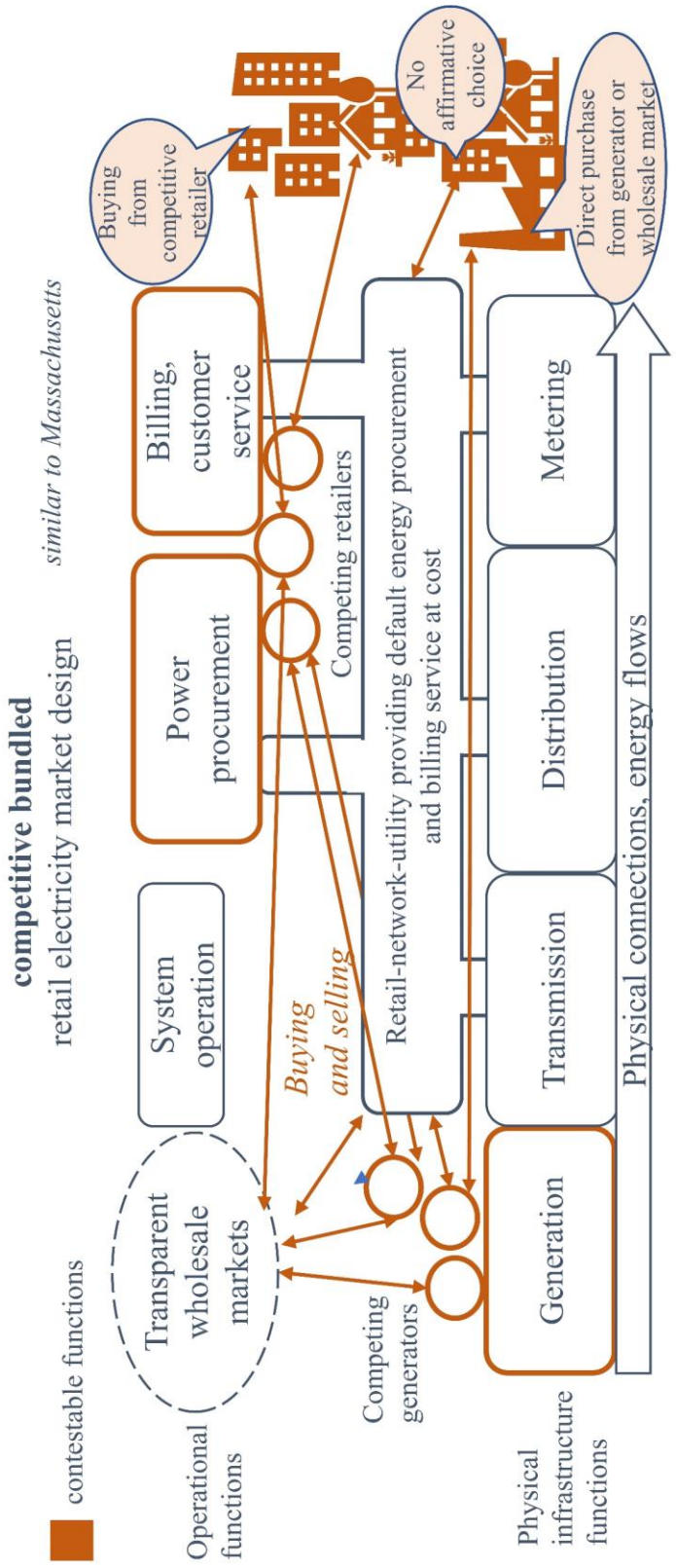


Figure 5: competitive bundled market design, similar to Massachusetts

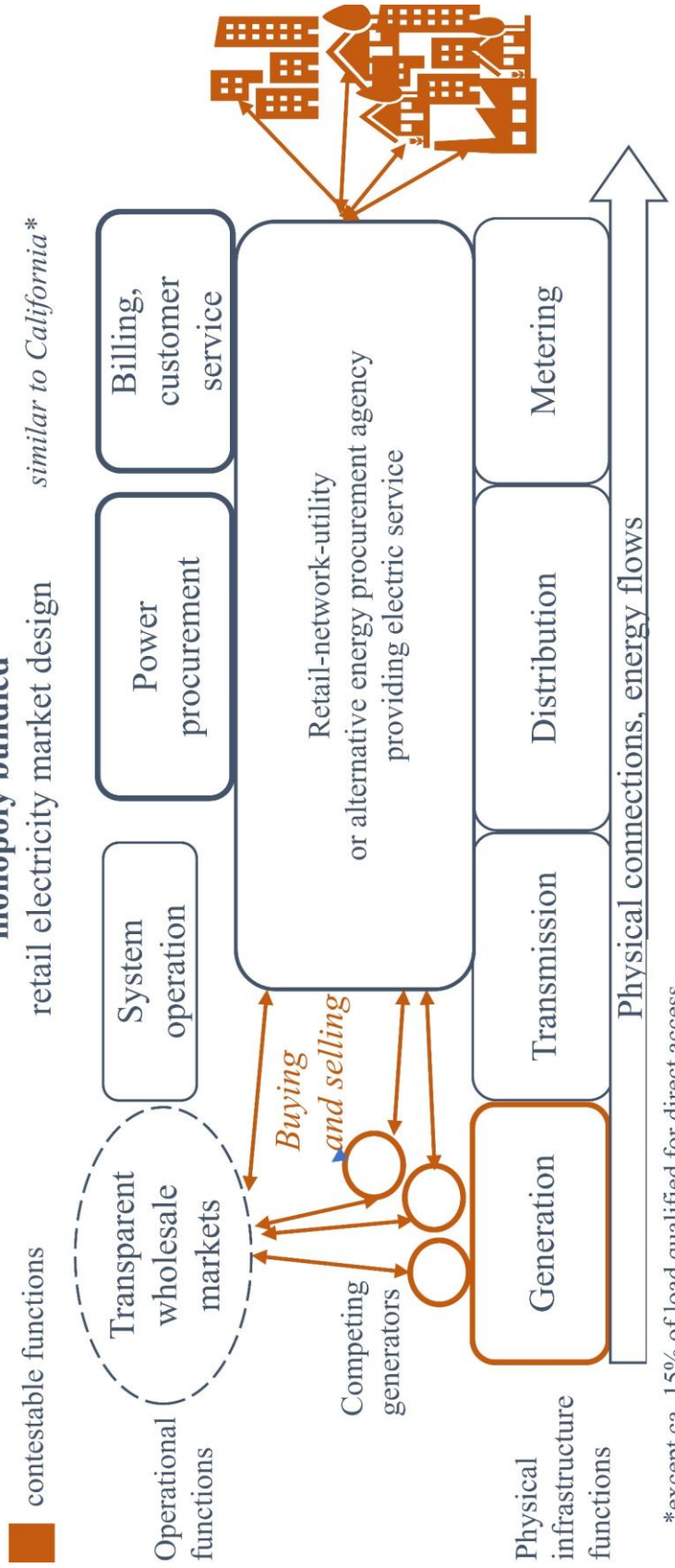


Figure 6: Monopoly bundled market design, similar to California

The reform adopted by Texas for the ERCOT region went furthest: electricity users in all customer classes were allowed to choose among competing retailers or generators if purchasing power wholesale. Network companies were unbundled not only from generation, but also from retailing functions. This meant that all customers were initially assigned a competitive retailer acting as the default provider. Customers who never made an affirmative choice remained with this company (initially at a regulated 'price to beat') (Kiesling and Kleit 2009). Unbundling created new firm structures: retailers and 'network-only' utilities who may not sell electricity to end-users.

In Massachusetts too, all electricity users were permitted to choose among competing generators and retailers when power procurement was made contestable. However, Massachusetts network operators were forced to divest only power plants, but not retail functions, so today they are structured differently from those in ERCOT. These 'network-retail' utilities participate in the electricity retail market as regional default providers of energy procurement and billing[13]. Even where customers have chosen to buy electricity from a competitive retailer, the regulated-franchise utility sends a bill and collects revenue on competing retailers' behalf. Some retailers also send a second separate bill that covers the energy procurement charges.

Finally, California originally introduced competition to retailing but reversed this decision in 2001, so that today energy procurement and billing remain monopoly functions for most[14] energy users in California. The difference between this monopoly

[13] Some cities have chosen to take over the role of default electricity provider as 'community choice aggregators' (Brinker and Satchwell 2019). Then, unengaged customers default to be served by this newly created municipal electricity retailer, unless they choose an alternative provider, but billing and revenue collection is still provided by the network-retail utility.

[14] Only a few large customers are allowed to contract with power generators or retailers directly in California: the cap on load qualifying for 'direct access' was raised slightly, once in 2009 (SB 695), and again in 2018 (SB 237) to a total of 28,000 GWh, or ca. 15% of load qualifying (Doc-71-GTM). The

market design and the competitive market designs pictured above is that in California 'direct access' to wholesale power markets to buy from generators is not permitted for most electricity users, and only few authorised agencies may act as retailers buying power on behalf of energy users. In California, the only parties allowed to operate as energy procurement agencies in a given region are the investor-owned network-retail utility, and a retailer set up by a municipal Government ('community choice aggregator', CCA) permitted to operate within the bounds of their city[15]. In Massachusetts and ERCOT under contestable energy procurement, anyone who can demonstrate compliance with certain standards is permitted to enter and compete in the electricity retail market. Californian network operators always remained bundled with retailing functions and are therefore organised similarly as in Massachusetts.

The market designs represented only apply in the territories served by private investor-owned utilities because municipal utilities and rural cooperatives established before restructuring reforms were granted exemptions and most chose to remain vertically integrated monopolies (Int-A-7). Although they remain interconnected and exchange power, institutionally they operate as monopoly islands surrounded by territories served by restructured utilities.

remaining customers are served by network-retail utilities or municipal aggregators and don't have further choice.

[15] Although CCAs effectively compete with the investor-owned network-retail utilities in their city because customers can choose to opt out of receiving service from the CCA, California is still classed as having a monopoly retail framework for the purpose of this thesis. CCAs are effectively monopolies in their region, given that customers only have the choice to switch back to the network-retail utility, but market entry for independent retailers other than the CCA and direct access is not allowed for most customers.

4.2 Changing landscape, regime, and niche-developments

This section examines contextual factors which preceded restructuring and came together to enable the destabilising of the dominant discourse of a 'natural monopoly' in electricity generation and retailing. It summarises changes in diverse 'trajectories', such as in technology, ideas, science, practices, and public policy that accumulated to enable a debate about market reform to ensue. Figure 7 illustrates how a variety of changes at niche, regime, and landscape level came together to enable the large-scale institutional changes that restructured electricity markets.

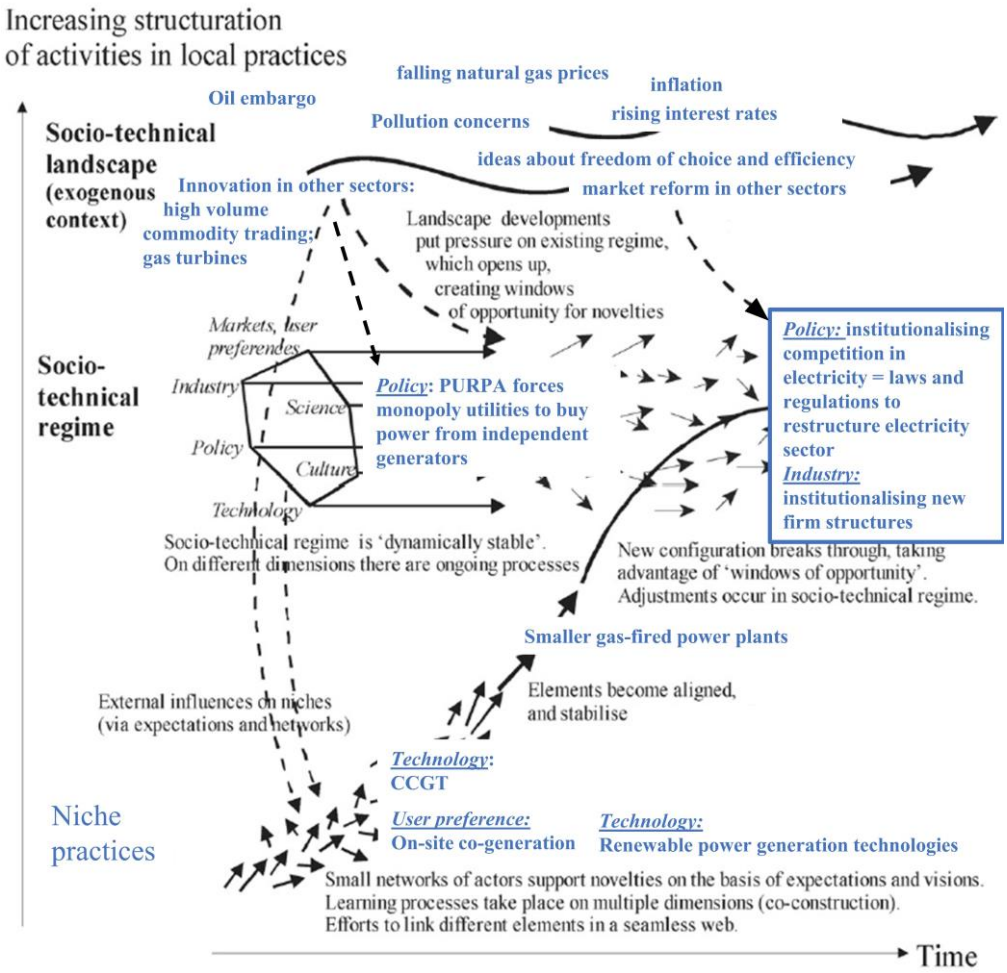


Figure 7: Niche, landscape, and regime factors that destabilised the vertically integrated 'natural monopoly' in electricity generation and retail. Adapted from Geels and Schot 2007; Geels 2002; adaptations in blue.

At the landscape-level, fuel shortages following the Oil Embargo on the US in 1974 led to PURPA, a far-reaching policy change that introduced first elements of competition. Environmental concerns about the effects of pollution from coal-fired power plants were also a driver of change. As outlined in Chapter 2, PURPA legislation forced US utilities to buy electricity from power plants they did not themselves own and operate at 'avoided cost'. Effectively, PURPA was the first step that introduced competition (Carley 2011) because it enabled independent entrants, including electricity users with on-site generation, to sell and transport their power using electricity networks on public land, owned and operated by the monopoly network operators. Transparent markets or auctions were not created yet, but because monopolies were forced to purchase the power through bilateral, long-term 'power purchase agreements' (PPAs), they no longer had a monopoly over power transported through their networks, so that power generation was now contestable on a wider scale. The 'avoided cost' at which monopoly utilities had to buy independent generators' power was often adjudicated by regulators (Patterson 1999). Where the calculation of the guaranteed tariff benchmarked against high oil prices of the time, it was generous (Int-A-8).

Technological change that originated outside of the electricity regime in other industrial sectors played a role in changing the views of which power plant size was regarded as economically viable (Int-A-8). Following innovation in gas turbine technology in the aircraft industry, a new type of power plant was widely adopted in the 1980s, the combined-cycle-gas-turbine plant (Markard and Truffer 2006). Once prohibitions to generate electricity from gas, considered a premium fuel during the oil crisis, were lifted (Patterson 1999 : 74), innovations in gas turbine technology could be applied in the electricity sector. By the 1980s, comparatively cheap gas prices meant that smaller-scale plants with lower capital requirements and shorter

construction times were possible and being rapidly constructed in many countries (ibid.), in the US also promoted by PURPA.

On-site generation as a niche-practice was also promoted by tariffs for independent power producers under PURPA. The policy led large energy users with the means to install co-generation plants to self-generate because they could sell their surplus at 'avoided cost' and buy shortfall from utilities at regulated prices. In states where power prices rose, for instance following upgrades to nuclear power plants, self-generation became more and more attractive, leading some to suggest a 'vicious cycle' (Patterson 1999) of rising costs that encouraged more self-generation. Where onsite-generation grew as a power-supply niche and smaller power plants in front of the meter were built, systems began to decentralise.

Further technological developments in computing technology in the 1980s offered the possibility to change the management of networked systems, including electricity. Computing innovation that enabled coordinating large scale commodity transactions permitted envisioning the sale of electricity in transparent wholesale markets (Isser 2015). Technology of this kind had already been applied in other sectors, for instance in natural gas (ibid.).

Together, these developments between 1974 and the late 1980s led to material changes at the regime-level in the early 1990s with profound impacts for how the institutions organising electricity procurement and other retailing functions would develop. In Massachusetts and California, electricity unit prices had been rising steeply. There were several drivers of rising electricity rates: monopoly utilities asked for regulators to approve rate increases so they could recover the costs of newly signed PPAs with independent generators at 'avoided cost' (Int-A-8). At the same time, change in the configuration of systems fundamentally altered the economics

underlying regulated electricity rates: the trend of continuously growing demand had reversed by the early 1990s. While demand for electricity had grown continuously in the US into the 1960s because of utilities' territories expanding to electrify regions, and because ever more services in homes, businesses, and factories were electrified as new appliances were adopted, demand growth halted in the 1970s and 80s. This meant that increasing costs of electricity systems were no longer 'masked' by increasing volume sales (Doc-1-CPUC). Another set of material factors creating pressures was the rise of interest rates and inflation (Joskow and Schmalensee 1983). These changes at the landscape-level again led to monopoly utilities asking regulators to raise electricity rates to recover increasing costs.

The changing economics of power were not the same in all states and electricity rates differed. States like Massachusetts and California had invested more heavily in nuclear power plants in the wake of the oil crisis than other states with lower-cost indigenous sources such as hydro or coal. The new nuclear plants proved to be very high-cost investments and additionally, older ones regularly required upgrades. These nuclear investments meant that utilities asked to recover hundreds of millions of dollars in single rate cases (Int-A-8). All of these 'legacy costs' incurred by the monopoly utilities on customers' behalf were averaged into electricity rates according to formulas devised by regulators. In the early 1990s, the confluence of new turbine technology and gas and oil prices falling below what had been previously forecast meant that gas-fired power procured through newly signed PPAs was cheaper than power stations the monopolies had invested in previously (ibid.). Therefore, the marginal cost of power sank below the average cost designed to recover previously committed investments. This difference between marginal and average cost was greater in states like Massachusetts and California than in Texas, and other US states.

Furthermore, new economic ideas and beliefs about the superiority of markets were imported to the electricity sector and triggered change (Int-A-5). After competition had been tried successfully in other previously monopolised sectors such as airlines and trucking, ideas about the primacy of 'free markets' were applied also to the electricity sector. A new discourse brought together economic ideas about competition as a more efficient mechanism to organise economic activity than central planning with philosophical ideas about 'freedom of choice'(Chang 2002). These ideas had been niche within the economics discipline previously, but were embraced by Margaret Thatcher in Britain (Helm 2004), Ronald Reagan in the US (Fourcade and Healy 2007), and many other policymakers around the world (Patterson 1999). The new intellectual climate also affected policymakers at US-state level:

> *"At the time of restructuring, it was very much, 'the market will do better than any central planner.' It was all of this crescendo of the free-market period that started under Reagan and filtered down to the states"* (Int-A-5).

These new ideas were key drivers of public policy changes that ensued and institutionally restructured the electricity systems in California, Massachusetts, and Texas.

4.3 Tracing disagreement: discourse coalitions and storylines

As the previous section outlined, in the early to mid-1990s, *"the ingredients for profound change came together"* (Kiesling and Kleit 2009 : 25) across the US and discourses about the need to reform the institutional structure of electricity systems began to gain traction. This section outlines the discourse coalitions in support of different approaches to organising electricity markets at the time. The disagreements analysed here concerned whether electricity retailing functions, specifically, energy

procurement, billing, and metering, should be opened to competition[16] and unbundled from network operation, or not. The sub-section first summarises the actors involved in the debate and the discourse coalitions they formed. Then, three opposing sets of ideas and associated 'problem-solution-framings' are outlined in detail.

4.3.1 Summary of main actors and competing discourse coalitions

Many of the actors involved in the debate about whether electricity retailing should be made contestable and how the sector should be restructured had been part of the electricity regulatory community for some time. Interviews and archival material revealed the actors who participated actively in the debates in the three jurisdictions:

- State-level utility regulators in charge of supervising monopolies and authorising their investments and revenues,
- Legislators at the state-level
- IOUs: Monopoly investor-owned electricity utility industry (representing management and shareholders)
- IOU labour representatives
- Residential and small business ('small') electricity consumer groups
- large energy users (e.g., industrial and commercial facilities, universities)
- environmental advocacy groups
- economists and legal professionals, publishing in journals and books, and sometimes hired by stakeholders to provide evidence and expert analysis to regulators
- city and municipal Government representatives, including those running municipal energy companies

[16] In the US, also referred to as 'retail wheeling' and 'direct access'; these terms will be used interchangeably.

With PURPA and technological changes outlined above, a new range of stakeholders had more recently become interested in electricity policy debates:

- Independent power producers
- On-site generation industry, specifically in co-generation
- Prospective energy service providers interested in selling commodity electricity
- Commodity traders looking to enter the electricity sector, including financial intermediaries (Joskow and Noll 1999)

Some independent power producers with novel power plant technologies, self-generating large customers, and the cogeneration industry facilitating on-site generation occupied niches within the system. Prospective retailers and electricity traders, prominently the Enron corporation, challenged electricity systems coming from other regimes (conceptualised as the landscape (Avelino and Rotmans 2011)). They were already trading commodities in other sectors and were looking to electricity as a new market. Several companies saw opportunities in applying novel computing and analytical capabilities to the sector.

The stakeholders publicly disagreed about whether retail competition and unbundling should be implemented and thereby formed discourse coalitions arguing for different policy outcomes. Table 2 summarises problem-solution framings and the discourse coalitions in favour of policy change in the three jurisdictions in the 1990s. Table 3 summarises those supporting institutional continuity. The following sections explain in detail the storylines and discourse coalitions. Several conflicts emerged from the data: firstly, discourse coalitions disagreed about the best way to minimise the cost of running an electricity system and what would be 'efficient'; secondly, they disagreed on how innovation and value propositions desired by customers could be best achieved; and thirdly, there were different perceptions of how competition or centralised coordination respectively would affect 'public interest' goals.

Storylines	**Problem framing**	**Solution suggested**	**Main Promoters**
In support of electricity retail competition			
Competition lowers ***cost***	Demand-side: Non-cost reflective pricing leads to inefficient consumption. Supply-side: Monopoly firms and investors do not face risk, and hence make bad decisions. The monopoly regulatory process to set prices and revenues is cumbersome and inefficient.	Competition produces the 'right signals'; corrects incentives on the demand and supply side	Economists Prospective retailers and energy traders Co-generation industry Large energy users with multiple sites and energy trading capability
Competition enables (more) ***innovation***	Customers' "tastes, resource availabilities, and technological possibilities change incessantly" (Kirzner 1997). Monopolies and regulators can't or don't want to establish customers' preferred products and terms of service; can't exhaust all the available opportunities.	Competition as discovery process	Economists Prospective retailers and energy traders Co-generation industry Large energy users demanding access to more detailed energy consumption data
Individual ***choice*** is a right, or a duty	Collective choice limits people's freedom. Cross-subsidies are unjust.	Allow customers to shop in a market	Politicians
In support of unbundling retailing from distribution networks			
Under competition, customers must make a ***choice*** only between competing retailers	Regulated franchise utilities participating in electricity retailing will distort competition and prevent competitive entry (the 'Bell doctrine')	Distribution franchise should divest retail business; Customers assigned to a newly created competing company and encouraged to switch	Economists and experts in Britain, only few expert witnesses in US Some prospective retailers

Table 2: Storylines promoting institutional change in electricity retail in the US in the 1990s

Storylines	Problem framing	Solution suggested	Main Promoters
In favour of centralised coordination			
Costs of competition will outweigh benefits	Economies of scale Inelasticity of demand; transaction costs; market signals are difficult to establish	Improve demand-side incentives through cost-reflective pricing under monopoly Improve signals for the monopoly through 'incentive regulation' Introduce competition to generation/ wholesale markets	Economists Environmental advocates
The ***public interest*** will be jeopardised under competition	Market failure; costs of environmental degradation and loss of load not internalised Consumers, and retailers do not invest enough in renewable energy and conservation… … and generation capacity. Security of supply will be in danger when coordination is decentralised. Markets create differences in price, access, and service quality through 'cherry-picking', which is unjust.	Centrally procure power to ensure resources in the public interest; Use electric utility regulation to redistribute in the desired way Allow municipal aggregators to purchase power for small users; to improve service and prices	Environmental advocates Monopoly utility employee representatives Small consumer representatives
In support of allowing distribution network operators a role in retailing, if competition is introduced			
Costs of disaggregating networks from retail will outweigh benefits	Economies of scope; costs of suboptimal outcomes following fragmentation if signals externalise costs Electricity is an essential service so relying on 'unregulated' competing entities to provide default supply is risky	Assign provision of last resort in energy procurement and billing to the established monopoly distribution network operators	Monopoly IOUs Some US utility economists
In competitive markets, companies should ***choose*** their business activities and firm organisation	Regulatory intervention distorts competitive markets	Allow competition without divestment of generation and retailing functions and assets	Monopoly IOUs

Table 3: Storylines promoting institutional continuity in the US in the 1990s

4.3.2 Debating the costs of the system

One key point of contestation within reform debates was about how the institutional structure and regulatory model would affect electricity system cost. Advocates of both competition and monopoly electricity retailing argued that their preferred model would perform better in terms of overall cost to consumers or the public than the alternative, drawing attention to different problems and solutions. Proponents of retail competition stressed the importance of accurate information conveyed transparently in markets, coordinating buyers and sellers (see e.g., Goulding et al. 1999 : 62). Supporters of monopoly organisation highlighted transaction costs, economies of scale and scope, and cost of capital (see e.g., Hunt and Shuttleworth 1996). The following section outlines each storyline and associated discourse coalition in turn.

4.3.2.1 Retail competition will deliver cost savings

Ideas about the merits of competition and 'deregulating' industries by allowing entrepreneurs to compete with regulated-franchise companies gained traction in the US since the late 1960s and were first institutionalised in the 1970s and 1980s with reforms to the airlines, trucking, and telecommunication industries. Ideas about the advantages of competition were then also applied to the electricity sector to suggest contestable electricity retailing would bring benefits (Hogan 1994). Some other leading utility economists in the US advising policymakers, like Kahn, Joskow and Schmalensee, were sceptical about the ease with which learnings from other sectors could be applied to the networked electricity system (Joskow and Schmalensee 1983). Economists in the UK also played an important role within the debate because the UK was one of the pioneers of electricity sector reform, from where regulators in

California took inspiration (Int-A-8). California in turn was the US pioneer and its retail reform efforts were followed closely by other states.

Overall, the storyline in support of competition promoted by economists suggested that competition would lead to welfare gains. As later summarised by Kiesling and Kleit in lauding the Texas market design:

> *"Given the diversity of buyers and sellers in the [electricity] industry with diffuse private knowledge about their own preferences and/or costs, decentralized coordination in the open market was the approach most likely to maximize (…) gains from trade, or welfare creation, that accrued to all parties to this exchange"* (Kiesling and Kleit 2009).

One of the key problems with the monopoly retail structure economists identified was policymakers' tendency to set electricity tariffs not reflective of *"marginal costs as they would be reflected in competitive markets"* (Doc-8-Kahn: 5826). Tariffs diverging from the marginal cost of supplying an additional unit were argued caused inefficient allocation of capital by sending the 'wrong' price signals to consumers (ibid., see also Joskow and Schmalensee 1983). Advocates believed that retail competition would move prices and signals toward cost-reflectivity[17], where policymakers setting tariffs administratively had chosen not to reflect variance across dimensions such as time, geography, customer demand levels, and payment method, or customer class. Littlechild claimed,

> *"the social value of electricity retailing [is] establish[ing] the prices that are the best that suppliers can offer at any time, and it identifies how these prices differ by product attribute, such as time of day and duration into the future"* (Littlechild 2002 : 4–5).

[17] Generally, utility-service charges to users can be based on the cost to serve, average costs, willingness to pay, or ability to pay (Lazar 2016). In reality, they are based on a mix of these principles, both under competition when competing retailers design offers to maximise profits, or under a regulated franchise where administrators and regulators design tariffs.

Hogan suggested that retail competition would improve signals for energy efficiency investment because *"with a move to marginal-cost pricing that should be inherent in a more competitive electricity market (...) the important market failure created by average cost pricing will be eliminated and incentives recast"* (Hogan 1994 : 32). Those who predicted that retail competition and cost-reflective pricing would lead to welfare gains assumed that many customers would be interested in cost-reflective tariffs, and would be able to shift or reduce their demand in response (Joskow 2000 : 7–8).

Secondly, economists and other advocates of competition in retail argued that choices were also inefficient on the supply-side because policymakers, regulators, and monopoly utilities did not have incentives to make prudent decisions and reduce costs.

> *"Utilities and regulators, who do not have to test their judgements in the market, are typically not well placed to judge the costs and risks of long-term contracts. They can nevertheless force customers to enter such contracts and to bear the resulting costs and risks"* (Littlechild 2002 : 11).

Critics of centralised energy procurement identified both the *inability* and *unwillingness* of administrators to perform as well as decentralised players under competition were expected to. In 1993, California's regulator wrote,

> *"the state relies on an administrative process which (…) attempts to predict the most cost-effective addition to the utility system, even though […], 'The main thing we know about [forecasts] is they are all wrong…'"* (Doc-1-CPUC : 144).

Based on the assumption that administrative decision-making had to be inferior because of limited information, competition was heralded as the better model for electricity system planning. Both in Europe and the US, proponents of retail competition believed that

> *"the individual need only know their own preferences, the price and the goods on offer for sale; whereas the state planner had to*

> *know all the consumers' preferences and the production costs"*
> (Helm 2004 : 261).

This, the critics of central planning argued, meant that administrative electricity system planners overseeing monopoly energy procurement were unable to allocate capital as efficiently as decentralised market players under competition. This storyline was supported by the fact that oil and gas prices were falling in the early 1990s, so that plants previously invested in looked comparatively expensive.

Furthermore, economists criticised that some policymakers were unwilling to promote the least-cost options. For instance, *"excessive intrusion of political considerations [such as the] promotion of nuclear power for defence-related reasons"* caused *"long term misallocation of capital"* in capacity choices (Goulding et al. 1999 : 65). Monopolies were also argued to have incentives to expand their asset base because this would increase their profits (Averch and Johnson 1962), especially if investor-owned. Having identified all of these problems with centralised electricity capacity planning and procurement, the discourse coalition in favour of retail competition identified a solution: to relieve customers of risks by enabling them to choose among competing retailers (or generators) who would have to put their own investments at risk. Bearing the risk, this storyline suggested, would incentivise investors to make better decisions under uncertainty (Hogan 1994).

Some believed that allowing energy users, competing retailers, and generators to decide about where to invest would also address a third problem: the presumed inefficiency of the administrative regulatory process itself. The regulatory system adjusting rates regularly in 'rate cases' adjudicated by the regulator was under pressure especially from the rapid rise of interest rates and inflation because there was concern that the process was too slow in responding to the changes in cost base (Doc-1-CPUC). In California, the proposals on how to address this problem ranged from

incremental changes in the rate setting process, all the way to full electricity retail competition with entirely unregulated electricity rates (ibid.).

Some economists proposed that in addition to allowing competition, network functions that would remain regulated as monopolies should be 'unbundled' from contestable activities. Downstream unbundling, that is separating electricity retailing from distribution functions did not gain as much traction among utility economists in the US as it did in Britain. In the US, the policy to split regulated (network) monopoly firms from competing affiliates had become known as the 'Bell doctrine' after a high-profile case of unbundling in telecommunications (Joskow and Noll 1999). Proponents believed unbundling would lead to more competitive markets because monopoly network companies would be less able to distort markets and create barriers to entry in retailing and generation (Bergman et al. 1999 : 65). Littlechild (2000) supported unbundling downstream: the better information available after introducing competition *"stems, inter alia, from the performance of retail suppliers and distribution businesses trading as separate entities [and] from observation of the costs of new entrants into retailing and into other unbundled activities (…)"*. Leading US economists had proposed that policymakers should consider potentially unbundling transmission and distribution networks from *generation* (Doc-8-Kahn), but only few expert witnesses consulted by regulators in the US promoted the storyline that unbundling of *retail* and networks was necessary (e.g., Doc-16-MRW).

The disagreement about unbundling of networks from retailing was related to different proposals on how 'default service' should be organised, in other words, how customers not actively choosing a retailer should buy electricity. This was a point of contention between economists internationally. When electricity retail competition was first debated after California's regulator had proposed the reform, US economists recommended that the incumbent regulated-franchise companies should provide

default electricity service (Hogan 1994 following Ruff). This proposal meant that network operators would not be unbundled from retailing, allowing *"competition for the commodity electricity without disrupting the rest of the regulatory structure"* (Hogan 1994 : 40). Other US economists later supported this model and foresaw the default offer as passing through wholesale-spot-market prices at cost. A default offer frequently fluctuating in price they expected would encourage customers to seek fixed-price offers (hedging services) with competitive retailers (Joskow 2000). The British model by contrast foresaw default service provided by a newly created competitive entity, emerging from the divestiture of customers and operations from the monopoly network companies (Littlechild 2000). This proposal entailed the phasing out of price regulation, once a suitable number of new retailers had entered the market to compete, or a sizable number of customers had switched (ibid.).

There were different assumptions about whether benefits of retail competition could accrue across the board or only to larger energy users. These were related to varying proposals for default service design. For instance, Joskow (2000) argued that residential and small business customers would have fewer financial advantages from choosing a competitive retailer's offer than industrial and large commercial energy users. Firstly, he maintained that retailers would incur high costs for advertisement and settlement (accounting procedures to reconcile electricity contracted for with actual consumption) which they would have to pass on to customers. Secondly, he believed residential energy users would be hardly able to respond to price signals. This idea assumed that advanced metering infrastructure was prohibitively costly for small users, and that the elasticity of residential electricity demand would be low, presuming electricity was an essential, non-replaceable good for households. Therefore, he proposed many customers would not benefit from competition and were

better served by a regulated-franchise providing default electricity service at cost. Littlechild thought that Joskow

> *"underestimate[d] the role of retail competition in price formation, in establishing the most efficient suppliers, in discovering the most preferred products and terms of supply, and in strengthening wholesale competition"*(Littlechild 2000 : 2).

These assumed advantages led to the expectation that electricity retail competition would bring benefits across the system which required strong, undistorted competition across all customer segments.

In all three states, firms interested in trading and retailing power were very vocal promoters of the storyline that competition in energy procurement would bring economic benefits. Some had experience in the restructured natural gas industry (Chick 2007) and in trading energy commodities like oil. Enron, an energy trading firm that had evolved from a Texas natural gas company, lobbied policymakers across the US to open retail markets to competition. *"They were everywhere"*, Joskow (Doc-15-NYT) later recalled. Famously, *"Jeff Skilling [of Enron] (…) gave this speech to the PUC about how California was losing millions of dollars every day that they delayed restructuring"* (Int-A-5). *"You can triple the number of police officers in Los Angeles, San Francisco, Oakland and San Diego,"* Skilling told policymakers. *"The stakes are huge and every minute that we delay bringing competitive markets to California allows the meter to keep ticking"* (Doc-15-Skilling).

The storyline that restructuring would bring such great cost savings was constructed by excluding a key dimension, namely the costs of assets considered stranded. The cost difference between previously committed PPAs and new contracts meant that older assets were considered stranded (Doc-7-Kahn), as monopoly utilities could not be sure they would be able to recover these investments, given customers would be free to contract for cheaper power with independent generators. To honour these

previous commitments, the 'stranded costs' would have to, in the process of institutional reform, be borne by someone, either monopoly utility shareholders, the state, or energy consumers. Enron's narrative that retail reform would save 8.9 billion dollars for California (Doc-15-NYT) did not include an explanation of who should absorb the 'stranded costs'. Many stakeholders believed politicians would have to force customers to bear at least some of these stranded costs through 'transition charges' to allow monopoly-utility-investors to recover their investments[18]. This was demonstrated in California early on, when Assembly committee chairman Sher asked a representative of *Californians for Competitive Electricity*: *"did you entertain the possibility that the transition costs may be so high that there will be no benefits to large or small customers?"* (Doc-2-Share). The witness addressed preferred to evade this issue, stating, *"we have an inherent belief that competition will improve the efficiency of the system"* (Doc-2-Sheeren). This storyline was promoted all over the US by commodity trading firms who saw a lucrative commercial opportunity in the opening of electricity retail markets to competition.

Large energy users in the three states also advocated the storyline of efficiency gains from retail competition. This interest group had two main reasons to lobby for the right to 'directly access' wholesale electricity market and networks, to buy from generators and retailers independently from monopoly utilities. Firstly, they found the tariffs regulators designed for different classes (types) of customers disadvantaged them (Doc-2-CLECA). While some industrial energy users in territories served by municipal utilities were given preferential treatment in rate design to promote economic growth (Lazar 2016), large energy users in IOU-territory felt they were paying more than it cost monopolies to serve them, so that they were effectively cross-

[18] This was a key difference to restructuring outcomes for instance in the UK, where in the process of privatisation, the state, and thus essentially taxpayers, bore 'transition costs'.

subsidising residential and low-income customers. Those large energy users for whom electricity was a substantial expense had for some time been lobbying for pricing they argued more adequately reflected their cost to serve. Through the introduction of competition in electricity retail, they saw opportunities to lower their energy cost in directly contracting with generators, and they hoped they would no longer be forced to cross-subsidise residential energy users' costs to serve[19] (Int-A-8); (see also Borenstein and Bushnell 2015; Kiesling and Kleit 2009).

Secondly, with advancements in small scale generation, several large commercial and industrial customers had installed distributed generation using combined heat and power technology. Players with multiple sites, sometimes spanning utility territories, like supermarket chains and the University of California, saw electricity retail competition as an opportunity to improve the profitability of their niche: they demanded permission to use the IOU's transmission and distribution networks to 'wheel' their power, so they could use surplus power generated on one site at another location (Int-A-4). In an alliance with their customers, the co-generation industry also promoted electricity retail competition (Doc-5-Dzykewicz). Other independent power producers operating power plants at grid-scale were focused on lobbying for competition in wholesale energy markets and for forcing monopolies to divest generation plants, but mostly did not take a position on retail restructuring (Int-A-8).

Players within the discourse coalition in favour of retail competition commonly framed electricity rates as a problem for economic development and monopolies as taking advantage of their position. For instance, the California Large Energy

[19] The fact that industrial consumers were being charged more than the cost to serve them did not necessarily mean they were paying more per unit: In 1983, industrial consumers in the US were paying lower prices per kWh than residential and small commercial customers (Joskow and Schmalensee 1983 : 20).

Consumers Association (CLECA) argued that industrial competitors in neighbouring states, *"face electric rates (…) that are roughly half (…) of those in California"* (Doc-1-CLECA). They contended that these high costs were seriously endangering economic competitiveness, jobs, and growth. In Massachusetts too, a manufacturer demanded, *"any electric industry restructuring should provide for self-service wheeling"* (Doc-4-IPC : 4). They blamed the monopoly utilities, calling on policymakers to *"ensure that utilities cannot exercise their monopoly retail electric franchises in a manner that arbitrarily and unfairly drives up the cost of doing business in Massachusetts"* (Doc-4-IPC : 7). Large energy users were using such narratives to suggest that competition would enable customers to protect themselves from monopolies taking advantage of a captive customer base.

The analysis of competition in electricity retail reveals different discourse coalitions than when analysing the debate on electricity market restructuring more widely. Some proponents of substantially restructuring the electricity industry upstream were at the same time opposing retail competition downstream. A US-based environmental advocacy group argued that the expensive *"big mistakes"* in nuclear power investment, could in future be avoided if monopoly utilities were forced to divest generation assets (Doc-2-Sheingold-Ralph). The regulated-franchise utilities would then be required to procure power from competing independent generators in tenders or transparent wholesale markets. Centralised planning would be preserved, but the *"portfolio management by the utilities [should have] more diversity in procurement"* (ibid.). The solution suggested by this constituency was to promote resources considered lower-cost on the demand-side (Int-A-7) and renewable generation (Int-A-6) at the expense of large, capital-intensive conventional fossil and nuclear power plants.

Similarly, there were economists sympathetic to upstream competition, but critical of retail competition. They argued that monopoly utilities could be incentivised to search for means of lowering costs and capturing benefits of technological innovation without introducing electricity retail competition (Hunt and Shuttleworth 1996 : 34). Instead, they proposed mechanisms of 'incentive regulation' that they anticipated would assign more risks to the monopolies, by tying profits to performance rather than cost, limiting the pass-through of cost-increases, and thereby improving efficiency in the short and long-term (ibid.).

Some proponents of retail competition however objected that retail competition was important to ensure functioning wholesale competition (Int-A-7). For instance, the economists Goulding et al. (1999) argued it was imperative to allow customers choice of retailers because in the absence of downstream competition, upstream market power would douse all the benefits of restructuring along the supply chain. They argued that if competition at the retail level was not extended to all customer classes and did not become vibrant, over time *"adverse effects will trickle upward, limiting the efficiency of still nascent wholesale markets and affecting large commercial and industrial customers as well"* (Goulding et al. 1999 : 73). This was based on analyses of integration in manufactured product supply chains that suggested vertical restraints to competition could be privately beneficial, but were not necessarily at the aggregate level welfare-maximising (ibid., citing Tirole and Rey 1986). Additionally, Joskow (2000) believed that competition in retail would lead retailers to invest in increasing their customers' demand elasticity, so that demand response could limit generators' opportunity for market power.

4.3.2.2 The costs of retail competition and unbundling may outweigh the benefits

On the side opposing competition in electricity retail and unbundling of networks, a discourse coalition also promoted storylines related to cost. Critics of electricity retail competition on economic grounds argued that it would not lead to welfare gains because the costs were likely to outweigh the benefits. Key worries articulated at the time concerned the cost of capital, the potential loss of economies of scale and coordination between disaggregated units, and the transaction costs of setting up markets and infrastructure to make competition work as intended.

One reason to oppose contestable energy procurement was the fear that retail competition, by increasing risks for investors, would raise prices for end-users through driving up the cost of capital for power generation investment. This storyline was promoted for instance by environmental advocates. The Conservation Law Foundation, an environmental advocacy group promoting especially energy efficiency, argued in California, *"retail-wheeling could substantially increase electricity cost on the generation side by increasing the cost of capital to build generation, as recovery becomes less certain"* (Doc-2-Cohen). They claimed that competition at the wholesale level between independent generators from whom monopolies would procure power in a central planning process would be sufficient to reduce costs: *"It simply doesn't stand to reason that customers can obtain new capacity any less expensively than utilities currently are through the market auction processes that they are running"* (Doc-2-Cohen). Proponents of competition generally did not deny that cost of capital would rise once investors faced higher risks, but they implicitly or explicitly assumed that efficiency gains from competition would outweigh these higher costs of capital.

Another storyline promoted by economists indicated that the transaction costs of creating and maintaining functioning markets and contracts between unbundled companies would be high in the electricity sector (Joskow and Schmalensee 1983). Organisational or 'institutional' economics (Coase 1937; Williamson 1979) had shown that in some cases, depending on the characteristics of transactions, costs of several firms transacting vertically may be higher than coordination managed hierarchically within one firm. Several prominent US utility economists cautioned that reforms, especially unbundling companies, could lead to inefficiencies (ibid; Doc-8-Kahn). Some of these economists were hired to testify as witnesses on behalf of the incumbents.

Moreover, some economists cautioned that unbundling could lead to externalised costs and related inefficiencies. In a report for submission to utility regulators across the US, funded by the investor-owned utilities' industry association, Kahn et al., in reference to unbundling of generation from networks, explained:

> *"in a de-integrated environment one must place prices on all of these services and find some way to internalize externalities and cost complementarities. (…) If we are unable to do so, it is possible that the efficiency benefits (…) could be more than entirely offset by the deteriorated coordination"* (Doc-8-Kahn : 29).

This storyline argued that the new institutional arrangements that would use prices and contracts to coordinate separated steps of the electricity supply chain would not necessarily work as intended[20]. This assumed that within hierarchically coordinated, vertically integrated firms, the coordination was working efficiently.

[20] These ideas were only recently articulated with reference to the unbundling of distribution, electricity retail, and the demand-side (Brunekreeft 2015). Brunekreeft argues that the *"sound market design and effective market mechanisms"* necessary to facilitate transactions between actors are *"challenging"* to establish (Brunekreeft, 2015, p. 13). Therefore, when one party incurs *"costs that create benefits for another party, but which cannot be fully recouped"* (2015, p. 12), overall system costs may be increased if *"incentives are misaligned"*.

Although they also argued that competition could improve performance because cost-reflective pricing would improve efficiency of the system, several economists cautioned that retail restructuring would be costly because of the need to create and manage the new institutional arrangements (ibid.). Institutions would be required to standardise procedures, create trading, settlement, and network access arrangements, and manage litigation (see also Hunt and Shuttleworth 1996). Moreover, some economists predicted that these institutions required to make competition work could create barriers to entry, which in turn would hinder competition from developing to the extent expected by proponents (ibid.).

The vertically integrated investor-owned utilities in the three states strongly promoted the storyline that unbundling would increase transaction costs, to lobby fervently against reforms to break up their companies (WMECO, 1996). They emphasised the economies of scale and scope they were able to achieve as large, vertically integrated firms. Most incumbents did not oppose the entry of competitors in procurement and generation. Some were actively voicing support: California's largest IOU alleged,

> *"at Pacific Gas and Electric Company we believe that competition in electric supply is desirable and inevitable. (…) [T]he development of future electric generation will rest more in the hands of independent entrepreneurs, and less in the hands of vertically integrated, regulated monopolies"* (Glynn 1994 : 52–53).

But competition should not be combined with unbundling, so that they could compete without having to restructure their companies.

Part of IOUs' discourse to oppose unbundling was a storyline about forced divestment as logically incompatible with competition. They claimed that competition demanded laissez-faire principles of non-intervention, so forcing the regulated-franchise utilities to divest operations and assets was wrong: for competition to work, regulation should not interfere in the decisions of firms on how to organise. As one Massachusetts IOU

reasoned, *"in competitive markets, firms must decide which of various different related products and services they will offer"*, and regulators should not try to *"determine the appropriate amount of vertical integration via regulation"* (Doc-9-WMECO : 10-11). This storyline interestingly adopted competition as a solution but argued for an entirely structurally unregulated market. Arguably this framing completely abandoned ideas of 'natural monopoly' that had led to utilities' right to an exclusive franchise in the first place. It denied that former monopolies as large, established firms in control of networks might have a preferential position over new entrant competitors that would adversely distort competition.

Their storyline also relied on framing themselves as companies with long-established expertise, to argue for keeping the obligation to serve as regional default providers and provide billing and metering (Int-A-7). Emerging energy retailers demanded the opportunity to send their own bills and to access customers' data in disaggregated formats. But the incumbent regulated-franchise utilities claimed that contestable billing would be *"very expensive"* and add *"a huge amount of money to the rates"* (Int-A-12).

The role of the default energy provider, billing, and control of the meters were important to the monopoly utilities for several reasons. Firstly, they wanted to hold on to the *"relationship with the customer, and they saw the metering and billing as the portal for that"* (Int-A-7). Moreover, keeping billing and metering was arguably beneficial for cost-of-service-regulated utilities' earnings because investment in the associated infrastructure would increase the asset-base, and thereby the returns. Finally, any function a regulated-franchise provided would require manpower, even if energy procurement for default customers would not generate profits for the companies (Int-A-10). *"Even if they were going to provide default service at cost, they didn't want to lose the staff and management functions".* Therefore, the investor-

owned incumbent utilities in the US fought against losing customer-facing functions where possible: *"Sure, they would have to give up on big customers, but they were really going to fight for the small ones"* (ibid.).

One reason US incumbent monopolies supported competition reforms was that at a holding company level, their commercial interests were mixed. Many regulated-franchise IOUs were affiliated with competing companies in independent power production and energy services. These had been set up in other states since the 1980s as ways to expand business to other territories (Int-A-10) and to *"circumvent regulations that set upper limits on their profit margins in monopoly activities"* (Doc-77-Mullen). Reforms to introduce competition in generation and retail would hurt the regulated franchise-side of the business, but at the same time help their affiliates gain business in other states. If shareholders and corporation managers expected competitive affiliates' profits to be more important to the corporation's earnings than the regulated monopoly business, they could view competition in generation and retail positively (Doc-1-CPUC).

Another reason for the utilities to support electricity retail competition was articulated by the CEO of SCE, one of California's big three IOUs in 1994. After Californian regulators had introduced regulatory reforms to improve the performance of the regulated monopolies, the utilities felt regulators were intervening onerously. Therefore, Bryson welcomed the CPUC's new proposal to introduce electricity retail competition, looking forward to the end of *"regulatory micromanagement"*. He was happy and *"willing to face competition for customers in exchange for the Commission and its staff getting off his back"* (John Bryson cited in Myers 1997 : 461). Overall, the opportunities from competition seemed greater to IOUs than the risks, as long as they would not be forced to divest operations and assets, and bear economic losses following reforms.

4.3.3 Innovation as entrepreneurial discovery or managed process of consultation

Another line of disagreement was about how improvements in electricity retailing service and offers desired by customers could be achieved. On one side, the discourse coalition in favour argued that competition would deliver innovation which regulated monopolies would not. On the other, critics of retail competition maintained that the opportunities for innovation were limited, or that offers customers demanded could be just as well or better accommodated by monopoly utilities, if regulatory mechanisms were reformed.

Advocates of retail competition claimed that under a retailing monopoly, utilities were not providing what customers preferred. This storyline was promoted prominently by large energy users and prospective retailers. An Enron representative argued that *"new services have been slow in coming from the traditional franchised electric utilities, and that productivity growth and innovation could be significantly enhanced through competition"* (Doc-10-Fernando). Some policymakers agreed: at the time, *"there was a feeling that when you looked at the deregulation of telecommunications and natural gas that a lot of innovation had come in. You don't expect [monopoly] utilities to be particularly innovative"* (Int-A-9).

The problems identified with respect to innovation were that monopolies and their regulators were either incapable or unwilling to meet customers' changing demands. The problem framing that under monopoly, preferences cannot be met was linked to an underlying assumption among some economists that consumer preferences were either unknown or too diverse to be articulated within a regulatory procedure. Hogan (1994) believed that because energy users vary in their willingness to accept volatility in price and service reliability ('firmness'), the infinite number of different

preferences could be better accommodated by competition. He framed variety as an intrinsic good and argued that a regulated monopoly and its regulator could never offer the range of options decentralised competing players would (ibid.). Economists of the 'Austrian' school such as Littlechild in the UK were also prominent in promoting the storyline that competition would lead to innovation (Defeuilley 2009a). Taking inspiration from Hayek (1978) and Kirzner (1997), Littlechild argued that electricity retail competition would bring benefits *"in creating and discovering new and more attractive terms on which electricity can be sold"* (Littlechild 2000 : 13). Following the Hayekian notion of competition as a 'discovery procedure', the underlying assumption was that competition generates *"such facts as, without resort to it, would not be known to anyone"* (Hayek 1978 : 179). This storyline implied that articulating desires in a regulatory or political process of negotiation between stakeholders, utilities, and regulators is impossible because consumers are *not aware* of their (future) desires in the absence of competition. As Kirzner (1997) later articulated, only the creativity of profit-driven entrepreneurs under competition can reveal these hidden preferences, so as to ultimately deliver the wide range of options customers value, and *"all the available opportunities for social economic gain"* (Kirzner 1997 : 78).

In some cases, critics of the regulated monopoly argued that utilities were unwilling to accommodate customers' desires. Some industrial and large commercial energy users at the time had clearly articulated demands for more accurate, granular consumption data and complained that monopoly utilities were actively resisting this (Int-A-11). They found the billing services provided by monopolies did not deliver the information necessary to adequately manage their demand. Scepticism about regulators' and monopolies' incentives to accommodate what customers demanded was in some instances justified with reference to public choice theory about

governments and bureaucrats being inherently self-interested or captured (see e.g., Littlechild 2002 : 16; Niskanen 1975).

Proponents of competition promised a wide range of innovations (Hogan 1994), including in electricity procurement through novel hedging and insurance options, new tariffs changing the relationship between fixed and variable costs, and new billing options. Prospective retailers promised even more innovation: 'value-added services' beyond commodity electricity, including renewable energy and energy efficiency investment, would be driven by retailers' desire to differentiate themselves in the marketplace (Doc-2-Sheingold-Barry).

Prospective retailers in all three jurisdictions used the innovation storyline to argue for extensive institutional change. Enron demanded full competition in all customer-facing functions and unbundling: *"all services should be separated from distribution and delivered by the competing retailers"* (Doc-10-Enron). The coalition created a narrative on the benefits of 'pure' market design, where incremental reforms would not suffice to realise all the possible benefits. In Massachusetts, one retailer claimed that competitive provision of metering was

> *"important for developing a lively energy service market. (…) [Retailers] providing comprehensive services for a customer will need to provide metering integrated with the energy management systems and the power acquisition systems in order to minimize the customer's costs"* (Doc-12-Arny).

Contestable billing, the prospective retailers argued, was essential because they would use the data to come up with new service ideas (Int-A-9). Some large energy users also called for contestable billing, hoping that competing providers would enable more detailed access to electricity consumption data which they could use to better manage their demand (Int-A-12). Prospective retailers in the US wanted access to the billing function because they believed it was key to establishing a brand. *"To send*

our own bill" was *"the only way we were going to get brand recognition"* (Int-A-12). They called to ban vertically integrated regulated-franchise utilities from delivering customer-facing functions because they wanted to exclusively control the commodity electricity customer relationship.

On the other side, economists sceptical of retail competition disagreed that innovation was possible only under contestable retailing: *"if you can do it under monopoly, it isn't a benefit of competition",* (Shuttleworth cited in Littlechild 2002 : 16). This storyline assumed that new options could be just as well provided within a monopoly regulatory process, if customers communicated their desires, and monopolies' and regulators' incentives were aligned accordingly. Hunt and Shuttleworth believed that performance-based regulation could be used to improve the range of services and products provided by a retail monopoly (Hunt and Shuttleworth 1996). This was also based on an implicit assumption that regulatory capture by companies could be avoided or at least controlled.

4.3.4 Markets and the 'public interest', or the right to individual choice

Another disagreement between critics of retail competition and those in favour of it was about whether collective, public policy aims would suffer or not, once the state, government, and its regulator no longer decided which resources should be procured through the centralised planning process. Related were concerns about how costs of public-interest investments would be recovered once customers were no longer captive. The discourse coalition critical of retail competition promoted the storyline that outcomes in the 'public interest' would be threatened under decentralised decision-making by private agents. Critics believed competing retailers and large

customers buying directly from generators would not pay regard to public 'goods' related to environmental protection, energy security, adequate capacity margins, or 'fairness' in the treatment of different customers or stakeholders. Regulators in Massachusetts, California, and Texas so far had been expected to consider these public-interest concerns in decision-making on electricity investment and rate design.

There were different sets of ideas and problem-solution framings that together formed a storyline on how electricity retail competition could threaten 'public-interest' goals. Firstly, environmental advocates and economists concerned about adequate capacity margins commonly chose a problem-framing through the lens of economic theory emphasising 'market failures' (based on Samuelson 1954). The idea was that electricity retail markets would fail to 'internalise' all the costs of actors' economic activities, imposing for example costs of environmental damage on the public. Similarly, non-rivalrous and non-excludable 'public goods' such as insurance against supply shortages would be under-consumed. This 'market failure' lens implied that individual market actors' behaviour in these cases would not, as general equilibrium theory otherwise suggested, lead to the greatest welfare gain.

Secondly, stakeholders concerned about 'fairness' and principles of solidarity or equality of access, service, and treatment between customers relied on the construction of a category of specific services with 'essential' or public nature. They argued that some services and products are especially significant and therefore justify centralised coordination, or in some cases state provision, for example by local government (Doc-13). Constructing a category of 'essential service' offered a positive justification for intervention or central control of utility services as opposed to the negative one common in conventional economic theory through the concept of 'market failure' (Prosser 2005). On this basis, critics of retail competition demanded that electricity should not be commoditised like other products and services (Doc-2).

A concerned legislator in California identified the commoditisation of electricity as a problem, because *"the cheapest electrons, regardless of their environmental impact or contribution to resource diversity, will reign supreme"* (Doc-2-Share).

Discourse coalitions agreed that independent players under competition would not take into account the 'public-interest' in the same way regulators had, so that following competition, 'public-interest' decision-making would be separate from power-sector investment planning and budgets (Doc-2). Under retail competition, consumers would no longer be captive, and therefore subsidies and social policies, in other words, 'special treatment' of resources and energy users would have to be managed in separate budgets (Doc-2-Cohen). Economists promoting retail competition suggested early on that *"programs to improve environmental performance can be compatible with customer choice"* and that *"explicit subsidies to environmentally preferred"* technologies and resources *"can replace command-and-control procurement directives"* (Hogan 1994 : 32). Economists promoting competition saw the fact that public interest aims would have to be promoted through explicit, separate policies as a benefit: they argued that making the favouring of *"particular interest groups"* transparent would improve the system's efficiency and "*restrict the scope for 'unauthorised' redistribution"* (Littlechild 2000). Others believed this would reduce *"the ability to accommodate social policy obligations"* (Hunt and Shuttleworth 1996 : 35). *"[T]hey were hidden in the electric industry in the first place"* because having to pass specific legislation and subsidies would be more difficult (Hunt and Shuttleworth 1996 : 75)[21] than accommodating the public-interest

[21] Reforms that introduce wholesale energy competition to expose generators to market prices and risks already eliminate scope to pursue *generation*-related policy objectives, e.g., an above-market capacity margin and choice of specific generating technology (Hunt and Shuttleworth 1996). Introducing retail competition additionally eliminates the scope for investing in demand-side resources on the basis of avoided supply-side expenses (Blumstein et al. 2000), the duty to serve all customers, and the regulators' ability to specify how costs for energy procurement should be spread between customers. In many cases,

goals within centralised planning exercises. The discourse coalitions therefore disagreed about whether the separation of public-interest goals following competition downstream in energy procurement would support or hinder outcomes in the 'public interest'.

As outlined above, many US environmental advocates supported restructuring reforms upstream, hoping that especially unbundling of generation would reduce the influence of monopoly utilities obstructing positive change (Int-A-13). As a Texas-based environmental advocate said, before restructuring, *"there were all these new emerging technologies, renewable energy and energy efficiency, that were trying to come into the market, but the utilities were blocking the evolution of the electric utility industry"* (Doc-14-Smith). Therefore, the environmental advocates supported reducing the monopolies' role.

However, most US environmental protection advocacy groups did not believe that competition in retail would help their cause to promote renewable energy and energy efficiency (Int-A-13). Environmental advocates argued that preferences in procurement for renewable energy technologies and resources on the demand-side would not be delivered by competitive retail markets, unless elements of central planning were retained, so investment options could be compared in taking into consideration 'public-interest' concerns. As one energy conservation advocate told California legislators:

> *"The logic of a commodity market is not for people to go along and make long term contracts with regard to the benefits for society as a whole (…). Renewable energy and conservation simply cannot compete on that sort of short-term commodity price basis. So, we're not going to see much of that, as (…) has*

policymakers have retained these powers though by explicitly layering on top instruments like licensing, price regulation, subsidies, and investment obligations.

> *already occurred in the retail wheeling experiment in the U.K."*
> (Doc-2-Cohen).

Many environmental advocates preferred a centrally planned system managed by regulators and legislators, which they could influence as consulted stakeholders, and where regulators would balance cost criteria with other public interest aims.

Representatives of residential and small business customers did not support electricity retail competition because they believed that individual consumer choice would lead to a cost shift. They emphasised equity and fairness as a key 'public-interest' concern that should be considered in designing an institutional structure for the sector. Utility regulators in the three jurisdictions had used their control of rate setting to distribute costs between ratepayers in ways that deviated from the cost to serve[22], for instance through low-income discounts. While sympathetic economists lauded electricity retail competition for reducing policymakers' scope to distribute costs according to principles diverging from cost-reflectivity, representatives of small users did not believe that this would yield equitable or socially desirable outcomes.

Advocates of residential energy users assumed that few if any competing retailers would offer advantageous terms and prices to this customer segment, especially to those on low incomes. Part of the institutional framework in the electricity sector had been an 'obligation to serve' all energy users. Monopoly IOUs had been required to serve also those in their territory to whom service was not considered an attractive economic proposition including rural and poor customers (Hunt and Shuttleworth 1996 : 35). This had been part of the reason to introduce regulated franchises. Now, it was argued that *"the concept of an obligation to serve is not consistent with a competitive market [where it] is replaced by the notion of willingness to serve at a*

[22] Costs to serve vary across several dimensions, for instance time, geography, capacity and volume of energy consumed, billing and payment methods, and the 'peaky-ness' of demand.

certain price" (Blumstein and Bushnell 1994 : 25). Especially advocates of low-income residential customers were worried that retail competition in electricity would not deliver uniform access: *"I doubt that a marketer is going to say, 'Gee, I have a nice market niche here of the elderly and disabled' and try to serve that market better. I think it will not work that way"* (Doc-13-Brockway). Therefore, this coalition framed problems related to electricity retail competition at the core as related to equity and fairness between customers with different abilities and costs to serve.

However, small energy user representatives in the US did not clearly oppose competition for monopolies because they were in many cases not satisfied with monopoly IOUs. Small consumer advocates were historically antagonistic, working against monopoly utilities within adjudicated rate cases, and some argued that regulators had been captured by IOUs at the expense of ratepayers. As a consumer advocate in California complained in 1994, the public utilities commission (PUC) historically *"looks out for the utility shareholders first, industrial customers next, and us last"* (Doc-3-Florio). Therefore, a municipal aggregation model was proposed as an alternative to 'direct access'. They called for *"ways for the little guys to jump ship with their bigger brothers"* in the form of municipal or cooperative aggregators (Brockway, cited in Maize 1994 : 12). The idea was *"to say, don't just let the big customers go out; make them take all the citizens of the surrounding community with them"* (Int-A-5). Advocates believed this form of collective city-wide choice would prevent the unjust 'cherry-picking' of profitable at the expense of less desirable customers (ibid.).

Finally, reliable supply was another public interest goal which some critics argued retail competition would endanger. Some monopoly utilities and economists warned about inadequate investment in generation capacity (Doc-9-Jaffe), given that the consequences from system-wide power outages would be borne by energy users and

ultimately politicians rather than private investors. Utility employee representatives also criticised restructuring on the grounds of protecting reliability. One cautioned, *"if the people supplying electrical energy make mistakes in their forecasting and there is inadequate supply, as always happens in every business cycle, California will face high electricity prices and scarce supply, possibly brownouts"* (Doc-2-Carter). Union-representatives feared retail competition and wider energy market reform because they were worried that jobs would be lost or move to organisations with a non-unionised workforce (Int-A-10). Again, effects of restructuring in the UK had been followed closely in the US (Int-A-5) and informed employee representatives' position.

Within the other discourse coalition, stakeholders argued that retail competition would not threaten but help achieve public interest goals, specifically investment in renewable energy and energy savings. Some argued that environmental improvements could be better promoted by individuals making choices in markets because consumers would be willing to pay more for renewable power and environmentally beneficial energy services. Some pro-market environmentalists *"thought, the voluntary market [for green electricity], would be more effective and that we had to move from mandate to markets"* (Int-A-13). Prospective retailers promised that competition would not be solely price-based but encourage innovation in energy efficiency services and environmentally friendly resources. For instance, the representative of a power marketing company told California legislators in 1994, *"companies like mine will essentially look at this as a marketing tool"* (Doc-2-Sheingold-Barry). Prospective retailers at the time were trying to build energy service offers to large customers and thought that bundling services with commodity would be a promising business opportunity (Int-A-10). The storyline that competition would enable energy services markets to grow and therefore improve energy efficiency was

supported by the narrative that under retail competition, prices would more clearly reflect the real costs of consumption (Hogan 1994).

Finally, some proponents of electricity retail competition promoted storylines that individuals' choice in markets itself was in the public interest, and superior to choices made by bureaucrats and politicians on behalf of the collective. The associated storyline that individual choice had intrinsic value was not promoted by many experts and stakeholders in regulatory and legislative hearings, but more fervently by politicians. For example, Texas state senator Sibley said, it was *"important"* for customers to *"have the choice. The choice to choose"* (Doc-14-Sibley).

Discourse coalitions that disagreed about how the 'public-interest' could be achieved implicitly assigned responsibility differently. Those calling for central coordination to ensure the 'public-interest' assumed that the state and its agents should on behalf of citizens define the collective good and within this remit control electricity utility companies (through regulation or ownership). This contrasts with the libertarian perspective claiming moral superiority for organising economic activity through competitive market forces. Responsibility in this view is assigned to individuals (Int-A-3) rather than the state. Ideas about individual choice in markets as the essence of 'freedom' were based on a Hayekian moral philosophy (see also Nozick, 1978 on property rights). These ideas had gained popularity in the US since the 1980s after being promoted especially by the 'Chicago School' and Milton Friedman (Friedman and Friedman 1962; Fourcade and Healy 2007). These philosophical ideas also played a role in debates on whether competition should be introduced to electricity retail.

4.4 Institutionalising the discourses

The following section explains how the institutionalisation of the new ideas in favour of competition and unbundling unfolded differently in the three case jurisdictions.

4.4.1 Ideas meet technological change and falling marginal costs of power

Individuals elected and appointed into top decision-making positions were important for retail competition to be put on the agenda. In California and Massachusetts, utility regulators initially spearheaded electricity retail competition with orders which were later followed by state legislation. In the early 1990s, California was appointed a new PUC president Daniel Fessler who *"was in love with anything British"* (Int-A-8). As Britain at the time was in the process of restructuring, there was *"intellectual curiosity"* about these reforms (ibid.). *"After travelling the planet, Fessler was pushing, 'hey, I really want to see if we can go ahead with markets'"* (Int-A-4). In Texas, leadership on retail competition came from the very top. Governor George W. Bush (Junior) believed in competition along the supply chain and after his election in 1994 gave the impetus for restructuring.

California was the first state to propose the reform. Pressure on the state's economy presented a window of opportunity for the head regulator to explore the possibilities. There was a *"very significant recession (...) largely driven by the (...) Cold War ending [and the] huge aerospace industry"* closing. Therefore, *"Governor Wilson instructed all those different agencies to come up with proposals to help create more business opportunities, more revenue for the state"* (Int-A-8). After California's regulatory commission had published a report exploring options for market reform in

1993, in 1994 it proposed electricity retail competition, alongside further wholesale market reforms in what became known as the 'blue book' in 1994. Soon after, the Massachusetts regulators (DPU) began to consider restructuring. They recommended wholesale energy market competition, but were less enthusiastic about competition at retail level than in California (Marritz 1994) initially. In Texas, the joint effort on retail competition between the PUC and legislators began in earnest in 1995, after legislation to create wholesale electricity markets had already been passed.

In all three jurisdictions and globally, the success of previously niche power generation technologies enabled change on the demand-side. Technological change meant that the accepted notion of what was an efficient scale of power plant changed which cast doubt on the established wisdom of 'bigger-is-cheaper' and the 'natural monopoly' discourse. For the new, less capital-intensive generation of technologies PURPA had promoted, scale effects of unit size were less important than those of series manufacture and the learning curve with each series of smaller units (Patterson 1999). The smaller scale at which power could be viably generated also led to the questioning of the retail monopoly because more large energy users were themselves generating on-site. Concerned policymakers constructed the narrative that large customers were going to exit the system and rely solely on electricity generated on-site, leaving all others to pay for previous investments. Electricity retail competition was framed as *"inevitable"* and already occurring without policy change (Doc-11-Montigny). This enabled presenting adjustment of the institutional structure to technological and practice change as the only option.

In California and Massachusetts, the rise in electricity prices and the difference between marginal and average cost of power following the decline of natural gas prices gave credibility to the storyline promoted by large energy users and retailers that policymakers needed to address the cost of electricity through market reform.

When proponents of competition framed the cost of the system as intolerably high, the techno-economic changes in the sector that had led to the difference between marginal and average cost of power supported this storyline. When assumptions that oil and gas prices would continue to rise turned out to be wrong (Int-A-8), this supported the storyline that central planning and administrative decision-making in electricity were principally flawed and led to overpriced supply. These developments allowed proponents of competition to argue that planning was inferior to the 'market' allocating investment.

There was disagreement in Massachusetts and California about whether or not electricity prices rising actually constituted a 'crisis' that demanded policy action. Politicians supporting the 'crisis' narrative were concerned about large energy users' competitiveness. In Massachusetts, a state senator demanded that *"restructuring, finally, has to address the impossible cost of doing business in Massachusetts"* (Doc-11-Montigny). When representatives of small energy users complained that retail competition would benefit industrial customers at the expense of households, the head California regulator opined: the advocates of small energy users *"have always been bitter enemies of what they call industrial ratepayers. Other Californians know those same people as employers"* (Doc-3-Fessler).

On the other side, critics of reform questioned the narrative that rising electricity rates in fact presented a 'crisis'. The construction of a crisis relied on presenting data on unit-cost, for instance that electricity rates in California were 50% higher than the national average (Doc-2). Others preferred different metrics to assess the cost of energy. The California Energy Commission Chair argued that while rates per unit were high, overall expenditure (bills) was not:

> *"we actually have relatively low energy cost in our state. We're 46th in per capita energy cost among the 50 states [and] rank*

> *49th in energy cost per dollar of state gross product (…). So, that does not (…) represent a competitive issue that works to the disbenefit of California"* (Doc-2-Imbrecht).

This alternative framing considered the relative efficiency of turning electricity into useful services for end-users and the demand for these, which the focus on rates per unit did not.

Decision-makers in Texas were very enthusiastic to introduce competition, although there were not the same narratives of economic crisis. Texas' electricity rates for all customer classes were below the national state average before market reform (Doc-67-EIA). However, Texas had *"a political will from the top down to do something (…) big"* (Doc-14-Klein). The Governor's *"strong belief in markets"* was shaped also by his own professional background in the competitive West Texas natural gas business (Kiesling and Kleit 2009 : 25).

Restructuring bills were enacted in all three jurisdictions with broad support. In California, AB1890 in 1996 passed as *"an urgency statute"* to allow *"citizens and businesses to achieve the economic benefits of industry restructuring at the earliest possible"* (section 1(a)) (Doc-73). The Massachusetts Electricity Restructuring Act was passed in 1997 as an *"emergency law, necessary for the immediate preservation of the public convenience"* (Doc-74). In Texas, although the public utilities commission began inquiries in 1995 shortly after Massachusetts and California, restructuring reforms were passed as Senate Bill 7 only in 1999. While in California and Massachusetts, retail competition was to begin in 1998 shortly after legislation was passed, Texas allowed for a longer implementation period. Full retail competition was specified should be extended to all customer classes in 2002, to allow time for the detailed rules to be designed by the utilities commission.

In all three states, electricity retail market reform was combined with other policy decisions, to ensure support from as many stakeholders as possible. Legislative and regulatory proceedings lasted for months and insiders reported that policymakers facilitated 'marathon-negotiations' (Doc-14-Wolens; Int-A-8; Int-A-13) to achieve *"settlements"* (Int-A-5). Stakeholders had different priorities which required balancing to achieve a consensus. One environmental advocate in New England explained how stakeholders strategically traded support for key priorities: *"every constituency had some other big bottom line they were hard on"* (Int-A-13). To defend these priorities, trading support for other stakeholders' aims was as a good way to achieve policy aims:

> *"Once we got going [with restructuring], in the way big legislation works in the US, individual actors rarely have the power to make things happen, but often much more power to block things"* (ibid.).

The institutional context in which the reforms were developing meant that compromise between stakeholders was needed because *"ultimately, restructuring (…) had to be supported by the courts"* (Int-A-12), so winning the support in the legislative chambers did not suffice. *"Buy-in"* from constituencies with skilled litigators was necessary (ibid.). This meant that the new institutional framework had to reflect a balancing of what different constituents perceived was in their interest.

Large energy users, prospective retailers, and politicians supportive of 'choice' achieved their main ask: 'direct access' to public networks to buy power from other companies, which enabled electricity retail competition. As one California stakeholder explained, *"retail competition has done so well as it has, because the utilities have not used much political capital to fight it"* (Int-A-1).

The second major issue was decided in favour of the monopoly utilities and their shareholders. In all three states, they were granted recovery of investments deemed

stranded through 'non-bypassable' transition charges recovered on customer bills. This meant that rates did not immediately reduce after retail competition was introduced because any benefits energy users could have gained from buying power from new gas plants at lower marginal cost would be delayed because the costs of stranded power plants could not be avoided (Int-A-5).

In Massachusetts and California, the monopoly utilities again got their preferred outcome in terms of how default service for customers who do not switch was designed. They were assigned the default provider role and were not unbundled from customer-facing functions. In Texas however, IOUs were forced to divest customer-facing functions, so they were split into competing entities and regulated-franchise network companies. They were however able to resist complete ownership unbundling (Doc-14), so that at a holding level, network firms could remain integrated with competitive affiliates, albeit under rules prohibiting cooperation to prevent competitive advantage for incumbents.

In all states, billing was made contestable. However, in California and Massachusetts, distribution utilities managed to retain responsibility for billing, even for those customers who chose additional alternative billing providers[23]. In Texas, they were unbundled, so that billing was purely competitive. Metering was classed as part of the regulated distribution monopoly in all three states. One expert reported that making metering competitive had been perceived in several states as *"generally very difficult to set up"* (Int-A-11). Furthermore, policymakers were persuaded by the storyline that procuring metering infrastructure for several million customer accounts exhibited

[23] This was enabled by separating out the cost of energy procurement, i.e. the generation element, from distribution, transmission, and other 'system costs' including transition charges on the bills. A customer choosing alternative billing providers would receive two bills: one from the network-retail utility covering all costs and one from the competitive provider covering the energy cost.

large returns to scale, so it was widely believed that competing retailers procuring and managing meters would not deliver material cost savings for consumers (ibid.). Moreover, in Massachusetts, *"the utilities pushed very hard legislatively; they wanted to continue to own the meters and control the data"*. So competitive metering *"was not something we went ahead with"* (Int-A-7). Overall, the discourse of the 'natural monopoly' and the benefits of centralised coordination remained dominant in the case of metering.

All three states forced monopoly utilities to divest all (or in California a majority) of power plants. Thereby independent power producers, consumer advocates, and environmental advocates achieved a *"big win"* in upstream restructuring (Int-A-13).

Small energy users and utility employees were guaranteed some protection through capping the allowed price for default service. In California, all customers were protected by a 'rate-freeze', and as an *"attempt to buy off the small customers"* (Int-A-5) an additional 10% rate reduction below pre-restructuring prices was mandated for residential energy users (Int-A-2). However, this rate reduction was ultimately going to be recovered on bills again, so

> *"they basically were forcing residential customers to borrow from themselves to make it look like they're getting a rate reduction. (...) I'm sure they were concerned that otherwise residential customers would be very angry about the fact they weren't getting any benefits out of restructuring" (ibid.).*

A small consumer advocate recalled, *"We used to call it the phony 10%, because their customers were financing their own rate reduction, but it did have some minor benefits"* (Int-A-5)[24]. Massachusetts also mandated a rate-freeze. In all three states, programmes to give low-income energy users discounts on electricity rates or bills

[24] This was engineered by allowing the monopoly utilities acting as default providers to sell bonds which in return for receiving an immediate rate reduction, residential customers would pay off over a number of years through their bills, and on a present value basis there would be a saving (Int-A-5).

were continued and financed through public-benefit-charges by all energy users. As part of the *"various side deals"* in the legislature to codify the California PUC decision, any utility employees facing redundancy were going to be compensated (Int-A-5).

Environmental advocates and the associated industries felt that they achieved good outcomes from the restructuring process in Massachusetts and Texas (Int-A-13; Doc-14-Smith) because at least some levels of investment in their preferred resources were mandated; in Massachusetts even at higher levels than expected (Int-A-13).

Retail competition was eventually supported by several environmental advocates because they saw restructuring legislation presented an occasion to push their own agenda, a renewable portfolio standard (RPS). Before, monopoly utilities had been resisting the mandated levels of investment in renewable energy technologies which environmental advocates and the renewable energy industry called for (Doc-14-Smith). As one Massachusetts environmental advocate recounted,

> *"No way at that point, could we have affirmatively passed a stand-alone RPS, but in the context of restructuring, we did recognize there was a political opportunity for a deal. (…) And so we tried to play as hard ball as we can, no restructuring unless its included as part of the package"* (Nogee, 2017).

In Massachusetts and Texas, the restructuring bills included a renewable portfolio standard (RPS). Although Enron and other prospective retailers lobbied against standards and argued they were already investing heavily in wind power (Galbraith and Price 2013), George Bush thought a mandate was a *"great idea"* (Doc-14-Sibly). In California, renewable energy investment would be funded through non-by-passable public-benefit-charges, as would the continuation of demand-side management

programmes monopoly utilities had been running since the 1970s (Int-A-4)[25]. Public-benefit-charges were also included in Massachusetts to fund energy efficiency and load management programmes. In all three states, these charges would fund research and development. In Texas, unbundled network-utilities were mandated to invest in energy savings and allowed to recover these costs from energy users via bills, although measures had to be marketed through retailers or energy service providers (Int-A-15).

All three states created the option for city or county governments to buy power on behalf of energy users in their territory. However, only in Massachusetts were cities allowed to automatically acquire all customers in their territory who were not served by competitive retailers already on an 'opt-out' basis (Doc-47 : section 247). The enshrining of the right to act as 'municipal aggregators' coincided with allowing these city- or county-run retailers to take over the role of default provider in their area from the investor-owned network-retail utilities. This required one or several municipal Governments to vote to set up a municipal aggregator, and its plan to be approved by the state Department of Energy (ibid.). Billing, metering, and other customer service functions would remain with the investor-owned network-retail company, like for small energy users choosing a competitive retailer. In Texas and California, the option to set up municipal aggregators was institutionalised on an 'opt-in' basis, so that local governments setting up these retailing businesses could not function as default providers for customers. They would have to convince individuals to opt into their programme, as any other competitive retailer would.

Finally, cities or rural communities running their own utilities were allowed to opt out of restructuring reforms in all three states (Int-A-7). From the beginning of debates, most municipalities running electric utilities had been critical of retail competition

[25] An RPS was legislated for in California in 2002.

because they did not want to be forced to compete (ibid.). They were adamant that control over their energy supply should remain local and unfettered by state-level reforms. Their success in defending their position meant that these firms could remain vertically integrated monopoly territories in an otherwise competitive, and in the case of ERCOT, unbundled territory.

4.4.2 Friendships, varying ideas, and a shock: The evolution of different electricity retail market designs

Evidence indicates that close ties between the Texas Governor and Enron helped the prospective electricity traders to lobby for competition and unbundling. The competitive, unbundled market design corresponded closely to what prospective retailers including Enron had advocated, with the exception of metering remaining with the network operators. Bush had personal ties to Enron founder and chief executive Kenneth Lay who reported to be *"very close"* to Bush and his family, having spent *"quality time"* (Doc-45-Lay)[26]. Many politicians at state-level across the US in both major parties received campaign finance contributions of several tens of thousands of dollars from Enron executives and supporters tied to the monopoly utility industry (Doc-15-NYT). However, Enron's influence on the Texas Governor went further. George Bush's choice to appoint Pat Wood as head of the regulator to implement restructuring plans was reportedly based on a recommendation by Enron's CEO himself (Doc-45-NYT). On another occasion, the Governor was reported to at Lay's request call *"the governor of Pennsylvania (…) to vouch for Enron, which was trying to break into that state's electricity markets"* (ibid.). These events suggest that

[26] Later, Bush denied these ties after Lay and other Enron leaders were accused of committing major accounting fraud (ibid.).

Enron executives had a special kind of personal influence on Bush which may have further strengthened his support for restructuring reforms.

The newcomers' links to high-level decisionmakers constituted a significant shift because traditionally, the regulated-franchise companies were often able to shape the institutional environment in their favour, as several observers reported. Investor-owned utilities *"have very skilled lobbyists who have power over the legislature to shape laws"* (Int-A-12). Monopoly utilities in the US were reported had always successfully mobilised resources through campaign contributions, lobbying, and control over the siting of investment and jobs (Int-A-2). As a result, during restructuring negotiations, the incumbent utilities felt entitled to make many demands as the *"800-pound gorilla in the room"* (Int-A-13). In Texas, they were less successful than in Massachusetts and California in resisting the breaking up of their companies downstream.

In Texas, the newcomers seeking to alter their selection environment were also successful because normative ideas about the importance of individual consumer choice were widely accepted. These ideas were not institutionalised in the other states. In ERCOT, all electricity users were assigned to competing retailers (emerging from the integrated company divesting retailing operations and customers), so that after an initial phase of price regulation (Int-A-3)[27], all customers including those not making an affirmative choice would be exposed to the market. This was because Texan decision-makers propagated choice as 'freedom', a citizen's *right*, or even *duty*. As a former civil servant explained: *"it was important to us that the customer needs to take*

[27]Analysts claim that the Texas approach to default service with the 'price to beat' was a success. During the first 5 years, incumbent default retailers had to offer prices at a specified higher level than those offered by new entrants. This provided 'headroom' and analysts say was important in motivating customers to shop (Rai and Zarnikau 2016).

ownership of their service and be able to exercise their freedom of choice" (Int-A-3).

PUC chairman Wood also described,

> *"In 1995, George W. Bush interviewed me with his boots on his table, and he said, 'Pat, we can promise better prices, and I think we can get 'em, we can promise better customer service and I think we can get it, and we'll most likely get better technological innovation. But the bigger issue is that (…) the utilities care more about what we', and he pointed to the house, the senate, and himself, 'think, than what the customers think, and that's wrong. And you're going to change it"* (Doc-14-Wood).

This shows that economic ideas about innovation and efficiency played a role but were ultimately secondary for the Governor. Philosophical ideas about the primacy of individual consumer choice over collective decision-making were a key driver of restructuring in Texas.

Ideas about the intrinsic value of individual 'choice' were not as popular among decision-makers in Massachusetts. As the top regulator at the time, J. G. Besser, explained, *"it was never important to us that residential consumers switch, we didn't think choice in itself was very valuable"* (Int-A-7). Instead, she explained, they pursued retail competition to increase liquidity in wholesale markets, and for that, *"a critical mass of customers switching is sufficient, you don't need residential consumers to choose"* (Int-A-7).

Unlike in Texas, the introduction of competition in Massachusetts was not guided by principal philosophical ideas therefore, but by technical economic ideas and pressure by large energy users.

The different frames of meaning also meant that policymakers in Texas and Massachusetts emphasised different learnings from telecommunications restructuring. The top Massachusetts regulator explained that negative customer experiences with competitive providers in the telecommunication industry informed

their decision on default electricity service design. She described that *"it was viewed as a consumer protection measure to say the distribution company will be the default provider instead of somebody else"* because there was a lot of concern about *"what's called 'slamming' where customers were automatically assigned to a company without their knowledge"*, and about billing issues. So, the *"backdrop"* in Massachusetts was *"to not say 'you have to choose and if you don't, we'll fine you'"* (Int-A-7).

In Texas, policymakers also looked to telecommunication reforms for learnings, but framed different issues as key problems. The head of the commission in Texas believed that competition in retail markets would only succeed without participation by the incumbent network company. *"Chairman Wood had particularly strong thoughts that we needed to have full structural separation and it was based on this experience in telecommunications"* (Int-A-3). There was a general feeling that allowing the integrated network operator to compete "*gives a huge incumbent advantage and we wanted to have a really competitive market"* (Int-A-3). This demonstrates that the evolution of different market designs was also influenced by different framings of past experiences.

Policymakers in other states decided that unbundling networks from retailing was not necessary and that anticompetitive behaviour by network operators could be policed (Joskow and Noll 1999). Stakeholder pressure also did not promote downstream unbundling. Besides the prospective retailers, it was not pursued by many stakeholders as a priority, unlike competition and generation unbundling. In California, one observer recounted *"there were free market ideologues who said, let's just open these markets up, but they weren't institutionally powerful"* (Int-A-10). Moreover, leading utility economists in the US also supported assigning default provider status to the network-retail utilities (e.g., Hogan 1994).

Opposition to unbundling on the other hand was strong. The monopoly utilities as powerful players lobbied against the breaking up of their companies to retain their customer relationship as a regulated-franchise. Moreover, *"small (...) consumer advocates said, we're really worried about competition, (...) our customers don't want price shocks (...). They want that protection"* (Int-A-10). A former advocate for large energy users in California explained, *"there was no model to trust that there would be an entity that would pick up at a reasonable cost, those people who (...) didn't want to switch"* (Int-A-4). Policymakers were not sure whether *"Enron or whoever else (...) could really provide decent services especially for residential customers"* (ibid.). Some large energy users too had lobbied against being automatically assigned to a competitive retailer:

> *"We are certainly not experts with respect to the electric utility industry, but (...) We are quite satisfied with the service we receive from Massachusetts Electric and we would be very concerned by any restructuring proposal which would potentially force us to change suppliers or endanger the dependability of our electric service"* (Doc-76-David-Clark-Company),

a medium-size manufacturer told the Massachusetts regulator. Policymakers in California and Massachusetts therefore decided to implement more incremental reforms downstream than Texas.

The third type of electricity retail market design, the monopoly retailing structure, was reinstated in California a few years after competition was introduced. Retail competition was rescinded in 2001, in the aftermath of what came known as the 'Western electricity crisis'. Wholesale energy market prices spiked to record levels because fewer power plants bid into the market. There were a range of reasons: Firstly, a number of plants were scheduled for maintenance (Int-A-2). Investigations found that some of these were scheduled not for technical necessity, but to increase the scarcity in the market, and that traders, notably Enron, exercised market power to

profit from price spikes (Hausman and Neufeld 2011; Joskow 2008). Fuel shortages through a pipeline failure and weather impacts have also been cited as reasons for the supply scarcities (Int-A-8).

Downstream, the problems unfolded because neither investor-owned network-retail utilities nor retailers had hedged through purchasing in longer-term contracts, so had to rely on purchasing short-term at spiking prices[28]. Because of the guaranteed rate freeze, utilities and retailers were not allowed to pass these spiking prices on to customers and could not recover these costs (Sweeney 2002). What ensued were brownouts, retailers declaring bankruptcy and leaving the state, customers defaulting back to the network-retail utilities, and the bankruptcy of one, with the others teetering on the brink. This led the state government to enter long-term power purchase agreements, in some cases for plants that had not yet been built, to stabilise the situation and ensure capacity would become available again (Sweeney 2002). Retail competition was frozen, meaning customers were no longer allowed to choose alternative retailers, so that the long-term power purchase contracts the state had procured could be honoured. This intervention locked the state into debt for many decades and led to the largest issuance of state bonds California had ever seen (Asmus 2009). At the same time, the institutional change that froze retail competition reinstated central coordination of power purchasing and the retailing monopoly in California.

After the monopoly in retailing was restored, the law allowing community choice aggregation was also amended in 2002 to allow municipal aggregators to acquire their

[28] There is wide-spread agreement that discouraging network-retail utilities from hedging their positions through long-term advance contracting was a flaw in California's original market design (Joskow 2008). This way, they were entirely exposed to the shortage of supply in the wholesale market.

customers automatically, on an 'opt-out' basis, rather than opt-in as remains the rule in ERCOT. Since cities may take over energy procurement from network-retail utilities for all consumers in their area, many have set up energy companies to do this. Community choice aggregation has increased the number of eligible agencies that may fulfil retailing functions, but retail competition is not available, given energy users may not buy directly from competing retailers or generators. Energy procurement and price-setting are still managed for the collective by a regionally assigned agency rather than in a decentralised fashion by competing retailers.

The discourse on the superiority of centralised coordination has prevailed and is widely accepted in California, although large customers and retailing companies in California continued to press for reinstating retail competition. In some instances, they succeeded: The cap on 'direct access' has been lifted several times, so that a few more non-residential customers may directly buy power from the market, most recently in 2018 to around 15% (Doc-71-GTM). Moreover, the growth of community choice aggregators also challenges California's market design because the number of parties acting as energy procurement agencies is growing. However, policymakers in California have rejected reintroducing full-scale retail competition several times since 2001, and instead embraced central resource planning and procurement (Int-A-5). Several interviewees explained that the crisis had left a strong imprint on the Californian psyche, policymakers, and the public:

> *"the crisis made everybody very distrustful of markets. It's pretty strongly ingrained (…) that we can't rely on markets to give us reasonable prices (…) and that the state should be involved in deciding when new power plants need to be built"* (Int-A-5).

This means that in ongoing regulatory and legislative reforms of electricity sector institutions, the memory of brownouts in the early 2000s looms large and remains linked to electricity retail competition: *"the ghost of Enron overshadows everything*

here in California" (Int-B-58-EXP). As a result, centralised, regulated-franchised power procurement and retailing functions remain institutionalised in California today.

4.5 Conclusion

This chapter addressed the sub-research question: *How did different electricity retail market designs evolve in California, Massachusetts, and Texas?*

The chapter showed that the processes of electricity market restructuring were contested. Similar landscape pressures and niche developments did not produce the same market reform outcomes in the three jurisdictions because ideas, priorities, and influence by stakeholder groups differed.

Shifts that led to electricity system decentralisation were set in motion by several landscape and niche-level changes and allowed putting electricity market restructuring on the agenda in all three states. These changes supported the destabilisation of the dominant discourse of the industry as a 'natural monopoly', where large, centralised power plants were assumed to be always preferable to smaller-scale generation. Following the landscape 'shock' of the Oil Embargo, in 1978 the US law PURPA enabled new players to enter the electricity regime because it forced monopoly network-retail utilities to purchase output from independent generators, including from energy users who invested in co-generation facilities on-site. This public policy change created an institutional space and a revenue stream for independent generators to challenge the incumbent, centralised monopoly regime. In the 1980s, the combined-cycle-gas-turbine emerged as a niche innovation in

electricity that supported significantly smaller unit size for power plants. The co-generation industry and their customers, large energy users with the capital and demand to justify investing in on-site generation, were key interest groups driving electricity retail market competition. They promoted reforms together with commodity traders seeking to enter the sector to trade and retail electricity as a commodity.

The various processes of alignment within the trajectories regulation, markets, and user practices resulted in a difference between average and marginal power prices in the early 1990s in Massachusetts, California, and Texas. This supported the storyline that the monopoly structure of the industry was inferior to a competitive framework.

Two further landscape influences shaped the evolution of market designs: ideas about markets as generally more 'efficient' allocation mechanisms were applied to the electricity sector and promoted by the discourse coalitions in favour of competition. In all three states, individuals who embraced these new ideas were elected to office, but in Texas especially, a Governor with personal history in and relations to energy trading companies took office with a promise to restructure electricity markets.

Ideas about individual consumer choice as intrinsically valuable dominated in Texas which in Massachusetts and California did not find as much support. Moreover, executives of energy trading company Enron, seeking to create for their firm a favourable selection environment to enter the electricity sector, were more influential in Texas than in the other states. In California and Massachusetts, they did not manage to convince policymakers that network companies should be unbundled from retailing functions. Soon after opening markets to competition, California was hit by a crisis of power shortages and spiking wholesale prices which led to the discourse of the

primacy of central planning to be re-institutionalised in California in 2001. As a result, the three states have different electricity retail market designs in place today.

Chapter 5 – Distributed energy business models challenging centralised electricity regimes

Electricity retail market restructuring more than two decades ago changed the institutional organisation of electricity 'regimes': the dominant practices, players, and structures that define how electricity is supplied. Today, electricity regimes are changing again in many jurisdictions. The purpose of this chapter is to outline the nature of centralised electricity regimes in business model terms, and how they are changing through demand-side resources. It explains the regime-level commercial structures that emerged after competition and unbundling reforms; how distributed energy resources challenge regimes, and how regime-level companies resist change.

It addresses the subsidiary research question: *"How are DER niche players today challenging the electricity regime through building business models?"*

The question is broad, so the results are differentiated, representing the diversity of regime players, distributed energy resources, and niche players.

Electricity regimes in some jurisdictions have made revenue streams and value pools available for DER niche players to target, sometimes in competition with incumbents, and sometimes offering value directly to incumbent companies, and thereby cooperating. But niche players also report a range of barriers, and this chapter explains those directly linked to incumbent electricity firms' activities. It thereby addresses the third subsidiary question: *"How are DER niche players experiencing incumbent company regime resistance, when trying to access key resources and opportunities?"*

The chapter first introduces the nature of centralised electricity regimes. This includes established business models operated by electricity system players since restructuring, and associated value pools challengers are trying to access. Then, the chapter shows the variety of business models DER players are trying to build to access the associated revenue streams, including key activities, capabilities, and customer channels. Finally, the chapter explains regime resistance through a range of barriers identified by DER niche players.

5.1 The nature of the regime today: incumbent business models and value pools across the system

5.1.1 Incumbent electricity business models

Electricity sector restructuring and the creation of markets led to the emergence of new types of incumbents. Electricity retail market design choices influenced electricity firms' business models (see Table 4). The restructured electricity companies' roles were in many countries enshrined in licensing frameworks (Newbery 2000). Institutionalising roles also meant, depending on the stringency of the rules, institutionalising core parts of electricity companies' business models: activities, and in some cases, customer segments and channels. Licensing also served to regulate standards of operation and provide a high degree of certainty to private-sector investors (Lockwood, Mitchell, et al. 2017).

Incumbent type	Physical assets invested in	Electricity operations, activities	Jurisdictions, e.g.
Competing firms			
Pure retailer	None	Retailing: energy procurement (trading, price risk management, brokering contracts between generators and large energy users), billing	ERCOT, Massachusetts
Gen-tailer	Power plants	As above, plus power generation	GB, ERCOT, Massachusetts
Third-party-retail-intermediary (broker)	None	Brokering contracts between end-users and energy retailers	GB, ERCOT, Massachusetts
Independent power generator	Power plants	Power generation, trading in wholesale energy markets	GB, ERCOT, California; any jurisdiction which allows competitive entry to power production
Regulated-franchise incumbents, regulated as 'natural monopolies'[29]			
Poles-and-wires company/ network operator	Networks (distribution and/ or transmission)	Network operation, metering	ERCOT
Network-retail utility	Networks (distribution and/ or transmission)	Network operation, retailing: energy procurement (price risk management, trading), billing, metering	Massachusetts, California
Transmission system operators	Transmission networks	System balancing, transmission network operation	Germany
Independent system operators	None	System balancing	California, ERCOT, Massachusetts (New England)

Table 4: Incumbent centralised electricity business models

Restructured electricity systems maintained their core functions: generation, system operation, transporting power through networks, and retailing. Restructuring reforms

[29] This list excludes vertically-integrated utilities which operate along the entire power supply chain without any unbundling because the thesis does not consider jurisdictions which have not implemented at least some unbundling of generation from networks (e.g. Florida, Arizona, and many non-OECD countries).

introduced competition to generation and in some cases to retailing functions. There are several types of competing electricity companies which emerged from market restructuring. They differ from incumbents regulated as 'natural monopolies' because they do not have the exclusive right (franchise) to provide a service in a region, but face competition if new entrants manage to establish viable business models.

Firstly, *pure* electricity *retailers*' main activities consist of procuring energy, managing customers' data, providing customer service, and, depending on the jurisdiction, also managing billing. Great Britain is one of the few jurisdictions where metering was also assigned to retailers. Secondly, reforms that opened up power generation to competition enabled emergence of power *generators* as independent, competing players. However, power generation and retailing consolidated quickly after market reform (Thomas 2006; MacGill and Healy 2013; Markard and Truffer 2006) in Europe and Australasia, where retail operations and customers were divested from network operators. The newly created electricity retail firms, who had been assigned the status of regional default providers, were in many cases acquired by electricity generation companies (ibid.). This meant that the large default retailers bundled power generation with retailing in one company, a business model known as '*gen-tailers*'. Vertically integrating between generation and retail within one corporate structure was seen as a beneficial strategy because physical hedges are believed to reduce risks from volatile wholesale power prices as compared to hedging through long-term contracts between independent generators and retailers (Newbery 2000). Gen-tailing recently became more prevalent in the US as well, when large independent power producers (IPPs) began acquiring retailers (Int-B-103-RET). Finally, *intermediaries* broker contracts between energy users and competing retailers (Int-B-57-RET). Rather than themselves purchasing power from generators, they help end-users 'navigate' the tariffs and options competitive retailers offer. They therefore

do not have to themselves interface with electricity wholesale markets and network operators, as retailers must.

The various competitive business models premised on selling electricity from centralised plants have different value configurations and cost structures: 'Pure-play' retailers and electricity brokers are fairly 'asset-light', and therefore operational costs and variable power prices define their cost structure. Gen-tailers and power generators are 'asset-heavy' and as such have a substantial capital cost to manage (Int-B-67-RET).

Incumbent regulated-franchise business models since restructuring vary according to whether or not jurisdictions adopted unbundling of network activities from other functions. Unbundling created regulated-franchise *distribution* and *transmission network companies*[30] in Great Britain, ERCOT, some Australian and Canadian provinces, Europe, and New Zealand, sometimes referred to as 'poles-and-wires' companies (Adib et al. 2013; Bertram 2013; Brunekreeft 2015; MacGill and Healy 2013). As outlined in Chapter 4, in Massachusetts and other US states with electricity retail competition[31], network companies had to divest power generation businesses, but not retailing operations (Lesser and O'Connor 2014). They were assigned the role of provider of last resort, and hence integrate network operation, energy procurement, billing, and metering (Kim 2013) as '*network-retail utilities*'. Finally, 'system operation', the balancing of electricity demand and supply in real-time, is another function that was considered should remain managed as a 'natural monopoly' by a regulated-franchise. In the EU, market restructuring policies did not mandate

[30] In some jurisdictions, distribution and transmission were separated (e.g., GB), in others these functions remain bundled in one firm (e.g., ERCOT, Massachusetts, California).
[31] US states with unlimited retail electricity competition for all customers in 2014 were ERCOT, New England states, Pennsylvania, Illinois, Ohio, Rhode Island, New York, New Jersey, Maryland, Delaware, and Washington D.C. (Lesser and O'Connor 2014).

complete separation of system operation from transmission network operation (Meletiou et al. 2018), so there are *transmission-system-operators*. In a number of US states, system operation was disaggregated entirely, so that several electricity systems today have independent system operators (ISOs).

Furthermore, there are variations between incumbent business models because the stringency of 'unbundling' varies between jurisdictions, depending on how the norm of non-interference was institutionalised and applied. Some incumbents are strictly limited to a single function, as is the case for US ISOs who are 'ownership-unbundled'. This is the most stringent form of separation where affiliation within a holding company is not allowed. Less stringent forms of unbundling have been applied in Europe (see e.g. Meletiou et al. 2018) where holding companies may own network, system operation, and competing firms, but they must be legally, operationally, and managerially separated into distinct firms to prevent interference in contestable markets, for example through sharing information, resources, and a brand. Under these forms of unbundling, electricity companies run several daughter firms with separate business models alongside one another.

Finally, some incumbents have only been unbundled to a 'shallow' extent (ibid.) in accounting to prevent cross-subsidisation between networks and competing business units. For instance, EU unbundling requirements allowed exemption of distributors with fewer than 100 000 customers from legal, managerial, and operational unbundling. In Germany, many small distributors therefore today operate power generation, retailing, and distribution within one firm, sharing staff and management (Int-B-39-EXP), although they are formally required to separate accounts and information. This shallower unbundling means that their company structure is more integrated than the company structure of legally unbundled 'network-only' companies. Shallowly unbundled companies are nevertheless formally more

disintegrated than US-style 'network-retail' utilities. These have not undergone any separation between customer-facing and network operations and have no restrictions on sharing staff, information, and resources between business units.

Between competing retailers within jurisdictions there are business model differences in terms of customer acquisition which are directly linked to how competition reforms were implemented. In jurisdictions where default energy provider status was assigned to competing retailers, these companies, often gen-tailers, have enjoyed an automatically assigned customer base. Because small business and residential energy users in competitive electricity retail markets around the world have been shown to exhibit 'inertia' (Hortaçsu et al. 2017), that is reluctance or disinterest in regularly switching energy commodity retailer, default energy providers with an assigned legacy customer base have had a comparatively secure customer base for the power generated upstream in their 'gen-tailing' business (Defeuilley 2009a; Levin 2015; MacGill and Healy 2013). Where default supply is not price-regulated, critics have argued that default retailers' business models depend on legacy customers on high-priced default tariffs. The margins from these customers allow default retailers to cross-subsidise engaged energy users who regularly shop for lower-price tariffs (Int-B-27-EXP).

New entrants in contestable electricity retail markets have had to find ways to motivate customers to leave the default supplier, and many have built business models around a customer segment interested in a specific value proposition. For example, some retailers offer price risk management for large sophisticated energy users with high tolerance for price volatility who buy power in 'blocks' (Int-B-68-RET) or offer the service of administering access to energy wholesale markets and networks. Retailers have also been successful at targeting small energy customers interested in buying more renewable energy than common in the average power mix with 'green

tariffs' (MacDonald and Eyre 2018). Some of these new entrants have also chosen the strategy of investing in physical hedges through power plants upstream, and thereby turned from retailers into gen-tailers (Int-B-23-RET). In Europe, some retailers have also built business models around targeting very price-conscious residential and small business customers (Int-B-25-EXP).

5.1.2 Value pools and revenue streams targeted by DER providers

Interviewees trying to build business models around DER explained they were targeting explicit value pools across electricity systems to recover revenue from. The accessibility of the revenue streams and value for DER depends on the electricity regime itself, namely the institutions which organise electricity markets and transactions, and the practices and decisions of key players in the regime, including incumbent electricity firms, end-users, and policymakers. DER providers can challenge the centralised regime, if practices of incumbents, including policymakers, energy users, and electricity companies with key functions in the system are supportive. In many, but not all cases, the economics of DER will influence these players' decisions: if DER projects are realisable at costs competitive with centralised alternatives, they may be more readily able to successfully challenge the regime. Demand-side resources in some jurisdictions are becoming increasingly competitive with supply-side resources because digital technology allows aggregation and the costs of technologies are reducing.

Depending on their function, incumbent electricity regime players control different value pools across an electricity system. For the majority of requirements, they have traditionally relied on centralised players and assets: Most energy users have passively bought power transported to them through grids. System operators pay power plants for short-term response to balance the system, energy retailers contract with power

generators or invest in centralised assets to provide energy (kWh) to meet their customers' demand, and distribution and transmission network operators invest in electricity network capacity. Where they contract with or invest in demand-side resources, this displaces centralised resources. Table 5 summarises the value pools and revenue streams across an electricity system, and the entities DER players and customers can provide value to in each instance.

Value proposition	Function in electricity system	Entity value is delivered to (regime-level players)	Revenue streams (key resources) (examples)	DER players who could access these
Energy use optimisation (e.g. energy cost reduction and/ or service improvement)	Consumption	End-user/ customer	Direct fees from customer to service provider or vice versa, or savings on commodity energy costs (shared savings)	Energy savings Micro-generation Demand response Distributed storage
Grid services	Transmission and distribution	Transmission and/or distribution network operating entities, and parties not being allowed to connect due to congestion	Payments for services, and/ or availability, energy	Energy savings Micro-generation Demand response Distributed storage
Energy in wholesale markets (kWh)	Energy procurement/ demand and supply aggregation and resale	Entity procuring and/or trading energy	Power purchase agreement payments; spot-market revenues; retail bill credits	Micro-generation Demand response Distributed storage
System services	System operation	System operator/ entities controlling demand and supply balancing close to and in real-time	Payments for services, and/ or availability, depending on contract design	(controllable) micro-generation Demand response Distributed storage
Capacity (kW) where rewarded separately	Ensuring desired capacity margin on behalf of Government, or regulator	Entity administrating capacity payments	Payments for availability	Energy savings Micro-generation Demand response Distributed storage
Public interest value	Government or regulator schemes (e.g. obligations to procure storage, renewable energy, energy efficiency; feed-in-tariffs; tax incentives; installation grants)	System: policymakers (e.g. state or national Government) has chosen to buy or subsidise the resource on behalf of customers	Guaranteed remuneration through feed-in-tariffs; bill credits, lump-sum grants; mandated power purchase agreement payments, tax credits	Energy savings (common) Micro-generation (common) Demand response Distributed storage

Table 5: Summary of value propositions and revenue streams DER business model builders look to offer and capture, Source: the author, based on Int-B-29-DER; Int-B-42-DER; Int-B-98-DER

Firstly, firms who develop micro-generation, distributed storage, demand response, and energy saving projects can offer value to the energy users on whose premises they are sited. DER can for instance lower overall energy cost, improve quality of electricity supply, provide back-up in case of grid-supply shortages, or improve a facility's environmental footprint by replacing higher carbon energy imported from the grid with low-carbon resources. Some or all of the demand traditionally met by buying electricity from retailers or network-retail utilities can be met through DER, depending on a range of factors including the building, energy demands, and region. In return, energy users can make resources and opportunities available to DER providers, if they have capital and means to manage their consumption.

The core electricity system value pools other than consumption are controlled by incumbent electricity firms by virtue of the functions they have been assigned. With functions such as system operation, energy procurement (retailing), and network operation, incumbent electricity firms have financial resources which they have traditionally channelled toward centralised power plants and network assets (Int-B-98-DER).

A second value proposition DER providers and associated energy users can potentially provide to the system is through alleviation of network constraints, on both the distribution and transmission grids (Int-B-107-IOU). Investment in demand reduction, behind the meter generation or load shifting can replace investment in grid upgrades or extensions, and also free up capacity on the network to enable the connection of generation behind the meter. The revenue generated for this service could come from different parties: energy network operators' budgets directly, or from parties wanting to use the network in a way which the network operator believes will cause a constraint (Int-B-29-DER). The grid upgrades proposed by network operators to enable the connection or network use may exceed the network user's

budget, and DER providers can by alleviating these constraints enable the network user to connect and realise their project.

A third value proposition is available to dispatchable DER from micro-generation and storage units or load shifted[32]. These can, when aggregated, provide energy to anyone participating in energy wholesale markets where MWh and kWh are traded, so that aggregators of power sources and demand response (sometimes referred to as 'virtual power plants' (VPPs)), or customers who produce power ('prosumers') can replace centralised power plants in providing energy (Int-B-22-DER). Electricity is bought and sold like other commodities in bilateral purchase agreements and transparent markets where these were created during restructuring. Both bilateral and transparent power trading happens close to real-time (for instance, day-ahead or hour-ahead) and long in advance (years and months) (Koliou et al. 2014). Energy value can be accessed either through the companies procuring energy (kWh) (Vine et al. 2003), that is competing retailers and network-retail utilities who buy power on their customers' behalf in advance, or through accessing transparent wholesale energy markets directly if these markets' institutional setup allows demand-side participation (Int-B-22-DER).

A difference between unbundled network-operators and network-retail utilities in the US is that the latter, where policymakers decide that they should, act as aggregators of demand-side resources into other markets, such as energy, ancillary service, and capacity markets. This means that customers with on-site resources can access these markets through their regulated-franchise utility, if the market rules allow, and can obtain additional revenues (Int-B-69-DER). In unbundled environments, aggregation

[32] Energy savings are considered 'non-dispatchable' because they cannot be turned up and down, they are active all the time.

services can only be provided by competing entities (e.g., virtual power plants or retailers), not the regulated franchise.

Fourth, dispatchable DER can provide 'system services' (sometimes referred to as 'reserve' or 'ancillary' services), and thereby provide value to System Operators or utilities who have system operation functions[33]. System operators procure these services to balance supply and demand in, or close to, real-time in their assigned territory (Künneke 2008). This value pool is sometimes referred to as 'flexibility' provision because DER respond flexibly in the short-term, like some conventional power plants traditionally have. Depending on the type of service, revenues are provided for energy delivered, or for being available to be called upon by System Operators, even if response is finally not required (Int-B-22-DER).

Finally, DER providers have been able to secure revenues from 'public-interest-schemes'. Lobbying policymakers to make available revenue for their technology or resource has been an important element of building business models for some types of DER. In these instances, DER offer value to policymakers who appreciate qualities beyond the core electricity system requirements which they believe 'markets' (that is customers and competing companies serving them) may not take into account when making investment decisions. To value these 'public-interest' goods, policymakers create mechanisms to express this value and make it accessible as 'public-interest-schemes'[34].

Figure 8 visualises how these value pools are related in the electricity supply chain.

[33] In some jurisdictions with independent system operators, some system balancing services are procured by network-retail utilities on behalf of the SO, e.g., in California (Int-B-69-DER).
[34] Where monopolies procure energy, capacity, and system services, the distinction between what is a public-interest-scheme and what is otherwise directed procurement (i.e. procurement on the basis of more than least-cost considerations) can be blurry.

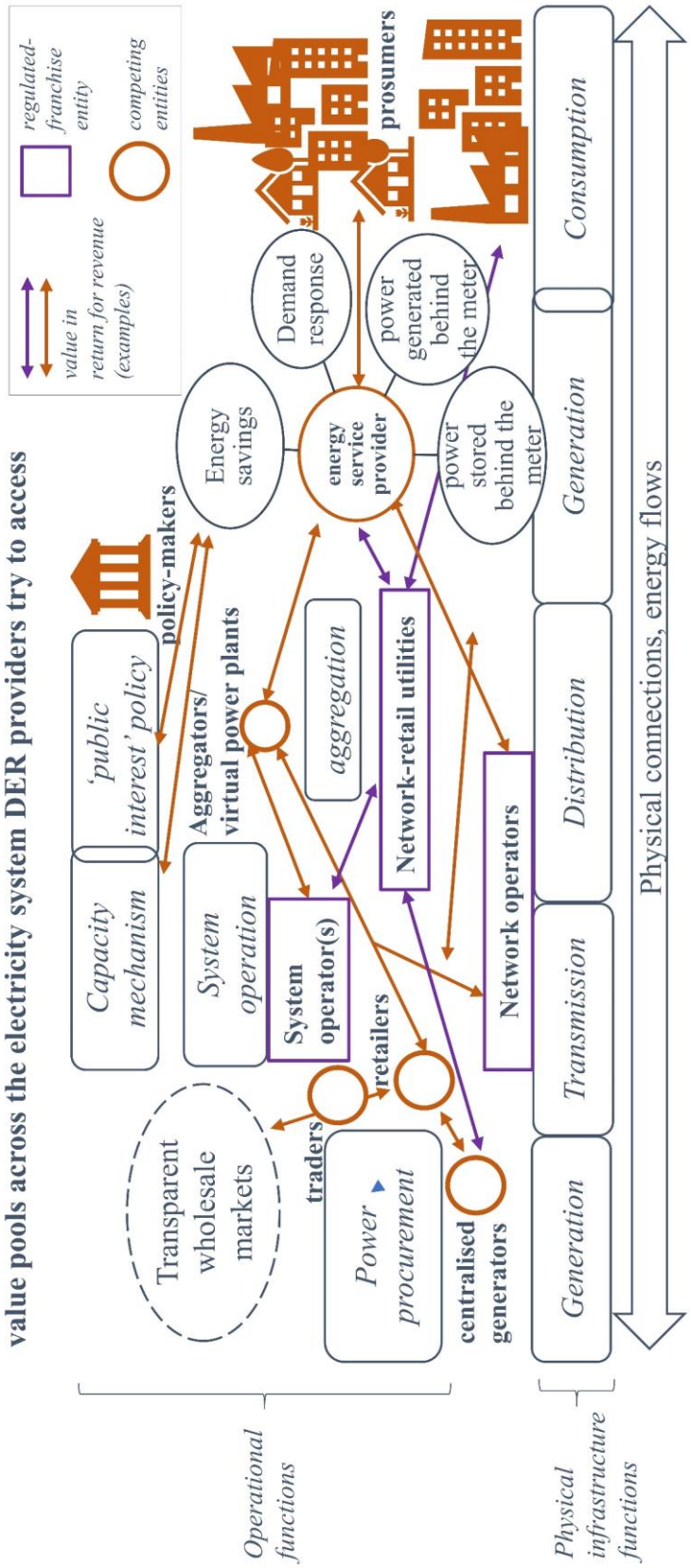


Figure 8: Value pools for DER across the regime, source: the author, based on Int-B-29-DER; Int-B-42-DER; Int-B-98-DER

With a growing role for DER, electricity generation is no longer located on the left only, separated from consumption by networks, but now also integrated with consumption, in instances where consumers are active participants generating their own resources to meet their demand as 'prosumers'. Moreover, aggregation of resources behind the meter is important now as a new function within the supply chain because under most markets' current rules, resources of only few kW or even MW are not eligible to participate in marketplaces or auctions to recover revenue (Doc-20-GTM).

'Public-interest' value propositions have long since been important drivers for DER (Int-B-16-DER; Int-B-32-DER; Int-B-85; Int-B-98) and comprise a wide variety of instruments. Some public-interest-schemes are designed to make revenue available from the budgets controlled by incumbent electricity companies. These incumbents are then obligated by policymakers to make resources and opportunities available to DER by procuring, investing in, or creating revenue streams for demand-side resources. As outlined in Chapter 2, from the 1970s onwards, incumbents had to invest in energy efficiency, demand response, and co-generation based on public-interest-schemes aimed at reducing reliance on imported fuels, negative environmental effects of centralised power plants in the US and Europe. Some schemes were also designed to reduce peak load.

One public-interest value DER providers interviewed explained they were directly targeting is 'capacity value' to policymakers who want to ensure they reach a desired system capacity margin. In some jurisdictions, revenue streams have been created through 'resource adequacy' or 'capacity' mechanisms where policymakers prefer not to rely on power prices peaking to incentivise construction of capacity. DER providers can provide this capacity to the system if they are allowed to participate in the procurement of these resources. Here, DER providers compete with centralised power

plants for revenue. Where they manage to capture value and displace centralised electricity players, they directly challenge the regime.

Some public-interest-schemes are designed to explicitly support specific demand-side resources and technologies, while others are designed more openly, so that various technologies and resources on both the demand and supply-side compete for the revenue available. Where public-interest-schemes have been designed to privilege or 'carve out' revenue for specific types of demand-side resources, DER do not have to compete with supply-side resources. These public-interest-schemes create revenue streams for DER providers to capture by either directly making revenue available (for instance through grants or feed-in-tariffs) or by mandating incumbent players to invest in DER. For instance, renewable energy obligations with DER 'carve-outs' (Wiser et al. 2011) make revenue available for renewable generators behind the meter; building standards mandate landlords to improve building efficiency; and energy saving obligations require obligated utilities to invest in energy savings (Bertoldi et al. 2010). Some schemes, such as feed-in-tariffs, operate as instruments of niche protection (Geels and Schot 2010) by making 'protective space' for the demand-side available temporarily, to enable technologies and resources to develop commercially. Once costs are lower and a supply chain has been established, niche protection may be phased out or reduced, and DER providers must compete with centralised, high carbon resources for revenue from other value pools across the system. Other distributed resources, namely energy savings, have been shown are characterised by more enduring 'barriers' and 'market failures' (Rosenow 2012), so support policies are designed as longer-term schemes.

In building business models, DER providers often look to combine several of these value propositions and revenue streams, referred to as 'value stacking' (Ruz and Pollitt 2016). For some DER developers or investors, the ability to 'stack' various

value propositions and recover revenue from several streams simultaneously is essential, especially where propositions are capital-intensive or operationally costly (Int-B-98-DER).

5.2 DER activities and capabilities

This section explains the range of activities and capabilities that underlie DER business models. Most business models focus on one or a few of these activities. Based on several interviews, the following activities and capabilities within DER supply chains were identified:

- data analysis and management capabilities
- site analysis, design, and prospecting
- installation of measures and potentially maintenance
- material or hardware (manufactured component, e.g. insulation material, storage device, micro-generation unit, retrofittable dispatch device to control a load)
- Contract design and management/ customer relationship
- Control/ dispatch software
- market access, qualification, and scheduling capabilities (for accessing energy, capacity, flexibility markets with aggregated DER)
- Potentially: owner and/or financer, if end-users do not themselves invest capital in the demand-side resource
- to offer a bundled commodity-and-services product, energy procurement to provide 'back-up electricity' (unless the premises is self-sufficient after installing DER)

The activities that pertain to managing energy demand are generally described as energy services. Companies providing planning, installation, consultancy, energy analysis, audits, energy management, maintenance and operation of energy-using equipment, monitoring, and evaluation of energy savings are known as 'energy

service providers' (Bertoldi et al. 2006). Energy services have traditionally been offered to large energy users and building owners by firms coming out of technology or engineering sectors who hence have different core capabilities: subsidiaries of large electrical and manufacturing companies, technical consultancies, engineering and building companies, and smaller technology firms (Kindström and Ottosson 2016). As decentralised energy resources become more widespread also in the smaller business and residential buildings sectors, the range of players who develop DER energy services offerings remains broad (Int-B-38-DER).

Firstly, data analysis and management capabilities allow processing available information on energy consumption and assessing opportunities for and the costs of DER interventions in each instance. Since advances in data analytics technology have enabled the emergence of 'remote energy audits', this capability has grown in importance because analysts can make recommendations on which measures could be adopted without visiting a site (Int-B-116-DER). Granular energy consumption data are key resources needed for in-depth analysis because they allow analysts to disaggregate the consumption of individual processes or appliances, and thereby give recommendations for technological upgrades to reduce or shift demand. These data can be recorded through the main meter or through submetering at the appliance or process-level (Int-B-115-DER).

Having understood a certain type of customer's demand can ease the process of customer acquisition (Int-B-69-DER). Building a relationship with an energy user and motivating their interest in participating or even investing in a DER development on their premises can be challenging. Depending on the value proposition and type of customer, energy users may be more or less motivated to pursue advice on optimising their energy demand through DER (Int-B-65-DER). Marketing the proposition to the

right types of customers is especially important for a DER business model to succeed (ibid.).

Physical site analysis is needed for some types of DER propositions. Energy auditing, prospecting, and planning of measures is required for energy saving interventions that involve changes to a building's fabric (Int-B-61-DER). Depending on how standardised or bespoke a DER measure is, different degrees of site analysis capability are needed. For instance, adding micro-generation or storage units to an energy users' premises requires little analysis and planning, while interventions to reduce industrial energy demands or a buildings' heating and cooling demands require more (Int-B-65-DER). The latter are bespoke measures because the context varies, so greater analysis capability is required and the risks of measures not performing as expected are higher (ibid). Energy saving projects are generally more complex and riskier to implement than *"cookie-cutter assets"* like solar PV units which are standardised, (Int-B-25-EXP). Different energy saving measures also vary in this regard: replacing or upgrading individual appliances or lighting technology may require comparatively little analysis and bespoke planning because the loads can be upgraded fairly independently of the building performance or industrial process as a whole. Demand response interventions also vary depending on the type of process and load to be altered. Some can be easily implemented through retrofitting while others require more bespoke analysis of a users' processes or behaviour (Int-B-34-DER).

Installation of technological assets or energy saving measures are another capability key to many DER propositions. If ongoing operation of physical assets require maintenance, upkeep and installation may be offered by the same entity (Int-B-16-DER). Some micro-generation companies have tried to integrate within one firm installation and maintenance with hardware manufacturing and sales. In the case of US solar-PV companies this approach was not very successful. Several large solar

firms targeting residential customers found that marketing costs were high and that it was difficult to compete with local installers and building companies (Int-A-10-EXP). Therefore, several found that partnering with local installers working across smaller geographic regions was more viable than themselves owning and controlling installation businesses (Doc-17b-Litvak).

DER offers usually also comprise physical and material components which need to be developed, designed and manufactured. For micro-generation and storage units, the development, design and manufacturing end of the supply chain recovers much of the value because the units are technologically complex to develop and often contain high-value materials (Int-B-85-DER). For energy efficiency upgrades that involve changes to a buildings' fabric, this is different: here, on-site planning and implementation requires higher skills and labour costs are higher than when installers implement more standardisable measures like micro-generation and storage (Int-B-65-DER).

Most DER measures require some capital investment on the energy user's premises. For some DER providers, administering the investment is a core part of the business model. It is important in cases where energy uses or building owners don't themselves invest, or where the DER provider has a strategic interest in retaining ownership of the asset (Int-B-52-DER). The capital required could be comparatively small, as is the case for some demand response aggregators retrofitting industrial appliances for load shifting (Int-B-22-DER), or substantial if deep retrofitting measures or costly hardware, such as micro-generation and storage units, are installed.

The design of contracts with end-users defines key elements of the customer interface. In cases where DER providers themselves take on price and, or performance risk, designing contracts can be one of the most complex aspects of building a viable

business model (Int-B-31-DER). Firstly, when the customer does not themselves invest in, own, and take risk for a measure's performance, contracts must be designed very carefully in ways to allow the resolution of conflicts about the origin of performance problems, and these can be challenging to assess (Int-B-65-DER). Another complexity inherent in DER contract design has been reconciling recovery of investment for the investor with building occupier's flexibility to move to other service providers or premises (Int-B-17b-DER).

Capabilities and permissions to access markets and public-interest-schemes are required (Eyre and Lockwood 2016), for business models which rely on revenue streams from players other than the energy user. Access to electricity system revenue streams often requires obtaining licenses and permits which prove that the party recovering the value has the capabilities and systems in place to ensure system integrity, quality of service, and good outcomes for consumers. For some public-interest-schemes aimed at promoting DER, policymakers have deliberately tried to keep qualification processes simple. The aim was to ensure barriers to entry remain low and smaller players and customers themselves can successfully apply and recover the associated revenue (Int-B-16-DER). For scheduling and bidding DER into energy wholesale, capacity and system service markets on the other hand, the right to participate and schedule (aggregated) loads is often more difficult to obtain and requires more complex capabilities and systems (Int-B-79-DER).

Technology to aggregate, control and dispatch small-scale resources is key to DER propositions seeking to realise wholesale energy, system service, capacity, and grid service value streams (Int-B-85-DER). Dispatchable DER, i.e. power from micro-generation, storage, and demand response, can recover revenue from markets where value varies over time and space, but this requires information technology designed to control individual assets to achieve a critical mass of aggregated resources that

respond with precision (Int-B-22-DER). This capability is provided by specialised technology companies which have been growing in importance as digitalisation of the electricity sector progresses (Burger et al. 2017). Where they access a range of revenue streams traditionally dominated by centralised fossil-fuelled power plants, these companies are sometimes referred to as 'virtual power plants'.

Finally, some DER providers seek to build a value proposition covering a building's energy needs entirely, beyond what the distributed resources provide. Unless the site is completely energy self-sufficient following the DER installation, this requires procuring energy from centralised resources on the customer's behalf. Thereby, the DER provider bundles electricity retailing activities with a distributed energy offering. This activity has been described as 'back-up' supply, procuring power either directly from wholesale energy markets and generators, or from retailers to resell to end-users (Int-B-67-RET).

When DER providers design their product to bundle several activities, and construct their partner network, contract, and value proposition such that energy users benefit from DER without upfront investment, this is sometimes referred to as 'energy-as-a-service' (Int-B-31-DER), or 'contracting'. The 'energy-as-a-service' value proposition involves the customer paying for energy or performance from an asset on-site on a subscription-basis. For the DER provider it means financing the asset, but additionally taking on performance and, or price risk. 'Energy contracting' is another term used to describe offerings that involve assuming risk linked to investments in demand-side-management (Int-B-122-DER). Energy contractors, in the literature treated as one form of ESCOs (Marino et al. 2011), may guarantee a certain energy expense, efficiency outcome, or environmental improvement from the measure they have implemented.

'Energy contracting' describes three broad types of offerings (Int-B-122-DER, based the German standard norm 'Din 8051'): firstly, under 'operational contracting', an energy service provider operates a system or appliance on the customer's behalf and guarantees reliability of the system. Secondly, under 'performance contracting', the ESCO guarantees equipment performance, often specified levels of energy saving (Int-B-121-DER). Thirdly, 'energy supply contracting' entails the customer buying a final energy service such as heat, light, or cooling[35].

Table 6 gives an overview of different types of energy service offers and the differences between 'financing' and 'contracting'.

	Financing	**Operational contracting**	**Performance contracting**	**Energy supply contracting**
Description	User pays for measure or asset in instalments	Energy service provider manages and improves a system's operation	Contractor guarantees energy savings or energy use optimisation	Contractor guarantees delivery of energy service at an agreed cost
Technical risk lies with	Customer	Customer	Contractor	Contractor
Operational risk lies with	Customer	Contractor	Contractor	Contractor

Table 6: Types of energy contracting offered by energy service companies, plus financing (based on German industry norm DIN)

All three types of contracting involve bundling several of the core capabilities and activities into one offering from the customer's vantage point: the ESCO needs to take responsibility for planning, implementing, and financing assets or measures. However, only energy supply contracting includes commodity energy (fuel or electricity) (Int-B-121-DER) as part of the offering. Under energy supply contracting,

[35] Energy contracting business models vary substantially, and the literature has in some cases defined energy service contracting in other ways, for instance as 'outsourcing' of energy-related services (Sorrell 2007).

both commodity and demand-side services are provided under one contractual agreement by the same ESCO, so this type of offering is referred to, for the purpose of this thesis, as a bundled commodity-services offer.

Under energy performance and operational contracting, commodity energy is not covered by the agreement and the customer buys fuel and back-up electricity to operate the appliances, the heating, or the cooling system separately. The customer therefore retains the commodity price risk (Int-B-121-DER). In these cases, energy users have separate relationships which greatly vary in length: with ESCOs the contracts can last for several years so investments can be recovered, while contracts with commodity electricity retailers may only last over a few months (ibid.) where there is electricity retail competition.

To sell commodity electricity, some energy service firms with core abilities in aggregation, facilities management, engineering, or building retrofit have acquired the permission to trade in wholesale energy markets and procure power as fully licensed retailers (Int-B-32-DER; Int-B-122-DER). Others cooperate with electricity retailers (Int-B-38-DER) to market their proposition as part of a bundled offering.

Some DER providers seeking to sell to residences and small businesses believe that bundled offers which include financing, commodity energy, and DER measures in one transaction are more attractive to customers than having to manage separate contracts and transactions. This is based on the idea that small energy users do not have the ability or willingness to manage several separate relationships that pertain to energy (Int-B-17bDER; Int-B-31-DER; Int-B-38-DER). For instance, one retailer interested in financing residential lighting upgrades with LEDs and smart thermostats argued that these propositions would need to be bundled with commodity electricity

to make them viable with households. The aim was to recover the investment costs from the commodity energy bill in a single transaction:

> *"Creating two financial transactions - one that is pure cost and one that is getting lower because of the technology is problematic. If the implications of the technology to my energy bill aren't made clear to me - a lot of people don't have the nuanced understanding to relate those two items. Households are not like C&I customers who have energy managers"* (Int-B-67-RET).

Many DER developers targeting residential energy users are therefore trying to bundle DER with commodity electricity. In the commercial and industrial ESCO sector, the ability to bundle commodity with services is viewed as less important because customers are perceived as sophisticated enough to manage separate relationships, pertaining to DER and to commodity electricity (Int-B-67-RET).

5.3 Customer interface: utility-facing or energy user-facing strategy

The 'customer interface' describes several features of a business model defining how a company relates to its customers (Osterwalder et al. 2005). The following section presents some core differences between DER strategies in this respect which emerged from interviews. Firstly, there are several possible customer channels through which a DER provider initially reaches and potentially acquires a customer who will invest in or host a DER asset. A second part of the customer interface is the 'relationship' which describes how firms interface with their customers on an on-going basis (ibid.).

All four types of DER considered, energy savings, micro-generation, demand response, and storage, are applicable to a wide range of energy end-uses, buildings, and processes. Therefore, various customer segments are suitable for DER providers to target, for example building developers or owners (landlords), energy end-users in

residences and small businesses, or industrial and commercial end-users with large consumption and sometimes specialised processes to power. With varying capabilities and characteristics, newcomer firms initially find some customer segments more suitable than others. Once a concept has been proven, niche players may attempt to scale beyond the initial target customer if they believe their proposition is realisable in other customer segments with different energy demand characteristics and facilities (Conf-7).

A key difference between DER newcomers' strategies to build business models is that some choose to market their products or propositions using their own brand while others try to use other firms' brands already established with customers. Incumbent electricity firms are one type of player several DER newcomers have targeted as suitable business partners to market their solution. Electricity retailers and network-retail utilities have brands and customer relationships already in place and can therefore help newcomers build a customer interface. In these cases, newcomers take a more cooperative than challenging approach to interaction with the regime, and incumbent electricity firms are key players within the network they are seeking to construct. These differing strategies were described as 'utility-facing'[36] or 'customer-facing' (Int-B-85-DER).

The utility-facing strategy is common among DER newcomers without already established brands and customer channels, especially those targeting small energy users. One demand response firm interested in aggregating residential loads as a VPP explained that they prefer working with electricity retailers with already established customer relationships, rather than having to recruit thousands or millions of residential customers whose load responses from household appliances they would

[36] 'Utility' is used to describe the entity selling power to end-users, i.e. retailers or network-retail utilities.

like to aggregate. *"Once our contract to provide system operator services is in place, in the end, we just want to scale our technology"* (Int-B-62-DER). 'White-labelling' allows one party, in this case the retailer, to offer an energy service proposition under its own brand, while the technology company, in this case, the demand response aggregator, operates behind the scenes. For a newcomer VPP without an established brand and customer channel, having to themselves recruit residential customers would make scaling up their proposition prohibitively costly (ibid.). There are also some solar-PV, battery and 'smart home' solution firms who prefer the 'utility-facing' strategy as compared to competing head-on with established names. *"Companies like Mercedes and Tesla have brands, that's their selling point, people recognise them, so they will go to customers directly (...) so we prefer to be utility-facing"* (Int-B-85-DER).

Other companies enter the electricity sector with the aim to build strong brands, for example Solar City and Tesla. With a 'customer-facing' strategy they themselves recruit energy users as buyers or leasers of their technology, or market through local installers, appliance stores, or energy service companies who sell several brands (Int-B-16-DER). They have had substantial success with the customer-facing strategy in building *"disruptive (...) customer loyalty"* that *"rivals that of Apple or Amazon"*, according to some analysts (Doc-17a-Utility-Dive). Thereby, these DER companies with strong brands take over the role incumbent electricity companies or brokers had in becoming trusted 'energy advisors'. This means that DER players are now challenging incumbents' established roles and their customer relationship around 'energy' (Int-B-82-IOU).

But also some DER providers without a valuable 'customer-brand' find a customer-facing strategy preferable. Firstly, firms targeting large industrial and commercial energy users require fewer customers to grow projects to profitable scales and

therefore have lower customer acquisition costs than companies targeting small energy users (Int-B-32-DER). Marketing directly instead of cooperating with an electricity retailer allows to keep more revenue for themselves (Int-B-122-DER). Secondly, sales of more complex energy efficiency services (ibid.) or a demand response offering tailored to an industrial process require expertise to build trust, and this can be challenging for electricity retailers without specialised staff (Conf-6). The complexity in installation and operation of these more bespoke DER propositions requires expertise to ensure high-quality outcomes (ibid.). Therefore, partnering with electricity companies to use their customer channels has worked less well for complex measures than in cases where installation and implementation are more standardised.

5.4 Regime resistance: DER newcomers' barriers to building business models

A variety of regime-level practices and institutions prevent an accelerated transition of electricity systems to rely more on demand-side resources. DER niche players described barriers as difficulties in accessing markets, constructing commercial networks, and building business models. Different types of DER newcomers have varying capabilities and strategies, and therefore perceive a range of barriers.

DER newcomers explained that incumbent electricity companies are responsible for making opportunities available in some instances, and at the same time, actively oppose the decentralisation of the regime. Sometimes, tactics fall within incumbent companies' scope of commercial activity based on the roles and responsibilities they are assigned as part of the institutional setting. At other times, tactics include influencing regulators and policymakers and public policy reform processes. Influence is discursive, for instance when incumbents frame newcomers as

incompetent (Conf-11). It is also material, for instance when incumbents use their superior resources to research and propose public policy changes, or to influence decisions on industry standardisation panels. DER newcomers in some cases argue that regulators and policymakers have been captured by incumbents (Int-B-112-DER) or are overly cautious and scared of change (Int-B-29-DER).

5.4.1 Access to and conditions in energy, capacity, and ancillary service markets

Many promoters of demand-side resources targeting energy, capacity, and ancillary service markets have protested that institutions which organise how these revenue streams are accessible are biased in favour of centralised, conventional electricity generators (Doc-18-Beasley; Int-B-22-DER). On the one hand, this is institutional lock-in and inertia based on the fact that these markets and system operator procurement mechanisms were originally designed for large generators (see also Strbac 2008). On the other, some niche-players argue that incumbents actively oppose reforms that would allow demand-side resources to benefit (Int-B-61-DER). DER aggregators lament that market access is entirely foreclosed, that reforms to allow access are being progressed at too slow a pace, or that where participation is formally allowed, access requirements and conditions for demand-side resources makes participation so costly that building a business model around these revenue streams is impossible (Int-B-22-DER; Int-B-34-DER).

Moreover, when newcomers cooperate commercially with incumbents, in many instances these prefer to channel the resources they control towards centralised generators and network assets (Int-B-69-DER; Int-B-34-DER). For instance, in Britain, generators behind the meter have long since had difficulty accessing

electricity wholesale markets. For many years, most of the power was traded bilaterally between vertically integrated gen-tailers' generation and retail companies (Int-B-112-DER) (see also Bolton and Foxon 2013; Hall and Roelich 2016). This meant that markets were illiquid, so that combined-heat-and-power generators could not easily sell their output. This situation only recently improved through intervention by the regulator to improve market liquidity (DOC-23-Ofgem).

Network-retail utilities in California have been accused of being conservative in their demand response dispatch strategies, privileging the dispatch of supply-side resources. They run demand response programmes, aimed at reducing reliance on fossil-fuel resources. Here, customers willing to have their demand controlled automatically when called upon, are paid for being ready. Network-retail utilities can bid these demand-side resources into wholesale energy and system service markets run by the SO, alongside the supply-side resources they have contracted for. Investor-owned network-retail utilities in California have been accused of calling on residential customers less frequently to reduce demand than the demand response companies who would receive additional payments from the dispatch believe is acceptable to customers (Doc-26-Hawiger). This means that in these instances, power from centralised generators is dispatched instead.

Some competing retailers have also not procured demand-side resources to balance their portfolios, where these are available at arguably lower cost than supply-side resources. DER aggregators have found it difficult to come to mutually beneficial agreements with electricity retailers. One British demand response aggregator explained that retailers serving commercial and industrial customers recognise *"many benefits"* in cooperating, but that with *"suppliers' margins being so tight, and us threatening those margins by getting into the balancing mechanism, they're quite public about"* the fact that suppliers' and aggregators' interests are not aligned (Int-

B-22-DER). Because negotiations between retailers and DER aggregators often stall, the demand response industry at EU level has demanded public policy change to standardise agreements, to enable demand-side aggregators to access energy markets independently from commercial negotiation with electricity retailers who are often competitors (Doc-25-Thies). In the residential customer segment in some jurisdictions, there may not be enough pressure on incumbents to innovate. For instance, the British Competition and Markets Authority suggested that incumbent gen-tailers who were assigned default energy customers are not under enough competitive pressure to reduce their cost base. Therefore, they may not be incentivised to procure demand-side resources by partnering with demand-side aggregators or customers directly, even if these resources would come at lower cost than procuring power from conventional power plants (Doc-24-CMA)[37].

An alternative for newcomers under electricity retail competition is to themselves qualify as retailers, but some DER providers have complained that the prequalification procedures and ongoing compliance requirements are prohibitively cumbersome and costly. Regulations so far meant that companies had to take on the role of a fully qualified trading party to independently bid energy into wholesale markets[38]. To gain access to energy wholesale markets and become fully qualified, for example as retailers, newcomers need to go through authorisation procedures and demonstrate key capabilities and systems are in place. *"The main barrier is cost - so much money and paperwork. Unless there is a very clear business incentive, [it's a too] risky*

[37] Since 2019, the energy regulator caps most default electricity retail offers (standard variable tariffs), following UK legislation in 2018, so that pressure for retailers to reduce their cost base may increase.
[38] These roles have different names across jurisdictions, in GB for instance the 'the balancing mechanism unit', in the EU a 'balancing responsible party', or in California the 'scheduling coordinator'. Reforms are ongoing in both the EU and US states to create new types of authorised market roles to allow demand-side participants independent access to wholesale energy markets. E.g., in the EU, national regulatory bodies are implementing rules developed at EU level under 'project TERRE' to allow demand-side aggregators access to the balancing mechanism with fewer obligations and rights (Doc-19-Elexon), and in US states similar proceedings are on-going (Doc-20-St. John).

game" and comes with a *"whole load of responsibilities"* (Int-B-22-DER). Costs are high because, for instance, wholesale energy trading parties must guarantee adequate credit cover or capitalisation in Europe and the US, to demonstrate the ability to manage energy market risks. This can pose barriers to entry for newcomers, especially those not affiliated with well-resourced mother companies (DOC-21-Ofgem). The British regulator also acknowledged that the number of rules and regulations creates barriers for newcomers: the system *"is overly complex, with the entirety of the codes estimated to run to over 10,000 pages and weighing 50kg. This is a barrier to new entrants and to innovation"* (DOC-22-Ofgem).

Despite high barriers to entry, some DER companies have taken on the cost and effort to register as fully qualified trading parties (e.g., EnerNoc in the US, or Limejump in GB). Some DER newcomers have specialised in bidding demand-side resources into wholesale energy and ancillary service markets as virtual power plants (VPPs) and help other DER providers access these revenue streams (such as NextKraftwerke based out of Germany or Olivine in California).

Incumbent electricity players invested in conventional generation assets have also in several cases tried to limit competition from demand-side resources through discursive and legal tactics. One successful case was the design of the British capacity mechanism. Following heavy lobbying by incumbent electricity generators and gen-tailers against measures that would have supported the demand-side, detailed specifications of the capacity mechanism design were adopted which considerably disadvantage demand-side resources (Lockwood 2017). In consultation processes running up to the Energy Act 2013, incumbent electricity gen-tailers and generators decried demand-side measures as less reliable resources which should be remunerated less generously than power generators (ibid.). Demand response companies have criticised the British capacity mechanism, for example for granting guaranteed

revenues for 15 years to newly constructed generation plants successful in the auction, while demand response providers receive only 1-year contracts (Doc-27-PA-Consulting). Another policy proposal which could have supported demand-side response at the expense of conventional generators was to consider the carbon content of resources (Lockwood 2017). Again, GB incumbents successfully lobbied to exclude this provision from the public-interest-scheme (ibid.). Energy demand reduction was also largely excluded (Liu 2017). The GB capacity market design was after its inception heavily criticised and legally challenged by demand response representatives (Lockwood 2017).

In the US, centralised power generators have also actively restricted revenue opportunities for demand-side resources available from energy and capacity markets. The US federal energy regulatory commission (FERC) with jurisdiction over electricity trades across borders in 2011 ruled in favour of demand response providers that load reduction clearing in wholesale electricity markets should be compensated at the same rates as if this demand had been met with electricity generated ('Order 745'). After incumbent generators had lobbied their case unsuccessfully ahead of the FERC decision, the lobby group Electricity Power Supply Association, representing some of the largest competitive electricity generation companies in the US, legally challenged this decision, on the grounds that the federal regulator did not have jurisdiction over electricity retail markets (Doc-28-Walton). The US Court of Appeals in D.C. in 2014 sided with the generators, ruling that demand-side resources were being unfairly compensated if paid the full locational marginal price (ibid.). This resulted in the loss of tens of millions of dollars' worth of revenue for aggregated demand-side resources (ibid.).

In both these cases, supreme courts eventually took decisions against incumbent electricity generators. The European Court of Justice deemed the GB capacity market

unlawful in 2018, and the US Supreme Court ruled in favour of FERC on Order 745 in 2016. However, both examples of incumbent regime players resistance to protect their own profits led to several years of legal uncertainty, limiting opportunities and resources available to demand-side aggregators and their customers.

Incumbent electricity generators and gen-tailers have also used tactics to delay institutional change to wholesale electricity markets, to protect their privileged position from challengers. In Britain, the six large gen-tailers dominating electricity generation and retail markets have successfully dominated the multilateral agreements known as 'industry codes' which were delegated to industry players in a system of 'self-authored regulation' (Lockwood, Mitchell, et al. 2017). Several interviewees reported instances of large incumbent electricity companies blocking reforms that would improve the environment for DER, using their advantage in terms of specialised knowledge and staff resource (Int-B-52-DER; Int-B-34-DER). One interviewee remarked that even lobbying for policy change was risky sometimes because incumbents have enough control over complex code reform process to delay change:

> *"as soon as it goes to a [balancing and settlement code] panel member, you've now raised the profile of something, and unless you know that it's going to get through, it's an opportunity for Centrica or somebody to kick it into the long grass and make sure that it won't anytime soon"* (Int-B-52-DER).

Blocking changes served to either bolster centralised generators' and gen-tailers' competitive advantage over decentralised resources, or at least keep newcomers from developing viable business models before the incumbents could themselves create equivalent offerings.

System operators as single buyers of balancing and system services have also been accused of withholding resources and opportunities from DER aggregators through

the institutional rules that organise their procurement mechanisms. As one British demand response aggregator stated, *"everything is designed for centralised generation, like DRAX, but not for companies like us. It totally supports them, and that's not radical to say, just a fact"* (Int-B-22-DER). For instance, requirements to commit large volumes or capacities, up to several MW to participate in tenders create barriers for aggregators of smaller loads (Koliou et al. 2014). Other barriers were linked to response times and availability windows in which resources contracted to provide a system service were expected to guarantee delivery (Int-B-22-DER). Moreover, measurement and verification systems required to provide services to SOs were reported are too costly for individual small units like residential-scale battery applications, for instance, in GB (Int-B-52-DER). Aspects of these rules as specified in tenders and contracts have been unsuitable for DER firms, and while reforms are underway in many jurisdictions (see e.g., Doc-72-National-Grid), several interviewees stated that reform processes are too slow and require dedicated lobbying efforts (Int-B-39-EXP; Int-B-32-DER; Int-B-43-DER). Independent system operators in the US have been described as conservative and their regulatory processes as slow to change (Int-B-69-DER). Some European system operators integrated with transmission have been accused of deliberately protecting the competitive advantages of centralised generators to improve profitability of their transmission network assets (Conf-6).

Another barrier reported was that different regime-level players and markets were not harmonised, and regulatory regimes often do not allow easily 'stacking value' in order to achieve economies of scale across value pools and regions (Int-B-61-DER). For example, in Europe, information on an end-users' site needs to be provided in separate procedures and formats, so customers with the ability to provide a variety of services to the system find it administratively costly to access revenue from different ancillary

service auctions, capacity markets, and potential network operator services (Int-B-112-DER). The customer with demand-side resources wants to say,

> *"I can over-rate my CHP plant for 30 minutes to provide local system requirements (…). My battery has a maximum generation time of x hours, and also can provide this rate, this amount of change of frequency response"* (Int-B-112-DER).

Rather than having to apply for the capacity market separately from the System Operator's Frequency Response service, and again separately from the local balancing options to the distribution grid, *"all of this information should be put into one place. They're all asking the same questions in different ways, so administratively it should be simpler"* (ibid.). Moreover, DER providers have called for harmonisation of measurement and verification procedures including baseline calculation and metering equipment specifications to enable easier scaling across jurisdictions and value pools (Int-B-61-DER). Another example is the limited harmonisation of distribution network rules and pricing across the many hundred small distribution network operators' regions in Germany. This range of rules across regions an expert argued has made it difficult for innovative DER business models to achieve economies of scale because the transaction costs of redesigning offers for every network operator's region is high (Int-B-36-EXP).

Finally, value stacking is limited in several jurisdictions by regulators' and policymakers' scepticism of allowing some demand-side assets to contract with more than one party for reliability reasons. In the US, especially battery companies have protested that they are offered contracts conditional upon the asset providing services exclusively to the SO or the local network-retail utility (Conf-2; Int-B-85-DER). Regulators and utilities *"don't understand that batteries are more reliable than demand response, so we need to be treated differently"* (Int-B-98-DER), one company

demanded. The scepticism toward multiple commitments for battery assets is perceived as a barrier to growth for storage in front of and behind the meter.

5.4.2 Tariff design for commodity electricity and network use

Several DER providers and experts explained that the design of commodity electricity tariffs is a key institutional battle ground, where incumbent electricity firms try to protect the profitability of centralised generation and network assets to the detriment of DER (Int-B-29-DER, Int-B-80-DER; Int-B-85-DER; Int-B-64-MUN). The design of tariffs energy users are charged for electricity delivered through the grid influences the economic benefits recoverable from demand-side management, and whether a DER provider's proposition justifies investment. Rates varying in time offer opportunities for load shifting and storage assets. Additionally, the prospects for DER are affected by the balance between fixed cost elements (often 'capacity' or 'demand' charges), and variable cost elements that vary with the overall volume used (Vine et al. 2003). The higher the fixed cost element of an electricity bill, the lower the scope for demand-side resources to reduce the overall energy cost (Int-B-80-DER).

Some DER players believe they would benefit from more cost-reflective pricing of network use and energy consumption. Several interviewees criticised that centralised generators managed to capture regulators to prevent policy change that would lead to price signals more accurately reflecting system costs. For instance, one interviewee argued that, although *"regulators are interested in cost-reflectivity, (…) big electricity generators manage to persuade the European Union to limit the cost of access to a power network at €2.50/MWh no matter how much the network costs"* (Int-112-DER). This showed that these incumbents manage to *"lobby for things that are not in the*

interest of customers" but benefit incumbents. These rules allow centralised generators to bid into power, ancillary service, and capacity markets more cheaply than if network tariffs reflected costs, and therefore, these network tariffs disadvantage the demand-side (ibid.). In some jurisdictions, regulators have instated some cost reflectivity in network charging that varies over time and geography. However, some DER providers argue that these price signals are not granular enough, and do not allow building business cases around load shifting, micro-generation, and storage (Int-B-42-DER). Several DER companies have called for completely cost-reflective pricing of the network that would price in also the cost of energy supply in a system of 'nodal pricing'. This would allow investors and developers to see where investment on the demand and supply-side could be most beneficial to the network to alleviate local constraints (ibid.).

Another key driver of system cost is overall peak demand for energy. Here too, cost-reflective pricing to pass signals on to energy users can provide opportunities for investment in demand-side management, and incumbents have been accused of resisting these. For large business customers who could themselves see value in time-varying offers, competition between retailers did lead to these tariffs emerging. However, small business' and residential energy users' energy consumption is important for peak shaving in many countries, and they remain on flat tariffs that do not vary over time.

One demand response expert explained that electricity retailers operating as vertically integrated gen-tailers with conventional fossil-fuelled peaking-power plants have heavily resisted the introduction of peak-time pricing in several European countries (Int-B-61-DER). This entailed both lobbying against regulated default tariffs being transitioned to time-of-use tariffs and ensuring that their own tariff designs would not encourage reducing demand at peak-time (ibid.). While some policymakers

considered mandating these options, any tariffs which encouraged shaving electricity system peaks have been opposed by integrated gen-tailers because this would directly hurt the conventional generators' profits (Int-B-61-DER). *"The CEO's fiduciary responsibility to his shareholders means he is legally not allowed to lose money there (…) so vertically integrated retailers will never do this"* (Int-B-61-DER). Network-retail utilities have also lobbied against having to offer time-varying pricing, for instance recently in California (Int-A-11). This shows that central-station managers of investor-owned utilities still prefer average pricing to more cost-reflective varying pricing (Yakubovich et al. 2005), as discussed in Chapter 2 was the case when electricity systems first emerged. One expert hypothesised that investor-owned network-retail utilities

> *"probably saw [time-of-use-pricing as] being a contributor to their decline as a stable revenue producing industry. (…) The concept of dynamic rates (…) would cause customers to use energy more efficiently, it would allow (…) customers a much better economic case"* (Int-A-11).

As a result, time-varying tariffs are available only for large industrial and commercial customers where retailers face competition, unless policymakers have intervened to force electricity retailers and regulated-franchise utilities to offer them. Therefore, some DER providers believe they and their customers have been denied opportunities to realise savings and build economic propositions around load shifting and storage.

Furthermore, regulated-franchise utilities in the US have lobbied for fixed-cost tariff elements that would reduce the economic opportunities for DER (Doc-29-Trabish; Int-B-80-DER). California IOUs call for fixed charges which energy users cannot bypass or influence, independent of how much grid electricity they consume, and when. They frame these charges as a solution to the problem of inequity between customers, following the growing adoption of rooftop solar-PV systems (Conf-1-Payne). Under tariffs which recover most costs on a volumetric basis, energy users

with micro-generation (and storage) installed contribute less to the recovery of fixed costs incurred by franchise utilities on behalf of all connected customers than customers without generation behind the meter (Doc-29-Trabish) who happen to be customers on lower incomes (Conf-1-Payne). Rooftop solar industry representatives challenge that *"there's no evidence to justify (…) fixed charges"* in California (Doc-29-Johnson) and that network-retail utilities are unwilling or unable to recognise the benefits the distributed generators bring to the grid and thereby indirectly to all customers. States where policymakers agreed to introduce higher fixed charges are less accessible to DER providers, or entirely inaccessible, unless this disadvantage is offset by other public-interest-incentive schemes (Int-B-80-DER).

Furthermore, US regulated-franchise utilities have heavily opposed public-interest-schemes that remunerate electricity generated on customer-premises at the retail rate for electricity fed into the grid ('net-energy-metering'). These tariffs were introduced in many US states to promote solar-PV behind the meter and have been an important driver of solar-PV on rooftops where implemented. Regulated-franchise utilities have long since lobbied for reforms to these rates (Doc-31-St. John). In 2017, the majority of respondents to a US-wide survey among electric network utility executives said that rooftop solar-PV in their region should be compensated less generously than at the retail rate: either not all (9%), at wholesale energy market rate or other avoided cost of generation (35%), or at the retail rate minus grid usage fees (24%).

> *"This position highlights a common utility argument that they should not pay more for distributed generation than they would for power from a central-station solar array or any other power plant"* (Doc-30-UtilityDive : 53).

A large majority of utility executives also expressed scepticism about location-based solar PV compensation rates based on no state having so far found a functional

mechanism for locational DER remuneration (ibid.). These positions once again pitted the IOUs against the demand-side niche players in debates about regulatory reform.

5.4.3 Network connection

The costs and procedures related to connecting to the electricity network have been described as another barrier for DER companies. Electricity network incumbents were reported to use their power specially to impede demand-side generation projects. One US-based mini-CHP manufacturing and servicing firm explained, *"for me, the hidden battle is interconnection! Nobody talks about that"* (Int-B-80-DER).

For instance, there have been cases of distribution-network-operators delaying network connection of microgeneration units arguing that detailed testing was required to assess network capacity (Int-B-88-MUNI). Solar advocates in Germany for example declared that the network operators were systematically stalling connection to 'bully' small installers and their customers and that the delays were disproportionate to the size of a small installation on a single rooftop (Doc-33-SFV). Regulation in several jurisdictions has since mandated that installations of only a few kW in size shall be treated as immaterial and not be subject to as lengthy network connection procedures as larger installations.

A similar tactic to slow down the installation of generation behind the meter was reportedly the requiring of complex and costly technical standards to authorise equipment for connection. For example, California introduced 'simplified interconnection' for power generation units behind the meter in 2000 to reduce costs and the need for several-month-long review and testing processes for pre-certified devices ('rule 21'). However, when designing the standards, one of three IOUs,

PG&E, reportedly required a costly relay device designed to reduce disturbances to the grid which would have greatly increased costs for each installation (Int-B-80-DER). According to an interviewee, this meant smaller micro-cogeneration equipment manufacturers, without the means to upgrade their technology accordingly or to legally challenge the incumbent, could not be pre-certified for faster interconnection (ibid.). While larger micro-generation companies and the solar industry *"with a lot more political clout"* managed to negotiate exceptions and changes, striking compromises with the utility, *"most types of cogeneration were left out"* (ibid.). PG&E went even further in obstructing cogeneration reportedly: After changing to fit the utility's requirements, this manufacturer was told that the utility was *"too busy"* and could not find the time to approve their units for simplified connection. These reports demonstrate the various political and operational tactics through which regulated-franchise utilities purportedly obstruct interconnection, to the detriment especially of DER providers with little political power to mobilise regulatory support for their cause.

Where grid operators believe that the electricity network will need upgrading to accommodate a new power source, there have also been conflicts about how the cost of upgrades should be shared between customers and DER company demanding the connection, and all other customers who pay for the network (Int-B-21-DNO). Some DER companies see the requirements to pay for or even contribute to network upgrades as unfair, given the benefits they claim they are providing to the system overall (Conf-8). Some believe they are not being rewarded for these system-wide benefits adequately.

5.4.4 Lack of or limited access to data

Another key barrier many DER providers cite is the limited access to data, both on the electricity network, and on customers' energy consumption (Int-B-105-EXP). There are a range of issues niche players argue hamper the adequate access to data. Firstly, DER providers in several jurisdictions have called for more data at a greater granularity to be made accessible by the incumbent companies managing them to third parties. Secondly, some DER players require advanced metering to be invested in widely before they can build their proposition, and this has not been available in all jurisdictions. Other DER players have had the opposite problem: they would like to use their own monitoring equipment but incumbent metering providers, in this case network operators, oppose this. Fourth, the design of technical and commercial standards underpinning the collection, storage, and transmission of customer data have not accommodated all use cases, which some DER providers have argued poses barriers to successful business models. Finally, some DER providers have explained that lack of standardisation of metering specifications furthermore made building a scalable business more difficult.

Firstly, access to data held by incumbents has been a key concern. DER providers argue that access to these key resources is withheld unduly, preventing demand-side resources from displacing centralised resources on the system (Int-B-98-DER; Int-B-115-DER). Incumbents use both lobbying on public policy and operational room for manoeuvre within interpreting their obligations under regulations in place to limit data sharing.

Customer data are controlled by incumbent providers of energy procurement, billing, and metering who have privileged access and can make information available, usually once customers have consented. The holders and managers of customer energy data

are, depending on the jurisdiction, electricity retail market design in place, and energy users' own choices, retailers, network-retail utilities, independent billing providers, or otherwise appointed metering data managers. The data on energy users, their demand, appliances, and facilities are valuable to DER companies interested in identifying suitable end-users to host their proposition (Int-B-69-DER). While customers have the right to share their data with third parties in principle, in practice incumbent electricity companies have been accused of delaying granting access. One demand response aggregator explained that especially ESCOs interested in offering efficiency advice were finding it difficult to access customer consumption data:

> *"we see that retailers don't like it much, that other companies can access data around what the consumer is doing. They usually fear that this will somehow interfere with what they are doing as a utility. They like to have a privileged relationship, even though they don't do much with it. They don't know what it will be for, but they want to keep it"* (Int-B-116-DER).

Regulated-franchise utilities in the US were similarly protective. One interviewee developing distributed-energy-resource-management software for utilities argued this was because *"they will never do anything that would empower the customer"* (Int-B-89-DER). A demand response aggregator competing with US regulated-franchise utilities for customers complained that utilities were obstructing third-party access to energy consumption data because it gave them an informational advantage for targeted recruitment, based on their visibility of customers with high consumption at peak-time (Int-B-69-DER). Policymakers in several cases have intervened. For instance, the US federal and state governments have tried to promote easy customer data access through the 'green button initiative' (Doc-34-OpenEI).

Data on electricity *networks*, including on projected load growth and areas of expected congestion are collected and managed by grid operators for purposes of network asset management and investment planning. These data are valuable for DER providers to

understand where they will be permitted to install distributed resources (hosting capacity), and where in the future there will be opportunities for value capture, once revenue mechanisms for 'non-wires-alternatives' are established beyond trial phase. Knowing how distribution grids are developing enables to project where DER providers could be rewarded for helping grid operators manage constraints and defer investment in conventional network upgrade measures (Conf-1).

Regulators in many jurisdictions have intervened explicitly to improve data access for third parties including promoters of DER, after newcomers accused incumbent electricity companies of withholding access to these key resources. For instance, following state legislation in 2013, the California regulator specified that from 2015 onwards, utilities must share information on feeder-level conditions such as

> *"coincident and non-coincident peaks, capacity levels, outage data, real and reactive power profiles, impedances and transformer thermal and loading histories, and projected investment needs over the following 10 years (…) in as near-real time as possible"* (Doc-35-St. John).

Since then, DER providers have complained that these data have not been shared at all, not in easily accessible formats, or not to the required granularity and speed (Doc-35-Hanley). One interviewee argued that the modelling underlying distribution grid investment was not managed openly and the information not available: *"utilities have a monopoly on D-grid modelling, nobody can say 'we could have done it more cheaply than putting this new transformer here'"* (Int-B-89-DER). In these ways, challengers argue incumbents seek to protect the status quo and their centralised regime from behind the meter competition.

Incumbents frame their privileged monopoly role in managing data and analysis as justified based on their nature as 'public service' providers with responsibility to

protect customers and the system. When a DER representative challenged the chief executive of Southern California Edison (SCE), he replied,

> *"it really presents a balancing act. On the one hand, we understand the hunger for data, and what it means for the folks (…) in how they target their efforts to get customers to make the kind of decisions that we all need them to make. One the other side, (…) the utilities have an obligation to protect customer data, personal data, critical infrastructure data that might be a way for someone to create harm to the system if they had it, also market sensitive data (…). How can we provide enough data so that people can get what they need (…) without (…) giving out data that we really should be protecting for the greater good?"* (Conf-1-Payne)

The utility executive agreed also that 'stakeholder input processes' should be designed to give people confidence in the utility's decisions. However, he firmly asserted their own right to a monopoly position: *"I don't think we need to turn all the different DER providers into utilities for duplicating our planning processes"* (ibid.). This position is disputed by DER providers who demand transparency and hope to recover revenue which utilities otherwise invest in conventional distribution and transmission network infrastructure.

Furthermore, in some jurisdictions, a lack of advanced metering infrastructure has stalled some DER business models. These DER businesses relied on more detailed energy consumption data and needed advanced metering to be invested in before they could realise their offering, for instance for monitoring demand response (Int-B-69-DER), for varying tariffs to justify investment in on-site storage (Int-B-16-DER), or for giving energy efficiency advice on the basis of detailed energy consumption data (Int-B-115-DER). These tended to be companies with propositions to small-scale energy users. Companies targeting large, sophisticated energy users rarely found that metering was a barrier because in many cases, advanced monitoring infrastructure was already in place, or the scale of a demand-side project was sufficiently large to justify investment in a system of the appropriate quality (Int-B-122-DER). DER providers

seeking to offer value to end-users by reducing overall demand for grid-electricity or improving reliability did not find a lack of advanced metering problematic (Int-B-85-DER).

Where policymakers decided to invest in advanced metering to encourage innovation and demand-side resources, some DER providers criticised that the meters' specifications and capabilities were inadequate. One complaint was that systems were designed to record consumption, receive signals, and transmit information at too slow intervals or speeds than needed for faster responding system services, loads and power sources (Int-B-85-DER; Int-B-116-DER). Others complained that the capabilities to communicate between devices within a customer premises had not been activated by the incumbents operating the meters (Int-B-89-DER). Furthermore, for some applications, even advanced electricity meters do not provide high enough data quality because of measurement gaps and errors (Int-B-115-DER). These features of the metering infrastructure meant that some DER providers with specific requirements could not benefit from mandated advanced-metering-roll-out-policies (ibid.).

Some interviewees who preferred using their own monitoring capabilities reported that incumbents had tried to impede their progress by trying to force any newcomers to use only the incumbents' meters as legitimate monitoring equipment. In these cases, incumbents try to ensure they retain visibility and control of key functions within the system, so that DER providers continue to be dependent on them, while newcomers seek to challenge them independently. One European demand response aggregator explained,

> *"the DNOs have been fighting to avoid that DR aggregators would be able to use data collected from their own equipment, and they were saying that it wasn't reasonable data to use because it was not 'official', only because they were the ones collecting the data".* Although monitoring did not need to meet the same legal requirements as for billing purposes, *"they were*

> *desperately trying to put this in the same box as the billing data (…). We sell most of our demand response to the TSO or the wholesale markets, so we don't need DSOs most of the time. It's quite legitimate regarding the congestion perspective that they want to look at the data and have a seat at the table but we don't need their equipment and they don't like that"* (Int-B-116-DER).

Similarly, IOUs in California in regulatory proceedings heavily resisted arrangements which would allow electric vehicle companies to use their own metering, against which utilities would then bill for electricity consumed (Int-A-11-EXP).

Finally, another barrier to building and scaling business models on the demand-side has been the incomplete standardisation of communication protocols and technical specifications of advanced metering systems across regions and customers in some jurisdictions. When metering systems have different specifications, this creates greater transaction costs in accessing customer data, as compared to where common standards are adopted (Int-B-43-DER). For instance, in Denmark distribution network operators rolling out advanced metering did not coordinate sufficiently, so that meter specifications were not uniform across regions (AlAbdulkarim and Lukszo 2009). In Britain, coordination was also badly executed, and some retailers rolling out mandated advanced metering installed incompatible equipment so that customers could no longer switch to competing energy retailers (Int-B-52-DER). While limited harmonisation has been described as happenstance, incompetence, or inertia by some, others have identified this barrier as another attempt by incumbent electricity firms to wilfully hamper progress in decentralised energy and a more active demand-side (Conf-8).

The wide range of complaints about the gathering of and access to data and how these processes are standardised, have led to heightened attention to questions of 'data governance', including in the energy sector.

5.5 Conclusion

This chapter has discussed a range of strategies and approaches firms promoting DER have taken to challenging centralised electricity regimes, and the difficulties they perceive are linked to regime players trying to stymie competition from demand-side resources. The following section summarises the findings and answers the research questions:

- How are DER niche players challenging electricity regimes through business model building?
- How are DER niche players experiencing incumbent company regime resistance, when trying to access key resources and opportunities?

Niche players promoting demand-side resources are targeting key value propositions and revenue streams centralised power plants, retailers, and energy networks have occupied since electricity systems grew in scale. Electricity sector incumbents control some resources and opportunities DER players target, based on having been assigned retailing and network operation responsibilities. As digital innovation has enabled the aggregation of distributed resources at lower cost, more value pools across the system are theoretically available for DER newcomers to target. Some DER providers try to access these in cooperation with incumbent electricity firms, while others prefer to lobby for public policy change that enables them to independently access resources, so they can directly challenge centralised incumbents.

The value propositions and revenue streams DER promoters are targeting are: value to energy users; energy (kWh) procured bilaterally or in transparent wholesale markets; capacity where this is rewarded separately (kW); electricity system balancing and ancillary services; and value to electricity network operators. Revenue streams and value pools have opened up to the demand-side in some jurisdictions, sometimes in response to niche players lobbying for policy change. Revenue has also

been available through the creation of public-interest-schemes where policymakers have targeted revenue specifically at demand-side resources, justified generally with the argument that DER deliver benefits not adequately valued by markets, including improvements in decarbonisation, air quality, energy resilience, and energy security (independence). Public-interest-schemes have created institutional space, and incumbents have been forced to make available key resources and opportunities. In some cases, DER companies have actively lobbied for these revenue streams to be created specifically for the demand-side, while other public-interest-schemes are open also to players on the supply-side.

DER business models challenging the regime rely on diverse capabilities and activities which range across sectors such as manufacturing of electrical products, analysis of buildings and behaviour, installation and building retrofit, and information technology sectors. Some of these new entrants to the electricity sector are large firms coming from other 'regimes', such as appliance manufacturing, buildings and automobile sectors, while others are smaller specialised firms.

The chapter showed that the ecosystem of niche players and approaches to building business models is diverse. DER providers target different customer segments and use varying customer channels. This leads to different strategies of interaction with incumbent electricity companies. Some DER firms find it important to be able to bundle their service or technology with commodity electricity in one transaction, while others are content to market their DER proposition independently from commodity electricity. Moreover, companies with already established customer relationships and brands tend to want to leverage these. Others who have not yet established customer appeal and loyalty prefer to build relationships with companies who will recruit end-users on their behalf. Firms retailing electricity, such as retailers

and network-retail utilities have been important business partners in these cases, providing a channel to recruit customers.

The chapter also found that instances of regime resistance remain, where institutions are designed to suit centralised players, incumbents lobby against policy change and use commercial or legal tactics to curb the growth of DER. The chapter reviewed the main difficulties DER niche players reported: firstly, market entry barriers to energy, ancillary service, and capacity markets; secondly, adverse design principles for electricity and network tariffs; thirdly, high network connection costs and onerous procedures; and finally limited access to key data resources DER providers claim they require to grow out of their niches. Some critics argue incumbents intend to protect their privileged status and the value of the centralised assets, associated capabilities, and business models, while incumbents claim they are acting in customers' interest, especially on behalf of those without the ability to themselves invest in and host DER.

Chapter 6 - Incumbent electricity business models in transition?

This chapter investigates demand-side transitions from the perspective of electricity regime players. It focuses on processes of business model evolution to accommodate DER among incumbent electricity companies connected to the demand-side. Depending on the electricity retail market design adopted in a jurisdiction, there are different types of incumbents interfacing with energy users today: competing retailers and gen-tailers, franchise network-retail utilities and, or unbundled electricity network companies[39].

The chapter addresses the research question, *"How are electricity retail and distribution network incumbents using their resources and opportunities to promote DER as part of their business model evolution?"*

For this thesis, these types of incumbents are of greatest interest among the range of regime-level players because their business models vary between jurisdictions with different electricity retail market designs.

The chapter addresses another research question, *"Which difficulties do agents of change promoting DER face within incumbent electricity firms?"*

[39] So far, only large energy users buy electricity directly from generators and are connected directly to transmission networks. The majority of electricity users is connected to the distribution grid and served with electricity commodity by companies acting as retailers. This may change in areas where regulations change to enable 'peer-to-peer' electricity trading.

It investigates dynamics of regime-level lock-in in organisational practices, institutions, and business model structures. These encourage incumbents to further promote the centralised business as usual.

The definition of 'incumbency', as in the previous chapter, is focused on the business model: if the company's main business is related to energy provision from centralised sources (procuring power from centralised power plants and transporting it through public networks), it is considered to operate an incumbent business model. The findings reflect the diversity within the ecosystem of regime players. Although the question is broad enough to encompass retail and network incumbents generally, the results are differentiated to account for differences between retail and network incumbents with varying business models.

Incumbent electricity firms have influence over how to allocate the resources they control (capital, staff time, etc.) to differing extents. As explained in Chapter 5, in many cases, policymakers with an interest to promote DER have forced incumbent electricity companies, of both the competing and regulated-franchise type, to promote demand-side resources. However, there are also cases where incumbents have chosen to do so. This process of incumbent business model evolution works differently between regulated-franchise and competing electricity incumbents.

Regulated-franchise electricity companies are less independent in their decision-making than competing companies because, in return for their exclusive right to provide electricity services in an assigned region such as network operation, system balancing, or electricity retailing, business models are in many jurisdictions to a higher degree dictated by regulators. Utility functions regulated as quasi-monopolies or 'natural monopolies' are funded through revenues authorised by regulatory agencies to protect customers who are deemed captive.

Firstly, to protect customers from monopoly power, prices and in some cases profits are controlled and approved by regulators. Secondly, the allowed scope of activities for regulated-franchise firms is often tightly controlled by regulators to prevent these companies from using their privileged position in one sector to distort markets in other sectors.

Competing companies have more space for manoeuvre to independently launch new units and offers, build supply chains, and devise contracts with business partners and customers. This is not to suggest that competing electricity firms are free in their decision-making. Retailers under competition must comply with a multitude of industry arrangements to ensure system integrity at least, and in some jurisdictions also with special customer protection rules. Additionally, some Governments direct retailers' procurement decisions to promote low-carbon resources or ensure adequate capacity (e.g., France placed its 'capacity mechanism' obligations on retailers (Doc-75-Euractiv). However, as they are not regulated as franchises, they are not restricted in their freedom to enter new lines of business and their revenues and profits are not capped overall. This means processes of business model evolution work differently:

> *"the context for innovation in electricity networks is very different from that in competitive markets. (…) The balance of risk and reward for regulated companies is determined almost entirely by the nature of the regulatory regime, and those companies react to that regime rather than to market opportunities" (Lockwood 2016 : 112).*

Overall, for regulated-franchise firms, evolving their business models is more a process of negotiating public policy change than independently developing strategies for value creation and capture.

The chapter is structured as follows. First, it discusses how *competing retailers'* business models have been destabilised, how and why they have promoted DER, and which difficulties they have faced in trying to integrate DER into their business

models. The next section discusses *regulated-franchise incumbent firms*, how their business models have been challenged, how they are supporting the integration of decentralised electricity resources, and what they perceive as difficulties.

6.1 Competing incumbents: electricity commodity retailers and gen-tailers

6.1.1 Acquisition and investment

After promising that competition in electricity would deliver innovation in energy services, commodity retailers and industry analysts in the US and Europe in the years following market reform predicted that energy technology, appliance, and commodity markets would converge. They predicted that customers would buy 'energy-as-a-service' such as ambient temperatures or lumens of light, rather than kWh and appliances separately (Int-A-10; Int-B-117-EXP).

After market restructuring, US electricity retailing companies or associated holding firms in the 1990s and early 2000s did make acquisitions and investments which indicated they were interested in fulfilling their promises to develop demand-side innovation. One US expert recalled, *"there was a tremendous amount of hype during this period about integrated energy services"* (Int-A-10-EXP). Several electricity firms invested resources to diversify into energy services, trying to combine their expertise in centralised power generation and trading with energy services for large industrial and commercial energy users.

Among the most famous and ambitious companies trying to realise demand-side innovation bundled with commodity was Enron, working all over the US, but also in Europe. Their offering involved investing on energy users' premises, for instance in

CHP or HVAC chilling plants, upgrading these to reduce demand, supplying electricity and fuel they had bought wholesale, and packaging these components as a fixed-price service in the form of for instance an agreed indoor temperature (Int-B-121-DER). This was similar to energy-supply-contracting offers available in some European countries today (Bertoldi et al. 2006). Enron's offer was thus premised on optimising cost both on the supply side, through reducing the cost of power procured from centralised plants, as well as on the demand-side, through investment in energy saving and load shifting (Int-B-65-DER). Because Enron were offering customers appealing prices and investors very attractive returns, their model was widely admired in the industry:

> *"They were really innovative at the time, they had the entire market focused on this. Every company in their board room was trying to figure out how to emulate the Enron model and they attracted the best minds in the energy business"* (Int-B-121-DER).

Following Enron, many of the independent competitive affiliates of monopoly IOUs in the US also began offering demand-side management services together with commodity energy (Int-A-10-EXP). Furthermore, some large players from the technology and engineering sectors entered energy commodity trading, once competition reforms opened up the market. These large technology companies, whose main business was in facilities management, demand-side energy project development, or buildings and appliance control technology, thought that their customers would be interested in buying commodity energy and services in one transaction (Int-B-121-DER).

However, energy-supply-contracting did not become established as a successful business model in the US, so that today, energy services offers remain mainly separate from electricity retailing (Int-A-10-EXP; Int-B-121-DER). Initially, competition in electricity retail did enable some innovation because some competitive retailers in the

US offered large customers improved accessibility to billing data and associated analysis, allowing them to better manage demand (Int-A-8). However, on both the power-side and the engineering-and-technology sides, firms gave up their attempts to combine commodity retailing with demand-side management for large energy users after a few years (Int-A-10-EXP). Enron filed for bankruptcy in 2001 after it emerged that senior managers had hidden billions of dollars in debt through obscure accounting techniques aimed at keeping badly performing assets off the company's balance sheet and stock prices high (Healy and Palepu 2003). One interviewee hypothesised that Enron's collapse played a role in the wider demise of the energy-supply-contracting model in the US (Int-B-121-DER). The electricity market crisis in California and subsequent rescinding of reforms in several US states also contributed to technology companies abandoning their forays into the commodity energy procurement business (Int-A-10-EXP). Moreover, electricity utilities sold their demand-side energy services units specialised on energy performance contracting because they found the business too risky, difficult, and not profitable enough (Int-B-121-DER).

In Europe, incumbent electricity companies since restructuring also acquired energy services businesses (Bertoldi et al. 2006; Hannon 2012; Sorrell 2005). After the market for industrial energy services initially grew in the 1990s in Europe, it reduced again when electricity unit prices fell for large energy users (Bertoldi et al. 2006; Hannon et al. 2013). Since their initial investment, these European energy companies have over the years at times increased and at other times parted with their investments and ventures into energy services firms (Hannon et al. 2013 on the UK specifically). Initially, European electricity incumbents focused on demand-side energy services for large customers around heat networks and combined-heat-and-power (see e.g., Doc-40-Energyst). More recently, large electricity companies have also invested in smaller, newcomer DER companies which promote for example, demand response or

rooftop solar PV without necessarily taking full ownership of these players (Doc-41-GTM). Several electricity companies have also run start-up-incubator programmes (Conf-4; Doc-42-UKTN).

Today, leaders of competing electricity incumbents in Europe are still promoting the discourse that commodity electricity will be superseded by 'energy-as-a-service', promising that they will turn into energy service companies offering integrated offers that combine commodity with DER (Int-B-18-RET; Int-B-23-RET; Int-B-67-RET; Doc-36-Centrica; Doc-37-E.ON). Several see demand-side resources as a key business to pursue (ibid.). In the US, senior executives of some of the competing incumbent IPPs, several of which have recently acquired retailers to form gen-tailers, have also identified DER as an important future business (Doc-38-Gaudette). However, the narrative that commodity energy and appliance markets will converge, so that forms of energy supply contracting will become the new norm, is not common in the US (Int-B-121-DER).

The dominant gen-tailers' business models have been destabilised in jurisdictions across Europe and the US, where renewable energy at grid-scale and demand reduction (through energy efficiency and on-site generation) have depressed wholesale power prices. This means that profits from conventional fossil-fuelled power generation assets, and relatedly, incumbent holding firms have lost billions of Euros (Doc-58-GTM; Doc-39-Prabhu). Although gen-tailers in Europe, ERCOT, and Australian states have default provider status and therefore serve most of the load, they are still challenged by the reduced profitability of their upstream assets (Int-B-18-RET). As a result, these firms are under more pressure than ever to look for new ways to improve margins. One interviewee suggested that for gen-tailers with conventional fossil-fuelled power plants, innovating to offer DER was a *"survival strategy"* (Int-B-57-RET).

Several gen-tailers invested only in renewable energy assets, new entrant retailers who built a successful business around offering green power, and some 'pure' retailers not invested in generation upstream at all are also actively exploring energy services offers, although these business model types do not face the same pressures as the long-established competing incumbents with fossil-fuel power plants. This is because, as interviewees explained, retailing commodity power is perceived as a low-margin business (Int-B-17aRET; Int-B-18-RET; Int-B-103-RET). Although it involves hedging (risk management), contractual, data management, and compliance capabilities, the returns on these activities are lower than many want to accept, while risks are comparatively high. Many believe that DER services will enable building longer-term, lasting customer relationships through offering 'added value' beyond commodity (ibid; Int-B-120-RET). In jurisdictions with advanced solar-PV adoption on buildings, retailers are also seeing more and more of their customers generating on-site (Int-B-40-RET). As one retailer specialised in renewable energy tariffs (Int-B-23-RET) explained:

> *"we don't want customers to join us and then leave within 12 months or 2 years, but to be with us for a long time, especially in a market where margins are slimming, and people are taking generation into their own hands. The value in a customer are those that are with you for 10 years, 7 years".*

Therefore, several retailers traditionally buying power from centralised plants see offering DER as an important strategy to retain customers in competitive retail markets (ibid.).

Today, the energy services companies affiliated with incumbent European electricity firms successfully compete in the energy services market for large industrial and commercial customers with technology, engineering, and specialised energy consultancy firms (Kindström and Ottosson 2016). This means that at the holding-firm level, there has been some regime variation where centralised electricity

incumbents have engaged in niche activities through acquisition. Turn-over from centralised electricity lines of business remains greater (Hannon et al. 2013; Kindström and Ottosson 2016), but these incumbent electricity firms are nonetheless using some of their financial clout to promote demand-side resources. From the other side, some engineering companies who operate as ESCOs have also developed the capability to procure energy and fuel and access energy markets (Int-B-122-DER). In Europe today, energy-supply-contracting is therefore one form of bundled commodity-and-DER-services offering available from both energy service firms affiliated with centralised retailers and gen-tailers, and by independent ESCOs linked to technology and engineering expertise.

However, in practice, energy services have not been integrated with retailing at the firm-level in many cases. Bundling DER services and commodity within one contract for the customer does not necessarily mean that the same firm manages both electricity wholesale market access and energy service provision. Often, the energy services firm cooperates with a retailer rather than themselves buying power from generators (Int-B-122-DER).

When centralised, competing electricity companies have invested in DER companies, they in some cases did not even try to integrate these with established retailing operations. In many cases, businesses were kept separate if the incumbent firm was large, so that from the outside these acquisitions looked like mere hedging strategies rather than innovation of business-as-usual. One expert explained that the British incumbent energy companies

> *"went through phases, (…) going around and buying those renewable companies (…). The strategy was not to build that into their offer to customers, but to take a stake in lots of little renewable energy outfits (…) just to make sure they were backing the winner some way or other"* (Int-B-27-EXP).

Some incumbents run the DER businesses as operationally separate entities, although under the same brand, while others set up entirely new companies, sometimes as joint ventures (Doc-43-Times). Confining innovation activities to a separate firm is a strategy often advised in management literature, teaching that trying to change internal processes may be a less successful approach to innovation than if new operations are taken out of a long-established company entirely and run independently, with a different structure and staff (Utterback 1994).

In other cases, incumbents tried to integrate acquired DER companies with their business-as-usual but failed. The difficulties of operationally integrating demand-side with conventional activities are discussed in section 6.1.4.

6.1.2 Public-interest-schemes obligating competing retailers to create revenue for DER

There are several examples of competing incumbents making resources accessible to DER providers, driven by regulatory obligation. Here, retailers were forced to make revenue streams accessible for DER because policymakers chose electricity retailers as delivery agents or administrators of public-interest-schemes, the costs of which are then recovered through energy bills. For example, retailers in several jurisdictions have been obligated to deliver energy efficiency investment (Eyre 2013b; Nadel et al. 2017; Rosenow 2012). This is the case for instance in Great Britain, France, and the Australian states South Australia, Victoria, and New South Wales[40]. Moreover, feed-

[40] Under these obligations, retailers are obligated to prove that energy savings or measures have been installed. To demonstrate compliance, energy savings are certified. There are different approaches to energy-saving-obligation design with respect to how accessible these subsidies are to third parties independent of electricity retailers: in New South Wales and Victoria, energy service providers receive certification from a regulatory body and can independently implement measures and sell certificates to a market for retailers to purchase (Int-B-120-RET). In Great Britain and South Australia, obligated retailers can also outsource delivery to third parties, but are themselves liable for the measures implemented, and

in-tariff schemes have mandated retailers to administrate payments for electricity fed into the grid from on-site generation.

Experts have argued that these obligations have not triggered an evolution of incumbents' business models from a focus on commodity electricity to energy services (Int-B-117-EXP, Int-B-27-EXP). This impression is consistent with the fact that it is most common for retailers in GB and Australia under energy saving obligations to outsource the management of supply chains of technology firms and building companies needed to deliver the obligations (Eyre 2013b) (Int-B-120-RET), rather than managing these relationships themselves.

The implementation of energy saving obligations involves strategies to meet the obligation through different measures and 'programme design'; managing relationships with contractors; developing quality assurance systems; promoting programmes to customers; and implementing projects at specific sites (Blumstein et al. 2005). Policymakers control some of these functions through regulatory agencies in charge of overseeing energy saving scheme administration, while other functions are left to the obligated parties to deliver.

Rather than themselves playing a key role in managing implementation and subcontractors, obligated retailers have tended to either work with specialised implementation companies whom they have long-term relationships with, or to buy energy saving certificates from energy service providers who have implemented the measures (Int-B-118-EE). While early on, some retailers were themselves managing implementation, overall, most have learned that subcontracting the delivery of their obligation out to specialised intermediary companies is more successful. Retailers

must directly contract with intermediaries or service providers, rather than buying in a certificate market (ibid.).

found that themselves managing relationships with manufacturers and contractors to deliver measures such as boiler replacements, insulation, lighting upgrades, or solar water heating systems is complex and requires local staff, connections, and capital investment. As one Australian incumbent retailer explained, in an early phase of the obligation scheme

> *"we were actually participating in the Victorian scheme. We had a warehouse full of energy saving products and we had various vendors going out to install them, but (…) it was an absolute nightmare. Because that wasn't the business we were in. We badly managed that and had to get rid of a million dollars' worth of stock that was useless […]. Because whilst we knew our customers, we didn't know how to roll out energy efficiency. Since then, none of the retailers are involved in the scheme because it's more cost-effective to do it in other ways"* (Int-B-120-RET).

An expert from an energy saving obligation implementation company in GB hypothesised that another reason obligated incumbent retailers preferred not to manage implementation themselves was the limited flexibility in terms of the range of measures and customers that qualify under the obligation (Int-B-118-EE). As a public-interest-scheme where cost is socialised, qualified measures and customer segments to target are determined politically in a process negotiated between policymakers, incumbents, and interest groups before each obligation phase (ibid.). In several countries, low-income customers who live in fuel poverty especially are earmarked to receive sizable shares of the subsidised measures (ibid.; Int-B-120-RET). As a result, implementation of energy saving measures can *"mean that you're actually looking for a needle in a haystack"* (Int-B-118-EE). But also in other customer segments it can be costly to recruit eligible customers because *"once the low-hanging fruit have been picked, it gets harder to identify the right people to participate"* (Int-B-118-EE). But even where eligibility for subsidy under such a scheme includes a broader range of measures and customers, implementing energy

saving obligations is costly and a highly specialised business which, when building measures are involved, requires local knowledge (Int-B-30-EXP).

Moreover, obligations to save energy have not led to business model evolution because some retailers believe the integration of core commodity business with the measures delivered as regulatory compliance could be perceived as an illegal conflict of interest. For instance, one Australian retailer reported that, although to improve their company's image they brand energy efficiency subcontractors with their logo and market the obligated measures under their name, they are careful not to give the impression that receipt of a measure is conditional upon a commodity contract.

> *"We possibly could do it, but legals are always quite keen to make sure that there's no conflict, that you can only get this, if you become a customer. So that's why we keep it very distinct"* (Int-B-120-RET).

This means that the retailer can potentially benefit from the overall brand advantage and good relationship that providing subsidised energy saving measures under their own brand may provide, but that the obligation cannot contribute to the core business growing.

Overall, activities driven by energy saving obligations therefore remain independent from electricity incumbents' core business of retailing commodity. New commercial structures have been created through the supply chain of energy-efficiency-programme implementers and service providers whom retailers contract with, but they are managed separately from the commodity retailing business and have not led to incumbent retailers' business models to change.

6.1.3 Partnerships with DER providers, enabling access to revenues and customers

There are several examples of where incumbent retailers have made opportunities accessible to DER providers independent of regulatory obligation through partnerships. For example, several retailers in Europe, ERCOT, and Australia have chosen to buy energy (kWh) from customers or their associated aggregators, integrating them into their energy portfolios, and facilitating for customers and DER providers access to energy wholesale and ancillary service markets. In these cases, some of the electricity these retailers would otherwise procure from centralised plants has been replaced with resources behind the meter, aggregated as 'virtual power plants' (Int-B-40-RET; Int-B-114-MUNI; Int-B-68-RET). A few new-entrant retailers around the late 2000s were pioneers in this respect and internally developed the technical capability to turn retailing into a *"bi-directional business"* of aggregating customer-sited resources into markets (Int-B-40-RET; also Int-B-68-RET). Here they were competing with the newcomer technology companies independent of retailers introduced in Chapter 5. Today, these companies increasingly enable established retailers, including gen-tailers operating as default providers, to use their technology to operate virtual power plants (Int-B-114-MUNI; Int-B-120-RET; see also Doc-44-NextKraftwerke).

Procuring demand-side resources is beneficial for the retailer if they can earn a margin on bidding the resources into energy and ancillary service markets or can lower their cost base because procuring demand-side resources costs less than power from centralised plants, but the economics of DER vary in this respect. In jurisdictions like ERCOT and Australian states, dispatchable micro-generation, demand response, and distributed storage are more valuable to retailers. This is because, firstly, operating in

energy-only-markets where capacity is not rewarded separately means these retailers face sharply spiking wholesale power prices in the short-term. This improves the economic proposition of integrating dispatchable DER into retailers' portfolios, as compared to markets with capacity mechanisms and fewer price spikes. Secondly, these jurisdictions have summer-peaking systems driven by air-conditioning demand, so peaks are sharper than in temperate climates (Darby and McKenna 2012), and most buildings have a load that can be economically shifted. In Europe, as large incumbent electricity companies are increasingly investing in fluctuating renewable energy plants, they too have a theoretical interest in balancing these supply-side resources with demand response (Int-B-43-DER). Especially where conventional gas-fired plants have been separated from the corporate entity that retails electricity, controlling customers' resources could be beneficial for gen-tailers going forward (Int-B-27-EXP).

There are also examples of electricity retailers promoting micro-generation assets by designing their commodity tariffs explicitly to suit a particular service or technology provider they cooperate with. These DER providers can then make attractive offers to energy users. This was the case for instance in ERCOT where solar-PV companies had not succeeded in persuading policymakers to grant them subsidies. Then, several retailers partnered with large rooftop solar-PV firms to offer exclusive tariffs to residential customers, buying the surplus power generated on their customers' rooftops (Doc-47-GTM). Although the overall installed capacity of rooftop solar-PV systems remains low in Texas compared to jurisdictions with net-energy-metering-schemes, these partnerships with commodity retailers have allowed solar-PV firms the entry to the Texas market they had been seeking. After the industry had unsuccessfully lobbied Texas legislators and regulators for years to follow other states' example in net-energy-metering policies to provide guaranteed revenues for

electricity fed into the grid, several distributed PV firms interviewed stated that now,*"yes, Texas works for us"* (Int-B-98-DER; also Int-B-85-DER). The retailer pioneering these special solar-PV tariffs explained that they hoped this would help acquire new retail customers whose demand profiles are especially beneficial because of the way solar affects their demand 'shape' (Doc-47-MP2). Other retailers and solar firms in ERCOT followed suit in copying similar partnerships.

Moreover, many retailers serving industrial and commercial retailers make an opportunity for DER available, when they pass through price signals which DER technology providers can help their customers manage demand against.

As explained in Chapter 5, some innovative retailers also partner with DER providers to make their customer channel available through 'white-labelling'. This, retailers hope, will provide them with a brand advantage (Int-B-34-DER). For DER providers, making use of retailers' customer channel has been successful for some types of DER, but less for others. Easily scalable solutions that are not labour-intensive and complex to implement have benefitted from retailers' incentive to offer their customers DER solutions (Int-B-62-DER). Measures that require bespoke site analysis and expertise however are more difficult for retailers to promote (Int-B-122-DER).

In some cases, retailers also operated behind the scenes, providing services for third-party-intermediaries, and thereby supported business models that promote DER. For example, since 2017, 'tenant power' legislation in Germany created a new route to market for solar-PV firms in cooperation with electricity retailers. Building owners in Germany are now permitted to operate as intermediaries, selling solar-PV-generated power, bundled with 'back-up' commodity to their tenants, while recovering subsidy support (Doc-48-VKU). Electricity retailers have begun to develop services for building owners to invest, manage compliance, and procure back-up power to offer

their tenants a bundled product. This is proving a viable route for electricity retailers to promote solar-PV on rooftops in Germany (Int-B-114-MUNI).

Commodity retailers have different strategies in the longer term. Several incumbent retailers are trying to establish their position as aggregators and traders of distributed resources, for instance providing services to network operators (Int-B-85-DER). Some of the large incumbent energy companies are investing in developing infrastructure and systems through which distributed resources could be transacted on 'local' trading platforms (e.g., Doc-46-Centrica). Here, they are competing with independent newcomer technology firms who have entered the energy sector as start-ups to build platforms on which buyers and sellers of distributed energy resources and 'flexibility' can transact. To an extent, some network companies are also competing in this sphere, because some have identified dispatch of DER as a potential future business model (Conf-8).

There were mixed views on what viable future strategies for competing retailers and gen-tailers could be. Respondents disagreed about whether retailers would have to themselves invest in assets behind the meter to provide customers with 'value-added' DER options, or whether they could be profitable enough as 'pure' retailers, partnering with technology companies and aggregating DER. One interviewee argued that the value recoverable from procuring power as retailers and energy traders has shrunk so much in Europe, since wholesale energy markets have become more transparent, that retailing without being invested in assets would not produce high enough margins (Int-B-114-MUNI). On the other side, some retailers look to aggregate DER into markets and build on partnerships with contractors in an advisory role. They believe that helping customers access markets and DER offers and manage market volatility without owning assets could be the basis of a viable business model in the future (Int-B-40-RET; Int-B-68-RET).

6.1.4 Difficulties

Despite high ambitions communicated publicly by competing electricity companies and the examples of successful partnerships with DER providers, there remain obstacles competing retailers face in the process of transitioning their business models. In many cases, challenges reported in interviews were similar across different types of retailing business models. In a few instances, gen-tailers and independent retailers, large and small companies, reported different experiences.

6.1.4.1 Aligning the old and the new

Where electricity companies acquired DER firms and tried integrating operations with their commodity retailing business, this has proved difficult in practice (Int-B-31-DER; Int-B-103-RET).

One reason is that, traditionally, the revenue model which retailers have relied on is volumetric which means that new products and services which reduce the volumes of commodity electricity sold directly hurt the traditional business' profitability. Conventional revenue models and tariff designs in commodity electricity retailing vary between customer segments, but are mostly volumetric, so that a large portion of costs are recovered per unit used, with a smaller portion through fixed charges. Several interviewees reported that changing the retailing business model from one centred around increasing volume sales to one focused on giving advice, reducing energy use, or installing technology was difficult (Int-B-17aRET; Int-B-20-RET; Int-B-24-RET). As long as retailers recover their fixed costs through a mark-up on each increment sold rather than through a fixed fee, they have an incentive to sell more volume. Many commodity energy products, including very sophisticated offers with

time-varying prices, 'blocks' of power, or hedges bought for set time-periods, involve retailers charging per increment. One gen-tailer looking to integrate solar-PV offers with commodity retailing explained,

> *"from a business perspective they are somewhat in conflict: if I want to sell you more commodity I make more money and the solar cuts into that so there's a real question whether they are complementary or competing. While there is a lot of talk (…), it's a tough nut to crack: how do you make money from selling less? You have to move customers into a monthly fee, subscription type service"* (Int-B-103-RET).

Some industrial and commercial retailers have moved in this direction by developing a subscription-based revenue model with a fixed charge for the pass-through of wholesale energy prices (Int-B-68-RET). Whether this is a viable model in the long-term is unclear.

Another element of the volume driver for retailers is that managing risks in wholesale commodity energy markets incentivises to move more volume because this lowers imbalance risk[41]. Having more demand and more customers (in different regions) under contract improves diversity of demand (Int-B-33-RET) which reduces imbalance risk. Overall, retailers feel there is an incentive to sell more commodity:

> *"moving more volume tends to lower your general overheads, so having more MWh is better than less (…). I think there's always an element of volume in the retail game"* (Int-B-103-RET).

This means that short-term incentives for a retailer are ill-aligned with promoting demand-side business at a scale that truly reduces demand.

Furthermore, gen-tailers integrated with upstream generation assets have a counterincentive to pursue demand-side resources. While giving some energy saving

[41] Imbalance occurs when a party's previously contracted and physical position differ within the electricity settlement system. Being out of balance is usually penalised to incentivise trading parties to forecast well and contract accordingly.

advice may improve the company's standing with Government and customers as a retention mechanism, actually reducing demand harms the upstream business. One observer reported, *"when E.ON first had a demand response unit, the leader was told that they cannot grow beyond a certain point"* so as not hurt the conventional business (Int-B-61-DER). Here, there was clear competition within the incumbent company between old and new business units:

> *"it becomes what is an age-old management question: do you put two competing things together and have someone consciously decide and optimise which way they go, or do you keep them separate and let the best man win, let the customer decide?"* (Int-B-103-RET).

As outlined above, several incumbents have chosen to let new business units run alongside traditional ones. In an early prominent case, E.ON split its conventional generation business into a company separated from its 'new energy' business. *"Since the split, E.ON's demand response business is less constrained, apparently"* (Int-B-61-DER), the observer reported.

Another reported difficulty was integrating activities and mindset of a new business with an established one (Int-B-115-DER). Both at strategic level and in operational practices, differences in purpose, culture, and skillsets posed challenges to integration (Int-B-17aRET; Int-B-31-DER). One interviewee reflecting on the British 'big six' incumbent energy companies highlighted two distinct properties that made it difficult for large and long-established incumbents to embrace distributed energy. Firstly, culturally they were described as having an engineering rather than customer-focused mindset. The incumbent retailers who emerged from the monopolies after restructuring were assigned default provider status, and therefore did not initially enter the market with a mind-set of *"what is it that customers want"* (Int-B-17aRET). Having retained at least some staff and a corporate culture from times of being

monopoly energy companies, this interviewee described the type of people working for one of the 'big six' as different from staff working for new entrants and innovators:

> *"You often went in there because you wanted a job for life (…), because you were an engineer; [and] you felt that you were doing a service, (…) looking after the state's movement of gas and energy and making sure everybody has hot homes and stuff - an essential service. So, all of those factors created an engineering, detailed- based kind of environment. So, they were inward-looking, not outward looking. (…) Then (…) competition comes in and (…) you're very internally and engineering focussed, not customer-focused because you've never worried about the customer. You've always done something to engineer a solution"* (Int-B-17aRET).

In a similar vein, the CEO of one of the German 'big four' said, *"the hardest thing is to get people who have been successful at one thing to do something different all of a sudden"* (Conf-3-Mastiaux).

The second property making DER innovation difficult for British incumbents the interviewee argued was their size (Int-B-17aRET). The big energy companies, in Britain and elsewhere, are large corporations, serving millions of customers, sometimes operating across states. As large companies they found it difficult to take newcomers to the sector seriously. Their size as

> *"the biggest player in the marketplace (…) tends to mean a degree of arrogance. (…) We're the biggest player, we've done this, we know all the technical detail... and you come along as a new start-up thinking you know more than we do' And therefore I don't partner very well. (…) I'm a 200-ton gorilla and you're a little fly and you want me to partner with you? Why should I?"* (Int-B-17aRET).

These cultural barriers to innovation have made the reorientation of incumbent retailers' business models difficult.

The scale at which large electricity retailers work makes particularly energy services innovation difficult. A representative of a large incumbent electricity firm in Germany

explained that their retailing business operated at a national-scale and this did not integrate well with energy service operations.

> *"We might offer a service for customers to enter some numbers on their energy consumption and look at some energy saving options, but we're too big to send an energy auditor to every one of our large consumers. We can't or don't want to afford that kind of small-scale effort in retailing, we're too big for that. Elsewhere in the holding, we have energy services, but we can't do that as part of our retail business"* (Conf-7, personal communication, authors' translation).

This demonstrates that for large retailers managing many customer accounts, integrating the commodity business with energy services is challenging, or even impossible. While energy procurement, risk management, and billing systems work well at large scale (Int-B-27-EXP), complex energy service offers that involve bespoke analysis of customer sites do not (Int-B-122-DER). As one interviewee from an energy contracting firm explained,

> *"Decentralised energy requires decentralised structures. (…) The big four (German electricity utilities) can't do energy services and contracting across [all the regions they retail commodity], they will have to do them on a project-by-project basis. They can maybe replicate some models, maybe up to a few hundred projects but ultimately, they fall apart (…), managing so many individual projects centrally, I just don't think it can work"* (Int-B-122-DER, author's translation).

While easily scalable solutions have been marketed by retailers as white-labelled solutions, more complex, bespoke offerings are therefore difficult to integrate with their commodity retailing business.

Finally, some retailers found it difficult to align customers' focus on switching retailers regularly with offers that involve financing of DER through commodity electricity bills. For instance, an interviewee from an energy-saving-obligation-implementation-firm in Texas explained that retailers seeking to finance energy efficient appliances in their customers' residences had difficulty realising these offers,

despite using funds from the network operators obligated to deliver energy savings to reduce pay-back times. *"They have the conundrum that they cannot get beyond a two-year contract, and to recover these investments they'd really need three or four"* (Int-B-102-EE). Alongside other well-documented reasons why residential energy users may not be taking up energy efficiency offers (see e.g. Brown 2001), the regulatory campaigns in Texas to motivate customers to switch energy retailers regularly (Kiesling and Kleit 2009) may have engendered a particular norm of engagement among customers that is centred on regularly switching commodity retailers.

6.1.4.2 Resources to develop and sustain innovation

Furthermore, some electricity incumbents have in the past had difficulties to innovate because their investors withdrew support. For example, NRG as one of the largest conventional power companies active in both generation and retail in the US began seriously exploring DER solutions for residential customers in 2013 with entry into the solar-rooftop business through acquiring several companies and partnering with smart thermostat producer NEST (Doc-50-businesswire). Then, losses in the solar business by the end of 2015 led to the share price falling, investors ousting the CEO who had driven the strategy forward, and the incumbent pulling out of the solar home business altogether (Doc-51-GTM). The CEO later said, *"Wall Street really does hate renewables, at least in the hands of fossil-fuel companies"* (Doc-52-Crane). This indicated that some investors did not believe that corporations with an established pedigree in conventional power generation should be funded to learn how to become downstream service businesses, and instead preferred to themselves redeploy their capital, once margins were no longer in the two-digit range. As CEOs *"keep a close eye on their share price"* (ibid.), the impatience of investors in publicly listed energy

incumbents has made innovation activities difficult (Int-B-27-EXP). This barrier may be less challenging for incumbents financed by longer-term, more 'patient' investors.

Small, independent retailers, although they may have more patient investors, overall are less well resourced than large integrated holding companies. Several retailers explained that time and resource to strategically explore business model evolution and invest in innovation activities was sparse (Int-B-23-RET; Int-B-24-RET; Conf-4). Having to manage business as usual in a competitive market, attending to regulatory requirements (Doc-18-Beasley), and keeping up with reform processes makes it more difficult to invest in innovation activities with unknown outcomes.

One example of where resources are short is apparently for the analysis of customer data. There is a discourse about how the availability of information about energy demand patterns, infrastructure, preferences, and behaviour can drive innovation in value-added services, but some retailers invest more in this area than others (Conf-4). According to a data management service provider in GB, their electricity retail clients *"don't actually collect all the data they could because the costs of storing, managing, and interrogating it is high. Those that have the cash can engage in innovation in this regard, but many cannot"* (Conf-4). This British experience shows that incumbents' abilities to innovate vary also within jurisdictions.

Retailers in the US Northeastern states such as Massachusetts complained that having to compete with network-retail utilities limited their resources available for innovation (Int-B-67-RET; Int-B-103-RET). They explained that because the regulated default tariff offered by network-retail utilities was artificially low and hence difficult to compete with,

> *"we've found in the Northeast that it's very difficult to justify from a business perspective a lot of additional products and services. Default service is not explicitly subsidised but it is not a*

> *representation of the true cost to acquire and serve customers. So you're competing against a very low-priced bare bones product that is using a lot regulated utility overheads and services that aren't explicitly factored in, so you're competing on an uneven playing field"* (Int-B-103-RET).

This is in line with what has been suggested in the literature on default electric service (Treadway 2015). Therefore, these retailers call for a redesign of the institutional structure in the US Northeastern states (Int-B-103-RET; Int-B-67-RET).

6.1.4.3 Partners turning into competitors

Another challenge incumbent electricity retailers reported was that innovation activities bear the risk of losing the customer relationship to the business partner, in this case a DER niche player. One retailer (Int-B-23-RET) explained,

> *"it's great for us that there are loads of [demand response aggregators] who want to help us offer an additional service to our customers, but it could also be viewed as a threat because they have a great relationship with the customer, giving them a check every month. (...) They could go out, get a license to supply energy, and say 'oh we have this great service every month and we can also supply you with power, are you interested?'"*

This demonstrates that there exist tensions between retailers and DER providers around who owns the customer.

An example of where a DER partner turned into a competitor was the relationship between battery manufacturer Sonnen and green electricity retailer Lichtblick in Germany. Sonnen-branded batteries first joined Lichtblick's virtual power plant (pool of aggregated dispatchable DER) in 2013. Later, Sonnen launched its own VPP and electricity retail offering, branded as a virtual energy 'community', and now competes with Lichtblick. They claim to continue working together, especially on Sonnen's access to system services markets which Lichtblick has experience in (Doc-53-

Schröder). However, Lichtblick has inevitably lost potential customers for its own rooftop-PV-battery offering to the newcomer.

There are several reasons why the relationship with the energy user is coveted by a range of different players. Firstly, because the customer relationship is such a core resource for any DER business model, it could be expected to come with relatively high bargaining power, as compared to some other activities key to a DER energy services business model. Additionally, many players may believe that owning the customer-relationship potentially allows developing further future value propositions, as well as creating an income stream from the value of data on the customer (Conf-4).

6.1.4.4 Reputational and regulatory risks

Another difficulty perceived by some retailers in relation to innovating in DER was reputational risk, especially as concerns the residential customer segment. Despite having an interest in differentiating themselves from other players in the market by offering new products and services, several retailers in Britain reported to be worried about reputationally damaging media coverage related to failed trials.

> *"Expensive offerings like roof-top solar or heat pumps are risky. If [retailers] offer that, the press will be all over them, saying they only offer these things to high-end customers (…). This happened to one of our competitors: came out with an innovative product and three weeks later the press had them"* (Int-B-18-RET)[42].

[42] In Britain, public perception of energy companies may be worse than in other European states, and the debate on electricity is highly politicised. Therefore, the fear of negative reputational risk may be especially pronounced.

Many DER solutions require high-value investments and are only suited to customers with particular characteristics. This suggests that before rolling out an innovative product, retailers may want to be able to have high confidence that the solution would not create reputational damage. This means that default retailers with a large customer base, even if they could build a partnership with a DER firm, may choose to not to be a first-mover on launching a DER offering. New entrant retailers with fewer customers may be less concerned about reputational risks. However, because they have fewer customers they are also less interesting as partners to DER newcomers with a 'utility-facing' strategy, who are seeking to scale their solution quickly and widely.

Finally, some incumbents also see risks in innovation activities that could invite regulatory intervention which changes the market environment. Several British retailers serving residential and small business customers explained that the regulatory treatment of electricity as an 'essential service' meant that policymakers demanded higher levels of consumer protection and 'fairness' than of other sectors. This made their innovation activities related to DER risky. For instance, one interviewee suggested:

> *"If you allow an area of innovation, then some of that will turn out to be wrong (…). Like time-of-use tariffs: quite straight forward, but somewhere somebody will end up on that, but it's inappropriate for them or they can't actually deliver the behavioural change they wanted. Then they'll complain to their [Member of Parliament] and someone will say 'someone has to regulate these TOU tariffs'"* (Int-B-24-RET).

Although DER services are not considered essential services (so far) and are unlicensed activities, integrating them with commodity electricity retailing looks risky to some retailers, especially because of how DER can benefit some customers more than others.

In all cases, the influence of individual leaders at the head of competing electricity companies played an important role for the level of risk organisations were willing to incur. The behaviour of large incumbent electricity firms in acquiring demand-side businesses often changed when a new, visionary CEO was installed who set in motion innovative investments which were often abandoned again by the next leader (Int-B-27-EXP). Differences in leaders' approaches can be related to varying levels of risk-aversion and these influence perceptions of opportunities for success of innovation activities (Int-B-103-RET).

6.2 Regulated-franchise incumbents: electricity network operators and network-retail utilities

There are several ways in which electricity network operators and network-retail utilities have improved opportunities for DER in jurisdictions where policymakers and regulators have used their power in favour of the demand-side. The drivers are either obligations or softer political and regulatory pressure. Under public-interest-schemes, regulated-franchise incumbents have been obligated to invest in specified DER measures or make revenue streams available, or change their operations to support DER. Softer political and regulatory pressure directs regulated-franchise incumbents to explore innovation activities without obligation.

6.2.1 Public-interest-schemes

Policies that promote energy savings and demand response on a public-interest-scheme basis have driven much investment in demand-side management by regulated-franchise utilities in the US. Depending on policymakers' ambition, regulatory obligations to invest in energy savings have led to sizable investments in all end-use sectors in states like California and Massachusetts, or to more modest investments in states like Texas with limited ambition (Berg et al. 2017). Some European states have also obligated regulated-franchise utilities to invest in energy savings, namely unbundled distribution-network-operators (e.g. Italy, Denmark). Dispatchable DER from demand response, distributed storage (Doc-78-GTM), and micro-generation (Wiser et al. 2011) have also been promoted through obligations on US network-retail utilities who remain in the power procurement business.

There are two broad approaches to determining the funding levels for energy saving obligations in the US: firstly, 'integrated resource planning' is still used in some states, so energy efficiency investment decisions take into account the avoided cost of supply (Int-B-99-REG). Integrated resource planning compares investment in *"a broad range of resource options including new generation, transmission capacity, and demand-side alternatives"* (Blumstein et al. 2005 : 1053). The same budget is then used to invest in both megawatts and 'negawatts' (through contracts or direct investment). In the other approach, the level of investment in energy savings is determined independently from supply-side investments. Studies which project cost-effective energy saving potential are used as a basis for policymakers and stakeholders to set targets for savings or financial resources to be invested (Int-B-99-REG). In these instances, the energy saving budgets remain separate from the energy procurement budget and demand-side resources are not formally compared with supply-side

resources. Only few states in the US use 'integrated resource planning' processes as business as usual, notably states in the Northwest (Int-B-87-EXP).

Like where competing retailers are obligated, decisions about which types of measures and customers are eligible to benefit from a public-interest-scheme obligation are determined by policymakers and processes of political settlement between stakeholders (Int-B-95-IOU). Interest groups representing for instance large energy users, low-income customers, and small business users lobby regulators and utilities to earmark subsidies to be spent in ways they believe will benefit their own constituency (ibid.). Regulated-franchise utilities with an energy saving obligation also rely on intermediary energy-efficiency-programme-implementation-specialists who help utility staff design programmes, manage local contractors, and market measures to customers.

The freedom utilities have to determine the customer channels through which energy saving measures are marketed varies between jurisdictions with different electricity retail market designs. Unbundled electricity network operators in jurisdictions where the norm of non-interference remains institutionalised, for instance in Texas, are not permitted to actively market energy saving measures to customers under their brand, to prevent them from competing with energy service providers (Int-A-15-TDO). They must use other channels to recruit energy users for their programmes, most commonly installers, energy service companies, and equipment retailers (ibid.). In some jurisdictions, schemes are designed for obligated unbundled network operators to procure white certificates, so that their role in implementation is even smaller. Policymakers decide the degree to which funds are accessible for third party service providers independently or remain in a utility's responsibility.

In Massachusetts and California, where network companies were not unbundled from retailing, regulated-franchise utilities have maintained relationships with energy users. Regulators permitted them to market energy services under their brands. They may use their customer channels to market demand response and energy saving opportunities, and many use key account representatives for large customers (Int-B-83-IOU). Large energy users in these states tend to buy commodity from competing retailers or generators, while maintaining long-term energy service relationships with their regional regulated-franchise utility who can offer them energy services supported through public-interest-schemes (Conf-2).

Policymakers in several jurisdictions have tried to align regulated-franchise utilities' incentives with promoting the demand-side, by changing the regulatory mechanisms that organise their revenues and profits (Satchwell et al. 2011). Depending on the regulatory model in place in each jurisdiction, regulators determine revenues, prices, and, or profits in negotiation with utilities and stakeholders in what is often in practice a regulatory settlement. Recognising that utilities are traditionally skilled at and interested in investing in supply-side assets, reforms for bundled utilities have included, for instance, 'decoupling' earnings from electricity volumes sold or transported, and revenue-adjustment mechanisms (Kushler et al. 2006). In Britain, regulators have changed the mechanism that determines how network operators generate profits to encourage operational spend equally to capital spend (Bolton and Foxon 2013). In some US states, in addition to adjusting revenues, shareholders are rewarded for energy savings achieved. This is aimed at making demand-side resources not only equally attractive as traditional investment, but at linking energy savings to additional profits (Kushler et al. 2006). These 'shareholder incentives' have elevated demand-side management activities from a mere *"regulatory obligation to a profit centre. Prior to having the incentives, we added zero to the bottom line, now we bring*

in between 7 and 10 million of additional revenue a year to the company" (Int-A-15-TDO). This means that shareholder incentives have increased the strategic importance of regulated-franchise utilities' demand-side management departments, although critics believe they unduly increase the costs for energy users (Int-B-99-REG).

In several Australian states, distribution-network-operators have been obligated to consider demand-side resources to alleviate network constraints first before upgrading the network (Crossley 2010). After introducing measures to reduce economic disincentives did not lead the companies to consider demand-side resources on equal footing with investment in network assets, policymakers introduced more stringent obligations in several cases (ibid.: 46). Here, regulators now require electricity distribution companies to make available information on where constraints are expected, so that DER providers and customers can propose demand management solutions. Then, network companies must demonstrate to have considered all available opportunities for demand-side measures before upgrading the network. While this obligation does not designate a certain amount of resources to invest in, this public policy change does alter the selection environment for demand-side resources.

The obligation to publish data in combination with the mandate to consider demand-side resources first may have played a role in leading these incumbents to change their practices. There are now several Australian distributors who use demand-side measures to reduce the peak demand on their networks, mainly through the direct control of air conditioners and electric water heaters (Swinson et al. 2015), or swimming pool pumps. These activities go beyond trials: for example, more than 50 000 residential air conditioners were controllable by the distributor Energex in South East Queensland in 2015 (ibid.), and programmes for recruitment are ongoing (Doc-54-Energex). To procure these resources, customers are not primarily recruited

through energy retailers or aggregators, but directly when they buy the appliance and have it installed: The distributor works together mainly with

> *"air conditioner manufacturers, major appliance retailers and specialist air conditioner dealers involved in the promotion, selling and installation of demand response ready air conditioners"* (Swinson et al. 2015).

These help customers apply to the distributor to participate in the programme if necessary. Customers receive an economic incentive to reward participation once, directly from the unbundled network company as a lump sum (Doc-54-Energex).

6.2.2 Soft regulatory pressure

Softer regulatory pressure on regulated-franchise incumbents has also in some cases motivated network-retail utilities to make resources available to DER providers and customers. For example, in California, informal regulatory pressure reportedly led at least one utility to sign contracts with DER providers over and beyond the dedicated demand-side management budget earmarked through a regulatory obligation. In 2014, after the unplanned sudden shut-down of the San Onofre Nuclear Generation Facility in Southern California, the regional network-retail utility Southern California Edison (SCE) conducted an 'all-source request for offers' as a tender open to anyone capable of supplying energy and capacity to replace the resource lost from the failure of the nuclear power station (Doc-32-GTM). Several demand-side resource providers were successful in the tender, and SCE signed power purchase and reliability service contracts with DER providers to cover 449 MW of the total 1,892 MW procured (130 MW of energy savings, 75 MW demand response, 44 MW renewable resources behind the meter, and 160 MW storage behind the meter (Doc-56-Sierra-Club).

SCE's 'all-source-procurement' exercise was driven decisively by soft, discursive regulatory pressure, alongside the sudden resource need in response to a centralised plant failure. As one technology vendor successful in this auction explained, the Californian regulator (CPUC) did not exert this pressure formally in the rate case, through rules or specific policies, but simply by *"often publicly talking about the fact they would like to see utilities try all-source procurement, for example at conferences"* (Int-B-98-DER). Politicians and regulators in California have for years strongly promoted demand-side resources, and a 'loading order' formally mandates considering cost-effective energy efficiency and demand response, followed by other low-carbon resources (Doc-55-GTM) before investing in fossil-fuel resources. However, the 'loading order' is not a hard obligation tied to targets, but more an aspirational policy.

Soft regulatory pressure on regulated-franchise utilities works if utilities anticipate their behaviour will influence the next regulatory settlement. An important reason why SCE is receptive to *"the CPUC pressuring them publicly"* (Int-B-98-DER) is that regulators have discretion in setting allowed profits or rates of return. A regulatory commissioner's satisfaction with the monopoly's performance can make a difference of several percentage points between an allowed 6 or 9% rate of return on investments in the US (Int-B-81-IOU). While many factors influence US rate cases, utilities definitely have an incentive to make the regulator feel like they are not resisting change and working on innovation (ibid.). In jurisdictions where network companies' allowed revenues are fixed ex ante, regulators may have less discretion than in the Californian case. Nevertheless, regulated-franchise utilities in many cases still have incentives to demonstrate 'good will' in anticipation of the next regulatory settlement that determines the company's balance of risk, return, and opportunities for profits, depending on the precise regulatory design of a price control regime.

6.2.3 Difficulties

6.2.3.1 Technical and operational change

In jurisdictions where the environment for DER behind the meter and other decentralised power generators[43] has improved, requirements are changing for companies with the responsibility to ensure the functioning of electricity distribution networks. When power was generated mostly by large plants with several hundred MWs capacity connected to electricity transmission networks, distribution-network-operators' main functions required maintenance: operating network assets so that power from the transmission system could be transported to end-users. This included load forecasting and investing in network assets at the right time (Int-B-21-DNO).

The demands of distribution-network-operators have increased, as more distributed generators are demanding connection. Their export to the network can create capacity constraints (Bolton and Foxon 2013) and more reverse flows of power need to be accommodated (Int-B-21-DNO). New load growth linked to the electrification of heat and transport, such as for instance from heat-pumps or electric vehicles, can also create capacity constraints. Because upgrading the network to relieve constraints and enable connection is costly, network user representatives and regulators are increasingly expecting network companies to find 'non-wires-alternatives' to investing in network assets, by actively managing loads and generators on the network and procuring services of demand turn-up, turn-down and storage (Int-B-21-DNO). This means that DER providers and customers have opportunities for value capture. DER can ensure revenue collected from energy users can be used more efficiently

[43] Power generators connected to distribution networks in front of and behind the meter are often referred to as distributed or embedded generation (Int-B-21-DNO).

(ibid.), for both distribution and transmission network planning (Int-B-81-IOU). Opportunities to actively manage loads and power sources have improved because of emerging information technology (IT), so network operators are being expected to evolve from 'dumb' grids with limited visibility of loads and generators to digitally enabled 'smart grids' able to measure and control demand and supply side resources on their networks (Bolton and Foxon 2011; Hall and Foxon 2014).

So far, distribution-network-operators claim they have limited visibility and knowledge of real-time network usage (Int-B-21-DNO). This means they have difficulty responding to DER providers' demands for transparency, ascertaining areas with scope for the demand-side to contribute, and communicating opportunities for value recovery.

> *"It's all about information flows ultimately, how do we know what's going on the network, forecast it, to be able to react to it. We're not particularly advanced. The perception is that we know more about what's going on in real-time than we do in reality. The amount we can monitor (…) is much lower than people think. So, we have a big step-change to develop better and more monitoring and forecasting"* (Int-B-21-DNO; also, Conf-1-Payne).

Trials focused on improving capabilities and making data available to third parties are ongoing in many jurisdictions (ibid.; Conf-1-Payne).

Network companies also foresee difficulties if price signals through cost-reflective network charging were used as the primary means to incentivise and reward grid-beneficial behaviour on the demand-side to feed in and use power. While DER providers argued that systems such as 'nodal pricing', 'local markets', and associated price signals could encourage innovation to reduce the need to invest in network upgrades (Int-B-29-DER; Int-B-42-DER), several network company representatives did not feel they could rely on coordination of resources in response to price signals. On the one hand, demand elasticity, or the ability to shift or reduce demand, is

expected will be small on days of high demand, especially in systems with peaks driven by residential energy use (Int-B-113-DNO). On the other hand, there is concern about high degrees of automation, should appliances be programmed to respond to changes in price signal. *"The network has been designed with diversity in mind"*, because in the past not everyone used power at exactly the same time (ibid.). Demand response and power sources, especially electric vehicles and batteries triggered in response to price signals will cause loss of demand diversity, and hence requirements to upgrade the network again (ibid.), one interviewee predicted. Overall, relying on price signals rather than on longer-term contracted services or direct control by utilities implies leaving control to third parties, including customers and their agents. This vision is difficult for network operators to accept, as compared to the idea that they have the power to themselves control resources (Conf-8).

Another concern was related to difficulties in designing novel institutional arrangements to procure demand-side services. One network operator cautioned that it would be difficult to prevent un-intended consequences.

> *"If someone is not regulated they will respond to the incentives that are given to them so the market needs to be extremely well designed to induce the right behaviours. (…) Like with demand management: if you're a factory in a constrained area you have an incentive to nudge up your demand until suddenly the prices fluctuate in that area, we call for reduction and you've essentially created a new market there for yourself. So there are unintended consequences and loopholes, so we have to be really careful"* (Int-B-113-DNO).

The difficulty of designing institutional arrangements well and the possibility of some players to take advantage is therefore another challenge distributors claim poses risks for the system and the wider customer base.

Furthermore, several interviewees in regulated-franchise utilities described internal capabilities and skills to understand, assess, and contract with demand-side resources,

especially to provide value to network operation functions, were underdeveloped (Int-B-21-DNO, Int-B-110-IOU, Int-B-100-MUNI). More than technical difficulties, network operators in Britain have been grappling with how to develop suitable contractual relationships and business models for third parties to offer services to grid operators (Hall and Foxon 2014). One British network operator representative explained,

> *"the problems are that most of the innovation projects are run by engineers, we like grey boxes and buy lots of them. Whereas when it comes to the commercial terms of how we use those grey boxes or the services that come out of them, there has been less innovation"* (Int-B-21-DNO).

In the US also, interviewees reported that, while novel data collection technology and software to improve forecasting, analysis, and control capabilities were developing, network-retail utilities struggled to learn how best to design 'requests for offers' (tenders) for demand-side resources to offer energy saving or load response at the required times and speeds (Int-B-70-DER) for network-use. High-profile innovation activities on 'non-wires' alternatives have often not led to change in practices: *"There's high visibility in announcing what you've done, what you've learned. But when you look around, little has moved into business as usual"* (Int-B-21-DNO). Overall, the process of learning how to assess, use, and contractually organise resources with very different characteristics has been challenging the internal skillset and operations of network operation and planning functions in many utilities (Int-B-21-DNO; Int-B-110-IOU; Int-B-100-MUNI; Int-B-83-IOU).

Gaining trust in new kinds of resources and contractual parties was described as another key cultural challenge, both for regulated-franchise incumbents who perceive reliability as their core responsibility, as well as for regulators. In California, a utility employee explained that to transition from physical assets to aggregated demand-side resources created reliability concerns for utility employees and the SO.

> *"The customer facility is not designed only for the purpose of providing grid resources. What if the building closes, what if the measure lives go out of business? For our electricity traders and the system operator it is the difference between concrete and steel in the ground and rainbows and unicorns. If I blow my horn, will the thunderous herd of unicorns come? Whereas with the power plant, I can see the steam pouring out of the stacks and it's physically there. So those are the differences in the cultural perceptions we're trying to change"* (Int-B-110-IOU).

Concerns about whether demand-side resources would perform to the same desired standards as conventional, centralised assets were reported to grow, now that Californian utilities are conducting 'all-source' procurement and resources are integrated into wholesale energy and ancillary service markets (Int-B-110-IOU). In the past, demand response programmes the utilities had run had not been bid into markets. Now, *"in the wholesale market, that's a different world. There it's tough, I need this at this time, and I don't care what it is, have to provide that capacity"* (Int-B-110-IOU). This means that the required trust in performance has risen dramatically (ibid.).

A Californian policymaker also explained that trust in companies running since the 1890s with a proven track record was instinctively greater than in complete newcomers to the sector. With an all-source procurement exercise,

> *"you get a lot of different proposals, from a lot of different companies who have never done this (…). So, you say, what have you done before? (…) I've done satellite TVs. So, then you go (…), how do I convince myself that these people can actually perform? So, you can try to encourage innovation, put some structure on it, but these are not easy choices"* (Int-A-9).

This shows that the responsibility of policymakers and regulated-franchise utilities for reliability of electricity supply makes these incumbents risk-averse, and that embracing change is difficult. Concerns about the reliability of power supply are evidently a key element of lock-in to a proven system based on supply-side resources.

Another concern voiced by a regulated-franchise utility representative in California were moves by technology manufacturers and software companies to promote proprietary communication standards in appliances, devices behind the meter, and connected-home platforms. Proprietary communication standards can pose *"barriers to market transformation"* (Int-B-110-IOU) in residential 'smart home' and 'internet of things' development. Utilities implementing demand-management programmes care about communication standards and infrastructure platforms because a lack of common or open standards risks limited interoperability of devices and systems (Ford et al. 2016). As Ford et al. explain (2016 : 76), *"interoperability issues may exist today due to a lack of standardization in how different devices store and manage data, and how they are addressed and process commands".* Regulated-franchise utilities tasked with promoting certain technologies as part of their demand-management programmes find interoperability worrisome because it can lead to customers discarding devices, not using them as was intended, or disengaging from a programme (ibid.). Furthermore, utilities do not want to be locked into certain technology brands: if problems arise with a device or customers want to choose a new brand, changing providers should be smooth and continue to allow utility communication and control. One California utility employee explained, *"markets want to be proprietary, so they all want their own special system that you have to buy and invest in"*, but *"it doesn't do any good for DER integration if we can't talk to them"* (Int-B-110-IOU). Therefore, some Californian regulated-franchise utilities call for *"strict legislation that will say, this is what you will do"*, to standardise communication protocols and infrastructure platforms. To this end, Californian utilities have been working together with technology companies, policymakers, and standardisation agencies (ibid.).

6.2.3.2 Business model evolution

Difficulties in developing suitable commercial arrangements to reward DER for providing services are related also to the evolution of regulated-franchise utilities' business models. The rise of DER challenges network operators' business models with respect to cost recovery, revenue, and ultimately profits. Firstly, for unbundled distribution companies, accommodating and procuring DER entails a shift from pure asset management to more actively managing the network. Procuring services implies a *"shift towards more emphasis on operating costs and less capital-intensive"* activities (Int-B-21-DNO). While the traditional financial model for British network operators relied on a *"regulated asset-base and an allowed return, with reasonable operating costs"*, the shift towards a focus on operational costs creates uncertainty:

> *"There is this concern that if we procure a service and in order to make it economic you got to offer someone a 10-year contract and then it's demonstrated that's it not actually needed, the regulator will say 'that was a really bad investment decision' or won't allow that within your price control. Whereas historically we've always found that when we've done hard assets, even if later events showed that it wasn't the best investment, we've never had the issue that it will be crossed out of the regulated asset base. I know they have the ability to, but to date it's never happened. So, there is a reasonable comfort with the asset investment model, but less with contracting for long-term services"* (ibid.).

Therefore, using demand-side resources contracted for with third parties and customers challenges network operators' established business model.

Secondly, some utilities are concerned that they will not recover sufficient revenues from energy users, if many more customers invest in DER. This has been a concern for network operators especially in sunny jurisdictions where the economics of generation behind the meter are good all year round (ibid.) and generous net-energy-metering policies were put in place. Where absolute demand is reducing through investment in energy efficiency measures, onsite generation, and self-consumption,

network operators recover lower revenues when costs are recuperated volumetrically, while rising electricity rates in turn encourage further self-generation (Fox-Penner 2014). These fears about their future profitability have led utilities to demand fixed charges (Conf-1-Payne). Network charging reforms are underway in many jurisdictions with high DER adoption.

Publicly, regulated-franchise utilities in California have argued that because they procure power 'at cost' and do not earn profits from selling more volume because of their 'decoupled' revenue model, they do not face negative financial implications from more demand-side resources being added to the system (e.g., Conf-1-Payne). A discourse that emphasises cost-shifts between energy users with DER and those without (ibid.) is beneficial when trying to look supportive of policymakers' agenda to encourage low-carbon DER, while lobbying for fixed charges and other policies DER providers object to. However, their decoupled revenue model does not change the fact that these incumbents face longer-term uncertainty about the value of their network assets. Especially transmission network assets may become less valuable following further decentralisation of electricity systems, when loads and supply locate at shorter distances from one another. When load and supply balance one another out more locally, less power may need transporting through transmission networks. These changes require reforms to how network operators recover their costs from end-users, and, while there are only a few regions where network assets may become entirely obsolete, politically contentious decisions may be required on how stranded costs will be shared. Reforms to the regulatory mechanisms which enable network operators' investors to earn a return, and how these firms recover costs from customers, are in the US sometimes discussed as debates on 'the utility of the future' (Fox-Penner 2014).

Finally, network-retail utilities who still have customer relationships highlighted a challenge in the evolution of their future business model related to the customer interface. Network-retail utilities in California reported that they find it challenging to raise rates to accommodate DER innovation and make revenue available for the demand-side, while DER providers build relationships around 'energy' (Int-B-83-IOU). After the large investor-owned network-retail utilities in California for many years managed and marketed demand-side management measures to energy users, recently the California regulator has required them to reduce their brand exposure and their role in designing demand-management programmes. Following rule changes, larger proportions of funds designated for energy efficiency and demand response must be allocated through tendering and implemented by third parties, (Doc-57-CPUC). This means that the utilities will no longer get to market the measures under their brand, while the funds are still recovered through their electricity bills. As one Californian IOU representative explained, utilities find the prospect of technology vendors, energy service firms, or other agencies marketing subsidised demand-management programmes disconcerting because they prefer energy users to associate any services or benefits available with the utility's brand.

> *"Utilities here are concerned about [their] bills being used as a tax collection device for things that the utility does not have brand identity associated or control of. (…) We do see higher satisfaction rates for customers who participate in [our] energy efficiency programmes (…). That is important for us because if they are up in arms, the commission also will not feel as favourable about our company"* (Int-B-83-IOU).

These concerns reflect anxiety about instances of 'rate revolt' and about the ways customer-satisfaction directly influences the profits granted to companies by regulators (Int-B-82-IOU; Int-B-95-IOU). Franchise network-retail utilities hope that customers will be less likely to protest against tariff increases, the more measures and services are offered under the utility's brand. For US utilities more generally,

institutional memory of past instances of 'rate revolt' are important in influencing decision-making, as several interviewees explained (Int-B-82-IOU; Int-B-83-IOU).

In California and other states, regulators are once again re-considering the adequate roles for regulated-franchise utilities and reassigning functions between competing market players and monopoly players. This challenge for the incumbents emerged because market conditions changed, but also because some DER providers have been calling for the regulated-franchise utilities' role in delivering customer-sited measures to be reduced. These providers prefer not competing with utilities in recruiting customers for demand-side management programmes and would rather access the funds which utilities collect from customers independently (Conf-1; Conf-2; Int-B-69-DER).

6.3 Conclusion

The chapter has shown how competing retailers, regulated-franchise network operators, and network-retail utilities have used their resources to promote DER, and which difficulties they perceive within processes of evolving their business models. The following section summarises the findings and answers the research questions:

- How are electricity retail and distribution network incumbents using their resources and opportunities to promote DER as part of their business model evolution?
- Which difficulties do agents of change promoting DER face within incumbent electricity firms?

Answering these questions about electricity incumbents in general required outlining the difference between competitive and regulated-franchise incumbents, as well as the

diversity of incumbent business models and experiences within jurisdictions. Competing incumbent electricity companies have promoted DER because of regulatory obligations, to find new profitable lines of business, and to improve electricity retail customer retention through offering value-added services. Different types of retailer business models have faced varying pressures: while new entrants have had to gain market share quickly and keep the cost-base low, retailers who were assigned default provider status have been under fewer pressures in the absence of price caps, because residential and small business customers have remained loyal. This more stable customer base has given default providers an advantage over other retailers, and they can use this to maintain their centralised business model, or to invest in decentralised innovation activities. At the same time, gen-tailers have faced significant losses on the conventional generation-side of their business, in jurisdictions where renewable energy has depressed wholesale power prices.

There are several examples of competitive electricity sector incumbents promoting DER through acquisition or cooperation. Energy service companies acquired by electricity utility holding firms successfully compete with technology and engineering firms. Cooperation with newcomers, rather than acquisition has been the route of choice for independent electricity retailers with fewer financial resources than their large, integrated competitors. Several retailers have allowed micro-generation, demand response and storage resources behind the meter to access energy and ancillary service markets by running virtual power plants and using their customer channels to market demand-side propositions. These examples show that some competitive electricity incumbents have used their resources and opportunities, of financial nature, access to energy markets, customer data, and their established relationships with energy users, to enable revenue for DER.

In some jurisdictions, policymakers have forced competing incumbents to promote energy savings and micro-generation through public-interest-schemes. Incumbents have been obligated to invest in energy efficiency and to buy electricity fed into the grid by low-carbon generators behind the meter. In the case of energy efficiency, electricity retailers have not evolved their business models in response to these obligations however: increasingly, retailers outsource the implementation of their obligation, rather than themselves managing supply chains of technology companies, engineering, installation, and marketing companies.

Regulated-franchise electricity companies have also used their resources to support DER, where regulators and policymakers have obligated or incentivised them to do. Where unbundled network operators have been obligated to deliver public interest schemes to promote energy saving, they must work through third parties to market the measures. Where network companies were not unbundled, they have retained customer channels. They can use these relationships to market energy saving and demand response measures, as long as regulators don't require them to step back from marketing measures.

The chapter has shown that incumbent utilities have faced a range of difficulties. Competing incumbents have acquired energy services expertise through acquisition of firms, although integrating these operations with conventional retailing operations has been challenging in some cases. Where solutions are standardisable, some integration was possible, but bespoke energy service offers that require on-site operations and analysis do not integrate well with energy retailing operations. This means that these more bespoke demand-side offerings are operated separately alongside the commodity retailing business, even they are run under the same brand. Moreover, integration has been challenging because demand-side and centralised commodity lines of business are in competition often, rather than complementary.

For regulated-franchise utilities, internal shortages in skills, knowledge, and understanding of how to evaluate and procure new types of resources has created challenges for scaling up DER innovation activities and progressing these into business as usual. It has been difficult to institutionalise workable commercial arrangements that adequately incentivise and reward DER providers for value to the network on a locational basis, while the regulated-franchise utility finds risks and returns acceptable.

Risk-aversion has been a barrier for both competing and regulated-franchise incumbents. Regulated-franchise utilities and policymakers fear reliability impacts from demand-side resources being less 'firm' and dependable than supply-side resources. Competing retailers fear reputational damage, losing competitive advantage when cooperating with competitors, and regulatory intervention following innovation. Franchise incumbents do not face commercial risks from innovation activities in the same way. However, they are also confronted with commercial uncertainty because their business models, allowed activities, revenue models, and customer segments are politically negotiated, and the institutional frameworks that govern the electricity regime are once again under reform.

Chapter 7 - Discussion

This chapter discusses the evidence presented in preceding chapters with reference to the overarching research question, *"what is the political significance of electricity retail market design institutions for decentralised energy transitions on the demand-side?"* It addresses this question by discussing the data presented in previous chapters comparatively.

The first empirical chapter traced processes of public policy change in three US jurisdictions. It showed that different market designs emerged in the US in response to new economic and philosophical ideas, techno-economic change, and the influence of niche players who saw opportunities to disrupt the regime and sought to change their selection environment. Since market restructuring, electricity systems in some jurisdictions have further decentralised, with a greater role for demand-side energy resources. Chapter 5 explained these changes within socio-technical systems as processes of *building* business models from the perspective of newcomers trying to grow out of their niche. Chapter 6 outlined processes of incumbent electricity business model *evolution*, from the perspective of companies already connected to end-users as retailers and network operators. The evidence showed that variation is currently occurring in electricity firm populations. New commercial structures have potential to change electricity systems towards relying more on DER to meet electricity needs.

This chapter analyses these historic and current processes of institutionalising new demand-side structures to consider two sides to the 'political' dimensions of electricity retail market design: the realm of contestation, and of differing distribution

of resources and opportunities. It is structured as follows: section 7.1 shows that the historic processes through which electricity retail market institutions were created have political significance today because the lines of disagreement between discourse coalitions at the time are recurring. The section compares the frames of meaning and assumptions underlying different electricity retail market designs and the discourse coalitions' positions during competition reforms. It then relates the findings from the comparison to the data presented in Chapters 5 and 6 on barriers and how incumbents and challengers would like public policies to change. In section 7.2, the chapter turns to a view of politics as differing access to resources and opportunities. It assesses regime-niche interaction comparatively to highlight the differences and similarities between the ways in which incumbent companies under different electricity retail market designs have made resources and opportunities accessible for DER players, and have tried to impede access. In discussing how DER players' experiences have varied under different electricity retail market designs, the analysis addresses literature reviewed in Chapter 2 on how electricity retail institutions affect demand-side energy services. Section 7.3 reflects on how the findings relate to wider, conceptual and methodological literature on sociotechnical change and electricity systems, specifically the frameworks that were employed to guide the research.

7.1 The contested nature of electricity retail market design

This section discusses in detail how electricity retail market design institutions are contested. From the empirical data on discourse coalitions presented in Chapter 4, this analysis draws out contrasting assumptions and frames of meaning. The analysis of competing problem-solution framings and assumptions in the three cases allows wider conclusions about which dimensions of electricity retail market design were

contested, and how various stakeholders perceived different market designs would benefit them and the wider system. Analysing these contested assumptions, meanings, and frames underlying historic processes of policy change is useful to assess the political significance of electricity retail institutions generally, and today. This is because there remains disagreement about the underlying terms of debate and these disagreements influence current policy debates relevant to DER. As in the past, incumbents and niche players try to influence public policy institutions in their favour. Paying attention to discourse, disagreements, and contestation is important for policy analysis within transition studies because practices of framing constitute acts of power.

From the data on discourse coalitions presented, three high-level disagreements about how to interpret key terms and concepts were identified:

- Firstly, the meaning of efficiency and welfare was contested, along with assumptions about what type of market design increases these dimensions.
- Secondly, some framed electricity as a special type of service while others believed it should be treated similarly to other products. This relates to different assumptions about whether it is fair when benefits of competition accrue more to some customers than to others.
- Thirdly, framings of meaningful 'choice' differed, and therefore assumptions about how it can be achieved.

From the interviews and documents about how newcomers and incumbents experience processes of building and changing business models and public policy reforms, more detailed ideas about how institutions should be designed were identified; what has been referred to as 'programmatic ideas' that suggest specific paths for policy action (Campbell 1998; Schmidt 2011). The higher-level ideas about

'how things work' and *'what is just'* can be linked to these more applied ideas about '*what should be done'*, in other words, how institutions should be reformed.

7.1.1 Framings of efficiency and welfare

7.1.1.1 Differences in high-level meanings and assumptions

The comparison of proposals for how to design electricity retailing showed that the concepts of (short-run) 'cost-efficiency' as well as 'welfare gains' were framed differently. This was linked to divergent assumptions about how these aims could be best achieved. As outlined in Chapter 4, proponents argued that competition would reduce the overall system-cost, both through sending signals for demand-management following cost-reflective electricity tariffs, and by improving investors' behaviour and incentives by exposing them to market risk. Proponents of unbundling network companies also argued their reform would reduce cost by ensuring that incumbents would not distort markets. By contrast, critics of unbundling argued it could increase transaction costs in the system because of the need to design complicated contracts and price signals. Finally, supporters of a monopoly retail market design argued that centralised planning was preferable, suggesting that correcting 'market failures' would be more difficult alongside competition. Their assumption was that aims like environmental protection could be more effectively achieved within the process of electricity sector planning, promoting preferred resources, than through separate policy instruments.

These varying assumptions are linked to different higher-level frames of meaning. Firstly, the concept of 'efficiency', while always ascribed positive meanings, was interpreted differently, and used to attain credibility for storylines. Economists in

favour of competition defined efficiency as the existence of a market mechanism itself, thus equating means and ends: *"we use the term "efficiency" to denote a functioning market in which buyers and sellers receive accurate and timely price information with limited transaction costs"* (Goulding et al. 1999 : 62). Other economists arguing against unbundling used the term to describe benefits in general. For instance, Michaels wrote on behalf of vertically integrated utilities: *"Failure to recognize the value of integration may foreclose the realization of important efficiencies"* (Michaels 2004 : 12). A third view of how to run an 'efficient' electricity system was linked to promoting demand-side resources which, where there is ample potential, were assumed to be inherently lower-cost than supply-side resources. Those who believed that demand-side resources should be privileged framed efficiency as the adoption of 'negawatts': *"the goal was to achieve efficiency and therefore push demand response and energy efficiency as cheaper, better ways to meet customers' demand than building a new power station"* (Int-A-7). The different framings of 'efficiency' used by discourse coalitions support the contention that within the professional practice of economics and policy advice, 'efficiency' has emerged as an *"accepted behavioural norm that allows the economist to offer up an efficient outcome as both evidence of a 'good' thing (…) and as proof of scientific objectivity"* (Bromley 1990 : 87). Referring to efficiency allowed stakeholders and policymakers in all three states to professionalise their storylines and justify their preferred reform outcomes. This explains the ubiquitous use of the term, albeit with varying meanings.

Relatedly, the interpretation of 'welfare gains' differed between coalitions, and these frames of meaning underly different market designs today. Some economists believe that welfare gains are the natural result of competition: *"market processes are positive-sum games because they generally make both consumers and producers better off than they would have been otherwise"* (Kiesling and Kleit 2009 : 2). This

view assumes that centralised planning must lead to welfare losses because planners have inaccurate or insufficient information about preferences and costs. It supports the unbundled market design with unregulated end-use prices which was adopted in ERCOT because the market is trusted to allocate resources in ways that will increase welfare overall. The monopoly market design in California incorporates wider and collective interpretations of social welfare. For example, policymakers may pursue 'public interest' outcomes such as social cohesion, solidarity between customers with different abilities and costs to serve, environmental protection, or effects on employment (Parker 2009; Prosser 2005). Planners can consider other criteria besides cost and can compare resources in light of these objectives.

7.1.1.2 Relevance today

These different frames of meaning and assumptions are relevant still today in debates about policy change to enable further decentralisation and new business models. Stakeholders still discuss where the boundary of monopoly and competition should be drawn, whether administrative or market-based allocation of resources is preferable, and what are the comparative advantages and disadvantages of unbundling electricity network functions.

One area of relevance is the debate about how to organise 'flexibility' or 'local energy markets' in future. Some believe that for management of loads and power sources on the distribution network, price signals and trading of power can be realised using a system of 'nodal pricing' (Int-B-42-DER). Others argue that services should be procured centrally because relying on price signals and competition could in fact jeopardise reliability and raise costs (Int-B-113-DNO). One vision of the future is that DER will be procured in transparent markets with multiple buyers, where actors

respond to price signals (in the long and short-term). Another is that monopoly actors (a distribution-system-operator or unbundled system operator) should decide which services to procure and tender these out, in order to ensure better reliability of response and acceptable cost (Int-B-113-DNO). Again, assumptions differ about whether coordination through price-signals in markets produces better outcomes, or whether high degrees of cost-reflectivity are in fact institutionally challenging to establish and come with high transaction costs and externalities (see also Brunekreeft 2015). This dispute about whether control of dispatchable DER in future should be centralised or decentralised is arguably an extension of debates about energy wholesale market design that have been discussed in the past for larger scale systems (see e.g., Green 2008). A mix of approaches may become finally institutionalised also at distribution-level.

For all retailing functions, debates continue about whether they are best delivered competitively or by regulated-franchise utilities. Where policymakers decided to mandate investment in advanced metering infrastructure (AMI), there are again disagreements about whether competing players or regulated-franchise network utilities should manage implementation. This debate is particularly controversial for instance in Great Britain, where competing retailers have been obligated (Hielscher and Kivimaa 2019). In California, where centralised planning in energy procurement remains institutionalised for most customers since 2001, stakeholders still today discuss whether or not to reintroduce competition to electricity retailing functions. On one side, large energy users and some electricity retailers continue to call for direct access (Doc-26-CLECA). On the other, some experts and policymakers believe that California's franchise-market design without competition is best suited to reach decarbonisation goals (Int-A-1) because decarbonisation requires long-term contracts for low-carbon generation, with costs recovered through non-by-passable charges

(Doc-26-Tierney). DER providers remained largely undecided on the matter in 2017 (Doc-26). For instance, the rooftop solar-PV industry did not take a view on whether or not competition in commodity electricity procurement should be reintroduced (Doc-26-Hoskins).

Furthermore, the billing function remains contested in jurisdictions where network-retail utilities were not unbundled. Like during the initial struggle over restructuring outlined in Chapter 4, some prospective retailers in Massachusetts and other states demand banning network-retail utilities from providing commodity bills, so they don't have to compete with the regulated-franchise's strong brand (Int-B-67-RET). One expert explained, *"I think it shows you how important that customer point is (…). The bill is what consumers see, so the utilities want to hang on to that"* (Int-A-7). *"The competitives want to get access to that"* because they expect it will help with brand recognition and providing services (Int-A-7).

At the same time, some smaller firms who are less well-resourced than the gen-tailers and than Enron were, support a stronger role for the network-retail utilities in billing and collecting revenue from customers on retailers' behalf. This model where the regulated-franchise incumbent manages revenue collection is seen as efficient by many, reducing the need for credit screenings, risks of non-payment, and problems with bad debt for the retailer (Doc-61-RESA). The contested role of billing is one part of a wider contest over the relationship with residential energy users who are considered less sophisticated and not likely to manage several 'energy-related' relationships. The opportunity to establish, maintain, and further develop a relationship with suitable energy users who offer potential for future value generation is highly attractive to a range of incumbents and challengers.

Finally, debates about the design of public-interest-schemes promoting DER also echo the different framings of 'efficiency' and of the appropriate role for regulated-franchise companies. As outlined in Chapter 6, Californian network-retail utilities' traditional role in managing energy efficiency and demand response measures and a supply chain of intermediary 'programme implementers', technology companies, and building contractors is being challenged. In California, regulators are increasingly *"adopting principles of market-driven"* distributed resource programmes (Doc-57-CPUC), following complaints from challengers who would rather work independently than with the network-retail utility. These reforms remain hotly debated, also in other states.

Again, differences in assumptions underlie the varying proposals, often implicitly. One disagreement is about whether integrated assessment of resources or decentralised, market-based assessment of options is preferable. For instance, one Californian network-retail utility representative argued a monopoly player assessing in a centralised manner a range of resource options, at the individual building level in this case, could achieve more efficient outcomes than competing service providers. They argued that as monopolies not themselves invested in specific DER assets, technologies, and capabilities, they should remain involved in implementation because they could offer their customers independent advice on the improvement of their premises (Int-B-83-IOU). With knowledge of all different public-interest-incentive-schemes, the utility representative argued that their staff could, for instance, combine roof-insulation with solar-PV and more efficient fans, while a solar PV-company would not likely provide such an integrated approach (ibid.). A lack of integrated assessment, they argued, could lead to inefficiencies, for instance because the solar system may be oversized if efficiency potentials were not considered (ibid.). For large energy users, specialised energy services and consultancy offers already

offer integrated assessment of options for energy management, but for small energy users, these offers have not so far been widely available. Academics independent from utilities have made similar arguments about integrated assessment of DER potential and coordinated delivery of measures improving outcomes for energy users (Goldman et al. 2010; Darby and McKenna 2012).

By contrast, proponents of entirely market-driven DER programme implementation argue that competition is more important in generating 'efficiency' than integrated assessment and delivery, and that network-retail utilities adversely interfere with competitive energy service markets. They therefore call for the vertically integrated network-retail utilities to step back from running and marketing DER programmes (Int-B-69-DER). The assumption is that network-retail utilities as powerful players with advantages over newcomers thwart competition, and in some cases also work against DER resources reaching their full potential, so proponents of unbundling call for the norm of non-interference to be institutionalised.

7.1.2 Framings of electricity as a special type of service

7.1.2.1 Differences in high-level meanings and assumptions

Disagreements about whether electricity has a special social dimension or should be treated like other products were central during debates about market restructuring. Representatives of small consumers proposed policies based on principles of politically negotiated fairness in access, terms, and cost burden. Others argued that electricity should be treated similarly to other goods with less regulatory scrutiny, to allow innovation and entrepreneurship to emerge, once access was provided to everyone. At the heart of the debate about electricity retail competition was the

question whether it was fair that large energy users would benefit more from the new institutional arrangements than residential and small business customers would, given retailers in the US were waiting to make attractive offers to large energy users. Small energy user representatives in the three states believed their constituency would not benefit at all, because few retailers would seek to make offers, and because prices would increase to reflect the higher cost to serve residential customers.

There was agreement that if price regulation was removed, under competition in retailing, the distribution of costs and benefits would no longer be decided directly by regulators weighing different user groups' interests (except in the case of network tariffs). Instead, greater cost reflectivity in pricing and potential for innovation in energy commodity offers were expected to create inequality of terms and prices. Unless required to by regulation or other political pressure, most do not expect markets and competing entrepreneurs to respect political aims related to solidarity and social cohesion. Nor do most expect competing entrepreneurs to distribute resources and opportunities according to principles of equality or fairness, given that the investors backing them have put capital at risk, with the expectation of a return.

Those who wanted to see electricity treated similarly as other products framed a market-based distribution of costs, benefits, prices, and terms of service as acceptable. Others framing electricity as a special, essential type of service (Prosser 2005) called to retain regulatory intervention intended to correct some of these inequalities according to politically defined principles. The two different framings were linked also to different assumptions about fairness. Calls for ongoing regulation of the special type of service assumed that fairness would need to be assessed based on outcomes, that is whether the resulting distribution was considered just. In contrast to this 'outcomes-based' view of justice, a 'process-based' perspective of justice is commensurate with the belief that distribution resulting from individual choices in

well-functioning markets are just, as long as the rules that organise the interactions are. This perspective assesses the fairness of an institutional framework not linked to results, but to whether the rules were designed in a fair way in the first place (Greenberg 1987). From this perspective, if the market functions well, the fact that some customers have access to more varied electricity offerings and terms than others is perceived as fair. Redistribution from this vantage point should then be taken care of by other policy means outside of electricity sector regulation (Littlechild 2002), and not built into decision-making about terms and prices available in the electricity retail market.

7.1.2.2 Relevance today

The higher-level disagreement about whether electricity should be regulated with special scrutiny is relevant today to the following discussions about policy change for demand-side transitions: firstly, proposals endure to reform rules making charges for energy and distribution network use more cost-reflective. These reforms would bring varying prices and terms of electricity supply for different customers and regions which some consider inacceptable for an 'essential service'. Secondly, there are calls to reduce regulatory burden and prescriptions related to electricity retail to enable more innovation. Finally, stakeholders disagree on whether regulators should take more risks on behalf of consumers to enable innovation to emerge, or whether the special status of electricity requires especially strong consumer protection.

Firstly, the DER providers seeking commercial opportunity in optimising users' energy consumption and controlling dispatchable DER in response to price signals call for more cost-reflectivity in network and energy costs, or even 'nodal pricing'. This they hope will enable them to optimally site and dispatch DER (Int-B-29-DER;

Int-B-42-DER). Like the discourse coalition of large energy users, co-generation industry, and prospective electricity traders in the 1990s, these DER newcomers tend to speak about the wider system-benefits their propositions can bring, but give less emphasis to associated cost shifts and distributional impacts. Cost-reflectivity of network and retail tariffs invariably creates inequality of access and price, given that, like in the past, different types of energy users have varying means to shift their demand through behaviour change or capital investment in technology (Darby and McKenna 2012). Moreover, opportunities to benefit from these changes would also vary across regions, and between customers who are more 'digitally engaged' and internet-connected and those who are not. Where costs have so far been spread equally across customers with different characteristics, reforming regulatory institutions with the aim to allocate costs more reflective of differences such as time, location, and volume of power consumed, will in many cases re-distribute previously socialised costs and benefits. Whether this is perceived as 'fair' depends, as discussed above, on conceptions of justice, and assumptions about whether electricity should have a special status. It also depends on assumptions about the likeliness that benefits from an active demand-side lowering energy network or balancing costs across the system will 'trickle down' to unengaged energy users who don't themselves participate in the system.

Ideas about electricity as an 'essential service' were institutionalised in a variety of rules and regulations designed to protect customers in retail competition jurisdictions like Britain (Eyre and Lockwood 2016) and Texas (Int-B-68-RET). For instance, the institution of 'default electric service' was intended to ensure users do not have to make a conscious choice to receive electricity. Further rules were devised to ensure the quality and terms would meet certain standards, also outside of default electric service. Where regulators were concerned about adverse treatment of customers by

competing companies, additional rules supplementary to general consumer protection legislation were institutionalised, to ensure customers are protected especially well in the electricity retail market.

These rules that institutionalise ideas about electricity as a special product tend to structure business models in certain ways, especially in residential electricity retail markets where rules are more prescriptive often than for retailers serving large consumers (Int-B-51-REG). For example, in Britain there are rules related to how costs may be distributed between customer groups, and to whom retailers are required to make offers (Int-B-48-REG). Because of such regulatory requirements, business models in electricity are more homogenous than in other sectors.

Critics have argued that these rules homogenising prices and offerings across regions and customer segments have created barriers to entry for players with novel business models and therefore hamper innovation. 'Non-discrimination clauses' in the UK for instance forbid offering widely varying prices across regions and have been argued to obstruct competition from developing to its full potential (Waddams Price and Zhu 2016). Hall and Roelich (2016) argue that rules dictating that retailers must make offers to customers anywhere across the country frustrate locally oriented energy service business models. By contrast, the British regulator Ofgem insists that its particular approach to implementing the 'universal supply obligation', principally enshrined in EU law, *"is in place for good reason (...)"*. Ofgem's requirements for retailers to offer terms and conditions to all residential customers irrespective of features such as location and credit worthiness were

> *"included as a licence obligation to mitigate the risk of 'cherry-picking' by suppliers and the concern that therefore certain groups of customers would be excluded from the benefits of the competitive market"* (Doc-65-Ofgem).

These concerns are based on a meaning attached to electricity as an 'essential service' that requires not only universal, but as far as possible, equal access to opportunities.

As long as residential customers were relatively homogenous in their capabilities to manage their demand, this approach to the universal supply obligation worked reasonably well. However, with increasing availability of distributed energy resources and digitalisation, energy users also at residential scale will be less homogenous in future. This means that tensions will increase between the desires to enable innovative, diverse retail offers and to ensure equal, universal terms of supply for a product considered 'essential'.

Finally, differing views of whether the special characteristics of electricity merit particular protection for customers lead to disagreements about whether and how policymakers should take risks on behalf of customers to enable innovation and market entry for newcomers (Int-B-46-REG). On the one hand, policymakers try to balance the risks and benefits of opening markets up to newcomers, and weigh up the opportunities for some customers with risks to others (ibid.). On the other hand, challengers seeking to enter the sector call for fewer regulatory impediments. One start-up demanded (Int-B-29-DER),

> *"the regulator should take more risk, even if maybe in the short term some people get trodden on, but if they're always looking after the granny and the little guy, the least common denominator is always risk mitigation, then you're going to be anti-innovative. (...) The rate of which pro-suming, consuming smart appliances, storage will come... all of that is happening measured in months, whereas the think, consult, get it through parliament, that takes years (...). The rational thing is to remove policy impediments, let people try stuff and don't consult, just observe what's the reality commercially and regulate what's there. (...) Otherwise you'll fail because you're too slow for the rate of change in the market."*

Regulators see risks in opening electricity markets and changing network charging arrangements, mainly related to distribution of costs and benefits, protection for

customers, and to the wider reliability of the system (Int-B-44-REG). In some jurisdictions, negative experiences with fraudulent practices including deceptive marketing and pricing even led regulators to enforce moratoria on electricity retail competition for certain customer segments (for instance in the State of New York, Doc-66-NYPSC).

In relation to electricity retailing, one proposal in particular would require regulators to re-evaluate the status of electricity as an essential service that requires special licensing, screening, and customer protection rules. Some parties have called for policy change to enable further scope for intermediation between retailers and customers or 'billing consolidation' (Int-B-67-RET), so that commodity electricity could be re-sold by third parties that have not qualified as electricity retailers. This type of intermediation would go further than the currently available brokering or automatic switching and make electricity accessible as a product to retail for more different types of players who could bundle it with other services and products. For DER business models, this would be important only where providers want to offer on-bill financing of investments in customer premises or want to sell their proposition bundled with electricity commodity.

Support or doubts about 'resale' proposals are linked to assumptions about how much regulators and policymakers should trust new types of companies and business models to deliver good outcomes, and the risks fit for what is framed as an 'essential service'. Allowing further intermediation and bundling of other services with electricity with fewer regulatory requirements would lower the entry barriers to the electricity retail market and allow more players from other sectors to sell electricity with more diverse business models. This in turn would make supervising electricity retail markets more difficult than where business models are homogenous and there are fewer players.

Overall, a difficult trade-off exists for policymakers between protecting customers from exploitation and the potentially negative implications of unknown, untested business models, and enabling individual consumers and the system as a whole to benefit from the potential for innovation. So far, electricity is commonly perceived as the realm of 'essential service' along with other utility services, while DER are not. However, as energy supply decentralises, ideas about where the appropriate boundary for this category lies may shift, and some may conceptualise energy services as essential services as well. This discourse is being promoted for instance by environmental justice groups in California calling to enable low-income communities' access to solar-PV and other DER (Doc-26-CEC). Or, regulations and prescriptions for how to sell electricity could be removed or softened, allowing intermediation and a wider set of less tightly regulated players to 'resell' it. Institutional change could shift the boundary of the 'essential service' related to energy in various directions.

7.1.3 Framings of 'choice'

7.1.3.1 Differences in high-level meanings and assumptions

The analysis of discourse coalitions in Chapter 4 showed that advocates of different electricity retail market designs had varying ideas about the concept of 'choice'. Those who called for all customers to choose retailers framed individual 'choice' as a right or in some cases even a duty. Supporters of a monopoly retail market design framed collective choice articulated through the regulatory (political) system as adequate. These higher-level distinctions in framing were linked to differing assumptions about which institutional arrangement could deliver customers' desires. Some assumed that only a competitive framework could 'discover' consumers' wants and needs, while

others maintained that administrative decision-makers could accommodate these through a well-functioning regulatory process.

Related were contrasting assumptions about what constitutes 'innovation', and a suitably differentiated range of options. What seemed like a genuine range to some was considered homogeneous by others. While the British regulator Littlechild assumed that choice between retail providers and different ways to pay for commodity electricity would increase 'choice' and improve options for all types of customers, US economists like Joskow believed that these choices would be primarily valuable for larger energy users, but less for small ones. Joskow argued that retailers would have to offer 'added-value' over and above what the distribution utility would provide, so that their offer could be deemed innovative and their profits justifiable (see Joskow 2000; and Littlechild 2000). In a similar vein, one California policymaker argued that the qualitative range of options in competitive electricity retail markets is poor because electrons are homogenous, and therefore individual 'choice' in these markets is an illusion or cannot be meaningful (Int-B-99-REG). In this view, technology companies with a range of DER offers are framed to provide more, or a better quality of 'choice' in energy than a competitive electricity retail market with varying commodity offerings can.

The comparison of discourse coalitions also showed that there is disagreement about whether a large number of options which proponents of competition were arguing would be a benefit of market restructuring would be desirable at all. Some proponents of individual choice and competition believed that a greater range of options would be intrinsically valuable (Hogan, 1994). This contrasts with the assumption that too many choices in fact can overwhelm and demotivate people (Int-A-2).

7.1.3.2 Relevance today

Still today, there are different framings of offerings in electricity retail markets. For instance, the British Competition and Markets Authority (CMA) in its GB market investigation took the view that commodity competition has not led to wider customer engagement and differentiation of products and services. It describes the range of offers available to retail energy consumers as *"homogenous"*, and claims that based on the authority's survey, cost and price are the most important product characteristic for British residential customers (Doc-24-CMA : 346). Large British retailers reject this framing and claim that their customers do have a large range of pricing and hedging options, are engaged, and actively choose to remain with default-retailers based on quality of customer service and additional services offered (ibid., pg. 350).

The different framings of and assumptions about 'choice' are relevant today in all debates about electricity retail market design, but especially in those related to default electric service. The different framings of individual choice in energy markets as a *burden* on customers, a *privilege*, or even a *duty* lead to supporting different market designs. Those who believe in poor quality of choices in electricity, little to gain in exercising them, or in individual choice in electricity as a burden tend to support price-regulated default offers, and in effect 'freedom *from* choice'. Regulated prices supposedly enable customers who don't make an affirmative choice to rest assured that retailers are not overcharging them, relying on regulators to exercise the collective responsibility of managing the price of electricity supply on customers' behalf. While the argument that individual choice can be a burden does not necessarily call for absolute equality of price or central planning, it does reject the notion of large differentials in price and service terms, and therefore calls for regulators or Governments to ensure standards and defined 'fair' prices for retailing commodity.

Price protection is criticised by those who frame choice in commodity markets as a privilege or even a duty because there are worries that protecting unengaged customers through price regulation limits choices for others who value them (Kiesling 2014; Treadway 2015). The default service model in the Northeastern US states where network-retail utilities provide electric service close to or at cost is argued reduces freedom of choice (ibid.). Because new entrants claim that competing viably is difficult when the default tariff is too low, critics argue that the model proposed by Joskow (2000) and others deprives consumers of the many desirable options they argue markets like ERCOT and GB offer (Kiesling 2014). The disagreement again is about what constitutes a desirable range and quality of choices.

Retailers in Europe who provide default service have also criticised default electricity tariff regulation. Framing non-engagement in the market as 'loyalty', they argue that 'choice' should not have to be affirmative to count (Int-B-41-EXP). Based on framing a refusal to switch as loyalty, intervention to regulate prices on behalf of customers can again be framed as reducing 'freedom' or 'choice'.

Proponents of a stronger role for municipal Governments in energy procurement and retailing rely on framing 'choice' as collective rather than individual. In several US states, legislation to create the opportunity for city Governments to form 'community choice aggregators' relied on institutionalising the assumption that elected representatives could have a role in exercising collective choice, procuring energy on behalf of all users in their territory. A similar model has been discussed by British scholars Hall and Roelich (2016), suggesting that choosing a monopoly (municipal) retailer via a public referendum could be a good way for citizens to engage in electricity retail markets. This proposal frames energy users as voters and citizens rather than consumers exercising individual choice in competitive retail markets.

The different meanings and importance players attach to collective or individual 'choice' also have relevance to debates about whether players with public-benefit character such as municipal energy market players should be subject to special rules, based on having been given a licence to operate by democratic mandate in their city. For instance, PUC President Picker explained that California must determine how and by whom community choice aggregators as newly emerging city-owned energy companies should be regulated, and whether they should be treated with the same regulatory scrutiny by state-level regulators as privately-owned energy companies and DER newcomers (Conf-2). Arguments that municipal companies should receive less regulatory scrutiny than privately-owned companies rest on the assumption that where companies are controlled by elected representatives, decision-making is already aligned with the interests of energy users and citizens, and therefore requires less direction by a state-level regulator.

Overall, the preceding analysis showed how electricity retail market design is politically significant because different models rely on varying framings of key concepts: efficiency and welfare, essential services, and 'choice'. These contested framings are linked to differing assumptions and disagreements about how to achieve the best outcomes for an electricity system, energy users, and society more widely. By making visible these disagreements and underlying assumptions, the interpretive policy analysis highlighted how electricity retail institutions are contested, and therefore political.

7.2 Electricity retail market design and access to resources and opportunities for DER

The previous section investigated the contested nature of electricity retail market designs. This section turns to a view of politics as linked to distribution of resources and opportunities. To this end, it analyses the evidence presented about interactions between DER challengers and electricity incumbents, specifically those whose business models are directly influenced by electricity retail market design: retailers, unbundled network utilities and bundled network-retail utilities. It also outlines the likely possibilities of incumbent electricity business model evolution going forward, based on the evidence presented.

The assumption is that because market design determines the structure of the electricity sector supply chain and influences these incumbents' business models, it also affects how resources and opportunities are accessible. The chapter argues that where DER challengers' experiences in interacting with electricity incumbents varied because of different electricity retail market designs, market design has had political significance for the distribution of resources and opportunities within demand-side transitions. Where niche players' experiences were similar, market design has not significantly impacted demand-side access to resources and opportunities.

The research on trends of co-evolving commercial structures has revealed several key resources and opportunities in direct control of retail and distribution incumbents which newcomers with certain business models require:

- a customer channel
- energy commodity procurement budget
- control of commodity bills including the potential ability to enable on-bill financing and price signals in commodity tariffs to arbitrage against

- energy-wholesale market access
- opportunities for value from non-wires-alternatives for distribution grid services
- customer data
- distribution grid data

Where niche players gained access to these resources and opportunities by cooperating with incumbents, processes of 'selection' created variance in the population (Schaltegger et al. 2016) because new commercial structures emerged and incumbents' practices changed.

Resources and opportunities in control of other regime-level players are not included in this discussion as they are considered not directly related to electricity retail market design. For instance, whether policymakers make available public-interest-schemes, SOs make available ancillary service payments, or DER are eligible to access capacity payments or wholesale electricity markets independently, I argue is more directly influenced by other public policy arrangements, or other regime-level actors' decision-making processes. Retailers, network-retail utilities, and network operators do not have direct control of these other revenue streams and opportunities. They are out of scope for this thesis because it investigates electricity retail market design as the public policy framework which organises electricity system functions downstream: electricity procurement, billing, metering, and distribution, and the business models and structures of incumbent electricity companies providing these.

7.2.1 Similarities in how DER newcomers have accessed resources and opportunities under different market designs: The insignificance of electricity retail market design

The comparison of how access to resources and opportunities worked for DER niche players under different market designs showed several similarities (see Table 7): Dissatisfied DER challengers found that incumbents in both environments have impeded access to distribution grid data and customer data, so that no notable differences related to market design were identified. Access to revenue from network operators procuring demand-side services ('network value') was also not found to be significantly more or less advanced in markets with different approaches: here, there are leaders and laggards among bundled and unbundled network operators. Electricity retail market design also has not directly influenced access to revenues from public-interest-schemes if these were managed by incumbent retail and distribution companies. This was mainly because the range of measures incumbents make revenue available for is not left to them, but pre-determined in the process of scheme design and politically negotiated. The following sections discuss each of these points in turn.

Resources and opportunities	Type of DER provider it is relevant to	Type of incumbent in control	Findings on interaction between niche and regime
Distribution network revenue	DER providers targeting distribution network value	Unbundled network operators, network-retail utilities	incumbents prioritise capital investment, and find DER-for-network-operation challenging
Distribution network data	DER providers targeting distribution network value	Unbundled network operators, or network-retail utilities	incumbents have been protective, or don't have data and ability to analyse the information
Customer data	Most	Procurement entity, billing provider, metering data manager	incumbents have been protective
Public-interest-scheme value	DER types which qualify; scheme type and resource support vary across jurisdictions	Competing retailers, unbundled network operators, bundled network-retail utilities, or others	Niche is promoted because scheme-design is negotiated with policymakers, so incumbents must promote chosen types of DER, sometimes in prescribed customer segment

Table 7: Similarities: instances where electricity retail market design has not influenced demand-side access to resources and opportunities

7.2.1.1 Bundled and unbundled incumbents operating networks

When comparing electricity retail market designs, the progress network utilities have made in innovating to procure 'non-wires-alternatives' from DER providers does not seem to differ. This means that unbundling of distribution networks and metering has not so far negatively influenced the emergence of distributed energy, as some of the literature that criticises unbundling tentatively suggests (Hall and Foxon 2014; Vine et al. 2003).

For instance, Vine et al. (2003) suppose that bundled utilities engaged in energy procurement would be more willing to invest in demand-side measures for grid-purposes than unbundled distributors because they could realise savings in both energy and network operation. Hall and Foxon (2014 : 605) suggest, based on interviews with distribution-network-operators (DNOs), that because *"the UK's smart meter roll out [is] being delivered by energy [retailers]"* who don't focus on regions but operate nation-wide, *"the DNOs will not have direct access to demand side response (DSR), i.e. real-time management of electricity demand"*. They propose that British distributors do not procure demand response because meters, customers, and tariff design are owned *"by large national utilities [retailers] who may be unwilling or unable to engage at neighbourhood level with DNOs".* They suggest that a supplier business model with a *"close geographical focus"* would enable demand response for network purposes: *"once customer connections in a given area are high enough, DNOs would be willing to pay for demand side response"* (ibid. : 604-605). Both contributions suggest that unbundling can prevent DER recovering distribution-network value.

However, the comparison of distribution-network-operators' innovation processes across jurisdictions suggests that demand response for distribution purposes is not more advanced in states with bundled network-retail utilities than in unbundled environments. The Energex example in South-East-Queensland (Australia) (Swinson et al. 2015) shows that unbundled distributors have been able to buy residential demand response independently from aggregators or retailers, through appliance installers and shops. Like Californian network-retail utilities, air-conditioning units are controlled to reduce their usage at peak-time. To the author's knowledge, Energex' programmes are some of the largest-scale residential demand-side projects for *distribution network* management (independent from system balancing or energy

value) globally. This demonstrates that for demand response to be used for network purposes, unbundling does not have to be a barrier, if the supply chain works separately from retail markets altogether. Electricity retail market design with respect to energy procurement and metering has not directly mattered to these types of programmes because they work independently: the customer is rewarded with a lump-sum rather than bill credits and load shifted can be made visible through the appliance directly, or a separate communication channel.

British distribution-network-operators' barriers to procure demand response are more likely related to the operational and strategic business model challenges outlined in Chapter 6, and potentially also to availability and cost of suitable demand response resources, than to the retail market design and unbundling. Both bundled and unbundled distribution-network-operators have explained in interviews that they have had difficulties to implement learnings from trials and change operational practice. This confirmed what Grünewald et al., (2011 : 454) outlined: distributors are recognised to be *"culturally deeply conservative organisations." "Rooted norms and practises"* underlying long-established processes of *"forecasting the timing, capacity and cost of network upgrades (transformer or wiring)"* would have to *"undergo deep changes if distributed storage were to be considered alongside its alternatives"*. As a distributed-energy-programme-manager in a monopoly (municipal) utility in California explained about colleagues in the distribution department:

> *"The functions of distribution system planning are solely about building a system that is going to be reliable, not at this point about 'how can we connect more distributed resources to decarbonise our grid faster?' That has not penetrated those disciplines at all"* (Int-B-100-MUNI).

This shows that distribution-network-operation is a deeply locked-in practice, also for municipal utilities who as monopoly retailers in California aggregate many customers

in one region, directly control loads for energy-value and incentivise load shifting through dynamic tariffs.

Therefore, it is not clear why British DNOs should be able to take advantage once meters were rolled out on a regional basis, appropriate commodity tariffs were available, and customers were signed up to load-control programmes (Hall and Foxon 2014). The 'deep changes' required to DNOs' organisational practices shed doubt on the contention that distribution-network-operators will *"pay for demand side response"* as soon as enough aggregated load is available (Hall and Foxon 2014).

Furthermore, some literature has suggested that unbundled *"'wires' businesses may not have sufficient relationships with the retail customers to be able to implement customer programs"* (Vine et al. 2003 : 411). This implicitly suggests that bundled network-retail utilities could retain vertical learning, cooperation, and work together between departments. However, the research has shown that network-retail utilities in Massachusetts and California who procure demand-side resources for energy and capacity purposes have not easily been able to use these resources for network purposes. The idea that network and customer-teams can easily work together, or conflicts can be resolved better internally has not been substantiated. Literature that suggests unbundling reforms created strong boundaries between firm's units, a lack of communication, and prevents joined-up working to the detriment of demand-side operations (Apajalahti 2018) overstates the importance of electricity retail market design vis-à-vis other factors impeding change. It also overstates the degree to which vertical integration in practice implies joined-up working between different units and functions. One representative of a Californian utility never having undergone unbundling explained that sharing skills and knowledge within the company was difficult, because *"the people helping [customers] and the grid people, they're a different part of the company, a lot of us don't even talk to each other because we're*

so large" (Int-B-110-IOU). Although some conversations are beginning to develop (ibid.), the ability to work together internally will arguably not enable the bundled utility to promote the demand-side at the expense of network investment at a greater pace or quality than without this 'neighbouring' department. This is because the different types of skills and operations inherent to demand-side services and distribution grid operation will always mean that at a company-level, these different options for investment compete. Operational units will put forward their cases and conflicts exist just as clearly in bundled utilities who have DER departments and customer relationships, as they do in unbundled utilities for whom DER are novel territory.

There are always tensions between network and supply-demand operations because both sides can externalise costs to the other. Conflicts always require resolution, and it is not clear that this is easier in bundled or unbundled environments. One British distribution-network-operator representative compared operations before and after unbundling and described that it meant conversations *"moved to another building"*, but they had *"always been in different rooms"* anyway (Int-B-113-DNO). This means that the interaction with retailers, aggregators, or installers under unbundling did not feel more difficult to manage than before restructuring when these functions were housed in the same company. Reflecting to times before separation, they outlined how conflicts had been difficult to resolve when the retail-supply-department began to market night-time storage heaters to match nuclear power generation without coordinating with their distribution-colleagues who had to accommodate the load growth (ibid.). This confirms that coordination is required, whether hierarchically within a firm or through contracts and price signals externally (Brunekreeft 2015).

A shift to treat demand-side options fairly or even preferentially will not emerge through the distribution planners 'learning' through conversations, coordination, and

training at operational levels. As the insider to the DER solutions department in a bundled utility in California explained, conflicts related to investing in the demand-side, supply-side, or in conventional network options *"have to be resolved at the executive board level"* (Int-B-100-MUNI). I argue that because of the inherent primacy network-planners will give to what they know and trust, higher-level decisionmakers will have to exert pressure, if demand-side resources are to replace conventional network asset investment.

Across jurisdictions with different electricity retail market designs, access to other resources and opportunities controlled by network companies was also similar. Complaints by DER providers about limited availability of distribution grid data and unnecessarily arduous and slow network connection procedures were made about both unbundled and bundled distribution grid operators. Some distributors are clearly more supportive of the demand-side than others, but the interviews and trends across jurisdictions do not suggest that unbundling is clearly related to these behaviours.

Policy support will be necessary to shift practices, through regulatory institutions that explicitly support DER, incentivise, and obligate distribution-network-operators through 'carrots' and 'sticks' (Satchwell et al. 2011). To address the challenges of limited understanding of demand-side resources, lack of trust in their reliability, and wider commercial uncertainty about how network incumbents will be able to benefit from DER, financial and other rewards and penalties that directly affect a company's performance will be necessary. Experience in Australia has shown that policymakers privileging demand-side resources over centralised assets in forms of niche-protection is helpful: DNOs forced to make available data and consider DER options before they are permitted investment in network upgrades have made progress with 'non-wires-alternatives'.

Potentially, somewhat more diffuse, longer-term signals such as real threat from policymakers to restructure the industry if performance is not satisfactory could also motivate management to drive change in ways which policymakers demand. These signals exist, for instance for municipal utilities in the US under threat of 'annexation' by private utilities, in other words, through the threat of privatisation (Int-A-11-EXP). The same mechanism is used by US city governments in the reverse, where local authorities systematically threaten municipalisation to pressure incumbent investor-owned utilities to better accommodate their community's priorities (Doc-59-APPA).

Whether signals from policymakers are immediate and institutionalised in regulatory mechanisms, or more diffuse in the form of threatening institutional change, it is clear that incumbent network operators will try to influence public policy and thereby the regime's 'selection environment' to continue operation with minimal change, rather than allow their importance and independence to be reduced by newcomers. While they may embrace change under sufficient pressure, electricity retail competition and unbundling do not seem to impact these change processes.

7.2.1.2 Access to customer data

Access to data on customers' energy consumption has been an important battle ground for DER providers under both types of electricity retail market designs. Processes of institutional reform organising access were described as complicated. This was true both for data which require customers to consent, and which are made accessible without customer consent in anonymised (aggregated) form. Incumbents in both environments have been protective of the valuable resource. Incumbent companies and regulators cite concerns about security, privacy, and cost while newcomers argue limited data access stifles innovation. Several DER interviewees believed that both

competing and regulated-franchise incumbents would continue to prevent easy access to customer data to protect advantages data access brings over newcomers (Int-B-69-DER; Int-B-89-DER; Int-B-116-DER).

The wide-scale adoption of advanced metering has involved regulatory intervention under both competitive and regulated-franchise metering. More significant than the organisation of metering as a competitive or regulated-franchise function were the outcome of policy debates, public-interest economic analyses, and policy decisions. Where metering is provided by regulated-franchise utilities, they have usually sought regulatory approval of additional funds to invest in advanced metering because the required capital investment is substantial. Under competitive metering, initially, individual customers, their retailers, or energy service providers assess the 'business case' for investing. Market-led assessment previously led to only large energy users adopting advanced metering. In many jurisdictions, policymakers decided to mandate investment also for smaller users, based on aims such as improving billing accuracy, information to energy users, reducing energy theft, and reducing energy demand (Darby 2010). Therefore, advanced metering has been viewed as *"basic public service equipment"* that enables better grid-management (Leiva et al. 2016). Hence, whether a jurisdiction has broad adoption of advanced metering has not been determined by incumbent electricity companies' commercial decisions.

Problems during mandated roll-out of limited coordination and inadequate standardisation across regions and customers have also occurred in both environments. In Britain, electricity retailers installed early versions of advanced meters which lose their functionality when a user switches retailer (Int-B-20-RET). This prompted suggestions that had metering roll-out been assigned to distribution-network-operators, the process would have been more coordinated (Int-B-27-EXP; Int-B-52-DER). However, in jurisdictions where distributors installed advanced

metering, limited standardisation of specifications has also occurred (AlAbdulkarim and Lukszo 2009). What matters more is how coordination is managed by policymakers mandating the advanced roll-out.

While DER newcomers have complained that retailers' and regulated-franchise utilities' protectiveness of energy consumption data has created barriers to innovation, DER challengers have of course themselves been reluctant to share information on energy users once they have it. For them too, customer data are valuable resources which can provide additional revenue streams, prospects to sell further services, and generally power within the network of players that build a supply chain. As one player working on residential demand response and solar-home management propositions explained,

> *"all manufacturers, whether it's cars or heat pumps, have a drive to wall themselves off. The exchange of data needs to be much more open. (…) Without open standards to exchange data, a household as a whole can hardly be optimised, and no manufacturer wants to make their device's energy consumption available"* (Int-B-38-DER, author's translation).

Customer data as valuable resources will remain highly contested in any electricity market and are hence of political significance. Trade-offs exist between encouraging innovation through private entrepreneurship, managing cost, and ensuring positive outcomes with respect to privacy and cybersecurity concerns.

7.2.1.3 Business models independent from electricity retailers

Some DER niche-players have not needed to cooperate with incumbents retailing electricity because they have successfully built a business model that challenges the dominance of centralised resources by targeting a variety of value pools, revenue

streams, and customer channels independent from commodity electricity retail players, products, and tariffs.

For instance, several DER business models have not been affected by electricity retail market design directly because they have sought to access customer, energy, ancillary service, and capacity value pools directly. Direct access to associated revenue streams without needing to cooperate with incumbents has in all cases required reforms to industry rules, and therefore, lobbying efforts on behalf of DER niche players. Retailing and network incumbents have in several cases succeeded in influencing public policies such as industry standards, public-interest-scheme designs, market access rules, and market design to the detriment of DER, but the means they employed do not seem directly linked to electricity retail competition and unbundling, and the structure of incumbent companies. Both competing and regulated-franchise utilities have used their power on industry-decision-making bodies, influenced public discourse and knowledge production, and pressured policymakers, if they could benefit from protecting their conventional business models and centralised electricity assets.

Interviewees whose business models largely relied on revenue streams from public-interest-schemes and who are happy to themselves recruit customers did not perceive the electricity retail market design in place as affecting their opportunities for growth. Several micro-generation firms stated that in comparing markets with different approaches to electricity retail competition, they did not find accessing the guaranteed revenue provided by feed-in-tariffs or net-metering, installation grants, or subsidies from obligation schemes more or less difficult based on different approaches to electricity retail competition (Int-B-80-DER; Int-B-86-DER; Int-B-92-DER). Similarly, an implementor of energy efficiency programmes, working for both bundled network-retail utilities across the US and unbundled network operators in

Texas, thought there was no evidence for energy saving obligations working better or worse in Texas with a competitive, unbundled retail market design (Int-B-102-EE). The fact that only competing energy service providers, technology companies, installers, and retailers may actively market measures to customers, while ERCOT distributors may not, they believed did not affect the success of programmes. Instead, they believed the success of the obligation scheme was determined by the size of the obligation or funds made available, and by the extent to which obligated parties were rewarded for delivering savings (ibid.).

There is no clear evidence that electricity retail competition and unbundling hamper the implementation of well-designed policies to promote demand-side energy resources. Obligations on incumbents to invest in specified resources have worked similarly in the different environments and have delivered growth in DER. However, in academic and public discourse, several concerns remain about the effect of electricity retail competition on policymakers' ability to promote energy sector decarbonisation.

Firstly, one of the key criticisms of competition in energy procurement was that it supposedly reduces the ability of a centralised system planner to compare investment options, taking into account all externalities effectively. Especially in the context of power sector decarbonisation, critics of competition suggest, often implicitly, that because electricity retail competition eliminates centralised planning of power generation capacity, it makes choosing preferred resources more difficult. A framework which privileges individual choice by consumers, translated into decentralised decisions by electricity retailers and generators is deemed inferior to integrated power sector planning (Int-A-1; Int-B-99-REG) which requires a captive customer base. Through the use of techniques such as cost-benefit-analysis, central planning approaches can theoretically take into account all the benefits and costs

which markets cannot price without very large transaction costs. European analysts have also proposed that because of 'liberalisation' reforms, rapid decarbonisation may be more difficult than if these had not been adopted (Mitchell 2008).

Comparing how energy saving obligations work under different electricity retail market designs does not suggest that a mobile customer base has to impede policies based on centralised planning for energy efficiency investment, or other demand-side resources. Energy saving obligations on competing retailers or unbundled distributors have been implemented also in jurisdictions under energy procurement competition, and they have been successful in many cases (Bürger et al. 2013; Eyre 2013b). Moreover, calculations and even auctions for capacity can be run, where supply and demand-side resources can compete because the costs for these schemes can still be recovered from energy users as non-by-passable levies.

The difference lies in funding, following competition reforms. With electricity retail competition, utility budgets to invest in energy savings had to be separated from energy procurement budgets (Blumstein et al. 2000) because the customer base for energy expenses was no longer captive. While a captive customer base under electricity retail monopoly allows investing in energy savings from the same budget as supply-side power purchase agreements, in an environment of electricity retail competition, separate funds, from budgets not directly linked to supply-side investment must be used. It is not clear why this difference in budgeting should lead to more ambitious energy saving targets under retailing monopoly with a captive customer base than if an 'integrated planning' analysis that compares supply-side with demand-side resources was conducted by policymakers under electricity retail competition, for instance in the implementation of a capacity mechanism.

Moreover, the comparison has shown that despite diversity in approaches to implementation, there are similarities across electricity retail market designs. In both environments, utilities act either as financial administrators, collecting funds which are then allocated to energy service providers with responsibility to deliver; or obligated parties work closely with intermediary programme-implementation companies. Decisions on measures and end-use sectors are usually determined within the process of designing the obligation. Intermediaries work with energy service providers subcontracted or otherwise remunerated to deliver energy saving measures. If policymakers design schemes accordingly, measures can also be targeted to end-users who may otherwise not be the customer segment of choice for competing entrepreneurs (for instance because they are on low incomes). This research did not in detail assess different approaches to energy saving obligations (Blumstein et al. 2005), but the supply chains, business models, and mechanisms of implementation look similar under varying electricity retail market designs.

Furthermore, there was a concern about how competition would affect policymakers' ability to influence electricity companies. The literature suggested incentivising competing firms to support the demand-side may be more difficult: because a captive customer base enables regulators to alter a regulated-franchise utility's profit logic to incentivise support for the demand-side, competition could hamper the implementation of savings policies (Vine et al. 2003).

The comparison showed that regulators do have an additional tool to influence regulated-franchise incumbents which does not work on competing incumbents: softer regulatory pressure. Retailers and generators require more formal obligations (legislation) to be motivated to invest in the demand-side. However, where a regulated-franchise is 'decoupled', utilities have nevertheless remained resistant to greater decentralisation of electricity systems. Even if they are rewarded for delivering

energy savings, their bundled nature with networks and uncertainty about business model evolution means that they resist overall, system-level demand-reduction, as long as their business model is not reformed to give them a clear understanding of their future role in a very decentralised system.

It is not clear that competing incumbents have or invest more resources to resist change than do regulated-franchise utilities. Recently, MacGill and Healy suggested that competition and privatisation reforms *"created powerful incumbents"* lobbying heavily against decarbonisation (2013 : 633). This assessment ignores that incumbent players in markets that were not restructured or privatised also remain deeply locked into the status quo. Moreover, centralised high-carbon generation interests were not *created* by restructuring but shifted into new companies where investors bear more risk. Because as competing companies they may set up affiliates or acquire innovators to evolve their business models independently, it is not clear why they should resist changes more than integrated, regulated-franchise companies.

Under both restructured and monopoly environments, it is likely that those invested in high-carbon, and, or centralised assets will resist change that reduces the value of their assets and capabilities. As in the past, change may require some forms of compensation if assets become stranded (for redundant employees, and, or shareholders) to break these incumbents' resistance. Where energy companies are investor-owned, policy direction must come from regulators and Government (at various levels). In publicly-owned companies, internal policy pressure from elected representatives on incumbents' boards may also promote change (see also other recent research on publicly-owned incumbents Apajalahti 2018; Kindström and Ottosson 2016). It is likely that obligation from external regulators is also necessary, in both competitive and monopoly environments. Overall, it is not at all evident why implementation of policies to promote electricity sector transitions should be more

challenging under competition than where no restructuring reforms were implemented.

This thesis has not found evidence that electricity retail competition has visibly hampered or supported the emergence of energy service business models that provide financing of measures on customers' premises. However, it has not assessed whether the opportunity to switch retailers has engendered a culture of transience among energy users which makes the marketing of demand-side measures attached to long-term contracts more difficult (Cappers, Goldman, et al. 2013). Nor has it assessed whether competition negatively influences energy users' engagement in response to 'choice overload' (Iyengar and Lepper 2000). To explore these questions, research among end-users investigating interest in energy saving measures under retail competition and monopoly could be useful which this thesis did not attempt.

When public policies designed to protect DER niches through guaranteed revenues are phased out or reformed following wider adoption of DER, companies who grew on their basis must evolve their business strategies to access other value pools across the system. For some, electricity retail market design institutions may become more relevant in the future. As the next section will argue, these institutions will have greater significance for DER players who cannot directly access wholesale energy markets as virtual power plants, who seek to bundle their propositions with commodity electricity, and who want to use customer channels linked to commodity electricity.

7.2.2 Differences in how DER providers have been able to access resources and opportunities

The following section outlines differences between the options and experiences of DER players in building viable business models under varying electricity retail market designs. Where the differences identified are clearly linked to competition and unbundling, electricity retail market design has influenced access to resources and opportunities which some DER providers require.

Notable differences found from comparing trends were:

- Electricity retail competition enables DER newcomers to become retailers and hence organise energy market access independently from retailers or network-retail utilities. This means they don't have to cooperate with incumbents to offer combined commodity-and-service offers.
- Similarly, another difference relates to contestable or franchise billing: under competition, DER newcomers can themselves, independently from incumbents, design and brand commodity electricity bills. In environments where franchise utilities bill energy users for commodity, options like on-bill financing require regulatory intervention.
- Incumbents under varying electricity retail market designs and business models have behaved differently with respect to their control of customer relationship and channel.
- Energy procurement decisions vary between competing retailers and regulated-franchise utilities: under retail competition, energy value has been accessible to dispatchable DER newcomers without dedicated public policies that force retailers to make revenue available. Regulated-franchise utilities are

unlikely to support the demand-side in their energy procurement decisions, until policymakers mandate them to, or explicitly reward them.

- Similarly, incumbents' behaviour in designing tariffs influences independent DER providers' and customers' arbitrage opportunities: a range of price signals have been made available to large energy users in competitive electricity markets which have enabled DER providers to build customer propositions, for instance through load shifting. These have existed also in franchise retailing environments, but again, require policymakers' intervention.
- Default service design influences retailers' motivation and means to innovate.
- Finally, unbundling was found to influence two dimensions of how DER newcomers interact with incumbents: while network-retail utilities can act as aggregators of demand-side resources in markets because they have not been unbundled, the 'stacking' of network operator value with revenue from other markets requires DER providers to themselves access these markets or find another competing partner firm who can enable them to access these revenues. Secondly, some bundled network-retail utilities with responsibility for load-management are concerned about proprietary communication standards for controllable appliances and call for open-source standardisation.

Table 8 summarises how these differences relate to resources and opportunities.

Resources and opportunities	**Type of DER provider it is relevant to**	**Type of incumbent in control**	**Interaction between niche and regime, and relevant electricity retail market design dimension**
Opportunity to bundle electricity commodity and DER services	Those interested in selling commodity and services in one contract and one bill (e.g., on-bill financing)	competing retailers, bundled network-retail utilities	Contestability of energy procurement and billing allow newcomers to sell commodity, and design/ brand commodity bills independently from incumbents
Customer channel	Newcomers with 'utility-facing' strategy	competing retailers, bundled network-retail utilities	Competition in energy procurement and billing motivates retailers to cooperate with DER companies
Energy market access (energy procurement budget)	Dispatchable DER – microgeneration, demand response, storage	competing retailers, bundled network-retail utilities	Competition in energy procurement and billing enabled customers to be paid for kWh without direct policy support
Price signals	DER providers looking to arbitrage against commodity prices	competing retailers under billing competition, bundled network-retail utilities	Competition in energy procurement and billing enabled a range of price signals (tariffs) in the I&C retail market without direct policy support
			Default service design influences whether competing retailers are under competitive pressure and have the means to make above resources and opportunities available to DER
Opportunity to stack distribution grid value with energy, capacity, SO market value	Some, especially capital-intensive DER	Integrated network-retail-utilities	Unbundling means newcomers contracting with distribution-network-operators must access other value pools independently

Table 8: Differences in access: instances where electricity retail market design has influenced demand-side access to resources and opportunities

7.2.2.1 Combined commodity-and-services offers independent from incumbents

Electricity retail market competition enables energy service providers to bundle their offerings with commodity electricity into one contract without having to cooperate with incumbents. As retailing is contestable, DER providers with enough risk appetite, capital, and capabilities can themselves qualify as retailers and thereby access energy markets and provide electricity bills independently. The significance of competition in energy procurement and billing is that bundled supply-and-commodity offerings and on-bill financing are then possible without forming a partnership with an incumbent or designing the offer or bill on the incumbents' terms.

Not all DER providers value this opportunity. Firstly, many do not care to bundle commodity with services. Secondly, independent market entry as retailers to develop commodity-services-offers has been viable for players with sufficient capabilities and capital only. Entry costs are lower in the industrial and commercial sector than in the residential electricity retail market (Int-B-32-DER), and in some jurisdictions, costs of regulatory compliance are also lower (Int-B-24-RET). Nevertheless, in all customer segments, there are DER newcomers who prefer partnering with incumbents over qualifying and entering markets independently, to offer a bundled product.

In monopoly retail environments, combined energy-service-and-commodity-offers can be accommodated if regulators support them. Energy-supply-contracting that involved on-site generation existed before restructuring, for instance in Germany (Int-B-122-DER) and in the UK (Hannon et al. 2013). In California today, customers can buy commodity and energy services from the same company, be billed in one transaction and receive one contract. However, the incumbent network-retail utility remains a key player in this supply chain that newcomers cannot avoid.

On-bill financing is another type of contractual arrangement where contestability of electricity retailing has offered flexibility because energy service providers and niche players can independently from incumbents design bills and recover costs of investments. On-bill financing is possible under monopoly billing if policymakers provide for it. For instance, in California, IOUs have been ordered to finance upgrades to properties which are repaid through the electricity bill (Doc-60-ACEEE). Building contractors or customers can apply for this loan from the monopoly, but if a third-party energy service provider wants to provide financing, the investment cannot be recovered through the commodity electricity bill provided by network-retail utilities. Regulated-franchise utilities can be obligated to recover investment behind the meter on a third party's behalf, but in a monopoly billing environment this requires policy change. Moreover, it would neither entail freedom to design the bill independently from incumbent electricity utility, nor enable the brand advantage competing companies are seeking to realise from sending an electricity bill.

Introducing competition in electricity procurement ('retail choice') in the US Northeastern states without unbundling distribution-network-operators from the delivery of demand-side-resource programmes may have led to energy services markets remaining separate from electricity commodity markets in the large consumer segment. As explained in Chapter 5, energy-supply-contracting and offers bundling electricity commodity with energy services are widely established in some European countries, but not in the US (Int-B-121-DER). This difference in how energy services supply chains have developed may be linked to the continuing role of regulated-franchise utilities in energy services whose key account representatives offer industrial and commercial customers demand response and energy efficiency solutions. At the same time, large energy users buy energy services from competing energy service firms and frequently switch energy retailers. This means that where

regulators have not forced regulated-franchise utilities to step back from marketing demand-side solutions, they compete with other energy service firms.

One of the main narratives with which proponents argued for retail competition in the 1990s was that competition would encourage innovation in 'value-added' services and that these would promote demand-side resources, based on the idea that retailers would seek to set themselves apart from their competitors. Analyses after reform claimed that competition in Europe improved the opportunities for ESCOs and 'value-added services' because market reform facilitated *"new contractual arrangements"* (Marino et al. 2011). The fact that offers bundling commodity with services (energy-supply-contracting) have emerged in Europe, and uptake has been limited in the US where competition in retail is more constrained, could be interpreted as supporting this contention. However, calling these contractual arrangements 'novel' is exaggerated, given energy-supply-contracting existed already before restructuring reforms and can be implemented under monopoly. It is true that contestability of retailing commodity facilitated creating contracts freely between market players without having to lobby for public policy change with monopoly utilities' regulators. Furthermore, the variety of contracting offers may be greater, and the continuing role of regulated-franchises in energy services may influence the variety and opportunities for service providers having to compete with them. But the contention that electricity retail reforms facilitated radically different contractual arrangements for ESCOs is not supported by the evidence.

There is no clear evidence so far that the ability to bundle commodity and services into one product offering drives investment in the demand-side that would otherwise not occur. In public discourse, ideas of innovations around 'energy-as-service' and the end of electricity as commodity are popular (see e.g., Giordano and Fulli 2011) and retailers still today promise that electricity retail competition could lead to these

offers emerging. But interviews with energy service companies showed that many DER providers do not need to sell commodity to successfully market their proposition. Energy services promoting DER, including where a service provider finances, owns, and operates the asset, can be organised separately from electricity bills, revenue from energy procurement budgets, and the retailers' customer channel. The wide adoption of the 'solar-service' model in the US residential energy user segment (Strupeit and Palm 2016) is one example where public policy institutions have been reformed to improve value access, and energy service business models have emerged although DER providers are not allowed to retail electricity. In other words, commercial structures promoting DER-related energy services can be built outside of electricity retail markets because customers can have separate relationships.

Some may argue that the ability to bundle commodity with services will be more important, once business models no longer rely on public-interest-scheme value. But there is disagreement about whether a DER proposition is more attractive or profitable if bundled with commodity or not. This is linked to the assumptions about whether customers are content to manage several separate relationships related to 'energy' or prefer one interface, and to assumptions about how much additional revenue a service provider can generate from offering a bundled product.

According to interviewees serving industrial and commercial customers, the ability to sell commodity electricity alongside DER services has not influenced whether a contracting offer can be realised (Int-B-65-DER; Int-B-122-DER). The measures implemented to upgrade buildings and processes, the costs, and the savings the customer can generate were described as more important to the sales process (Int-B-122-DER). In many cases, industrial and commercial customers were reported to prefer the transparency of buying contracting solutions independently from commodity which they can then procure and negotiate separately (ibid.). For the

contractor, the ability to resell commodity electricity as part of an energy services contract enables the possibility to make a margin not only on the DER measure, but also on the commodity, as the bundled offer is less transparent for the customer (ibid.). However, this interviewee noted that the profitability of the business did not depend on this option. As explained in Chapter 5, another interviewee hypothesised that building a DER services offer for residential energy users would require bundling commodity with services into one transaction, although this was an expectation rather than based on experience (Int-B-67-RET).

In summary, competition in electricity procurement and billing is not required for DER to challenge the centralised regime, but it is politically significant because it allows independence from incumbents and brand value. This is valued by those newcomers who find bundling commodity with services important and have the capital and abilities to take on the responsibilities that come with retailing commodity electricity.

7.2.2.2 Access to energy market value, and access to commodity tariff price signals

Electricity retail competition has contributed to the emergence of micro-generation, demand response and storage, where no public policies to explicitly promote the demand-side are in place. DER companies and customers seeking to cooperate with retailers have found partners where retailers are under competitive pressure and can see that cooperating with DER niche players could improve the retailing margin. Incumbent retailers traditionally marketing power from centralised plants have enabled DER providers or energy users to make a return on their investment in several ways: firstly, by making price signals available in tariffs to industrial and commercial

customers; secondly, by buying energy (kWh) provided by the demand-side resources for their portfolios and scheduling these resources into markets; and thirdly, by using their customer channel to market DER solutions to customers.

In the retail monopoly environment, DER niche players cannot access these revenue streams, unless there is policy support. For instance, in the US Pacific Northwest, policymakers promote energy savings, but micro-generation has not been widely adopted (Int-B-87-EXP). As discussed in Chapter 5, regulated-franchise utilities have been initially hostile towards the demand-side in their procurement decisions, until they have been obligated or politically pressured to support DER. Even then, some DER providers accuse them of being conservative in their operational dispatch decisions. Therefore, without support from policymakers, it is unlikely that DER providers could have accessed revenue without electricity retail competition motivating retailers to partner.

Figure 9 shows that electricity retail competition has enabled access to revenue or opportunities to arbitrage in instances where the institutional selection environment has not been reformed in favour of DER because there was limited explicit policy support for the demand-side (highlighted in green).

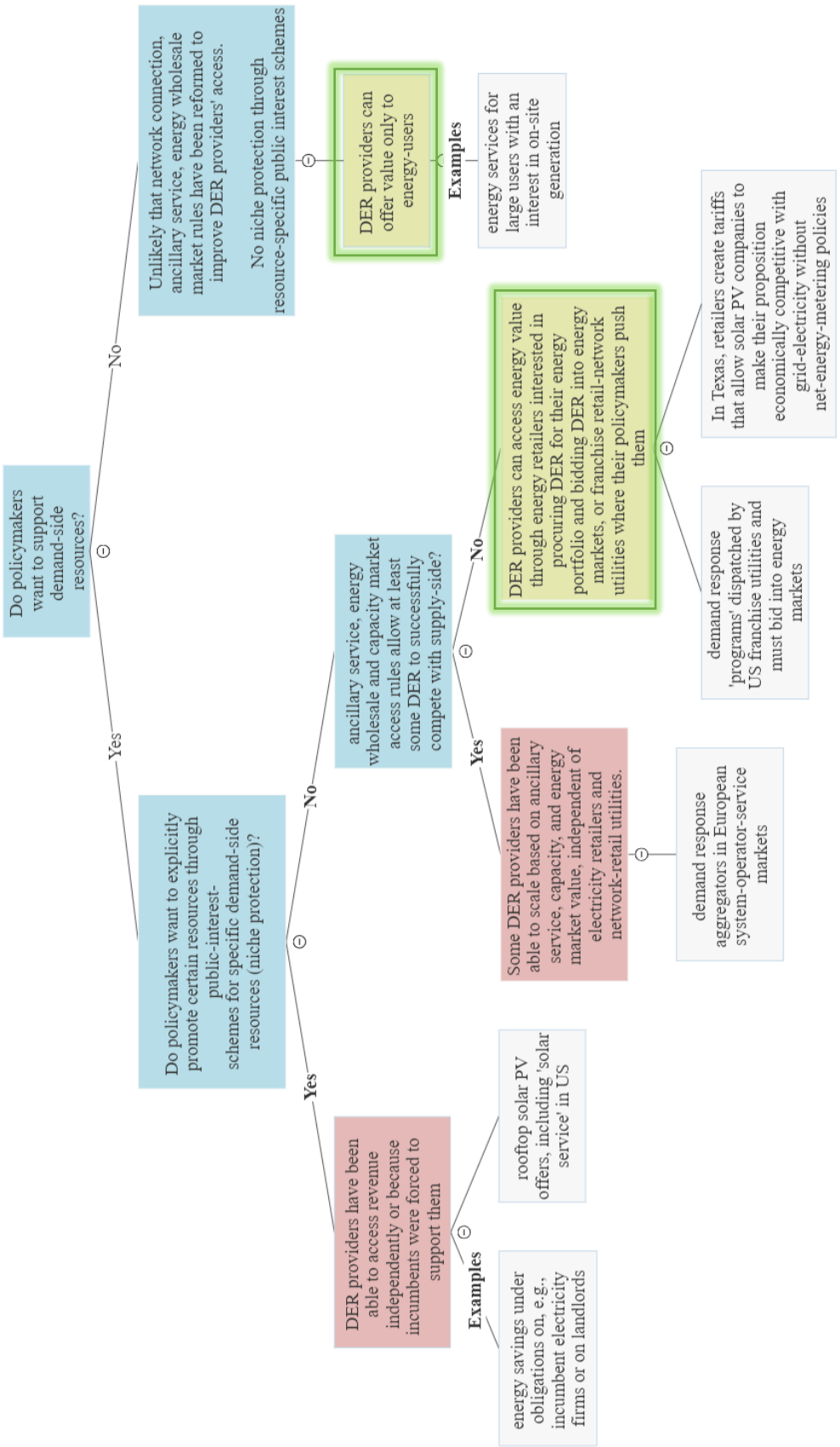


Figure 9: Access to revenue for DER providers in environments with and without policy support, and the role of retailing incumbents

Access to energy revenue has been enabled by electricity retail market competition where policymakers have chosen to not explicitly promote the demand-side, or where direct energy market access for aggregators of demand-side resources has been only slowly evolving. The example of how rooftop solar-PV companies have recently been able to enter the ERCOT market (see section 6.1.3) shows for instance that competitive retailers' interest in building their brand with customers as trusted energy advisors can enable some types of DER niche players and their customers to access energy value, and be paid for electricity fed into the grid. State-level policymakers in ERCOT have not encouraged micro-generation as in other states and therefore adoption remains small (Orrel et al. 2016), but is growing. The renewable portfolio standard as the main power sector decarbonisation policy has led to the installation of large, grid-scale wind-power projects for which Texas has an abundant resource. However, for rooftop solar-PV companies to access the market, innovative retailers had to build partnerships.

When new rules, standardised contracts, and roles for wholesale energy market access are created, DER aggregators could access energy market value without being qualified as retailers or contracting bilaterally with retailers on negotiated terms. However, without policymakers' support for the demand-side, achieving reforms that improve access conditions to wholesale energy and ancillary service markets in favour of DER is likely difficult, given how much incumbent generators and gen-tailers stand to lose from demand-side competition.

Retailers have been able and willing to integrate certain types of DER into their portfolios, namely those which customers themselves are interested in, and which do not require bespoke site analysis and implementation measures. These are standardisable assets and operations, for instance: power generated from rooftop-solar-PV, batteries, demand response linked to air-conditioning and 'smart'

thermostats popular with residential customers, as well as demand response in commercial and industrial facilities linked to standardised appliances.

Another way electricity retail market design has been significant for DER providers is that competing retailers have offered the opportunity to realise value to large commercial and industrial energy users through arbitrage against price signals. Static or dynamic time-of-use-tariffs or time-varying 'demand charges' for electricity enable value capture for DER interventions that shift demand in time. As retailers compete with a range of tariff options, DER players can today advise their commercial customers on which tariffs to choose. This confirms Vine et al.'s contention that electricity retail competition and unbundling reforms could offer incentives for demand-side management through tariffs more closely reflecting costs (Vine et al. 2003; also Hogan 1994).

In monopoly retail markets, variable tariffs have also been available for large users, but these are determined within regulatory processes and require support from policymakers. As the previous chapters discussed, regulated-franchise utilities have frequently lobbied against dynamic tariffs and in favour of fixed cost elements within rates. DER niche players without influence and resources to lobby for their preferred outcome may find it more difficult to enable energy users to take advantage of price signals than in retail competition environments.

For smaller energy users, the availability of price signals which DER providers could seek to exploit has so far not differed clearly between jurisdictions with and without retail competition. Therefore, in this customer segment, electricity retail market design does not seem to have had a significant effect on price signals. Under competition, most tariff offers to residential and small business customers are averaged over time and therefore do not reflect variance in cost to serve (Cavanagh

and Levin 2016). Although advanced metering has been available for several years in ERCOT, and residential customers are reported to switch retailers comparatively often, truly cost-reflective pricing that would enable for instance battery firms to make customers a good offering have not been widely available beyond what can be described as 'window-dressing' 'free Saturday' tariffs (Int-B-57-RET). For the residential segment, Lazar and Hledik's (2016) concern is thus supported, that retailers find it not strategically beneficial to pass price signals through to end-users.

Given that not all residential energy users will be able to benefit from time-varying tariffs (Darby and McKenna 2012), retailers' concerns about reputational damage and regulatory intervention following a launch are perhaps understandable, especially where a universal supply obligation is in place. Nevertheless, a few innovative tariffs are emerging, sometimes directly linked to a certain technology or asset which end-users may adopt, such as electric vehicles. However, when it comes to peak-time pricing, especially incumbents invested in peaking-plants, or in future perhaps grid-scale storage, may not have a strategy compatible with empowering their customers to shift demand at this time of the day.

7.2.2.3 Customer channel

Retailers and network-retail utilities have relationships with thousands or millions of electricity users whom they serve with commodity. This position gives them power over a key opportunity valuable to DER providers who themselves don't already have customer relationships or a valuable brand: a channel through which to market the DER proposition. Retailers and bundled network-retail utilities who control this resource have behaved differently with respect to allowing intermediation. While some retailers under competitive pressure are willing to either step back to allow

others to manage the customer interface, or use their customer channel to scale a DER measure, regulated-franchise utilities who still have customer relationships may be less willing to allow intermediation. Therefore, electricity retail competition has political relevance for the 'customer channel' resource because it changes the ecosystem of players competing for a relationship with users around 'energy'.

Under competition, some retailers interested in improving their own customer relationship have cooperated with DER players, allowing them to scale through 'white-labelling'. Other retailers operate behind the scenes (Int-B-40-RET) to allow energy service providers or technology companies to intermediate and take over the customer relationship. This has allowed bundled offers that combine commodity with energy services to emerge, independently from regulatory reform. These are marketed by technology companies, energy service providers, or building owners. As outlined in Chapter 6, regulated-franchise utilities in a monopoly retail environment have also marketed DER solutions to their customers as part of their DER programmes, and bundled offers are possible also without retail electricity competition. The difference has been that regulated-franchise utilities are rarely willing to voluntarily give up their customer-facing role to allow intermediation.

Retailers' DER innovations under competitive pressure demonstrate that concerns in the literature that the retailing business model is inherently commoditised and locked into a desire to always sell increasing volumes of kWh (Cavanagh and Levin 2016; Vine et al. 2003) are not justified. There are some retailers who are looking to change their business model, evolve into virtual power plant managers, offer their customers options to actively participate, and aggregate (schedule) their customers' demand and supply into electricity and flexibility markets. Some new entrant retailers, followed at some distance by longer-established incumbents, have been able to innovate, offering their customers energy services in cooperation with third parties. These instances of

success, even if not wide-spread, can be interpreted as evidence that the *"major technological, knowledge or market discontinuities"* have occurred which Defeuilley predicted would change the sectoral characterisation of innovative patterns in electricity retail markets (Breschi et al. 2000; Malerba 2002; Defeuilley 2009a). The drivers of DER business models presented in Chapter 5 suggest that these discontinuities are linked to: public policy change that provides niche-protection for micro-generation in many jurisdictions; the ensuing cost reduction of these solutions; digitalisation which enables aggregation and control of smaller-scale resources; and the higher demand for flexibility in electricity systems following the growth of renewable power generation, again linked to public policy decisions.

However, the research has also shown that retailers' innovation success in micro-generation, simple demand response, and some storage solutions do not apply to deeper, bespoke energy efficiency measures. Electricity retailers outside of public-interest-schemes have not enabled deeper electricity demand reduction and bespoke measures that require complex on-site analysis or operations. Here, the situation is similar between competitive and monopoly electricity retail market designs because these types of DER propositions require dedicated policies to promote investment. At the time of market reform, several commentators challenged the narrative that restructuring would promote the realisation of all cost-effective energy efficiency opportunities, suggesting that competition by itself would not be able to overcome the well-documented range of barriers to energy efficiency (Eyre 1998). The findings support this contention: retailers have had success with easily scalable, standardisable measures end-users covet, rather than bespoke, risky, and operationally more difficult energy services related to energy saving. In the large commercial and industrial sectors, energy service companies affiliated with retailers have offered these, but they are not integrated with commodity retailing operations. This means that retailers are

not in this business, and energy service companies who are, run as separate units. This demonstrates that energy service offers for these more bespoke solutions do not improve the margins of commodity retailing operations.

In US states where regulated-franchise firms retain customer relationships, they have been resisting intermediation (Int-B-83-IOU), and generally the opportunity for newcomers to take over the customer relationship related to 'energy'. Companies who are seeking to themselves build a customer relationship find this problematic, as they must compete with regulated-franchise companies in these environments who are looking to protect their direct connection to customers.

However, for some DER providers, the monopoly retailing environment has worked at least as well or better than under electricity retail competition. Not all DER providers have found coming to agreements with competing retailer incumbents easy, such as the demand response aggregators in Europe who lobby for standardised contracts to interface with retailers (Int-B-22-DER; Int-B-61-DER). Moreover, there are some DER providers who have successfully accessed customers and built solutions under network-retail utilities' brands in Massachusetts and California. The DER providers and programme implementation intermediaries who have established good working relationships here are content with the strong role the regulated-franchise utilities play in designing and marketing DER measures (Int-B-102-EE).

There are a range of DER players who call for policymakers to restrict incumbent regulated-franchise utilities' role in the marketing of DER programmes. For example, players who have not been able to build a close working relationship, and have not been selected as one of the utilities' 'preferred vendors', called for more competition and tendering of the public-interest-funds Californian utilities control (Int-B-83-IOU), so they have better chances to access the resources. Others lobby for reducing the

incumbent's role because they seek to build relationships around energy under their own, already valuable brand. For instance, BMW trialled demand response from electric vehicle (EV) batteries with PG&E in California. After the trial, BMW argued that they should market the offering rather than network-retail utilities, because BMW could build better customer trust (Conf-2). Finally, some DER providers working with network-retail utilities felt that they could grow better independently, and for this reason called for tendering. For instance, one demand response provider argued that utilities dispatched their demand response conservatively once it had been contracted (Int-B-69-DER).

Network-retail utilities' behaviour and interviews in California and Massachusetts have suggested that they will not be willing to give up the customer relationship voluntarily. This is consistent with the initial struggles around energy market restructuring outlined in Chapter 4. Where policymakers did not implement unbundling of networks from customer-facing functions, the relationship with small energy users is still contested today. Anxieties about rate revolt mean that regulated-franchise utilities would like to hold on to their role in marketing energy services (Int-B-83-IOU). Commercially, having to step back from providing DER to customers is *"not a positive development (...) because it feels good to give money back, that provides some brand value"* (Int-B-82-IOU).

The strong drive to hold onto customers also leads Californian network-retail utilities to fight for their role in energy procurement, although their revenue model has been 'decoupled' and commodity retailing costs are passed to customers without allowed return. One interviewee linked this to uncertainty about the future business model:

> *"We ultimately maybe don't care that much [about retailing power] because we don't make any money. But you could argue that if we are supplying all the services, the customer may be more dependent, feel more affinity, so there may be some value*

> *from a customer relationship perspective if we continue to manage and control everything. (…) the more you control, the more you're in command of your own destiny. 300 000 of our customers have installed rooftop solar, and we've taken a long time to get comfortable with that. It's a product another company is providing that you would like to provide"* (Int-B-82-IOU).

This shows that regulated-franchise utilities resist giving up functions, even where there is no direct financial reason. As all phases of transition involve uncertainty about the future shape of commercial and institutional structures, they oppose being reduced to 'wires-only' companies and fight for owning the customer relationship around 'energy'.

The importance of the customer relationship for utilities was demonstrated by the contest around the billing function outlined above, and furthermore by one of the three large investor-owned utilities in California. In 2010, the first Californian municipality made use of its right to form a community choice aggregator (CCA), taking all customers in their region out of the monopoly's customer base on an 'opt-out' basis as a new default provider (see Brinker and Satchwell 2019). To prevent losing customers to municipal aggregators, PG&E initiated a state constitutional amendment, funding a ballot measure that would have, if a majority had supported it, required a 2/3 majority of voters for a city government to establish a CCA (Int-A-2). The initiative lost, despite the incumbent spending reportedly 46 M USD on launching and advertising it (Doc-62-GTM). Since then, the number of CCAs in California has been growing.

The research has shown that the relationship with energy users is considered a valuable intangible asset to many players. The contest for the 'customer relationship' gives high political significance to the institutions that determine who may have a relationship around 'electricity' and perhaps bundle other 'energy-related' products and services through this channel.

7.2.2.4 Default electric service design

Under electricity retail competition, the design of default electric service has political significance because it influences whether retailers serving small energy users are motivated and able to partner with DER players. Newcomers trying to build partnerships with retailers to harness their energy market access (energy procurement budget), price signals through favourable commodity tariffs, or their customer channel, need retailers as business partners who are under enough competitive pressure, but also have enough resources to explore these innovation activities. For DER newcomers seeking to negotiate favourable terms of cooperation with retailers, it is important that there are enough retailers who are seeking opportunities to partner and are willing to take risks. For DER providers not looking to partner with retailers, the default electric service design is less relevant.

Earlier literature on the default service model in Northeastern US states suggested that because policymakers had not implemented unbundling, residential electricity retail market competition could not fully develop. Kiesling (2014) argued that a model relying on price-regulated default service delivered by network-retail utilities prevented the emergence of bundled commodity-and-services-products for residential energy users. The evidence from other states does not support this argument because so far, few bundled products for residential energy users have emerged in unbundled, retail competition states such as ERCOT and Great Britain.

However, there is reason to believe that the Massachusetts model may not afford sufficient profit opportunities for retailers in the residential and small business customer segment to motivate retailers to innovate. Where the network-retail utility's offer is priced at cost, minimal 'headroom' (Treadway 2015) is provided, so that competing retailers have difficulty offering a cheaper product (Int-B-103-RET). This

was intended by the designers of this default service model because, as Joskow (2000 : 23) argued, the *"retail margin (…) is not beneficial from a societal perspective"* unless retailers offer customers 'added-value' as compared to what they could buy directly in wholesale energy markets. Today, the value retailers can offer residential energy users in Massachusetts is price stability because the network-retail utilities' default offer is designed to vary regularly with wholesale energy market volatility (Int-A-12). However, most residential customers do not choose competing retailers' offers, so pure 'asset-light' electricity retailing to residential energy users is a hardly profitable business in US Northeastern states. This means that there may not be many retailers with the motivation and the means to pursue partnerships with DER providers in markets like Massachusetts.

Conversely, where default energy supply has been assigned to competing retailers, these incumbents have been under little competitive pressure in the residential customer segment. The reasons were two-fold: Firstly, at the time of market creation, they automatically acquired (or retained) a large, inert customer base which meant they did not have to pursue innovation to improve customer retention, as long as these customers remained loyal. Secondly, the privilege to accommodate unengaged energy customers went to companies later integrating to form gen-tailers in jurisdictions like ERCOT, GB, and Australian states. Integration with conventional generation assets has created disincentives to pursue DER, as demonstrated by gen-tailers lobbying against peak-shaving tariffs for residential users and privileging their supply-side assets over viable demand-side alternatives. Where retailers have innovated to promote DER, these activities were led by independent, 'asset-light' retailers without default customers and generation assets. These findings support literature that suggested default gen-tailers had limited incentives to evolve their business models based on good profits from serving unengaged customers when prices were not

capped (Hannon et al. 2013 on GB 'big six'). Moreover, default retailers with a large residential customer base may be more risk-averse with respect to reputational damage related to DER and innovative tariffs (Int-B-18-RET) than new entrants who have not gained as many customers yet.

These findings suggest that claims in the literature that electricity retail competition *"transformed the semi-public energy sectors of some member States into sectors with competing market oriented companies"* (Marino et al. 2011) do not apply to residential energy user segments. The way the default electric service regime was designed in some countries, such as Great Britain, means that most customers today are served by large incumbent companies who because of their inert customer base and business model oriented around power generation did not have to become customer-oriented at all. Because these default providers for many years could continue with business-as-usual based on healthy profits (Hannon et al. 2013), DER providers in these jurisdictions also had fewer options of retailers under enough competitive pressure to partner with. Only when these incumbents' business models were destabilised, did their previously comfortable position come under pressure. This disruption did not result from introducing electricity retail competition in the 1990s and 2000s (Marino et al. 2011), because only large industrial and commercial customers and a fewer number of residential customers chose to switch regularly. Rather, disruption ensued on the supply-side, through financial losses for fossil-based power generation assets following policies mandating the purchase of renewable electricity. Additionally, some jurisdictions, notably GB, have reintroduced price regulation for default service, so the margin on retailing electricity to unengaged customers can now be expected to shrink.

Going forward, there remain doubts that competition in retailing can engender or promote innovation in energy services that involve more complex measures, as

Marino et al. have suggested (2011). The findings on business model evolution indicate that retailers struggle to promote bespoke energy services, instead focusing on standardisable solutions. This is because energy services that require on-site analysis do not integrate well with commodity electricity retailing at the firm-level.

On the incumbent electricity firm side, the interviews also showed that internal competition can create barriers to integration, so some large European utilities' strategy to keep their commodity retailing business separate from energy services operations which reduce demand may also be deliberate. The findings coincide with recent literature. Kindström et al. (2017) studied incumbent municipal energy companies in Sweden trying to develop energy services business operations. They showed that energy services employees found it difficult to compete with incumbent firms' core activities, and that without very clear strategic support from the top, energy service divisions lose *"resource allocation struggles to the product-oriented traditional business"* (Kindström et al. 2017 : 28). Integrating services and commodity retailing within one firm has often worked to the detriment of the demand-side business which can better grow in independence.

From the engineering and technology company side, the integration of retailing with bespoke energy services operations within one firm is also unlikely. For contractors, a more established approach to procuring electricity is a partnership with firms specialised in retailing commodity. As one energy contractor explained, although they held a license to operate as a retailer, they nonetheless preferred outsourcing energy procurement: in practice, it is easier to *"call up a few energy companies and ask them for a quote, rather than organising it ourselves"* (Int-B-122-DER). The research suggested that the different scales at which retailing and bespoke energy services operate are not well aligned, and this seems to be one of the main reasons the two operations are not commonly run together. For electricity retailing, the more

customers can be served across diverse regions, the better because this improves the risk profile (Int-B-33-RET). By contrast, energy service provision that involves more complex operations than simply exchanging an appliance was described as a more local business, managing fewer customer projects simultaneously (Int-B-122-DER). For example, whole-building upgrades, some low-carbon heating solutions, or bespoke industrial and commercial efficiency measures require expertise and time on-site.

By contrast, more standardised DER measures premised on selling and installing assets manufactured in factories require less expertise on-site and project management, so appliances exchange, micro-generation, or an algorithm dispatching flexible loads operated from afar can be more easily marketed by retailers. Marketing these standardised products which are more like commodities than bespoke energy service offers is therefore more easily integrated with the business of electricity retailing.

7.2.2.5 Stacking of distribution-network value with other revenue streams and open standardisation

The comparison identified two further differences between bundled and unbundled network companies that influence how DER supply chains are developing. Firstly, unbundled network-operators lack a power valuable to some DER newcomers: the right to operate as an aggregator of resources into markets. This is significant because if DER providers want to combine ('stack') revenues from network value *and* system operator, capacity, and energy markets, unbundled distributors may not act as aggregators into these markets. Bundled network-retail utilities in California and Massachusetts do participate in these markets, where they bid in resources they

contracted for on the supply and demand-side. Here, competition was introduced without institutionalising the norm of non-interference in competitive markets in rules that prescribe unbundling.

Therefore, stacking network value with revenue from these other value pools across the system in an unbundled environment requires an additional competing company as a business partner, or the capability needs to be internally developed. With the aggregation function in the competitive realm, there may be opportunities for value capture, and this can be beneficial for DER newcomers with capabilities to act as aggregators. Those without this capability must in the unbundled environment find a suitable aggregator to partner with. This could be a more or less preferable alternative to a regulated-franchise aggregating the resources into these markets on pre-defined terms, depending on the DER provider's position and capabilities, and the range of players available to partner with.

Furthermore, once a DER provider or customer has succeeded in coming to an agreement with an unbundled network operator, there is legal ambiguity around how to design contracts to share control over a dispatchable resource (Int-B-113-DNO). Designing shared contracts with competing third parties who may aggregate these resources into system-operator and energy-markets has been difficult (ibid.). So far, none of the DER providers interviewed had experience with stacking energy network operator value with other value streams. This is because for capital-intensive DER providers, who need to combine several value streams, realising revenue available from network operator services has not been developed commercially at a significant scale beyond field trials (Int-B-98-DER). In the future, this difference between market designs may become significant for DER propositions which are so capital-intensive or costly to operate that they cannot be justified on either network value, *or* energy, ancillary service, capacity, and energy user value (Int-A-3).

This research showed that only stacking of network-value with other value pools is encumbered by unbundling. Stacking of other revenue streams is possible independent of electricity retail market design and is influenced by other institutional arrangements: wholesale energy market design, ancillary service and system-operator, capacity market, or other public-interest-scheme designs and access rules. This challenges literature that suggested electricity retail competition and unbundling can make 'stacking' of value across the system from different value pools generally more difficult. For instance, Vine et al. (2003 : 411) argued that because under unbundling, transmission, distribution, generation, and retail costs are assessed separately, *"the incentives for the individual businesses to carry out any energy efficiency or load management"* are greatly reduced, given that benefits no longer accrue within a single business. However, in the US, where wholesale energy, ancillary service, and capacity markets are all organised such that providers can enter a single auction (Int-B-112-DER), this enables stacking all of these values, independent from partnering with retailers or network-retail utilities through power purchase agreements. Integration of these value streams is thus possible independent of choices about unbundling if the other institutional arrangements allow. Unbundling only affects the integration with network value streams.

The second difference between environments with varying approaches to unbundling is that bundled network-retail utilities with responsibility to manage demand response programmes have more actively promoted interoperability of devices behind the meter. This 'public interest' agenda is not being championed as much where the customer relationship is owned by competing incumbents. The research showed that new entrants to the electricity sector, such as appliance manufacturers with the potential to gain from a more active demand-side, are institutionalising lock-in of individual customers. Electricity retail market design has significance in this regard:

where the customer relationship is owned by a regulated monopoly who is given a 'public-interest' brief by regulators, these players may seek to reduce the lock-in of customers to particular competing players. Taking this role also provides regulated-franchise utilities with a justification to frame themselves as protectors of the 'public interest'.

As explained in Chapter 6, regulated-franchise IOUs in the US see the adoption of proprietary communication standards which can lock in energy users to one private company's system as problematic. This is because proprietary communication standards would imply that any newcomers wanting to 'plug in' to the 'smart' building would likely have to pay for access or be prevented altogether. Then, one company (usually a manufacturer), and potentially an association of partner companies, would become gatekeepers to the supply chain serving this customer. Because in California, network-retail utilities run DER programmes and control these resources, they have an interest in appliances being replaceable, so they are promoting the adoption of common, open-source standards by technology companies and others (Int-B-110-IOU). In Europe, policymakers and academics have been trying to promote interoperability. Private players on the other hand, it has been argued, are not *"driving this forward"* at all (Conf-2, demand response aggregator).

Unbundled distributors also have an interest in interoperability, but only once they contract with customers for load control, and as outlined above, DER for network-purposes are only beginning to emerge commercially. Energex today, as one of the unbundled distributors controlling residential air conditioners in Australia, supports the adoption of appliances compliant with the relevant standard (AS/NZS4755) (Swinson et al. 2015), but they were not the initial drivers behind standardisation efforts. The development of common standards for remote demand management of electrical appliances was launched in 2005 in Australia *"following a number of*

electricity supply problems related to demand from air conditioning" (Doc-64-DCCEE : 1). The development of common standards required Government, motivated by electricity supply shortages, to bring together appliance manufacturers, retailers, and distribution grid operators to set up common standards (ibid.). This is an example of how the institutionalisation of commercial structures to ensure openness in markets requires a 'public interest' impetus because private actors have an interest to lock customers into a long-term relationship.

Regulated-franchise utilities already aggregating resources into energy markets by contrast have a short-term interest in interoperability, so that customers can switch appliances. As one manager of DER programmes explained, interoperability is core to successfully delivering operational targets in demand response programmes (Int-B-110-IOU). In unbundled environments, competing aggregators or retailers fulfil this role. If their primary business model is based on growing a fleet of distributed resources behind the meter to run virtual power plants, they may also have an interest in the adoption of open communication standards in connected devices in businesses and homes. However, as these firms are often start-ups, they may neither have the resource, nor the institutional influence as members of industry working groups to promote open standardisation. Moreover, as private actors they stand to possibly gain advantage from locking in customers, especially if they have ambitions to be acquired by larger firms. By contrast, regulated-franchise utilities' business model evolution in the longer term is premised on regulatory reform, rather than partnership or acquisition by manufacturers and technology companies.

There is a tension between the benefit retail competition offers through competitive firms' profit motive, which can drive easily scalable, standardisable DER as described above, and keeping the regime open to entry from newcomers to aid 'market transformation' during a time of rapid technological innovation in the DER space.

This tension illustrates a long-standing dispute in economic innovation theory (Marino et al. 2019) about the question whether market power and scale foster innovation because they provide incentives and resources to invest in innovation (Schumpeter 1942), or whether firms with market power innovate less and protect their position (Arrow 1962). Where regulated-franchise companies have a role in supplying customers with DER, they have no interest in building market power through proprietary standards because it is unlikely that regulators would allow them to exploit it further. Retailers and DER challengers on the other hand are clearly incentivised to lock customers into their systems.

7.2.3 Summary: Significance of electricity retail market design for DER niche players

The research has shown that under both electricity retail competition and monopoly, wider 'selection' of demand-side innovation (Schaltegger et al. 2016) has occurred. The comparison of differences and similarities in business model evolution under different electricity retail market designs has demonstrated that:

- Innovation in energy services at a wider scale, in other words, 'selection' of demand-side resources to meet electricity demand, does not require electricity retail competition, or unbundling of distribution network companies. Energy services business models require the alignment of institutional parameters so that the demand-side can compete with supply-side resources for revenue: in energy wholesale, capacity, ancillary service markets, and in regulatory frameworks that fund and incentivise network operators. Where these public policy institutions are reformed to accommodate DER, under all electricity retail market designs, commercial structures have been created which

promote demand-side resources and energy services, independent from electricity retail markets.

- Where public policy institutions have not been reformed, electricity retail competition has promoted DER. Some competing retailers with incentives to reduce their cost-base and, or improve their customer relationship have partnered with DER providers. This has enabled access to revenue and customer acquisition for standardisable, 'simple' dispatchable demand-side resources (storage, demand response, and micro-generation), where they are cost-competitive with supply-side resources, and customers are interested in adopting them.
- Some competing retailers may going forward allow intermediation of the customer relationship by technology companies or others with valuable brands if this suits their strategy. Regulated-franchise utilities by contrast are more reluctant to concede their customer relationships, and lobby to retain their customer-facing functions.
- Once electricity retail competition is implemented, the institutional design of default electric service influences whether competing retailers are motivated and able to partner with DER providers.
- Unbundling of network-operators from customer-facing functions means they are not as interested in the open-access standardisation of appliance control and communication protocols as are network-retail utilities. They cannot act as aggregators of demand-side resources into contestable markets, where policymakers are maintaining the previously institutionalised norm of non-interference in competitive markets by regulated-franchise players.

- Energy service business models which include more bespoke on-site analysis and operations, including for building energy efficiency, have not been driven by electricity retail competition.
- There is no clear evidence that electricity retail competition and unbundling hamper the implementation of well-designed policies to promote demand-side energy resources.

The research has shown that electricity retail market design is politically significant in terms of access to resources and opportunities because demand-side players with varying business model characteristics find different environments favourable. Specifically, the thesis has shown that competition in energy procurement and billing can provide access to resources and opportunities for standardisable, 'simple' DER solutions where public policymakers do not explicitly promote them. This means that customers' and competing retailers' interest can promote DER.

However, the evidence also suggests that this form of decentralised decision-making enabled by competition is not likely to lead to a wider adoption of DER, to the point where electricity systems transform from a mainly centralised to mainly decentralised configuration because incumbents would seek to protect their own centralised assets, where they compete with DER for value. Even if trajectories aligned to make demand-side resources more cost-effective than centralised power generation in a particular jurisdiction, and more energy users looked to self-supply, public policy change in terms of network connection rules, safety standards, and customer protection, among others, would need to change to support the demand-side. As the research has shown, there are many realms of public policy which would require reform and incumbents invested in centralised assets, including network infrastructure, standing to lose importance, influence, employment, and potentially profits through decentralisation, actively seek to prevent their decline. Therefore, although competition gives

customers and their retailers power to make available resources and opportunities for DER, it would not lead to a *wider* decentralised transformation without public policymakers' support. This supports Bolton and Hannon's (2016) view on how business models can affect system change: wider-scale shifts beyond individual firms can be achieved only with engagement in processes of public policy change. Because of incumbent, centralised companies' influence, this thesis argues that policymakers as regime-level actors would need to actively support the demand-side, or support the decline of centralised assets, for a system to decentralise radically.

7.3 Contributions to the study of socio-technical change in electricity systems

This section discusses the findings with reference to the study of socio-technical change in electricity systems and offers lessons for research on transitions. This entails reflecting on the theoretical frameworks employed in light of the findings, and on literature about the evolution of electricity systems.

Firstly, studies of socio-technical change should pay more attention to ideas and discourse, as shown by the findings on how different electricity retail market designs evolved and are contested today. The analysis demonstrates how in the coevolution of technology, business strategies, practices, and public policy institutions, frames of meaning and beliefs influence how players interpret and act upon techno-economic change. This thesis' attention to ideas has made a valuable contribution because it investigated in detail how ideas influenced institutional and technological change in the electricity sector. This addresses a gap in the literature because, while several academic analyses of electricity market restructuring recognise that ideas or beliefs were important factors for competition reforms to be adopted (Carley 2011; Hausman

and Neufeld 2011; Isser 2015; Marino et al. 2019), how ideas link to varying processes of coevolution in electricity competition reforms has not been investigated.

Secondly, the findings on current niche-regime interaction suggest that socio-technical change analyses that study business models should pay attention to the role of incumbents as gate-keepers to valuable resources and opportunities in a supply chain. Previous analyses have investigated novel business models as growing or replicating through selection by end-users. This focus risks reducing the role of incumbents to copying or acquiring novel business model elements (Schaltegger et al. 2016). This research showed that before 'selection' by end-users can occur, the inception of some novel business models in initial moments of variation already relies on cooperation with incumbent companies because many types of novel business models are not necessarily initially customer-facing. Important elements of the power struggle between niche and regime happen also further up the supply-chain.

Thirdly, the research indicates that public policy institutions do not affect sustainability transitions in deterministic ways and that institutions' effects on incumbents are not linear and generalisable. The study of how public policy institutions affect the evolution of commercial structures and business models should pay attention to specificities of place, time, and organisations, and recognise that uncertainty is key to business model evolution.

7.3.1 The role of ideas and frames of meaning in socio-technical change

The evidence on processes of creating new public policy and firm structures in three US states makes two contributions to the existing literature on the evolution of public policy institutions in the electricity sector. Firstly, the research enriched literature on

electricity market restructuring because it investigated how downstream, different market designs evolved, thereby focusing on a more specific set of reforms. This enhances the understanding of electricity retail market design and its political significance today. Secondly, the thesis showed that ideas and discourse can be usefully incorporated into the analysis of how technologies, practices, public policy institutions, and business structures co-evolve. This is useful because it enables examining *how* ideas and frames of meaning matter, and how they are linked to technological and material factors with influence on policy change. Studies of socio-technical change would benefit from more explicitly incorporating ideas, frames of meaning, and discourse as units of analysis.

The research supports what scholars of economic sociology have shown about the first phases of coevolution within electricity systems: the institutional dimensions of systems do not transform in response to technological change to accommodate the universally most 'efficient' structures, as some historians of technology (Hughes 1983) imply. Rather than mere reflections of the techno-economic configuration of products and infrastructure, institutions and structures that organise economic activity are negotiated between actors with different perceptions of what is in their best interest, under mobilising political influence (Granovetter and McGuire 1998). But the interpretive analysis of electricity retail market design processes has added the insight that discursive techniques of framing are key means through which this political influence is wielded (Hajer 1995; Schmidt 2011). This addresses debates reviewed in Chapter 2 about the evolution of scale, structure, and institutions in the electricity sector throughout the late 19th and 20th century. The findings complicate more technologically determinist views of socio-technical change in electricity.

Determinist views privilege technological as driving institutional change. For instance, the regulatory economist Joskow suggests that *"as time passes, technology*

change may and has in many cases undermined the initial assumptions about where the "natural monopoly" segments begin and end" (Joskow 2009). This implies that, firstly, at any given time there is one valid assumption about the boundary of the 'natural monopoly', depending on technology. Secondly, it assumes that the 'undermining' is not driven by actors and social processes, but by technological change. The research presented in this thesis on the influence of discourse and institutional work by actors actively shaping institutional arrangements has shown that neither is the case. The appropriate boundary of the monopoly in electricity does not naturally shift in response to technological changes. Rather, institutional changes are often required to unsettle the technological status quo, and then, the appropriate boundary of the monopoly remains contested. The views differ depending on framings of technological change and beliefs about which aims are most important and virtuous. Moreover, the research showed that for a new discourse to become institutionalised and the accepted boundary of the monopoly to shift, it requires acts of framing and lobbying.

The empirical research on electricity retail restructuring reforms complicates the view that configurations of electricity systems are designed by 'system builders' seeking the best institutions to accommodate technological, cultural, and physical features of a place (Hughes 1983). Instead, it highlights how scale, technology, and institutions are to a large extent socially constructed by players strategically seeking to create markets for their own products and capabilities and profit from lasting, institutionalised influence (Granovetter and McGuire 1998; Yakubovich et al. 2005). The different public policy institutions did not evolve as rational processes of decision-making in response to changing techno-economic conditions. As was the case when the 'natural monopoly' was first institutionalised, lobbying and network building, and wider 'institutional work' by actors who believed they would benefit

from particular industry rules and structures decisively shaped the adoption of electricity retail competition. Without entrepreneurial actors seeking to shape their selection environment, it is not clear that the 'emergency' of high electricity prices and opportunities from technological innovation would have necessarily led even the most enthusiastic policymakers to adopt the policy. The evidence confirmed that actors actively pursuing or resisting the institutionalisation of new ideas and structures are key to processes of institutional (Schmidt 2011) and wider socio-technical change (Fuenfschilling and Truffer 2014; Lovell et al. 2009).

However, the research also showed that explaining the social construction of markets with reference mainly to the self-interested pursuits of entrepreneurs (Granovetter and McGuire 1998) cannot suffice to make sense of coevolutionary dynamics. The interests actors pursued in seeking to institutionalise structures that benefitted them were not consistent across actor groups or clear-cut in all cases. Because actors operate under uncertainty, ideas are important (Blyth 2002) for how the techno-economic context is interpreted and acted upon (Hajer 1993). In the three cases studied, interpretation of technological and economic changes at landscape and niche-levels mattered for how new structures were institutionalised.

Ideas, discursive work, and frames of meaning were important factors in the evolution of different electricity retail market designs. The research shed light on *how* practices of framing were key to the process of institutional change in California and Massachusetts. The framing of rising *unit*-prices as a state of emergency enabled market reform to be tabled as a pressing policy change. The existence of a 'crisis' of electricity costs was disputed and there were disagreements about how to respond to changing economic and technological conditions in the electricity sector. The framing of electricity prices as an 'emergency' that demanded action were based on emphasising unit cost metrics instead of total expenditure (bills) or percentage of

GDP. This framing privileged the concerns of energy-intensive energy users competing with manufacturers in states with lower unit prices for industrial users. However, even within this group, there was disagreement: distinct frames of meaning through which actors perceived technological innovation and economic change meant that not all manufacturers perceived the same institutional reform as in their interest.

Ideas, framings, and discursive struggles on how to best interpret the changing context (Hajer 1993) were also important in the evolution of *different* market designs. This complicates a narrative still popular today which explains the differences between US market designs with reference to variations in economic pressures and resource endowment. The differences are then reduced to the fact that the 'crisis' of rising electricity rates had hit some states, while others with lower electricity rates did not face economic pressure to act (Newbery 2000 : 259). For instance, Newberry argued that the competition reforms in US states were adopted in response to rising electricity retail rates and the efficiency benefits expected in light of falling marginal costs of power from new power plants (ibid.). In a similar vein, a former legislator and regulator in a state with abundant indigenous coal resources recounted:

> *"Like nearly all other states with much below average cost electricity, the value proposition [of market reform] for North Dakota did not pencil out"* although *"as a philosophical conservative, the notion of a freer market, competition, and consumer choice resonated with me"*(Doc-70-Clark).

However, the Texas case does not support the contention that the variety of market designs adopted in the US reflect the extent to which states were under economic pressure. Nor does it suggest that reforms were adopted as rational responses to rising electricity rates and perceived opportunities to reduce costs. Texas had lower electricity unit costs than the US average across states in all customer classes and sectors in the years leading up to restructuring (Doc-67-EIA, table 53). Yet, the electricity retail market reform adopted went further than in any other US state.

Frames of meaning and importance given to individual consumer 'choice', and ties between beneficiaries of market reform and policymakers in Texas were important factors in the evolution of the ERCOT market design. Other reforms that could have addressed high energy expenditure were not embraced as fervently. For instance, the mandating of more stringent efficiency measures could have ameliorated Texas' overall high per-capita energy expenditure (bills), which some environmental advocates had called for. However, more stringent energy efficiency measures would have neither benefitted prospective electricity and gas traders, nor would they have aligned with policymakers' beliefs in promoting electricity 'choice' for all customers and reducing regulatory intervention. Restructuring reforms met both requirements.

The importance of ideational differences between jurisdictions suggests that ideas and discourse are important dimensions to consider when studying the complex interplay of material, institutional, and social factors that influence socio-technical change. In Texas, both economic ideas about efficiency and philosophical ideas about 'freedom' (Chang 2002) were influential, while in Massachusetts only the economic efficiency ideas became institutionalised. The Texas Governor and regulators saw an institutional structure that performed reasonably well in economic and technological terms (as compared to other states) as paternalistic and privileging collective over individual choice, and therefore sought to replace it. In Texas, competition was combined with unbundling and default service provided by competing parties, but in Massachusetts, policymakers did not believe choice for small users was needed or even necessarily desirable at all (Int-A-7). This allowed the incumbent network utilities to successfully lobby against unbundling downstream and to retain their customer relationships as default providers. Similarly, California's reaction to maintain a monopoly for most customers in retailing following their electricity supply shortage crisis in 2001 is firmly linked to discourse and ideas. It is not a rational

response to bad experience with markets, but rather a deeply engrained suspicion observers admit is more cultural than 'evidence-based' (Int-A-2; Int-B-58-EXP).

In summary, this research has demonstrated that ideas and discourse are important factors in coevolutionary processes and thereby contributes to the literature on socio-technical change dynamics, particularly in the electricity sector.

7.3.2 The coevolution of business models and public policy institutions

Firstly, the research has contributed insights into dynamics of interaction between niche and regime-level within a socio-technical system. The research indicates that for some business models, incumbents already play a key role at the initial moment of variation, as gate-keepers to valuable resources and opportunities in a supply chain. Some literature on the role of business models for socio-technical change proposed that, once variation in business model characteristics has occurred, incumbent players are important for scaling up innovation. The framing is that after a novel business model is launched, niche-regime interaction can lead to selection, and eventually retention of novel characteristics within a population (Schaltegger et al. 2016). The role of incumbent companies (and other companies in the market) in scaling up niche innovations was explained through a number of 'pathways': as replicating the novel characteristics, copying them through mimicry, or scaling them up through merger and acquisition, always in response to competition from newcomers (ibid.). The research confirmed that in the case of DER propositions the pathways proposed have led to scaling: the evidence discussed included instances of where novel DER business models grew within a single organisation, where replication within several

organisations occurred, where incumbents copied, and in many cases acquired DER propositions and companies.

However, the research added nuance to the accounts of how business model innovation can change populations because it showed that not all novel business models choose to launch and challenge the incumbents independently. Niche-regime interaction does not always involve niche-players directly competing and encroaching on incumbents' market share as *challengers* of incumbency. In other cases, they cooperate directly with incumbents, and sometimes the relationship involves collaboration between competitors, what is known as 'coopetition' (Ritala and Hurmelinna-Laukkanen 2013). For some DER providers, cooperation with incumbents is necessary earlier, at the moment of variation itself. Some need incumbents from the outset to build an initial network and launch a viable business model. Where important resources and opportunities are in the hands of incumbent firms, newcomers may choose to launch a new business model in cooperation because they find accessing the resources and opportunities independently, including relationships with customers, prohibitively costly or impractical. Because incumbents in sectors such as electricity are gate-keepers to important resources needed to build business models, niche-regime interaction in certain cases is more cooperative than has been suggested in some of the literature.

The high importance of incumbent players in holding access to key resources and opportunities is a characteristic of the energy sector which may be less applicable to some other sectors. The particular technical characteristics of electricity and framings of the product as essential have led to the especially strongly institutionalised role of incumbents as privileged gatekeepers. Schaltegger et al. based their framework also on the drinks, ice cream, car, supermarket, and cosmetics sectors where market entry barriers can arguably be lower, and a broader range of consumers show active interest

in the products ('consumer goods'). In these sectors, incumbent companies' control over resources and opportunities may be less exclusive, so that innovators can more readily challenge incumbency independently.

Secondly, the research has confirmed what socio-technical scholars have long discussed: public policy institutions as key structures defining regimes influence dynamics of socio-technical change. The research showed that opportunities incumbents have to support or impede innovation varies across jurisdictions, and this is influenced by public policy institutions. This reinforces the contention that public policy institutions influence how incumbents can wield power (Kuzemko et al. 2016). Specifically, the research showed that to study the politics of socio-technical change, investigating how institutions influence which resources and opportunities incumbents can control is useful. Analysing institutional differences carefully through the lens of resources and opportunities allows tracing how institutions influence *various* types of niche-players' prospects for challenging the regime. For example, niche-players with already powerful brands, customer channels, and, or the capability to aggregate resources into markets may prefer different institutional selection environments than those who lack a customer channel, or who don't have these capabilities. This analytical perspective therefore allows politicising accounts of socio-technical change.

However, the research has also demonstrated that the institutional structure of a regime does not determine incumbents' behaviour. Although public policy institutions clearly influence incumbents' opportunities and their behaviour in interaction with niche-players, their behaviour cannot be predicted based on the institutional environment. Some authors are interested in building theory on which 'governance' systems or 'varieties of capitalism' lead to which outcomes within sustainable energy system transitions (Kuzemko et al. 2016; Lockwood, Kuzemko, et al. 2017). They are

correct that differences between jurisdictions' public policy institutions imply different levels of power for incumbents, different incentives and articulation of incumbents' interests, and different degrees of openness of policy and regulatory processes to capture by interest groups (ibid.). However, the evidence presented supports the contention that building generalisable theory aimed at predicting which institutional arrangements are more or less supportive of sustainability transitions (Lockwood, Kuzemko, et al. 2017) risks unduly reducing the complexity of processes through which new commercial and public policy institutions are constructed, or impeded.

Firstly, the research has shown that incumbents do not behave rationally in response to public policy change. This is because they operate under uncertainty about how institutional structures influence them, and because lock-in is not always material, but also cultural and organisational. The evidence showed that while public policies can change material factors locking incumbents into traditional practices, incumbents will not entirely change their behaviour in response. For example, some US regulated-franchise electricity utilities' motivation to protect their customer-facing role may be irrational in light of how their revenue models have been altered through 'decoupling' and shareholder incentives. However, because these firms retain management and operations culturally and organisationally averse to change, they protect the status quo, even if the incentive structure changes following public policy reform. The research also showed that the uncertainty about their future business model means that regulated-franchise incumbents, including unbundled network operators in Europe, are averse to giving up responsibility and functions more generally. Their drive to seek control of as many functions as possible confirmed the importance of uncertainty in influencing firm-decision-making, processes of innovation, and institutional change (Hodgson 2007).

Moreover, energy companies as key players at the centre of the regime are not uniform agents. As all organisations, they consist of internally competing units, and there are also conflicts between management, shareholders, and workers. This means that processes of business model evolution are fraught with controversy, so that the same types of firm under very similar environmental conditions may respond differently to change in the socio-technical system. This is not only because of uncertainty as evolutionary economists have shown, but also because of ideas, priorities and frames through which options and information are perceived and assessed. Furthermore, the decisions of individuals in management positions have been highly influential. Interviews suggested that, rather than rationally reacting to a changing environment, personal judgement and convictions play an important role for change. This means that the analysis of socio-technical change must not generalise about types of firms in a deterministic fashion.

These findings suggest that research on institutional design of regimes should continue to privilege place-specific analysis of how institutions work, with careful examination of how institutional reforms to support change have worked in other environments, and how learnings could be applied to a jurisdiction's specific context. Comparison of institutional arrangements across jurisdictions allows valuable insights, but generalising theories that seek to export one jurisdiction's institutional arrangements abroad, without careful examination of the context, risk ignoring the complexities of how institutions, technologies, business models, and user practices coevolve.

Analyses of institutional frameworks can make useful generalisations if they focus on narrower processes and are not aimed at explaining large-scale, transformative change. Investigating how *specific* public policy institutions affect narrower change processes can generate valuable learnings for other jurisdictions. For instance, specific

instrument design choices (see e.g., Mitchell et al. 2006 on renewable energy incentive schemes), planning rules (Dóci and Gotchev 2016), or types of financial institutions (Hall et al. 2016) have explicit implications for how particular new business models and ownership structures evolve. Tracing these implications is useful to inform policy reform in other jurisdictions. But building theory on broader 'systems of governance' and their effects on socio-technical system transitions will not produce useful insights, as this requires aggregating many layered public policy institutions into few overarching variables. Socio-technical systems and their institutional configurations are too multifarious to reduce complexity in this way. Theories that aim to identify the 'first cause' of large-scale change will not yield useful results, because these larger-scale transformation processes consist of many change processes at more detailed level of analysis.

Chapter 8 - Conclusion

Since the early emergence of electricity-generation technologies and appliances to turn power into useful services like light, there has been a struggle of scales between the supply and demand-side: initially, the system developed around centralised power stations, transporting electricity through networks, and firms grew in scale and reach into large, national- and even international systems crossing state borders. Demand-side generation and active demand management reduced in importance while interconnected electricity systems grew. The centralised structure with resources generated far removed from demand co-evolved with an institutional structure that guaranteed vertically integrated electricity companies monopoly status.

Since the 1970s, electricity systems are decentralising in terms of the resources used: investment to meet demand was located in closer proximity to where electricity was consumed, power plant size reduced, and demand-side management was promoted. Alongside changes in scale, the institutional structures of the industry also changed in some jurisdictions: where electricity restructuring reforms were adopted, policy change introduced competition and separation of network businesses. DER behind the meter have always been part of electricity systems but have played a niche-role in meeting demand as compared to large centralised resources. Recently, the importance of demand-side resources is growing in many electricity systems. This means that in some jurisdictions, DER players take market share in meeting demand and balancing the system from dominant incumbents whose business models are premised on generating power in large plants, transporting power through networks, and retailing commodity electricity to a passive demand-side.

This thesis investigated political dimensions of coevolutionary processes related to demand-side transitions. It focused on the contested nature and implications of a particular set of public policy institutions: electricity retail market design. This set of institutions organises how and from whom end users may buy electricity. For the purpose of this thesis, it was defined as the rules that determine whether commodity electricity retailing functions are contestable (competition or monopoly) and whether distribution network operations are separated from retailing (vertical integration or unbundling).

The following chapter concludes the thesis by summarising the answers to the subsidiary research questions again, followed by the answer to the overarching question. It then outlines the implications of the findings for public policy. Finally, it proposes avenues for future research and reflects on the contribution made by the thesis.

8.1 Answering the research questions

The thesis addressed five subsidiary research questions. The data presented to answer these described socio-technical change processes in electricity in two phases. The first, historic, phase led to different electricity retail market designs in three US states investigated as case studies. The second, currently ongoing, phase of socio-technical change leads to a wider adoption of distributed energy resources on customer premises.

8.1.1 Subsidiary research questions

The first subsidiary question asked, *"How did different electricity retail market designs evolve in California, Massachusetts, and Texas?"*

Chapter 4 traced three different outcomes of market reform: the competitive, unbundled electricity retail market design in ERCOT (Texas); the competitive, bundled market design in Massachusetts, and the bundled monopoly retail market design in place in California. These cases exemplify three archetypal electricity retail market designs that exist in similar form also elsewhere.

Innovation in decentralised energy generation on-site through co-generation was one of several developments driving change in the institutional structure of the sector. Electricity retail market reform was preceded by public policy change that promoted smaller-scale power generation, including on customer premises. Several years later, technological change, innovation, and landscape pressures including pro-competition ideas initially put competition in retailing on the political agenda. Some large energy users were able to self-generate power on-site aided by technological and public policy changes. They lobbied for further policy reforms to implement electricity retail competition and access to the monopoly utilities' networks, so that they could buy power directly from generators and use their self-generated power across multiple sites. These self-generating energy users, other large energy consumers, and firms interested in trading and retailing power had an important role in driving retail competition reforms forward.

Technological innovation enabling smaller-scale power plants, self-generation, and trading destabilised the discourse of the 'natural monopoly' in retailing. However, the arguments, underlying assumptions, and the urgency to implement changes were

contested. Philosophical ideas about the importance of individual choice in markets gained stronger support in Texas than in the other states, bolstered by personal ties between prospective electricity traders and top-decisionmakers. In Massachusetts, energy users' freedom to individually choose energy provider and tariff option was given less importance, but competition downstream was believed would support competition in wholesale energy markets upstream. In contrast, after initial enthusiasm for opening retail electricity markets to competition in California, the experience of a supply shortage crisis in 2001 established as dominant a discourse principally sceptical of competitive markets in electricity. Since these initial reform processes, market designs and associated rules have evolved continuously in all three jurisdictions.

This research illustrated the coevolutionary processes which led to different electricity retail market designs, where technologies, business strategies, and public policies coevolved. It demonstrated the value of incorporating ideas, discourse, and frames of meaning as important dimensions to analyse when investigating processes of socio-technical evolution. As coevolutionary analyses do not have to identify the 'first cause', the research did not seek to ascertain whether the driving forces determining how electricity systems developed were primarily technological change or social and institutional shifts. But the findings support literature that understands institutions, market structures, and boundaries between sectors as socially constructed (Granovetter and McGuire 1998) rather than rationally designed and determined by technological developments (Hughes 1983).

The second subsidiary research question addressed processes of forming new commercial structures and asked: *"How are DER niche players today challenging the electricity regime through building business models?"*

Chapters 5 and 6 showed that since restructuring, there has been further challenge to centralised electricity regimes traditionally based around large-scale electricity generation, transmission, and distribution to a passive demand-side. Socio-technical change processes occur where DER newcomers and customers build new commercial structures and business models. In many cases, public policy changes enable these new commercial structures when policies are reformed to accommodate change. DER players access revenue across electricity systems: energy value, capacity value where rewarded separately; value directly to the energy users on whose premises DER are sited; 'public-interest' value through leveraging schemes created by policymakers; and, slowly emerging, also network operator value.

Among DER providers, there are different approaches to building business models. Some enter the market independently and directly compete with retail and network incumbents for supplying energy to cover customers' demand. Other newcomers choose to work with incumbents, some of whom are looking to evolve their otherwise centralised business models. DER promoters were found to take different strategies with respect to their preferred customer channel: some prefer cooperation to leverage other firms' brands or customer relationships, if they don't have a strong brand and customer channel in place themselves. Electricity incumbents offer one type of customer channel to leverage for DER providers looking to cooperate. Other newcomers try to market their proposition to energy users under their own brand, meaning they directly challenge incumbent players retailing electricity for the 'energy relationship'. In building a value proposition and revenue model, some DER players aim to bundle their offer with commodity electricity into one contract or transaction, while others are content to offer their proposition separately.

The third subsidiary research question asked, *"How are DER niche players experiencing incumbent regime resistance, when trying to access key resources and opportunities?"*

The behaviour of regime players resisting niche-growth was found to be important in influencing DER newcomers' success. The data presented showed that, notwithstanding successful cases of cooperation between DER companies and incumbent electricity firms, the same incumbents or firms with similar business models have also stalled progress in electricity system decentralisation on the demand-side. DER providers claimed that incumbent electricity firms with a range of functions across the system use their privileged positions to prevent DER newcomers' access to key resources and opportunities. Incumbents have lobbied policymakers to limit DER providers' access to energy, ancillary service, and capacity markets. They have promoted principles for electricity and network tariff design that DER providers argue discourage their growth. Network operators were accused by some newcomers of creating barriers to network connection through inflated costs and onerous procedures. Finally, incumbents were accused of unduly limiting access to key data resources DER providers argue they require to grow out of their niches.

Fourth, the thesis addressed the sub-research question: *"How are electricity retail and network incumbents using their resources and opportunities to promote DER as part of their business model evolution?"*

The investigation here turned to processes of business model evolution from the perspective of incumbent electricity firms with customer-facing functions (retailing and distribution network operation). Depending on the electricity retail market design in place in each jurisdiction, these incumbents operate under varying business models and firm structures. In all cases, they control budgets, customer relationships, and data

which are valuable resources for DER newcomers trying to build business models on the demand-side. The research showed that there are several cases where electricity incumbents have enabled the demand-side to access these resources, through cooperation with or acquisition of energy service and DER companies. Various factors motivate competing, centralised retailers and gen-tailers to do so: profits from upstream generation assets have reduced in many jurisdictions, as have margins from trading and retailing commodity. Moreover, in some jurisdictions, public-interest policies that work as niche protection force these competitive incumbents to make revenue available for the demand-side. For regulated-franchise incumbents, distribution network operators, and bundled network-retail utilities, policy pressure is the driving factor that motivates them to support DER.

The fifth question inquired, *"Which difficulties do agents of change promoting DER face within incumbent electricity firms?"*

The thesis found that even if incumbent electricity firms are strategically motivated to support DER, they face a range of challenges. For some competing electricity retailers, reputational and regulatory risks make innovation in DER difficult, especially in the residential energy user segment. Where large incumbents acquired DER companies with the aim to bundle the commodity business with DER services, fully integrating energy service operations with commodity retailing operations proved difficult. Especially where DER services require bespoke analysis on customer premises, retailing commodity has mostly been run as a separate business unit. Regulated-franchise incumbents have also been risk-averse in trusting the demand-side to replace resources traditionally provided by conventional power plants and network asset investment. Moreover, a lack of skills and viable institutional arrangements to allow network operators and demand-side resource providers to profit from cooperation has stalled progress. Overall, regulated-franchise electricity firms

face uncertainty about their future roles and business models in a changing electricity system.

8.1.2 Overarching research question

After describing these socio-technical change processes of building public policy institutions and new demand-side energy business models, the thesis analysed the data presented comparatively. This allowed addressing the overarching research question:

"What is the political significance of electricity retail market design institutions for decentralised energy transitions on the demand-side?"

Data on discourse coalitions were compared to identify the main disagreements in frames of meaning and assumptions underlying different electricity retail market designs. Data on processes of building and evolving business models in electricity and demand-side energy resources were compared to identify differences and similarities in the context of varying market designs.

Investigating the 'political' as a contest of ideas, the thesis found that electricity retail market design is politically significant because it is a disputed set of institutions, where players arguing about how it should be configured use different underlying assumptions and frames of meaning to justify their proposals. The contested facets of electricity retail market design are, firstly, the meaning of efficiency and welfare, along with assumptions about what type of institutional arrangement best increases these gains. Secondly, there are disagreements about electricity retail market design between those who frame electricity as a special type of service that requires different rules, and those who believe it should be treated similarly to other products. This disagreement relates to different assumptions about justice, and whether it is fair when

benefits accrue more to some customers than to others. Finally, electricity retail market design is contested because framings of what constitutes meaningful 'choice' differ between those who privilege individual market choices over collective choice by policymakers with a respective mandate. This is related to different assumptions about what is a desirable range and quality of choices. These differences in framing and assumptions were key in the 1990s in California, Massachusetts, and Texas, and remain important today, for how changing techno-economic conditions in the electricity sector are interpreted and institutions are reconfigured.

In terms of the 'political' as the realm of different distribution of resources and opportunities within a decentralising electricity system, retail market design was found to be politically significant in some instances. The thesis argued that the main instances where electricity retail market design notably influenced demand-side transitions were: in cases where service providers seek to offer energy services bundled with commodity electricity into one contract and bill; in cases where the business model requires combining revenue from distribution network operators with value from ancillary service, energy, and capacity markets; in the way electricity retail market design structures who may have a relationship with users around 'energy'; and in jurisdictions where policymakers have not provided guaranteed revenue to DER providers.

Firstly, electricity retail competition is significant for DER players looking to bundle their service offering with commodity electricity in one contract and bill. Under monopoly electricity retailing and billing, newcomers cannot independently from the incumbent bundle commodity with services because the regulated-franchise utility retails and bills for electricity. Under contestable billing and power procurement, DER players seeking to offer bundled offers can themselves qualify to operate as commodity retailers and send bills accordingly, or partner with other competitive

players in the market. In the large commercial and industrial customer segments, this is already common in several European countries. Where energy procurement and billing are not contestable, the DER player seeking to offer a product that bundles commodity with energy services would need to negotiate with a monopoly utility and their regulators, and the regulatory framework would need to change to enable this.

Secondly, going forward, unbundling of distribution network operation will have significance for how newcomers seeking to recover distribution grid value can combine this with other value pools across the system. Bundled network-retail utilities in states like California and Massachusetts currently bid demand-side resources into energy, ancillary service, and capacity markets. Unbundled 'wires-only' companies, for instance in Britain, are prohibited from acting as aggregators of DER into these markets. Therefore, to 'stack' distribution-grid value with other revenue streams, DER providers must either themselves access these markets, or partner with another competitive company qualified to do so. Another area of significance going forward is that unbundled distribution network operators, before they have developed programmes to procure demand-side resources, have no direct gain from promoting industry-wide standardisation of communication protocols for connected devices on the demand-side. By comparison, some bundled network-retail utilities who still have customer relationships and themselves control demand-side appliances have been actively engaged in promoting open, non-proprietary communication standards. As regulated-franchise companies they can't as directly benefit from locking customers into a certain technology brand, as competing retailers and technology companies can.

Thirdly, electricity retail market design has significance in jurisdictions where policymakers have not embraced a *distributed* low-carbon energy vision and therefore have not designed support-schemes to provide revenue explicitly for demand-side resources. Under these conditions, electricity retail competition has enabled access to

energy value and a customer channel for standardisable forms of DER, for instance solar-PV, distributed storage, and simple demand response, if economic market conditions were otherwise favourable. It is unlikely that regulated-franchise utilities who own network infrastructure would choose procurement of DER to meet energy demand without explicit (formal or informal) public policy pressure. DER adoption would initially decrease their revenues and reduce the need for their network in the longer-term. Innovative retailers seeking to evolve their business models have cooperated with DER newcomers also without being mandated, and this has enabled niche players to grow where there was otherwise no support scheme in place.

Where DER have been encouraged through 'niche protection' policies, so far, choices about competition and unbundling have not greatly affected the emergence of demand-side resources. Here, incumbents have been forced to support DER whether they operate under a competitive or monopoly electricity retail market design. Electricity retail market competition and unbundling were not found to positively or negatively affect the implementation of these public-interest-schemes designed to promote specific resources.

Electricity retail market design has less significance for micro-generation and demand response players targeting revenue and customers independently from electricity retailers and retail utilities, and without bundling commodity electricity into their offering. This thesis found evidence that several successful business models work by marketing to customers through channels other than the commodity electricity relationship; by offering value directly to energy users independent of commodity bills; or by directly accessing energy, ancillary service, and capacity markets. Although independent access to these value pools is not always available, reforms are progressing in several jurisdictions, and have already allowed some revenue and market access for DER providers. This finding refutes suggestions that electricity

retail competition is a necessary condition for innovation in energy services. It also contradicts assumptions common in public discourse that a greater adoption of demand-side measures is best achieved through energy-supply-contracting offers that bundle commodity electricity with demand-side measures to provide guaranteed levels of 'energy-as-a-service'.

Unbundling of distribution networks from retailing functions does not seem to significantly influence network operators' propensity to invest in DER instead of network assets. Opportunities for DER providers to be paid for offering 'non-wires' alternatives have advanced slowly, whether these resources are controlled by bundled or unbundled network operators. The evidence suggests that processes of business model evolution for distributors and their interaction with demand-side resources are more dependent on how regulators incentivise network operators through rewards, penalties, mandates, and informal regulatory pressure, than on whether a distribution network operator still maintains customer relationships.

The research also investigated how different types of demand-side resources and business models are affected by electricity retail market design institutions. It found that complex micro-generation and building energy efficiency measures have not benefitted from electricity retail competition, and that for these types of DER, electricity retail market design does not seem to significantly influence prospects for growth. Because these energy service measures require bespoke analysis and on site-operations, they are difficult to integrate with commodity electricity retailing operations which cover larger geographical scales. This means that the market for bespoke energy services is unlikely to converge with the electricity commodity market. These findings support literature suggesting that on-going policy support for energy efficiency is necessary because competitive markets and innovation on their own do not lead to cost-effective levels of investment in energy saving.

In comparing different types of incumbents' behaviour in impeding DER, the research found that electricity retail market design itself does not influence clearly how strongly the regime resists decentralisation and challenge from newcomers. The more heavily incumbents are invested in conventional centralised assets and operations, the more they resist change that can challenge these lines of business. This is true also where another part of their business can profit from DER. The market design and firm structures within which incumbents operate influence which resources and opportunities they have to impede DER growth and the techniques they can use. But DER challengers interviewed did not find regime resistance overall varied in force under different market designs.

Electricity retail market design does influence the ecosystem of companies competing for a relationship on 'energy'. This relationship and the brand value attached to commodity electricity bills historically were and continue to be contested. In unbundled environments, the commodity customer relationship is owned by competing retailers. Some of these, if they face enough competition, see advantages in working together with technology or service companies who have strong customer brands and value propositions, and therefore are willing to allow intermediation of their customer relationship. This could benefit DER newcomers with customer-facing strategies. Franchise network-retail utilities in the US on the other hand are in the process of negotiating the evolution of their business models with regulators, policymakers, and other stakeholders because once more, the institutional structure of the sector is being challenged by new policy pressures, environmental concerns, and innovation in technologies and practices. Under this uncertainty, the utilities, for instance in California and Massachusetts, see strategic value in owning the customer relationship around commodity electricity and in energy services (through demand management programmes). Even if their revenue models are designed such that they

do not generate more revenue from selling commodity electricity or marketing energy services under their own brand, than if third parties intermediated the relationship, they are still wary to give up their customer relationships. For DER providers with utility-facing strategies this is beneficial if they can build good relationships with incumbents. But many energy service providers marketing directly to customers do not like competing with incumbent vertically integrated utilities and demand that they step aside.

Overall, different types of DER newcomers and customers can benefit from varying types of electricity retail market design. Competition enables those newcomers and customers with the necessary understanding and capabilities to benefit from a greater range of options and contestable functions. Retail monopoly reduces the options and thereby the complexity. Competition enables DER companies who want to work independently from incumbents to access markets and customers as new entrant retailers, and independently build relationships. This is not possible in a monopoly retail market design where regulated-franchise utilities control more functions exclusively. However, independently accessing markets, customers, and managing a supply chain of partnerships requires considerable resources which can pose barriers to entry. Some types of DER players do not have the required resources and capabilities and have therefore found monopoly franchise retail environments comparatively easier to access. If policymakers support DER and incumbent utilities are forced to promote them, the terms under which DER customers and companies can access revenue and other resources are at a high level negotiated in a regulatory process. The negotiation of favourable terms of partnership with the incumbent in the regulated-franchise environment is then a question of lobbying for institutional change which, depending on the case and organisation, may be more or less difficult than negotiating favourable terms in a competitive market.

This is analogous to how electricity retail market designs structure access to resources and opportunities for energy users: for customers with resources to engage and manage their energy demand, electricity retail competition through individual choice offers a greater range of competitors and commodity offers in the market to choose from. Electricity retail monopoly and regulated default service by comparison offer simplicity to those who feel they do not or cannot benefit from individual choice. These customers may therefore prefer to rely on regulators and lobby groups to negotiate favourable terms on their behalf within a regulatory process.

8.2 Implications for public policy

The findings have a number of implications relevant for public policy.

Firstly, policymakers should not expect deeper building efficiency and more complex demand-response measures to be delivered by innovation in the electricity retail market. This is based on the finding that electricity retailers have so far not been successful at integrating commodity electricity with complex, bespoke energy services operations in customer offerings and operations (see sections 6.1.2; 6.1.4.1). Their skillset in trading and energy market risk and their operational footprint across regions, serving thousands of customers, are not well aligned with managing supply chains for more complex energy service offers. Deeper energy savings and complex demand response measures require skills on-site, time-intensive sales interactions, and a degree of specialisation. Therefore, competition in electricity retailing and retailers' desire to improve their customer relationship will not drive innovation in deeper energy savings. It is possible that innovation in electricity retail markets will include more easily standardisable solutions such as micro-generation, storage assets and

simpler, retrofittable demand response solutions, as these can be 'white-labelled' and more easily marketed and scaled by retailers (see section 7.2.2.2). Moreover, if there is enough consumer demand, competing retailers can be expected to provide a broader variety of electricity commodity tariffs to suit particular assets like electric vehicles and heat-pumps than would be expected to emerge under administrative tariff-setting. However, commodity electricity retailers should not be expected to promote more complex and bespoke measures as part of their innovation activities to offer value-added services.

The findings confirm that to promote energy saving, policymakers should focus on providing dedicated, strong policy support through a range of instruments (Rosenow et al. 2016), including obligations, standards, information, and subsidised loans and grants. Focusing attention on reforms to lower entry barriers for newcomers to the electricity retail market or enabling innovation in digitalisation and artificial intelligence will not deliver energy savings and other more complex measures. Rather than removing barriers to innovation in energy retailing, energy services companies who promote bespoke measures need access to capital and revenue streams, as end-users often themselves do not see the value in adopting these more complex, deeper measures, and a range of other barriers prevent cost-effective energy saving from being adopted (Brown and Wang 2015). Deeper and wider demand reduction in buildings needs dedicated policies to promote awareness, appliance, material, supply chain, and skills development (Fawcett and Topouzi 2019; Killip 2013).

Some policymakers with belief in the power of competition to engender innovation still promote the narrative that reducing barriers to competition and innovation will deliver the demand-side measures needed to reach climate change mitigation targets. For example, the British business secretary in 2018 predicted that the *"transformation of [power] distribution and supply should deliver, amongst other things, the prize of*

domestic energy efficiency improvements" (Doc-79-Clark). This thesis showed that there is no evidence to support this belief. Some may argue that if market entry barriers to competitive retail markets were lower, energy service firms with the expertise to deliver energy savings could build more viable business models and compete with traditional retailers. However, the opportunity to bundle commodity electricity with energy services into one contract or bill is not always attractive to service providers and customers. Where it is, there is no evidence to suggest that the ability to bundle a DER offering with commodity electricity is what determines whether the project goes ahead or not. Evidence from interviews suggests that selling a bespoke DER measure to end-users depends on a wide range of factors related to a proposed intervention's expected impacts and the customer's and the building's situation. Whether the customer can buy electricity from the same provider or not is less important in determining the successful sale and implementation (see section 7.2.2.1). These findings likely also apply to low-carbon heating systems that require bespoke site analysis and skilled installation within a building, such as heat pumps.

Narratives that promise the transformation of electricity retail markets from commodity offers to 'energy-as-a-service' offerings negate the wide range of reasons for which energy services based on building upgrades are difficult to implement. Sometimes the discourse on 'energy-as-a-service' is linked to calls for reform to increase competition and lower entry barriers to retail electricity markets, rather than focusing policy on standards, mandates, and incentives for energy saving. However, this research has confirmed the importance for policymakers to focus on providing energy service companies with the active policy support to promote measures which decades of research have shown are not adopted by markets and customers without explicit interventions (Brown and Wang 2015; Rosenow et al. 2016; Eyre 1998).

This means that *for deeper energy savings* to be invested in more widely, niche-protection' *policies that provide guaranteed access to revenue and resources cannot be phased out*, they are continuously required. This makes energy efficiency different from demand response, micro-generation, and demand-side storage. These types of DER interventions are more standardisable and could be promoted by commodity retailers where there is consumer demand, because, as the research showed, retailers can integrate these types of DER products more easily into their offerings. Moreover, DER measures popular with customers can, when they are aggregated as virtual power plants, compete with larger-scale, centralised energy and flexibility resources like renewable power plants, storage assets, and interconnectors, if requirements for participation in energy, capacity, and system service markets don't privilege larger-scale contestants. This means that once commercial conditions for these more standardisable types of DER have improved and supply chains have developed, niche-protection policies that mandate specified remuneration for or procurement of defined quantities could be phased out if they deem this preferable or politically opportune. Policymakers may prefer to phase out 'niche protection' policies if they in future prefer not to plan which resource mix should be procured (e.g., in capacity auctions, wholesale energy auctions, by retailers or utilities). In some jurisdictions, support schemes like net-energy-metering and feed-in-tariffs are already being reformed to reduce the extent to which DER are sheltered from competition with other resources in the system. Some policymakers who prefer competition between resources to planned procurement might also want to consider creating policies to value additional benefits of DER, for instance benefits for resilience, positive health impacts, or local employment, to ensure that demand-side resources could compete with the supply-side.

There are calls in jurisdictions with and without electricity retail competition for reforms to allow a broader range of players and offerings to intermediate or 'resell' commodity electricity. Without themselves qualifying as retailers, having to procure power wholesale, or negotiating a cooperation with retailers or utilities, third-party-intermediaries could then purchase electricity from a fully qualified retailer or a utility and resell it. Depending on what the rules permitted, intermediaries would then have freedom to use their preferred brand, billing, and pricing structure[44]. Some DER providers have called for intermediation rules to be designed such that the resold electricity can then be bundled with DER measures into one contract and transaction by one or several energy service providers, building owners, or other third-party-intermediaries. *If these policies forced retailers and utilities to allow intermediation on politically negotiated, pre-defined terms, this would lower the barriers to selling electricity and could increase the range of competitors in the retail electricity market.* The research showed that such reforms broadening the types of offers and players allowed to resell electricity on pre-defined terms were supported by some energy service providers seeking to offer combined service-commodity products, who either did not have resources to negotiate successfully with retailers or utilities, or could not come to mutually agreeable terms in negotiations. The research also suggested that bundling commodity with DER services is only one among many types of successful approaches and not always required. Reforms to allow reselling without having to partner with retailers or utilities would benefit DER providers who believe that their

[44] In instances where billing and power procurement are monopolised as is the case for most customers in California, allowing resale would look in some ways similar to allowing competition in billing without allowing competition in power procurement. While utilities would retain their power procurement function as single buyers, customer-facing functions such as billing could then be handled by an intermediary.

success is contingent upon being allowed to bundle commodity and services into one offering.

There is an alternative way to enable recovery of costs for DER interventions linked to commodity electricity in jurisdictions where regulated franchise utilities provide billing. Policymakers can require franchise-regulated utilities to recover costs for DER interventions provided by third parties from customers through the utility's electricity bill. This would mean that also energy service providers without the resources and sophistication to themselves provide a financing offer and billing service could offer their customers bundled billing for DER services and commodity electricity, provided by the incumbent. This research did not evaluate this arrangement however.

Jurisdictions considering reforms to introduce the right for customers to directly access energy markets and choose competitive electricity retailers should recognise that allowing competition in power procurement results in redistribution of costs between customers, from a politically negotiated distribution under administrative tariff-setting to a market-based distribution. At the same time, the innovation engendered by competition in commodity electricity retail remains commodity-based rather than service-based. This means that novel products that competition enables include a greater diversity of commodity tariffs and hedging offers but as outlined above, there is no evidence that commodity competition engenders innovation in energy services. Innovation in energy services for many types of business models occurs independently from competition in commodity retailing and the latter is not necessary, if DER providers can market their propositions to customers and access revenues through channels independent from retailers and utilities (see section 7.2.1.3). The research does suggest that competition in power procurement could enable energy contracting offers that bundle commodity with services to emerge

independently from incumbent utilities (see section 7.2.2.1). This means that competition in retailing, while it doesn't promote DER, does promote a greater diversity in the types of contracting offers available, and hence a greater range of choices for customers. But if greater diversity of offers and players are desirable, allowing intermediation or resale of power procured by utilities as single buyers, as discussed above, would suffice and be potentially preferable. So, while large, sophisticated energy users may call for direct access, it is a reform that primarily influences the distribution of costs rather than the transition of energy systems towards decarbonisation or decentralisation.

In this light, jurisdictions now considering introducing competition in power procurement may find that its disadvantages outweigh its benefits, particularly in the smaller customer segment. Disadvantages include adverse experiences for some customers, related to misconduct in marketing, as well as potential for retailers failing, when they have not hedged adequately which creates costs that probably need to be socialised.

Allowing intermediation for more players and offers would mean a strong increase in compliance and enforcement work for agencies seeking to ensure customer protection, in jurisdictions where electricity framed as an 'essential service' comes with high expectations of good conduct. A larger number of more decentralised players in the marketplace would make customer protection monitoring and enforcement more resource-intensive than if only a smaller number of larger electricity retailers and utilities are permitted to retail electricity.

If policymakers want to enable a wider range of players to sell electricity by allowing intermediation, *eligibility for intermediation should be limited* explicitly to projects with wider system benefit that deliver particular policy aims (such as greenhouse gas

reduction, energy savings, the integration of renewable energies, the reduction of fuel poverty, and, or the promotion of particular measures or technologies). Allowing resale only in combination with certain desired interventions could ensure that the social costs of adverse customer outcomes and the administrative costs of supervising a very large market would not outweigh the benefits. Otherwise, products with no direct effect on decarbonisation or social hardship, such as 'consolidated utility offers' that bundle for instance electricity, water, and broadband or simple brokering business models, could crowd out firms seeking customers' attention for energy services that also address public interest aims, but may be a harder sell to customers. Therefore, market entry barriers should only be lowered for those players and types of offers that provide a system-benefit. Arguably, decarbonisation should be one, if not *the* key consideration in this respect.

8.3 Avenues for further research on demand-side energy transitions

This thesis revealed several avenues for additional research on the topic of electricity retail market design that would benefit from further inquiry.

Firstly, this research focused on decision-making by policymakers and firms but did not study the decisions and perspectives of end-users of electricity, technology, and buildings. Their decision-making is key to the socio-technical changes on the demand-side that this thesis investigates, and processes of institutionalising new energy practises are important to electricity systems decentralising. Rather than focusing on processes of creating new business models, the politics of electricity retail market design could have been approached through the study of practices and behaviour of end-users. Future research could investigate energy users' practices of engaging with

demand-side energy businesses; their interest in, and their abilities to adopt energy services offerings in the context of different electricity retail market designs.

For example, a variety of methodologies could help investigate whether competition in electricity commodity 'distracts' energy users in ways that mean they are less likely to accept and support DER offerings. Surveys or experiments could be used to test hypotheses on whether energy users under different market designs are more or less willing to agree to long-term energy services contracts that allow financing of assets and measures. Research on the differences between customer segments in this regard could also yield interesting results on how electricity retail market design may affect adoption of DER among different types of users and energy demands.

Secondly, another interesting avenue for further research would be to investigate cases in which incumbents have acquired newcomers and challenger firms on the demand-side or supported them, to see if there are instances of acquisition or partnership with the clear purpose to slow transition processes. Although difficult to execute given commercial confidentiality of corporate strategy, research into incumbents' tactics after entering a partnership or making an investment could yield interesting and important insights into how regime-players seek to slow down transitions while reallocating resources to newcomers. It is likely that some incumbent companies with significant investments in conventional resources, in this case oil and gas, have the interest and resources to constrain challenge from innovative newcomers by acquiring them – activities which to the outside can look deceptively innovative.

Research could also explore further the significance of other differences in regime structure for demand-side energy transitions. This thesis focused on the differences between electricity retail market designs and between competitive unbundled, regulated-franchise, and bundled incumbent electricity firms in promoting and

impeding DER growth. It found that other differences in the institutional nature of the regime also influence the propensity for incumbents to embrace demand-side resources, and these could be researched. For instance, differences in terms of low-carbon resource mix incumbent electricity firms control are likely to impact the strategies in relation toward DER, for instance whether incumbents operate renewable, fluctuating generation plants or rely on large-scale inflexible resources such as nuclear power. The size of companies and their operational footprint is also likely to play a role for how processes of incumbent business model change unfold, for both regulated-franchise and competing firms. The capital market environment and whether firms rely on patient or impatient capital and the corporate form and ownership model in terms of private, public-sector, and cooperative ownership could also be investigated as different institutional arrangements that influence demand-side energy transitions.

An aspect of electricity retail market design this thesis did not investigate that would benefit from further research is the detailed design of default electricity service. Most literature focuses on whether default service is price-regulated or not, and whether it is delivered by bundled or unbundled firms, and this thesis has contributed to this debate. But within these broader differences, there are more detailed design differences. These determine, for instance, the volatility of a default offer over time, whether it has been explicitly designed to expose default customers to this volatility, and the amount of head-room regulated prices provide to enable competition. These dimensions have important consequences for energy users, market offerings, and demand-side energy transitions.

Finally, this thesis did not investigate the relationship of retail and wholesale electricity market design, the set of institutions that organises the functions at the upstream end of the electricity supply chain. The scope was limited to the institutions

that determine whether customers may choose from among competing retailers, and whether network operators must be unbundled from retailing functions. This delineation of scope as 'electricity retail market design' was useful but avoided investigating the interaction with wholesale electricity market design. How competition between power-system resources is organised upstream; the unbundling of network companies from power plants; wholesale electricity market dispatch arrangements; the design of capacity mechanisms; of other schemes that allocate fixed payments to certain resources through auctions; and the design of other rules that determine how power is traded and dispatched could be considered part of wholesale electricity market design. Like the institutions which this thesis has considered as 'electricity retail market design', these rules also influence electricity planning and investment. It is possible that demand-side resources can be better integrated into some market designs than others. The thesis has not taken account of the relationship between wholesale and retail markets, although functions upstream and downstream are of course in reality linked through electricity procurement. Further research in this area would be beneficial.

8.4 Contribution

The thesis makes new contributions to the study of socio-technical change in electricity systems. The data presented on how different electricity retail market designs evolved allow contributing to literature on electricity market restructuring which has not so far focused in detail on downstream competition and unbundling. Historical analyses tended to focus on competition reforms more generally but did not in detail analyse the differences in actor coalitions and arguments with respect to retail restructuring. Moreover, an interpretive analysis of restructuring processes that

empirically assesses how different meanings and problem-solution framings were used to argue for different reform options was not previously attempted. The research therefore made an important contribution to knowledge about restructuring because it politicises accounts of this key moment in the socio-technical evolution of electricity systems.

The thesis also contributed to the theoretical literature on how to study socio-technical transition processes. Firstly, it speaks to literature on the relationship between 'governance' and transitions. The analysis showed that projects of theory-building on how broad 'governance' varieties such as 'liberalised' or 'coordinated' approaches influence transitions in electricity need to be treated with caution (see section 7.3.2). While public policy institutions do influence regime and niche players' access to resources and opportunities, it is essential not to assume that their design determines the outcomes of socio-technical change processes. Analyses that predict incumbents and newcomers will behave rationally in response to incentives structured by their institutional environment underestimate the complexity of firm decision-making. Incumbents and niche players can have internally competing units, operate under uncertainty, and perceive the world and their own interests through different frames of meaning. Therefore, public policy institutions direct but do not determine firms' behaviour, or the trajectory of system change. The findings support the contention that analyses of institutional frameworks should not generalise too broadly, but rather focus on the details of how *specific* public policies affect narrower change processes. These narrower analyses will yield more useful results than projects trying to explain and predict differences in large-scale system change as results of differences in public-policy environment.

Secondly, the thesis demonstrated the importance of studying discourse, frames of meaning, and ideas within transitions research. Socio-technical research can benefit

from incorporating interpretive policy analyses for two reasons. Differences in frames of meaning can play an important role in socio-technical change. Studying how changes in the technological and economic environment are interpreted, how they are contested, and in some cases strategically constructed as problems that require action helps elucidate instances of agency in the coevolution of technologies, practices, and institutions. The cases analysed in Chapter 4 demonstrated that technological change, interest groups, and path dependencies did not produce the policies adopted during electricity market reforms as inevitable outcomes. How changing technological and economic factors were interpreted was important for how actors perceived what was in their interest, and for how institutions evolved. Moreover, an interpretive approach can strengthen socio-technical analyses because studying discourses and frames, while examining what is contested about institutions and transitions, is one useful way to analyse the politics of transitions. It allows elucidating power in transitions because in discursively constructing problems and solutions, actors invariably categorise sectors, groups, and concepts; create binaries; and make assumptions about preferences of groups and cause-effect relationships.

Practically, analysts of socio-technical transitions using the multi-level-perspective framework can study ideas, discourses, and frames by examining actors' language. They can thereby identify acts of framing as one type of agency that can promote change or protect the status quo. Niche-players and incumbents at regime-level engage in acts of framing and analysts can trace how they influence the institutionalisation of technological and practice changes in structures like industry networks, standards, policies, and business models. This implies analysing as data the ways actors express themselves, what they choose to talk about, and what to avoid. Instead of scrutinising only the content of speech that reports event-chains and cause-effect relationships as given, studying discourse implies deconstructing what is said.

To apply discourse analysis techniques, the analyst can question the assumptions underlying statements and contrast them with other actors' opposing statements. This allows the analyst using discourse analysis to examine how actors interpret the world, which issues and events they single out as worthy of attention and present as problematic, and which assumptions about cause-effect relationships underlie their proposed solutions. Analysts can then trace which discourses become hegemonic and institutionalised in the regime, using more realist forms of content-analysis of event-chains, process-tracing, and evolutionary analysis of populations. The interpretive approach allows the analyst to be reflexive about their own assumptions and improve the quality of debates by making other players' assumptions more visible.

The thesis also made new empirical contributions to debates about energy services, electricity retail competition, and unbundling by examining recent evidence on new DER business models. Investigating how incumbents have enabled and impeded access to resources and opportunities, and how this differs across electricity retail market designs allowed assessing in more detail claims in the literature about how restructuring reforms have influenced demand-side resources and innovation. DER can benefit from electricity retail competition and retailers' interest to evolve their business models if the demand-side resources involve easily standardisable assets and measures which do not require on-site analysis. However, the evidence suggests that more bespoke measures, including deeper energy savings and more complex energy service innovation will not be driven by electricity retail competition or the bundled contractual offers (energy-supply-contracting) it enables.

Moreover, the interpretive analysis this thesis presented can contribute to debates on how to organise institutional arrangements in the electricity sector. By making visible differences in underlying assumptions and frames of meaning, it can aid policy practice by improving reflexivity of debate and decision-making.

Bibliography

Abbott, A.D. (2001) *Time matters: on theory and method*. Chicago: University of Chicago Press.

Adib, P., Zarnikau, J. and Baldick, R. in FP Sioshansi (editor), (2013) Texas Electricity Market: Getting Better. *Evolution of Global Electricity Markets: New Paradigms, New Challenges, New Approaches* Waltham, MA: Elsevier. 265–296.

AlAbdulkarim, L. and Lukszo, Z. (2009) Smart metering for the future energy systems in the Netherlands. Linkoping, Sweden: IEEE.

Aldrich, H. (2008) *Organizations and environments*. Stanford, California: Stanford Business Books.

Apajalahti, E.-L. (2018) *Large energy companies in transition: From gatekeepers to bridge builders. Three essays on energy incumbents' activities*. Aalto University.

Arrow, K. in Universities-National Bureau Committee for Economic Research and the Committee on Economic Growth of the Social Research Councils (editor), (1962) Economic Welfare and the Allocation of Resources to Invention. *In The Rate and Direction of Inventive Activity: Economic and Social Factors* Princeton, NJ: Princeton University Press. 609–626.

Asmus, P. (2009) *Introduction to Energy in California*. Berkeley: University of California Press.

Avelino, F. (2017) Power in Sustainability Transitions: Analysing power and (dis)empowerment in transformative change towards sustainability. *Environmental Policy and Governance* 27 (6), 505–520.

Avelino, F. and Rotmans, J. (2011) A dynamic conceptualization of power for sustainability research. *Journal of Cleaner Production* 19 (8), 796–804.

Averch, H. and Johnson, L.L. (1962) Behavior of the Firm Under Regulatory Constraint. *The American Economic Review* 52 (5), 1052–1069.

Baldwin, E., Rountree, V. and Jock, J. (2018) Distributed resources and distributed governance: Stakeholder participation in demand side management governance. *Energy Research & Social Science* 39, 37–45.

Barnes, J., Durrant, R., Kern, F. and MacKerron, G. (2018) The institutionalisation of sustainable practices in cities: how initiatives shape local selection environments. *Environmental Innovation and Societal Transitions* 29, 68–80.

Behrangrad, M. (2015) A Review of Demand Side Management Business Models in the Electricity Market. *Renewable and Sustainable Energy Reviews* 47, 270–283.

Béland, D. (2016) Ideas and Institutions in Social Policy Research. *Social Policy & Administration* 50 (6), 734–750.

Béland, D. and Cox, R.H. (editors) (2010) *Ideas and Politics in Social Science Research*. Oxford: Oxford University Press.

Belhomme, R., Trotignon, M., Jover, L. and Glorieux, L. (2016) Market Design Analysis and Role Modelling: Methodology and First Results. Paris-Saclay: EnergyCon.

Berg, W., Vaidyanathan, S., Nowak, S., Kelly, M., Shoemaker, M., Chittum, A., DeLucia, H. and DiMascio, M. (2017) *2017 State Energy Efficiency Scorecard*.

Bergman, L., Brunekreeft, G., Doyle, C., von der Fehr, N.-H., Newberry, D., Pollitt, M. and Régibeau, P. (1999) *A European market for electricity?*. London: Centre for Economic Policy Research.

Bergman, N. and Eyre, N. (2011) What role for microgeneration in a shift to a low carbon domestic energy sector in the UK? *Energy Efficiency* 4 (3), 335–353.

Berka, A.L. and Creamer, E. (2018) Taking stock of the local impacts of community owned renewable energy: A review and research agenda. *Renewable and Sustainable Energy Reviews* 82, 3400–3419.

Bertoldi, P. and Boza-Kiss, B. (2017) Analysis of barriers and drivers for the development of the ESCO markets in Europe. *Energy Policy* 107, 345–355.

Bertoldi, P., Rezessy, S., Lees, E., Baudry, P., Jaendel, A. and Labanca, N. (2010) Energy supplier obligations and white certificate schemes: Comparative analysis of experiences in the European Union. *Energy Policy* (38), 1455–1469.

Bertoldi, P., Rezessy, S. and Vine, E. (2006) Energy service companies in European countries: Current status and a strategy to foster their development. *Energy Policy* 34 (14), 1818–1832.

Bertram, G. in FP Sioshansi (editor), (2013) Weak Regulation, Rising Margins, and Asset Revaluations: New Zealand's Failng Experiment in Electricity Reform. *Evolution of Global Electricity Markets: New Paradigms, New Challenges, New Approaches* Waltham, MA: Elsevier. 645–678.

Bevir, M. and Rhodes, R.A.W. in D Marsh & G Stoker (editors), (2002) Interpretive Theory. *Theory and Methods in Political Science* 2nd Edition. Basingstoke: Palgrave Macmillan. 131–152.

Blumstein, C. and Bushnell, J. (1994) A guide to the blue book: Issues in California's electric industry restructuring and reform. *The Electricity Journal* 7 (7), 18–29.

Blumstein, C., Goldman, C. and Barbose, G. (2005) Who should administer energy-efficiency programs? *Energy Policy* 33 (8), 1053–1067.

Blumstein, C., Goldstone, S. and Lutzenhiser, L. (2000) A theory-based approach to market transformation. *Energy Policy* 28 (2), 137–144.

Blyth, M. (2002) *Great Transformations: Economic Ideas and Institutional Change in the Twentieth Century*. Cambridge: Cambridge University Press.

Blyth, M.M. (1997) 'Any More Bright Ideas?' The Ideational Turn of Comparative Political Economy. *Comparative Politics* 29 (2), 229–250.

Boait, P.J., Snape, J.R., Darby, S.J., Hamilton, J. and Morris, R.J.R. (2017) Making legacy thermal storage heating fit for the smart grid. *Energy and Buildings* 138, 630–640.

Boardman, B. (2010) *Fixing fuel poverty: Challenges and solutions*. London: Earthscan.

Bolton, R. and Foxon, T.J. (2011) Governing Infrastructure Networks for a Low Carbon Economy: Co-Evolution of Technologies and Institutions in UK Electricity Distribution Networks. *Competition and Regulation in Network Industries* 12 (1), 2–26.

Bolton, R. and Foxon, T.J. (2013) Urban Infrastructure Dynamics: Market Regulation and the Shaping of District Energy in UK Cities. *Environment and Planning A: Economy and Space* 45 (9), 2194–2211.

Bolton, R. and Hannon, M. (2016) Governing sustainability transitions through business model innovation: Towards a systems understanding. *Research Policy* 45 (9), 1731–1742.

Boons, F. and Lüdeke-Freund, F. (2013) Business models for sustainable innovation: state-of-the-art and steps towards a research agenda. *Journal of Cleaner Production* 45, 9–19.

Borenstein, S. and Bushnell, J. (2015) The U.S. Electricity Industry after 20 Years of Restructuring. Energy Institute at Haas.

Breschi, S., Malerba, F. and Orsenigo, L. (2000) Technological Regimes and Schumpeterian Patterns of Innovation. *The Economic Journal* 110 (463), 388–410.

Brinker, L. and Satchwell, A. (2019) A comparative review of municipal energy business models in Germany, California, and Great Britain: Institutional context and forms of energy decentralization. *Renewable and Sustainable Energy Reviews* (Special Issue on Energy Decentralization and Institutional Context) .

Bromley, D.W. (1990) The ideology of Efficiency: Searching for a Theory of Policy Analysis. *Journal of environmental economics and management* 19, 86–107.

Brown, D.P. and Eckert, A. (2018) The effect of default rates on retail competition and pricing decisions of competitive retailers: The case of Alberta. *Energy Policy* 118, 298–311.

Brown, M.A. (2001) Market failures and barriers as a basis for clean energy policies. *Energy Policy* 29 (14), 1197–1207.

Brown, M.A. and Wang, Y. (2015) *Green Savings: How Policies and Markets Drive Energy Efficiency*. Santa Barbara: Praeger.

Brunekreeft, G. (2015) Network unbundling and flawed coordination: Experience from the electricity sector. *Utilities Policy* 34, 11–18.

Burger, S., Chaves-Ávila, J.P., Batlle, C. and Pérez-Arriaga, I.J. (2017) A review of the value of aggregators in electricity systems. *Renewable and Sustainable Energy Reviews* 77, 395–405.

Bürger, V., Rohde, C., Rosenow, J. and Eyre, N. (2013) Overcoming the upfront investment barrier - comparing the German CO2 Building Rehabilitation Programme and the British Green Deal. *Energy and Environment* 24 (1), 83–103.

Callon, M. (editor) (1998) *The Laws of the Markets*. Oxford: Blackwell.

Cambini, C., Caviggioli, F. and Scellato, G. (2016) Innovation and market regulation: evidence from the European electricity industry. *Industry and Innovation* 23 (8), 734–752.

Campbell, J.L. (1998) Institutional Analysis and the Role of Ideas in Political Economy. *Theory and Society* (27), 377–409.

Campbell, J.L., Whitley, R., Morgan, G., Crouch, C. and Pedersen, O.K. (editors) (2010) *The Oxford Handbook of Comparative Institutional Analysis*. Oxford: Oxford : Oxford University Press.

Cappers, P., Goldman, C. and MacDonald, J. (2013) *Market and Policy Barriers for Demand Response Providing Ancillary Services in U.S. Markets*. Berkeley: Energy Technologies Division, Ernest Orlando Lawrence Berkeley National Laboratory.

Cappers, P., MacDonald, J., Goldman, C. and Ma, O. (2013) An assessment of market and policy barriers for demand response providing ancillary services in U.S. electricity markets. *Energy Policy* 62, 1031–1039.

Carley, S. (2011) Historical analysis of U.S. electricity markets: Reassessing carbon lock-in. *Energy Policy* 39 (2), 720–732.

Casadesus-Masanell, R. and Ricart, J.E. (2010) From Strategy to Business Models and onto Tactics. *Long Range Planning* 43 (2–3), 195–215.

Cavanagh, R. and Levin, A. in FP Sioshansi (editor), (2016) Rehabilitating Retail Electricity Markets: Pitfalls and Opportunities. *Future of utilities - utilities of*

the future: how technological innovations in distributed energy resources will reshape the electric power sector Amsterdam ; Boston: Elsevier. 175–192.

Chang, H.-J. (2002) Breaking the Mould: an Institutionalist Political Economy Alternative to the Neo-liberal Theory of the Market and the State. *Cambridge Journal of Economics* 26 (5), 539–559.

Chick, M. (2007) *Electricity and Energy Policy in Britain, France and the United States since 1945*. Cheltenham, UK ; Northampton, MA: Edward Elgar.

Chilvers, J. and Longhurst, N. (2016) Participation in Transition(s): Reconceiving Public Engagements in Energy Transitions as Co-Produced, Emergent and Diverse. *Journal of Environmental Policy & Planning* 18 (5), 585–607.

Cloke, P.J., Cook, I., Phillip, C., Goodwin, M., Painter, J. and Philo, C. (2009) *Practising Human Geography*. Los Angeles: Sage Publications.

Coase, R.H. (1937) The Nature of the Firm. *Economica* 4 (16), 386–405.

Cramton, P. (1997) The FCC Spectrum Auctions: An Early Assessment. *Journal of Economics and Management Strategy* 6 (3), 431–495.

Creutzig, F., Roy, J., Lamb, W.F., Azevedo, I.M.L., Bruine de Bruin, W., Dalkmann, H., Edelenbosch, O.Y., Geels, F.W., Grubler, A., Hepburn, C., Hertwich, E.G., Khosla, R., Mattauch, L., Minx, J.C., Ramakrishnan, A., Rao, N.D., Steinberger, J.K., Tavoni, M., Ürge-Vorsatz, D. and Weber, E.U. (2018) Towards demand-side solutions for mitigating climate change. *Nature Climate Change* 8 (4), 260–263.

Crossley, D. (2010) International Best Practice in Using Energy Efficiency and Demand Management to Support Electricity Networks. Prepared by Energy Futures Australia for the Australian Alliance to Save Energy.

Darby, S. (2010) Smart metering: what potential for householder engagement? *Building Research & Information* 38 (5), 442–457.

Darby, S.J. and McKenna, E. (2012) Social implications of residential demand response in cool temperate climates. *Energy Policy* 49, 759–769.

Defeuilley, C. (2009a) Retail competition in electricity markets. *Energy Policy* 37 (2), 377–386.

Defeuilley, C. (2009b) Retail competition in electricity markets—Expectations, outcomes and economics: A reply. *Energy Policy* 37 (2), 764–765.

DiMaggio, P.J. in LG Zucker (editor), (1988) Interest and Agency in Institutional Theory. *Institutional patterns and organizations: culture and environment* Cambridge, MA: Ballinger Publishing Company..

Dixon, D.P. in B Gomez & JP Jones (editors), (2010) Analyzing Meaning. *Research Methods in Geography. A critical introduction* Chichester, West Sussex, U.K, Malden, MA: Wiley-Blackwell. 392–408.

Dóci, G. and Gotchev, B. (2016) When energy policy meets community: Rethinking risk perceptions of renewable energy in Germany and the Netherlands. *Energy Research & Social Science* 22, 26–35.

Doganova, L. and Eyquem-Renault, M. (2009) What do business models do? *Research Policy* 38 (10), 1559–1570.

Dooley, J.J. (1998) Unintended consequences: energy R&D in a deregulated energy market. *Energy Policy* 26 (7), 547–555.

Dryzek, J.S. (2005) *The politics of the Earth : environmental discourses*. 2nd ed. Edition. Oxford: Oxford : Oxford University Press.

Eid, C., Bollinger, L.A., Koirala, B., Scholten, D., Facchinetti, E., Lilliestam, J. and Hakvoort, R. (2016) Market integration of local energy systems: Is local energy management compatible with European regulation for retail competition? *Energy* 114, 913–922.

Eid, C., Codani, P., Perez, Y., Reneses, J. and Hakvoort, R. (2016) Managing electric flexibility from distributed energy resources: A review of incentives for market design. *Renewable and Sustainable Energy Reviews* 64, 237–247.

Eyre, N. (1998) A golden age or a false dawn? Energy efficiency in UK competitive energy markets. *Energy Policy* 26 (12), 963–972.

Eyre, N. in R Fouquet (editor), (2013a) Decentralization of governance in the low-carbon transition. *Handbook on Energy and Climate Change* Cheltenham: Edward Elgar. 581–597.

Eyre, N. (2013b) Energy saving in energy market reform-The feed-in tariffs option. *Energy Policy* 52, 190–198.

Eyre, N. and Lockwood, M. (2016) The governance of retail energy market services in the UK: A framework for the future. UKERC working paper.

Eyre, N. and Mallaburn, P.S. (2014) Lessons from energy efficiency policy and programmes in the UK from 1973 to 2013. *Energy Efficiency* (7), 23–41.

Fawcett, T. and Killip, G. (2019) Re-thinking energy efficiency in European policy: Practitioners' use of 'multiple benefits' arguments. *Journal of Cleaner Production* 210, 1171–1179.

Fell, M.J. (2017) Energy services: A conceptual review. *Energy Research & Social Science* 27, 129–140.

Fischer, F. in F Fischer, GJ Miller & MS Sidney (editors), (2007) Deliberative Policy Analysis as Practical Reason: Integrating Empirical and Normative Arguments. *Handbook of Public Policy Analysis: Theory, Politics, and Methods* Taylor and Francis. 223–236.

Flinders, M. and Wood, M. (2014) Depoliticisation, governance and the state. *Policy & Politics* 42 (2), 135–149.

Flyvbjerg, B. (2006) Five Misunderstandings About Case-Study Research. *Qualitative Inquiry* 12 (2), 219–245.

Ford, R., Karlin, B., Sanguinetti, A., Nersesyan, A. and Pritoni, M. (2016) *Assessing Players, Products, and Perceptions of Home Energy Management*. San Francisco, CA: Pacific Gas and Electric.

Foucault, M. (2002) *Archaeology of Knowledge*. London: Routledge.

Fourcade, M. (2007) Theories of Markets and Theories of Society. *American Behavioral Scientist* 50 (8), 1015–1034.

Fourcade, M. and Healy, K. (2007) Moral Views of Market Society. *Annual Review of Sociology* 33, 285–311.

Foxon, T.J. (2011) A coevolutionary framework for analysing a transition to a sustainable low carbon economy. *Ecological Economics* 70 (12), 2258–2267.

Foxon, T.J. (2013) Transition Pathways for a UK Low Carbon Electricity Future. *Energy Policy* 52, 10–24.

Fox-Penner, P.S. (2014) *Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities*. Washington D.C.: Island Press.

Fraquelli, G., Piacenza, M. and Vannoni, D. (2005) Cost Savings From Generation and Distribution with an Application to Italian Electric Utilities. *Journal of Regulatory Economics* 28 (3), 289–308.

Friedman, M. and Friedman, R.D. (1962) *Capitalism and Freedom*. Chicago: University of Chicago Press.

Fuenfschilling, L. and Truffer, B. (2014) The structuration of socio-technical regimes—Conceptual foundations from institutional theory. *Research Policy* 43 (4), 772–791.

Galbraith, K. and Price, A. (2013) *The great Texas wind rush: how George Bush, Ann Richards, and a bunch of tinkerers helped the oil and gas state win the race to wind power*. 1st Edition. Austin: University of Texas Press.

Geels, F. (2002) Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy* 31 (8–9), 1257–1274.

Geels, F. and Schot, J. (2007) Typology of sociotechnical transition pathways. *Research Policy* 36 (3), 399–417.

Geels, F.W. (2014) Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective. *Theory, Culture & Society* (May 2013), 0263276414531627–.

Geels, F.W. (2011) The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions* 1 (1), 24–40.

Geels, F.W. and Schot, J. (2010) The Dynamics of Transitions: A Socio-Technical Perspective. *Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change* 11–103.

Geels, F.W., Sovacool, B.K., Schwanen, T. and Sorrell, S. (2017) The Socio-Technical Dynamics of Low-Carbon Transitions. *Joule* 1 (3), 463–479.

Genus, A. and Coles, A.-M. (2008) Rethinking the multi-level perspective of technological transitions. *Research Policy* 37 (9), 1436–1445.

George, A.L. and Bennett, A. (2005) *Case studies and Theory Development in the Social Sciences*. Cambridge, MA: MIT Press.

Gerring, J. (2017) *Case study research: principles and practices*. 2nd Edition. Cambridge, United Kingdom: Cambridge University Press.

Giordano, V. and Fulli, G. (2011) A business case for Smart Grid technologies: A systemic perspective. *Energy Policy* .

Glynn, R. (1994) Offering Customers Direct Access: Using Choice to Stimulate Competition. *The Electricity Journal* 7 (7), 52–57.

Goldman, C., Silverstein, A., Reid, M. and Levy, R. (2010) *Coordination of Energy Efficiency and Demand Response*. Lawrence Berkeley National Laboratory.

Goulding, A.J., Rufin, C. and Swinand, G. (1999) The Role of Vibrant Retail Electricity Markets in Assuring that Wholesale Power Markets Operate Effectively. *The Electricity Journal* 12 (10), 61–73.

Granovetter, M. (1985) Economic Action and Social Structure: The Problem of Embeddedness. *American Journal of Sociology* 91 (3), 481–510.

Granovetter, M. and McGuire, P. in M Callon (editor), (1998) The Making of an Industry: Electricity in the United States. *The Laws of the Markets* Oxford: Blackwell. 147–173.

Grant, R.M. (2010) *Contemporary strategy analysis: text and cases*. 7th Edition. Hoboken, N.J: Wiley.

Green, R.J. (2008) Electricity Wholesale Markets: Designs Now and in a Low-carbon Future. *The Energy Journal* 29 (01), 91–124.

Greenberg, J. (1987) A Taxonomy of Organizational Justice Theories. *Academy of Management Review* 12 (1), 9–22.

Grünewald, P.H., Cockerill, T.T., Contestabile, M. and Pearson, P.J.G. (2011) The Socio-technical Transition of Distributed Electricity Storage into Future Networks—System value and Stakeholder Views. *Energy Policy* 50, 449–457.

Hajer, M. in F Fischer & J Forester (editors), (1993) The Case of Acid Rain in Great Britain. *The Argumentative Turn in Policy analysis and Planning* 1st Edition. Durham, NC: Duke University Press. 43–76.

Hajer, M. and Versteeg, W. (2005) A Decade of Discourse Analysis of Environmental Politics: Achievements, Challenges, Perspectives. *Journal of Environmental Policy & Planning* 7 (3), 175–184.

Hajer, M.A. (1995) *The Politics of Environmental Discourse: Ecological modernization and the policy process*. Oxford: Oxford University Press.

Hall, P.A. (1993) Policy Paradigms, Social Learning, and the State: The Case of Economic Policymaking in Britain. *Comparative Politics* 25 (3), 275–296.

Hall, P.A. in MI Lichbach & AS Zuckerman (editors), (1997) The Role of Interests, Institutions, and Ideas in the Comparative Political Economy of Industrialized Nations. *Comparative politics: rationality, culture, and structure* Cambridge, U.K. ; New York, NY, USA: Cambridge University Press. 174–207.

Hall, P.A. and Taylor, R.C.R. (1996) Political Science and the Three New Institutionalisms. *Political Studies* 44, 936–957.

Hall, S. and Foxon, T.J. (2014) Values in the Smart Grid: The co-evolving political economy of smart distribution. *Energy Policy* 74, 600–609.

Hall, S., Foxon, T.J. and Bolton, R. (2016) Financing the civic energy sector: How financial institutions affect ownership models in Germany and the United Kingdom. *Energy Research & Social Science* 12, 5–15.

Hall, S. and Roelich, K. (2016) Business model innovation in electricity supply markets: The role of complex value in the United Kingdom. *Energy Policy* 92, 286–298.

Hannon, M. (2012) *Co-evolution of innovative business models and sustainability transitions: The case of the Energy Service Company (ESCo) model and the UK energy system*. Leeds: University of Leeds.

Hannon, M.J., Foxon, T.J. and Gale, W.F. (2013) The Co-evolutionary Relationship Between Energy Service Companies and the UK Energy System: Implications for a Low-carbon Transition. *Energy Policy* 61, 1031–1045.

Hargreaves, T., Longhurst, N. and Seyfang, G. (2013) Up, Down, round and round: Connecting Regimes and Practices in Innovation for Sustainability. *Environment and Planning A* 45 (2), 402–420.

Hausman, W.J. and Neufeld, J.L. (2011) How politics, economics, and institutions shaped electric utility regulation in the United States: 1879–2009. *Business History* 53 (5), 723–746.

Hay, C. in RE Goodin & C Tilly (editors), (2006) Political Ontology. *The Oxford handbook of contextual political analysis* Oxford : New York: Oxford University Press. 78–95.

Hayek, F.A. von (1978) *New studies in philosophy, politics, economics, and the history of ideas*. London: Routledge.

Healy, P.M. and Palepu, K.G. (2003) The Fall of Enron. *Journal of Economic Perspectives* 17 (2), 3–26.

Helm, D. (2004) *Energy, the state, and the market: British energy policy since 1979*. Rev. ed Edition. Oxford: Oxford University Press.

Hess, D.J. (2014) Sustainability transitions: A political coalition perspective. *Research Policy* 43 (2), 278–283.

Hielscher, S. and Kivimaa, P. (2019) Governance through expectations: Examining the long-term policy relevance of smart meters in the United Kingdom. *Futures* 109, 153–169.

Hledik, R. and Lazar, J. (2016) *Distribution System Pricing with Distributed Energy Resources*. Berkley, California: Ernest Orlando Lawrence Berkeley National Laboratory.

Hodgson, G.M. (2007) Evolutionary and Institutional Economics as the New Mainstream? *Evolutionary and Institutional Economics Review* 4 (1), 7–25.

Hogan, W.W. (1994) Efficient direct access: Comments on the California blue book proposals. *The Electricity Journal* 7 (7), 30–41.

Hortaçsu, A., Madanizadeh, S.A. and Puller, S.L. (2017) Power to Choose? An Analysis of Consumer Inertia in the Residential Electricity Market. *American Economic Journal: Economic Policy* 9 (4), 192–226.

Hughes, T.P. (1983) *Networks of power: electrification in Western society, 1880-1930*. Baltimore: Johns Hopkins University Press.

van Hulst, M. and Yanow, D. (2016) From Policy "Frames" to "Framing": Theorizing a More Dynamic, Political Approach. *The American Review of Public Administration* 46 (1), 92–112.

Hunt, S. and Shuttleworth, G. (1996) *Competition and choice in electricity*. Chichester, U.K. ; New York: John Wiley & Sons.

IRENA (2018) Renewable Power Generation Costs in 2018. International Renewable Energy Agency, Abu Dhabi.

Isser, S. (2015) *Electricity Restructuring in the United States. Markets and Policy from the 1978 Energy Act to the Present*. New York, NY: Cambridge University Press.

Iyengar, S.S. and Lepper, M.R. (2000) When choice is demotivating: Can one desire too much of a good thing? *Journal of Personality and Social Psychology* 79 (6), 995–1006.

Jamasb, T. and Pollitt, M. (2008) Liberalisation and R&D in network industries: The case of the electricity industry. *Research Policy* 37 (6–7), 995–1008.

Johnson, M., Kagerman, H. and Christensen, C. (2008) Reinventing Your Business Model. *Harvard Business Review* 86 (12), 1 - 11.

Johnson, M.W. (2010) *Seizing the white space: business model innovation for growth and renewal*. Boston, Mass: Harvard Business Press.

Joskow, P. (2009) Deregulation. Boston, MA: MIT Available at: https://economics.mit.edu/files/3875.

Joskow, P.L. (2008) Lessons Learned From Electricity Market Liberalization. *The Energy Journal* (Special Issue. The Future of Electricity: Papers in Honor of David Newbury), 9 - 42.

Joskow, P.L. (2000) Revised Discussion Draft: Why do we need Electricity Retailers? Or can you get it cheaper wholesale? .

Joskow, P.L. and Noll, R.G. (1999) The Bell Doctrine: Applications in Telecommunications, Electricity, and Other Network Industries. *Stanford Law Review* 51 (5), 1249.

Joskow, P.L. and Schmalensee, R. (1983) *Markets for power: an analysis of electric utility deregulation*. Cambridge, Massachusetts: MIT Press.

Keay, M., Rhys and Robinson, D. in FP Sioshansi (editor), (2013) Electricity Market Reform in Britain: Central Planning Versus Free Markets. *Evolution of Global Electricity Markets: New Paradigms, New Challenges, New Approaches* Waltham, MA: Elsevier.

Kern, F. (2011) Ideas, Institutions, and Interests: Explaining Policy Divergence in Fostering 'System Innovations' towards Sustainability. *Environment and Planning C: Government and Policy* 29 (6), 1116–1134.

Kern, F., Kuzemko, C. and Mitchell, C. (2014) Measuring and explaining policy paradigm change: the case of UK energy policy. *Policy & Politics* 42 (4), 513–530.

Kiesling, L. (2014) Incumbent Vertical Market Power, Experimentation, and Institutional Design in the Deregulating Electricity Industry. *The Independent Review* 19 (2), 239–264.

Kiesling, L.L. and Kleit, A.N. (editors) (2009) *Electricity restructuring: the Texas story*. Washington, D.C.: AEI Press.

Kim, Y. in FP Sioshansi (editor), (2013) Unfinished Business: The Evolution of US Competitive Retail Electricity Markets. *Evolution of Global Electricity Markets: New Paradigms, New Challenges, New Approaches* Waltham, MA: Elsevier. 331–362.

Kindström, D. and Ottosson, M. (2016) Local and regional energy companies offering energy services: Key activities and implications for the business model. *Applied Energy* 171, 491–500.

Kindström, D., Ottosson, M. and Thollander, P. (2017) Driving forces for and barriers to providing energy services—a study of local and regional energy companies in Sweden. *Energy Efficiency* 10 (1), 21–39.

Kirzner, I.M. (1997) Entrepreneurial Discovery and the Competitive Market Process: An Austrian Approach. *Journal of Economic Literature* 35 (1), 60–85.

Koliou, E., Eid, C., Chaves-Ávila, J.P. and Hakvoort, R.A. (2014) Demand response in liberalized electricity markets: Analysis of aggregated load participation in the German balancing mechanism. *Energy* 71, 245–254.

Kominers, S.D., Teytelboym, A. and Crawford, V.P. (2017) An invitation to market design. *Oxford Review of Economic Policy* 33 (4), 541–571.

Künneke, R.W. (2008) Institutional reform and technological practice: the case of electricity. *Industrial and Corporate Change* 17 (2), 233–265.

Kushler, M. and Molina, M. (2015) Policies Matter: Creating a Foundation for an Energy-Efficient Utility of the Future. An ACEEE White Paper. American Council for an Energy-Efficient Economy.

Kushler, M., York, D. and Witte, P. (2006) *Aligning Utility Interests with Energy Efficiency Objectives: A Review of Recent Efforts at Decoupling and Performance Incentives*.

Kuzemko, C., Lockwood, M., Mitchell, C. and Hoggett, R. (2016) Governing for sustainable energy system change: Politics, contexts and contingency. *Energy Research & Social Science* 12, 96–105.

Lasswell, H.D. (1936) *Politics: who gets what, when, how*. New York: Whittlesey house.

Lazar, J. (2016) *Electricity Regulation in the US: A Guide. Second Edition*. Montpelier, VT: The Regulatory Assistance Project.

Leiva, J., Palacios, A. and Aguado, J.A. (2016) Smart metering trends, implications and necessities: A policy review. *Renewable and Sustainable Energy Reviews* 55, 227–233.

Lesser, J.A. and O'Connor, P.R. (2014) The Electricity Choice Debate: Conjectures and Refutations. *The Electricity Journal* 27 (7), 9–22.

Levin, A. (2015) Customer Incentives and Potential Energy Savings in Retail Electric Markets: A Texas Case Study. *The Electricity Journal* 28 (3), 51–64.

Li, S. (2017) Ethics and market design. *Oxford Review of Economic Policy* 33 (4), 705–720.

Littlechild (2000) *Why we need electricity retailers: a reply to Joskow on wholesale spot pass-through.* https://ideas.repec.org/f/pli522.html Accessed 17 July 2016.

Littlechild, S.C. (2002) Competition in Retail Electricity Supply. *Journal des Economistes et des Etudes Humaines* 12 (2).

Liu, Y. (2017) Demand response and energy efficiency in the capacity resource procurement: Case studies of forward capacity markets in ISO New England, PJM and Great Britain. *Energy Policy* 100, 271–282.

Lockwood, M. (2016) Creating protective space for innovation in electricity distribution networks in Great Britain: The politics of institutional change. *Environmental Innovation and Societal Transitions* 18 (March), 111–127.

Lockwood, M. (2017) The development of the Capacity Market for electricity in Great Britain. IGov, Energy Policy Group, University of Exeter.

Lockwood, M., Kuzemko, C., Mitchell, C. and Hoggett, R. (2017) Historical institutionalism and the politics of sustainable energy transitions: A research agenda. *Environment and Planning C: Politics and Space* 35 (2), 312–333.

Lockwood, M., Mitchell, C., Hoggett, R. and Kuzemko, C. (2017) The governance of industry rules and energy system innovation: The case of codes in Great Britain. *Utilities Policy* 47, 41–49.

Lovell, H., Bulkeley, H. and Owens, S. (2009) Converging agendas? Energy and Climate Change Policies in the UK. *Environment and Planning C: Government and Policy* 27 (1), 90–109.

MacDonald, S. and Eyre, N. (2018) An international review of markets for voluntary green electricity tariffs. *Renewable and Sustainable Energy Reviews* 91, 180–192.

MacGill, I. and Healy, S. in FP Sioshansi (editor), (2013) Is Electricity Industry Reform the Right Answer to the Wrong Question? Lessons from Australian Restructuring and Climate Policy. *Evolution of Global Electricity Markets: New Paradigms, New Challenges, New Approaches* Waltham, MA: Elsevier. 615–644.

Maize, K.P. (1994) Advocates for the Poor Are Sceptical of Retail Wheeling. *The Electricity Journal* 7 (September).

Majone, G. (editor) (1996) *Regulating Europe*. London ; New York: Routledge.

Malerba, F. (2002) Sectoral systems of innovation and production. *Research Policy* 31, 247–264.

Marino, A., Bertoldi, P., Rezessy, S. and Boza-Kiss, B. (2011) A snapshot of the European energy service market in 2010 and policy recommendations to foster a further market development. *Energy Policy* 39 (10), 6190–6198.

Marino, M., Parrotta, P. and Valletta, G. (2019) Electricity (de)regulation and innovation. *Research Policy* 48 (3), 748–758.

Markard, J. and Truffer, B. (2006) Innovation processes in large technical systems: Market liberalization as a driver for radical change? *Research Policy* 35 (5), 609–625.

Marritz, R.O. (1994) ‘Not So Fast,’ Say Mass. and Conn., To Competition Express. *The Electricity Journal* 7 (7), 10–11.

Marsh, D. (2009) Keeping Ideas in their Place: In Praise of Thin Constructivism. *Australian Journal of Political Science* 44 (4), 679–696.

Meletiou, A., Cambini, C. and Masera, M. (2018) Regulatory and ownership determinants of unbundling regime choice for European electricity transmission utilities. *Utilities Policy* 50, 13–25.

Michaels, R.J. (2004) Vertical Integration: The Economics that Electricity Forgot. *The Electricity Journal* 17 (10), 11–23.

Mitchell, C. (2008) *The Political Economy of Sustainable Energy*. Basingstoke: Palgrave Macmillan.

Mitchell, C., Bauknecht, D. and Connor, P.M. (2006) Effectiveness through risk reduction: a comparison of the renewable obligation in England and Wales and the feed-in system in Germany. *Energy Policy* 34 (3), 297–305.

Moran, A. and Sood, R. in FP Sioshansi (editor), (2013) Evolution of Australia’s National Electricity Market. *Evolution of Global Electricity Markets: New Paradigms, New Challenges, New Approaches* Waltham, MA: Elsevier. 571–614.

Morey, M.J. and Kirsch, L.D. (2016) *Retail Choice in Electricity: What have we learned so far? Prepared for Electric Markets Research Foundation by Christensen Associates Energy Consulting*. Madison, WI.

Mouffe, C. (2005) *On the political*. London ; New York: Routledge.

Muniesa, F., Millo, Y. and Callon, M. (2007) An Introduction to Market Devices. *The Sociological Review* 55 (2), 1–12.

Myers, W.A. (1997) *Affairs of Power: Restructuring California’s Electric Utility Industry, 1968-1998*. Riverside, CA: University of California, Riverside.

Nadel, S., Rosenow, J., Cowart, R. and Crossley, D. (2017) Energy saving obligations across three continents: contrasting approaches and results. *ECEEE 2017 Summer Study - Consumption, Efficiency and Limits* Hyeres, France: ECEEE. 295–308.

Nelson, R. and Winter, S. (1977) A Useful Theory of Innovation. *Research Policy* 6 (1), 36–76.

Newbery, D.M. and Pollitt, M.G. (1997) The Restructuring and Privatisation of Britain’s CEGB-Was It Worth It? *The Journal of Industrial Economics* 45 (3), 269–303.

Newbery, D.M.G. (2000) *Privatization, restructuring, and regulation of network utilities*. Cambridge, Mass: MIT Press.

Niskanen, W.A. (1975) Bureaucrats and Politicians. *Journal of Law and Economics* 18 (3), 617–643.

North, D.C. (1990) *Institutions, institutional change, and economic performance*. Cambridge ; New York: Cambridge University Press.

Nozick, R. (1974) *Anarchy, state, and utopia*. New York, NY: Basic Books.

Nykvist, B. and Nilsson, M. (2015) Rapidly falling costs of battery packs for electric vehicles. *Nature Climate Change* 5 (4), 329–332.

Oppel, R.A. and Van Natta, D. (2002) Enron's Collapse: the relationships. Bush and Democrats Disputing Ties to Enron. The New York Times.

Orrel, A., Homer, J., Bender, S. and Weimar, M. (2016) *Energy Policy Case Study – Texas: Wind, Markets, and Grid Modernization*. Technical Report Oak Ridge, TN: Pacific North West National Laboratory.

Osterwalder, A., Pigneur, Y. and Tucci, C.L. (2005) Clarifying Business Models: Origins, Present, and Future of the Concept. *Communications of the Association for Information Systems* 16, 1–25.

Ostrom, E. in PA Sabatier (editor), (2007) Institutional Rational Choice: An Assessment of the Institutional Analysis and Development Framework. *Theories of the Policy Process* 2nd Edition. Boulder, Colorado: Westview Press. 21–64.

Parker, D. (2009) *The official history of privatisation*. Abingdon, Oxon; N.Y., NY: Routledge.

Patterson, W.C. (1999) *Transforming electricity: the coming generation of change*. London: Earthscan.

Prosser, T. (2005) *The limits of competition law: markets and public services*. Oxford; New York: Oxford University Press.

Rai, V. and Zarnikau, J. in FP Sioshansi (editor), (2016) Retail Competition, Advanced Metering Investments, and Product Differentiation: Evidence From Texas. *Future of Utilities Utilities of the Future* How Technological Innovations in Distributed Energy Resources Will Reshape the Electric Power Sector: Elsevier. 153–173.

Rein, M. and Schön, D.A. (1994) *Frame reflection: toward the resolution of intractable policy controversies*. New York: Basic Books.

Rein, M. and Schön, D.A. in P Wagner, H Weiss, B Wittrock & H Wollmann (editors), (1991) Frame-reflective Policy Discourse. *Social Sciences and Modern States. National experiences and theoretical crossroads* Cambridge: Cambridge University Press. 261–289.

Richardson, A.J. (2009) The Production of Institutional Behaviour: A Constructive Comment on the Use of Institutionalization Theory in Organizational

Analysis. *Canadian Journal of Administrative Sciences / Revue Canadienne des Sciences de l'Administration* 3 (2), 304–316.

Ritala, P. and Hurmelinna-Laukkanen, P. (2013) Incremental and Radical Innovation in Coopetition-The Role of Absorptive Capacity and Appropriability: Incremental and Radical Innovation in Coopetition. *Journal of Product Innovation Management* 30 (1), 154–169.

Rochlin, C. (2016) Distributed renewable resources and the utility business model. *The Electricity Journal* 29 (1), 7–12.

Roe, E. (1994) *Narrative policy analysis: theory and practice*. Durham: Duke University Press.

Rosenbloom, D., Berton, H. and Meadowcroft, J. (2016) Framing the sun: A discursive approach to understanding multi-dimensional interactions within socio-technical transitions through the case of solar electricity in Ontario, Canada. *Research Policy* 45 (6), 1275–1290.

Rosenow, J. (2012) Energy savings obligations in the UK—A history of change. *Energy Policy* 49, 373–382.

Rosenow, J., Fawcett, T., Eyre, N. and Oikonomou, V. (2016) Energy efficiency and the policy mix. *Building Research & Information* 44 (5–6), 562–574.

Rudolph, R. and Ridley, S. (1986) *Power struggle: the hundred-year war over electricity*. 1st ed Edition. New York: Harper & Row.

Russel, S. (1993) Writing energy history: explaining the neglect of CHP/DH in Britain. *British Journal of the History of Science* 26, 33–54.

Ruz, F.C. and Pollitt, M.G. (2016) Overcoming Barriers to Electrical Energy Storage: Comparing California and Europe. *Competition and Regulation in Network Industries* 17 (2), 123–149.

Samuelson, P.A. (1954) The Pure Theory of Public Expenditure. *The Review of Economics and Statistics* 36 (4), 387–389.

Satchwell, A., Cappers, P. and Goldman, C. (2011) Carrots and sticks: A comprehensive business model for the successful achievement of energy efficiency resource standards. *Utilities Policy* 19 (4), 218–225.

Schaltegger, S., Lüdeke-Freund, F. and Hansen, E.G. (2016) Business Models for Sustainability: A Co-Evolutionary Analysis of Sustainable Entrepreneurship, Innovation, and Transformation. *Organization & Environment* 29 (3), 264–289.

Schmidt, V.A. (2008) Discursive Institutionalism: The Explanatory Power of Ideas and Discourse. *Annual Review of Political Science* 11 (1), 303–326.

Schmidt, V.A. (2011) Speaking of Change: Why Discourse is Key to the Dynamics of Policy Transformation. *Critical Policy Studies* 5 (2), 106–126.

Schmidt, V.A. (2010) Taking Ideas and Discourse Seriously: Explaining Change through Discursive Institutionalism as the Fourth 'New Institutionalism'. *European Political Science Review* 2 (01), 1.

Schmidt, V.A. and Radaelli, C.M. (2004) Policy Change and Discourse in Europe: Conceptual and Methodological Issues. *West European Politics* 27 (2), 183–210.

Schmitt, C. (2002) *Der Begriff des Politischen: Text von 1932 mit einem Vorwort und drei Corollarien*. Berlin: Duncker und Humblot.

Schot, J. and Geels, F.W. in J Grin, J Rotmans & D Loorbach (editors), (2011) Reflections: Process Theory, Causality and Narrative Explanation. *Transitions to sustainable development: new directions in the study of long term transformative change* First issued in paperback Edition. New York London: Routledge. 93–104.

Schumpeter, J. (1942) *Capitalism, Socialism and Democracy.* New York: Harper & Brothers.

Shove, E. and Walker, G. (2010) Governing transitions in the sustainability of everyday life. *Research Policy* 39, 471–476.

Sioshansi, F.P. (editor) (2013) *Evolution of Global Electricity Markets: New Paradigms, New Challenges, New Approaches*. Waltham, MA: Elsevier.

Smith, A. and Raven, R. (2012) What is protective space? Reconsidering niches in transitions to sustainability. *Research Policy* 41 (6), 1025–1036.

Smith, A., Stirling, A. and Berkhout, F. (2005) The governance of sustainable socio-technical transitions. *Research Policy* 34 (10), 1491–1510.

Smith, A., Voss, J.-P. and Grin, J. (2010) Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research Policy* 39 (4), 435–448.

Sorrell, S. (2018) Explaining sociotechnical transitions: A critical realist perspective. *Research Policy* 47 (7), 1267–1282.

Sorrell, S. (2005) *The contribution of energy service contracting to a low carbon economy*. Tyndall Centre Technical Report No. 37.

Sorrell, S. (2007) The economics of energy service contracts. *Energy Policy* 35 (1), 507–521.

Stirling, A. (2011) Pluralising progress: From integrative transitions to transformative diversity. *Environmental Innovation and Societal Transitions* 1 (1), 82–88.

Strbac, G. (2008) Demand side management: Benefits and challenges. *Energy Policy* 36 (12), 4419–4426.

Strupeit, L. and Palm, A. (2016) Overcoming Barriers to Renewable Energy Diffusion: Business models for Customer-sited Solar Photovoltaics in Japan,

Germany and the United States. *Journal of Cleaner Production* 123, 124–136.

Sweeney, J.L. (2002) *The California electricity crisis*. Stanford, California: Hoover Institution Press ; Stanford Institute for Economic Policy Research.

Swinson, V., Hamer, J. and Humphries, S. (2015) Taking demand management into the future: Managing flexible loads on the electricity network using smart appliances and controlled loads. *Economic Analysis and Policy* 48, 192–203.

Tansey, O. (2007) Process Tracing and Elite Interviewing: A Case for Non-probability Sampling. *Political Science and Politics* 40 (4), 765–772.

Thelen, K. (1999) Historical Institutionalism in Comparative Politics. *Annual Review of Political Science* (2), 369–404.

Thomas, S. (2006) The British Model in Britain: Failing slowly. *Energy Policy* 34 (5), 583–600.

Tirole, J. and Rey, P. (1986) The Logic of Vertical Restraints. *The American Economic Review* 76 (5), 921–939.

Treadway, N. (2015) *Annual Baseline Assessment of Choice in Canada and the United States 2015*. Distributed Energy Financial Group LLC.

Tsai, C.-H. and Tsai, Y.-L. (2018) Competitive retail electricity market under continuous price regulation. *Energy Policy* 114, 274–287.

Unruh, G.C. (2002) Escaping carbon lock-in. *Energy Policy* 30 (4), 317–325.

Unruh, G.C. (2000) Understanding carbon lock-in. *Energy Policy* 28 (12), 817–830.

Utterback, J.M. (1994) Invasion of a Stable Business by Radical Innovation. *Mastering the Dynamics of Innovation* Harvard Business Review Press.

Vallés, M., Reneses, J., Cossent, R. and Frías, P. (2016) Regulatory and market barriers to the realization of demand response in electricity distribution networks: A European perspective. *Electric Power Systems Research* 140, 689–698.

Van der Vleuten, E. and Raven, R. (2006) Lock-in and change: Distributed generation in Denmark in a long-term perspective. *Energy Policy* 34 (18), 3739–3748.

Verbong, G. and Geels, F. (2007) The ongoing energy transition: Lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004). *Energy Policy* 35 (2), 1025–1037.

Vine, E. (2005) An international survey of the energy service company (ESCO) industry. *Energy Policy* 33 (5), 691–704.

Vine, E., Hamrin, J., Eyre, N., Crossley, D., Maloney, M. and Watt, G. (2003) Public policy analysis of energy efficiency and load management in changing electricity businesses. *Energy Policy* 31 (5), 405–430.

VKU and Zuber, F. (2018) *Vom Mieterstrom zur Quartiersversorgung*. https://www.vku.de/publikationen/2018/neue-broschuere-vom-mieterstrom-zur-quartiersversorgung-erschienen/ Accessed 15 December 2018.

Volberda, H.W. and Lewin, A.Y. (2003) Co-evolutionary Dynamics Within and Between Firms: From Evolution to Co-evolution. *Journal of Management Studies* 40 (8), 2111–2136.

Voss, J.-P. (2007) *Designs on Governance: Development of policy instruments and dynamics in governance*. Berlin: University of Twente.

Vulkan, N., Roth, A.E. and Neeman, Z. (editors) (2013) *The Handbook of Market Design*. Oxford University Press.

Waddams Price, C. and Zhu, M. (2016) Non-discrimination Clauses: Their Effect on British Retail Energy Prices. *The Energy Journal* 37 (2), 111–132.

Wainstein, M.E. and Bumpus, A.G. (2016) Business Models as Drivers of the Low Carbon Power System Transition: a Multi-Level Perspective. *Journal of Cleaner Production* 126, 572–585.

Walton, R. (2016) What the Supreme Court decision on FERC Order 745 means for demand response and DERs. *UtilityDive* 3 February.

Watson, J. (2004a) Co-provision in sustainable energy systems: the case of micro-generation. *Energy Policy* 32 (17), 1981–1990.

Watson, J. (2004b) Selection environments, flexibility and the success of the gas turbine. *Research Policy* 33 (8), 1065–1080.

Williamson, O.E. (1981) The Economics of Organization: The Transaction Cost Approach. *The American Journal of Sociology* 87 (3), 548–577.

Williamson, O.E. (1979) Transaction-Cost Economics: The Governance of Contractual Relations. *Journal of Law and Economics* 22 (2), 233–261.

Wiser, R., Barbose, G. and Holt, E. (2011) Supporting solar power in renewables portfolio standards: Experience from the United States. *Energy Policy* 39 (7), 3894–3905.

Yakubovich, V., Granovetter, M. and Mcguire, P. (2005) Electric charges: The social construction of rate systems. *Theory and Society* 34 (5–6), 579–612.

Yin, R.K. (2009) *Case study research: Design and Methods*. 4th Edition. Los Angeles: Sage Publications.

Zott, C. and Amit, R. (2010) Business Model Design: An Activity System Perspective. *Long Range Planning* 43 (2–3), 216–226.

Zucker, L.G. (1977) The Role of Institutionalization in Cultural Persistence. *American Sociological Review* 42 (5), 726–743.

Appendix 1

List of primary documents

Code	Stakeholders cited	State	Date	Source
Doc-1	CPUC	CA	1993	*The Yellow Book*, California Public Utilities Commission, Division of Strategic Planning.
	California Large Energy Consumers Association (CLECA)			
	California Energy Commission (CEC) official			
Doc-2	Share, Byron. Chairman of Natural Resources Committee, California Assembly	CA	May 23, 1994	Joint hearing of Utilities Committee and Natural Resources Committee, State of California Assembly, Sacramento.
	Sheeren. Californians for Competitive Electricity			
	Imbrecht, Charles. CEC			
	Smutney-Jones, Jan. Independent Energy Producers			
	Sheingold, Barry. Citizens Light and Power (broker/ marketer)			
	Smith, D.J. Californians for Competitive Electricity (business consumers)			
	Sheingold, Ralph, Natural Resources Defence Council			
	Carter, Art.			
	California Utility Employees			

	Cohen, Armond. Conservation Law Foundation			
	Grueneich, Dian, Grueneich Resource Advocates			
	Jordan, Jerry. California Municipal Utilities Association			
	Cavanagh, Ralph. Natural Resources Defence Council			
Doc-3	Florio, Mike, attorney, Toward Utility Rate Normalization (TURN)	CA	May 16, 1994	Vargas, Dale. May 16, 1994. *Public Utilities Plan for Competitive Future*. 'METRO', San Francisco
	Fessler, Daniel, PUC president.			
Doc-4	International Paper Company (IPC)	MA	May 25, 1995	DPU proceeding 95-30, Massachusetts Department of Utilities Archives *Reply Comments on Electric Industry Restructuring by International Paper Company*
Doc-5	Dzykewicz, Andrew, New England Cogeneration Association	MA	1996	DPU proceeding 96-100, Massachusetts Department of Utilities Archives *Comments by New England Cogeneration Association*
Doc-7	Kahn, Alfred	MA	1995	DPU 95-30 Massachusetts Department of Utilities Archives *Comments of Alfred E. Kahn on Competition in Electric Power*, on behalf of Massachusetts Electric
Doc-8	Kahn, Alfred E.; Baumol, William, J.; Joskow, Paul L.	MA	1994	DPU 95-30 Appendix to Comments by Alfred Kahn to DPU. *The Challenges for federal and state regulators: Transition from regulation to efficient competition in*

				electric power, funded by Edison Electric Institute William J. Baumol, Paul L. Joskow, and Alfred E. Kahn December 9, 1994, Appendix A to Initial Comments of Edison Electric Institute, Federal Energy Regulatory Commission, Docket No. RM94-7-000
Doc-9	WMECO, Western Massachusetts Electric Company Jaffe, Adam B. Kalt, Joseph P.	MA	March 30, 1995	D.P.U. 95-30: *Initial comments on MA DPU inquiry into electric industry restructuring.* Appendix A: *Economic analysis of electric industry restructuring in New England*. Prepared on behalf of WMECO by Adam B. Jaffe, Brandeis University and The Economics Resource Group, Inc .; Joseph P. Kalt, Harvard University and The Economics Resource Group, Inc.
Doc-10	Enron	MA	March 31, 1995	DPU 95-30 *Unbundling the US Electric Power Industry: A Blueprint for Change.* Fernando, Chitru; Kleindorfer, Paul; Tabors, Richard D.; Pickel, Fred; Robinson, Sandra J. Funded by Enron Capital and Trade Resources, Houston Texas
Doc-11	Montigny, Mark. MA State Senator	MA	1996	Testimony to MA Department of Public Utilities
Doc-12	Arny, Michael, Director Consortium for Integrated Resource Planning, University of Wisconsin.	MA	1994	DPU 95-30: Attachment A to evidence submitted by Wheeled Electric Power Co. (WEPCO)
Doc-13	Brockway, Nancy; National Consumer Law Centre	MA	July 19, 1995	DPU 95-30: Testimony to Commonwealth of Massachusetts, Department of Public Utilities, Vol 14, 9 - 175/ 7268. Public hearing held

				at the Leverett Saltonstall Building, 100 Cambridge Street, Boston, Massachusetts
Doc-14	Smith, Tom; Director, Public Citizen Texas	TX	2017	DirectEnergy; Widespread Creative; Zpryme, Energy Thought Summit (ETS): *Choice to choose: The Journey to a Competitive Electricity Market in Texas*. Published on Youtube on April 20, 2017. https://www.youtube.com/watch?v=lS42dELXyXA. Producers: Mark Ishac and Jason S.Rodriguez. Accessed on June 15, 2017
	Wood, Patrick III, former PUCT Chairman	TX	2017	
	Klein, Becky, PUCT chairman 2001-2004	TX	2017	
Doc-15	Joskow, Paul	US	2002	Wayne, Lesley. (2002) Enron's many strands: the politics. Enron, preaching deregulation, worked the statehouse circuit. *The New York Times*. 2 February 2002, Business section. https://www.nytimes.com/2002/02/09/business/enron-s-many-strands-politics-enron-preaching-deregulation-worked-statehouse.html https://www.nytimes.com/2002/05/08/business/enron-s-many-strands-strategies-enron-got-california-buy-power-it-didn-t-need.html?mtrref=www.google.com&gwh=414B799760A67E33C43A3E1869AC2F24&gwt=pay
	Skilling, Jeffrey			
Doc-16	MRW Associates	MA	1995	D.P.U. 95-30: *Comments on MA DPU electric industry restructuring*
Doc-17a	UtilityDive Boler, B.	US	2016	*Tesla-SolarCity merger: A utility's worst nightmare or sweetest dream?* Available from: https://www.utilitydive.com/spons/tesla-solarcity-merger-a-utilitys-worst-nightmare-or-sweetest-dream/429222/ (Accessed 25 July 2017).
Doc-17b	Greentechmedia, Litvak, N.	US	2017	*Residential Solar Installers Can't—And Shouldn't—Scale Nationally*.

				Available from: https://www.greentechmedia.com/articles/read/residential-solar-installers-cant-and-shouldnt-scale-nationally
Doc-18	Beasley, Andrew. Managing Director, Flow Energy. Interview with Utility Week, Vallely, Lois	GB	April 22, 2018	*Some of the social costs we're seeing are causing a significant break to growth. It is a huge overhead.* https://utilityweek.co.uk/andrew-beasley-managing-director-flow-energy/ (Accessed 05 May 2018)-
Doc-19	Elexon	GB	2019	*About TERRE and wider access*. Available from: https://www.elexon.co.uk/about/trading-electricty-market/terre-wider-access/ (Accessed 20 May 2019).
Doc-20	St. John, J.	CA	2017	*As California Prepares for Wholesale Distributed Energy Aggregation, New Players Seek Approval* Available from: https://www.greentechmedia.com/articles/read/california-companies-are-vying-for-aggregated-distributed-energy#gs.wralgw (Accessed 16 June 2017).
Doc-21	Ofgem	GB	2018	*Consultation - Supplier Licensing Review*. Available from: https://www.ofgem.gov.uk/system/files/docs/2018/11/supplier_licensing_review_0.pdf (Accessed 3 January 2019).
Doc-22	Ofgem	GB	2018	*Energy Codes Review: Terms of Reference*. Available from: https://www.ofgem.gov.uk/system/files/docs/2018/12/tor_revised_final_301118.pdf (Accessed 22 May 2019).
Doc-23	Ofgem	GB	2013	*Wholesale power market liquidity: final proposals for a 'Secure and Promote' licence condition*. Available from: https://www.ofgem.gov.uk/publications-and-updates/wholesale-power-market-liquidity-final-proposals-secure-and-

				promote-licence-condition (Accessed 3 March 2017).
Doc-24	Competition & Markets Authority (CMA)	GB	2016	*Energy market investigation. Final Report*. Available from: https://www.gov.uk/cma-cases/energy-market-investigation#final-report. (Accessed 12 December 2016).
Doc-25	Thies, Frauke Euractiv	EU	2017	*EU push for electricity 'aggregators' risks distorting market, warns study*. Available from: http://www.euractiv.com/section/electricity/news/commission-push-for-electricity-aggregators-risks-distorting-market-warns-study/.
Doc-26	Hawiger, Marcel. Attorney for the Utility Reform Network (TURN) Weisenmiller, Robert B., Commissioner, CEC Picker, Michael J., President CPUC Tierney, Sue, Analysis Group Strela Cervas, California Environmental Justice Alliance Anne Hoskins, Chief Policy Officer, SunRun	CA	5 May, 2017	Transcript of *Joint En Banc on Changing Nature of Consumer and Retail Choice in California*, California Energy Commission
Doc-27	PA Consulting	GB	2016	*Aggregators - Barriers and External Impacts*. Available from: https://www.ofgem.gov.uk/system/files/docs/2016/07/aggregators_barriers_and_external_impacts_a_report_by_pa_consulting_0.pdf.
Doc-28	Walton, R. UtilityDive	US	2016	What the Supreme Court decision on FERC Order 745 means for demand response and DERs. *UtilityDive*. 03

				February. Available from: https://www.utilitydive.com/news/what-the-supreme-court-decision-on-ferc-order-745-means-for-demand-response/413092/. (Accessed 20 September 2017).
Doc-29	Trabish, H. K. UtilityDive Johnson, Solar Energy Industries Association	CA	2015	*Inside California's rate restructuring plan and the battle for fixed charges looming over it*. Available from: https://www.utilitydive.com/news/inside-californias-rate-restructuring-plan-and-the-battle-for-fixed-charge/402117/ (Accessed 20 September 2017).
Doc-30	UtilityDive	US	2017	*UtilityDive 2017 State of the Electric Utility Survey Report*. Available from: https://www.utilitydive.com/library/2017-state-of-the-electric-utility-survey-report/ (Accessed 18 May 2018).
Doc-31	St John, J. Greentechmedia		2016	*In Texas, MP2 Energy Sees the 'Shape' of Rooftop Solar as Value to Substitute for Net Metering*. Available from: https://www.greentechmedia.com/articles/read/in-texas-mp2-energy-sees-the-shape-of-rooftop-solar-as-value-to-substitute-#gs.H9aNVSg (Accessed 24 October 2017).
Doc-32	St. John, J. Greentechmedia	CA	2016	*SoCal Edison's Grid Edge Experiment Contracts for 125MW of Batteries and Demand Response* September 13. Available from: https://www.greentechmedia.com/articles/read/socal-edisons-grid-edge-experiment-contracts-for-125mw-of-batteries-and-dem
Doc-33	SFV	DE	2009	*Verzögerung beim Anschluss einer PV-Anlage*. Available from: http://www.sfv.de/artikel/verzoegerung_beim_anschluss_einer_pv-anlage.htm (Accessed 14 May 2017).

Doc-34	Open EI	US		The Green Button Initiative https://openei.org/wiki/Green_Button
Doc-35	St John, J. Greentechmedia Hanley, Solar City	CA	2015	California's Distributed Energy Challenge: Sharing the Data. *Greentech Media*. 18 May 2015. Available from: https://www.greentechmedia.com/articles/featured/Californias-Distributed-Energy-Challenge-Sharing-the-Data#gs.ya6gk0 (Accessed 12 June 2017).
Doc-36	Centrica		2018	*What we do: our strategy. Centrica plc is an international energy and services company*. Available from: https://www.centrica.com/about-us/what-we-do/our-strategy (Accessed 3 October 2018).
Doc-37	E.ON		2018	*Interim Report II/2018*. Available from: https://www.eon.com/en/investor-relations.html.
Doc-38	SmartEnergy International Gaudette, Robert, President of NRG Business Solutions	US	2017	*US utility expands DER services for industrial customers* December 15 Available from: https://www.smart-energy.com/regional-news/north-america/industrial-consumers-nrg-energy/
Doc-39	Prabhu, A. UtilityDive	US	2019	*As renewables and DER expand, can IPPs be investment grade?* UtilityDive Opinion. Available from: https://www.utilitydive.com/news/the-cold-truth-todays-market-conditions-are-hurting-independent-power-pro/564592/
Doc-40	Coyne, B Energyst	GB	2016	*Centrica buys ENER-G's CHP business in bid to scale distributed energy operation* May 18. Available from: https://theenergyst.com/centrica-buys-ener-gs-chp-business-in-bid-to-scale-distributed-energy-operation/

Doc-41	Wesoff, E. Greentechmedia	DE	2015	*Sungevity Partners With E.ON in Germany to Scale Residential Solar* May 12, 2015 Available from: https://www.greentechmedia.com/articles/read/sungevity-partners-with-e-on-in-germany-to-scale-residential-solar
Doc-42	Spaven E UKTN	UK	2017	*Howz named winner of EDF Energy 2016 Blue Lab accelerator* 17 February. Available from: https://www.uktech.news/news/howz-named-winner-edf-energy-2016-blue-lab-accelerator-20170217
Doc-43	Carey, B. The Sunday Times	EU	2015	*Glen Dimplex out to shock giants. Appliances group aims to shake electricity industry with smart heaters* January 18. Available from: https://www.thetimes.co.uk/article/glen-dimplex-out-to-shock-giants-xf2ddvk0glt
Doc-44	Next Kraftwerke	GB	2018	*Ecotricity selects Next Kraftwerke's NEMOCS to build Virtual Power Plant.* Available from: https://www.next-kraftwerke.com/news/ecotricity-selects-next-kraftwerkes-nemocs-to-build-virtual-power-plant
Doc-45	New York Times (NYT) Lay, Kenneth	US	2002	Oppel, R. A. & Van Natta, D. (2002) *Enron's Collapse: the relationships. Bush and Democrats Disputing Ties to Enron.* Available from: https://www.nytimes.com/2002/01/12/business/enron-s-collapse-the-relationships-bush-and-democrats-disputing-ties-to-enron.html (Accessed 17 December 2017)
Doc-46	Willuhn, M. Centrica	GB	2018	*Centrica starts installation of Cornwall Local Energy Market.* 24 September. Available from:

				https://www.pv-magazine.com/2018/09/24/centrica-starts-installation-of-cornwall-local-energy-market/
Doc-47	St John, J. Greentechmedia MP2	TX	2016	*In Texas, MP2 Energy Sees the 'Shape' of Rooftop Solar as Value to Substitute for Net Metering*. 22 July. Available from: https://www.greentechmedia.com/articles/read/in-texas-mp2-energy-sees-the-shape-of-rooftop-solar-as-value-to-substitute-#gs.H9aNVSg
Doc-48	Verband Kommunaler Unternehmen. (VKU) Zuber, F.	DE	2018	*Vom Mieterstrom zur Quartiersversorgung* Available from: https://www.vku.de/publikationen/2018/neue-broschuere-vom-mieterstrom-zur-quartiersversorgung-erschienen/ (Accessed 15 December 2018).
Doc-49	BBC	GB	2019	*Utilitywise goes into administration*. 13 February. Available from: https://www.bbc.co.uk/news/business-47225792
Doc-50	Businesswire Crane, David, CEO NRG	US	2013	*NRG Expands Nest Thermostat Partnership Through Its Retail Companies Reliant and Green Mountain Energy* 22 April. Available from: https://www.businesswire.com/news/home/20130422006833/en/NRG-Expands-Nest-Thermostat-Partnership-Retail-Companies
Doc-51	Lacey, S. Greentechmedia	US	2017	*NRG Fully Exits the Home Solar Installation Business*. February 15. Available from https://www.greentechmedia.com/articles/read/nrg-sheds-the-final-remnants-of-its-home-solar-business#gs.u6y4rw
Doc-52	Crane, D. Greenbiz	US	2017	*Inside the rise and fall of NRG's green strategy*. Available from: https://www.greenbiz.com/arti

				cle/inside-rise-and-fall-nrgs-green-strategy (Accessed 17 August 2017).
Doc-53	Schröder, Phillip, Geschäftsführer Vertrieb und Marketing von Sonnen pvmagazine	DE	2016	*Wie die Sonnencommunity im Detail funktioniert und Batteriespeicher nutzt*. Available from: https://www.pv-magazine.de/2016/06/09/fragen-und-antworten-zur-sonnen-community/ (Accessed 4 April 2018).
Doc-54	Energex	AUS, QUE		*Positive Payback for households. How to claim your reward.* Available online: https://www.energex.com.au/home/control-your-energy/positive-payback-program/positive-payback-for-households
Doc-55	Trabish, H. Greentechmedia	CA	2012	*Research Spotlight:* *How Electricity Gets Bought and Sold in California* *And how do wind and solar power fit in?* March 29 Available from: https://www.greentechmedia.com/articles/read/how-electricity-gets-bought-and-sold-in-california
Doc-56	Sierra Club Vespa, M.	CA	2014	*A Mixed Bag: Southern California Edison's Proposed Replacement for San Onofre Nuclear Plant*. Available from: https://www.sierraclub.org/planet/2014/11/mixed-bag-southern-california-edisons-proposed-replacement-san-onofre-nuclear-plant (Accessed 6 June 2018).
Doc-57	St John, J. CPUC	CA	2016	*Sweeping Changes Proposed for Demand Response in California*. September 7. Available from: https://www.greentechmedia.com/articles/read/big-changes-proposed-for-demand-response-in-

				california#gs.jDwCU9w (Accessed 6 January 2017).
Doc-58	Lacey S. Greentechmedia	DE	2014	*This Is What the Utility Death Spiral Looks Like* *In Germany, utility revenues are spiraling down the rabbit hole. Will American power companies follow?* 4 March. Available from: https://www.greentechmedia.com/articles/read/this-is-what-the-utility-death-spiral-looks-like
Doc-59	American Public Power Association (APPA)	US	n. a.	Community Engagement. Available from: https://www.publicpower.org/
Doc-60	ACEEE	US	n. a.	*State Policy Toolkit: On-bill financing.* Available from: https://aceee.org/sector/state-policy/toolkit/on-bill-financing
Doc-61	Retail Energy Supply Association (RESA)	US	2010	Investigation by the Department of Public Utilities regarding Purchase of Receivables pursuant to G.L.c. 164, 76 D.P.U. 10-53 *Comments of the Retail Energy Supply Association* on June 7, 2010, proposed model terms and conditions https://www.resausa.org/sites/default/files/documents/filings/MA/10-53_RESA_Comments_001.pdf
Doc-62	Hunt, T. Greentechmedia	CA	2014	*PG&E and Politicians Looking to Gut Utility Competition Law*. June 09, 2014 Available from: https://www.greentechmedia.com/articles/read/utilities-and-politicians-looking-to-gut-community-solar-aggregation#gs.40v455
Doc-63	Rivard, R. Voice of San Diego	CA	2018	*SDG&E Is Looking to Leave the Power-Buying Business* November 19, 2018. Available from: https://www.voiceofsandiego.org/topics/government/sdgee-

				is-looking-to-leave-the-power-buying-business/
Doc-64	DCCEE and Equipment Energy Efficiency (E3) Program: Department of Climate Change and Energy Efficiency, Australia	AUS	2011	Market Review Submission EPR0022 - Department of Climate Change and Energy Efficiency - 110826 *Information for the Australian Energy Market Commission in response to the Issues Paper: Power of choice – giving consumers options in the way they use electricity* Appliance Energy Efficiency Branch https://www.aemc.gov.au/sites/default/files/content/e8022d79-2a59-495e-8466-3bde1e386f5c/Department-of-Climate-Change-and-Energy-Efficiency.pdf
Doc-65	Ofgem	GB	2017	*Local Energy in a Transforming Energy System*. Available from: https://www.ofgem.gov.uk/system/files/docs/2017/01/ofgem_future_insights_series_3_local_energy_final_300117.pdf. https://www.ofgem.gov.uk/ofgem-publications/39016/14317-duty-suppy.pdf (Accessed 15 September 2017)
Doc-66	State of New York Public Service Commission (NYPSC)	NY	2018	Initial Post-hearing brief of the utility intervention unit and New York Attorney General's office (UIU/NYAG) *In the Matter of Eligibility Criteria for Energy Service Companies. Proceeding on Motion of the Commission to Assess Certain Aspects of the Residential and Small Non-residential Retail Energy Markets in New York State.* *In the Matter of Retail Access Business Rules* Case 15-M-0127; Case 12-M-0476; Case 98-M-1343 Dated: March 30, 2018 http://documents.dps.ny.gov/public/Common/ViewDoc.aspx

				?DocRefId=%7BE17801DE-1CDE-479D-B7A6-2287B5C47F78%7D
Doc-67	US Energy Information Administration (EIA)	US	1998	EIA (1998) *Table 53. Estimated U.S. Electric Utility Average Revenue per Kilowatthour to Ultimate Consumers by Sector, Census Division, and State, October 1997 and 1996. Electric Power Monthly January 1998*. [online]. Available from: https://www.eia.gov/electricity/monthly/archive/pdf/02269801.pdf (Accessed 21 February 2016).
Doc-68	Australian Government, Department for Environment and Energy	AUS	n. a.	*Energy Information for all Australians. Solar PV and batteries* https://www.energy.gov.au/households/solar-pv-and-batteries
Doc-69	Ofgem	GB	2017	*Future supply market arrangements – call for evidence* https://www.ofgem.gov.uk/system/files/docs/2017/11/future_supply_market_arrangements_-_call_for_evidence.pdf
Doc-70	Clark, T.	US	2017	*Regulation and Markets: Ideas for Solving the Identity Crisis*. http://wbklaw.com/uploads/file/Articles-%20News/2017%20articles%20publications/Market%20Identity%20Crisis%20Final%20(7-14-17).pdf (Accessed 8 May 2018)
Doc-71	St John, J. Greentechmedia	CA	2018	*How a New California Law Will Expand the State's Competitive Energy Market*. https://www.greentechmedia.com/articles/read/california-law-will-expand-direct-access-market#gs.7vil00.
Doc-72	National Grid	GB	n. a.	*Power Responsive Project* http://powerresponsive.com/ (Accessed 15 March 2018)
Doc-73	California State Assembly	CA	1996	The Electric Utility Industry Restructuring Act, AB1890

Doc-74	Senate and House of Representatives, Commonwealth of Massachusetts	MA	1997	Chapter 64. An Act relative to Restructuring the electric utility industry in the Commonwealth, regulating the provision of electricity and other services, and promoting enhanced consumer protection therein
Doc-75	Schwarz, V. Euractiv	FR	2018	Why France believes capacity mechanisms are necessary. *Euractiv*. 14 September 2018. https://www.euractiv.com/section/electricity/opinion/why-france-believes-capacity-mechanisms-are-necessary/ (Accessed 25 May 2019).
Doc-76	David Clark Company Incorporated	MA	1996	D.P.U. 96-100: *Letter to Mary L. Cottrell.* April 9, 1996
Doc-77	Mullen, T. New York Times	US	1990	Unseating the Electrical Utilities' Monopoly. *New York Times* 11 March, New York.
Doc-78	Spector, J. Greentechmedia	MA	2017	The Long-Awaited Massachusetts Energy Storage Target Has Arrived. June 30. Available from: https://www.greentechmedia.com/articles/read/the-massachusetts-energy-storage-target-has-finally-arrived#gs.wt8fah (Accessed 24 January 2018)
Doc-79	Clark, Greg Department of Business, Energy, and Industrial Strategy	GB	2018	"After the trilemma - 4 principles for the power sector" Speech by Business Secretary Greg Clark on the future of the energy market on November 15, 2018. https://www.gov.uk/government/speeches/after-the-trilemma-4-principles-for-the-power-sector (Accessed November 22, 2018)

Appendix 2

List of Interviews

Interview code	Jurisdiction	Name	Position or affiliation	Month and year
Int-A-1	CA	Cavanagh, Ralph	Natural Resources Defence Council	07.17
Int-A-2	CA	Dr Weissman, Steven	Berkeley Law School	07.17
Int-A-3	TX		Former PUC employee, Texas	07.17
Int-A-4	CA	Grueneich, Dian	Former large energy user advocate and CPUC commissioner	07.17
Int-A-5	CA	Florio, Michael	Former consumer advocate and utility commissioner	07.17
Int-A-6	CA	White, John	California Energy Efficiency and Renewable Technologies (CEERT) advocate	08.17
Int-A-7	MA	Besser, Janet Gail	Former president of MA Department of Public Utilities	08.17
Int-A-8	CA	Smutney-Jones, Jan	Independent power producer association	08.17
Int-A-9	CA	Weisenmiller, Robert B.	California Energy Commissioner; former CPUC employee	08.17
Int-A-10	CA	Goldman, Charles	Energy efficiency expert, Lawrence Berkeley National Laboratory	08.17
Int-A-11	US		Metering expert, consultant	08.17
Int-A-12	MA	Kates-Garnick, Barbara PhD	Former energy retailer representative, New Energy Ventures, and Commissioner of Public Utilities, Massachusetts	08.17
Int-A-13	MA	Nogee, Alan	Former Union of Concerned Scientists,	08.17

			Clean Energy Program Director	
Int-A-14	TX		Expert	08.17
Int-A-15-TDO	TX		Energy efficiency employee, ERCOT electricity network company	08.18

Interview code	**Jurisdiction**	**Name**	**Type/ affiliation*** ** ** Participants were interviewed as individuals. Their views are not endorsed by their affiliated organisations* *** Job titles were not included to better protect participants*	**Month, year**
Int-B-16-DER	GB		Rooftop-solar-PV installation firm	08.16
Int-B-17aRET Int-B-17bDER	GB		Former 'big six' retailer; residential-PV-firm	08.16
Int-B-18-RET	GB		'big six' retailer	09.16
Int-B-19-EXP	GB		Electricity system expert	11.16
Int-B-20-RET	GB		'big six' retailer	11.16
Int-B-21-DNO	GB		Distribution-network-operator	11.16
Int-B-22-DER	GB		Commercial and industrial demand response aggregator	11.16
Int-B-23-RET	GB		GB retailer	11.16
Int-B-24-RET	GB		GB retailer	11.16
Int-B-25-EXP	GB		UK community energy expert	11.16
Int-B-26-DH	GB		GB district heat company	11.16
Int-B-27-EXP	GB	Simon Roberts	CSE	11.16
Int-B-28-EXP	GB	Ian Preston	CSE	11.16
Int-B-29-DER	GB		DER platform company	12.16
Int-B-30-EXP	GB	Helen Stockton	NEA	12.16
Int-B-31-DER	GB		Heat-as-a-service company	

Int-B-32-DER	GB		Industrial, commercial demand response aggregator-retailer	12.16
Int-B-33-RET	GB		White-label-retailer	12.16
Int-B-34-DER	GB		Residential demand response aggregator	12.16
Int-B-35-EXP	Germany		VKU, association of municipal utilities	12. 16
Int-B-36-EXP	Germany	Andreas Jahn	RAP	12.16
Int-B-37-EXP	Germany		BEE, association of renewable energy	12.16
Int-B-38-DER	Germany		Solar-battery-service company	12.16
Int-B-39-EXP	Germany		BNE, association of independent energy companies	12.16
Int-B-40-RET	Germany		Green retailer	01.17
Int-B-41-EXP	Germany		BDEW, energy and water utilities association	01.17
Int-B-42-DER	GB		DER platform company	01.17
Int-B-43-DER	GB		Residential demand response aggregator	01.17
Int-B-44-REG	GB		Ofgem, former	01.17
Int-B-45-REG	GB		Ofgem, former	03.17
Int-B-46-REG	GB		Ofgem	03.17
Int-B-47-REG	GB		Ofgem	04.17
Int-B-48-REG	GB		Ofgem	04.17
Int-B-49-REG	GB		Ofgem	04.17
Int-B-50-REG	GB		Ofgem	04.17
Int-B-51-DER	GB		Building company	05.17
Int-B-52-DER	GB		Residential battery company	04.17
Int-B-53-EXP	GB	Lesley Rudd	Sustainable Energy Association	05.17
Int-B-54-EXP	GB	Joanne Wade	Energy efficiency association	05.17
Int-B-55-EXP	GB	Howard Porter	BEAMA, association for manufacturers and providers	05.17

			of energy infrastructure technologies and systems	
Int-B-56-DER	EU		DER consultant	05.17
Int-B-57-RET	TX ERCOT		retailer	06.17
Int-B-58-EXP	US	Andrew Satchwell	Expert	06.17
Int-B-59-IOU	CA		Utility EV manager	06.17
Int-B-60-EXP	US	Dr Jeremy Firestone	Expert	06.17
Int-B-61-DER	EU, US		Demand response representative	06.17
Int-B-62-DER	EU, US		VPP provider, residential	06.17
Int-B-63-EXP	US	Galen Barbose	Expert	06.17
Int-B-64-MUN	CA		Municipal utility employee	06.17
Int-B-65-DER	US		ESCO	07.17
Int-B-66-EXP	US	Lisa Schwartz	Expert	07.17
Int-B-67-RET	North America		Gen-tailer	07.17
Int-B-68-RET	TX ERCOT		independent retailer	07.17
Int-B-69-DER	US		Residential demand response aggregator	07.17
Int-B-70-DER	US		DER platform company	07.17
Int-B-71-EXP	US	Dr Jo Seel	Expert	06.17
Int-B-72-EXP	US	Joe Eto	Expert	06.17
Int-B-73-EXP	US	Liz Stuart	Expert	06.17
Int-B-74-EXP	US	Pete Larsen	Expert	06.17
Int-B-75-EXP	US	Pete Cappers	Expert	06.17
Int-B-76-EXP	US	Greg Leventis	Expert	07.17
Int-B-77-EXP	US	Ben Paulos	Expert	06.17
Int-B-78-EXP	US		Electrical equipment manufacturer	06.17
Int-B-79-DER	CA		Demand response expert	07.17

Int-B-80-DER	US		CHP company	07.17
Int-B-81-IOU	CA		Investor-owned utility	07.17
Int-B-82-IOU	CA		Investor-owned utility, holding	07.17
Int-B-83-IOU	CA		Investor-owned utility, energy efficiency	07.17
Int-B-84	FR		Distribution company	07.17
Int-B-85-DER	US, AUS		Battery-solar company	07.17
Int-B-86-DER	US		Rooftop-solar-PV company	07.17
Int-B-87-EXP	US	Tom Eckman	North West Power and Conservation Council	07.17
Int-B-88-MUNI	CA		Municipal utility employee	06.17
Int-B-89-DER	US		DER platform company	06.17
Int-B-90-MUNI	CA		Municipal utility employee	07.17
Int-B-91-EXP	MA	Ben Dodge	Expert	07.17
Int-B-92-DER	US	Bob Redlinger	Sunpower	07.17
Int-B-93-CCA	CA		CCA representative	07.17
Int-B-94-IOU	MA		Investor-owned utility, energy efficiency department	07.17
Int-B-95-IOU	MA		Investor-owned utility, energy efficiency department	08.17
Int-B-96-CCA	CA		CCA representative	07.17
Int-B-97-EXP	CA	Dr Alexandra von Meier	Expert	07.17
Int-B-98-DER	CA		Battery-solar company	07.17
Int-B-99-REG	CA		Civil servant	07.17
Int-B-100-MUNI	CA		Municipal utility	08.17
Int-B-101-REG	CA	Dr Carla Peterman	CPUC Commissioner	08.17
Int-B-102-EE	US		Energy efficiency obligation implementation company	08.17
Int-B-103-RET	North-America		Gen-tailer	08.17
Int-B-104-MET	worldwide		Metering company	08.17

Int-B-105-EXP	MA		DER expert	08.17
Int-B-106-EXP	US	Rob Mork	Chair of NACUSA, consumer representatives	08.17
Int-B-107-IOU	MA		Utility contractor for energy efficiency obligation implementation	08.17
Int-B-108-TDO	TX ERCOT	William Muston and Tom Anthony	Network operator	08.17
Int-B-109-EXP	US	Warren Leon	Expert	08.17
Int-B-110-IOU	CA		Investor-owned utility, demand-side management programmes	08.17
Int-B-111-EXP	Australia	David Havyatt	Consumers Australia	08.17
Int-B-112-DER	GB		DER representative	09.17
Int-B-113-DNO	GB		Distribution-network-operator	10.17
Int-B-114-MUNI	Germany		Municipal Utility	01.18
Int-B-115-DER	EU, US, Australia		Demand response aggregator	05.18
Int-B-116-DER	EU, US, Australia		Demand response aggregator	05.18
Int-B-117-EXP	GB	David Green	Energy efficiency expert	09.18
Int-B-118-EE	GB		Energy efficiency programme implementer	09.18
Int-B-119	GB	Andrew Warren	Energy efficiency expert	09.18
Int-B-120-RET	Australia		Australian retailer, energy efficiency programmes division	09.18
Int-A-15-TDO	TX ERCOT		Network operator, energy efficiency programmes division	09.18
Int-B-121-DER	US		Large ESCO, controls company	06.19
Int-B-122-DER	Germany	Stefan Scherz	EWUS, medium-size ESCO	07.19

Appendix 3

List of conferences attended for participant observation

Code	Date	Place	Organiser	Title
Conf-1	June 21 2017	Sacramento Convention Center	AEE Advanced Energy Economy	Pathway to 2050 Verbatim citations from youtube: Fireside chat with Kevin M. Payne, SCE CEO https://www.youtube.com/watch?v=GbPrRNgdlqA&list=PL4bo0hkMpOn7erbTQ62UYXU2GR0SIDDij&index=5&t=0s
Conf-2	June 27-29 2017	San Jose Convention Centre	Greentechmedia	Grid Edge Forum
Conf-3	October 30 2017	Corpus Christie College, Oxford	Oxford University German Society	Frank Mastiaux, CEO of EnBW *Transforming EnBW*
Conf-4	September 21 2017	Millennium Mayfair Hotel, London	Marketforce	The Future of Energy Supply
Conf-5	September 26 2017	Energy UK offices, London	Energy UK	Breakfast briefing: *The road to a smart, flexible energy system - accessing the value of new sources of flexibility*
Conf-6	October 19 2017	Queen Elizabeth II Centre, London	Energy UK	Annual conference
Conf-7	November 20-21 2017	bcc Berlin Congress Center	DENA Deutsche Energie Agentur	Dena Kongress
Conf-8	December 06-07 2017	Telford Convention Centre	ENA	Low Carbon Network Innovation fund conference
Conf-9	May 03 2016	One Great George Street, London	Regulatory Policy Institute (RPI)	Westminster Conference
Conf-10	March 30 2017	CGI Offices, London	Energy UK	Breakfast briefing: *Making the energy market work for all consumers*

Conf-11	April 26 2018	ESC, Birmingham	Energy System Catapult, BEAMA, EnergyUK	*Building an energy market around the customer*
Conf-12	September 20 – 21 2018	St Catherine's College, Oxford	British Institute for Energy Economics (BIEE)	BIEE Conference
Conf-13	December 08 2016	The Royal Institution, London	Ofgem	Ofgem Innovation Link Launch
Conf-14	May 03 2017	One Great George Street, London	Regulatory Policy Institute (RPI)	Westminster Conference
Conf-15	May 02 2018	One Great George Street, London	Regulatory Policy Institute (RPI)	Westminster Conference
Conf-16	February 09 2017	One Great George Street, London	Ofgem	Ofgem Insights Event

Appendix 4

Sample interview outline 1

- Which position did you work in before and in during restructuring reforms?
- What have you worked on since?
- Why did reform happen at that particular moment?
- Who participated in the debates on restructuring?
- Which stakeholders supported competition? Why?
- Which stakeholders supported unbundling of networks from retailing? Why?
- Who argued against these changes?
- How did federal policy impact the individual states?
- Why were the utilities not forced to divest retailing operations?
- Why was billing not made fully competitive?
- Why was metering not made competitive?
- Why were municipalities allowed to opt out of competition reforms?
- How are people looking back on restructuring today? Which lessons have been learned?
- Which reforms are being discussed today?

Sample interview outline 2

- What is your current position and where did you work before?
- Which countries does your company work in?
- Which revenue streams are you seeking to capture?
- Which value propositions are you seeking to offer?
- Who are your target customers?
- Who are important business partners for you?
- Which barriers do you face in scaling your business?
- What is different about your business in different jurisdictions?
- Which jurisdictions are easier for you to access and why?
- If you don't already, would you like to offer your proposition combined with commodity electricity?
- Does it make a difference to your business whether direct access (retail competition) is allowed?
- [for longer established firms] How did your business change since restructuring? What caused these changes?
- What would you like to change about the regulatory framework and public policy?
- Who disagrees with you on these points?
- Are there any more things you would like to tell me which I missed in my questions?