THE ROLE OF INSTITUTIONAL INVESTORS IN FINANCING SUSTAINABLE ENERGY

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ABSTRACT

In the COP21 Paris Agreement, Parties agreed to hold the increase in the global average temperature to well below 2°C and to make finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development. The scale of investment needed in sustainable energy for this transformation is so large that it will, inevitably, have to rely in large part on mobilising private capital. A key potential source is the capital controlled by institutional investors. This thesis focuses on examining and improving the understanding of the role of institutional investors in financing sustainable energy, the barriers to investment, and how they may be surmounted.

One of the central contributions is the articulation of an original methodology and framework to understand and monitor what policy settings, financing instruments, risk mitigants and transaction enablers might be most effective and appropriate with regards to scaling up institutional allocations through a variety of principal investment channels. The thesis also examines the role of the debt capital markets, including the emergence of the 'green bond' market. I argue that if there is concerted attention by policy makers and market participants, the bond markets can be relied on as a critical foundation for mobilising institutional investors and raising part of the debt financing that will be needed for the transition to a low-carbon economy.

Underpinning the analysis is an empirical base of 110 examples of institutional investment in sustainable energy projects. It is hoped that this framework, along with the analysis, conclusions and policy recommendations, can assist in creating the fundamental settings needed to study how to scale up and mobilise greatly needed flows of this type of investment.

TABLE OF CONTENTS

ABSTRACT **2**

1. LIST OF ACRONYMS AND ABBREVIATIONS 7

2. LIST OF FIGURES 10

3. PREFACE 12

4. ACKNOWLEDGEMENTS 14

5. INTRODUCTION TO THE THEORETICAL FRAMEWORK, AIMS AND METHODS 16

5.1 Motivation and theoretical framework 17

5.2 Aims and contributions 19

5.3 Institutional investors defined 24

5.4 Sustainable energy infrastructure defined 24

5.5 "2°C Scenario" defined 25

5.6 Methodological approaches and data 26

5.7 Quantitative methodology 27

5.7.1 Construction of a unique proprietary data-set 27

5.8 Qualitative methodology 28

5.8.1 Case studies 28

5.9 The mixed method approach 29

5.10 Preserving academic research integrity 30

5.11 Guide to core components of the classification framework for mobilising institutional investment in sustainable energy 32

5.12 Towards a consistent and standardised language 36

6. LITERATURE REVIEW 39

6.1 Introduction 40

6.2 Broader academic fields of study 40

6.3 Economic and financial geography 43

6.4 Institutional investors, infrastructure finance and financial theory 44

6.5 Finance and innovation across time horizons 50

6.6 Energy & Environmental Physical Attributes, Effects and Economic Interactions 53

6.7 Environmental Policy and Government Intervention 59

6.8 Background Literature to the Policy Recommendations 61

7. THE SPACE OF INSTITUTIONAL INVESTORS IN FINANCING SUSTAINABLE ENERGY 66

7.1 Introduction 67

7.2 Climate change and the need to shift to low-carbon investment 67

7.3 Investment needs and incremental costs of 'going low carbon' 68

7.4 Sustainable energy deployment on the march 71

7.5 Dynamics of investment financing sources for sustainable energy 74

7.5.1 Strains on traditional sources of sustainable energy finance 76

7.6 Institutional investors and their potential to finance sustainable energy investments 80

7.7 Understanding institutional investor asset liability management and asset allocation decisions 85

7.8 Limitations and challenges for scaling up institutional investment in sustainable energy 88

7.8.1 Barriers specific to emerging and developing economies 94

7.9 Carbon lock-in, climate risk and stranded assets 96

8. THE PLACE OF INSTITUTIONAL INVESTORS IN FINANCING SUSTAINABLE ENERGY 103

8.1 Introduction 104

8.2 Strengthening the demand for green institutional investment to develop organically 105

8.3 A survey of institutional investment activity and demand for sustainable energy assets 106

8.3.1 Aggregated stocks and flows 106

8.3.2 Public statements and investment targets 109
8.4 The evolution of institutional investment in sustainable energy 111
8.4.1 The case of EU sustainable energy investment by institutional investors 114
8.4.2 The emergence of YieldCos 122
8.4.3 How the YieldCo model may need to evolve to achieve its potential 125
8.5 Financial intermediaries and geographical flows 125
8.6 Implications for subsequent chapters 129
9. THE CHANNELS FOR INSTITUTIONAL INVESTMENT IN SUSTAINABLE ENERGY: TOWARDS A CLASSIFICATION FRAMEWORK 131
9.1 Introduction 132
9.1.1 Defining sustainable energy financing instruments and funds 133
9.2 Methodology and samples summary data 134
9.3 Descriptive statistics and initial findings 137
9.3.1 Geographic flow of investments 142
9.4 Investment pathways used by institutional investors 144
9.5 The 'Make or Buy' Option 145
9.5.1 Pathways based on the 'make or buy' decision 147
9.5.2 Pathways based on underlying investments 150
9.6 The 'Matrix Frame': Mapping channels for investment 157
9.7 Breaking down the framework by a single deal 162
9.8 Future applications of the framework 163
9.9 Implications for subsequent chapters 164
9.10 Annotated key for Figure 9.8 providing detail of transactions and logic for classification 166
10. A STOCKTAKING OF RISK MITIGANTS AND TRANSACTION ENABLERS FOR SUSTAINABLE ENERGY INVESTMENT 178
10.1 Introduction 179
10.2 Risk mitigants 179
10.2.1 Credit enhancement and risk reduction 181
10.2.2 Subordination 183
10.2.3 Loan loss reserves 184
10.2.4 Guarantees and insurance products 185
10.2.5 Third-party guarantees and overcollateralisation 187
10.2.6 Performance guarantees 188
10.2.7 Project completion coverage 189
10.2.8 Production risk coverage 189
10.2.9 Political risk coverage 189
10.2.10 Policy and regulatory risk coverage 190
10.2.11 Public investment funds 192
10.2.12 Cornerstone investment 193
10.3 Transaction enablers for sustainable energy investment 195
10.3.1 Securitisation 197
10.3.2 Warehousing 199
10.3.3 Standardisation of contracts and reporting and data collection 200
10.3.4 Co-investment, joint-ventures and consortiums 201
10.3.5 The rise of co-investment platforms 202
10.3.6 Co-operation and collaboration, and other informal knowledge-sharing 203
10.4 Implications for subsequent chapters 204
11. THE EMERGING GREEN BOND MARKET 208
11.1 Introduction 209
11.2 The need to mobilise debt capital and bonds 210
11.3 Green bonds 216
11.3.1 Defining a green bond 217
11.3.2 Financial characteristics 218
11.3.3 The seven types of green bonds 219
11.3.4 Green bond pricing 221
11.4 Investor demand for sustainability and for green bonds rises 226

11.5 The green bond market 229
11.5.1 Use of proceeds 230
11.6 Promoting environmental integrity in the green bond market through guidelines and standards 231
11.6.1 Transparency in the 'use of proceeds' as a key to integrity 233
11.6.2 Review and assurance in the green bond market 234
11.6.3 Review and assurance in the green bond market 235
11.7 The emergence of green bond benchmark indices and exchange listings 237
11.8 The trajectory of green bond governance 240
11.9 The growing green bond market 241
11.9.1 The economic geography of green bond market evolution 241
11.10 The benefits of green bonds 243
11.11 The geography of the green bond market 246
11.12 Selected case studies on regional experiences with green bonds 246
11.12.1 China: Greening a financial system starting with bonds 246
11.12.2 Institutional investment in green bonds: The case of South Africa's Government Employees Pension Fund 248
11.12.3 United States: Municipal bonds 249
12. MOBILISING BOND MARKETS FOR A LOW CARBON TRANSITION 251
12.1 Introduction 252
12.2 Barriers to green bond market development and growth 252
12.3 Identifying barriers and challenges to scaling green bond markets 254
12.3.1 General challenges to bond market development 254
12.3.2 Lack of awareness of the benefits of green bonds and existing international guidelines and standards 255
12.3.3 Lack of local green bond guidelines 255
12.3.4 Costs of meeting green bond requirements 256
12.3.5 Lack of green bond ratings, indices and listings 256
12.3.6 Lack of supply of labelled green bonds 257
12.3.7 Difficulties for international investors to access local markets 257
12.3.8 Lack of domestic green investors 257
12.4 The risks, perceived and real, of green bonds 258
12.5 The economic geography of country experiences and actions to overcome barriers to green bond market development 260
12.5.1 Developing a Local Currency Bond Market (LCBM) 261
12.5.2 Unlocking institutional bond investors 263
12.5.3 Building the market 265
12.5.4 Demand-side policies 267
12.5.5 Supply-side policies 267
12.5.6 Assessing the effectiveness of policy measures 269
13. MOBILISING FLOWS OF INSTITUTIONAL INVESTMENT FOR SUSTAINABLE ENERGY 271
13.1 Introduction 272
13.2 Catalysing the supply of institutional capital: A stock-taking of approaches 273
13.3 Research Methodology 274
13.3.1 Attributes included in stock taking 274
13.4 Results of the stock-taking research 275
13.4.1 Financial geography of results 275
13.4.2 Physical assets 276
13.4.3 Public and official sector actors 277
13.4.4 Institutional investors involved 278
13.4.5 Towards a typology of risk mitigants 279
13.4.6 Towards a typology of transaction enablers 281
13.4.7 Plotting the stock-taking research examples on a 'Matrix Frame' for visualising channels 283
13.5 Towards a quantitative framework for analysing potential bond contributions in a low-carbon transition 286

13.5.1 High-level results in context 287
13.5.2 Results by type of bond 291
13.5.3 Results by geography 293
13.6 Implications for institutional investor asset allocation 295
13.7 Mapping channels for institutional investment in green bonds 298
13.8 Annotated key for providing detail of transactions and logic for classification 300
14. CONCLUSION: RECOMMENDATIONS FOR POLICY MAKERS 306
14.1 Introduction 307
14.2 Nine high-level policy recommendations to facilitate institutional investment in sustainable energy 308
1. *Establish preconditions for institutional investment and favourable framework conditions for long-term investment financing.* 309
14.3 Emerging options and policy considerations for mobilising the bond markets for sustainable energy and green infrastructure 317
14.3.1 Preconditions 318
14.3.2 Regulation 318
14.3.3 Market building 319
14.3.4 Demand side 324
14.3.5 Supply side 326
14.3.6 Public intervention 327
15. CONCLUSION: IMPLICATIONS FOR FUTURE RESEARCH 329
15.1 Overarching research conclusions 330
15.1.1 Towards an 'investment grade' policy framework 330
15.1.2 'Organic' institutional investment in sustainable energy 335
15.1.3 Catalysed institutional investment in sustainable energy 337
15.1.4 Mobilising the debt capital markets and scaling green bonds 339
15.2 Implications for future research 343
15.2.1 Institutional investors 343
15.2.2 Green bonds 349
16. ANNEX A: BACKGROUND TO THE POLICY RECOMMENDATIONS 353
16.1 Preconditions for Institutional Investment 353
16.2 Investment-grade Policy Environment 355
16.3 Investment Channels 359
16.4 Risk Mitigants 360
16.5 Transaction Enablers 362
16.6 New and Existing Public Finance Institutions 364
17. ANNEX B: FULL LIST OF PUBLICATIONS 366
18. ANNEX C: LIST OF INVITED PRESENTATIONS 368
19. ANNEX D: 33 CASE STUDIES USED IN CHAPTER 13 371
19.1 Sustainable Energy 371
19.2 Energy Efficiency 379
19.3 Low Carbon Mobility 381
19.4 Green enabling infrastructure 382
19.5 Agriculture and Forestry 383
19.6 Green Buildings 384
19.7 Water 384
19.8 Mixed green finance 385
20. REFERENCES 387
21. GLOSSARY 424

1. LIST OF ACRONYMS AND ABBREVIATIONS

ABS	Asset Backed Security
ADB	Asian Development Bank
AIMCo	Alberta Investment Management Corporation
ALM	Asset Liability Management
AMF	Ascending Markets Financial Guarantee Corporation
AODP	Asset Owners Disclosure Project
AUM	Assets under Management
BIS	Bank for International Settlements
BNDES	Brazilian Development Bank
BNEF	Bloomberg New Energy Finance
BPS	Basis Points (1/100th of 1%)
CalPERS	California Public Employees' Retirement System
CalSTRS	California State Teachers' Retirement System
CBI	Climate Bonds Initiative
CDPQ	Caisse de Depot et Placement du Quebec
CLO	Collateralised loan obligation
CO_2	Carbon Dioxide
COP	Conference of the Parties
CPI	Climate Policy Initiative
CPPIB	Canada Pension Plan Investment Board
CPV	Concentrated Photovoltaic
CSP	Concentrated Solar Power
EIB	European Investment Bank
EDF	Électricité de France
EKF	(Danish) Export kredit fonden
EPC	Engineering, Procurement and Construction
ETFs	Exchange-Traded Funds

FSB	Financial Stability Board
G20	Group of Twenty
GBP	Green Bond Principles
GCF	Green Climate Fund
GEPF	Government Employees Pension Fund (South Africa)
GFC	Green Finance Committee
GFSG	Green Finance Study Group
GIB	Green Investment Bank
GIC	Global Investor Coalition on Climate Change
GIEK	Garantiinstituttet for eksportkreditt (Export Credit Agency)
GP	General Partner
GSIA	Global Strategic Investment Alliance
GSIS	Government Service Insurance System
ICMA	International Capital Market Association
IEA	International Energy Agency
IFC	International Finance Corporation
IFI	International Financial Institution
IFM	Industry Funds Management
IPO	Initial Public Offering
ITF	International Transport forum
LCBM	Local Currency Bond Market
LCR	Low-Carbon and Climate-Resilient
LEV	Low-Emission Vehicle
LP	Limited Partners
MBS	Mortgage-Backed Securities
MIGA	Multilateral Investment Guarantee Agency
MW	Mega Watt
NAPF	National Association of Pension funds
NEA	Nuclear Energy Agency

NREL	National Renewable Energy Laboratory
OFTO	Offshore Transmission Owner
ONDD	(Belgian) Office National du Ducroire (Export Credit Agency)
OPIC	Overseas Private Investment Corporation
PACE	Property Assessed Clean Energy (United States)
PAIDF	Pan African Infrastructure Development fund
PBoC	People's Bank of China
PBCE	Project Bond Credit Enhancement
PE	Private Equity
PIP	Pensions Infrastructure Platform
PPA	Power Purchase Agreement
PPF	Pension Protection fund
PPP	Public-Private Partnership
PPRFs	Public Pension Reserve Funds
PRI	Principles for Responsible Investment
PV	Photovoltaic
REPIN	Renewable Energy Platform for Institutional Investors
SAA	Strategic Asset Allocation
SAPC	Solar Access to Public Capital
SSA	Supranational, Sub-Sovereign and Agency
SWF	Sovereign Wealth Funds
TCE	Transaction Cost Economics
UK BIS	United Kingdom Department for Business, Innovation and Skills
UK GIB	United Kingdom Green Investment Bank
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WACC	Weighted Average Cost Of Capital
WHEEL	Warehouse for Energy Efficiency Loans (United States)

2. LIST OF FIGURES

Figure 5.1 Defining instruments, funds, risk mitigants and transaction enablers to facilitate sustainable energy investment..... 38

Figure 6.1 Situating relevant bodies of literature in the context of academic disciplines and cross-cutting themes 42

Figure 7.1 Sustainable energy investment requirements in the '450 scenario' 2014-35 (USD 2012, billions) 71

Figure 7.2 Landscape of investment financing sources for sustainable energy and dynamics across the OECD 2008-14 (illustrative example, varies by country)..... 76

Figure 7.3 USD 95 trillion in assets under management by institutional investors in the OECD (2015)..... 81

Figure 8.1 Institutional equity investment in EU sustainable energy projects (€ mm.) by technology..... 115

Figure 8.2 Institutional equity investment in EU sustainable energy projects (€ mm.) by country 116

Figure 8.3 Change in equity mix in wind energy projects in Europe, 2010 and 2015..... 118

Figure 8.4 Global sustainable energy mergers and acquisitions by acquirer type 119

Figure 8.5 Institutional investment in EU sustainable energy by channel..... 120

Figure 8.6 Existing public and private entities that finance sustainable energy 128

Figure 8.7 Institutional investor interactions with private sustainable energy finance providers 128

Figure 9.1 Defining sustainable energy financing instruments and funds 134

Figure 9.2 Steps taken to classify investments..... 145

Figure 9.3 Investment pathway for direct investment by 'in-sourcing asset management' 148

Figure 9.4 Investment pathway for intermediated investment by 'out-sourcing asset management' 149

Figure 9.5 Pathways for investment in projects by pension funds (PFs) 154

Figure 9.6 Pathways for investment in pure-play corporates by pension funds (PFs)..... 155

Figure 9.7 Pathways for investment in diversified corporates by pension funds (PFs) 156

Figure 9.8 A matrix frame for mapping pension fund investment in sustainable energy with single examples..... 158

Figure 9.9 A matrix frame for mapping pension fund investment in sustainable energy with all observations 159

Figure 9.10 An illustration of the components of the classification framework for institutional investment in sustainable energy of a single deal 163

Figure 11.1 Investment in renewable energy in 2015 and the role of bonds 212

Figure 11.2 USD 97 trillion of outstanding global debt securities in 2014..... 213

Figure 11.3 Composition of the green bond market USD billion, gross issuance 217

Figure 11.4 Green bond use of proceeds raised in 2015 by sector..... 231

Figure 12.1 The phases of green infrastructure asset development at individual and market level 259

Figure 13.1 Plotting the stock-taking research examples on a 'Matrix Frame' for visualising channels..... 284

Figure 13.2 Scenario results to 2035 compared with low-carbon investment needs and new debt securities issuance (Annual)..... 288

Figure 13.3 Potential for low-carbon bond issuance ranges between USD 620 billion and USD 720 billion per year by 2035 (USD billion) 290

Figure 13.4 Financing in 2035 by type of capital and bond (baseline scenario)..... 291

Figure 13.5 Asset-backed and financial sector bonds have the largest potential to scale up (baseline scenario)..... 293

Figure 13.6 OECD institutional investor asset allocation to low-carbon bonds as modelled under the base case scenario 297

Figure 13.7 A 'matrix frame' to map channels for institutional investment in green bonds 299

3. PREFACE

This doctoral research project was supported by the Organisation for Economic Co-operation and Development (OECD), where I held an official appointment as an Economist and Policy Analyst from February 2010 until November 2016, and where I conducted the entirety of my fieldwork research.

The foundations for the scholarly research lie in applied policy work conducted on behalf of the OECD Secretariat. Components of this doctoral thesis have been published throughout my time at the University of Oxford from 2013-2017 in different forms, including as OECD books, reports, working papers and other types of publication listed in Chapter 17.

These OECD outputs all benefited from a routine review process whereby OECD government delegates were given the opportunity to comment on the work. Outputs from this research project have also been contributed as deliverables to the G20 Investment and Infrastructure Working Group and the G20 Green Finance Study Group over the course of 2014-2016. Where applicable, all related OECD peer-reviewed material has been cited and referenced. Some elements have been updated and modified in this thesis to reflect latest statistics or examples. The opinions expressed and arguments employed herein are my own and do not necessarily reflect the official views of OECD member countries or of the G20.

My OECD affiliation also enabled access to and participation in relevant G20 and APEC meetings and working groups, as well other official OECD events (such as the annual Green Investment Financing Forums, G20/OECD Long Term Investment Round Tables and High-Level Investor Breakfasts), all of which contributed to a better understanding of the field of study and the key actors. A list of the opportunities I have

had to present elements of my research and receive feedback over the course of the thesis period (2013-2016) is given in Chapter 18.

4. ACKNOWLEDGEMENTS

This doctoral thesis emerges from a decade of practical experience and research into the financing of sustainable energy, and the policy circumstances under which capital allocation by institutional investors may occur. As such, I owe a great deal of gratitude to many individuals that I have worked with and learned from, throughout my career and studies, in the academic, financial and policy domains, many of whom are recognised in the acknowledgements of my individual publications.

Special thanks are due to my family, for providing the foundations for my education and encouraging my endeavours. In particular, I give my thanks to my parents, Karin and Roger, my sister Melissa, and my uncle, Scott Townell for steering and supporting my studies and career.

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5. INTRODUCTION TO THE THEORETICAL FRAMEWORK, AIMS AND METHODS

> Tzu-lu said, "If the prince of Wei were waiting for you to come and administer his country for him, what would be your first measure?" The Master said, "It would certainly be to correct language." Tzu-lu said, "Can I have heard you aright? Surely what you say has nothing to do with the matter. Why should language be corrected?" The Master said, "Yu! How boorish you are! A gentleman, when things he does not understand are mentioned, should maintain an attitude of reserve. If language is incorrect, then what is said does not concord with what was meant; and if what is said does not concord with what was meant, what is to be done cannot be effected. If what is to be done cannot be effected, then rites and music will not flourish. If rites and music do not flourish, then mutilations and lesser punishments will go astray. And if mutilations and lesser punishments go astray, then the people have nowhere to put hand or foot.
>
> Therefore the gentleman uses only such language as is proper for speech, and only speaks of what it would be proper to carry into effect. The gentleman, in what he says, leaves nothing to mere chance."

Confucius

Book XIII, Ch. 3, p. 172

5.1 Motivation and theoretical framework

In the Paris Agreement adopted in December 2015 by the 21st Conference of the Parties to the United Nations Framework Convention on Climate (COP21), Parties agreed to hold the increase in the global average temperature to well below 2°C and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels. Parties also agreed to make finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development (United Nations, 2015a).

To meet these climate change goals, along with the Sustainable Development Goals (United Nations, 2015b), monumental levels of infrastructure investment will be required to sustain growth and meet the basic needs generated by rapid population growth and urbanisation in developing countries, even before considering climate and pollution challenges. The OECD (2017b) estimates that around USD 95 trillion of investments are needed from 2016 to 2030 in infrastructure (energy, transport, water and telecoms), equating to approximately USD 6.3 trillion per year without taking into account climate concerns. For this infrastructure to be consistent with a 2°C scenario, investment needs will need to reach USD 6.9 trillion per year in the next 15 years, an increase of about 10% in total infrastructure investment from the reference estimate.[1]

The scale of this investment is so large that it will, inevitably, have to rely in large part on mobilising private capital flows. Public finance can and does play a critical role to 'jump start', leverage and guide this investment, but transformational change will inevitably require large-scale private sector engagement. There is increasing recognition

[1] The additional capital cost is low overall and could be offset over time by fuel savings reaching USD 1.7 trillion per year up to 2030 – further reinforcing the case for robust low-emission economic growth (OECD, 2017b).

that policy makers need to focus on and strongly influence how private sector decisions are made to invest in long-lived infrastructure if global climate change goals are to be achieved. To meet these goals, a massive shift of investment toward low-carbon, climate-resilient infrastructure must occur.

However, traditional sources of private financing for sustainable energy – governments, utilities, project developers and financial sector sources – face significant financial, regulatory and structural constraints. While the banking sector remains a key provider of investment financing, significant attention has been focused on the potential for institutional investors – including pension funds, insurance companies, investment funds, and sovereign wealth funds – to significantly increase their investments in sustainable energy.

If governments wish to mobilise capital from institutional investors for sustainable energy, they need to simultaneously understand not only the barriers to investment and how to surmount them but also the channels through which such capital can flow. Discussions on innovative financing solutions often do not illuminate how capital is already allocated to infrastructure investments and the particularities of the different investment channels used.

Furthermore, institutional investors are often referred to generically without an appreciation of their sheer diversity. To effectively target government interventions to mobilise investment, it is important for policy makers with varying degrees of familiarity with finance to have an appreciation of the full range of investment channels available, and how the preferences, structures and risk appetites of different types of institutional investors impact on their investment decisions.

For example, large institutional investors evaluate prospective investments based on decisions concerning whether they wish to allocate to projects or companies, through debt or equity, on a listed or unlisted basis, and to make the investment directly ('in-house') or to create a contract with an intermediary ('out-source') to make the investment on their behalf. Channels can provide exposure to a single project asset or company or can bundle multiple smaller-scale projects together. Similarly, channels and the types of financial structures that they are composed of, can serve to aggregate and meld together capital from different types of institutional investors, who vary in scale.

5.2 Aims and contributions

This project focuses on examining in depth and improving the understanding of the role of institutional investors (defined in 5.3) in financing sustainable energy assets (defined in 5.4), the barriers to increasing their investment in this area and how they may be surmounted. A better understanding is needed of how different types of investors view these investments, and how policies, regulations and interventions can affect the attractiveness of these investments and investors' ability to participate through different channels that suit their characteristics. My approach is empirical and employs a mix of methods including both qualitative and quantitative techniques.

Whilst there is, increasingly, research on institutional investors and long-term investments and there is an abundance of research on 'green investments', before 2011, there had been very little that links the two areas with empirical evidence or in-depth academic research. The thesis represents the culmination of seven years of contributions that I have made to a deepening body of policy and academic literature examining the potential role of institutional investors in financing the transition to a low-carbon economy.

This thesis is intended to provide a wide array of actors (not necessarily just those familiar with financial policy or sustainable energy) with a more complete view of the channels for institutional investment in sustainable energy infrastructure. It also provides insights on the factors influencing investment decisions in different channels, the key policy levers, risk mitigants and transaction enablers that governments can use to facilitate sustainable energy infrastructure investments, and the emerging channels that hold significant promise for scaling up institutional investment. These channels include direct project investment, intermediated funds and green bonds.

Several original contributions are offered herein. First of all, through empirical research, an original methodological and theoretical framework is articulated that enables policy makers, academics and other researchers to analyse the economic geography of a country's institutional investor landscape (Clark and Wójcik, 2003; Clark *et al.*, 2003; Clark and Hebb, 2004) and understand what policy and investment settings, vehicles and instruments for sustainable energy projects might be most effective and appropriate with regards to scaling up institutional allocations through a variety of investment channels, while taking into account consideration of the geography of energy resources (Chapman, 1961; Luten, 1971; Solomon, Pasqualetti and Luchsinger, 2003; Hamhaber, 2015).

As an integrated framework, it classifies investments according to different types of financing instruments and investment funds, and highlights the risk mitigants and 'transaction enablers' that governments along with intermediaries like public green investment banks and other public financial institutions can use to mobilise institutionally held capital. Underpinning the analysis is an empirical base of 110 examples of institutional investment in sustainable energy projects and 'pure play' sustainable energy companies identified for the research. This framework can be used to identify where

investment is or is not flowing, and to focus attention on how governments can support the development of potentially promising investment channels.

I argue that given the imperative to mobilise alternative sources of investment finance, a central question that underlies the entire thesis can be summarised as: 'How can investment (flows) to sustainable energy projects from institutional investors be scaled up through various channels?'

To address this question and describe the economic geography of institutional investment in sustainable energy, I employ a heuristic conceptual device inspired by Gordon Clark (2005) of space (Chapter 7), place (Chapter 8), channels (Chapters 9-12) and flows (Chapter 13); which divides the thesis into four respective research questions using different conceptual frameworks (Hudson, 2004). This allows me to advance my argument through differentiation and separation, with the intention of producing a final product that is multidimensional in a similar approach used by many financial geographers (see Dixon, 2009; Knight and Sharma, 2015) and takes both top-down and bottom up perspectives of the role of institutional investors in financing sustainable energy (and the interactions between). This division is not meant to segment frameworks into mutually exclusive zones of analysis. As the thesis will show, the four domains are deeply interlinked and components of a system of arguments.

One of the central contributions of the thesis is the articulation (in Chapter 9) of a 'Framework for understanding investment channels by institutional investors in sustainable energy'. This is accomplished by constructing a classification system using an initial empirical base of 67 examples of institutional investment in sustainable energy (companies and projects). The system uses tabular and visual devices to illustrate how the classification works for different types of transactions. 'Investment pathways' illustrate

decision processes, including the ‘Make or Buy’ choice between direct or intermediated investment, in projects or corporations. ‘Matrix frames’ visually plot transactions together and display data. A ‘schematic overview’ visual device is used at the level of a single transaction to highlight how instruments, funds, risk mitigants and transaction enablers can all come together in a specific investment example.

Chapter 10 creates an arc that binds the discussion on ‘channels’ to ‘flows’ by describing the ‘risk mitigants’ and ‘transaction enablers’ that governments along with public financial institutions can use to mobilise institutionally held flows of capital. Chapters 11 and 12 take a deep dive into the world of debt securities, inspecting how ‘green bonds’ have become an emergent channel identified as having great potential to mobilise institutional investment for sustainable energy. It describes how institutional investors have driven the growth of a market for green bonds, investing in most issuances while working to improve the market’s structure and green integrity. Bonds are a core component of pension funds’ and insurance companies’ portfolios, and bonds with long tenors are potentially a good fit with institutional investors’ long-term liabilities, allowing for asset-liability matching. Green bonds fit within the investment portfolios of mainstream institutional investors and can reconcile latent and emerging demand from institutional investors for sustainability-themed, ESG-screened investments.

I argue that this project, focused on the understanding of the features of institutional investment in sustainable energy and developing a methodology and framework for policy makers, can assist in creating the fundamental settings to scale up this type of investment. To do this, I examine the relationship between different types of risk mitigants, transaction enablers and institutional investor participation, and type of capital provision in Chapter 13. I conduct empirical analysis to this effect, creating a proprietary

database collated from internal and external databases at the OECD on institutional investment in sustainable energy. I compare sustainable energy with other types of green infrastructure such as sustainable energy enabling infrastructure (e.g. grid interconnectors), energy efficiency and water investments. I use asset allocation statistics being collected top-down by the OECD and bottom-up by the Institutional Investors Group on Climate Change (IIGCC) and Global Investor Coalition.

I argue that the economic geography of institutional investors has important implications for how they can scale up their investment in sustainable energy. Across the G20, this agglomeration of capital varies in investment objectives and style, market structure, asset allocation, and ultimately, fit for long-term investment. Furthermore, there are significant national differences between investors, their regulations and investment practices. I use the rich sources of quantitative and qualitative data on national investor characteristics at the OECD to parse the economic geography of the institutional investor landscape and argue in Chapters 7, 8, 9, and 13 that this means that each class of investor has different characteristics and faces individualised constraints, many of which affect their ability to invest in sustainable energy through different investment channels.

Given the policy-practitioner origins and orientations of this academic research, the thesis has a two-part conclusion. The first part is Chapter 14, which offers nine high-level policy recommendations for governments and the official sector to consider in efforts to catalyse, accelerate, and scale up institutional investment in sustainable energy. Emerging from these high-level recommendations, are a further set of options and policy considerations in Chapter 14.3 focused on mobilising the debt capital markets for sustainable energy and green infrastructure. These recommendations and options are informed by the full body of work contained in the thesis, along with other G20/OECD

analysis that I have undertaken that is ancillary to this project, and the background to the recommendations is given in an annex to the thesis (Chapter 16), as they are presented and discussed in depth in Kaminker *et al.* (2015).

The second part in Chapter 15 synthesises overall conclusions from the research into four constituent areas: 1) the need for 'Investment-Grade' Policy Frameworks; 2) the evolution of 'Organic' investment, as distinct from; 3) 'catalysed investment' and; 4) conclusions specific to the emerging green bond market. The thesis concludes with implications for future research, also divided, into research specific to 1) institutional investors, and 2) green bonds.

5.3 Institutional investors defined

Though the term 'institutional investor' covers a wide range of organisations (including endowments, foundations, etc.), the focus of this research is on pension funds, public pension reserve funds, insurance companies (and to a lesser extent, sovereign wealth funds) as the OECD is the leading organisation collecting statistics on these institutions and has been undertaking extensive analysis on their investments and their regulatory environments.

5.4 Sustainable energy infrastructure defined

'Sustainable energy' infrastructure as defined in this thesis includes the following sectors: Power generation from solar, wind, small hydro[2], geothermal, marine, biomass and waste-to-energy, biofuels, carbon capture and sequestration and 'energy smart

[2] Although large hydro-electric power generation is a form of sustainable energy and has attracted significant institutional investment, it is outside the scope of this research, as this research relies primarily on the BNEF database (BNEF, 2017a) for investment transactions and its associated definition of "clean energy" which excludes large hydro. BNEF excludes large hydro arguing that this

technologies' (such as smart grids, inter-connectors, energy efficiency, storage and electric vehicles). However, the focus of this thesis is on commercially scalable sustainable electricity generation technologies such as wind (on/offshore), solar (PV/CSP), small hydro (less than 50MW), biomass, and geothermal, as this is where the majority of institutional investment activity tracked in this research is occurring.

Sustainable energy infrastructure is a subset of 'green infrastructure' (Kaminker, 2016b), also discussed at various junctures of this thesis (especially in Chapter 13 and those chapters on green bonds) which in addition to sustainable energy includes: 1) 'low-carbon and climate-resilient' infrastructure projects, which either mitigate greenhouse gas emissions or support adaptation to climate change or both; and 2) other investments, including sustainable agriculture, floodplain levees and coastal protection, waste management infrastructure and 'green' water infrastructure. Green water infrastructure may include wastewater treatment and infrastructure that requires less concrete, e.g. through rainwater harvesting, source control of surface water (such as sustainable urban drainage systems), green roofs, and local processing of grey or black water.

5.5 "2°C Scenario" defined

Decarbonisation pathways are discussed throughout this thesis; as such, it is important to set out a detailed definition up front. The IEA World Energy Outlook "450 Scenario" sets out an energy pathway consistent with the goal of limiting the global increase in temperature to 2°C by limiting the concentration of greenhouse gases in the atmosphere to around 450 parts per million of CO_2. The 2°C Scenario (2DS) is the focus of the IEA's Energy Technology Perspectives work. The 2DS describes an energy system consistent

technology has been mature for decades and is at a very different stage of its roll-out than, for instance, Solar PV.

with an emissions trajectory that recent climate science research indicates would give an 80% chance of limiting average global temperature increase to 2°C. It sets the target of cutting energy-related CO_2 emissions by more than half in 2050 (compared with 2009) and ensuring that they continue to fall thereafter. The 2DS acknowledges that transforming the energy sector is vital, but not the sole solution: the goal can only be achieved if CO_2 and greenhouse gas emissions in non-energy sectors are also reduced. The 2DS is broadly consistent with the World Energy Outlook 450 Scenario through 2035 (IEA, 2014b, 2015), and for the purposes of this thesis they are considered synonymously.

At COP21 Parties agreed to hold the increase in the global average temperature to 'well below 2°C and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels'. Corresponding investment needs figures had not been estimated by the IEA by the time this research concluded. However, more stringent mitigation scenarios are likely to require more early investments in lower emissions technologies, including sustainable energy. Applying the analysis elucidated in this research to these new policy pathways is discussed in the conclusions as an implication for future research.

5.6 Methodological approaches and data

My approach is empirical and mixed-methods; employing both quantitative and qualitative techniques. Yeung (2003) argues that practitioners of new economic geographies can no longer rely exclusively on established 'scientific' methodology for empirical research and data analysis, advocating instead a process-based methodological framework through which complementary methodological practices and triangulation are used. This approach aligns closely with my research objectives and I use in-situ research and theoretical abstraction as methods for my chapters.

5.7 Quantitative methodology

A key advantage that my OECD affiliation brought to this research project was the access to the data that are collected as part of the OECD's mandate and on-going programmes of work, as well as that of the International Energy Agency (IEA), a sister organisation. The OECD launched the Global Pension Statistics project (GPS) in 2002 (OECD, 2017d). The GPS which now incorporates insurer statistics (OECD, 2017c) provides a valuable means for analysing the economic geography of the institutional investor universe and permits inter-country comparisons of current statistics and indicators on key aspects of asset and liability structure and allocation in OECD and non-OECD countries.

The OECD also collects data on trends in pension fund assets and asset allocation, through the annual OECD Large Pension Survey which I was involved with over the years (OECD, 2016c). The Large Pension Fund Survey is based on a qualitative and quantitative questionnaire sent directly to Large Pension Funds and Public Pension Reserve Funds. The data are designed to illuminate the role that large institutional investors can play in providing a source of stable long-term capital (Monk and Sharma, 2016; Clark and Monk, 2017).

5.7.1 Construction of a unique proprietary data-set

For the purposes of this research project, during fieldwork at the OECD in 2014-2016, I constructed a database of 110 actual investment transactions ('deals') that featured institutional investor capital being allocated to sustainable energy (as well as some other types of green infrastructure, for special projects). This database draws on financial micro-data from the BNEF database (BNEF, 2017a), Preqin (Preqin, 2017), Clean Energy Pipeline (Clean Energy Pipeline, 2014) and HgCapital (HgCapital, 2016). These data

cover all sources of funds raised (from grants to public and private equity) and funds committed along the investment continuum (i.e., venture capital, debt and equity asset finance, etc.) for a wide variety of sustainable energy project types. All countries are included with data coverage over the last 15 years, although only BNEF and HgCapital systematically isolate institutional investor participation and both only for the EU. This data limitation is explored in Chapter 8.4.1 and highlighted as an area for future research in Chapter 15.2.

I then conducted primary research into institutional investor deals using public sources, which uncovered further data. This was supplemented with asset allocation statistics being collected top-down by the OECD in its Large Pension Fund Survey (OECD, 2016c) and bottom-up by the Global Investor Coalition (Global Investor Coalition on Climate Change, 2013). Chapter 9 uses a sample of 67 deals collected in this period. In 2016, I undertook further 'stock-taking' research described in Chapter 13, which uncovered more deals that were added to the database, taking the total to over 110 deals collected.

5.8 Qualitative methodology

5.8.1 Case studies

Given the heterogeneity of the global institutional investor landscape and approaches to mobilising capital, I conducted 33 short case studies in Chapter 13.2 (out of the 110 deals included in the database) of investments in sustainable energy (and other types of green infrastructure as comparison) which institutional investors have made, and examine which factors came together as supporting evidence. In Chapter 11.12, I also look at case

studies on different geographical experiences with mobilising institutional investors through green bonds.

Institutional investors are a diverse, highly differentiated group subject with very different regulatory and management environments. They rely on a chain of service providers, fund trustees, advisors, asset managers, policy makers and regulators to make investment decisions (IFC, 2013). Additionally, the sustainable energy project finance continuum involves various actors at the different stages of the project cycle from planning through to operation and refinancing of the asset. I made use of in-situ research and theoretical abstraction to study the channels and places of institutional investment in sustainable energy, examining institutions along these entire chains (Schoenberger, 1991) to understand their spatial logic.

5.9 The mixed method approach

As Knight (2010, p. 20) writes, 'multi-method approaches to social science research and economic geography research in particular are increasingly common, and the geography of financial markets is no exception (Buchanan and Bryman, 2009; Bryman, 2012)'. He argues that the advantage of using both qualitative and quantitative methodologies in the study of financial markets is to initiate and expand new approaches to examining the subject area.

Given the breadth of the subject area, my methodological decisions are problem-based, rather than method based, to benefit from the strengths inherent in both qualitative and quantitative approaches. The qualitative data I gathered has value for being rich, natural, detailed, contextualized, sensitive, and filled with authentic and complex representations. The quantitative data are highly structured and central to the systematic

study of empirical (numbers) properties and relationships. My methodology is informed by grounded theory techniques (Strauss and Corbin, 1967, 1998) which are used to analyse and describe investment channels and typologies.

Each chapter advances an articulated argument to answer a research question and my mixed methodology applies qualitative analysis to parse the space and place of institutional investors (with supporting descriptive statistics from quantitative analysis of my database). Qualitative case study analysis underpins the analysis of channels for institutional investment. In Chapter 13 on mobilising flows of institutional investment, I rely on quantitative analysis from the database construct to analyse the role of risk mitigants and transaction enablers, proposing a typology based on research conducted in Chapter 10.

5.10 Preserving academic research integrity

All research carried out for this project was conducted in accordance with Oxford Central University Research Ethics Committee (CUREC) as well as Economic and Social Research Council (ESRC) frameworks, protocols and guidance. Due consideration was given to issues such as research design, professional skills training, risk assessment, legal requirements, publication, collaborative working and conflicts of interest and commitment.

Given my professional role, I also conducted research in accordance with the OECD Code of Conduct and Research Ethics (OECD, 2007, 2016e, 2017a) recommendations and guidelines. Validated safeguards were employed and steps taken throughout the research, including in the qualitative and quantitative analysis, to be aware of, to avoid or to mitigate biases and improve objectivity, including issues such as flawed study design,

confirmation and selection bias as well as selective inattendance (Columbia University, 2004). As discussed in the methodological sections of Chapters 8 and 12, clear definitions and objectivity were established at the outset of data collection, and rigorous criteria were defined and used.

A valuable device for mitigating various biases was the process of delegate peer review that OECD outputs all benefited from (described in the Preface to this work), whereby OECD government delegates were given the opportunity to comment on the work. Outputs from this research project have also been contributed as deliverables to the G20 Investment and Infrastructure Working Group and the G20 Green Finance Study Group over the course of 2014-2016, where G20 government delegates also had an opportunity to comment on the work, especially via the G20/OECD Task Force on Institutional Investors and Long Term Financing. This also helped to mediate any potential biases related to peer review conducted exclusively by OECD-member country delegates.

My OECD affiliation has also enabled access to, and participation in relevant G20 and APEC meetings, as well other official OECD events (such as the annual Green Investment Financing Forums, G20/OECD Long Term Investment Roundtables, High-Level Investor Breakfasts with the Institutional Investors Group on Climate Change, and Green Bond Roundtables).[3] While organising and participating in all of these events clearly gave me a better understanding of the field of study and the actors involved, I did

[3] G20 Green Finance Study Group: http://unepinquiry.org/g20greenfinancerepositoryeng/; OECD Green Investment Financing Forums: http://www.oecd.org/environment/cc/2015-green-investment-financing-forum.htm; OECD High-Level Breakfasts: http://www.oecd.org/environment/cc/cop22session-7thannualoecdinstitutionalinvestorshigh-levelbreakfast.htm; OECD COP21 Green Bond Roundtable: http://www.oecd.org/environment/cc/cop21session-greenbondsroundtable.htm

not undertake any formal recorded participant observation or interviews (Marshall and Rossman, 1989; Kawulich, 2005).

Learning about methodological research approaches related to close dialogue (Clark, 1998b) and participatory research (Kindon, Pain and Kesby, 2007) proved useful during the many informal conversations I had in closed-door discussions with key actors (as demonstrated formally for instance by Dixon and Monk (2014)), but it would have been too challenging for me to undertake formal academic research in these professional contexts, especially given the potential for conflicts of interest and research biases.

5.11 Guide to core components of the classification framework for mobilising institutional investment in sustainable energy

Among other contributions, this research proposes a classification framework of financing instruments and investment funds, risk mitigants and transaction enablers for mobilising institutional investment in sustainable energy (see Table 5.1). The analysis is supported by 67 actual investment cases collected for this research and described in detail. The classification framework represents a system that can be used to better understand how institutional investors make sustainable energy investments (in projects or companies) through financing instruments (hereafter 'instruments') and investment funds (hereafter 'funds').

This classification framework was developed also as a contribution to a broader G20/OECD project to create a 'Taxonomy of Long-term Investment and Infrastructure Financing' (OECD, 2015c, n. 6). Whilst the classification framework was designed from the outset to inform and also complement this overarching analysis by providing an in-depth examination of sustainable energy as a discrete sector within the broader category

of economic infrastructure, it also provided the initial theoretical basis for key elements of the work, such as the G20/OECD Taxonomy of instruments and vehicles for infrastructure financing (OECD, 2015c, p. 15). Taxonomy is a scheme of classification often used in social sciences but with its history lying in the biological sciences. The classification efforts in this thesis are as defined by Hambrick (1984) undertaken as largely inductive research based on the characteristics of investment transactions in sustainable energy. These classifications then lead to conceptually derived typologies presented in different chapters.

As an iterative process, the framework for understanding investment channels in support of sustainable energy makes use of several graphics to sequentially discuss and illustrate different steps that have been used to classify investments (described in Table 5.1). These tabular and visual devices illustrate how the classification works for different types of transactions.

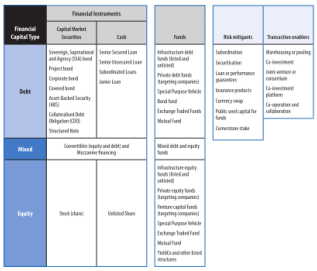
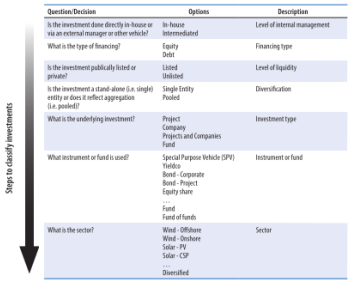
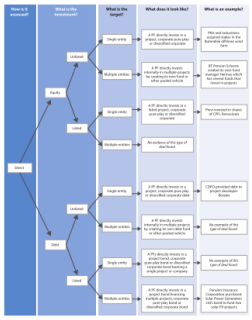
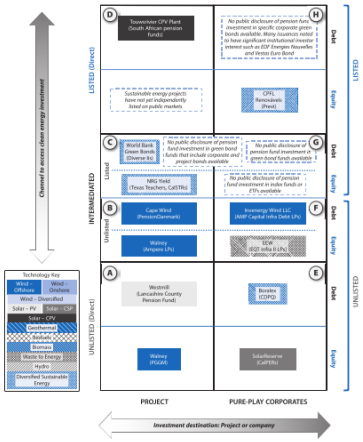
As a first step terms are defined and the different characteristics of investments are analysed. By examining investment traits, steps can be created to classify transactions. ‘Investment pathways’ illustrate decision processes, including the choice between direct or intermediated investment, in projects or corporations. These pathways epitomise the classification framework.

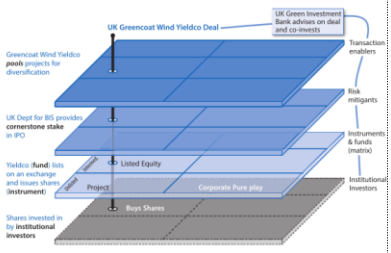
The logic developed through the definitions, classification steps and investment pathways lead to the creation of a ‘Matrix Frame’. These Matrix Frames are used in Chapters 9 and 13 to visually plot and map transactions into different theoretical investment channels.

The Matrix Frame can be seen as a form of heuristic device i.e., an ‘experience-based technique which involves the use of an artificial construct to assist in the exploration of social phenomena usually involving assumptions derived from extant empirical research’ (*Oxford Dictionary of Sociology*, 2017). As such, the Matrix Frame provides an integrated framework that can be used to: 1) understand and compare different instruments and funds available in practice and in theory; 2) illuminate where investment is or is not flowing; 3) highlight potentially promising instruments or funds in which policy makers may consider the use of risk mitigants or transaction enablers to address investment barriers and mobilise flows; and 4) target and undertake data collection on investments in different channels and conduct subsequent empirical analysis.

Finally, a ’schematic overview’ device is used at the level of a single transaction to visually inspect how instruments, funds, risk mitigants and transaction enablers have all come together in a specific investment example. Applications of the entire framework are discussed in multiple concluding sections.

Table 5.1 Guide to components of the classification framework for institutional investment in sustainable energy

Component	**Graphic used in thesis**	**Function**
1) Definitions (Figure 9.1), also Figure 5.1		Provides an overview of the definitions of terms for the purposes of this thesis; illustrating for instance the difference between the categories of instrument, fund, risk mitigants and Transaction enabler
2) Classification steps (Figure 9.2)		Describes foundational logic and steps taken to classify investments for the pathways.
3) Investment pathways (Figure 9.3)		Illustrates how specific transactions can be classified based on the steps, their characteristics and fundamental decisions to make an investment internally or externally and to invest in projects or companies.
4) Matrix frame (Figure 9.8)		Plots transactions on a matrix frame which is created using the logic, steps, classifications and decisions described previously.

5) Detailed transaction schematic (Figure 9.10)		Provides an in-depth look at an individual transaction to highlight the different instruments, funds, risk mitigants and transaction enablers used.

Source: Author, cited in (Kaminker *et al.*, 2015, p. 22)

5.12 Towards a consistent and standardised language

Importantly, and as hinted at by the Confucian wisdom at the start of this chapter, the classification framework (and broader thesis) is intended to help promote clarity and the consistent and standardised use of terms, in an effort to improve 'cross-disciplinary conversation and systematic building of understanding' that has long been a goal of social sciences research (Hill, Kern and White, 2012, p. 1).

In discussions on climate finance and financing sustainable energy, it can be a challenge for policy makers to speak the same language as investors. Institutional investors are by their nature technically-oriented (and sustainable energy infrastructure investments feature their own specialised terms). In contrast, there is an understandable desire in many climate finance discussions to provide relatively simple answers to complex questions that may require specialised knowledge of finance and investments. Policy makers also may speak generically about mobilising capital from institutional investors for sustainable energy, but fail to realise the sheer diversity of such investors.

These dynamics, and the tendency to search for 'silver bullet' solutions, create communication barriers between investors and non-technical policy makers. They also can leave policy makers with a fragmented sense of the range of investment channels

available to investors, how investors consider investments in these channels, and barriers to the development of these channels.

As such, this thesis endeavours to illuminate the myriad investment channels (instruments and funds) that can be used for sustainable energy infrastructure using a common language. Central to an institutional investor's choice of investment channel is its decision to make the investment directly ('in-house') or to create a contract with an intermediary ('out-source') to make the investment on their behalf (see Chapter 9).

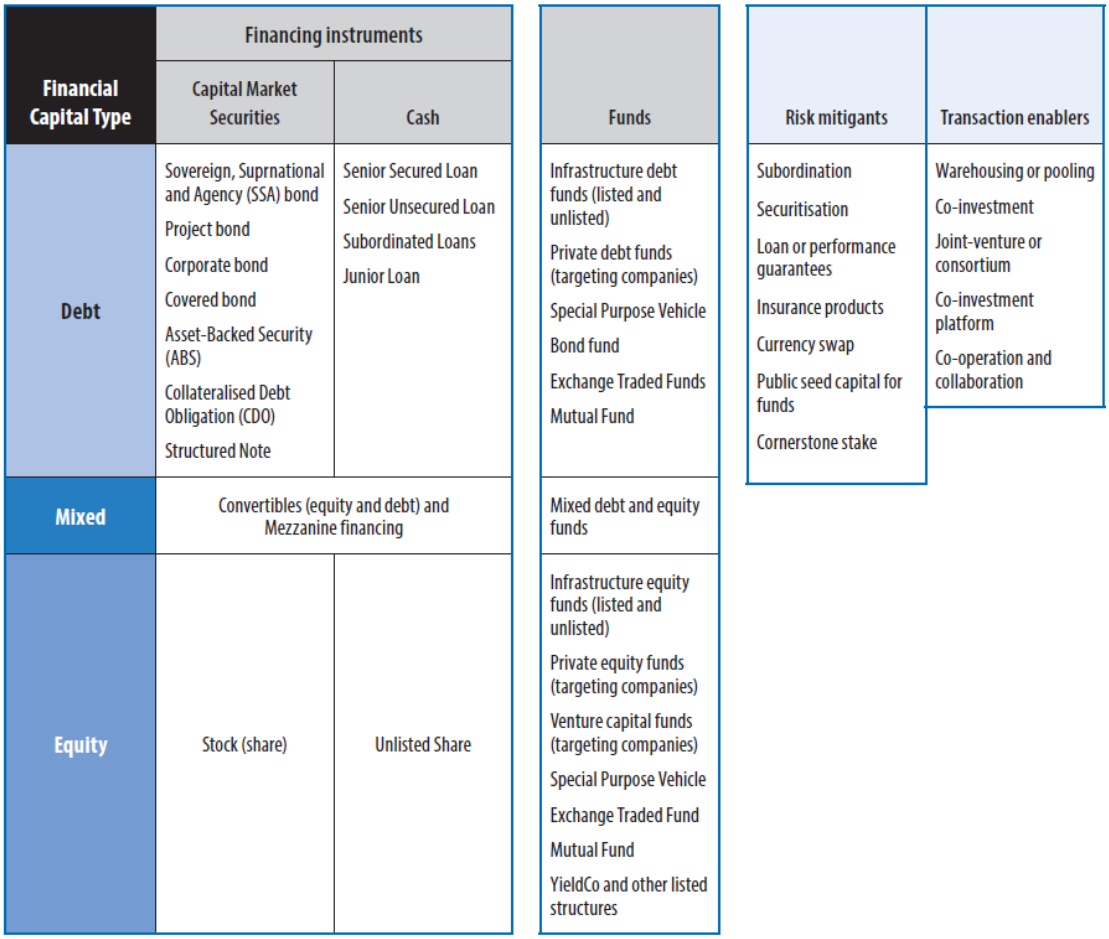
This thesis also provides further analysis and stocktaking of the risk mitigants that policy makers and other intermediaries can apply to the instruments and funds to enhance their effectiveness or appeal to institutional investors. In addition, the sustainable energy investments by pension funds examined in this thesis highlight the innovative transaction enablers that the investors themselves are developing (sometimes along with governments) to deploy capital more effectively in this sector and reduce transaction costs. These tools and techniques are often discussed in the climate finance and sustainable energy literature in a disparate way. This thesis endeavours to align them so that they can be understood alongside instruments and funds.

It is hoped that this effort to develop a focused, in depth classification framework as part of a broader G20/OECD taxonomy that uses consistent language and terms, will provide similar benefits to policy makers, institutional investors and other parties interested in facilitating investment in sustainable energy infrastructure. A glossary contained in Chapter 20 is a further effort in this direction.

Figure 5.1 is the component of the sustainable energy classification framework which provides an overview of the definitions of terms for the purposes of this thesis;

illustrating for instance the difference between the categories of instrument, fund, tool and technique. For academics and practitioners with a background in finance, this classification will be familiar, as it is inspired by recognised accounting standards.

Figure 5.1 Defining instruments, funds, risk mitigants and transaction enablers to facilitate sustainable energy investment



Note: This figure does not map relationships between instruments, funds, risk mitigants and transaction enablers and presents them as separate from each other although in fact direct relationships exist among them (e.g. CDO, Special Purpose Vehicle, Securitisation and Pooling). Analysis of derivatives such as swaps, options, futures and forwards are outside the scope of this research; however Chapter 10 discusses currency swaps. 'Other listed structures' include Master Limited Partnerships and Real Estate Investment Trusts and are discussed in the research as potential structures for sustainable energy investment.

Source: Author, cited in (Kaminker *et al.*, 2015, p. 23)

6. LITERATURE REVIEW

> ‘It goes so heavily with my disposition that this goodly frame, the earth, seems to me a sterile promontory; this most excellent canopy, the air, look you, this brave o’erhanging firmament, this majestical roof fretted with golden fire, why, it appears no other thing to me but a foul and pestilent congregation of vapours.’

William Shakespeare

The Tragedy of Hamlet, Prince of Denmark (1599-1602)

(Act II, Scene ii)

6.1 Introduction

This review commences from a level of elevation and then proceeds to a discussion focusing on how the individual research questions and themes explored in this thesis can be situated in the context of existing and emerging bodies of both academic and applied policy research literature.

6.2 Broader academic fields of study

The point of departure for the intellectual framework of this thesis is firmly anchored in the disciplines of economic and financial geography, as discussed further below. This intellectual heritage appeared from the outset to be especially valuable for situating the overriding thesis question, of how to mobilise institutional investment flows to sustainable energy, while also providing the right set of tools to extract key insights. However, over the course of the four years of research it became apparent that the empirical scope of the investigation and the cross-cutting nature of the issues to be examined necessitated picking up a whole raft of issues across disciplines, and required a broad reach across the social and natural sciences.

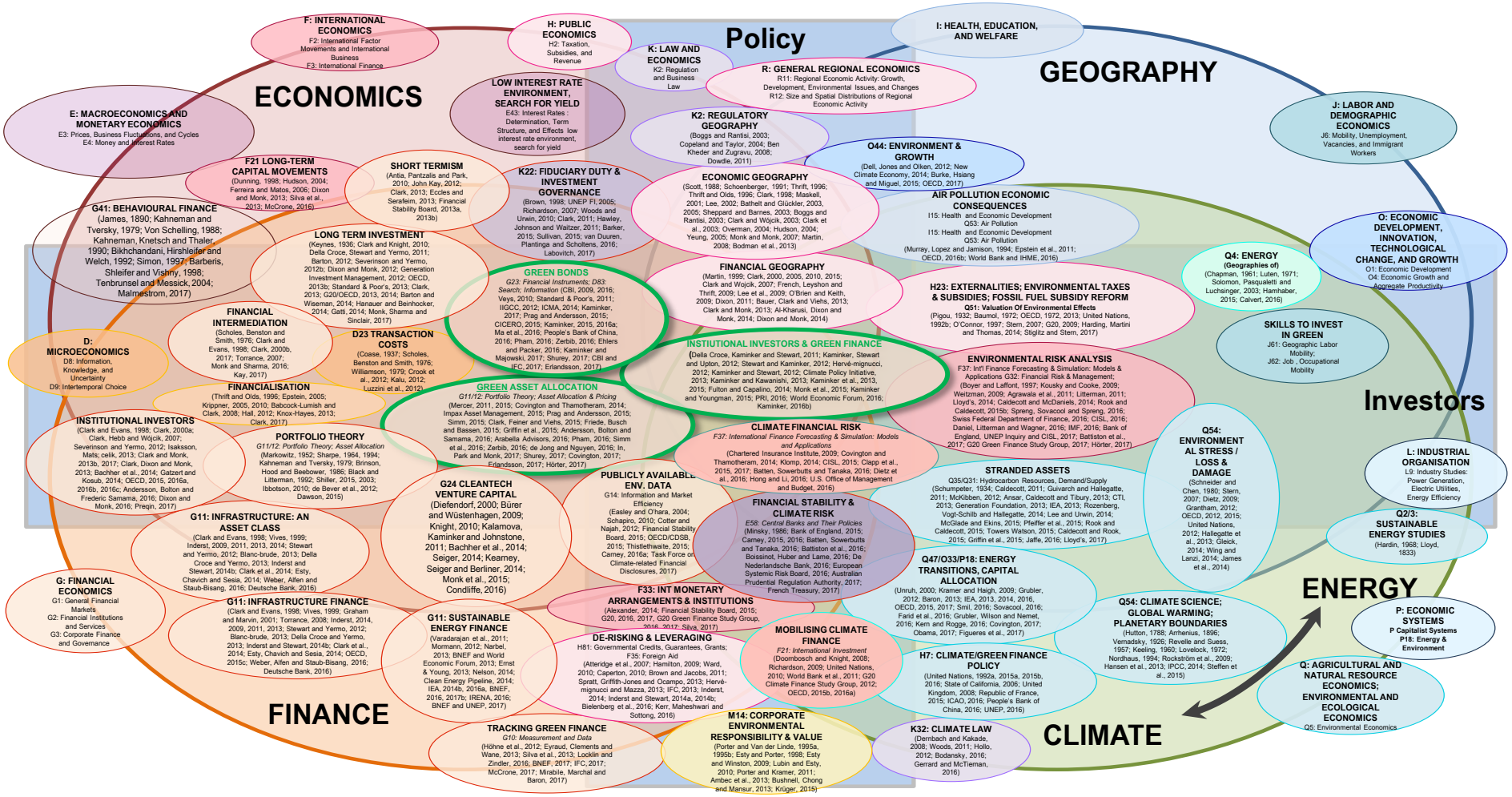
When viewing the role of institutional investors in financing sustainable energy through such a wide-angle lens, the research efforts contained in this thesis can be seen to fit within the four overlapping academic areas of 1) economics; 2) finance; 3) geography; and 4) the nexus between energy (resources and engineering) and climate (climate change science). For the purposes of this research, the domains of energy and climate are considered as a single overlapping field of inquiry due to their unified and intrinsic relationship with the topic of sustainable energy, but also given the interdependencies between these domains as part of a contiguous energy-climate-water-

food nexus (Beddington, 2009; Bazilian *et al.*, 2011; Hussey and Pittock, 2012; Kraucunas *et al.*, 2015).

Using the Journal of Economic Literature (JEL) system of classification (to the extent possible), Figure 6.1 explores how this thesis is situated amongst the individual bodies of existing and emerging literature that are broadly relevant to the subject matters explored herein. This construct moves from higher level disciplines on the margins of the four expansive areas of academic inquiry (in Venn diagram form) inwards to specific bodies of literature and illustrates linkages between the individual bodies of literature and how they relate to the four academic disciplines (through colour coding by parent JEL identifier).

Two cross-cutting thematic domains are drawn out of the thesis chapters and added to the construct to illustrate how the role of A) policy makers (the vertical bar) and B) investors (the horizontal bar), can be seen to intersect with the different bodies of literature. While this literature review does not endeavour to discuss each of the 70 individual bodies of research identified as broadly relevant (in Figure 6.1), it does aim to localise the central research topics examined in this thesis within this larger ecology of academic inquiry.

Figure 6.1 Situating relevant bodies of literature in the context of academic disciplines and cross-cutting themes



Source: Author

6.3 **Economic and financial geography**

Money and finance are basic to the form and operation of the economic landscape, yet traditionally geographers had accorded relatively little attention to the spatialities of financial systems (Thrift, Corbridge and Martin, 1994). The field of financial geography has evolved rapidly over the last 20 years to the point that it has become a sub-discipline of economic geography with a wide range of dimensions and perspectives (Leyshon, 1995, 1997, 2000; Martin, 1999; Ferreira and Matos, 2006; Clark and Wojcik, 2007; French, Leyshon and Thrift, 2009; Hall, 2012).

Considerations of scale are paramount to this thesis. As stated by Clark et al. (2009, p. 725), 'economic geographies are big but financial geographies dwarf them'. Updating the comparison made by Clark et al. (2009), the notional value of financial derivatives has risen from USD 81 trillion in 1998, less than three times world GDP, to USD 605 trillion (around 10 times GDP) by 2010. This issue of scale is reflected on the project side too. The challenge of scaling-up sustainable energy technologies is sometimes compared to the 1960's Space Race (Mormann, 2012). In his 2011 State of the Union address, President Obama (2011) referred to America's pressing energy challenges as 'our generation's Sputnik moment.' Indeed, there are striking parallels between the Space Race and the 'Race to Renewables', beginning with the shared need for technological innovation at an unprecedented scale (see for example IEA (2015) for sustainable energy or Tran et al. (2012) for sustainable transport).

The following tables unpack the bodies of literature shown in Figure 6.1 into their constituent literary components, starting with economic geography and financial geography in Table 6.1.

Table 6.1 Economic and Financial Geography

Body of Literature	JEL Codes (indicative, as applicable)	Key References
R: REGIONAL ECONOMICS	R: Regional General Economics	
ECONOMIC GEOGRAPHY	R11: Regional Economic Activity: Growth, Development, Environmental Issues, and Changes R12: Size and Spatial Distributions of Regional Economic Activity	(Scott, 1988; Schoenberger, 1991; Thrift, 1996; Thrift and Olds, 1996; Clark, 1998a; Maskell, 2001; Lee, 2002; Bathelt and Glückler, 2003, 2005; Sheppard and Barnes, 2003; Boggs and Rantisi, 2003; Clark and Wójcik, 2003; Clark *et al.*, 2003; Overman, 2004; Hudson, 2004; Yeung, 2005; Monk and Monk, 2007; Martin, 2008; Bodman *et al.*, 2013)
FINANCIAL GEOGRAPHY	R12: Size and Spatial Distributions of Regional Economic Activity	(Martin, 1999; Clark, 2000b, 2005, 2010, 2015; Clark and Wojcik, 2007; French, Leyshon and Thrift, 2009; Lee *et al.*, 2009; O'Brien and Keith, 2009; Dixon, 2011; Bauer, Clark and Viehs, 2013; Clark and Monk, 2013a; Al-Kharusi, Dixon and Monk, 2014; Dixon and Monk, 2014)

Source: Author

6.4 Institutional investors, infrastructure finance and financial theory

A key conceptual link to be made is that the geography of finance is concerned with institutions of finance, and consequently the interplay between institutional investors with financial markets and the world of investment opportunities (Clark and Wojcik, 2007; Clark, 2017). Institutional investors are central actors in economic and financial geography (Clark, 2000a) but their characteristics and activities are also the topic of many other areas of research as shown in Table 6.2.

An institutional approach to economic geography was elaborated by Martin (2008) in which investors fit into an economic landscape framed by institutional environments (from customs, norms, routines to the formal structure of rules and regulations) and

arrangements. These arrangements are organisational forms that evolve 'dialectically' (Dixon, 2011) from the environment and comprise the investors themselves, the entire ecosystem that exists around them including regulators, financial intermediaries and servicers (Monk and Sharma, 2015), and the financial theory that seeks to explain their behaviour.

In its most direct sense, this thesis contributes to an emerging policy literature on the role of institutional investors in financing green growth and sustainable energy through providing in depth academic research that had hitherto not been conducted. This niche can be seen to fit within a more established area of both academic and policy literature which has focused on the role of institutional investors in financing all types of infrastructure. Infrastructure and project finance is an adjoining area of finance research which has emerged alongside the widespread privatisation of infrastructure initiatives of the 1980s and 1990s.

Whilst this research aims to be cognizant of the relevant aspects of the ongoing debate over the roles and merits of public and private infrastructure investment (Klein and Roger, 1994; Daniels and Trebilcock, 1996; Clark and Evans, 1998; Kessides, 2005; Clark *et al.*, 2014; Esty, Chavich and Sesia, 2014), this thesis draws its boundaries at the door of the debate, and instead turns to the more recent policy and emergent academic literature on private investment in sustainable energy infrastructure, which has drawn increasing research attention; commensurate with the USD 2.3 trillion of investments that have been made in sustainable energy since 2004 (BNEF and UNEP, 2017).

This area of research, conducted mostly by private sector institutions such as investment banks and research providers (e.g. BNEF) as well as NGOs and international organisations, examines the trends, actors and characteristics of private financing of

sustainable energy and the policy circumstances under which it occurs. However, as previously stated, one connection that had been largely absent from formal research is that of how institutional investors participate in this financing ecosystem. A possible exception is the area of 'cleantech venture capital' (described in Table 6.2), which has a fairly vibrant academic research basis that could be attributed to interest in the rapid rise and fall of this type of investment activity in the 2000s (Knight, 2010; Bachher *et al.*, 2014; Gaddy, Sivaram and O'Sullivan, 2016). Although while examining the role of institutional investors in financing early stage *corporate* sustainable energy ventures is of great importance (as discussed in the implications for research in Chapter 15), the chapters of this thesis that follow aim away from this area, and instead are directed at the nexus of direct and intermediated institutional investment in sustainable energy *projects*.

An exploration of the role of institutional investors cannot be complete without being informed by the literature on portfolio theory and asset allocation. The rise of modern financial markets has been accompanied by a plethora of capital asset pricing models, the Black-Scholes option-pricing theorems, the arguments for and against modern portfolio theory and the efficiency of financial markets (Markowitz, 1952; Sharpe, 1964, 1994; Kahneman and Tversky, 1979; Brinson, Hood and Beebower, 1986; Black and Litterman, 1992; Shiller, 2015, 2003; Ibbotson, 2010; de Bever *et al.*, 2012; Dawson, 2015).

From amongst the work of these august mainstream financial theorists, a nascent strand of research into 'infrastructure as an asset class' (Weber and Alfen, 2010) has stretched out to bridge the areas of infrastructure finance, institutional investment and portfolio theory. Closely related are research efforts into how green investments,

including sustainable energy, perform from a risk-return basis within institutional investor's portfolios.

This work on 'green asset allocation' can come in the form of horizontal 'cross-asset' views of how instruments perform within portfolios, from equities (Clark, Feiner and Viehs, 2015; In, Park and Monk, 2017) to regular, as well as green bonds (Pham, 2016; Hörter, 2017; Shurey, 2017). The work has also begun to inspect vertical dimensions related to how portfolios might be affected by climate risk (Mercer, 2011, 2015; Covington and Thamotheram, 2014; Covington, 2017), or how portfolios may be designed to achieve certain types of goals such as decarbonisation (Griffin *et al.*, 2015), hedging against climate risk (Andersson, Bolton and Samama, 2016a; Simm *et al.*, 2016) or positioning for 'green alpha' outperformance (Simm, 2015; Erlandsson, 2017).

In the context of sustainable finance, much attention has been focused on environmental, social and governance (hereafter, ESG) factors, their materiality and impact on investment attributes.

ESG factors, broadly defined, include material financial issues which impact the bottom line of a company but which may not easily be modelled in a financial statement (Hopwood 2009). The important characteristic of ESG issues is that they refer to explanatory variables which have been demonstrated to impact on financial performance (Friede, Busch and Bassen, 2015; Kotsantonis, Pinney and Serafeim, 2016; In, Park and Monk, 2017). Although there is no comprehensive list of issues, the relevance of ESG factors to financial performance has been discussed in the literature in the context of management decisions (Hendry et al. 2007), environmental factors like climate risk (Daniel, Litterman and Wagner, 2016; Hong and Li, 2016) or resource efficiency (Gunningham et. al 2003; Derwall et al. 2005; Esty & Winston 2006), corporate

governance jurisdictions (Bauer et.al 2008) and social impacts (Orlitzky et. al 2003). The literature on fiduciary duty, investment governance and ESG factors has emerged over the last decade in this respect (Brown, 1998; Clark, 2011; Hawley, Johnson and Waitzer, 2011; Sullivan, 2015) as investors have evolved beyond mere permission or encouragement, to in some cases requirement, to take ESG matters into account when developing or reviewing their investment policy (Labovitch, 2017).

Table 6.2 Institutional Investors, Infrastructure Finance, Portfolio Theory

Body of Literature	**JEL Codes (as applicable)**	**Key References**
FINANCIAL ECONOMICS	G1: General Financial Markets G2: Financial Institutions and Services G3: Corporate Finance and Governance	
INSTIUTIONAL INVESTORS	G23: Non-bank Financial Institutions, Financial Instruments, Institutional Investors G22: Insurance Companies	(Clark and Evans, 1998; Clark, 2000a; Clark, Hebb and Wójcik, 2007; C. Severinson and Yermo, 2012a; Isaksson, Mats; celik, 2013; Clark and Monk, 2013c, 2017; Clark, Dixon and Monk, 2013; Bachher *et al.*, 2014; Gatzert and Kosub, 2014; OECD, 2015d, 2016b, 2016c, 2016d; Andersson, Bolton and Samama, 2016b; Dixon and Monk, 2016; Preqin, 2017)
INRASTRUCTURE & PROJECT FINANCE	G11: Investment Decisions	(Clark and Evans, 1998; Vives, 1999; Graham and Marvin, 2001; Torrance, 2008; Inderst, 2014, 2009, 2011, 2013; Stewart and Yermo, 2012; Blanc-brude, 2013; Della Croce and Yermo, 2013; Inderst and Stewart, 2014b; Clark *et al.*, 2014; Esty, Chavich and Sesia, 2014; OECD, 2015c; Weber, Alfen and Staub-Bisang, 2016; Deutsche Bank, 2016)
SUSTAINABLE ENERGY FINANCE	G11: Investment Decisions	(Varadarajan *et al.*, 2011; Mormann, 2012; Narbel, 2013; BNEF and World Economic Forum, 2013; Ernst & Young, 2013; Nelson, 2014; Clean Energy

		Pipeline, 2014; IEA, 2014b, 2016a, BNEF, 2016, 2017b; IRENA, 2016; BNEF and UNEP, 2017)
INSTIUTIONAL INVESTORS & GREEN FINANCE	G23: Non-bank Financial Institutions, Financial Instruments, Institutional Investors G22: Insurance Companies	(Della Croce, Kaminker and Stewart, 2011; Kaminker, Stewart and Upton, 2012; Stewart and Kaminker, 2012; Hervé-mignucci, 2012; Kaminker and Stewart, 2012; Climate Policy Initiative, 2013; Kaminker and Kawanishi, 2013; Kaminker *et al.*, 2013, 2015; Fulton and Capalino, 2014; Monk *et al.*, 2015; Kaminker and Youngman, 2015; PRI, 2016; World Economic Forum, 2016; Kaminker, 2016b)
PORTFOLIO THEORY	G11: Portfolio Theory and Choice; Asset Allocation	(Markowitz, 1952; Sharpe, 1964, 1994; Kahneman and Tversky, 1979; Brinson, Hood and Beebower, 1986; Black and Litterman, 1992; Shiller, 2015, 2003; Ibbotson, 2010; de Bever *et al.*, 2012; Dawson, 2015)
INFRASTRUCTURE: AS AN ASSET CLASS	G11: Portfolio Theory and Choice; Asset Allocation	(Clark and Evans, 1998; Vives, 1999; Inderst, 2009, 2011, 2013, 2014; Stewart and Yermo, 2012; Blanc-brude, 2013; Della Croce and Yermo, 2013; Inderst and Stewart, 2014b; Clark *et al.*, 2014; Esty, Chavich and Sesia, 2014; Weber, Alfen and Staub-Bisang, 2016; Deutsche Bank, 2016)
GREEN ASSET ALLOCATION / RISK/RETURN	G11: Portfolio Theory and Choice; Asset Allocation	(Mercer, 2011, 2015; Covington and Thamotheram, 2014; Impax Asset Management, 2015; Prag and Andersson, 2015; Simm, 2015; Clark, Feiner and Viehs, 2015; Friede, Busch and Bassen, 2015; Griffin *et al.*, 2015; Andersson, Bolton and Samama, 2016a; Arabella Advisors, 2016; Pham, 2016; Simm *et al.*, 2016; Zerbib, 2016; de Jong and Nguyen, 2016; In, Park and Monk, 2017; Shurey, 2017; Covington, 2017; Erlandsson, 2017; Hörter, 2017)
ESG & VALUE	M14: Corporate Environmental Responsibility & Value	(Porter and Van der Linde, 1995a, 1995b; Esty and Porter, 1998; Esty and Winston, 2009; Lubin and Esty, 2010; Porter and Kramer, 2011; Ambec *et al.*, 2013; Bushnell, Chong and Mansur, 2013; Eccles and Serafeim, 2013; Friede, Busch and Bassen, 2015; Krüger, 2015; van

		Duuren, Plantinga and Scholtens, 2016; In, Park and Monk, 2017)
CLEANTECH VENTURE CAPITAL	G24: Venture Capital	(Diefendorf, 2000; Bürer and Wüstenhagen, 2009; Knight, 2010; Kalamova, Kaminker and Johnstone, 2011; Marcus, Malen and Ellis, 2013; Bachher *et al.*, 2014; Seiger, 2014; Kearney, Seiger and Berliner, 2014; Monk *et al.*, 2015; Condliffe, 2016; Gaddy, Sivaram and O'Sullivan, 2016)

Source: Author

6.5 Finance and innovation across time horizons

The topics of financialisation, financial intermediation and investment across time horizons are fundamental to the role of institutional investors, especially those with multi-generational liabilities. The literature on long-term investment stretches back at least to Chapter 12 on the 'State of Long Term Expectation' of John Maynard Keynes' *General Theory of Employment, Interest and Money*. Research projects geared at 'focusing capital on the long-term' (Barton and Wiseman, 2014) and overcoming the phenomenon of short-termism in financial markets (John Kay, 2012; Clark, 2013) accelerated after the 2007-2008 financial crisis, and is especially relevant to the work in Chapter 7.

A connected area of research that has emerged as a tributary of the scholarship on long-term international capital flows (Dunning, 1998; Hudson, 2004) is that of 'mobilised climate finance'. These types of capital flows, which are targeted under the auspices of the UNFCCC (United Nations, 1992a) at climate change mitigation and adaptation infrastructure, are fundamentally geographical due to their 'North-South' directional flows, and also contain commitments from institutional investors (Buchner *et al.*, 2011; World Bank *et al.*, 2011; OECD, 2015b, 2016a).

Financialisation, or the process by which financial institutions, markets, instruments, evolve and increase in size and influence (Epstein, 2005; Knox-Hayes, 2013), is a central theme in this thesis along with the related concepts of financial intermediation (Scholes, Benston and Smith, 1976; Clark, 2017; Monk, Sharma and Sinclair, 2017) and product innovation (Clark and Monk, 2013c; Knight and Sharma, 2015; Monk *et al.*, 2015). The analysis and discussions in Chapters 8-9 on in-sourcing of investment management and direct investment by institutional investors, YieldCos and aligned-intermediary fund models, and the rapid evolution of the green bond market examined in Chapters 11-12 are all informed by, and discuss the confluences of these literatures that most closely relate to them.

Table 6.3 Finance and innovation across time horizons

Body of Literature	**JEL Codes (as applicable)**	**Key References**
F: INTERNATIONAL ECONOMICS / G: FINANCIAL ECONOMICS	F2: International Factor Movements and International Business F3: International Finance	
LONG TERM INVESTMENT	F21 International Investment / Long-Term Capital Movements	(Keynes, 1936; Clark and Knight, 2010; Della Croce, Stewart and Yermo, 2011; Barton, 2012; Generation Investment Management, 2012; C. Severinson and Yermo, 2012b; Dixon and Monk, 2012; OECD, 2013b; Standard & Poor's, 2013; Clark, 2013; G20/OECD, 2013, 2014; Barton and Wiseman, 2014; Hanauer and Beinhocker, 2014; Gatti, 2014; Monk, Sharma and Sinclair, 2017)
INTERNATIONAL FINANCIAL FLOWS	F21 International Investment / Long-Term Capital Movements	(Dunning, 1998; Hudson, 2004; Ferreira and Matos, 2006; Silva *et al.*, 2013; Dixon and Monk, 2014; McCrone, 2016)
MOBILISING CLIMATE FINANCE	F21 International Investment / Long-	(Doornbosch and Knight, 2008; Richardson, 2009; United Nations, 2010;

	Term Capital Movements	World Bank *et al.*, 2011; G20, 2012; OECD, 2015b, 2016a)
SHORT TERMISM	F32: Short-Term Capital Movements	(Antia, Pantzalis and Park, 2010; John Kay, 2012; Clark, 2013; Eccles and Serafeim, 2013; Financial Stability Board, 2013a, 2013b)
FINANCIALISATION	E44: Financial Markets and the Macroeconomy	(Thrift and Olds, 1996; Epstein, 2005; Krippner, 2005, 2010; Babcock-Lumish and Clark, 2008; Hall, 2012; Knox-Hayes, 2013; Clark, 2017)
FINANCIAL INTERMEDIATION & INNOVATION	G32: Financing Policy, Capital and Ownership Structure	(Scholes, Benston and Smith, 1976; Clark and Evans, 1998; Clark, 2000b, 2017; Torrance, 2007; Monk and Sharma, 2016; Kay, 2017)

Source: Author

The financial innovation that has occurred in the growth of the green bond market over the last decade can also be better appreciated and understood when viewed through traditional financial market and microeconomic theory. Green bonds are case study in financial product innovation as they were created to fill a hole in the green investment ecosystem for fixed income instruments that fit within the investment portfolios of mainstream institutional investors. In order to reconcile latent and emerging demand from institutional investors for sustainability-themed, ESG-screened investments, the green bond 'label' serves as a discovery mechanism for institutional investors and drawing on concepts from the transaction cost economics literature, helps to lower search costs (Bakos, 1997; Mayers, 1998) associated with identifying green opportunities in a figurative ocean of fixed-income opportunities.

The green bond market has also featured interactions that are meaningful to stakeholder theory (Freeman and McVea, 2001), as market participant-led initiatives such as the Green Bond Principles and Climate Bonds Standard, have arisen to shape and define rules, designs and norms that govern how the market operates. Institutional

investors have also congregated as stakeholders in associations (relevant to the topics in this thesis), such as the Institutional Investor Groups on Climate Change, the Investor Network on Climate Risk, or under the aegis of the UN-supported Principles for Responsible Investment, Carbon Disclosure Project or UNEP-Finance Initiative.

Table 6.4 Green Bonds, Transaction Costs and Stakeholder Theory

Body of Literature	**JEL Codes (as applicable)**	**Key References**
GREEN BONDS	G23: Financial Instruments; D83: Search; Information	(CBI, 2009, 2016; Veys, 2010; Standard & Poor's, 2011; IIGCC, 2012a; ICMA, 2014; Kaminker, 2017; Prag and Andersson, 2015; CICERO, 2015; Kaminker, 2015, 2016a; Ma *et al.*, 2016; People's Bank of China, 2016; Pham, 2016; Zerbib, 2016; Ehlers and Packer, 2016; Kaminker and Majowski, 2017; Shurey, 2017; CBI and IFC, 2017; Erlandsson, 2017)
TRANSACTION COST ECONOMICS	D23: Transaction Costs	(Coase, 1937; Scholes, Benston and Smith, 1976; Williamson, 1979; Crook *et al.*, 2012; Kalu, 2012; Luzzini *et al.*, 2012)
STAKEHOLDER THEORY	L14: Networks	(Mason and Mitroff, 1981; GRI, 1997; Harrison and Freeman, 1999; CDP, 2000; Ruf *et al.*, 2001; Freeman and McVea, 2001; INCR/Ceres, 2003; C40, 2005; Steurer *et al.*, 2005; CBI, 2009; SASB, 2011; IIGCC, 2012b; ICMA, 2014; Climate Policy Initiative, 2014; GIC, 2014; Hörisch, Freeman and Schaltegger, 2014; AODP, 2017)

Source: Author

6.6 Energy & Environmental Physical Attributes, Effects and Economic Interactions

As described in Chapter 7, the space that institutional investors occupy and operate in is affected by environmental change, and how these physical forces interact with the economy and financial system. As such, the literature on climate science is relevant to institutional investors, but the physical impacts of climate stress are even more so as they

come to be manifested in tangible economic loss and damage (United Nations, 2012; Dietz *et al.*, 2016). Other environmental interactions with the economy are pertinent as well, whether in the form of local air pollution as driver of regulatory response (World Bank and IHME, 2016), or how economic growth reacts to environmental change and policy intervention (Copeland and Taylor, 2004; Dell, Jones and Olken, 2012; NCE, 2014; OECD, 2017b).

Given the focus of this thesis on sustainable energy, there are several individual areas of research on this topic that are germane. The geography of energy resources (Luten, 1971) (whether renewable or not) is important for the siting of sustainable energy assets (Hamhaber, 2015), which may or may not be proximate to the sources of institutional capital. The science, engineering and technological deployment prospects of sustainable energy infrastructures (Chu and Majumdar, 2012; Obama, 2017) are closely monitored by institutional investors that may look to make long-term, illiquid asset allocation decisions, or at the other end of the time horizon, to speculate on corporate investments that have growth potential.

As sustainable energy sources decline in cost and as deployment ramps up, the topic of energy transitions, the speed at which they occur and associated technological and market disruption, comes clearly into focus (Schumpeter, 1934; Fouquet, 2016; Kern and Rogge, 2016; Smil, 2016; Energy Transitions Commission, 2017). As a vivid illustration of these dynamics, in 2015, France became the first country to institute an 'Energy Transitions for Green Growth Law' (Republic of France, 2015) that has widespread implications for domestic corporate and investor behaviour.

A growing body of literature examines how investors might better assess 'stranded assets risk' (Caldecott, 2011; Gurria, 2013; Bank of England, 2015) originating through

physical, liability and transition channels (Carney, 2015), and 'rebalance or tilt' their portfolios towards sustainable energy to hedge against these risks. One area that is relatively unexplored (Diaz-Rainey, Robertson and Wilson, 2017; Malmestrom, 2017) but may have great potential for future research, is what insights mainstream behavioural finance theory might be able to provide into investor's interactions with climate and stranded asset risk, as these risks become more prominent.

Out of some of these dynamics, environmental risk analysis has materialized as a spirited and interdisciplinary research discipline. Focused at the level of the firm or individual investor, studies and tools are appearing across different aspects of environmental stress, from applying asset pricing theory to climate risk (Daniel, Litterman and Wagner, 2016) to catastrophe modelling (Lloyd's, 2014) and corporate water risk analysis (Money, 2014). At the system level, studies are emerging looking at inter alia, investors (Clapp *et al.*, 2015, 2017), government budgets (U.S. Office of Management and Budget, 2016), and the financial markets (CTI, 2011; Dietz *et al.*, 2016; Hong and Li, 2016; Lloyd's, 2017).

In recent years, these efforts to develop better understanding as well as practical analytical toolkits has been driven by central banks and international financial institutions (IMF, 2016; Swiss Federal Department of Finance, 2016; Bank of England, UNEP Inquiry and CISL, 2017). The increased attention from central banks can be traced and largely attributed to the ground-breaking analytical work done by the Bank of England under the tenure of Mark Carney. In his capacity as Governor of the Bank of England, a research agenda on climate risk and financial stability was launched starting with the UK insurance sector (Bank of England, 2015).

These efforts were then elevated to the Financial Stability Board (2015), European Systemic Risk Advisory Board (ESRB, 2016), and G20 (2017). Research efforts have since percolated to academic work (Batten, Sowerbutts and Tanaka, 2016; Battiston *et al.*, 2016; Boissinot, Huber and Lame, 2016) as well as other national governmental inquiries into climate risk and financial stability (De Nederlandsche Bank, 2016; Australian Prudential Regulation Authority, 2017; French Treasury, 2017).

As discussed in Chapter 7, climate-related physical risk management in the insurance and reinsurance sectors is relatively sophisticated, but in other sectors, and with regards to other sources of risks (i.e. transition risks), the intellectual reservoir is still at an earlier stage in terms of data availability and quality, tools and methodologies as well as capacities devoted to environmental issues impacting the financial sector. In response to these limitations, a corollary research agenda has emerged focused on enhanced transparency and disclosure of 'publicly available environmental data' (Money, 2015; G20, 2017). Efforts to improve disclosure are being undertaken in particular by the FSB's Task Force on Climate-related Financial Disclosures (TCFD) (Carney, 2016a; Task Force on Climate-related Financial Disclosures, 2017).

Table 6.5 Energy & Environmental Physical Attributes, Effects, Economic and Financial Interactions

Body of Literature	**JEL Codes (indicative, as applicable)**	**Key References**
Q: AGRICULTURAL AND NATURAL RESOURCE ECONOMICS; ENVIRONMENTAL AND ECOLOGICAL ECONOMICS	Q01: Sustainable Development Q3: Nonrenewable Resources Q4: Energy Q5: Environmental Economics	

CLIMATE SCIENCE	Q54: Climate; Global Warming; Planetary Boundaries	(Hutton, 1788; Arrhenius, 1896; Vernadsky, 1926; Revelle and Suess, 1957; Keeling, 1960; Lovelock, 1972; Nordhaus, 1994; Rockström *et al.*, 2009; Hansen *et al.*, 2013; IPCC, 2014; Steffen *et al.*, 2015)
ENVIRONMENTAL LOSS & DAMAGE	Q54: Climate, Natural Disasters and Their Management / Q43: Energy and the Macroeconomy	(Schneider and Chen, 1980; Stern, 2007; Dietz, 2009; Grantham, 2012; OECD, 2012, 2015g; United Nations, 2012; Hallegatte *et al.*, 2013; Gleick, 2014; Wing and Lanzi, 2014; James *et al.*, 2014)
AIR POLLUTION ECONOMIC CONSEQUENCES	Q53: Air Pollution	(Murray, Lopez and Jamison, 1994; Epstein *et al.*, 2011; OECD, 2016f; World Bank and IHME, 2016)
ENVIRONMENT & ECONOMIC GROWTH	O44: Environment and Growth	(Dell, Jones and Olken, 2012; NCE, 2014; Burke, Hsiang and Miguel, 2015; OECD, 2017b)
ENERGY (GEOGRAPHY of)	Q4: Energy	(Chapman, 1961; Luten, 1971; Solomon, Pasqualetti and Luchsinger, 2003; Hamhaber, 2015; Calvert, 2016)
SUSTAINABLE ENERGY TECHNOLOGY	Q2/3: Renewable/Nonrenewable Resources and Conservation Q42: Alternative Energy Sources	(Lloyd, 1833; Hardin, 1968; Smil, 1993, 2000, 2005, 2010; McElroy, 2010; Edenhofer *et al.*, 2011; Chu and Majumdar, 2012; Baron, 2013; Bazilian *et al.*, 2013; IEA, 2017; IRENA, 2013; IEA, 2013, 2014a, 2016b; Farmer and Lafond, 2016; Obama, 2017; BNEF, 2017b)
ENERGY TRANSITIONS	Q47: Energy Transitions, Capital Allocation, and Forecasting	(Unruh, 2000; Kramer and Haigh, 2009; Grubler, 2012; Baron, 2013; IEA, 2013, 2014a, 2016b; NCE, 2014; OECD, 2015a, 2017b; Kern and Rogge, 2016; Smil, 2016; Sovacool, 2016; Farid *et al.*, 2016; Grubler, Wilson and Nemet, 2016; Covington, 2017; Obama, 2017; Energy Transitions Commission, 2017; Figueres *et al.*, 2017)
STRANDED ASSETS	Q35/Q31: Hydrocarbon Resources, Demand/Supply	(Schumpeter, 1934; Caldecott, 2011; Guivarch and Hallegatte, 2011; McKibben, 2012; Ansar, Caldecott and Tibury, 2013; CTI, 2013; Generation Foundation, 2013; IEA, 2013; Rozenberg, Vogt-Schilb and Hallegatte, 2014; Lee and Urwin, 2014; McGlade and Ekins, 2015; Pfeiffer *et al.*, 2015; Rook and Caldecott, 2015a; Towers Watson, 2015; Caldecott and Rook,

		2015; Griffin *et al.*, 2015; Jaffe, 2016; Lloyd's, 2017)
BEHAVIORAL FINANCE	G41: Role and Effects of Psychological, Emotional, Social, and Cognitive Factors on Decision Making in Financial Markets	(James, 1890; Kahneman and Tversky, 1979; Von Schelling, 1988; Kahneman, Knetsch and Thaler, 1990; Bikhchandani, Hirshleifer and Welch, 1992; Simon, 1997; Barberis, Shleifer and Vishny, 1998; Tenbrunsel and Messick, 2004; Malmestrom, 2017)
F: INTERNATIONAL ECONOMICS / G: FINANCIAL ECONOMICS	F2: International Factor Movements and International Business F3: International Finance	
ENVIRONMENTAL RISK ANALYSIS	G32: Financial Risk and Management, Tools and Models	(Boyer and Laffont, 1997; Kousky and Cooke, 2009; Weitzman, 2009; Agrawala *et al.*, 2011; Litterman, 2011; Lloyd's, 2014; Money, 2014; Caldecott and McDaniels, 2014a; Rook and Caldecott, 2015b; Spreng, Sovacool and Spreng, 2016; Swiss Federal Department of Finance, 2016; CISL, 2016; Daniel, Litterman and Wagner, 2016; IMF, 2016; Bank of England, UNEP Inquiry and CISL, 2017; Battiston *et al.*, 2017; G20, 2017; Hörter, 2017)
CLIMATE FINANCIAL RISK	G32: Financial Risk and Management	(Chartered Insurance Institute, 2009; Covington and Thamotheram, 2014; Klomp, 2014; CISL, 2015; Clapp *et al.*, 2015, 2017; Batten, Sowerbutts and Tanaka, 2016; Dietz *et al.*, 2016; Hong and Li, 2016; U.S. Office of Management and Budget, 2016)
CLIMATE RISK & FINANCIAL STABILITY	G32: Financial Risk and Management F37: International Finance Forecasting & Simulation E58: Central Banks and Their Policies,	(Minsky, 1986; Bank of England, 2015; Carney, 2015, 2016b; Batten, Sowerbutts and Tanaka, 2016; Battiston *et al.*, 2016; Boissinot, Huber and Lame, 2016; De Nederlandsche Bank, 2016; ESRB, 2016; Australian Prudential Regulation Authority, 2017; French Treasury, 2017)
PUBLICLY AVAILABLE	G14: Information and Market Efficiency	(Easley and O'hara, 2004; Engels, 2009; Hopwood, 2009; Schapiro, 2010; Lovell and MacKenzie, 2011; Cotter and

ENVIRONMENTAL DATA		Najah, 2012; Eccles and Krzus, 2014; OECD/CDSB, 2015; Thistlethwaite, 2015; Financial Stability Board, 2015; Money, 2015; Carney, 2016a; Eccles and Youmans, 2016; Task Force on Climate-related Financial Disclosures, 2017)
TRACKING GREEN FINANCE	G10: Measurement and Data	(Höhne *et al.*, 2012; Eyraud, Clements and Wane, 2013; Silva *et al.*, 2013; Locklin and Zindler, 2016; BNEF, 2017a; IFC, 2017; McCrone, 2017; Mirabile, Marchal and Baron, 2017)

Source: Author

6.7 Environmental Policy and Government Intervention

In the same way that institutional investors are affected by physical aspects of the environment, they are also impacted by policy and government regulation and interventions that respond to environmental challenges. The literature on regulatory geography gives explanations for how geographic differences in institutional investor form and structure can stem from financial and prudential regulations (B. C. Severinson and Yermo, 2012; Inderst, 2014), while also providing an intellectual framework for understanding why some geographic patterns of investment may occur in jurisdictions that have for instance, stringent or lax environmental regulations (Ben Kheder and Zugravu, 2008; Hascic and Cardenas, 2014) or favourable policy support for sustainable energy (Kaminker and Stewart, 2012; OECD, 2015a; IEA, 2016a; IRENA, 2016).

Climate and green finance policy can be administered at the international, regional, national or local levels, but all will have some bearing on the framework conditions and enabling environment for institutional investment in sustainable energy. A central feature of such policies is often the internalisation of negative environmental externalities (Pigou, 1932; Baumol, 1972; OECD, 1972) through various instruments of carbon pricing, energy

taxation or removal of fossil fuel subsidies (OECD, 2013a; Stiglitz and Stern, 2017). These interventions will influence the economics of the sustainable energy investments made by institutional investors, along with polluting alternatives. Another stream of research identifies barriers to low-carbon investment, and analyses the potential for innovative financial instruments and tools to use limited public funds to catalyse or de-risk private investment in support of climate action. Chapter 10 is intended as a contribution to this body of literature.

Table 6.6 Environmental Policy and Government Intervention

Body of Literature	**JEL Codes (indicative, as applicable)**	**Key References**
K: LAW AND ECONOMICS	K2:Regulation and Business Law, K3: Other Substantive Areas of Law	
REGULATORY GEOGRAPHY	K32: Energy, Environmental Law	(Boggs and Rantisi, 2003; Copeland and Taylor, 2004; Ben Kheder and Zugravu, 2008; Dowdle, 2011)
CLIMATE LAW	K32: Energy, Environmental Law	(Dernbach and Kakade, 2008; Woods, 2011; Hollo, 2012; Bodansky, 2016; Gerrard and McTiernan, 2016)
FIDUCIARY DUTY & INVESTMENT GOVERNANCE	K22: Business & Securities Law; G34: Corporate Governance	(Brown, 1998; UNEP FI, 2005; Richardson, 2007; Woods and Urwin, 2010; Clark, 2011; Hawley, Johnson and Waitzer, 2011; Barker, 2015; Sullivan, 2015; van Duuren, Plantinga and Scholtens, 2016; Labovitch, 2017)
H: PUBLIC ECONOMICS	H2: Taxation, Subsidies, and Revenue	
ENVIRONMENTAL EXTERNALITIES	H23: Externalities; Environmental Taxes and Subsidies; Q51: Valuation Of Environmental Effects	(Pigou, 1932; Baumol, 1972; OECD, 1972, 2013a; United Nations, 1992b; O'Connor, 1997; Stern, 2007; G20, 2009; Harding, Martini and Thomas, 2014; Stiglitz and Stern, 2017)

CLIMATE & GREEN FINANCE POLICY	H7: State and Local Government, Intergovernmental Relations K32: Energy, Environmental Law	(United Nations, 1992a, 2015a, 2015b, 2016; State of California, 2006; United Kingdom, 2008; Republic of France, 2015; ICAO, 2016; People's Bank of China, 2016; UNEP, 2016)
DE-RISKING / LEVERAGING PRIVATE CLIMATE FINANCE	H81: Governmental Credits, Guarantees, Grants	(Atteridge *et al.*, 2007; Hamilton, 2009; Ward, 2010; Caperton, 2010; Brown and Jacobs, 2011; Spratt, Griffith-Jones and Ocampo, 2013; Hervé-mignucci and Mazza, 2013; IFC, 2013; Inderst, 2014; Inderst and Stewart, 2014a, 2014b; Bielenberg *et al.*, 2016; Kerr, Maheshwari and Sottong, 2016)

Source: Author

6.8 Background Literature to the Policy Recommendations

The recommendations in Chapter 14 have some origins in lessons learned from OECD case studies of institutional investment in green infrastructure (Kaminker *et al.*, 2013), which provided confirmation for some of the OECD's previous policy recommendations to encourage green investments by institutional investors. For example, the note drafted for the G20 on Pension Fund Financing for Green Infrastructure and Initiatives (Kaminker and Stewart, 2012) offered recommendations to policy makers.

From a much broader perspective, at the G20 Leaders' Summit in St Petersburg in September 2013, G20 Leaders endorsed the High-Level Principles on Long-Term Investment Financing by Institutional Investors (G20/OECD, 2013), thereby recognising the importance of establishing conditions that could promote the role of institutional investors as sources of long-term investment financing, including for sustainable energy infrastructure. At the same time, G20 Leaders asked their Finance Ministers and Central Bank Governors to identify approaches to effectively implement the Principles, working

with the OECD and other interested participants by the next Leaders' Summit, in November 2014 in Brisbane, Australia (G20/OECD, 2014a and 2014b).

The recommendations are consistent with this broader initiative and draw on some of the analysis and principles of most relevance. Looking specifically at investment policy for infrastructure, OECD Investment Policy Reviews (IPRs) are an example of work that uses an investment policy lens to assess policy frameworks for sustainable energy investment. The OECD has undertaken IPRs based on the OECD Policy Framework for Investment in nearly 30 countries (OECD, 2006) and aim to help host governments assess and reform their investment regimes. In the recent past, they have increasingly focused on green investment at the request of partner countries, and notably on sustainable energy investment.

Drilling down to the sub-category of sustainable energy within infrastructure investment, and building on the OECD Policy Framework for Investment (OECD, 2006), on the paper 'Towards a Green Investment Policy Framework' (Corfee-morlot *et al.*, 2012), and on other OECD guidance and policy instruments; the OECD Policy Guidance for Investment in Clean Energy Infrastructure is a non-prescriptive tool to help governments – particularly in developing and emerging countries – identify ways to mobilise private investment in clean energy infrastructure (OECD, 2015). It goes into greater depth on the 'investment policy' element of the Green Investment Policy Framework, focusing on energy infrastructure questions and raising issues for policy makers' consideration in key areas relevant to institutional investment.

Another consideration for the development of a robust domestic framework for sustainable energy investment is the prevalence and effects of international trade and investment restrictions. In the post-crisis recovery context, the perceived potential of

sustainable energy to promote growth and employment has led several governments to design policies aimed at supporting domestic manufacturers. The OECD report Overcoming Barriers to International Investment in Clean Energy aims to take stock of policy measures that could hamper international trade and investment in sustainable energy, with a focus on solar PV and wind energy. These measures include local content requirements, preferential access to financing and technical barriers to trade (OECD, 2015). The report will assess possible impacts of such measures across the solar PV and wind energy value chains, and discuss policy options.

Cutting through all of these issues, another OECD case study examines the role of Public Finance Institutions (such as the European Investment Bank, KfW and others) in financing the transition to a low-carbon, climate-resilient economy in OECD countries (Cochran *et al.*, 2014): And finally, Eklin, et al. (2014, 2016) reviews how 'green investment banks' (GIBs) have sought to mobilise capital from institutional investors.

Table 6.7 OECD and G20 initiatives on long-term investors and infrastructure investment, and contributions to policy recommendations to facilitate investment in sustainable energy

Initiative or report	Description	Contributions
Case studies of Institutional Investment in Green Infrastructure (Kaminker *et al.*, 2013)	The report examines the channels through which institutional investors can access green infrastructure, assesses the extent to which this is currently happening, and identifies the barriers to scaling up these investment flows. The report examines positive factors that facilitated these deals, how barriers were overcome and draws out broader lessons for governments on the policy settings which may support investment in green	The report provides policy guidance on a number of key actions which governments can take to address the barriers and facilitate institutional investors' investment in green infrastructure projects. The report was submitted and annexed to the G20 Finance Ministers and Central Governors' meeting on 10-11 October 2013.

	infrastructure by institutional investors.	
G20/OECD High-Level Principles on Long-Term Investment Financing by Institutional Investors, and Effective Approaches to the Implementation of the Principles (G20/OECD, 2013, 2014)	The principles address regulatory and institutional impediments to long-term investment by institutional investors and aim to avoid interventions that may distort the proper functioning of markets.	The principles are intended to help governments facilitate and promote long-term investment by institutional investors, particularly among institutions such as pension funds, insurers and sovereign wealth funds, that typically have long duration liabilities and consequently can consider investments over a long period.
OECD Policy Guidance for Investment in Clean Energy Infrastructure (OECD, 2015f)	The policy guidance raises issues in a non-prescriptive manner for policymakers' consideration in the areas of investment policy; investment promotion and facilitation; and competition, financial market and public governance policies.	The policy guidance is intended to assist policymakers in developing and emerging economies to address investment barriers and identify ways to mobilise private investment in renewable energy and energy efficiency in the electricity sector. The report was submitted and annexed to the G20 Finance Ministers and Central Governors' meeting on 10-11 October 2013.
Green Investment Policy Framework (Corfee-morlot *et al.*, 2012)	The report develops elements of a Green Investment Policy Framework to help governments create and improve domestic enabling conditions to shift and scale-up private sector investments in green infrastructure	The policy framework can guide domestic reforms to steer use of limited public funds while also enabling and incentivising private investment to simultaneously deliver climate change and local development goals.
Overcoming Barriers to International Investment in Clean Energy (OECD, 2015e)	The report takes stock of policy measures that may distort international competition and hamper international investment in solar photovoltaic (PV) and wind energy value chains, with a focus on local content requirements.	The report provides policymakers with evidence-based analysis to guide their decisions, with the view of optimising policy support to green energy and levelling the playing field for international investment in green energy.
Public Finance Institutions in Financing the Low Carbon Transition	The report analyses the role of five public finance institutions (PFIs) in fostering the low-carbon energy	The study provides policymakers with analysis on key tools and instruments currently used by PFIs to

(Cochran *et al.*, 2014)	transition through domestic climate finance activities.	mobilise private sector investment, principally in OECD countries, in three areas of activity: 1. facilitating access to long-term financing, 2. reducing project and financial risks, and 3. filling the capacity gap.
Green investment banks (Eklin, Kaminker and Youngman, 2014; Eklin and Youngman, 2016)	The green investment bank initiative takes stock of green investment banks, and examine what they do, the reasons for their establishment, what they have in common, and how they vary.	This report provides the first comprehensive study of publicly capitalised green investment banks (GIBs), analysing the rationales, mandates and financing activities of this relatively new category of public financial institution. Based on the experience of over a dozen GIBs and GIB-like entities, the report provides a non-prescriptive stock-taking of the diverse ways in which these public institutions are catalysing private investment

7. THE SPACE OF INSTITUTIONAL INVESTORS IN FINANCING SUSTAINABLE ENERGY

Like one that draws the model of a house
Beyond his power to build it; who, half through,
Gives o'er and leaves his part-created cost
A naked subject to the weeping clouds
And waste for churlish winter's tyranny.

William Shakespeare

Second Part of King Henry IV (1596-1599)

(Act I, Scene iii)

7.1 Introduction

This chapter discusses the space in which institutional investors operate, in the greater context of the financing of sustainable energy. The chapter begins with a review of the rationale for investment in sustainable energy infrastructure and explores the financing needs and economic opportunities for the transition to sustainable energy provision. The chapter proceeds to highlight the strained financing capacity of governments, utilities and banks for sustainable energy project finance. Practical information is provided on the financial capabilities of institutional investors, as well as an examination of how their assets are allocated and their investment decisions are made internally. The barriers to institutional investment in sustainable energy are then explored, with an interlude on the emerging topic of 'stranded assets', and concluding with a discussion on how the demand for institutional investment may be strengthened. Elements of this work were published in 2015 and 2016 as G20 Finance Minister and Central Bank Governors deliverables under the Turkish and Chinese G20 Presidencies (Kaminker *et al.*, 2015; Kaminker, 2016b).

7.2 Climate change and the need to shift to low-carbon investment

In the Paris Agreement adopted in December 2015 by the 21st Conference of the Parties to the United Nations Framework Convention on Climate (COP21), Parties agreed to hold the increase in the global average temperature to well below 2°C and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels. Parties also agreed to make 'finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development' (United Nations, 2015a, sec. Article 2(c)).

Global investments in infrastructure will have a major impact on whether climate targets can be achieved, as they can 'lock-in' future emission levels. According to the OECD, unless CO_2 emissions are reduced, climate change could curb global GDP by 1.5% by 2060 and by nearly 6% in South and South-East Asia (OECD, 2014a). Given the long lifespan of infrastructure, failure to invest in the right type of infrastructure in the next 10 to 15 years would either lock the world into a GHG-intensive development pathway or risk stranding many assets. It would also imply serious and probably irreversible risks, not only of environmental damage, but also of financial instability that harms economic growth prospects.

However, it is clear from the OECD's report to the G20 'Investing in Climate, Investing in Growth' (OECD, 2017b) that countries can achieve strong and inclusive economic growth while reorienting their economies towards development pathways with low greenhouse gas emissions and high resilience to the effects of climate change. The report sees potential to increase long-run output by up to 2.8% on average across G20 countries in 2050, with a net effect of nearly 5% if mitigated climate impacts are considered. Importantly, growth impacts are positive in the near-term too: the report sees potential for a net GDP effect of around 1% for G20 economies by 2021.

7.3 Investment needs and incremental costs of 'going low carbon'

Key to the energy transition is the decarbonisation of electricity, including phasing out inefficient coal-fired power plants and unabated coal, the widespread deployment of sustainable energy sources, further development of nuclear power according to country choices, and potentially the development of negative emissions technologies (NETs) such as bio-energy with carbon capture and storage (BECCS) (IEA, 2017).

To address this challenge and seize these opportunities, investments in sustainable energy infrastructure need to be scaled up significantly and shifted from fossil fuels throughout advanced, developing and emerging economies. [4] Underscoring the importance of this, at the 2014 Ministerial Council Meeting, OECD countries invited 'OECD, in co-operation with the IEA, the NEA and the ITF […] to examine how to better align policies across different areas for a successful economic transition of all countries to sustainable low-carbon and climate-resilient economies', culminating in a landmark report (OECD, 2015a) released at the 2015 OECD MCM.

The financial resources required for this transition are substantial. It is generally accepted that an infrastructure investment gap exists and is estimated to be much larger than the increment required to address climate change. Beyond addressing this challenge, these investments will also support the broader sustainable development (United Nations, 2015b), economic, energy security, 'energy access-for all', resource efficiency and green growth agendas.

The OECD (OECD, 2017b) estimates that around USD 95 trillion of investments are needed from 2016 to 2030 in infrastructure (energy, transport, water and telecoms), equating to approximately USD 6.3 trillion per year without taking into account climate concerns. For this infrastructure to be consistent with a 2°C scenario, investment needs will need to reach USD 6.9 trillion per year in the next 15 years, an increase of about 10% in total infrastructure investment from the reference estimate. The additional capital cost is low overall and could be offset over time by fuel savings reaching USD 1.7 trillion per

[4] Underscoring the importance of this, at the 2014 Ministerial Council Meeting, OECD countries invited 'OECD, in co−operation with the IEA, the NEA and the ITF […] to examine how to better align policies across different areas for a successful economic transition of all countries to sustainable low-carbon and climate-resilient economies', culminating in a landmark report (OECD, 2015a) released at the 2015 OECD MCM.

year up to 2030 – further reinforcing the case for robust low-emission economic growth (OECD, 2017b). Green infrastructure typically involves higher up-front investments than traditional infrastructure, but comes with a wider set of returns and benefits.

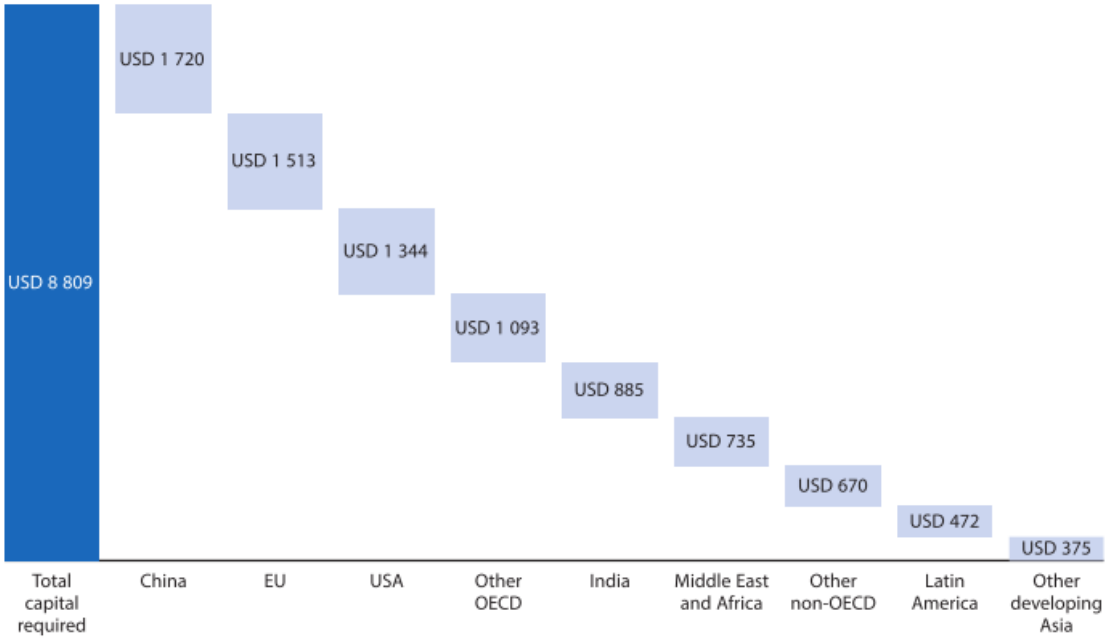
Investing in sustainable energy also makes economic sense. Using a different set of assumptions, the IEA (2014b) presents evidence that the USD 44 trillion[5] in additional investment needed to decarbonise the energy system in line with their '2 degree scenario' by 2050 is more than offset by over USD 115 trillion in fuel savings – resulting in net savings of USD 71 trillion.[6]

In the IEA 2°C scenario, 95% of the electricity would need to be low-carbon and sustainable by 2050, 70% of new cars would be electric, the entire existing building stock would have been retrofitted, and the CO_2 intensity of the industrial sector would be 80% lower than today (IEA, 2017). Specifically for sustainable energy, the IEA (2014b) projects that USD 8.8 trillion in total investment in sustainable energy power plants globally will be required in 2014-35, in order to reduce energy-related emissions by 50% compared to 2005 levels. The IEA affirms that 'private sector participation [including new sources such as institutional investors] is essential to meet investment needs in full' (2014b).

[5] In real 2012 USD, i.e. excluding inflation; includes other infrastructure beyond just sustainable energy

[6] Even with a 10% discount rate, the net savings are more than USD 5 trillion.

Figure 7.1 Sustainable energy investment requirements in the '450 scenario' 2014-35 (USD 2012, billions)



Note: Figures are for power plant investment in: biomass, hydro, onshore and offshore wind, solar PV and 'other renewables'. Figures do not add up due to rounding.

Source: Author (Kaminker *et al.*, 2015) based on IEA data; IEA (2014b).

These figures and estimates suggest that investment for sustainable energy and green infrastructure will need to take place at a far greater scale over coming decades to achieve the aims of the Paris Agreement and the Sustainable Development Goals. Public finance can and does play a critical role to 'jump start', mobilise and guide investment (see Chapter 10), however given that the scale of change required is systemic, not marginal, transformational change will ultimately require access to capital on a scale that only the private sector can provide.

7.4 Sustainable energy deployment on the march

Sustainable energy sources are becoming more cost-competitive every month and deployment is rapidly scaling up. The IEA Medium-Term Renewable Energy Market Report 2016 shows that in 2015, for the first time, renewables accounted for more than

half of net annual additions to power capacity and overtook coal in terms of cumulative installed capacity in the world. Record deployment was accompanied by continued sharp reductions in generation costs, with announced long-term remuneration prices ranging from USD 30/megawatt hours (MWh) to 50/MWh for both onshore wind and solar (photovoltaic, PV) plants. Onshore wind generation costs are expected to decrease by a further 15% on average by 2021, while utility-scale solar PV costs are anticipated to decline by another quarter (IEA, 2016b).

These trends are underpinned by a combination of sustained policy support, technology progress and expansion into newer markets with better renewable resources. The IEA projects that renewables are set to become the leading source of new energy supply from now to 2040 (IEA, 2015). The Global Commission on the Economy and Climate (NCE, 2014) finds that in some markets, the average cost of energy from many sustainable energy sources is approaching that of new conventional generation, when levelised over the life of a new energy project. In 2016, the World Economic Forum found that, the cost of new solar and wind installations is already lower than for coal power in 30 countries (World Economic Forum, 2016). While beyond the scope of this research, future work could look towards a post grid-parity (see glossary) world for sustainable energy and emerging sustainable energy technologies, as many of the technologies are decreasing in cost and increasing in efficiency, some much more rapidly than others, e.g. solar PV (IEA, 2016b). It is also worth noting that investment in grids, transmission and distribution is also needed to compensate for the variability of sustainable energy (IEA, 2016b).

These trends and trajectories were summarised by U.S. President Barack Obama, who became the first sitting U.S President to publish in an academic journal. In an article

in the journal *Science*, entitled 'The irreversible momentum of clean energy' (Obama, 2017)[7] President Obama argued that, inter alia: 'The trend towards a clean energy economy is irreversible', regardless of the different policy choices likely to come from his successor, and that the cost of sustainable energy is plummeting, and 'in some parts of the country is already lower than that for new coal generation, without counting subsidies for renewables'.

A stylised fact (Clark, 1998b) that has been described recently is that as technologies decrease in cost and become less subsidy-dependent, more conservative institutional investors feel more comfortable allocating capital to these projects (Clean Energy Pipeline, 2014). An economic rationale for optimising the capital structure of sustainable energy financing exists (Varadarajan *et al.*, 2011; Bradford and Hoskins, 2013) and places the focus of interventions on lowering the cost of capital for sustainable energy (Nelson and Pierpont, 2013; Nelson, 2014). In a world of low cost components and falling installation and 'soft costs', the cost of financing is the major driver of the long term levelised cost of electricity, particularly for those technologies that do not need fuel, such as most sustainable energy. An estimated 50-70% of the costs of electricity generation for sustainable energy are in the financial cost of capital, with only the balance being the physical or operational costs of the installation (Bradford and Hoskins, 2013; Samadi, 2017). Thus, small changes in the weighted average cost of capital (WACC) can have substantial impact on the levelised cost of a generator.

This provides impetus to identifying mismatches between investor and finance needs and finding solutions to optimising financial structures, even in minor ways, if the

[7] In fact, this article was the second to be published by a sitting U.S. President, Barack Obama's first published article was on advancing criminal justice reform in the Harvard Law Review.

goal is to continue driving down the cost of outputs of these solutions. For instance, the (NCE, 2014) finds that significant, near-term opportunities can reduce the costs of finance by up to 20% for low-carbon energy in all countries through a mix of financial innovation, greater use of national development banks and concessional debt, and increased development capital flows into low-income countries.

7.5 Dynamics of investment financing sources for sustainable energy

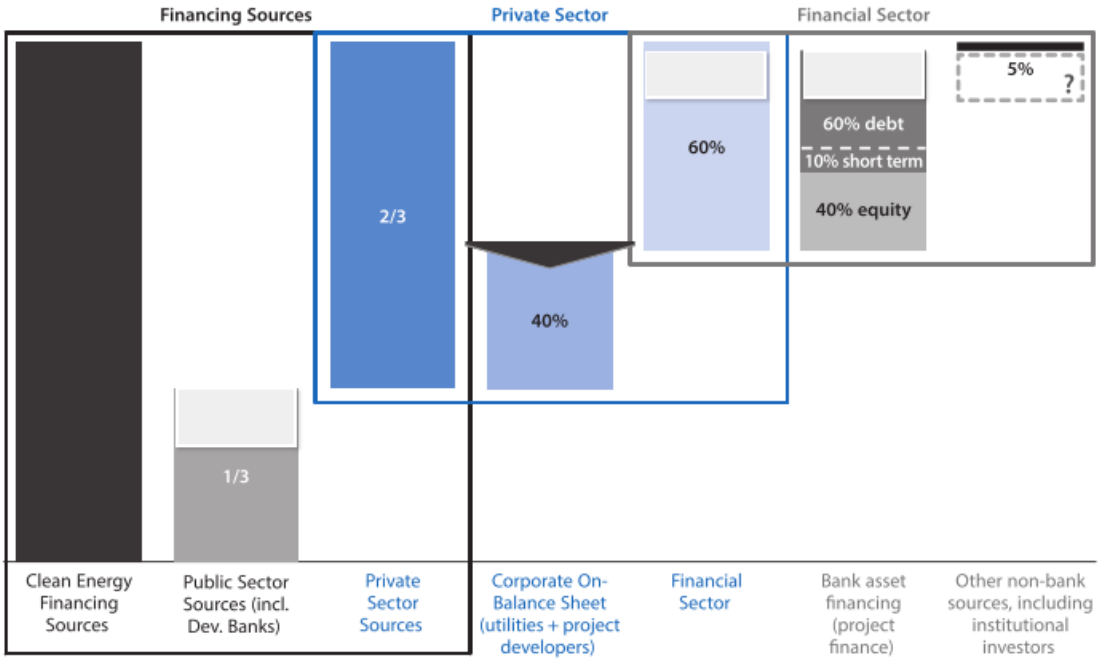
Strategies for closing the financing gap need to consider: a) A policy regime that establishes price incentives and policy coherence; and b) The significant financial, regulatory and structural constraints faced by traditional sources of financing for green infrastructure – governments, corporate actors (e.g. utilities, project developers and others) and the banking sector.

As presented in Figure 7.2 across the OECD the private sector accounts for roughly two-thirds of investment financing (through debt or equity) for sustainable energy infrastructure and public sector sources (i.e. local, regional and national governments, and national development banks) provide the remaining one-third.

In developing countries and emerging economies, the picture would be roughly reversed, with the public and 'quasi-public sector' (state-owned banks and corporations) providing two-thirds of investment financing. As these economies grow, however, so they come under pressure to expand the provision of pensions and healthcare. Demographic trends imply that these systems will require an increasing share of public expenditure creating more competition for capital and scarcer resources for investment finance (Benoit, 1996; Kaminker *et al.*, 2013; IEA, 2014b; Inderst and Stewart, 2014b)

Across the OECD, the private sector share is divided between corporate sources such as electric utility companies (40%) and the financial sector (60%). Bank financing, such as project financing consists of approximately 60% debt and 40% equity and accounts for roughly 95% of the financial sector's contribution and mostly consists of long-term loans. There is significant variation among countries; however, the 60% of investment transactions in non-hydro sustainable energy in 2013 that disclosed financial information to BNEF shows that financing of capital expenditures through retained earnings and equity represented around 40%, a share far lower than what is observed for financing of conventional power plants in OECD countries (IEA, 2014b). Most of the remainder was financed with long-term loans and 10% by short-term loans, such as bridge finance (BNEF Database, private communication). The final 5% is provided by non-bank entities, including institutional investors. This total represents just a small share of the total capital being mobilised for infrastructure by institutional investors.

Figure 7.2 Landscape of investment financing sources for sustainable energy and dynamics across the OECD 2008-14 (illustrative example, varies by country)



Note: white boxes indicate where investment financing has decreased and are figurative representations that do not present actual magnitudes. The black triangle represents a cap and downward pressure on corporate sources of financing.

Source: OECD Analysis based on Kaminker and Stewart (2012); Feyen and González del Mazo (2013); Kaminker et al. (2013); OECD (2013); IEA (2014b); BNEF database.

7.5.1 Strains on traditional sources of sustainable energy finance

The global financial crisis, and responses to it, led to a transformation of the financial landscape, with changes in behaviour by the public and banking sectors. Public, corporate (e.g. utilities, project developers) and financial sector sources of investment financing for sustainable energy projects face significant constraints, and investment from these sources is expected to diminish in coming years.

Long-term financing by banks has declined as they de-risk (deleverage) globally, although it is beginning to revitalise in some areas (ECB, 2017). In the capital markets, a range of factors including ambiguous macroeconomic prospects and declining forecasted

returns for equity investments in publicly traded companies have had adverse effects on demand for long-term equity capital (OECD, 2016d). In addition to constraints in the banking sector, other traditional sources of finance such as corporate actors also face their own constraints (OECD, 2016d).

The economic and financial crisis has constrained government budgets in many OECD countries, putting downward pressure on public sources of investment financing for sustainable energy infrastructure. The fiscal consolidation efforts to reduce the share of government debt in GDP has also been accompanied in some countries by pressure to cut support to sustainable energy (IEA, 2014b).

Utility companies and project developers have little capacity to expand their investment in sustainable energy, as their balance sheets are constrained due to the negative impacts which an increase of debt could have on their credit rating and cost of capital. The Economist (2013) notes that EU utilities have suffered vast losses in asset valuation, with their market capitalisation (see glossary) having fallen by over EUR 500 billion over the last five years. In May 2014 Barclays downgraded all high-grade bonds issued by the entire American electric utility sector because they 'believe that a confluence of declining cost trends in distributed solar photovoltaic (PV) power generation and residential-scale power storage is likely to disrupt the status quo' (Aneiro, 2014, p. 1).

More specifically, it is expected that these trends will reduce the profitability and credit-worthiness of utilities, which are generally vulnerable to decreasing electricity prices caused by the increased deployment of renewable energy. The IEA (IEA, 2014b) confirms that the extent to which utilities can provide investment faces constraints. In addition to new project development, utilities have often played an important role in

acquiring operating sustainable energy assets, allowing developers to recycle their capital for new projects.

In Europe, utility cash flows have been cramped by reduced operating hours for conventional plants, stemming from a ‘perfect storm of low demand, high natural gas prices, low carbon and coal prices, and increased shares of low-marginal-cost renewables’ (IEA, 2014b, p. 201). Utilities in Europe are also reported to be actively seeking partnerships with institutional investors to whom they might unload sustainable energy assets from their balance sheets (McKinsey & Co, 2014) .

The financial crisis has affected the maturity transformation (glossary) process in financial markets and the ability of banks to channel long-term financing. Recently exposed funding vulnerabilities, deleveraging (see glossary) and new regulations such as Basel III and Capital Requirements Directive (CRD IV) (see glossary) have prompted banks to reduce investments across illiquid asset classes and shorten tenors (i.e. the term or duration of loans).

Deleveraging in the EU is particularly relevant because EU banks that had been large domestic and international ‘specialist’ financiers of infrastructure have been harder to replace. The post-crisis Basel III rules aimed at strengthening the global banking sector have elicited concern, particularly in Europe, that new rules could result in reduced readiness from banks to provide long-term project and corporate loans, including for sustainable energy projects (Narbel, 2013; UNEP Inquiry into the Design of a Sustainable Financial System, 2014).

Despite these constraints, the banking sector remains a key provider of investment financing, but it likely will not be able to compensate for constraints among other

traditional sources and fill the massive financing gap for sustainable infrastructure on its own. For instance, the People's Bank of China (PBoC) estimates that China will need to invest at least RMB 2 trillion (USD 320 billion) per year in green sectors to meet the environmental targets under the 13th Five Year Plan (2016-2020). Public fiscal resources, however, can cover no more than 15% of these investments (Green Finance Task Force, 2015).

A related and broader issue is whether the financial system can enable capital reallocation consistent with the 'green' transition and for the long run, i.e. by providing financing for companies and industries that protect and improve the environment and shifting financing away from fossil fuel industries and environmentally-harmful activities (Boissinot, Hubert and Lame, 2016; Wehinger and Nassr, 2016). It is only through such a re-allocation that the infrastructural foundations of the global economy can be rewired to be consistent with keeping the global temperature increase to well below 2°C, as called for under the Paris Agreement.

Given the need for increased investment in sustainable energy infrastructure, and pressures on existing sources of financing, there is interest in exploring the extent to which institutional investors can expand their investments in this area (see dotted box in Figure 7.2), and play a greater role in directly filling the investment gap while also acquiring operating projects from banks that are expected to remain important project financiers and corporates, therein helping them to recycle their capital for re-investment in new projects.[8]

[8] Although activity has decreased since the financial crisis, banks remain important providers of infrastructure finance, particularly when capital markets are thin and secondary debt markets nascent. Although their involvement varies substantially by region, banks have historically participated in the debt financing – and, to a lesser extent, equity financing – of projects. As the banking sector recovers from the

7.6 Institutional investors and their potential to finance sustainable energy investments

In this context, much attention has been focused on the potential for institutional investors – including pension funds, insurance companies, investment funds, sovereign wealth funds, public pension reserve funds, foundations, endowments and other forms of institutional saving – to significantly increase their investments in sustainable energy and other green infrastructure.

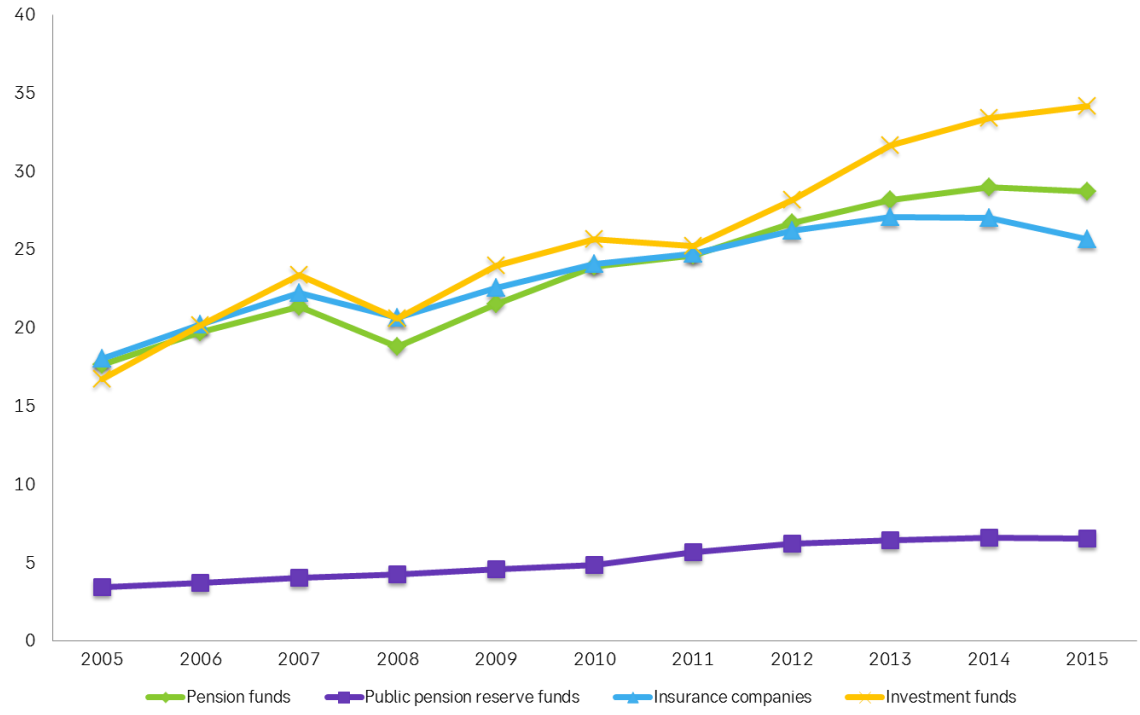
For instance, McKinsey & Co. (Bielenberg *et al.*, 2016) estimates that institutional investors could provide USD 1 trillion to USD 1.5 trillion in additional private capital for sustainable projects — up to half of the current annual infrastructure investment gap. But that will happen only if a range of structural challenges and market barriers are removed, and if policies are put in place to ensure adequate returns to meet institutional investors' liabilities.

As is shown in Figure 7.3, in OECD countries institutional investors managed USD 95 trillion in assets in 2015, which are projected to grow to USD 120 trillion by 2019 (OECD, 2015d, 2016d).[9] In emerging and developing countries, institutional investors managed USD 4.5 trillion in 2016 (Inderst and Stewart, 2014b), with sovereign wealth funds in particular being key sources of capital (Clark and Knight, 2010) managing USD 7.4 trillion in assets globally as of 2017 (SWF Institute, 2017).

financial crisis it is expected step in increasingly as project arrangers and facilitators, or to provide bridge financing (Standard and Poors, 2013).

[9] Note that there is a double counting issue with this number as investment funds manage some assets from pension funds and insurance companies. Total assets of institutional investors (excluding investment funds) amounted to USD 57.7 trillion in 2015. This lower Figure excludes assets of investment funds that are managed alongside pension and insurance funds.

Figure 7.3 USD 95 trillion in assets under management by institutional investors in the OECD (2015)



Source: OECD Global Pension Statistics, Global Insurance Statistics and Institutional Investors databases, and OECD staff estimates.

Note: Book reserves are not included in this chart. Pension funds and insurance companies' assets include assets invested in mutual funds, which may be also counted in investment funds. Total investments by pension funds are used as a proxy for total assets and may be a low estimate. Assets of insurance companies include assets of direct insurers and reinsurers.

For public pension reserve funds, data include Argentina's Sustainability Guarantee Fund (2011-2015), Australia's Future Fund, Belgium's Zilverfonds (2008-2015), Canada Pension Plan Investment Board, Quebec Pension Plan, Canada (2011-2015), Chile's Pension Reserve Fund (2010-2015), China's National Social Security Fund (2011-2015), Valtion Eläkerahasto, Finland (2013-2015), France's Pension Reserve Fund (2003-2012), Sustainability Fund, Germany (2015), Employees' Provident Fund Organisation, India (2012-2015), Ireland 's National Pensions Reserve Fund (2005-2013), Japan's Government Pension Investment Fund, Korea's National Pension Service, Fonds de Compensation Commun au Régime Générale de Pension, Luxembourg (2015), New Zealand Superannuation Fund, Government Pension Fund - Norway, Government Pension Fund - Global - Norway (2011-2015), Poland's Demographic Reserve Fund, Portugal's Social Security Financial Stabilisation Fund, National Wealth Fund, Russian Federation (2011-2015), Spain's Social Security Reserve Fund, Sweden's AP1-AP4 and AP6, Unites States' Social Security Trust Fund.

Continued growth in funds under management is occurring in most markets. The main exposure of institutional investors to green infrastructure so far has been through indirect investments[10], via holdings of the debt and equity of listed corporations active in the green infrastructure industry (Kaminker, 2015). Such indirect investments can be important for supporting sustainable energy projects as over half of the capital directed to sustainable energy in 2015 came from corporate on-balance sheet financing (BNEF, 2016).

However, the scope for institutional investors to increase their indirect sustainable energy infrastructure investment is constrained by their willingness to purchase new debt and equity issued from corporates, which depends on institutional investors' perception of risk-adjusted return opportunities and the state of corporates' balance sheets. Furthermore, indirect investment -- unlike direct investment in projects -- does not necessarily translate into investments in projects and contribute to addressing the infrastructure investment gap.

Institutional investors are increasingly important players in financial markets (Dixon and Monk, 2012; Al-Kharusi, Dixon and Monk, 2014; Clark and Monk, 2017) In OECD countries, these investors traditionally have been seen as sources of long-term capital, with an investment horizon tied to the often long-term nature of their liabilities (e.g. pension benefits provided at retirement and life-insurance pay-outs).

In a low interest-rate environment, infrastructure projects should in principle be attractive to institutional investors and these investors have the potential to play a much

[10] Indirect infrastructure investments are investments in companies which are involved in the infrastructure industry either as manufacturers, operators or providers of on-balance sheet financing, or via intermediaries such as private equity funds targeting corporate investments, as distinct from direct investments in infrastructure projects.

greater role especially as ‘recyclers of capital’ (i.e. being able to acquire and hold assets for the long term from the creators of those assets who can then proceed to create more assets having freed up financial capacity on their balance sheets). In many cases, institutional investors must invest for the long-term to fund liabilities that are multi-generational in nature.

These liabilities can be met in part through long-term investments, including direct investments in sustainable energy assets, which can provide steady, inflation-linked, income streams with low correlations to the returns of other investments (Kaminker and Stewart, 2012; Kaminker *et al.*, 2013; Nelson and Pierpont, 2013) Morgan Stanley (2013) finds that in rising interest rate environments associated with inflation, ‘real assets’ including infrastructure and sustainable energy have historically performed well, given their inflation-linkage and that such periods are associated with expanding economies and subsequent growth in demand for energy and power.

Despite these factors favouring sustainable energy investment, the broader context in which institutional investors make their capital allocation decisions has tended to limit their investments in these types of real assets. Their decision-making process for allocating capital among different types of instruments and asset classes is complex and varies significantly across institutions and geographies. Institutional investors have varying risk appetites, liability profiles, investment preferences, illiquidity tolerances and other constraints which will determine the extent to which they will seriously consider investments in green infrastructure. Moreover, institutional investors will not make an investment just because it is ‘green’. Their primary concern is the risk-adjusted financial performance of the asset. Their willingness to finance major investment projects in any

given country will be heavily influenced by perceptions of the country's sovereign risk, investment climate, policy settings, and institutions.

The next section provides an overview of asset liability matching and the asset allocation process for institutional investors, which are essential concepts for understanding how institutional investors make asset allocation decisions and manage risk, and for evaluating the feasibility of channelling institutional investor capital to sustainable energy investment. An understanding of these concepts can also guide policy makers to establish and support appropriate instruments, funds, risk mitigants and transaction enablers to facilitate greater investment flows.

Although there is significant potential for institutional investors to expand their investment in sustainable energy, in general their investments in this area to date have been minimal compared with the scale of their assets. Due to a range of barriers discussed below, 'direct investment' in infrastructure projects[11] of all types was reported in a recent OECD survey to account for 1% of large pension funds' asset allocation on average in 2013. Among just those large pension funds that reported having direct exposure to unlisted infrastructure equity, the average exposure was reported to be 3% to unlisted infrastructure equity (OECD, 2016c). OECD pension fund allocation to sustainable energy investment was much smaller – only 3% of that 1% share, according to some estimates (Kaminker and Kawanishi, 2013).

Yet while surveys report these small allocations, an increasing number of institutional investors have investments in infrastructure or are considering the asset class for future commitments. Indeed, in a handful of countries some institutional investors

[11] This should be contrasted with the more routine type of institutional investment made in corporate stocks and bonds.

have found ways to allocate substantial amounts of capital to economic infrastructure (such as transportation assets). For instance, another OECD report (Inderst, 2014) examined how defined benefit pension funds (see glossary) in Canada have been using transaction enablers such as 'seeding managers' to align interests and reduce fees for infrastructure investments. Defined contribution superannuation (see glossary) funds in Australia have been using intermediated fund structures (see discussion of transaction enablers in Chapter 9) to allocate over 10% of their assets to infrastructure. In most defined contribution plans, pension beneficiaries can switch between investment options, generating a need for liquidity. As a result, defined benefit funds may have more ability to invest directly in sustainable energy projects as they have greater illiquidity tolerances. This is an interesting example of how regulatory geography shapes the type of investment channel that is most appropriate for accessing sustainable energy in each jurisdiction.

There are also instances of large funds elsewhere that are growing quickly so have less need for liquidity and have established sophisticated in-house asset management capabilities for investment in infrastructure and sustainable energy (e.g. PensionDanmark). But these examples, which are explored in depth in later chapters, are largely exceptions to the rule that institutional investment in infrastructure and sustainable energy has been limited to a small percentage of the portfolio.

7.7 Understanding institutional investor asset liability management and asset allocation decisions

'Asset liability management' or 'asset liability matching' (ALM) entails managing assets and cash inflows to satisfy various cash outflow obligations (liabilities). It is a form of risk management, whereby an institutional investor endeavours to mitigate or hedge the

risk of failing to meet these obligations while seeking a target level of portfolio investment return.

ALM can be a resource-intensive and complex undertaking, making use of sophisticated mathematical models. The conclusion of the ALM process will provide quantitative recommendations for the amounts a fund can invest in different asset classes. The process attempts to create a blend of 'return seeking' investments, such as public and private equity, and 'liability matching' investments such as bonds and other fixed income instruments, relying on a large set of assumptions about the characteristics of the different asset classes, such as investment return, risk (standard deviation of investment returns), and correlation between different classes of assets. Notably, many ALM models are run by outside consultants to institutional investors and they are often not asked to include sustainable energy or infrastructure as a separate asset class. Without ALM to see the value of this asset class, allocations typically will not be made.

Beyond the standard decision to allocate a portion of most investment portfolios to publicly traded debt and equity instruments, each, it is also common for portfolio managers to make allocations to subcategories of these asset classes, as these allocations can be made in a manner that improves the risk-return profile of the entire portfolio (i.e. using academic portfolio theories).

Following the ALM process, the next move can be to define a strategic asset allocation (SAA) for the fund. This splits the general asset classes into separate 'mandates' (authorisations or instructions to invest a defined portion of the portfolio in a particular asset sub-class or sub- category) for instance, emerging market bonds versus American or European bonds. Mandates are then, typically, assigned to investment

managers. Some funds may bypass these previous exercises and proceed directly to defining specific mandates that are then, typically, given to investment managers.

The design and assumptions of ALM models vary with respect to the investment performance of different asset classes, leading to different model outputs (i.e. SAAs recommended by the model). Even if the ALM process includes sustainable energy and it is then defined within asset class allocations, the tactical asset allocation to sustainable energy will rely on investment beliefs about whether sustainable energy will outperform a benchmark or help the institution to meet a 'risk budget'. Consequently, the ALM model used and assumptions incorporated in the model can dictate whether an institutional investor will invest in sustainable energy across different asset classes.

Nelson and Pierpont (2013, p. 42) state that:

> The number of asset classes and their definition in the model, the return and risk characteristics ascribed to each of these asset classes and the estimated covariance between these asset classes, can have a profound impact on the ability of an institutional investor to invest in renewable [sustainable] energy and, possibly, take advantage of the specific investment characteristics that could provide more value to that investor.

Investors will also consider whether they will invest via funds, which use experienced teams to deploy capital, or whether they will pursue direct investments, which requires building internal teams and developing advisor and deal flow networks (Clark and Monk, 2013b; Standard & Poor's, 2013; Fulton and Capalino, 2014). Smaller pension funds typically use consultants for ALM modelling and the investment categories they prescribe generally refer to specific mandates to be given to external managers ('outsourced') (Nelson and Pierpont, 2013).

The largest insurance companies generally have the most refined ALM processes, possibly due to regulatory reasons and their larger scale which supports more

sophisticated modelling capabilities. The result is that from a strategic and ALM perspective Nelson and Pierpont (2013, p. 44) suggest that they appear to be much more able to see the value that the asset class has for reducing the institutions' risks and meeting future liabilities and invest in sustainable energy projects.

7.8 Limitations and challenges for scaling up institutional investment in sustainable energy

At the core of the issue of limited investment is that investors with fiduciary responsibilities generally require policy makers to foster investment certainty and improve the risk-adjusted returns available from sustainable energy. Many institutional investors have yet to conclude that sustainable energy investments offer a sufficiently attractive risk-adjusted financial return.

The regulatory environment in which institutional investors operate and the risk-return profile of investments will determine whether institutional capital can be mobilised to support infrastructure development – and whether the infrastructure in question is 'green'. Policymakers can take actions to create an investment environment in which investors have lower risk perceptions and there are significant reductions in the cost of capital, which is fundamental to reducing the costs of green infrastructure.

Standing in the way of increased investment are several potential obstacles, some that apply to infrastructure generally, others that are specific to sustainable energy. These issues can be summarised into four categories of barriers:

1. Weak, uncertain or counterproductive environmental, energy and climate policies.

2. Regulatory policies with unintended consequences.

3. A lack of suitable financial vehicles with attributes sought by institutional investors.

4. A shortage of objective data and skills to assess transactions and underlying risks and returns.

Table 7.1 provides additional details on and examples of barriers to institutional investment in sustainable energy. Standing in the way of increased investment are several obstacles, some that apply to infrastructure generally, others that are specific to sustainable energy.

Table 7.1 What are the barriers to institutional investment in sustainable energy infrastructure?

		Barriers
1. Issues with infrastructure investments	1.1 Direct investing challenges	a. Short term investment horizons of investors. b. Need for liquidity with many investors (low tolerance for illiquidity risk). c. Challenges with bidding process for assets on projects and timing; lack of investor best practice and expertise; smaller investors can lose out to more sophisticated, larger investors in bidding. d. Need scale > USD 25-USD 50 bn in AUM and dealflow to maintain costly direct investing team with expertise. e. Min USD 100-200 m deal "ticket" size; expensive and time-consuming due diligence; higher transaction costs.
	1.2 Regulatory and policy issues	a. Regulatory and policy uncertainty. b. Uncertain new policy application e.g. Solvency II for pension funds? c. Illiquidity and direct investment restrictions e.g. capital adequacy rules and higher charges (Solvency II, IORP II Directive). d. Accounting rules e.g. mark to market for illiquid assets.
	1.3 Lack of "bankable" project pipeline and quality historical data	a. Few countries publish infrastructure road maps with project pipelines. b. Decreased participation of project finance banks (due to Basel III, deleveraging, structural factors) creates interruptions in project development and construction. c. Little historical pricing data or indices for benchmarking investments such as private placement debt. d. No liquid market to exchange financial stakes in projects.
2. Issues particular to sustainable energy infrastructure investments	2.1 Risk-return imbalance	a. Market failures: insufficient carbon pricing and incentives; presence of fossil fuel subsidies. b. Insufficient economic business case: cost of capital and perceived risk is too high and return is too low. c. Electricity market challenges (structure and design). d. Low natural gas pricing in some jurisdictions.
	2.2 Unpredictable, fragmented, complex and short duration of policy support	a. Instances of retroactive support cuts and support switching (FiT to FiP creates cash flow volatility) or start and stop (PTC). b. Unintended consequences of unrelated policies (e.g. can discourage investment by tax-exempt pension funds or EU unbundling preventing majority ownership of both transmissions and generation/production).
	2.3 Potential misalignment with climate change risk and the transition to a low carbon economy	a. Lack of a responsible investment code. b. Lack of clarity on fiduciary duty and stewardship with respect to environmental, social and governance and stewardship (ESG) issues. c. Carbon content of portfolios rarely disclosed.
	2.4 Special species of risk and lack of data on the performance of sustainable energy investments across asset classes	a. Technology and volumetric risk management require expertise and special risk management tools. b. Lack of data on financial performance and risk of sustainable energy across different asset classes and investment channels.
	2.5 Competition for capital	a. Competition with traditional infrastructure assets and with transmission and distribution infrastructure.
	2.6 Small scale of assets	a. Distributed and micro-generation assets too small for institutional investors interest and few means exist to bundle them.
	2.7 Market perception	a. Negative publicity created by bankruptcies of early-stage companies and poor performance of venture capital investments due to temporal industry consolidation and macroeconomic factors transfer to projects which were unaffected.

3. Lack of suitable investment instruments and funds	3.1 Issues with fund and vehicle design	a. High fees associated with fund structures. b. Liquidity trade-off with connection to underlying asset and associated benefits: difficult to offer liquidity without asset disconnect, churn and leverage in fund. c. YieldCos are new innovations for listed equity but depend on bankable pipelines of projects and experienced human resources and may need to evolve further to fulfill their potential.
	3.2 Nascent green bond markets, few indices/ funds	a. Small pipeline of projects, high transaction costs, minimum deal size. b. Definitional uncertainty. c. Few liquid benchmark indices for listed debt and equity as market is still nascent or insufficient demand for products.
	3.3 Restricted access to existing vehicles (Covered Bonds, MLPs and REITs)	a. Current national legislation does not enable sustainable energy to qualify for these vehicles.
	3.4 Challenges with securitisation	a. Lack of standardised project documentation and credit risk assessments. b. Lack of large enough portfolios of loans on bank balance sheets. c. Legacy reputational risk from the GFC.
	3.5 Credit and ratings issues	a. Historical lack of ratings data, expensive process. b. Absence of monoline insurers since GFC.

Source: Author (Kaminker *et al.*, 2015) citing Kaminker and Stewart (2012), CPI (2013), BNEF (2013); as cited in Kaminker et al. (2013).

Acronyms and abbreviations: Asset-Liability Matching (ALM), Assets under Management (AuM), Institutions for Occupational
Retirement Provision (IORP II Directive), Feed-in Tariff (FiT) Feed-in Premium (FiP), Production Tax Credit (PTC), Global
Financial Crisis (GFC), Master Limited Partnership (MLP), Real Estate Investment Trust (REIT).

A two year, whole-of-organisation study on 'Aligning Policies for a Low-Carbon Economy' conducted by the OECD, IEA, NEA and ITF (OECD, 2015a) found that even though technology costs are falling fast, policy and market obstacles still constrain overall growth in investment in sustainable energy, limiting the pipeline of bankable projects and affecting the risk-return profile of investments. In addition to insufficiently ambitious climate mitigation policies, the misalignment of other policies and regulations with respect to climate goals can also act to hinder investment. Such misalignments may occur across the general investment environment, for instance in the areas of investment policy, competition policy and electricity market design, trade and financial markets policy (OECD, 2015a).

There are obstacles that favour investment in incumbent technologies reliant on fossil fuel over sustainable energy, regulatory policies with unintended consequences,

and a shortage of objective information, data and skills to assess transactions and underlying risks. Other barriers are specific to a lack of suitable financing instruments and funds, inconsistency among the contracts, documentation and assets which prevents project cash flows to be pooled into tradable and highly liquid securities, and inadequate tools for due diligence that would be necessary to build confidence among investors in new asset classes.

Misaligned policy signals such as continuing support for fossil fuel use and production, low or no prices on GHG emissions, and unpredictable changes to support policies for sustainable energy are all issues that cause investors to hesitate before investing in sustainable energy. In addition, many institutional investors still lack the risk management capabilities, knowledge, investment channels or the means to access sustainable energy infrastructure projects in a way that aligns with their varying sizes, operational models and investment objectives (Kaminker *et al.*, 2013).

As described in Kaminker et al. (2013), some investment barriers are of a regulatory nature. For instance certain countries place restrictions on pension fund investment which can apply to infrastructure (see Della Croce, Stewart and Yermo, 2011). In the EU unbundling regulations have been cited as obstructing funds from investing directly in electricity generation if they are also investing in electricity transmission and distribution assets. Solvency II (see glossary) regulations have been cited as limiting insurers' appetite for illiquid investments and their treating sustainable energy infrastructure as an investment as risky as hedge funds. In addition, pension fund 'fiduciary rules do not include an obligation to consider the risks of climate change in asset allocation decisions' (McCrone, 2013a, p. 1).

There are practical constraints that reflect a mix of scale and inertia: some sustainable energy projects may be too small to attract large funds; smaller funds may lack knowledge and the resources to build specialist teams; some institutions may feel that there are other, less risky types of infrastructure they can invest in making it not worthwhile to invest in building the expertise needed to evaluate sustainable energy; consultants, or 'gatekeepers', that advise pension funds on investments may not themselves be familiar with sustainable energy projects; and the new YieldCo formations (see discussion later in this section) may not be large enough yet and the models insufficiently robust, to command the attention of a wide institutional audience.

There are also policy and political issues. Ensuring a stable, clear and integrated 'investment-grade' policy environment will play an important role in addressing key barriers to investment by institutional investors. Concerns about the stability of subsidy support for sustainable energy and uncertain political consensus on future energy choices in some countries have reduced demand for sustainable energy infrastructure investments and raised the cost of capital. While as previously described, the practice of allocating capital to infrastructure is starting to become more conventional for institutional investors, many are 'hesitating about taking one step further into sustainable energy projects' because of these policy stability worries (McCrone, 2013a, p. 1).

7.8.1 Barriers specific to emerging and developing economies

In addition to the above-mentioned barriers, there exist further barriers that are unique to emerging economies and developing countries. Examples of further barriers affecting green infrastructure investment in these countries include: (i) options to mitigate regulatory, currency and corruption risk are generally less available to investors and costlier than in developed countries; (ii) investment contracts are not standardised across countries making due diligence more time consuming and expensive; and (iii) international arbitration is often not an option leaving disputes to be solved in local courts.

A more comprehensive set of supplementary barriers in emerging economies and developing countries is provided in OECD (2015a) and World Bank/IMF/OECD, (2015). Yet these are the countries that have large projected electricity demand that implies colossal future infrastructure build. The mismatch between investment opportunities and risks is particularly evident here.

Table 7.2 Risks and barriers are heightened for institutional investment in emerging

Market risks	Developer risk	Desire for proven track-record of asset developer, or guarantee from a larger parent or sponsor to backstop development risk
	PPA counterparty credit risks	Desire for high quality off-taker of energy, be it a nationalized energy company or investor owned utility; for prepayments, concern about being paid back in falling rates environment without attracting reinvestment alternatives
	Currency and rate risks	Ability of non-OECD investors to hedge foreign exchange risk if investment is outside OECD jurisdictions; concern about interest rate fluctuations and impact on market value of debt
	Concentration risk	Lack of investor depth requires significant hold position on original lender's balance sheet
	Liquidity risk	Concern on ability to exit investment, particularly for smaller-size opportunities
	Market risk	Concern about the borrower's ability to weather extreme fuel price dynamics that could undermine specific sustainable energy technology's competitiveness relative to alternatives
	Business model and execution risk	This concern is most pronounced for impact investors considering opportunities in energy access
Political risks	Retroactive policy change risk	Change in regulatory of legislative support for green investment undermines economic outlook for underlying credit of investment asset by changing revenue, tax or contract profile
	Sovereign risk	The degree of state-owned ownership in the energy sector is cited as a deterrent by many investors but it can also be a risk mitigant when SoEs are co-investors in projects. There is also a lack of creditworthiness of many state-owned power utilities as off-takers
		Currency convertibility and availability; repatriation and expropriation risks
	Communication risk	An absence of coherence and communication between investors and the respective public institutions can lead to sub-optimal policy development
Technology risks	Aversion to new platforms	Preferring evolutionary improvements on equipment platforms that have already undergone due diligence
	Scale concerns	Concerns about whether investment deal flow will be significant enough to justify investment of time to learn the sustainable energy sector

Source: Author (Kaminker *et al.*, 2015) citing Bank of America Merrill Lynch, BNDES and World Bank (2014).

PRI (2016) undertook a multi-year dialogue on ESG with institutional investors and found a series of barriers related to green finance (broadly defined), where policy makers' efforts are presently disjointed and fragmented. These are split between demand (i.e. the scale of the project pipeline) and supply (i.e. of financing from institutional investors) for green investment, along the same structure that this research takes.

After examining these barriers in depth, (Kaminker *et al.*, 2015) proposed nine high-level policy recommendations and policy considerations for governments to

facilitate institutional investors' investment in sustainable energy infrastructure, building on findings from previous G20/OECD reports. These are given in Chapter 14.

7.9 Carbon lock-in, climate risk and stranded assets

The preceding discussion focuses on factors impacting how institutional investors view the opportunity presented by investment in sustainable energy. Another consideration that could impact sustainable energy investment as well as investment in emissions-intensive projects and activities is how investors view 'climate risk'.

In the wake of the Paris Agreement, investors can be expected to perceive increased regulatory risks around unabated fossil-related investments and the potential for lower returns from such investments. Such changes in perceptions may be triggered by the expectation of increasingly stringent carbon pricing and climate change mitigation policy, and by an evolving investor governance and disclosure landscape.

Climate change itself, policies and technological changes in response to climate change, and green finance all create risks that have various implications for the financial sector and institutional investors (Wehinger and Nassr, 2016). As described by Bank of England (2015) and Carney (2015), among these are 'physical risks' from climate change that acutely affect the insurance industry[12] but can extend to other sectors (e.g. banks' mortgage loan portfolio can be exposed). There may be implications for banks where there is significant underinsurance of climate risks as uninsured losses from climate change-related extreme events could create financial stress for bank clients, e.g. uninsured or underinsured households forced to default on mortgages or other consumer credit as a

[12] The financial management of these impacts is a key challenge, and has been covered in work of the OECD; see Wolfrom and Yokoi-Arai (2016).

result of disaster losses (Wehinger and Nassr, 2016; Wolfrom and Yokoi-Arai, 2016). Related are 'liability risks' for corporations that may be held responsible for climate-change related losses or damages and from which affected parties may seek compensation.

There are also risks linked to policy and technological responses to environmental challenges including climate change which can affect the financial sector and institutional investors. These and related 'transition risks' (Carney, 2015) generally result from the adjustment process towards a cleaner and lower-carbon economy that can prompt a reassessment of asset values (Dietz *et al.*, 2016) as their ability to generate returns is impaired and they face pre-mature write-downs or even conversion to liabilities. Thus, there is a potential for these assets to become stranded ('stranded assets'). Stranded assets have been defined as 'the unanticipated or premature write-down, devaluation or conversion to liabilities of assets as a feature of the creative destruction that drives forward capitalism' (Caldecott and McDaniels, 2014b, p. 8). Fossil fuel assets (i.e. the coal, oil or gas resources and reserves that the fossil fuel companies have on their balance sheets) have been described recently as having:

> the potential to become stranded due to a range of environment-related factors – from climate or other environmental regulations, developments in clean energy technology, resource constraints, evolving social norms and litigation
>
> (Caldecott, McDaniels and Dericks, 2014, p. 2).

These climate risks mainly affect lenders and (equity) investors in projects concerned, but the re-pricing of assets may have effects that can go beyond the institutions or the sector in which it occurs, including broader economic effects (including for sovereigns and their ratings) and potentially impacts on financial stability (Bank of

England, 2015; Carney, 2015; Dietz *et al.*, 2016). This was stated by Mark Carney as follows:

> Too rapid a movement towards a low-carbon economy could materially damage financial stability. A wholesale reassessment of prospects, as climate-related risks are re-evaluated, could destabilise markets, spark a pro-cyclical crystallisation of losses and lead to a persistent tightening of financial conditions: a climate Minsky moment.
>
> (Carney, 2016b, p. 2)

As discussed earlier, infrastructure investments can 'lock-in' future emission levels. Any new investments in fossil fuel infrastructure have implications for the limited carbon budget consistent with avoiding dangerous interference in the climate system. As this budget shrinks and temperatures rise, asset stranding concerns will intensify. Angel Gurría, Secretary General of the OECD noted the following in the course of a lecture at the London School of Economics in October 2013 (Gurria, 2013):

> If policy makers cap carbon emissions, the risk of 'unburnable assets' could have a significant impact on the valuation of some companies. It is worth recalling that the investors are in so many cases people like you and me. The Asset Owners Disclosure Project estimates an average of over 55% of pension funds' portfolios is being invested in high carbon assets or sectors greatly exposed to climate change physical impacts and climate change-related regulation. The looming choice may be either stranding those assets or stranding the planet.

The IEA (2014a, p. 43) states that stronger climate change policies will not only have an impact on future investment decisions, but may also affect the economics of existing energy sector assets. As a result of changes brought about by climate policy, some investment in fossil fuel-based assets, it suggests, may not be able to earn an economic return prior to the end of their economic life and risk becoming stranded assets 'not recovering all or part of their investment during the time that they are operational' (ibid. p. 43). It finds that by 2035 in the 450 scenario (see glossary), new fossil-fuel

capacity in the power sector valued at USD 120 billion is stranded, upstream oil and gas investment of USD 180 billion is stranded, and coal mining investment of USD 4 billion is stranded (as most mines are old and have already recovered investment). However, the IEA suggests that if investors misread signals from policy makers and invest on the basis of a less ambitious climate policy environment (i.e. the 'New Policies Scenario' – see glossary) but end up in a 450 scenario world, then there is higher potential for fossil fuel stranding than the numbers presented. It also follows that clarity on future policy frameworks minimises additional risk.

Analysis and debate concerning the issue is ongoing (see for instance the work of; inter alia, Carbon Tracker Initiative, University of Oxford Stranded Assets Project, the Bloomberg LP Carbon Risk Valuation Tool, 350.org and the prominent media coverage of the issue in the Economist, Financial Times, Telegraph, etc.). There are also sceptical arguments, notably in independent oil company responses to shareholder petitions from concerned investors (see ExxonMobil and Shell for instance).

In a now seminal speech to Lloyd's of London, Mark Carney, Governor of the Bank of England and Chairman of the Financial Stability Board discussed the 'tragedy of horizons', essentially a failure by governments and businesses to internalise long-term considerations in decision making (Carney, 2015). In a subsequent lecture, Angel Gurria commented on the speech also introducing the concept of 'carbon entanglement' (Gurria, 2015):

> Climate change is a victim of this 'tragedy of horizons'. It will unfold over many decades, while political and business cycles at best extend over a few years. Thus, even known catastrophic losses in 100 years' time do not influence policy and investment decisions today. Jeremy Grantham has referred to this as the 'tyranny' of the corporate discount rate lens, through which our grandchildren end up having no value. Yet there is a real risk that between now and the end of the century, we may face severe, pervasive and

> irreversible climate impacts. And then we will regret our myopia. Two years ago I used the phrase "carbon entanglement" to describe the extent to which many governments and asset owners have deeply vested and sometimes conflicting interests in the status quo…

Despite growing awareness of climate-related risks to the financial sector and institutional investors in particular, the understanding of these risks is still incomplete (and may remain so) due to their complexity (ESRB, 2016). Climate-related physical risk management in the insurance and reinsurance sectors is relatively sophisticated, but in other sectors, and regarding other sources of risks (i.e. transition risks), the work is still at an earlier stage in terms of data availability and quality, tools and methodologies as well as capacities devoted to environmental issues impacting the financial sector (FDF, 2016). Enhanced transparency and disclosure of climate-related and environmental risk exposures across the corporate and financial sector could help not only to improve understanding and analysis of the risks, but also to improve the decision making of borrowers, lenders and investors alike. This could contribute to improved risk pricing and could support a more orderly transition to a low-carbon economy, allowing financial market actors to take a view on current as well as future risks, and adjust investment strategies, improve long-run decision making and foster long-term investment by institutional investors (Wehinger and Nassr, 2016).

For such reasons, disclosures with a focus on carbon exposures and their risks may become standard in the non-financial as well as the financial sector. Efforts to improve disclosure are being undertaken at the OECD (OECD, 2015c), as well as by the FSB's Task Force on Climate-related Financial Disclosures (TCFD) (FSB, 2016). The NGO CDP has also been very active on disclosure issues. It requests 'information on the risks and opportunities of climate from the world's largest companies on behalf of 827 institutional investor signatories with a combined US$100 trillion in assets.' In 2015,

France amended its Energy Transition Law (Republic of France, 2015) to become the first nation to require that corporations disclose climate risk and responses adopted, while also requiring institutional investors to disclose the carbon exposure of their assets.

Institutional investors also have interest in issues such as climate change which can have a long-term impact on economic growth and thereby impair the assets on which they depend to generate returns far into the future (see (GIC, 2014)). The Principles for Responsible Investment (PRI) 2017 annual report finds that 74% of asset owners see climate change as a long-term threat. Additionally, the World Bank, the US Export-Import Bank, the European Bank for Reconstruction and Development and the European Investment Bank have severely limited the cases in which they will finance new coal power projects and Dutch bank Rabobank has ceased lending to unconventional gas projects (McGarrity, 2013; Morales and Roca, 2013; Rabobank, n.d.).

In a response to these concerns, investors are finding ways to 'decarbonise' their portfolios, to lessen exposure to or to hedge 'carbon and climate risk'. These initiatives are discussed in detail in Chapter 8. Under the Montreal Pledge, investors committed to measure and publicly disclose the carbon footprint of their investment portfolios on an annual basis. Following a pledge by members to decarbonise USD 100 billion of institutional equity investment by the 21st Conference of the Parties to the United Nations Framework Convention on Climate (COP21), the Portfolio Decarbonisation Coalition will support the convening of a community of institutional investors measuring and disclosing the carbon footprint of a total of at least USD 500 billion assets.

Funds handling USD 2 trillion promised to support an expansion of the green bond market at COP21. Issuers, underwriters and others such as the World Bank Group, the HSBC and the Economist (2014) have argued that green bonds are a 'natural hedge' for

stranded assets and have the potential to offset climate risk exposure in investor portfolios and serve as a destination for capital divested from fossil fuels. As discussed in Chapter 11 there is potential to use pure-play, project and asset-backed securities green bonds as instruments to actively hedge against climate policy risks in a portfolio that includes emissions-intensive assets. In practice, most green bonds are secured on the balance sheet of issuers with diversified activities.

The PRI argues that bond markets have historically been the 'neglected child' of responsible investment, taking a backseat to equities and other asset classes. However, according to S&P (2015), with climate change and severe weather events garnering rising numbers of headlines, lenders and institutional investors have become more interested in how S&P Ratings Services incorporates environmental and climate risks into its corporate credit ratings, and the impact these risks have had on their ratings. S&P conducted a lookback review of corporate rating actions and surveillance reports and identified 299 cases in which environmental and climate factors either contributed to a rating revision or were a significant factor in their rating analysis. Fifty-six of these cases resulted in a rating action, CreditWatch placement or outlook revision, 44 of which (close to 80%) were negative in direction. The sub-sectors with the greatest exposure to environmental and climate risk thus far have been the oil refining and marketing, regulated utilities, and unregulated power and gas sub-sectors. S&P concludes that as the severity and frequency of environmental and climate risks continue to rise, the numbers of environmental and climate-related corporate rating actions are also expected to accelerate.

8. THE PLACE OF INSTITUTIONAL INVESTORS IN FINANCING SUSTAINABLE ENERGY

‘Let my armies be the rocks and the trees and the birds in the sky’

Attributed to Charlemagne, by Henry Jones (played by Sean Connery) in *Indiana Jones and the Last Crusade* (1989)

8.1 Introduction

The chapter examines and surveys the unique and evolving place that institutional investors occupy in the ecosystem of sustainable energy investment financing. The characteristics of the types of investments being made are described along with the financial capabilities of institutional investors, and an inspection of how they are approaching different types of investments, with a special focus on equity investments in the EU. As such, using information drawn from several databases, the chapter begins to quantitatively describe the emerging channels that hold significant promise for scaling up institutional investment.

In locations where sufficient preconditions are in place and other aspects of the enabling environment create circumstances in which investment demand is generated, investment will be more likely. Indeed, despite the overall low levels of investment in infrastructure compared with the size of the institutional investor market, investment demand for sustainable energy is strong and growing, and investment activity is ramping up.

Financial innovation that has led to new channels and options for investment becoming available has coincided with rapidly falling costs of sustainable energy since 2008. Whilst this chapter focuses primarily on equity investment, as discussed in Chapter 11, fixed income debt securities (bonds) are a key asset class for institutional investors, and the emergence of the green bond market over the last decade has created a simple and quick option for institutional investors to fund projects and corporations that fit within their traditional asset allocation process and does not involve building up direct investment capabilities or creating a separate investment class category. Elements of this work were published in 2015 and 2016 as G20 Finance Minister and Central Bank

Governors deliverables under the Turkish and Chinese G20 Presidencies (Kaminker *et al.*, 2015; Kaminker, 2016b).

8.2 Strengthening the demand for green institutional investment to develop organically

For institutional investors which manage a very large share of national savings, a fundamental pre-condition for investing in sustainable energy and other forms of green infrastructure, is the establishment of appropriate domestic framework conditions, which provide the clear price signals, predictability and policy coherence that investors need. While simple enough in principle, as discussed previously, such a framework often proves difficult to achieve in practice, as retroactive policy changes, weak carbon pricing, fossil fuel subsidies and unintended effects of non- climate-related (e.g. financial and investment) regulations can undermine policies that are otherwise supportive of the low-carbon transition OECD/IEA/ITF/NEA (2015) and OECD (2016b) both find that even though technology costs are falling fast, policy and market obstacles still constrain overall growth in investment in renewable energy, limiting the pipeline of bankable projects and affecting the risk-return profile of investments.

In addition to insufficiently ambitious climate mitigation policies, the misalignment of other policies and regulations with respect to climate goals can also act to hinder investment. Such misalignments may occur across the general investment environment, for instance in the areas of investment policy, competition policy and electricity market design, trade and financial markets policy (OECD/IEA/ITF/NEA, 2015). The first four recommendations from (Kaminker *et al.*, 2015) given in Chapter 14, were matched against barriers and targeted at creating preconditions and the enabling environment to drive demand for institutional investment.

8.3 A survey of institutional investment activity and demand for sustainable energy assets

8.3.1 Aggregated stocks and flows

While no unified and systematic database exists for tracking stocks and flows of investments in sustainable energy or green infrastructure by institutional investors, several estimates are available from different sources, and methodologies or templates for tracking and reporting investments are emerging. For instance, the Asset Owners Disclosure Project (AODP, 2016) estimates that the stock of 'low-carbon investments' across a range of asset classes by institutional investors is valued at USD 138 billion in 2016.

On an individual and proportional basis, the UK Environment Agency Pension Fund holds the highest rank in the survey with 26.4% of AuM invested in low-carbon investments. At the national level, the Netherlands tops the country table for low-carbon investments on both an absolute and proportional basis – with an aggregate of USD 39 billion invested in low-carbon, representing 3.4% of the total AuM in the country. This survey uses a reporting taxonomy for eligible investments elaborated by the 'Low Carbon Investment Registry', which in turn reports entries by institutional investors tallying to USD 50 billion. These figures could be considered as lower bounds to the stock of investments, given that they only describe investments by those who choose to report them.

The OECD's Large Pension Fund Survey (OECD, 2016c) found that of the 26 pensions and reserve funds that reported [13] sector allocations in their infrastructure portfolios, nine reported exposure to renewable energy totalling USD 1.4 billion of investments, compared with USD 25 billion of non-renewable energy sector investments and USD 27 billion of transport investments. Using a wider definition, funds reported 'green' investment through a variety of channels, with exposure to green equities, green bonds, and in alternative investments such as real estate, private equity, and infrastructure. The Swedish pension fund AP2 reported 9% of its total portfolio was invested in green assets. Dutch pension fund ABP, and the New Zealand Superannuation Fund both reported 6.7% of their total portfolios were invested in green assets. These funds were leaders in the overall survey population in terms of green investment – most funds reported much lower or no exposure to green investments. The largest allocation of an infrastructure portfolio to renewables reported was 19% (PFA, Denmark), while the smallest reported was less than 1% of total infrastructure investment (OMERS, Canada).

[13] The survey reviewed trends in assets and asset allocation by 99 Large Pension Funds (LPFs) and Public Pension Reserve Funds (PPRFs), which in total managed USD 10.3 trillion in assets, one third of the total worldwide assets held by this class of institutional investor.

Table 8.1 Green investments of select large pension funds and public pension reserve funds, 2014

% of total investments

Country head office	Name of the fund or institution	Total investments in 2014 (USD million)	Green investments (as a % of total investments)				
			Green equity	Green bonds	Alternative green asset classes[1]	Other green investments	Total green investments
Australia	Health Employees Superannuation Trust Australia[2]	25 030	..	..	0.3	..	0.3
Brazil	FAPES - BNDES	3 189	0.2	..	..	..	0.2
	Previ[3]	62 733	..	..	..	0.1	0.1
Denmark	PFA Pension	46 075	0.4	..	0.3	..	0.7
Finland	Valtion Eläkerahasto	21 378	..	..	0.3	..	0.3
France	ERAFP[4]	25 587	24.7	0.0	..	..	24.7
Netherlands	PFZW	196 333	1.4	0.5	0.4	0.5	2.8
	PMT	71 112	..	..	0.1	..	0.1
	Stichting Pensioenfonds ABP[5]	473 569	1.5	0.3	0.8	4.0	6.7
New Zealand	New Zealand Superannuation Fund[6]	21 473	..	..	0.0	6.7	6.7
Norway	Government Pension Fund – Global	872 607	..	..	..	0.6	0.6
Romania	Azt Viitorul Tau	1 152	..	..	..	0.2	0.2
Spain	Endesa	1 923	..	0.2	..	..	0.2
	Fonditel[7]	3 972	1.2	..	0.1	..	1.3
	Santander[8]	205	..	1.1	..	..	1.1
Sweden	Alecta	88 330	..	0.3	..	..	0.3
	AP2[6]	37 990	1.1	1.1	4.3	2.5	9.0
	AP3	37 271	..	1.3	0.0	0.0	1.3
	AP4	38 124	..	0.6	..	..	0.6
United Kingdom	USS[9]	62 972	..	..	0.3	0.1	0.4
United States	New York City Combined Retirement System	159 189	0.3	..	..	..	0.3
	United Nations Joint Staff Pension Fund	52 821	0.3	0.2	..	..	0.4

Source: OECD calculations based on responses to the OECD Survey of Large Pension Funds and Public Pension Reserve Funds.

Notes: Some funds have green investments (in 'green' indices for instance) but cannot separate these investments from other portfolio investments, as is the case for Keva in Finland, and Illinois SURS in the United States (green private equity).

... Not available.

1. The alternative green asset classes include hedge funds, natural resources, private equity, infrastructure and inflation-linked bonds. 2. Includes investment in private equity clean technology. 3. Green investments are defined by Previ as assets (such as stocks, exchange-traded funds and mutual funds) in which the underlying business(es) are somehow involved in operations aimed at improving the environment. 4. If investments based on the FTSE4Good or similar methodologies are considered as green investments, all the investments in equity by ERAFP could be seen as green, since ERAFP applied an environment, social and governance (ESG) best-in-class approach to all the equity mandates. 5. Other investments include green real estate, which are defined as properties with a GreenStar label in the Global Real Estate Sustainability Benchmark Index, and that have an above-average performance on sustainability. 6. Other investments include forestry. 7. Data refer to Fonditel's biggest pension plan: Empleados de Telefónica de España. 8. Reported values are as of 30 September 2015. 9. Other green investments include renewable and lower carbon infrastructure, cleantech private equity and a listed environmental technology fund.

8.3.2 Public statements and investment targets

In addition, through analysing public statements it is apparent that many institutional investors are poised to significantly increase investment in this area. Goldman Sachs (2015) finds that in the last few years, institutional investors have begun to recognise that successful low carbon technologies benefit from a mix of policy support, market acceptance, technical advances and cost reductions. For certain green infrastructure sectors (e.g. LEDs, onshore wind, solar PV, and hybrid & electric vehicles) these dynamics combine to create a virtuous (self-reinforcing) cycle. Table 8.2 summarises a wide assortment of existing institutional investor commitments, targets and allocations to 'green finance', all actions taken since 2013, with a handful of other financial actors added at the end of the table for context. While sustainable energy is a common theme in all the announcements, a mixture of terms is used for defining the nature of these green financing actions, with 24 different terms used across the 38 actions.

In September 2014, a coalition of three pension funds (CalSTRS, APG and PensionDanmark) pledged to increase low-carbon investments across all asset classes to USD 31 billion by 2020, and had already reached USD 29 billion by the end of 2015. Among insurance companies, the SRI Initiative launched in 2014 commits its participants to doubling their USD 42 billion of 'green, climate-smart investments' in 2012 to USD 84 billion by 2015, and increasing the 2012 figure by a further 10 times to USD 420 billion by 2020. By July 2015 the figure had already reached USD 109 billion, well more than the 2015 target. A plethora of other institutional investor initiatives geared at sustainable finance were showcased in the margins of COP 21 including, inter alia, the *Portfolio Decarbonisation Coalition*, the *Montreal Carbon Disclosure Pledge*, *PRIME* and the *Aligned Intermediary*.

In the case of the *Divest-Invest Pledge*, the details of the commitment are:

> 1) Stop any new investments in the top 200 fossil fuel companies. 2) Drop coal, oil and gas from our investment portfolio by divesting from the top 200 fossil fuel companies. 3) Invest at least 5 percent of our portfolio into climate solutions defined as renewable energy, energy efficiency, clean technology and clean energy access.

Table 8.2 Institutional investor commitments, targets and allocations

Actor	Sector	Commitment	Allocation (latest available)
		Aggregate	
Institutional investors	Sustainably managed assets	n/r	USD 21.4 trillion (2014)
Institutional investors	European renewable energy equity	n/r	EUR 26 bn or 37% of aggregate deal value
Institutional investors where public action deployed	Green infrastructure	n/a	USD 8 bn (2016)
Portfolio Decarbonisation Coalition	Low or lower-carbon assets	USD 100 bn by COP21	USD 600 bn (2015) – already 6x the target
Montreal Carbon Pledge	Disclosure of carbon footprint	USD 500 bn	USD 3 trillion (2015) – already more than 6x the target
Asset Owners Disclosure Project	Low-carbon investments	n/r	USD 138 bn or 0.4% of index AuM (2016)
Institutional investors in the Netherlands	Low-carbon investments	n/r	USD 39 bn (3.4% of total NL index AUM - 2016)
Low Carbon Investment Registry	Low-carbon assets	n/r	USD 50 bn
Industry			
OECD Large Pension funds	Renewable energy projects	n/a	USD 1.4 bn
Coalition of CalSTRS, APG and PensionDanmark	Low-carbon investments across all asset classes	USD 31 bn by 2020	USD 29 bn (2015)
Insurance industry (The SRI Initiative: ICMIF and IIS)	Green investments / Climate smart investments	Double the 2012 amount (USD 42 bn) to USD 84 bn by 2015, and increase by 10x to USD 420 bn by 2020	USD 109 bn (July 2015), already in excess of the 2015 target
Catalytic Finance Initiative	Clean energy projects	USD 10 bn by 2022	USD 1.5 bn (2015)
Cubico Fund (OTPP, PSP Investments, Santander)	Water and renewables projects	USD 2 bn	USD 2 bn
Aligned Intermediary (University of California Regents, TIAA CREF, NZ Super, OPTrust)	Climate infrastructure (clean energy, water, waste)	USD 1 bn	n/a
		Individual	
Pension funds			
PensionDanmark	Renewable energy projects	10% unlisted equity	EUR 2.5 bn
PFA Pension	Renewable energy projects	n/r	19% of infrastructure portfolio
PFZW	Sustainable investments	EUR 16 bn by 2020	USD 4 bn (2015)
UK Environment Agency Pension Fund	Low-carbon investments		26.4% of AUM (calculate USD figure)
AP2	Green assets	n/r	9% of total portfolio
AP2	Green bond strategic asset allocation	1% of portfolio	SEK 4.2 bn (USD 500 million) (2016)
ABP	Green assets		6.7% of portfolio
NZ Super	Green assets		6.7% of portfolio
New York State Common Retirement Fund	Sustainable investment	USD 5 bn (incl. launch of a USD 2 bn low-emission index)	USD 1.5 bn (2015)
Insurance companies			
Allianz	Renewable energy projects	EUR 4 bn	EUR 3 bn
AXA	Green investments	EUR 3 bn by 2020	
SwissRe	Climate risk and resilience coverage	USD 10 bn by 2020	USD 1.5 bn (2015)
Aviva	Low-carbon infrastructure	GBP 500 million per year to 2020	
Asset managers			
BNP Paribas Investment Partners	Low-carbon assets		EUR 14 bn (2015)
Endowments			
University of California	Breakthrough Energy Coalition	USD 1.25 bn over 2016-20	
Family offices			
Threshold Group	Impact investment		USD 1 bn
Other investors and financial institutions			
Divest-Invest (140 foundations and other investors)	Public pledge to divest portfolio of fossil assets and re-invest at least 5% in "clean energy and climate solutions"[13]	USD 12 billion in total assets that have committed at least 5%—and in many cases over 10% of redirected investment	Actual amount of funds divested and re-invested difficult to track due to varying degrees of disclosure
Citigroup	Green financing	USD 100 bn	
Bank of America	Low-carbon business	Increase from current USD 50 bn to USD 125 bn by 2025	
Wells Fargo	Greener economy	USD 30 bn by 2020	
Goldman Sachs	Clean energy	USD 150 bn by 2025	
Re-Invest 2015: Banks and non-banking financial companies	Renewable energy investment in India	INR 712 bn (USD10.7 bn)	INR 295 bn (USD 4.4 bn) (March 2016)
Google	Renewable energy projects	USD 2.5 bn	

Source: OECD analysis (author)

Source: Author (Kaminker, 2016b)

8.4 The evolution of institutional investment in sustainable energy

In locations where an adequate enabling environment, which may include public support measures, creates demand-side circumstances in which investment demand is generated 'organically', investment will be more likely, and activity has been rising continuously over the last decade. As discussed in section 8.4.1, focusing just on sustainable energy in the EU, in the UK and Germany, with perceived stable regulatory regimes, institutional investor equity has increased as a percentage of total equity investment in EU renewables from 1% in 2007 to 17.5% by the end of 2015.

In examining how to invest in sustainable energy projects, institutional investors are simultaneously considering where on the risk spectrum that they would like to invest and how they want to access the market. Sustainable energy assets at the operational phase can offer stable, bond-like long-term returns, but there is increasing competition for these assets. To compete for these assets, institutional investors must offer the asset owners a lower cost of capital – i.e. lower rates on long-term debt (Murley, 2014).

In comparison, there is a relative shortage of up-front, equity capital for developing and constructing new sustainable energy assets. Thus, investors are working to determine whether they want to compete for the lower-risk operational projects which are also a good fit for certain institutional investors, or whether they prefer to seek higher returns for taking development and construction risk. As discussed in Chapter 9.5 investors must also consider if they will develop expertise 'in-house' to deploy capital directly into projects and companies or they prefer to outsource this process to external managers. Institutional investors can participate in 'greenfield' investment, acquiring assets as they become operational or can acquire 'brownfield' operational assets from utilities, project developers and other financial investors.

An enduring low interest rate environment with low-yielding government bonds has led some pension funds to invest in renewable energy, citing their fiduciary obligation to identify stable attractive returns with low correlations to other asset classes (e.g. PensionDanmark which has allocated EUR 2.5 billion to renewables and Allianz owns 63 wind farms and seven solar parks worth EUR 3 billion). Since 2008 institutional investors have become well established actors in wind power in the United Kingdom, Sweden, Denmark, Germany, Netherlands, Australia, Canada and the US; and solar PV in Germany, Japan, South Africa, Australia, Canada, and the US.

There are a number of reasons for this increased activity. Sustainable energy projects offer many of the attributes of 'core' infrastructure assets as previously described. Sustainable energy is also increasingly competitive with conventional forms of power generation and a new stylised fact has been described of increased investment by institutional investors in line with decreasing cost. Globally, sustainable energy is the fastest growing source of new electricity generation capacity and projects are emerging as a discrete, 'investable' asset class for these investors with increasingly available instruments and funds that are overcoming some barriers.

In particular, sustainable energy projects have a number of unique characteristics which can appeal to these investors and are not monetised in internal rate of return calculations. For instance, institutional investors require stable and predictable cash flows to meet their liabilities. Some sustainable energy projects can now provide sufficient collateral, probability of success, and predictability of future cash flow to offer institutional investors the 'pledgeable future income' they need.

Within sustainable energy (i.e. excluding CCS power generation) renewable energy power generation sources are not subject to fuel price volatility and are typically backed

by long-term contracts with investment-grade counterparts, the cash flows streaming from power sales allow for asset-liability matching and help hedge the risks of long-dated liabilities[14].

In addition, sustainable energy assets could reduce exposure to the effects of inflation on pension funds' long-term liability (the pension benefit) if, for example, they are linked to Power Purchase Agreement contract structures which have protection against inflation. Another benefit of investments in sustainable energy projects is that if they are held through the economic life of the project, the returns should be minimally correlated with those of the general market (e.g. with broad stock market indexes).

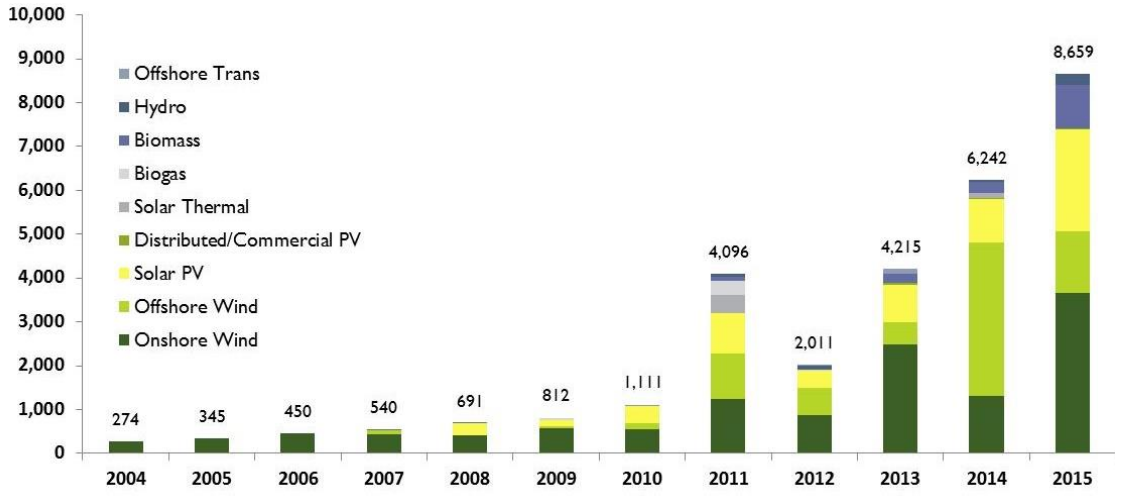
Clean Energy Pipeline (2014) states that for institutional investors return expectations for equity investments in sustainable energy projects are 5%-10% IRR p.a. after tax depending on country and technology; they are investing at 1-2 years after commissioning although will invest during construction if an EPC contract is in place and will look to holding the assets until the end of the assets' lifetime (20-30 years). Insurance companies prefer full control of the asset so often acquire a 100% ownership position whereas pension funds prefer to co-invest alongside experienced strategic or financial partners so will typically make minority investments. In terms of investment size, on average pension funds seek to deploy EUR 100-250 million at once while insurance companies seek to invest EUR 20-100 million (Clean Energy Pipeline, 2014).

[14] A section of the balance sheet that lists obligations of the company that become due more than one year into the future.

8.4.1 The case of EU sustainable energy investment by institutional investors

More so than elsewhere, institutional investors have identified sustainable energy assets in Europe as a source of attractive, inflation-linked, long-term and stable cash flows. This increased geographic appetite can be attributed to a number of factors including a large contiguous EU umbrella policy framework with carbon pricing in place (albeit at very low levels), ambitious EU-level climate action targets, the presence of policy support mechanisms that create revenue stability (e.g. Feed-in-Tariffs), and a very large, sophisticated, geographically proximate institutional investor base. Figure 7.1 illustrates results from a database maintained by HgCapital focused just on sustainable energy project equity investments in the EU. Using this dataset, 140 institutional investors (broadly defined) have made around 600 investments between 2004-2015, allocating over EUR 30 billion in equity to European projects that have a combined debt and equity value in excess of EUR 80 billion. Institutional equity investment in EU renewables grew with a 60% compound annual growth rate from EUR 2 billion in 2012 to EUR 8.7 billion in 2015. Onshore wind is the preferred destination for institutional investment, followed by closely by offshore wind and solar PV.

Figure 8.1 Institutional equity investment in EU sustainable energy projects (€ mm.) by technology



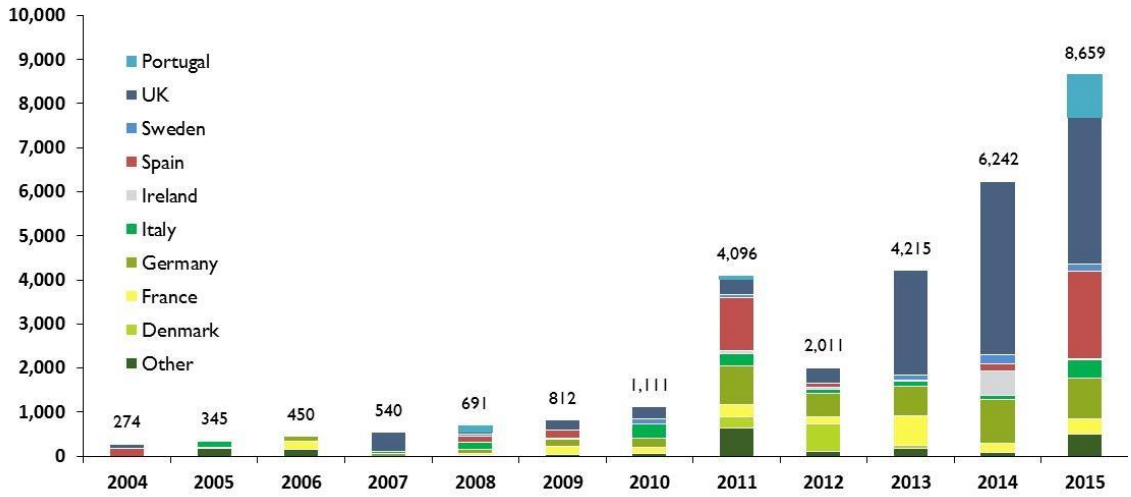
Source: (HgCapital, 2016)

Importantly, since 2010 the growth in institutional equity investment in EU sustainable energy comes despite falling overall growth in sustainable energy investment levels in the EU. According to BNEF, overall annual investment in EU sustainable energy in 2015 was at least 30% below 2011 levels, due primarily to regulatory change and macro-economic risks in Europe. Despite this, investments made by institutional investors have been increasing continuously as a share of overall investment levels, including when regulatory changes are announced in advance. However, as shown in Figure 8.2, when the changes are substantial and retroactive, or where support for new projects is abruptly removed, new investment comes to a effectively shuts down, as has been the case in Spain, Italy, Czech Republic, Bulgaria, Romania and Greece.

From 2006 through 2011 Spain was the second largest renewable energy market in Europe, behind Germany. Following a series of retroactive changes starting in 2010, institutional investors avoided Spain for five years. Economic challenges in Southern Europe, especially Greece and Italy have led to a decrease in investment levels. In the

Nordic region, investment slowed due to low power prices that have been a function of lower electricity demand linked to low levels of industrial activity. Investment is also skewed towards those countries that offer Feed-in Tariffs, which create revenue stability, in contrast to market-based green certificate regimes.

Figure 8.2 Institutional equity investment in EU sustainable energy projects (€ mm.) by country



Source: (HgCapital, 2016)

The number of active institutional investors in sustainable energy (across different channels) has increased from fewer than 10 in 2004 to 140 in 2015, with direct investment becoming the fastest growing source of new capital for sustainable energy in Europe. In the UK and Germany, with perceived stable regulatory regimes, institutional investor equity has increased as a percentage of total equity investment in EU renewables from 1% in 2007 to 17.5% by the end of 2015.

The number of pension funds and insurance companies that will invest directly in projects has increased from less than 10 in 2004 to over 40 by 2016, accounting for over a third of all institutional equity investment since 2011. As context, CPI suggests that

globally there are around 45 pension funds and 100 insurers large enough for direct investing, representing USD 25 trillion (Nelson and Pierpont, 2013).

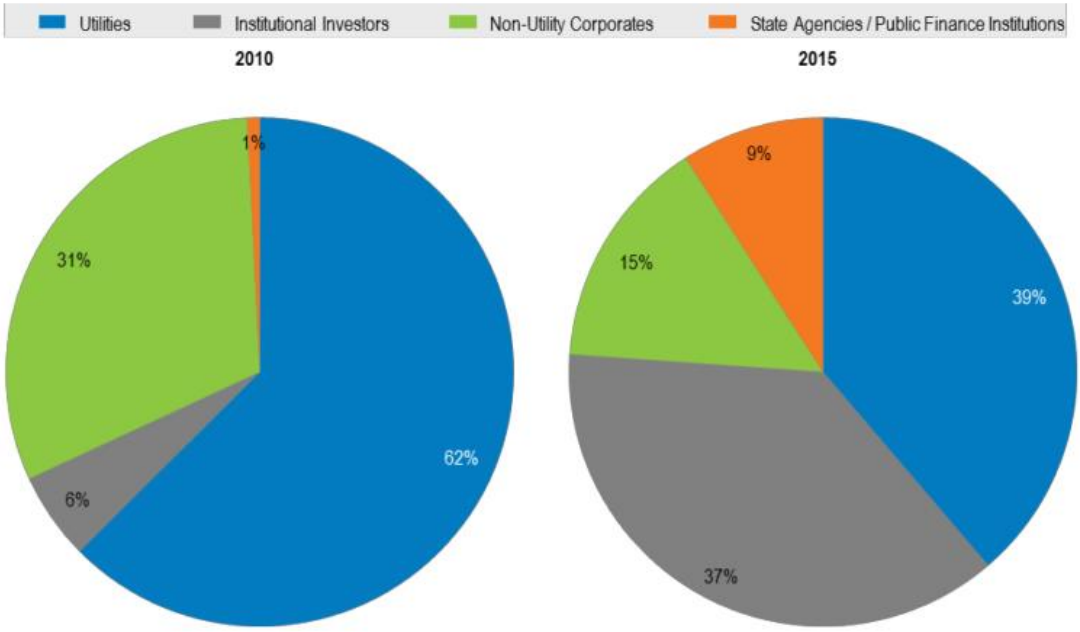
Pension funds and insurers are followed by intermediated vehicles such as general infrastructure funds and listed 'Yieldcos', which are managing pension fund and insurance company capital. As discussed in the next section, listed Yieldcos have also rapidly emerged as important investment sources, accounting for 17% of investment since 2011.

Operating projects or projects that have completed construction are overwhelmingly favoured by institutional investors, accounting for nearly 80% of all institutional equity capital invested in sustainable energy projects since 2011. The number of investors that will invest in completed projects (either directly or on an intermediated basis) has risen over the last four years, with 70 active investors out of 75. Around 20 institutional investors take construction risk and fewer than 10 could support project development. Institutional investors prefer investing directly in projects as opposed to investing in companies, listed or unlisted, that may hold projects in addition to development activities. Direct project equity accounts for 89% of institutional capital invested in renewables since 2004, and 93% since 2011.

Recent data from the OECD's 2016 Business and Finance Outlook confirms the growing prominence of institutional investors in sustainable energy in Europe (OECD, 2016b). In 2010, utilities financed 62% of equity in wind energy projects in Europe, while institutional investors had financed only 6% (Figure 8.3). By 2015, utility finance had decreased to 39%, while the share of institutional investors increased to 37%, making up for part of the difference. The increase of equity provision by institutional investors in the

sample[15] can be traced mainly to the acquisition of brownfield assets or portfolios for onshore wind deals. Pension funds and insurers were not involved in any greenfield onshore wind-power transactions included in the 2015 sample. This suggests that institutional investors look to the onshore wind sector mainly for the acquisition of existing projects.

Figure 8.3 Change in equity mix in wind energy projects in Europe, 2010 and 2015



Source: BNEF (2016), OECD calculations.

Note: Figures correspond to shares of total equity in sample.

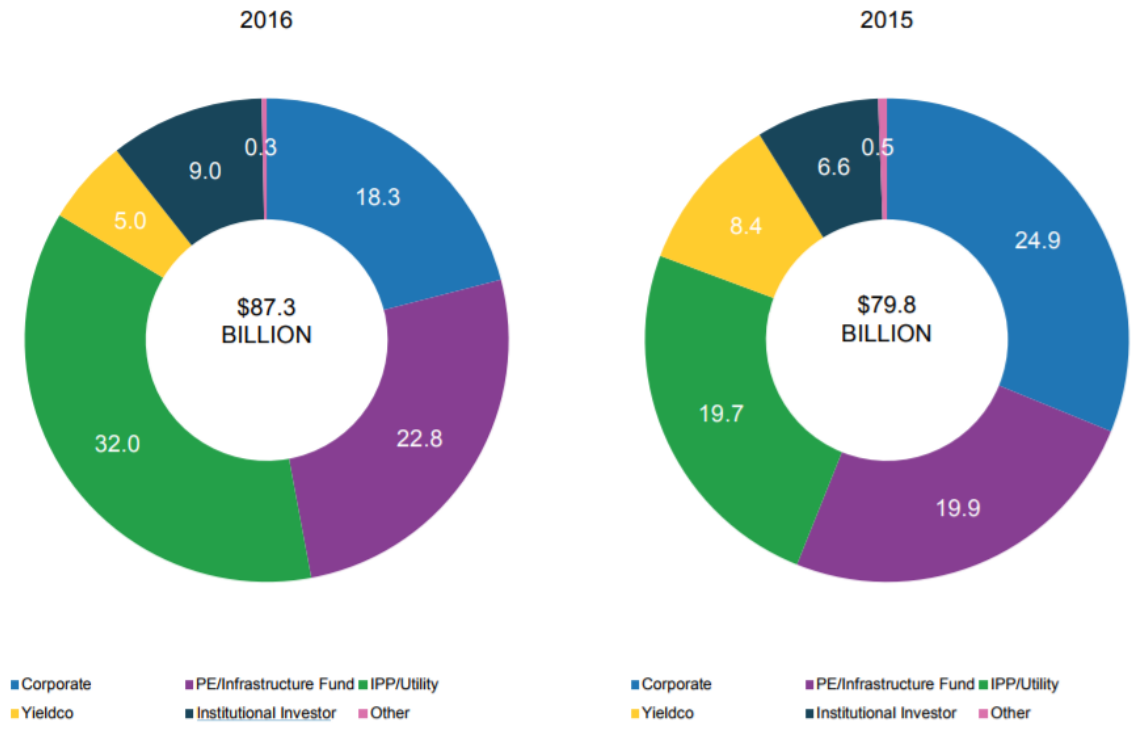
Data from HgCapital (2016) also describe an emerging ecosystem of investment in EU sustainable energy. It is one in which private equity funds, dedicated sustainable energy fund specialists, and large strategic developers such as Nordic utilities take the

[15] The data on investment, including new build and acquisition transactions, is compiled from the BNEF database of clean energy projects. The sample for 2010 includes 70 projects (57 new builds; 13 acquisitions), and the sample for 2015 includes 44 projects (29 new builds; 15 acquisitions). The total disclosed transaction value of the deals included in the sample was USD 11.7 billion in 2010 and USD 14.9 billion in 2015. The aggregated transaction value of greenfield projects stood at USD 10.8 billion in 2010 and USD 11 billion in 2015. The volume of total equity invested has decreased from USD 6.6 billion in 2010 to USD 6.1 billion in 2015. The institutional investor category includes pension funds, insurance companies, private equity and infrastructure funds.

early stage risks in developing, building and de-risking projects. Once de-risked, these projects become attractive investments for pension funds, insurance companies, listed Yieldcos and generalist infrastructure funds who are seeking stable but lower yields.

In this context, institutional investors are playing a role in recycling capital from the balance sheets of utilities through acquiring sustainable energy project. Figure 8.4 illustrates how this activity is expanding globally. Banks, private equity funds, project developers and utilities can then redeploy the proceeds into the development and construction of new projects (OECD, 2016d). Similarities have been drawn to the commercial real estate sector, where private equity type funds -- which are prepared to take on greater risks in exchange for higher returns -- develop, build and lease out new properties which are then sold on as cash flowing investments to pension funds, real estate investment trusts and other long term investors (HgCapital, 2016).

Figure 8.4 Global sustainable energy mergers and acquisitions by acquirer type

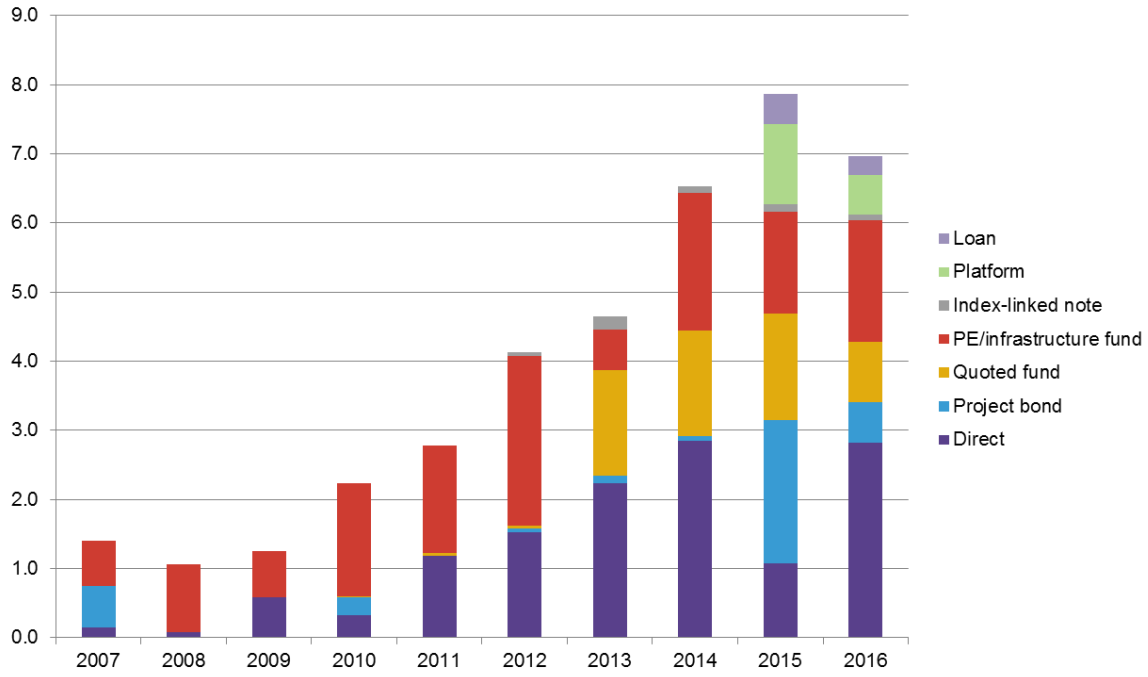


Source: Clean Energy Pipeline (2017)

Note: Institutional investors will also make commitments to PE/infrastructure funds and Yieldcos

Using a slightly different data set (BNEF, 2017a), which has a more restrictive definition of institutional investor, but has a more granular view of investment channel, Figure 8.5 shows a rising trend through diversifying channels for institutional investments in European sustainable energy projects. These combine direct investment in projects by investors such as Allianz, MunichRe and PensionDanmark, investment via project bond issues, via specialist European renewable energy infrastructure and private equity funds, or via listed project funds (YieldCos) such as Greencoat UK Wind and Bluefield Solar Income Fund. On this measure, disclosed institutional commitments increased from around USD 1 billion per year in 2008 and 2009 to USD 7-8 billion in recent years.[16]

Figure 8.5 Institutional investment in EU sustainable energy by channel (USD Bn)



Source: (BNEF, 2017a)

[16] These figures are not comprehensive. For instance, they exclude commitments to renewable energy infrastructure funds that invest worldwide, not just in Europe. They exclude commitments to companies that develop and construct projects as well as operate them. They also exclude fund closings that are not disclosed.

Table 8.3 describes the characteristics of several notable investments in European sustainable energy by pension funds and insurance companies in recent years.

Table 8.3 Characteristics of notable investments in European sustainable energy by pension funds and insurance companies in recent years

Investor(s)	Stake acquired	Target	Deal size	Date announced
PensionDanmark, through infrastructure fund manager Copenhagen infrastructure Partners	67%	900 MW DolWin3 offshore wind grid connection	EUR 384 million	Feb-14
Gothaer Versicherung	Undisclosed	Juwi Renewable IPP, owner of a 450 MW portfolio of solar PV and onshore wind capacity	EUR 150 million	Jan-14
Predica (subsidiary of Crédit Agricole Assurances)	50%	Futures Energies Investment Holding (subsidiary of GDP Suez), which operates 440 MW of installed onshore wind capacity	Undisclosed, although will enable GDF SUEZ to reduce its net debt by some EUR 400 million	Dec-13
Allianz Capital Partners (alternative asset investment platform for Allianz)	100%	100 MW portfolio of three onshore wind farms, including a 76.5 MW project in Germany and two projects in France totalling 23.5 MW	Undisclosed	Jun-13
MEAG (asset management arm of Munich Re), General Electricity, EDF Energies Nouvelles	100%	Iberdrola Renovables France (operating 32 onshore wind farms in France totalling 321 MW)	EUR 400 million	Dec-12
Aviva Investors (asset management arm of Aviva)	100%	23 MW portfolio of over 7 000 UK residential solar PV assets	EUR 126 million	Aug-12
Irish Infrastructure Fund, asset management arm of Irish Life &Permanent PLC	75%	104 MW portfolio of ten onshore wind farms in the Republic of Ireland and Northern Ireland	EUR 200 million	Jun-12
PensionDanmark A/S, PKA A/S	50%	400 MW Anholt offshore wind farm	EUR 900 million	Mar-11

Source: Adapted from Clean Energy Pipeline (2014).

Research of secondary news sources, such as BNEF, New World Energy Network, Clean Energy Pipeline and Clean Tech Connect, indicate that this trend is occurring in other markets, with ever-increasing institutional investor appetite in infrastructure assets in general and sustainable energy assets. This activity is further explored in later chapters. The sector has even caught the attention of companies such as Google and investors such as Warren Buffet who, through his MidAmerican Energy, has invested USD 17 billion in North American wind and solar projects (Wall Street Journal, 2014). In North America,

using data from Clean Energy Pipeline (2014), institutional investors exhibit sustained interest in acquiring operating sustainable energy projects in 2013 with pension funds, insurance funds, and infrastructure funds acquiring 38 renewable energy assets valued at USD 2.5 billion, in line with 39 acquisitions announced in 2012 (USD 5.0 billion), but significantly above the 13 acquisitions totaling USD 219 million in 2011.

8.4.2 The emergence of YieldCos

Alongside innovations in the debt markets, there has also been the development of equity funds that similarly fit and provide a potentially attractive subcategory within traditional equity asset allocations. Listed equity funds that pool projects, known as YieldCos, are a good example of this trend in the sustainable energy field.

A 'YieldCo' is a publicly traded (listed) investment fund structure that owns cash generating infrastructure assets which generally earn stable cash flows. Most notably, the YieldCo collects the stable cash flows and distributes them through public markets to shareholders as dividends while providing liquidity (i.e. investors are able to easily buy and sell shares in the YieldCo). YieldCos can also issue green bonds (e.g. NRG's USD 400 million green bond in 2014). YieldCos typically require an asset base of at least USD 500 million and an IPO value of USD 150-200 million.

A power producer creates a YieldCo to which it sells sustainable energy plants that have multi-year Power Purchase Agreements (PPAs) (see glossary). Those agreements are long-term contracts with utilities – the latter agrees to buy electricity from the plants at specified prices. The PPAs allow the YieldCo to pay a dividend. The YieldCo is liable for income tax but because of depreciation costs, it will not earn taxable income in the near future so no taxes are owed.

YieldCos are not the only investment fund structures that provide liquidity and more direct access to cash flows and can be listed and traded on an exchange. Real estate investment trusts (REITs) and Master Limited Partnerships (MLPs) are also examples where illiquid assets are bundled together in corporate structures with steady cash flows in the form of dividends, and then traded in liquid markets.

The markets for REITs and MLPs in the US alone were valued at over USD 1 trillion in 2014. Feldman and Settle (2013) has examined this issue and found that due to current US federal income tax laws, regulations, and administrative interpretations, REITs and MLPs cannot finance a significant portion of the cost of sustainable energy assets. Efforts are underway to alter these rules by changing the definition of 'real property' (for REITs) and 'qualified income' (for MLPs). Even with rule changes, Feldman and Settle (2013) state that both investment vehicles have structural challenges to efficiently finance sustainable energy assets. Listed and private infrastructure funds do exist, but investors have expressed concern about expensive management fee structures, excessive use of leverage, churn and disconnect from the cash flow profile of underlying assets (see glossary for definitions and (Nelson and Pierpont, 2013) for discussion).

As a response to these limitations, since 2013, sustainable energy and other infrastructure-type assets have been bundled into YieldCo structures that are traded on exchanges. BNEF (2014) finds that US YieldCos and their UK equivalents, the quoted project funds, raised approximately USD 4.5bn from investors in 2014. As the name implies, investors (both institutional and retail) that seek steady dividend cash yields based on real underlying assets are able to obtain these while also maintaining the ability to sell the shares easily with low transaction costs as they are liquid instruments traded on an exchange.

NRG Yield, Greencoat UK Wind Energy, Pattern Energy, Abengoa Yield and Nextera are all examples of YieldCos that have listed on US and UK exchanges. Additional favourable attributes of YieldCos are cited (Morgan Stanley, 2014) as their abilities to offer dividend and asset growth. This is accomplished through the process of a 'drop-down' where the YieldCo has a group of Right-Of-First-Offer (ROFO) agreements with its sponsor or parent that cover a set group of assets. Morgan Stanley explains that while the size of the potential acquisition differs by YieldCo, in aggregate they expect to see them increase their generation asset base over time (and as a result the cash flow and dividends).

However, because YieldCos are so new, their performance during a period of rising interest rates has not yet been tested. They also warn that if YieldCos do not manage to secure new projects with PPAs, perhaps because of a slowdown in the growth of the sustainable energy industry as tax breaks and other government incentives are withdrawn, then the companies will not be able to deliver their planned growth (Crooks and Bullock, 2014; Global Capital Finance, 2014; Financial Times, 2014). Indeed, over the course of 2015/2016 the U.S. YieldCo market suffered severely declining market capitalisations, attributed to many of these factors (Shurey, 2016).

Morgan Stanley (2014) expects YieldCos and their sponsors to play a signficant role in financing the deployment of sustainable energy in the United States through to 2020 but also states that the most significant risk YieldCos face is capital market risk, since access to reasonably priced funds to support expansion (i.e. finance the construction of underlying sustainable energy assets) is crucial. Other risks cited include trading and liquidity risk given that both markets capitalisations and public offering sizes are comparatively small.

8.4.3 How the YieldCo model may need to evolve to achieve its potential

Nelson (2014) argues that widespread use of YieldCos (combined with municipal finance) could allow for wind and solar costs to drop by more than 20% compared with current project finance models in the United States. Yet although the advent of YieldCos has been an important first step, Nelson argues that to realise their significant potential to drive down costs and bring in capital for sustainable energy, current designs would need to evolve to consistently: 1) provide highly predictable, long-term cash flows while paying out nearly all of the free cash generated from underlying projects, 2) provide liquidity through listing on exchanges and having a large enough set of investors to attract equity research analysis, 3) provide investment at low fees, and 4) become established as part of the portfolio of options for institutional investors.

Issues such as these could be addressed as the market matures and financial regulators work with investors to find solutions to these issues. Public green investment banks could also play a role to help YieldCos mature more rapidly and to connect YieldCos with sustainable energy projects that are smaller than utility scale but larger than residential.

8.5 Financial intermediaries and geographical flows

While this research focuses primarily on institutional investors, financial intermediaries play a critical role in the 'ecosystem' of climate finance and investment. They come in private (e.g. monoline insurers and investment banks – see glossary) and public forms (e.g. national or multilateral development banks or other public financing institutions such as domestically focused green investment banks). These financial intermediaries have as a common objective the engagement and mobilisation of private finance

(including from institutional investors). They deploy an assortment of instruments[17], funds[18], and risk mitigants[19] to finance sustainable energy infrastructure. Their activities have been examined in other related literature as discussed in Chapter 6. For example, public financing institutions' activities to support the transition to a low-carbon economy and mobilise private finance are the topic of increasing study (Hamilton, 2009; Caperton, 2010; Ward, 2010; Brown and Jacobs, 2011; Hervé-mignucci and Mazza, 2013; Bielenberg *et al.*, 2016).

Drawing on related OECD work (Eklin, Kaminker and Youngman, 2014; Eklin and Youngman, 2016), this thesis touches on how 'green investment banks' (GIBs) have sought to engage institutional investors. In recent years, at least a dozen special-purpose GIBs have been established. These are 'domestically-focused public institutions that use limited public capital to leverage or crowd-in private capital, including from institutional investors, for sustainable energy infrastructure investment' (Kaminker *et al.*, 2015, p. 1). A separate and very important question is how can institutional investors interact with and participate in sustainable energy investments in emerging markets and developing economies.

To date, institutional investment in sustainable energy projects has been predominantly in OECD countries and this is highlighted in Chapter 9, which provides details on the distribution of investments geographically across the sample of large pension fund investments. In addition to identifying promising channels for sustainable

[17] E.g. World Bank Group or European Investment Bank green bonds in which institutional investors invest.

[18] E.g. European Investment Bank (EIB) layered funds for institutional investment or the Renewable Energy Platform for Institutional Investors (REPIN).

[19] E.g. EIB's Project Bond Initiative credit enhancement tool which has attracted institutional investors. See Chapter 10 for a discussion of this initiative.

energy investments in OECD countries, it will be very important to explore how institutional investors can interact with international climate finance mechanisms targeted at emerging economies and developing countries. An emerging body of related literature has begun to explore these issues (see for instance: (IFC, 2013; Spratt, Griffith-Jones and Ocampo, 2013; IRENA, 2016)) building on an older and continuing body of literature which looks at how to mobilise institutional investment in general infrastructure in emerging and developing economies (see for instance:

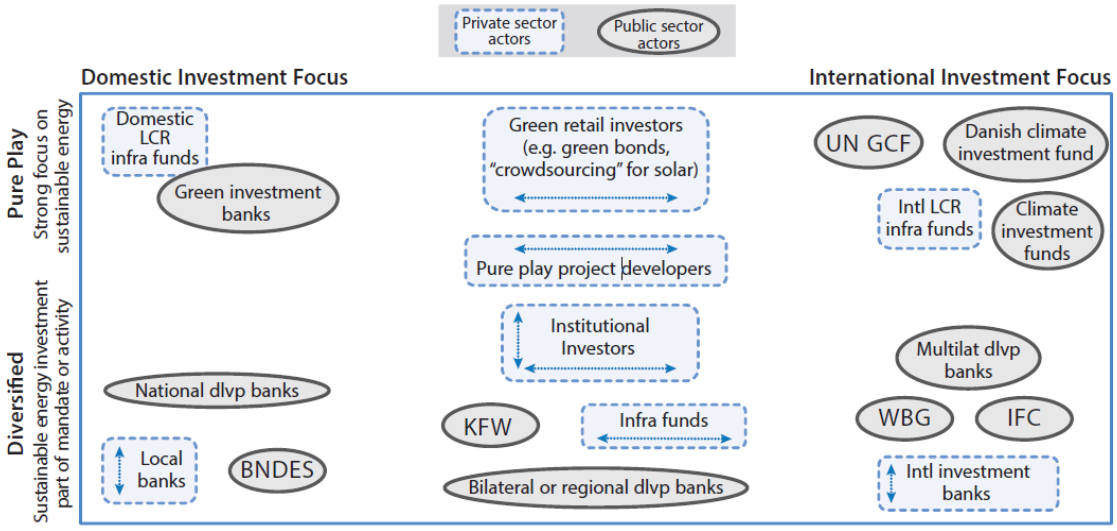
This thesis does not endeavour to cover all the possible channels for investments in developing countries and the risk mitigants that can be deployed to de-risk those investments to overcome additional barriers. It is necessarily limited in its analysis by the sample of investments covered which focus predominantly on OECD countries. Future work could explore these issues in greater depth, e.g. analysis of the further options that may be unique to Sovereign Wealth Funds and developing country institutional investors.

However, interesting examples in this space are starting to emerge. For instance, in January 2014 Danish pension funds PensionDanmark, PkA and Paedagogernes Pensionskasse invested in the Danish Climate Investment fund (a public-private fund backed by the Danish state to finance greenhouse gas emission-reduction projects in developing countries). An examination of the role of institutional investors in the emerging international 'climate finance' architecture is outside the scope of this analysis but these issues currently arise in discussions around international climate finance and fund mechanisms (see for instance the work of the Global Innovation Lab for Climate Finance).

Figure 8.6 illustrates the spatial characteristics (Clark, 2000b) of a number of the diverse actors involved in sustainable energy financing, their respective focus on

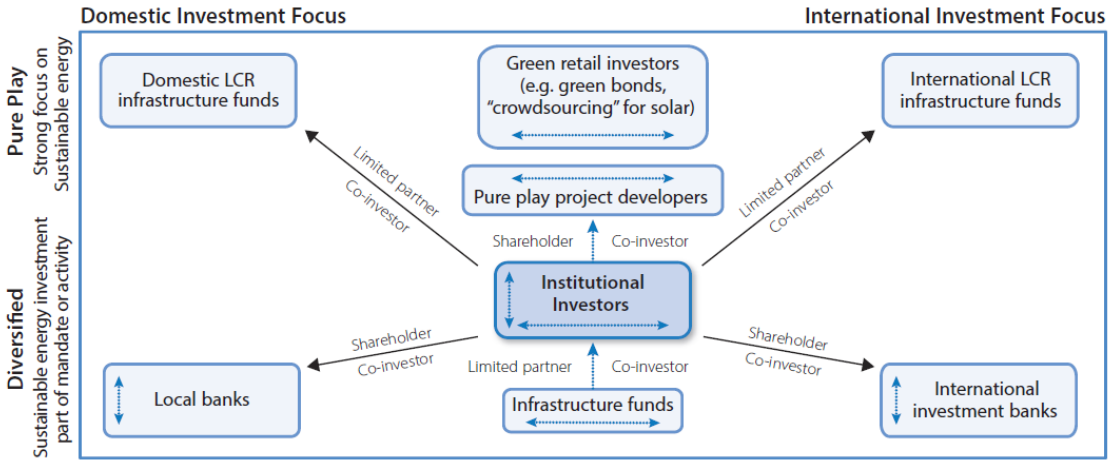
domestic vs. international investment and on 'pure-play' sustainable energy investment vs. diversified sustainable infrastructure investment (where sustainable energy is part of the mandate). For an additional illustration of the spatial interactions among private actors active in sustainable energy investment, including institutional investors, see

Figure 8.6 Existing public and private entities that finance sustainable energy



Source: (Kaminker *et al.*, 2015, p. 25)

Figure 8.7 Institutional investor interactions with private sustainable energy finance providers



Source: (Kaminker *et al.*, 2015, p. 25)

8.6 Implications for subsequent chapters

Since 2010, a significant increase in institutional investment in sustainable energy has occurred from negligible levels. There have also been innovations in the channels investors are using to access the assets. Yet, significant policy and investment barriers remain. The question is what investment channels and conditions will be required for a broader group of institutional investors to invest in sustainable energy at levels that contribute more meaningfully to total investment needs. These questions are explored in the following chapters.

Green bonds (including corporate, treasuries, project bonds, covered bonds and asset-backed securities), YieldCos, intermediated funds, and direct investment in projects all appear to be promising channels that have experienced growth and innovation, as well as challenges.

In the geographies where they have emerged, they all have unique challenges which will need to be surmounted to evolve to a position where they can mobilise institutional investors at scale, connect directly to projects of all sizes, and contribute to lowering the financing costs of sustainable energy. Uncertainty exists over the scope for these investment channels to emerge and develop in other geographies, especially in emerging and developing countries, and much further analysis is needed in this regard.

These nuances become clearer in the broader context of investment options available to institutional investors (instruments and funds), the ways in which risks can be apportioned, shared or mitigated, and how transaction costs can be lowered. The classification framework that follows will define these terms, provide examples of how they have been used for investments in sustainable energy, and illustrate how institutional

investors view and assess these different categories of investments and make investment decisions.

Considering the potential for investment and initial investment activities by some institutional investors, this research seeks to test the notion that sustainable energy is becoming more established and identifies factors that contribute to this increased activity. This research therefore screened for and subsequently identified 67 investment cases that are explored in the following Chapter. The cases identified and the investment classification system proposed build off the notions of asset liability management, asset allocation, and the different types of instruments and funds presented in this chapter.

9. THE CHANNELS FOR INSTITUTIONAL INVESTMENT IN SUSTAINABLE ENERGY: TOWARDS A CLASSIFICATION FRAMEWORK

‘To classify things is to bring parsimony and mental order to one’s view of them.’

Donald C. Hambrick

Taxonomic Approaches to Studying Strategy: Some Conceptual and Methodological Issues (1984, p. 27)

9.1 Introduction

This chapter proposes a framework for understanding how institutional investors, specifically large pension funds, allocate capital to sustainable energy investments in projects or 'corporates'. The analysis is supported by 67 actual investment cases collected for this research and described in detail. The chapter introduces a framework for understanding investment channels by constructing a classification system introduced in Chapter 5.

This chapter includes sub-sections which focus on analysing the instruments and funds used by pension funds to invest in sustainable energy, highlighting their use in actual investment cases. As the first database of institutional investor activity in sustainable energy was created for this research, the next sub-section describes the methodology used to identify specific cases of investments in sustainable energy projects by institutional investors. A table provides summary information regarding the 47 cases of sustainable energy project investment highlighted in this thesis. These cases, in addition to 20 further examples of investment in sustainable energy corporates, are analysed further in the subsequent sub-sections.

A second section on the geographic flow of investment exhibits the trends observed in the sample with respect to the direction of investment flows and highlights the tendencies for institutional investors to invest in domestic sustainable energy projects. A section on 'investment pathways' presents the investment cases as a result of different types of investment decision processes. For example, pension funds could frame the decision to invest in sustainable energy in the context of their own institutional capacity for such investment and their ability to support an in-house team that handles investment decisions versus the need to outsource investment management (e.g. investment funds)

or use pooled funds (e.g. green bond funds). In addition, institutional investors may prefer specific types of investment exposure to sustainable energy e.g. they may prefer investing in projects, 'pure-play' (see glossary) corporates or diversified corporates. Finally, a sub-section on investment pathways highlights the types of investments that are not yet being used by institutional investors. Examples of sustainable energy investment are then mapped in a 'Matrix Frame' (see Figure 9.8) to provide a visual representation of the distribution of the sample by transaction type. Elements of this work were published in 2015 and 2016 as G20 Finance Minister and Central Bank Governors deliverables under the Turkish and Chinese G20 Presidencies (Kaminker *et al.*, 2015; Kaminker, 2016b).

9.1.1 Defining sustainable energy financing instruments and funds

This section describes and proposes a framework for understanding how institutional investors, specifically pension funds, allocate capital to sustainable energy investments (in projects or 'corporates' i.e. corporations) using instruments and funds. Figure 9.1 highlights the part of the framework that is the focus of this section and the relevant instruments and funds. This section discusses instruments and funds that are currently being used for sustainable energy investment and identifies where they have not yet developed in the market. For those with a background in finance, this classification will be familiar, as it is inspired by recognised accounting standards.

Figure 9.1 Defining sustainable energy financing instruments and funds

Financial Capital Type	Financial Instruments		Funds
	Capital Market Securities	Cash	
Debt	Sovereign, Supranational and Agency (SSA) bond Project bond Corporate bond Covered bond Asset-Backed Security (ABS) Collateralised Debt Obligation (CDO) Structured Note	Senior Secured Loan Senior Unsecured Loan Subordinated Loans Junior Loan	Infrastructure debt funds (listed and unlisted) Private debt funds (targeting companies) Special Purpose Vehicle Bond fund Exchange Traded Funds Mutual Fund
Mixed	Convertibles (equity and debt) and Mezzanine financing		Mixed debt and equity funds
Equity	Stock (share)	Unlisted Share	Infrastructure equity funds (listed and unlisted) Private equity funds (targeting companies) Venture capital funds (targeting companies) Special Purpose Vehicle Exchange Traded Fund Mutual Fund YieldCo and other listed structures

Source: Author

9.2 Methodology and samples summary data

Information for this thesis is drawn from a review and screening of market data and interviews to identify investments by institutional investors in sustainable energy infrastructure carried out between February and July 2014. The two main resources for identifying institutional investors were the Towers Watson 2013 Pension Ranking of the 300 largest pension funds and the Sovereign Wealth Institute's Fund Rankings.

As established in Chapter 7, the financing gap for investment in projects is widely recognised (see also Kaminker & Stewart, 2012; Inderst & Stewart, 2014). Investment in

projects is considered to be key for filling in the infrastructure gap (Inderst & Stewart, 2014) and financing the transition to more sustainable energy (Inderst, Stewart and Kaminker, 2012). At the same time, direct investment is recognised to be the most difficult type of investment for institutional investors due to the skills and resources required (Nelson and Pierpont, 2013). Research for this chapter therefore focused on identifying institutional investors with the capability and resources to make direct, in-house investments in sustainable energy infrastructure projects and to assess their activity and interest in pursuing these investments. In addition, the research also sought to identify the use of risk mitigants and transaction enablers (see Chapter 10; expanded on in Chapters 12-14) that may have facilitated these project investments.

Not all pension funds will be capable or interested in investing in-house in sustainable energy projects. CPI suggested that assets under management (AUM) in the order of USD 50 billion are needed in order to justify the costs of building a dedicated team to invest directly in sustainable energy investments (Nelson and Pierpont, 2013) although as previously mentioned, instances exist of smaller pension funds accomplishing this successfully. To screen for pension funds and sovereign wealth funds (SWFs) with the capabilities to pursue these investments and allow an extra margin to capture potential investments, institutions with assets under management (AUM) exceeding USD 40 billion were initially targeted. Although insurance companies and asset managers often have significant AUM, they are not included in this initial screening and sample.

Insurance companies are often active in investment in sustainable energy infrastructure investment as both equity and debt investors while asset managers have shown relatively less activity in this field. In 2013, six major insurance companies in the UK (Legal and General Group, Prudential, Aviva, Standard Life Friends Life and Scottish

Widows) agreed to collectively invest GBP 25 million in UK infrastructure (including sustainable energy such as offshore wind) over the following five years (O'Donnell & Jones, 2013). As a recent example, UK insurance company Friends Life provided a GBP 75 million loan to Drax, a UK biomass producer (Osborne, 2013). Kaminker & Stewart (2012) provide additional examples of equity and debt investment in sustainable energy. The research presented in this thesis could be expanded in subsequent research to include greater analysis of insurance and investment manager activity in financing sustainable energy projects and corporates.

Future work could expand the screening to include insurance companies and asset managers. Select pension funds and SWFs with relevant investments that did not meet the AUM 40 billion cut-off were also added on a case-by-case basis as some are known to have developed significant in-house asset management capabilities (e.g. PensionDanmark).

Information on relevant investments was sourced using the Bloomberg New Energy Finance (BNEF) database and primary and secondary research using publicly available sources. Sustainable energy technologies covered in this effort include wind[20], solar[21], biomass, waste-to-energy, biofuels, geothermal and small hydro (under 30 MW) (see Chapter 5.4 for definition).

Approximately 130 institutions have been initially screened for relevant project investment in sustainable energy. As the focus of the research thus far has been on identifying and understanding debt and equity investments in projects by pension funds,

[20] Wind technologies include both onshore and offshore wind facilities.

[21] Solar technologies include solar CSP, solar PV and solar CPV. Concentrating solar power (CSP) devices concentrate energy from the sun's rays to heat a receiver to high temperatures. By contrast, photovoltaics (PV) and concentrating photovoltaics (CPV) produce electricity from the sun's rays using direct conversion with semi-conductor materials (IEA, 2011).

cases of investment in pure-play or diversified corporates that develop or invest in sustainable energy infrastructure have been noted but have not been analysed in detail for the purposes of this thesis. In addition, while many relevant cases of sustainable energy investments by SWFs were identified during the screening, the information presented analyses only pension funds for the purposes of this particular chapter. By using the screening methodology and capitalising on investment cases already identified, Chapter 13 examines some cases of SWF investment in sustainable energy infrastructure in greater detail.

9.3 Descriptive statistics and initial findings

The screening of 130 institutions identified 47 cases of sustainable energy infrastructure project investments between 2008-2014 by pension funds that have been evaluated and are noted in the figures. In addition, the screening also revealed an additional 20 cases of pension fund investment in pure-play corporates between 1996-2014. Summary information from the project database is shown below in Table 9.1. Based on estimates and available data, only about two-thirds of the 47 cases have disclosed financial transaction size information.[22] Of the 30 investment cases with available data, deals involving pension fund capital provided USD 8.03 billion for sustainable energy debt and equity financing.[23] Information regarding electricity generation capacity was available

[22] Due to data limitations, the transaction size reflects the overall deal size for a given debt or equity transaction as the exact pension fund commitments within a given transaction are not known. For example, in the Butendiek offshore wind farm transaction a USD 1.25 billion loan was provided by a public finance institutions and commercial banks and an equity investment of USD 643.1 million was made by Industriens Pension, Marguerite, Siemens Project Ventures and WPD. Only the equity investment of USD 643.1 million is included in the calculation of mobilised finance.

[23] All figures converted to USD using average 2012 exchange rates. Relevant exchange rates available here: http://www.ozforex.com.au/forex-tools/historical-rate-tools/yearly-average-rates

for 43 cases. Deals involving pension fund capital collectively promoted the creation or maintenance[24] of 9,450 MW of sustainable energy between the period of 2008 and 2014.

It is important to note that these 47 investments do not reflect the totality of debt and equity project investments in sustainable energy from the screened institutional investors. Rather, they represent a starting point for further analysis and can provide some initial findings regarding the instruments and funds used; the trends in terms of directionality of investment flow, targeted technologies and the level of project development. There are many limitations to this screening. As this screening has focused on using exclusively publicly available information to identify investment cases, it is likely to underestimate the examples of sustainable energy project investment and significantly underestimate activity in listed sustainable energy debt and equity. The granularity of public disclosure of investments varies widely across pension funds and therefore produces the following limitations.

For unlisted project investments (made in-house), the research revealed that most pension funds do not provide details on individual infrastructure asset exposure therefore reducing the ability to identify relevant sustainable energy project investments.

In terms of unlisted project investments (made via an external manager), pension funds that lack capacity to invest in-house in infrastructure will do so through externally-managed infrastructure funds. Most pension funds do not disclose information on each fund they have invested in and their relative investment exposures. If a pension fund chooses to outsource investment in projects or corporates through infrastructure or private

[24] Not all financing for sustainable energy projects is necessarily for greenfield construction. Institutional investors may provide financing that is used to refinance existing sustainable energy projects.

equity funds this information is not always publicly available. Infrastructure and private equity funds similarly do not publicly disclose their investors (i.e. limited partners).

Investment in a listed equity (e.g. amount of shares held in a sustainable energy corporate) or listed debt (e.g. amount of green bonds held in a sustainable energy project or a corporate) is very difficult to identify. These investments are liquid and can be actively traded; therefore the amount of shares or bonds held can vary daily. Pension funds generally report on their holdings in listed equity and debt on a quarterly basis but this disclosure is likely to show only total assets invested with limited detail. Some pension funds do disclose their top holdings by debt and equity yet are unlikely to disclose all holdings. Finally, many pension funds outsource or mandate the management of their listed debt and equity portfolios to external managers so only information on external management may be reported without details on those managers' subsequent investment allocations and exposures.

Table 9.1 below provides summary information from the 47 project investments by pension funds. As the focus of this screening was to assess the different instruments, funds, risk mitigants and transaction enablers used by institutional investors to access sustainable energy investments, the size (value) of investment was not considered to be a key factor to merit inclusion. This screening decision also reflected the view that available data on investment size may not be precise, as valuation data can conflict and often is not accurate or comparable. These limitations could potentially be addressed through expanding the data sources and using econometric analysis estimation transaction enablers. In the proceeding paragraphs, 'North' refers to the 43 countries that are Annex

I parties to the United Nations Framework Convention on Climate Change (UNFCCC) and all other non-Annex countries are considered as 'South'.[25]

Table 9.1 Summary of cases of project investment by pension funds in sustainable energy

	Number of cases	Percent of sample
Investor type		
Pension funds	47	100%
Investment type		
Direct	28	60%
Intermediated	19	40%
	47	100%
Geographic flow of investment		
North-North	39	81%
South-South	7	15%
North-South	2	4%
South-North	0	0%
		100%
Sector		
Wind	31	66%
Solar	11	23%
Biofuels	1	2%
Biomass	1	2%
Diversified sustainable energy	3	6%
		100%
Wind investment by type		
Wind – Onshore	21	68%
Wind – Offshore	10	32%
		100%

[25] For a list of Annex I and Non-Annex I Parties to the Convention see: http://unfccc.int/parties_and_observers/parties/items/2352.php

	Number of cases	Percent of sample
Solar investment by type		
Solar – PV	8	73%
Solar – CPV	2	18%
Solar – CSP	1	9%
		100%
Project location by region		
Europe	28	60%
United States and Canada	8	17%
Africa	4	9%
Asia	2	4%
Latin America	2	4%
Middle East	1	2%
Australia	0	0%
Global	2	4%
	47	100%
Year of investment		
2008	1	2%
2009	2	4%
2010	5	11%
2011	6	13%
2012	6	13%
2013	19	40%
2014	8	17%
	47	100%
Debt vs equity		
Equity	33	70%
Debt	14	30%
	47	100%
Project development status		
Greenfield	28	60%
Brownfield	16	34%
Both	3	6%

Source: OECD database on institutional investors and sustainable energy investments (Kaminker, C. Ed.)

Note: Diversified sustainable energy refers to transactions that involved more than one type of sustainable energy. For example, an investment in project that involves both solar and wind would be considered to be 'diversified solar energy'. Solar technologies include solar CSP, solar PV and solar CPV. Concentrating solar power (CSP) devices concentrate energy from the sun's rays to heat a receiver to high temperatures. By contrast, photovoltaics (PV) and concentrating photovoltaics (CPV) produce electricity from the sun's rays using direct conversion with semi-conductor materials.

9.3.1 Geographic flow of investments

Table 9.2 shown below provides an illustration of the geographic flow of equity and debt investment for some of the cases reviewed for this thesis (e.g. the 47 investments by pension funds). Note that only investments by pension funds are shown in the tables. There are numerous examples of South-North investments, particularly by sovereign wealth funds which are not currently reflected. The landscape of institutional investors is heterogeneous and there are broad differences for institutional investors in terms of size and the extent of concentration across nations and regions of the world (Clark and Monk, 2017), which can make a difference in terms of the channel they would choose for investment in sustainable energy (Kaminker *et al.*, 2013).

The investment strategies of institutional investors differ significantly across countries too. Institutional investors' asset allocation decisions are influenced by a variety of factors, such as market trends; the investor's risk appetite, liability considerations, governance structure and views on asset classes; regulation (e.g. pension fund regulations restricting investment in illiquid assets); cultural factors; tax issues; and the range of available investable assets and the depth of capital markets in the investor's home country. To date, investable assets and deep capital markets are predominantly located in the North.

Table 9.2 Selected examples of the geographic flow of equity financing for sustainable energy by pension funds

Source of Funds Country in (parentheses)	Investment destination – Country in [brackets]	
	North	South
North	London Array [UK] (Canada) Nysted Wind [Denmark] (Denmark) Walney Wind [UK] (Netherlands)	Pagudpud Wind [Philippines] (Netherlands, Philippines) Mareña Renovables [Mexico] (Netherlands)
South		Akhfenir and Haoum Wind [Morocco] (Morocco) Bokpoort CSP [South Africa] (South Africa) Pagudpud Wind [Philippines] (Philippines, Netherlands) Touwsrivier CPV Plant [South Africa] (South Africa)

Source: OECD database on institutional investors and sustainable energy investments (Kaminker, C. Ed.)

Table 9.3 Selected examples of the geographic flow of debt financing for sustainable energy by pension funds

Source of Funds Country in (parentheses)	Investment destination – Country in [brackets]	
	North	South
North	Bord Gais Eireann Wind [Ireland] (Denmark) Gemeni Wind [Netherlands] (Denmark) Seigneurie de Beaupré Wind [Canada] (Canada) Vents du Kempt Wind [Canada] (Canada)	
South		

Source: OECD database on institutional investors and sustainable energy investments (Kaminker, C. Ed.)

In the database of 47 project investments, 70% of investments were equity while 30% of investments were debt by number of deals. Of these 47 cases there were no examples of debt financing provided by institutional investors in the North to sustainable energy infrastructure projects in the South. In many cases, such debt financing is provided by multilateral or bilateral development finance institutions. Increased attention is being placed on developing investment funds using pooling and other transaction enablers to facilitate increased investment by institutional investors in the North and the South in sustainable energy infrastructure projects in the South.

In addition, the World Bank, IFC and many other development banks have issued green bonds that provide funding for projects that seek to mitigate climate change, including but not limited to sustainable energy projects. One possible reason for the absence of such deals is that these green bonds provide an attractive and easy solution for institutional investors, for they carry the AAA credit ratings of the supranational institutions and fit easily within existing asset allocations (see further discussion of green bonds in later Chapters).

9.4 Investment pathways used by institutional investors

The decision to invest in sustainable energy will depend on the characteristics of each institutional investor. The channel through which an investor chooses to invest in (or 'gain exposure to') sustainable energy will depend on the mandates set by the governance structure of the investor, the outcomes of the ALM exercise and Strategic Asset Allocation process, the level of risk appetite, and the technical ability to engage in different types of investments. A challenge is that for institutional investors 'sustainable energy' is not a discrete asset class. Rather, sustainable energy investments can appear in many different asset classes. Figure 9.2 provides one example of a way used in this thesis to classify investments.

Figure 9.2 Steps taken to classify investments



Question/Decision	Options	Description
Is the investment done directly in-house or via an external manager or other vehicle?	In-house Intermediated	Level of internal management
What is the type of financing?	Equity Debt	Financing type
Is the investment publically listed or private?	Listed Unlisted	Level of liquidity
Is the investment a stand-alone (i.e. single) entity or does it reflect aggregation (i.e. pooled)?	Single Entity Pooled	Diversification
What is the underlying investment?	Project Company Projects and Companies Fund	Investment type
What instrument or fund is used?	Special Purpose Vehicle (SPV) Yieldco Bond - Corporate Bond - Project Equity share … Fund Fund of funds	Instrument or fund
What is the sector?	Wind - Offshore Wind - Onshore Solar - PV Solar - CSP … Diversified	Sector

Source: Author (Kaminker *et al.*, 2015)

9.5 The 'Make or Buy' Option

The sustainable energy classification framework helps to describe the different combinations available for investing in sustainable energy infrastructure and using the decision to make an investment internally or externally as the starting point. This choice is referred to in the academic literature as 'the make or buy option' (Clark & Monk, 2012, 2013; Dixon & Monk, 2013). The make or buy option is a decision reflecting 'a choice between in-sourcing and outsourcing the production of a [beneficial] institution's target risk-adjusted rate of return' (Clark & Monk, 2013, p. 2). While academics have explored this decision for broader investment categories, this thesis explores the decision in the context of sustainable energy.

The Transaction Cost Economics (TCE) literature which dates back to at least 1937 (Coase, 1937) suggests that if an institution is sufficiently large to consider in-sourcing asset management and making the investment 'in-house', then it will make that decision based in large part on where the transaction costs are lower. In other words, a frontier exists where the in-house production cost is per unit more cost efficient than the outsourced option. Coase saw it as a question of where on the margin do those costs shift in favour of one or the other.

In infrastructure investment however, as Clark & Monk (2012) propose this may not apply as such in practice, as the frontier is more complicated and 'lumpy' and the make or buy option, while not irreversible, is a significant management decision. This derives from the fact that the fixed costs that come with establishing an in-house investment team may be quite significant and 'sunk costs'. In the first instance, an institution will either have the scale (i.e. significant assets under management) that is sufficient to consider a direct investment or will need to outsource the investment by writing a contract with an intermediary. This is the foundation for the following investment pathways.

Notably, some large pension funds have 'seeded' subsidiary funds to execute and manage their direct investments (e.g. OMERS and Borealis or BTPS and Hermes GPE). These funds may also be open to other institutional investors, or co-investors. For the purposes of this thesis, these subsidiary funds are counted as direct investment and 'in-house' as the assets are managed on behalf of parent institutional investors. Parent institutional investors may choose to separate these subsidiaries for legal and agency reasons, to improve alignment of interests, or to save on fees paid to specialist financial intermediaries. Clark & Monk (2014) explain how while these funds are functionally

similar to ‘in-sourced’ asset management, they provide more flexibility to parent institutional investors as sustainable and separate entities that can be sold or bought if over time parent interests diverge.

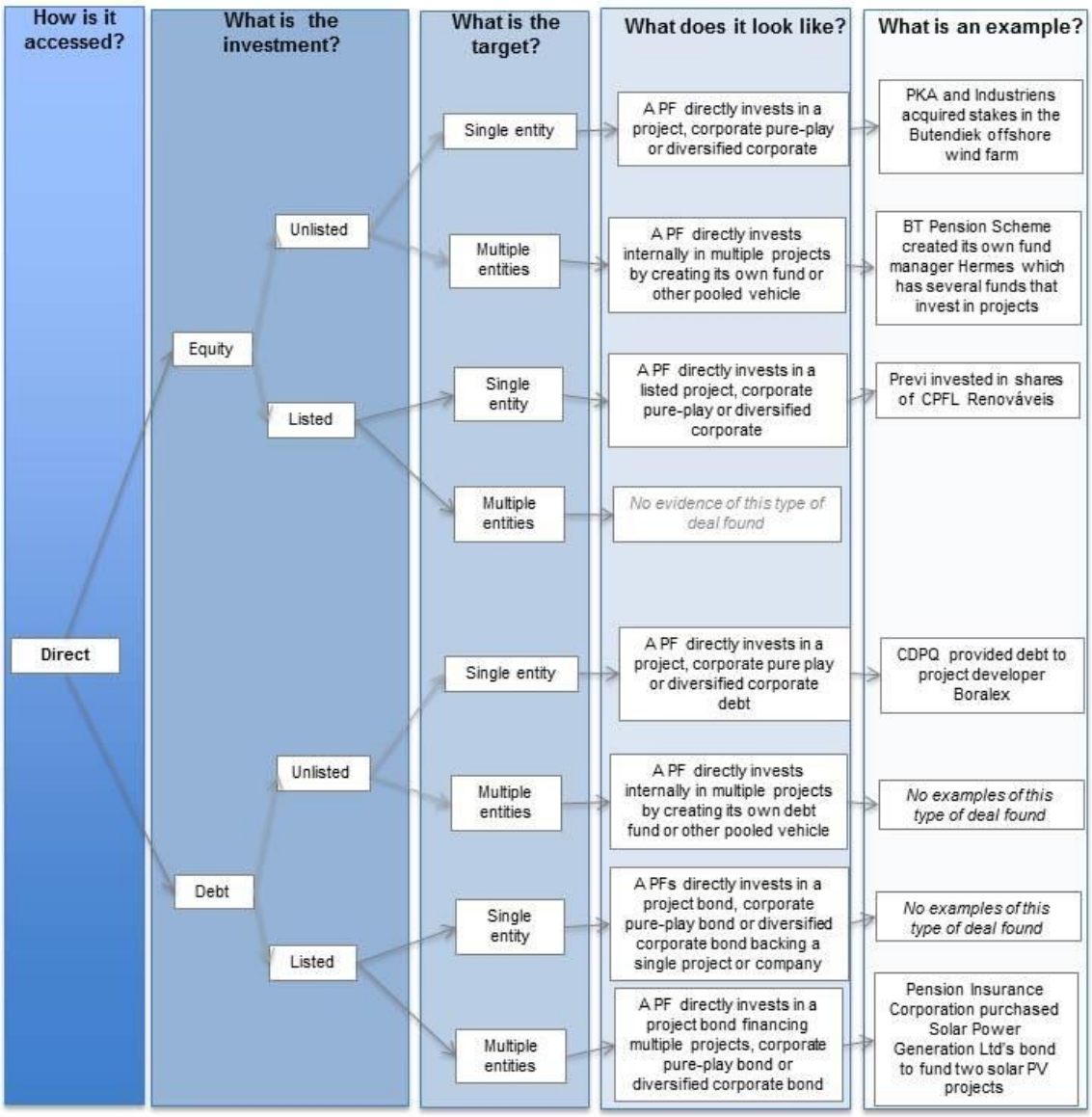
9.5.1 Pathways based on the ‘make or buy’ decision

Figures 9.3 and 9.4 provide a visual representation of the sustainable energy classification framework and the various characteristics and examples of investments based on the starting point of the investor’s decision between internally managing direct investment or using external managers or pooled funds to invest in sustainable energy infrastructure. The figures reflect a series of lenses or filters (composed of basic investment characteristics) through which investors consider different investment channels. Their decisions are informed by these lenses, and their preferences regarding these investment characteristics, including those relating to the make or buy option. The pathways put each of the 47 investments in context and spells out exactly which category each investment falls into. This helps map investments using common terminology. There are many kinds of funds, for example, and this helps clarify the key distinctions. The pathways also provide a visual introduction to terms that were introduced in the definitional overview.

The pathways presented are derived through primary research on institutional investor’s behaviour. This research was inspired by questions raised in a preceding OECD report for the G20 (Kaminker *et al.*, 2013), which called for more research to understand permutations and investment decisions. Examples of transactions are derived through secondary research using the database on institutional investors and sustainable energy investments constructed for this project. In some cases, no examples of investments in a certain ‘theoretical’ combination of characteristics were found. This may reflect data limitations, or that the type of investment might be impractical, uneconomic,

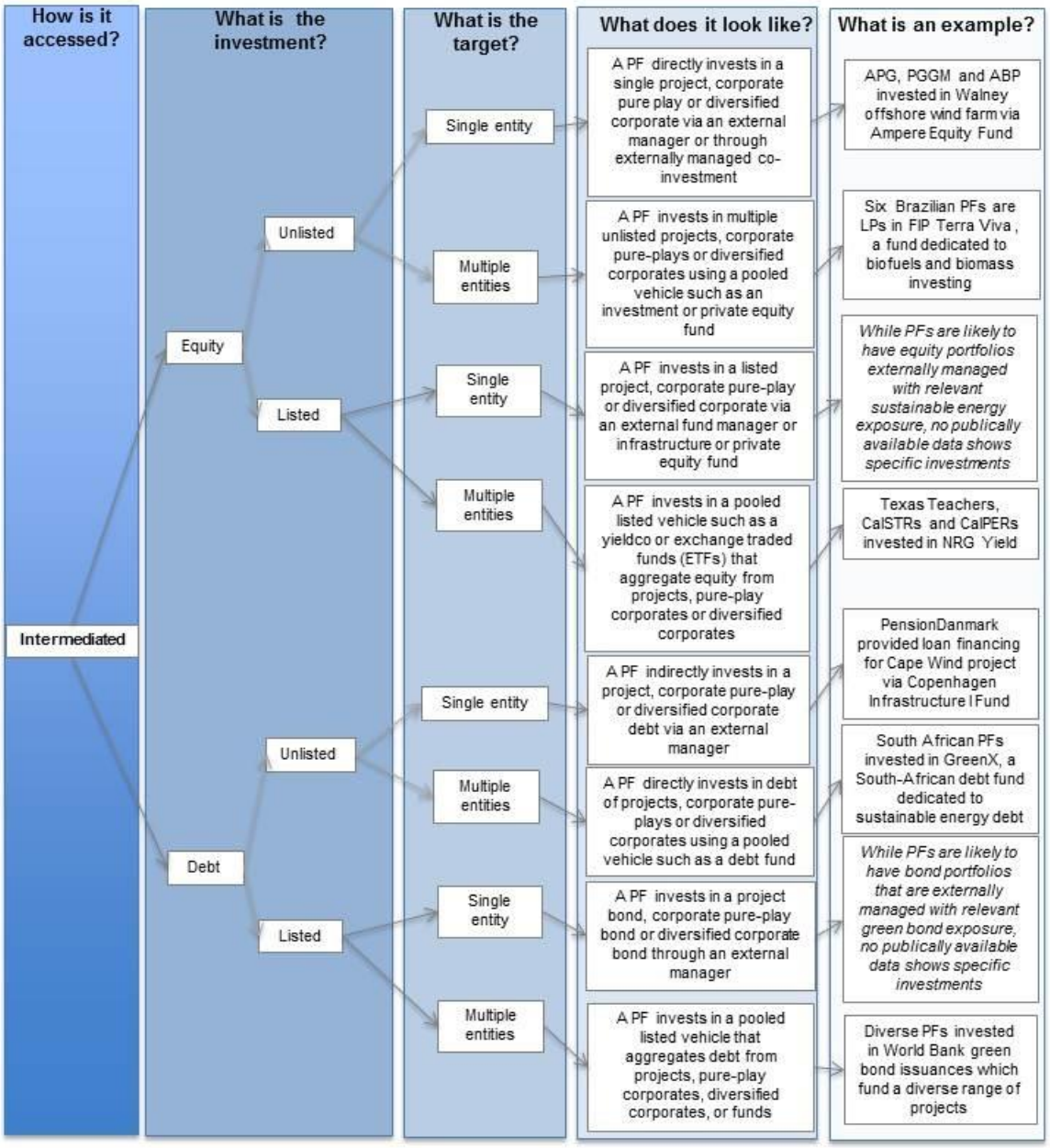
incompatible with risk considerations, more appealing to certain types of investor not covered by the sample (e.g. insurers), or simply unexplored by the financial sector.

Figure 9.3 Investment pathway for direct investment by 'in-sourcing asset management'



Source: Author (Kaminker *et al.*, 2015)

Figure 9.4 Investment pathway for intermediated investment by 'out-sourcing asset management'



Source: Author (Kaminker *et al.*, 2015)

Each investor will have different priorities when making decisions regarding how to allocate capital to sustainable energy which will also be strongly influenced by institutional rules and regulations regarding the types of permitted asset classes (C. Severinson and Yermo, 2012b; Stewart and Yermo, 2012; OECD, 2016b) and will have

targeted debt-to-equity splits for their portfolio. Institutional investor's interpretation of their fiduciary duties with respect to such types of investment differ widely as well (see for instance the work of Brown, 1998; Richardson, 2007; Clark, 2011; Sullivan, 2015; Labovitch, 2017).

For example, a defined benefit pension fund that is building its not yet paying out benefits may have a debt-to-equity split that is more heavily weighted toward equities to be able to generate higher returns. In contrast, a pension fund that is paying out benefits, is fully funded, and is not taking on any new pension benefit obligations likely will be more heavily weighted toward debt investments with relatively high credit ratings and lower standard deviation of returns than equity, to ensure that defined benefit payments may be made. The debt-to-equity split of pension funds with defined contributions (i.e. that do not guarantee a defined benefit, and for which participants can choose their investments) is determined by the investment choices of participants.

9.5.2 Pathways based on underlying investments

Figure 9.5, 9.8 and 9.9 shown below frame the decision to invest in sustainable energy as a decision based on the type of underlying investment and the subsequent types of investment options that can be considered as a result.

The investment pathways provided present alternative taxonomies to reflect the various characteristics and examples of investments if an investor decides to structure their investment decision as a choice between projects, pure-play corporates or diversified companies when assessing sustainable energy infrastructure. These decisions are fundamentally important as investments in projects and corporates come with very different characteristics and risks.

Corporate investment generally involves investment in publicly traded shares (equity) or bonds (debt) issued by corporations active in the sustainable energy sector. Such investments are generally easier for institutional investors to undertake given their liquidity, the availability of investment research and benchmarks. The disadvantage of this channel is that it has little or no connection to the infrastructure assets themselves. It therefore does not bring the associated benefits of direct investing (as described below), does not necessarily contribute to directly filling the investment gap, and does not necessarily help lower financing costs for sustainable energy infrastructure, in contrast (potentially) with direct investment in projects.

If a corporation raises additional capital from institutional investors, it will make an independent decision as to how it deploys this capital internally, i.e. the capital may go to any number of internal purposes or priorities and not immediately or directly be used for the construction of any new sustainable energy projects.

As examined in detail in earlier chapters, and by others previously, direct investments in projects have many characteristics which can appeal to institutional investors beyond yield (Della Croce et al, 2011; Kaminker & Stewart, 2012; Inderst & Stewart 2014). Sustainable energy projects that are 'bankable' can offer a form of 'pledgeable future income' through stable and predictable cash flows, because sustainable energy (excluding CCS except under certain circumstances) is not subject to fossil fuel price volatility and is backed by long-term contracts with generally Investment-grade[26] counterparts.

[26] Although this may not always be the case especially in developing countries.

The attractiveness of infrastructure returns to long-term investors is affected by movements in interest rates. In the post-2008 low-interest rate environment, a gap opened between the low yields on government bonds and those available on infrastructure investments.

Wind and solar projects also generally have an estimated 25-year lifespan, and often involve manufacturer warranties, long-term contracts with power purchasers (PPAs) and government support. Although these are also subject to policy reversal risk. Changing to a feed-in premium can also create electricity price volatility risk in some cases.

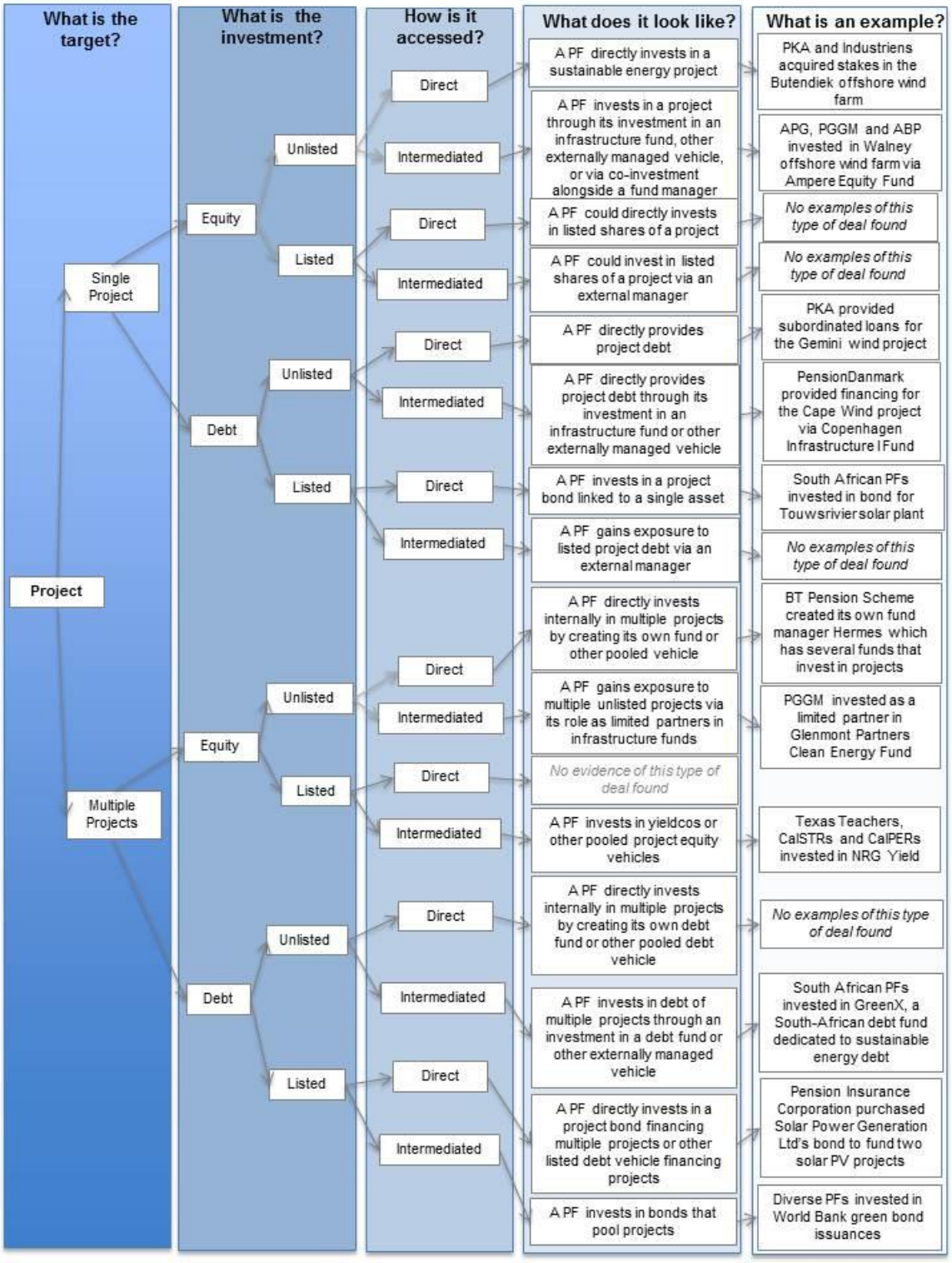
Most institutional investors seek long-term certainty. In some electricity markets PPAs are standard for sustainable energy and these can be particularly attractive if the counterparty is a utility with Investment-grade credit or a government. In the US and UK, for instance, long-term PPAs for sustainable energy projects are often driven by state Renewable Portfolio Standards or government Renewable Obligations, mandating utilities to buy a certain share of their power from these sources and encouraging long-term contracting.

Project investments can allow for asset-liability matching (e.g., cash flows from long-term investments and pension pay-outs), and help hedge the risks of long-dated liabilities. In addition, infrastructure assets could reduce exposure to the effects of inflation on their long-term liability (the pension benefit) if, for example, linked to Power Purchase Agreement contract structures which provide for stable cash flow and can have protection against inflation. Although PPA contract structures vary on a market-by-market basis, in various geographies renewable electricity tariff agreements include protection against inflation. For example, several tariffs in the EU are indexed to inflation

and adjusted on an annual basis. In projects where specific inflation protection is not provided, high current cash flows provide a certain level of inflation protection. Finally, the assets provide a hedge to energy inflation as they have long useful lives and potentially benefit from scarcity value in the future (i.e. fewer desirable wind/solar sites).

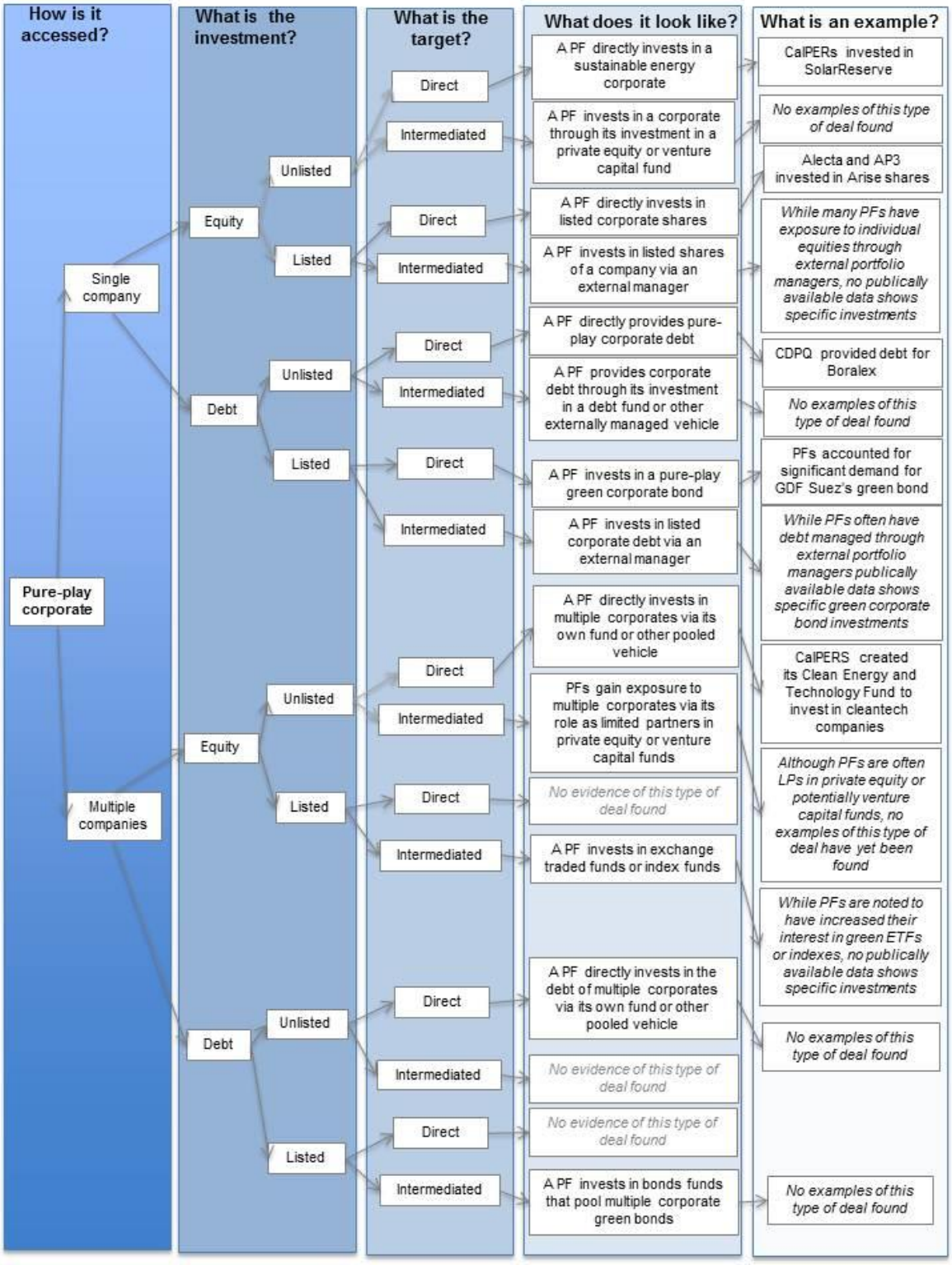
Another benefit of investments in sustainable energy projects is that if they are held through the economic life of the project, the returns should be negligibly correlated with those of the general market (e.g. with broad stock market indexes). RARE (2009) describes the correlation between the MSCI Global equity index and infrastructure investments between 2002 and 2008. Listed (i.e. publicly traded) infrastructure has a correlation of 0.65, while unlisted (privately held) infrastructure has a correlation of 0.23. Colonial First State Global Asset Management (2010) measures the correlation between infrastructure and other asset classes for the 10 years ending 2010. Listed infrastructure was shown to have a 0.45 correlation with equities, while unlisted infrastructure had a correlation of 0.10 (as cited and discussed in Kaminker *et al.*, 2013).

Figure 9.5 Pathways for investment in projects by pension funds (PFs)



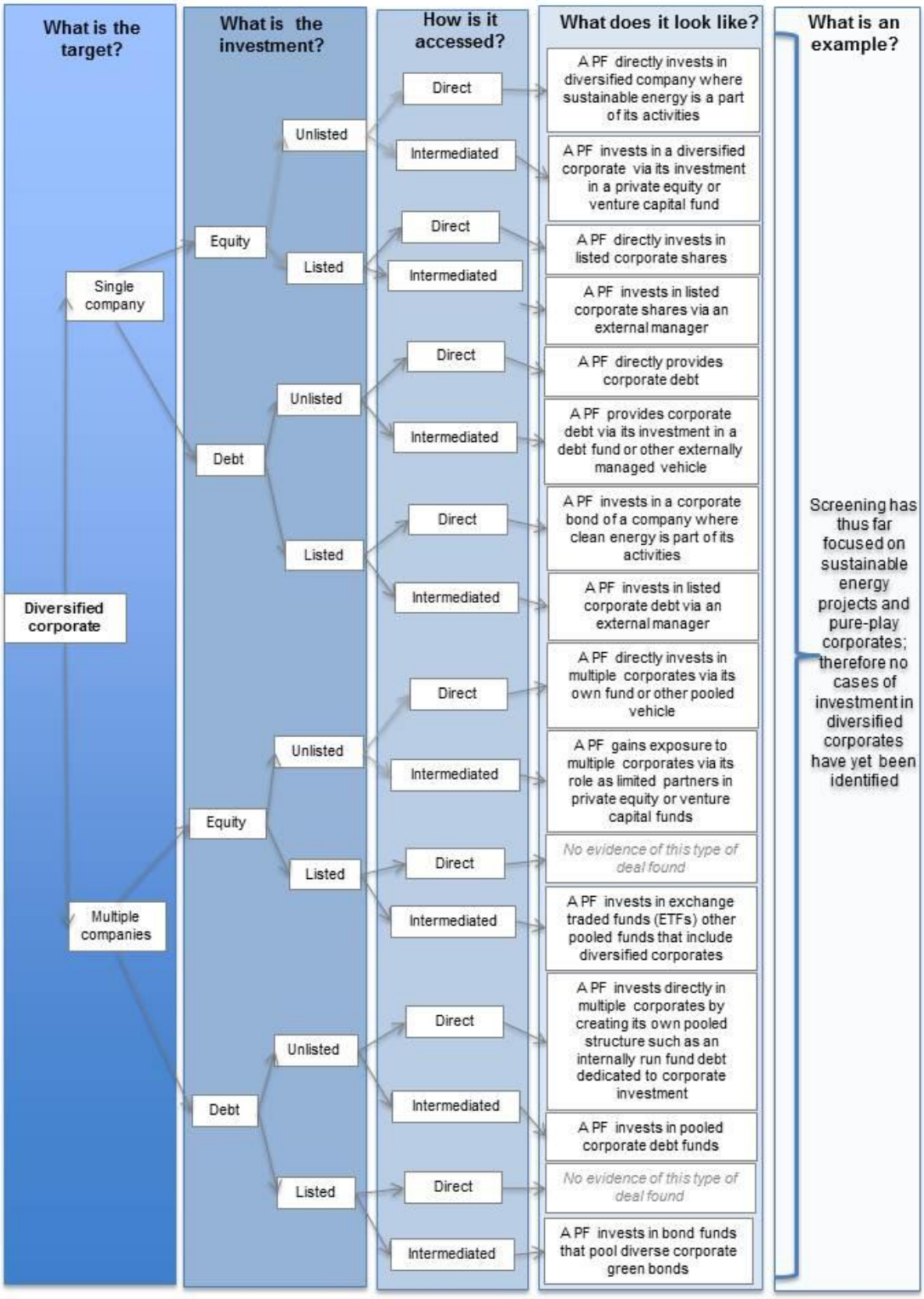
Source: Author (Kaminker *et al.*, 2015)

Figure 9.6 Pathways for investment in pure-play corporates by pension funds (PFs)



Source: Author (Kaminker *et al.*, 2015)

Figure 9.7 Pathways for investment in diversified corporates by pension funds (PFs)

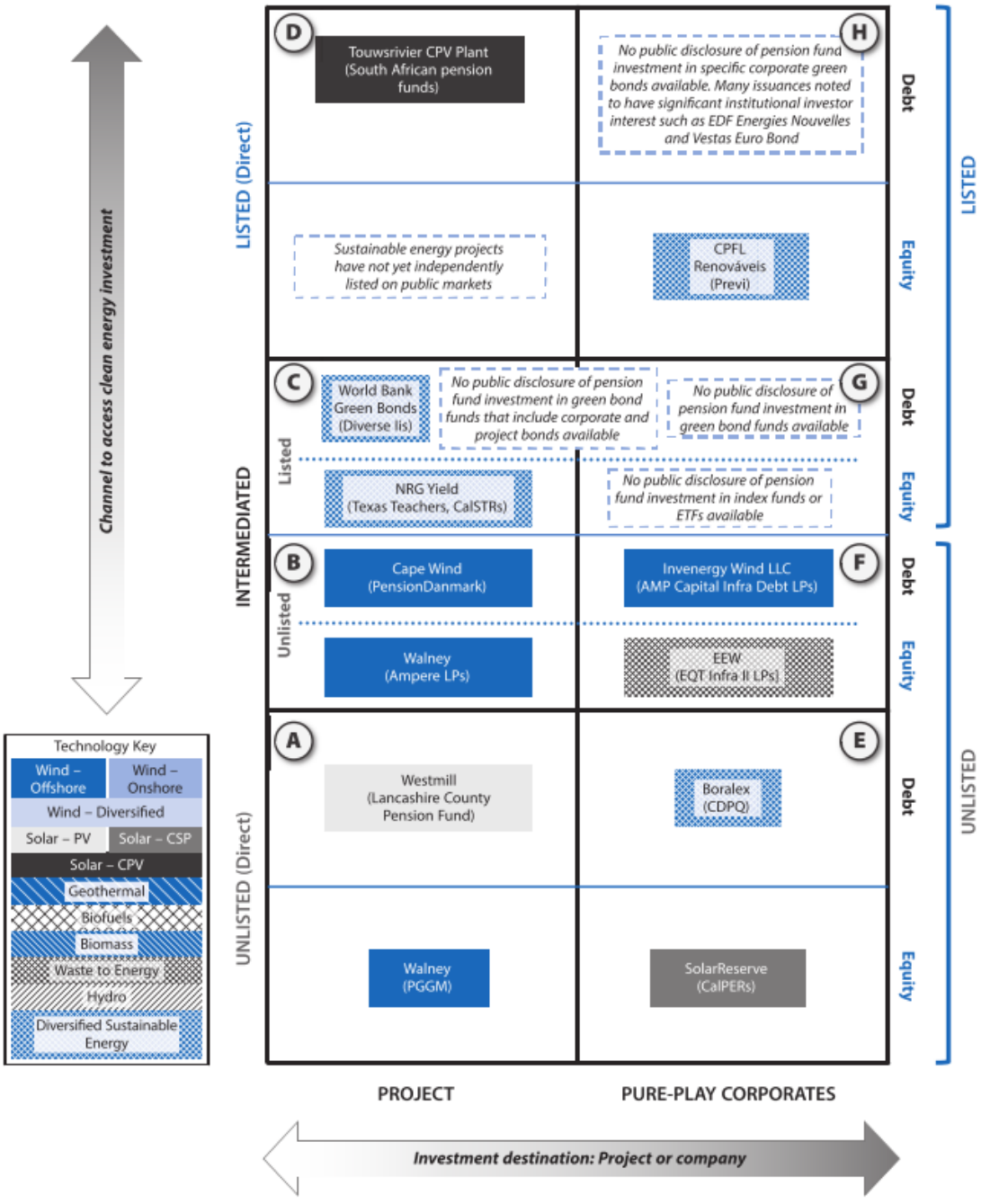


Source: Author (Kaminker *et al.*, 2015)

9.6 The ‘Matrix Frame’: Mapping channels for investment

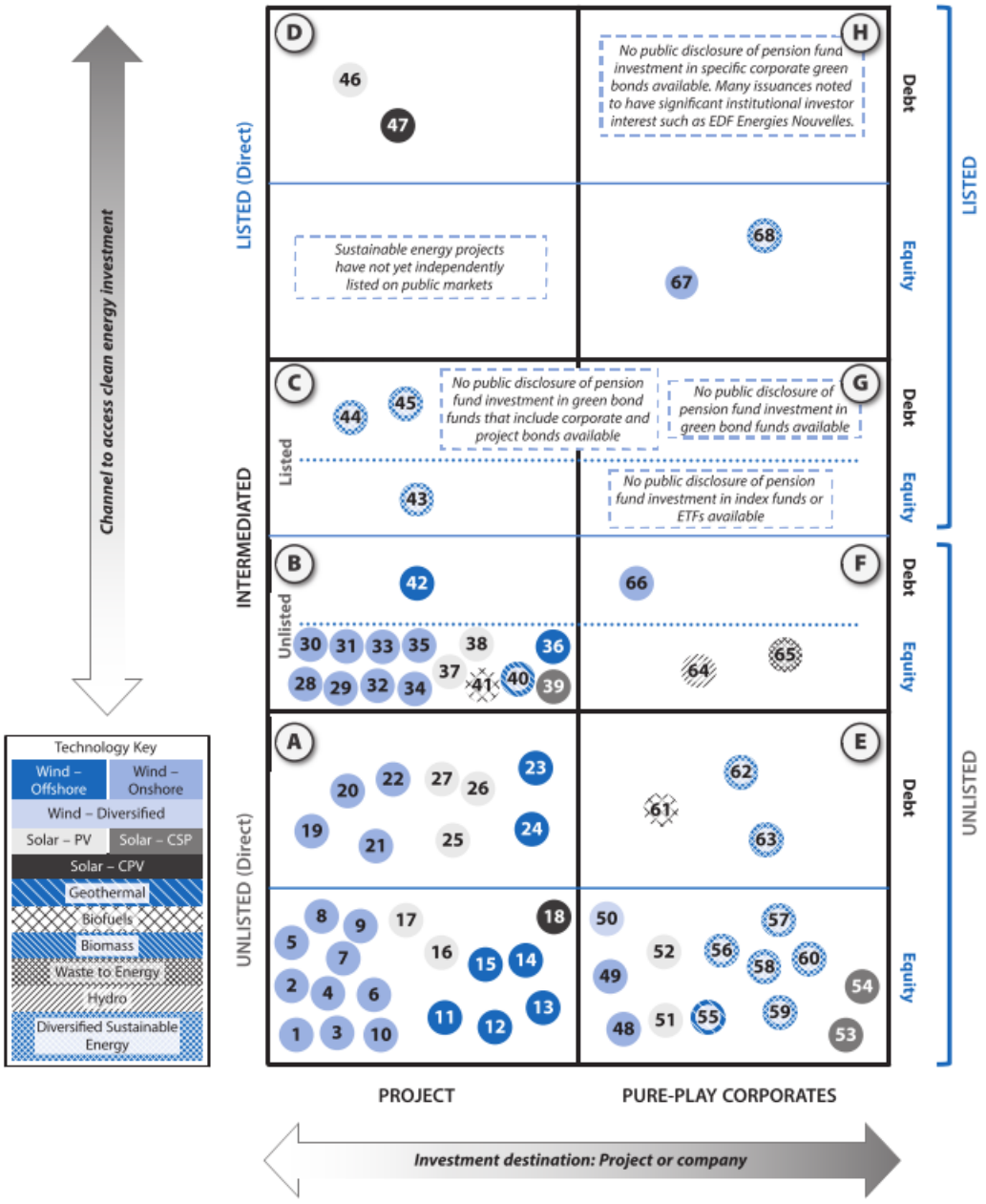
Having constructed the investment pathways to formalise the decision logic, they can then be combined in a ‘Matrix Frame’ which provides a theoretical investment framework for understanding and ‘mapping’ the transactions against channels that may or may not be options for investment. The Matrix Frame presented in Figure 9.8 plots a single example of where pension fund investment in sustainable energy projects as well as pure-play sustainable energy companies have been observed in the database. Note that not all relevant investments are shown on this figure. Figure 9.9 plots all 67 transactions observed in the database. An annotated key for these figures follows with additional information on the observations and reasoning for their classification given directly below the figures.

Figure 9.8 A matrix frame for mapping pension fund investment in sustainable energy with single examples



Source: Author (Kaminker *et al.*, 2015)

Figure 9.9 A matrix frame for mapping pension fund investment in sustainable energy with all observations



Source: Author (Kaminker *et al.*, 2015)

Key for Figure 9.9

A - Equity

1. Parc des Moulins Wind Farms (CDPQ)
2. Budendiek Offshore Wind Farm (PKA, Industriens)
3. Marena Renovables Wind Farm (PGGM)
4. Fallago Wind Farm (BT Pension Scheme, via internal manager Hermes GPE)
5. Braes of Doune Wind Farm (BT Pension Scheme, via internal manager Hermes GPE)
6. Invenergy North American Wind Portfolio (CDPQ)
7. Ulvemosen Wind Farm (Sampension)

8. Akhfennir, Haouma and Foum El Oued Wind Farms (Caisse Interprofessionnelle Marocaine de Retraites (CIMR))
9. Papalote Creek I, Papalote Creek II, and Stony Creek Wind Farms (PensionDanmark)
10. Dong Energy's Onshore Wind Portfolio (PFA)
11. London Array Wind Farm (CDPQ)
12. Nysted Wind Farm (PensionDanmark)
13. Walney Wind Farm (PGGM)
14. Anholt Wind Farm (PKA, PensionDanmark)
15. Gode Wind 2 Wind Farm (PKA, Industriens Pension, Laerernes Pension and Laegernes Pensionskasse)
16. Japan Solar (Qantas Superannuation, LGSuper)
17. German Solar Portfolio (BVK)
18. Touwsrivier CPV Plant (Government Employees Pension Fund (GEPF))

A – Debt

19. Vents du Kempt Wind Farm (CDPQ)
20. Bord Gais Eireann Wind Farm (PKA)
21. Seigneurie de Beaupre Wind Farm (CDPQ)
22. Jädraås Wind Farm (PensionDanmark)
23. Gemini Wind Farm (PKA)
24. Northwinds Wind Farm(PensionDanmark)
25. Westmill Solar Cooperative (Lancashire County Pension Fund)
26. Ashalim Sun Negev PV Plant (Clal Insurance Company, Clal Pension and Provident Funds, Atudot Pension Fund for Employees and Independents)
27. Amherstburg, Belmont, and Walpole PV Plants (CDPQ)

B – Equity

28. Pagupud Wind Farm (APG and GSIS via PINAI fund)
29. Spremberg Wind Farm (PGGM, ABP and other institutional investors via Ampere Equity Fund)
30. Carraig Gheal Wind Farm (PGGM, ABP and other institutional investors via Ampere Equity Fund)
31. German Wind Farm Portfolio (PGGM, ABP and other institutional investors via Ampere Equity Fund)
32. La Souterraine Wind Farm (British Airways Pension Fund, West Midlands Pension Fund, London Pensions Fund Authority and other institutional investors via Impax's NEF II)
33. Koegorspolder Wind Farm (PGGM, ABP and other institutional investors via Ampere Equity Fund)
34. Kuolavaara-Keulakkopää Wind Park (British Airways Pension Fund, West Midlands Pension Fund, London Pensions Fund Authority and other institutional investors via Impax's NEF II)
35. German Wind Project Portfolio (British Airways Pension Fund, West Midlands Pension Fund, London Pensions Fund Authority and other institutional investors via Impax's NEF II)
36. Walney Wind Farm (PGGM, ABP and other institutional investors via Ampere Equity Fund)
37. Puglia PV Plant (PGGM, ABP and other institutional investors via Ampere Equity Fund)
38. Spanish PV Portfolio (PGGM, ABP and other institutional investors via Ampere Equity Fund)
39. Bokpoort CSP Plant (Transnet Retirement Fund via Lereko Metier Sustainable Capital Fund)
40. Brigg Biomass Plant (PensionDanmark via Copenhagen Infrastructure I)
41. Alvorada Biofuels Plant (Funcef, BNDESPar, Fachesf, and Petros via FIP Terra Viva)

B – Debt

42. Cape Wind (PensionDanmark via Copenhagen Infrastructure I)

C – Equity

43. NRG Yield (Texas Teachers, CalSTRs)

C- Debt

44. World Bank Third Green Bond (California Teachers, AP Fonden 2, AP Fonden 3, UN Joint Staff Pension)
45. World Bank Green Kangaroo Bond (SunSuper)

D – Equity

No relevant cases

D – Debt

46. Somerset PV Plant Bond (Pension Insurance Corporation)
47. Touwsrivier CPV Plant Bond (South African pension funds)

E - Equity

48. Ogin Energy (New Zealand Superannuation Fund, AIMCo)
49. Invenergy Wind (CDPQ)
50. Dong Energy (ATP, PFA)
51. Alta Devices (AIMCo)
52. Solibro (AP Fonden 6)
53. SolarReserve (CalPERS)
54. Brightsource (CalSTRS)
55. GeoDynamics (Sunsuper)
56. PacificHydro (30 Australian pension funds)
57. Desenvix (Funcef)
58. BluEarth Renewables (Ontario Teachers)
59. Isolux Infrastructure (Public Service Pension Plan)
60. Boralex (CDPQ)

E – Debt

61. KiOR (AIMCO)
62. Boralex (CDPQ)
63. First Wind (AIMCo)

F – Equity

64. Ondina (APB)
65. EEW Energy From Waste (Alaska Permanent Fund, Ilmarinen, KEVA, Lancashire County Pension Fund, New Mexico Educational Retirement Board, SEB Pension, Skandia, Varma and VER)

F – Debt

66. Invenergy Wind (East Riding of Yorkshire Council)

G - Equity

No relevant cases

G – Debt

No relevant cases

H – Equity

67. Arise (Alecta, AP
68. CPFL Renováveis (Previ)

H – Debt

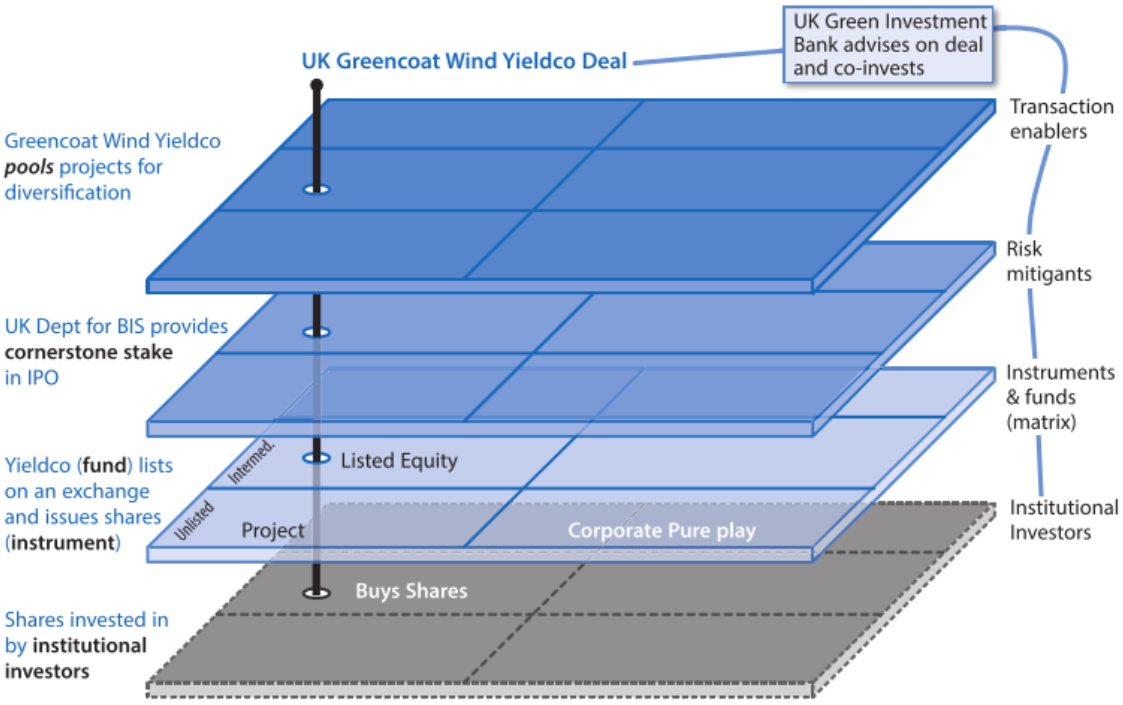
No relevant cases

9.7 Breaking down the framework by a single deal

Each of the 47 project investment transactions presented in this chapter involved different combinations of instruments, funds and at times also the use of risk mitigants and transaction enablers. The 3-dimensional wafer displayed in Figure 9.10 provides a visual construct of how these instruments, funds, risk mitigants and transaction enablers can come together in a single final transaction. The Greencoat UK Wind PLC is a closed-ended infrastructure investment company (also known as a 'YieldCo' fund) that is listed on the London Stock Exchange, and is described in detail in Chapter 10.2.12.

In this example, institutional investors (including the London Pension Fund Authority) in the UK Greencoat Wind IPO purchased shares (instrument), which involved a YieldCo (fund), that was de-risked by a cornerstone stake purchase from the UK government and benefitted from reduced transaction costs due to pooling (a transaction enabler). While institutional investors (e.g. the London Pension Fund Authority) are the asset owners and contributors of capital (i.e. the bottom layer of Figure 9.10) the core of the classification framework focuses on the instruments and funds that represent the actual investments made by institutional investors in sustainable energy infrastructure instruments and fund. The UK Green Investment Bank, a special-purpose public financial intermediary made the entire transaction possible by advising on all aspects of the deal and co-investing alongside the YieldCo in the underlying wind farms.

Figure 9.10 An illustration of the components of the classification framework for institutional investment in sustainable energy of a single deal



Source: Author (Kaminker *et al.*, 2015)

In the absence of a level playing field for sustainable energy manifested through elevated costs and risks and in the face of the multitude of barriers, a key challenge for policy makers (as well as private and public financial institutions) is to design risk mitigants that effectively address the barriers and increase the attractiveness of sustainable investment to institutional investors. These risk mitigants are discussed in the following chapter followed by a discussion of transaction enablers.

9.8 Future applications of the framework

The framework provided by the classification and figures in this section can be used as the basis for future collection of data and consequent empirical analysis of these issues in a standardised form as more data becomes available on transactions. As such, later

chapters build on this research. Future applications of the matrix frame using expanded data could examine institutional investment activity:

- By investor class (e.g. pension fund or insurer).
- Within an investor class (e.g. defined benefit pension funds or life insurers)
- By geography (e.g. individual countries, regions, G20, etc.)
- By single technology (e.g. offshore wind) or expanding to green infrastructure not covered in this thesis (sustainable agriculture, water, energy efficiency, etc.) or to technologies yet to be commercialised or to attract institutional investment (e.g. CCS and associated infrastructure)
- By technologies linked to specific policy support mechanism (e.g. offshore wind feed-in tariffs)
- Over time (snapshots of latest activity or over time periods), including as a method for examining the effects of certain regulatory frameworks being put in place or removed.

9.9 Implications for subsequent chapters

The investment pathways and Matrix Frame establish a systematic framework for interested researchers to understand the different channels and to communicate better with investors. They show illustrate where activity is and is not happening and can provide an update on recent activity.

Despite the challenges and barriers, pension fund investment in sustainable energy projects and pure-play project developers and other corporates is occurring. Future analysis could usefully examine how this is changing over time.

Flows in this sample are largely domestic; pension funds seem to be investing in local or regionally-relevant projects. There could be interesting economic geography linkages here to explore further, possibly also related to informational asymmetry reasons.

Examples exist of small pension fund (less than USD 35 billion in AUM) investment in sustainable energy projects, which may start to challenge the notion that only large pension funds are interested or capable of investing in projects on their own. Examples observed of small pension fund investments for local development of sustainable energy were unexpected (e.g. an example was observed of a local pension fund investment in a local community solar cooperative).

The cases also highlight the diversity of investments and the channels used to access these investments. Consideration of the geography of pension fund diversity (form, size, structure, governance) and national regulatory contexts are just as important and will be vital for shaping activity in general. Every country will be different. These differences will have implications for which investment channel is most logical or accessible for domestic institutional investors to access. Much more research is needed to match the geography of institutional investors to investment channels.

The absence of observations in certain investment pathways (e.g. listed single-project equity) can hypothetically be explained by four reasons: 1) observations exist but adequate data is not available due to lack of publicly available investment disclosure 2) there is a lack of demand due to reasons such as regulatory barriers, lack of investment experience with a particular type of investment or simply because the investment is deemed uneconomic, not accessible for pension funds (due to restriction or regulation), or impractical 3) pathway has not been explored or pursued by the financial community

so the investment pathway exists only theoretically but not in practice, 4) there is a lack of mandate for a type of investment as asset allocation or risk management practices may not provide a mandate for a given investment type.

9.10 Annotated key for Figure 9.8 providing detail of transactions and logic for classification

This section details the logic underpinning the categorisations and provides descriptive examples for why deals were classified into each section of the Matrix Frame.

A) Direct unlisted investments in projects

Direct unlisted project equity

Institutional investors can invest in unlisted sustainable energy projects by independently acquiring an equity stake in a project or through joint-ventures and consortiums to co-invest alongside other investors.

Deals in the sample under this heading include:

Dutch pension fund PGGM in consortium with the renewables-focused infrastructure fund Ampere Equity Fund acquired a 24.8% equity stake from Dong Energy in the UK Walney offshore wind farm.[27]

Dutch Pension Funds PKA and Industriens each acquired 22.5% equity stakes in the 288 MW Butendiek offshore wind farm in Germany (Marguerite, 2013).[28] The

[27] See Kaminker et al. (2013) and Hervé-Mignucci (2012) for detailed case studies of the Walney transaction.

[28] Other investors include Marguerite Fund (22.5%) and Siemens Financial Services (22.5%). WPD (the project developer) retained a 10% stake. The total investment is approximately EUR 1.3 billion and construction will continue through 2015. Project debt financing was provided by the EIB, the Danish export credit agency, KfW and nine additional commercial banks (Marguerite, 2013).

Butendiek project benefited from EUR 239 million in debt financing provided by the German development bank KFW and its subsidiary KfW IPEX-bank as part of their special program Offshore Wind Energy Programme (KFW, 2013).[29]

The Dutch pension fund PGGM and Mitsubishi Corp acquired a combined 67.5% equity stake in the 396 MW Marena Renovables onshore wind farm in Mexico, from the Mexican bottling company, Fomento Económico Mexicano SAB de CV, and Macquarie Capital, the corporate advisory arm of the Macquarie Group, which is active in infrastructure investments (LAVCA, 2012).[30]

Direct unlisted project debt

Institutional investors can finance unlisted sustainable energy projects by directly providing debt to project developers, financing alongside a group of lenders, or through purchasing privately placed asset-linked green bonds. Unlike most green bonds issued to date, asset-linked green bonds have credit ratings that are based on the risk that the asset (i.e. the sustainable energy project) will not provide expected levels of return on investment. CRC Breeze Finance Bonds is one example of an asset-linked green bond. It was the first securitisation of wind farms -- illiquid investments in wind farm projects were transformed into tradable investment products (asset-linked green bonds). One of the three tranches of bonds was privately placed. The bonds experienced credit downgrades due to lower-than-expected electricity generation from the projects[31], among

[29] KfW IPEX-Bank, together with Bremer Landesbank and Unicredit acted as the mandated lead arranger for the banking consortium of 12 institutes including the EIB and the Dutch export credit agency EKF.

[30] The Macquarie Mexican Infrastructure Fund will retain their 32.5% stake in the project (LAVCA, 2012).

[31] More specifically according to Moody's, the downgrades reflect the increasing statistical significance of poor wind conditions experienced on the portfolio to date, which have been substantially below the original energy production forecast since 2009, and provide growing evidence that initial wind resource projections were overly optimistic.

other factors, and have been a disappointment for investors, although they provide useful lessons for future securitisations (Kaminker *et al.*, 2013).

Deals in the sample under this heading include:

Danish pension fund PKA provided EUR 120 million of subordinated loans for development of the 600 MW Gemini offshore wind project in the Netherlands (Miller 2013).[32]

Canadian pension fund Caisse de depot et placement du Quebec (CDPQ) provided CAD 50 million term loan of a total CAD 300 million financing package for the Vents du Kempt onshore wind farm in Canada.[33]

The Westmill Solar Cooperative refinanced its 5 MW Watchfield PV plant in Oxfordshire with a GBP 12 million bond privately placed with UK Lancashire County Pension Fund (Lancashire County Council, 2013).[34]

B) Intermediated unlisted investments in projects

Intermediated unlisted project equity

Institutional investors can invest in unlisted sustainable energy projects through their financial commitments to pooled funds such as infrastructure funds, renewable energy funds or unlisted funds of funds.

[32] The total debt investment was EUR 200 million with the additional EUR 20 million coming from Canadian power company Northland Power.

33 Manufacturer's Life Insurance Company and KfW provided the remaining debt financing. The project developers are Eolectric Inc and fund Fiera Axium Infrastructure Canada LP. Pension funds are also significant investors in the Fiera Axium fund.

[34] The bond issuance allowed for a refinancing of the original project cost and was entirely purchased by the Lancashire County Pension Fund. The Westmill Solar Cooperative is community-owned and operated as a cooperative. The 23.5-year bond provides the Westmill Solar Cooperative with long-term finance and will guarantee a return of "3% above the retail prices index" for the Lancashire County Pension Fund (Williams, 2013).

Deals in the sample under this heading include:

PINAI, a Philippines-focused infrastructure fund invested USD 85 million in the 81 MW Pagudpud onshore wind farm. Pension funds that are limited partners in PINAI include the Dutch APG and the Philippines' state-owned pension fund Government Service Insurance System (GSIS) (ADB, 2013).[35]

Ampere Equity Fund invested in Walney offshore wind farm in the UK. Pension funds that are limited partners in the Ampere Equity Fund include Dutch pension funds APG, PGGM and ABP (Hervé-mignucci, 2012).[36]

There is a broad range of possibilities on the indirect or fund route in developing countries. Many commercial funds exist, mainly in the form of private equity funds, mutual funds or listed investment trust. Other types of funds are often in some form sponsored by governments, national agencies or multilateral development banks, frequently combining public and private involvement. Some other interesting examples of co-investment exist, e.g. funds jointly owned by pension funds, or dedicated trust funds and structure projects (Inderst & Stewart, 2014).

Intermediated unlisted project debt

Institutional investors can invest in unlisted sustainable energy projects through their commitments to pooled debt funds such as infrastructure debt funds or renewable energy debt funds. Structured funds are also used to pool projects into one product. Besides the pooling of projects, they also allow for a transformation of maturity, i.e. short-

[35] PINAI's investment (32%) in the project is a joint venture with AC Energy Holdings (64%), a subsidiary of Ayala Corporation and UPC Renewables (4%) (ADB, 2013).

[36] See Kaminker et al. (2013) and Hervé-Mignucci (2012) for a detailed case study of the Walney transaction.

term into long-term, and they can create different risk categories. They are most useful when information is unbalanced and consequently risks are overpriced (Lindenberg, 2014).

Deals in the sample under this heading include:

Danish pension fund PensionDanmark provided a USD 200 million mezzanine loan for the Cape Wind offshore wind project in the United States. PensionDanmark provided financing via Copenhagen Infrastructure I, an infrastructure fund dedicated to investing on behalf of PensionDanmark (Copenhagen Infrastructure Partners, 2013).

C) Intermediated listed project investment

Intermediated listed project equity (YieldCos)

Equity investment in sustainable energy projects has most commonly been the domain of private investment funds. However, institutional investors can now access a listed portfolio of projects using new project pooling structures such as YieldCos. Using a YieldCo an investor can diversify risk by owning equity in a portfolio of projects that may include varying stages of development, technology used and geographical location. Despite the promise of YieldCos and strong interest from institutional investors (see Box for a discussion of the emergence of YieldCos), there are few examples of specific YieldCo investment by pension funds in our sample. As noted earlier in the methodology discussion in this section, investments in listed equity and debt are very difficult to identify as they may be actively traded on the market and holdings can therefore change daily. In addition, most pension funds do not disclose every individual stock or bond holding in their portfolio.

Deals in the sample under this heading include:

Pension funds including Teacher Retirement System of Texas, CalSTRs and CalPERs invested in shares of NRG Yield, a YieldCo with a diversified portfolio of energy infrastructure assets including natural gas, solar, wind and thermal power generation (NASDAQ, 2013).

Intermediated listed project debt (green bonds)

Institutional investors can invest in a listed project debt through their investment in a green bond issuance that pools debt from diverse projects or a green bond fund that pools green project bonds. An example of a green bond fund is the SSgA (State Street Global Advisors) High Quality Green Bond Strategy which seeks to approximate specific characteristics of its benchmark – the Barclays Capital U.S. Treasury Index (an investment fund index of debt instruments with different durations issued by the U.S. Treasury) – through investments principally in green bonds and other debt instruments.

Deals in the sample under this heading include:

A diverse pool of institutional investors has purchased green bonds issued by the World Bank to fund diverse projects that support climate change adaptation or mitigation. Since 2008, the World Bank has issued approximately USD 4 billion in green bonds (World Bank, 2013). Notable pension fund investors include Sweden's AP Fonden 2 and AP Fonden 3, CalSTRS, New York Common Retirement Fund, and UN Joint Staff Pension Fund (World Bank, 2013).

The World Bank issued their first AUD-denominated Kangaroo Bond in 2014. Australian superannuation fund UniSuper was the cornerstone investor for the issuance, purchasing AUD 100 million of the total AUD 300 million offering (Fernyhough, 2014).

D) Direct (in-house) listed project investments

Institutional investors that seek investments in traditional equity and fixed income can access sustainable energy through investments in listed projects or companies.

Listed single-project equity

Sustainable energy projects have not yet independently listed (i.e. issued tradable equity shares) on public capital markets.

Listed single-project debt

A listed green project bond can provide financing for a single project, a portfolio of similar or standardised projects (such as wind farms or rooftop solar panel installations), or a portfolio of diverse sustainable energy infrastructure projects.

Deals in the sample under this heading include:

The Soitec project bond was issued to finance the Touwsrivier solar power plant using concentrated photovoltaic (CPV) technology. The South African bond was issued in local currency and attracted a diverse pool of investors including South African pension funds and asset managers (Soitec, 2013).

A publicly listed solar project finance bond was issued by Solar Power Generation Ltd to fund two 5 MW solar PV plants in England. The UK Pension Insurance Corporation purchased the entire GBP 40 million offering (PIK, 2012).

E) Direct unlisted investments in pure-play corporates

Direct unlisted (private) corporate equity

Institutional investors can take equity stakes in unlisted pure-play energy corporates. For start-ups or sustainable technology companies, equity stakes may be purchased through venture capital funding rounds in which an institutional investor may participate alone or can collaborate with a group of investors. Due to the risks associated with funding early-stage companies and the poor short-term performance associated with many sustainable technology company ventures, there has been a retreat in sustainable technology venture capital funding from pension funds (Maag, 2013). However, other investors have continued to pursue the sector including particular activity from corporates that are establishing their own internal venture capital units or investing in venture capital funds. Other institutional investors such as sovereign wealth funds and family offices have also continued to fund sustainable technology companies (Maag, 2013). Some institutional investors that seek investments in unlisted companies may create their own in-house unit or fund dedicated to equity stakes in unlisted companies.

Deals in the sample under this heading include:

California pension fund CalPERS has an in-house Sustainable Energy and Technology Fund.

CalPERS also participated in multiple venture capital funding rounds for SolarReserve, a California-based solar thermal electric generation project developer (BNEF, 2011).[37]

Direct unlisted (private) corporate debt

Institutional investors can finance unlisted pure-play sustainable energy corporates by providing debt directly to a company or through contributing a portion of the total financing alongside other lenders.

Deals in the sample under this heading include:

Canadian pension fund Caisse de depot et placement du Quebec (CDPQ) and the National Bank of Canada Financial provided revolving debt for Canadian renewable project developer Boralex (BNEF, 2006).

Two Canadian pension fund clients of Alberta Investment Management Corporation (AIMCo) provided USD 50 million of a total USD 75 million term loan for KiOR, Inc, a development-stage biofuels company (KiOR, 2012).

F) Intermediated unlisted pure-play corporate investment

Intermediated unlisted equity investment in pure-play corporates

Institutional investors can invest in unlisted pure-play sustainable energy corporates through pooled funds such as private equity funds or venture capital funds.

[37] CalPERS invested through their CalPERs Sustainable Energy and Technology Fund. Additional investors included Citi Sustainable Development, Bregal Energy, US Renewables Group, Seven Mile Capital Partners, ACS Cobra, Argonaut Private Equity, Nimes Capital, and Credit Suisse.

Deals in the sample under this heading include:

EQT Infrastructure II fund invested in EEW Energy From Waste, a German operator of 18 waste to energy plants. Pension funds that are limited partners in the EQT fund include Lancashire County Pension Fund, New Mexico Educational Retirement Board, Varma and VER (EQT, 2013).

Intermediated unlisted debt provision for pure-play companies

Institutional investors can invest in unlisted pure-play sustainable energy company debt through pooled debt funds such as infrastructure debt funds, specific renewable energy debt funds or unlisted debt fund of funds.

Deals in the sample under this heading include:

AMP Capital Infrastructure Debt Fund II provided subordinated debt for Invenergy, which describes itself as the largest independent wind company in North America with over 25 wind farm projects in operation and under construction. Pension funds that are limited partners in the AMP Infrastructure Debt Fund II include UK pension funds and Australian superannuation funds.

G) Intermediated listed pure-play corporate investment

Listed pure-play corporate debt

Institutional investors could invest in listed pure-play corporate debt through their investments in green bond funds which invest in a basket of corporate green bonds. Alternatively, a green bond which is linked to an equity index of pure-play corporates could fit in this category. An example of type of investment could be the 2014 issuance of a EUR 50 million structured green bond by the World Bank which is linked to the

Ethical Europe Equity Index (World Bank, 2014). No information is available on this investment channel, as pension funds do not specify in their public disclosures the extent of their investment in corporate green bond funds.

Listed pure-play corporate equity

Institutional investors can invest in listed pure-play corporate equity through their investments in sustainable energy exchange-traded funds (ETFs) or index funds. These funds may be composed of a basket of sustainable energy stocks in general or may be narrowed by industry such as a solar-only ETF.

No information is available on this investment channel, as pension funds do not specify in their public disclosures the extent of their investment in index funds or ETFs.

H) Direct (in-house) listed corporate pure-play investment

Direct (in-house) corporate pure-play listed equity

Institutional investors can invest in corporate pure-play equity by purchasing shares in a company during an initial public offering (IPO) or through trading. As in the case of corporate pure-play debt, institutional investors that manage their investments ‘in-house‘ directly manage their own equity portfolios and the equity exposure is deliberate, rather than simply being a secondary exposure through investment in a fund or index.

Deals in the sample under this heading include:

Swedish pension funds AP Fonden 3 and Alecta are among the top ten shareholders in Arise, a leading Swedish wind power company (Arise, 2014).

Brazil's largest pension fund Previ holds a significant shareholding (over 7%) in listed renewable energy company CPFL Renováveis (CPFL Renováveis, 2013a).[38]

Direct (in-house) corporate pure-play listed debt

Institutional investors can invest in pure-play corporate debt by purchasing corporate bonds. For institutional investors that opt to manage their investments (including their fixed-income – i.e. debt investment -- portfolios) 'in-house', their corporate bond exposure is deliberate; this contrasts with investments in funds or indexes where an external manager or entity determines the composition of a fund or index.

There is no public disclosure of pension fund investment in green bonds funds available, but there have been many corporate green bond issuances such as the Vestas Eurobond and the EDF (Électricité de France) Energies Nouvelles green bond that were noted in the press to have significant institutional investor interest.

[38] CPFL Renováveis has a portfolio of over 5,500 MW of renewable energy including wind, solar, hydro and biomass with a pipeline to develop an additional 3,800 MW of renewable energy (CPFL Renováveis, 2013b)

10. A STOCKTAKING OF RISK MITIGANTS AND TRANSACTION ENABLERS FOR SUSTAINABLE ENERGY INVESTMENT

The moon leaps
In the Great River's current…
Floating on the wind,
What do I resemble?

Du Fu

'Traveling at Night' (China, Tang Dynasty, 765)

As cited in *The Demon Haunted World*, (Carl Sagan, 1996)

10.1 Introduction

This chapter advances the discussion beyond the investment channels for sustainable energy that can be used by institutional investors to the interventions that can enable or facilitate these investments, either through mitigating risks or lowering transaction costs. The methodological approach used in this chapter is inspired by grounded theory and involves primary research into the literature on how such approaches have been developed and deployed.

By providing coverage for risks which are new and are not currently covered by financial actors, or are simply too costly for investors, risk mitigants increase the attractiveness and acceptability of sustainable energy projects. These include a range of targeted interventions generally aimed at reducing, re-assigning or re-apportioning different investment risks (e.g. credit enhancements, cornerstone stakes, and tools targeting different challenges across stages of the project lifecycle).

As a subset of risk mitigants, techniques facilitate institutional investment in sustainable energy infrastructure projects by reducing the transaction costs associated with these investments while also mitigating risk in some cases (e.g. warehousing, securitisation and supporting co-investment and collaboration among institutional investors). Elements of this work were published in 2015 and 2016 as G20 Finance Minister and Central Bank Governors deliverables under the Turkish and Chinese G20 Presidencies (Kaminker *et al.*, 2015; Kaminker, 2016b).

10.2 Risk mitigants

As introduced in 5.11, the classification framework presented in this report is based on the instruments and funds that are the channels for investments made today by

institutional investors in sustainable energy infrastructure. Although there are important pockets of investment activity, investments in sustainable energy infrastructure face a multitude of barriers (described in 7.8) and an uneven playing field for sustainable energy in terms of costs and risks. A key challenge for policy makers (as well as private and public financial institutions) is in designing risk mitigants and other interventions that address these barriers. To increase the attractiveness of sustainable energy investments for institutional investors, these interventions can be used to reduce the perceived risks associated with sustainable energy investment or to help make these transactions accessible to institutional investors in the first place.

The willingness of institutional investors to finance major investment projects in any given country will be heavily influenced by perceptions of the country's investment climate. More specifically, it will be influenced by policy settings and institutions that underpin a country's economy and political processes. Investors' perceptions of risks associated with a country or market and the ability to effectively mitigate these risks will play a key role in determining financing flows. Financial institutions and governments can have an impact on these perceptions using risk mitigants. For example, insurance companies, green investment banks and multilateral development banks all play key roles as providers of risk mitigants. Figure 8.6 provides an overview of these diverse public and private actors and their respective focus on sustainable energy investments.[39]

[39] It is worth noting that much many of the lessons discussed herein are also applicable to other types of infrastructure investment beyond sustainable energy which creates opportunities potentially for knowledge transfer between sectors.

10.2.1 Credit enhancement and risk reduction

As opposed to instruments and funds, which are essentially types of investments, credit enhancement involves targeted interventions generally aimed at reducing, re-assigning or re-apportioning different perceived investment risks. In the context of investment in infrastructure, including sustainable energy infrastructure, credit enhancement is often used by public and private financial institutions to make such investments more attractive to investors, including institutional investors.

While infrastructure projects in general have the potential to deliver attractive risk-adjusted returns to institutional investors, there is a common mismatch between the long-term, relatively low-risk investment needs of institutional investors and the available financing structures. Investments must therefore be structured to provide risk-return profiles that match institutional investors' liability structures and expectations for steady and long-term income flows. Many of the factors that weigh against institutional investors taking more interest in sustainable energy infrastructure can be broadly described as different types of risk. These risks can make it difficult for sustainable energy projects to obtain an investment-grade credit rating. Rating agencies are naturally conservative, particularly when trying to assess long-term projects or contracts, and especially if there is a limited long-term performance history to evaluate (Kaminker and Stewart, 2012; Stewart and Kaminker, 2012; Kaminker *et al.*, 2013). In emerging and developing countries, securing the sufficient investment-grade rating necessary for institutional investors to invest in certain projects is particularly challenging (Inderst and Stewart, 2014).

Sustainable energy infrastructure is becoming less policy-dependent as technology costs continue to decrease and in some jurisdictions is already commercially-viable

without support. However, sustainable energy investments are often still perceived as riskier than established carbon-intensive technologies. For example, technology risk – i.e. the risk that a given technology will not perform as specified – is often seen by institutional investors as an important obstacle to investment in sustainable energy. This is a particular problem for technologies at the pre-commercialisation phase and relevant for technologies such as carbon capture and sequestration which will be necessary in any cost-efficient transition to a low-carbon economy (IEA, 2014a; OECD, 2015a; Energy Transitions Commission, 2017). Carbon-intensive technologies are also subject to fuel-price risk and stranded asset risk but investors may perceive that these risks are more manageable (for instance through financial hedging using derivatives), more distant or less tangible and material.

Some actors have also retreated from their previous roles as providers of risk mitigants. For example, before the financial crisis, monoline insurers played an important role in providing bond issuers with insurance to upgrade the credit-worthiness of their bonds, lowering bond issuers' overall cost by giving confidence that the insured security would be paid in full. The financial crisis led to the disappearance of some significant actors such as monoline insurers that had been active in providing insurance to investors in the infrastructure market (Kaminker *et al.*, 2013).

Credit enhancements discussed in this chapter provide coverage for risks which are new, are not currently covered by financial actors or are simply too costly for investors to insurance against. Sustainable energy infrastructure may not be perceived to be able to provide high enough returns to attract commensurate risk-capital. Credit enhancement can help to stabilise project cash flows which broadens the investment opportunities for domestic and international debt markets (Streeter, 2014). These stabilised cash flows also

facilitate longer debt tenors which helps to correct the mismatch between the debt tenor and the life of a given infrastructure asset (Streeter, 2014).

The specific credit enhancement needs will depend on the country context as well as the level of development of local capital markets. Some risks, such as sovereign, currency and regulatory risks will be amplified in emerging and developing countries. The following discussion provides additional details on specific credit enhancement tools and how they have been used in the context of sustainable energy infrastructure investment.

10.2.2 Subordination

Debt subordination is a form of risk mitigant whereby particular classes of lenders are given priority with regard to claims on assets. By offering repayment priority to certain holders of 'senior' debt, a project can enhance its capacity to attract financing from this source. Institutional investors, for example, may find senior debt (made possible by debt subordination) attractive because it reduces repayment risk. However, in some cases institutional investors may be willing to provide subordinated debt for sustainable projects, despite a lower repayment priority and greater risk. For example, in one of the 47 investments in Chapter 9.3, PensionDanmark provided a EUR 120 million subordinated loan for the Gemini offshore wind project, which had been de-risked through financial structuring techniques by the project developer. The decision on whether to take on subordinated debt is made based on an assessment of whether the return on the subordinated tranche makes up for the additional risk, and whether it fits well into an investor's investment mandates.

The EIB and the European Commission have launched the Europe 2020 Project Bond Initiative which provides eligible infrastructure projects with a Project Bond Credit Enhancement (PBCE) in the form of a subordinated instrument – either a loan or contingent facility – to support senior project bonds issued by a project company. A key benefit of PBCE is the enhancement of senior bond credit ratings by mitigating the risk associated with losses in the event of default throughout the lifetime of the project, including the construction phase.[40]

Ultimately, the PBCE is expected to widen access to financing sources, including institutional investors, by minimising overall funding costs, improving market confidence regarding the potential pipeline of transactions, and simplifying and standardising project structures (EIB, 2012). A successful example of the way that the PBCE can facilitate institutional investment is the PBCE (GBP 45.8 million guarantee, representing 15% of the bond issuance) provided for the Greater Gabbard offshore wind project off the Suffolk coast in the UK. The PBCE features as a risk mitigant in several other case studies in Chapter 12. The project became the first UK-based sustainable energy infrastructure project to attract finance from institutional investors using the programme (EIB, 2012). This guarantee facilitated a one-notch upgrade in the project's credit rating provided by Moody's (EIB, 2013).

10.2.3 Loan loss reserves

Loan loss reserves set aside capital to cover potential losses and help to reduce repayment risk. If a borrower defaults, the lender is repaid using the reserve fund. By reducing repayment risk, loan loss reserve funds can lower financing costs, motivate financial

[40] See EIB (2013) for additional details on how the EIB provides the credit-enhancing subordinated tranche, and de-risked outcomes for senior bondholders.

partners to broaden consumer access to green infrastructure-related loans, and extend loan repayment periods.

Some green investment banks have been active providers of loan loss reserves and often provide a percentage of loan loss coverage for lenders (Eklin, Kaminker and Youngman, 2014; Eklin and Youngman, 2016). As part of its 'Smart-E Loan Program', the Connecticut Green Bank offers distinct residential energy efficiency and renewable energy financing products with corresponding loan loss reserve levels. Every time a lender underwrites an eligible loan under this programme, the Connecticut Green Bank reserves a percentage of the loan principal (between 7.5-15%) for the lender in the event of a default (Energize CT, 2013). In the Connecticut model, to promote sound lending practices and share risks, the lender assumes the 'first loss' (1.5%) on its portfolio before it is permitted to access the reserve fund.

10.2.4 Guarantees and insurance products

Guarantees and insurance are core credit enhancement tools that are used to mitigate perceived or actual risks to improve the attractiveness of investments. When discussing credit enhancement, the terms guarantee and insurance are often used interchangeably. While guarantees are often used as a credit enhancement mechanism for debt instruments (bonds and loans), guarantees can also be discussed in the context of guaranteeing the performance of a given technology such as solar panels or wind turbines.

Insurance products may protect against a range of risks such as construction or operational risk, market risks such as price changes, weather-related production volatility risks, and political, regulatory or policy issues. Institutional investors are often key purchasers of sustainable energy-related insurance policies and are helping to increase

demand for these types of offerings (Gilbert, 2013). Most sustainable energy insurance products provided are risk-transfer offerings supplied to insure against risks related to production, installation, repair, and replacement of wind turbine blades or solar panels. These insurance products may also cover sustainable energy production risks linked to plant construction and operation through to energy and power distribution.

While guarantees and insurance products can be provided by private bank or third-party actors, the public sector often has a key role to play by providing insurance and guarantees through national or supranational bodies which can play an important kick-starting role in driving sustainable energy infrastructure finance (OECD, 2014a). Bilateral or multilateral development banks often act as key providers of insurance and guarantees for sustainable energy investment. For example, the International Finance Corporation (IFC) provides a partial credit guarantee, which represents a promise of full and timely debt service payment up to a predetermined amount if the project does not provide the full repayment. The IFC's objective is to offer the minimum amount of guarantee necessary to facilitate a successful transaction (IfC, n.d.). It helps borrowers to broaden the access to investors of international and local capital markets including institutional investors, reduce borrowing costs, and extend maturities. This technique is used in the case studies in Chapter 13.

Export credit agencies can also play a key role in both commercial and political risk guarantees that can be instrumental in attracting institutional investors. The Danish export credit agency Export Kredit Fonden (EKF) has been particularly active in providing guarantees through their Export Loan Support Scheme which covers up to 90% of commercial and political risks for exporting companies and up to 95% of these risks for banks (Boyd and Hervé-Mignucci, 2013). Multiple export credit agencies may also

collaborate on transactions such as the EUR 890 million financing for the Belgian offshore Northwind project which included the Danish EKF as well as export credit agencies from Norway (GIEK) and Belgium (ONDD). Institutional investors for the Northwind project included Danish pension fund PensionDanmark as well as commercial banks. This type of structure is explored in depth by Boyd and Hervé-Mignucci (2013) for the case of the onshore Jädraås wind farm in Sweden, which included a guarantee from EKF that helped to mobilise institutional investor financing.

10.2.5 Third-party guarantees and overcollateralisation

Third-party guarantees can improve the credit-worthiness of bond issuances. For example, specialised financial guarantee insurance can also be purchased to guarantee financial obligations linked to asset-backed securities (ABS). As discussed in Chapter 11.3.3, ABS bonds are derived from a pool of loans or receivables. In the case of sustainable energy, energy efficiency loans or solar leases could be pooled, securitised and issued in the form of ABS. The process of pooling or warehousing these loans or receivables is discussed further on. To provide a credit enhancement, a specialised insurance provider guarantees or 'wraps' the ABS to insure against losses. The insurance wrap typically increases the credit rating of the issuance. Monoline insurers used to be the key provider of this type of credit enhancement.

A letter of credit is an additional credit enhancement for bonds; essentially a commitment by a financial institution, usually a bank, to guarantee payments for the principal and interest on debt issuances. If the bond issuer is unable to make payments, the letter of credit is drawn to repay bond holders. For both letters of credit and surety bonds described later, the credit rating is generally linked to the creditworthiness of the monoline insurer or bank providing the guarantee. Due to this linkage, if the institution

providing the guarantee is downgraded, the relevant bond may similarly suffer a downgrade.

Another technique referred to as 'overcollateralisation', whereby the collateral which 'backs' the issue is greater than the principal amount of the issue, can be used as a tool for credit enhancement, such that a buffer is created between the value of the assets and the amount of debt raised. This provides additional coverage and a high debt service coverage ratio (DSCR), and can fund a reserve in case of defaults.

10.2.6 Performance guarantees

A performance guarantee is a risk mitigant provided to give owners confidence that a given technology or system will perform as expected. Project developers in search of investment partners must seek to provide assurances that projects will meet the financial expectations of project investors. As such, performance guarantees serve to ensure the expected level of guaranteed revenue in the long-term.[41]

Project developers often ask the engineering, procurement and construction (EPC) contractor for comprehensive guarantees. For example, almost all large-scale solar PV projects have performance guarantee contracts (Taylor and Williams, 2011). The provision of a performance guarantee can also be insured by a commercial reinsurance company to provide solar plant operators and investors with greater planning security, which will give investors, including institutional investors, more confidence about revenue derived from projects (Munich RE, 2010).

[41] For example, performance guarantee could include a guaranteed electrical production for 10 years at 90% of rated power output and 25 years at 80% (Energy Informative, 2013).

10.2.7 Project completion coverage

A surety bond is an example of an insurance product that guarantees completion of a contract or fulfilment of an obligation. In the case of sustainable energy projects, surety bonds are useful to ensure project completion if a contractor defaults. Project contractors purchase these surety bonds from surety companies which assume liability for non-performance. If a contractor defaults, the surety company must find another contractor to complete the project or compensate the project owner for any losses incurred (SBA, n.d.). Therein, surety bonds provide a type of insurance for project completion.

10.2.8 Production risk coverage

An additional type of insurance product can provide financial protection against 'volumetric risk' (the risk that electricity delivered by a project is lower than expected). Traditional insurance products and parametric[42] insurance products cover revenue lost due to shortfalls in forecasted electricity generation as a result of insufficient wind, solar or other energy sources. Institutional investors that seek stable, long-term yields are increasingly demanding these types of insurance products to provide stability.

10.2.9 Political risk coverage

A relatively well established market exists for political risk coverage products (UNEP, n.d.). Political risk insurance can be especially useful in emerging markets and developing countries where the risk relating to the country's political and macroeconomic environment is among the key barriers to investment (Venugopal and Srivastava, 2012).

[42] Parametric insurance products are a type of insurance product that pays out when the coverage is triggered by a particular variable, such as the number of inches of rain over a designated time period.

The World Bank's Multilateral Insurance Guarantee Agency (MIGA) helps private investors, including institutional investors, by insuring eligible projects against losses relating to: 1) Currency inconvertibility and transfer restriction, 2) Expropriation, 3) War, terrorism, and civil disturbance, 4) Breach of contract, and 5) Non-honouring of financial obligation (MIGA, n.d.). For equity investment, MIGA guarantees up to 90% of the investment, in principle. For loans and loan guarantees, MIGA generally offers coverage of up to 95% of the principal (or higher, on a case-by-case basis), plus up to an additional 150% of the principal to cover interest that accrues over the term of the loan (MIGA, 2012).

10.2.10 Policy and regulatory risk coverage

Additional insurance offerings have emerged to cover policy risk that can include both legal and regulatory changes. Policy risk is frequently highlighted as one of the most significant risks facing investors in sustainable energy and has a significant role in dissuading investors from allocating capital to this sector (Parhelion, 2012; Micale et al., 2013).

Retroactive policy change risk is highlighted as a principal concern as it directly impacts expected and historical revenues from projects and lowers investor confidence in the stability of the financial support available over the investment lifetime (Parhelion, 2012; frisari et al., 2013; Micale et al., 2013). Retroactive changes to feed-in tariffs have notably been involved in recent years in a series of investor-state disputes (OECD, 2014, forthcoming; IISD, 2012). Governments could pre-commit to reduce these risks, e.g., through contractual penalties in the case of material policy changes, however this is quite rare.

Foreign investors involved in sustainable energy projects could initiate international investment arbitration to seek damages, under provisions included in bilateral investment treaties (BITs) and other multilateral agreements (OECD, 2014, forthcoming; Gaukrodger and Gordon, 2012). There is also a key role for the public sector to provide policy risk insurance products as the private sector will not underwrite these types of risks when there is a lack of alignment of interest between the 'risk influencer' (i.e. the government) and the 'risk carrier' (i.e. investors or insurers) (Parhelion, 2012, p. 1).

The US Overseas Private Investment Corporation (OPIC) is one of a few public institutions which provide regulatory risk insurance against policy changes, in addition to their political risk guarantees. Its regulatory risk product can protect against regulatory actions impacting on sustainable energy projects, such as 1) material changes to feed-in tariffs, 2) critical changes to taxation or other regulations affecting the project's ability to operate, 3) revocation of licences or permits necessary for the operation of a project, 4) improper interference with carbon credit generation or sales, and 5) repudiation of a concession, technical assistance, or forestry-related services agreement by a foreign government (OPIC, n.d).

As policy risks are increasingly recognised as a major barrier to investment flows to climate financing, the United Nations Environment Program has also recently proposed to establish a policy insurance mechanism. This mechanism, which is to be funded by both the private and public sector, will insure policy risks specifically related to sustainable energy investment. The proposed coverage would engage local insurers in developing countries and international reinsurers to facilitate investment in sustainable energy technologies (UNEP, n.d.)

10.2.11 Public investment funds

Governments can play a pivotal role in facilitating the flow of institutional capital into infrastructure assets including sustainable energy infrastructure by seeding investment funds that can attract outside sources of capital. Equity funds formed as partnerships of public and private institutions could become important sources of finance and providers of organisational capacity and expertise in support of the financing of infrastructure projects including sustainable energy. Multilateral development banks, such as the European Investment Bank, have been particularly active in setting up infrastructure or sustainable energy investment funds that attract institutional investors.

Green investment banks may also seek to create investment funds. Australia's national green investment bank, Clean Energy Finance Corporation (CEFC), launched an unlisted sustainable energy fund in partnership with Colonial first State Global Asset Management that attracted institutional investors. CEFC deployed AUD 80 million for the fund dedicated to sustainable energy to raise up to an additional AUD 500 million from private investors including superannuation funds (Paton, 2014). CEFC CEO Oliver Yates noted that:

> By providing a new investment option for superannuation funds and other institutional investors, the fund will attract new sources of investment in renewable energy, unlocking new sources of capital for the market and expanding the investor base for this sector (Parkinson, 2014).

The UK Green Investment Bank created the first fund that would invest exclusively in offshore wind. The fund is designed to appeal to institutional investors that may seek exposure to offshore wind but would be unlikely to risk investing in a single project (Shankleman, 2014).

10.2.12 Cornerstone investment

A cornerstone investment refers to a large investment in an offering that occurs early in the investment process so as to play a demonstration role to attract other investors. A cornerstone stake could be purchased in a company or a fund.

The term cornerstone investor is most commonly used in the context of initial public offerings (IPOs) in which an investor agrees to purchase a prominent share of the offering. Cornerstone investors may also commit to holding their shares for a specific time period. By purchasing a large stake of an offering and doing so early in the IPO process, cornerstone investors provide confidence for other investors (West and Piramal, 2013). In this thesis, the term cornerstone investor can also refer to a prominent investment in an investment fund, debt offering, or equity investment.

For example, the Asian Development Bank acted as a cornerstone investor in the Philippine Investment Alliance for Infrastructure (PINAI), an unlisted fund dedicated to investing in infrastructure assets in the Philippines, which subsequently attracted outside investors including APG, a Dutch pension fund asset manager.

One example that is featured at multiple junctures in this thesis is the case of Greencoat UK Wind. In this important example (visualised in Chapter 9), the UK Green Investment Bank (UK GIB) and UK Department for Business, Innovation and Skills (BIS) both acted as cornerstone investors and played a key role in bringing the GBP 260 million Greencoat Wind fund IPO to fruition on the London Stock Exchange.

The UK GIB and UK BIS also committed to a one year lock-up period in which they were prohibited from selling their Greencoat shares (London Stock Exchange, 2013). BIS invested GBP 50 million as a cornerstone investor which enabled the IPO to occur

and provided the necessary confidence to utility SSE and major institutional investors to join the offering. Greencoat's plan was to invest in proven operating UK wind farms greater than 10 MW in size on an unlevered basis. It expected to provide investors with an initial dividend yield of 6% on investment, which was evidently a sufficient incentive to attract institutional public investors, including notably the London Pension Fund Authority.

The fund closed its first acquisitions alongside the IPO, purchasing stakes in four wind farms from SSE in a deal worth about GBP 140 million. The UK GIB matched Greencoat's investment in the Rhys Flats wind farm, buying a 24.95% stake in the project for GBP 57.5 million in the first time it had contributed direct equity to an offshore wind farm.

Given that banks were not willing to launch the Greencoat IPO without the UK GIB and BIS as cornerstone investors, the IPO provides an excellent example of a transaction that would not have worked without the involvement of government as an investor. A combination of government (for profit) capital, and the name and reputation of these government entities helped the transaction be successfully completed. The government backing helped de-risk the IPO for institutional investors, but the deal also reflects the extent to which there is appetite for the kind of low-risk infrastructure-style investment in operational wind projects that Greencoat aims to execute.

10.3 Transaction enablers for sustainable energy investment

As shown in Chapter 9, institutional investors that would like to invest in sustainable energy infrastructure can either do so directly (in-house) or through intermediaries (out-sourced). While direct infrastructure investments have several characteristics which can appeal to institutional investors such as allowing for asset-liability matching and helping hedge the risks for long-dated liabilities, making direct investments in projects is generally complex and resource-intensive. It can be prohibitively expensive due to the costs of developing and maintaining a direct investing team in addition to transaction costs and legal fees.

Thus, many investors might consider using intermediaries because they do not have this expertise, or the scale that would justify creating an internal team. However, of these institutional investors, many have decided against investing in infrastructure or have withdrawn from contracts because they have determined that the transaction costs, management fees, are prohibitive. Nevertheless, some firms and public financial institutions have started to explore ways to reduce transaction costs for sustainable energy investment or otherwise facilitate or enable these transactions to be made more efficiently. For the purposes of this thesis, these approaches are referred to as 'transaction enablers', which can be applied by actors at the individual (micro) project level (e.g. securitization) all the way up to the (macro) forms of collaboration and stakeholder initiatives among institutional investors managing vast portfolios.

The traditional institutional investor was almost entirely outsourced, rarely possessing the expertise and competencies to execute even the most basic financial transactions without the help of some external advisors. But, over time, the extended chain of principal-agent relationships became problematic (Monk and Sharma, 2016). As

alluded to above, one of the key areas of tension between investors and fund managers with respect to infrastructure investments is a conflict of interest between investors and fund managers over fund fees and terms and conditions (OECD, 2014; Monk and Sharma, 2016). In addition, the global financial crisis has heightened dissatisfaction among many institutional investors with some of the existing institutions of finance and investment due to the perception of misaligned incentives, poor returns and short-termism embedded in certain third-party management agreements (Clark and Monk, 2013c; Kaminker *et al.*, 2013).

Those institutional investors who do not have the scale to 'in-source' asset management by building a dedicated team, or who may not have the technical or geographical expertise to execute a transaction, or who wish to bid on assets that are too large for them individually, have started to successfully explore the use of transaction enablers to make these direct investments possible. These transaction enablers described in the next sections can be instrumental in reducing the cost of direct investment by aggregating information, knowledge and capabilities across multiple institutional investors. There are also other types of initiatives led by investors such as co-investment, which enable them to come together informally to collaborate in investment platforms or share knowledge, which serve to reduce transaction costs or otherwise facilitate investments.

In addition, there have been a number of regional institutional investor initiatives, which make for an interesting case study in stakeholder theory (Hörisch, Freeman and Schaltegger, 2014), that have been formed to engage with governments, such as the umbrella Global Investor Coalition on Climate Change (GIC) which comprises multiple

regional initiatives and is also involved in collecting data, and the Asset Owners Disclosure Project (AODP).

For instance, as mentioned in Chapter 8, in the margins of the United Nations Climate Summit in 2014, nearly 350 global institutional investors representing over USD 24 trillion in assets called on government leaders to provide stable, reliable and economically meaningful carbon pricing that help redirect investment commensurate with the scale of the climate change challenge, as well as develop plans to phase out subsidies for fossil fuels (IIGCC, et al., 2014). The statement was coordinated by the umbrella GIC coalition comprising four investor groups on climate change – Ceres' Investor Network on Climate Risk (INCR) in the U.S., the European Institutional Investors Group on Climate Change (IIGCC), the Investors Group on Climate Change (IGCC) in Australia and New Zealand, and the Asia Investor Group on Climate (AIGCC); along with the United Nations Environment Program Finance Initiative (UNEP FI) and Principles for Responsible Investment (PRI).

10.3.1 Securitisation

Securitisation is a technique whereby illiquid or small-scale assets, such as cash flows from solar leases or power-purchase agreements, are transformed into a standardised and tradable asset. Before it can be sold, the resulting instrument (e.g. an asset-backed security or collateralised debt obligation) generally needs to be assessed by a credit rating agency (Neil, 2014). By transforming pooled assets into securitised products on the secondary market, securitisation can serve to reduce the cost of financing for the underlying assets while aggregating small-scale and unrated investments into securities of a scale that may appeal to institutional investors, therein enabling transactions to be made. This is

particularly true if the resulting securities receive a sufficiently high credit rating (Neil, 2013).

In addition, considering that bonds have traditionally been the dominant asset class favoured by pension fund managers in the OECD, securitisation that results in listed and benchmark index-eligible bonds can be particularly instrumental to better engage institutional investors. Accessing the capital markets through securitised issuances at scale can also be useful to develop a market for this type of sustainable energy investment. For example, securitised solar issuances in the U.S. are helping to build a solar market that is more liquid and has a lower cost of capital relative to traditional funding sources such as loans (Lowder and Mendelsohn, 2013). Many securitisation efforts are aimed at aggregating small scale assets to create structures of the scale that institutional investors would find attractive, although these initiatives can also have important risk diversification rationales.

While securitisation can be important to free up funds from the balance sheets of banks and corporates and reach a broader base of capital through security markets, it requires sufficient asset quality and assured cash flows to obtain and maintain a favourable credit rating. A few issues challenge the development of securitisation and need to be addressed to improve access to capital markets. These challenges include limited availability of performance data, lack of standardised contracts, and insufficient volume of existing debt (Lowder and Mendelsohn, 2013). A government or other public sectors actors such as green investment banks can play roles in establish platforms that

will help to bring small transactions to scale, as well as in mitigating the perceived risks, to encourage securitisation.[43]

10.3.2 Warehousing

As discussed in Chapter 7.8, many potential sustainable energy investments are unattractive for institutional investors because they lack the necessary scale. Through warehousing, smaller projects (such as energy efficiency loans or solar leases) are pooled to reach a size where the bundled asset becomes attractive for sell-off to large investors or for securitisation through bond issuances (discussed above). For instance, once its pool of purchased loans reaches a threshold of USD 25-100 million depending on the assets, NY Green Bank proposes securitisation (Booz & Co, 2013). Pooling techniques such as loan warehousing can be useful to reduce transaction costs and facilitate investment in small-scale projects, thereby helping to get them to a commercial scale that is attractive for institutional investors. These could also be considered as risk mitigants in that by pooling multiple loans, they reduce exposure to idiosyncratic project-specific risk. In addition to pooling and securitising commercial and industrial loans, the Connecticut Green Bank has bundled solar leases from many small projects to attract private companies and new investors. NY Green Bank is also interested in purchasing loans that conform to specific green standards.

Through the Solar Lease II programme, Connecticut's green investment bank aggregated solar leases. A private insurance company was attracted by the scale provided by the programme and has created a new product to provide insurance and warranties for

[43] The Clean Energy Finance and Investment Authority (CEFIA), Connecticut's green bank, played in a key role in a recent case of securitisation of commercial energy efficiency loan (CEFIA, 2014. (See http:// srmnetwork.com/wp-content/uploads/Press_Release_C-PACE_Sell-Down_Final_05-19-14.pdf, www.eib.org/products/project-bonds/).

solar leases. In addition, new sources of non-bank investment have been attracted by the aggregated pool of residential solar loans. Mosaic, a solar finance 'crowdsourcing' company will provide USD 5 million in 'crowdsourced' loans (Business Wire, 2014).

10.3.3 Standardisation of contracts and reporting and data collection

By promoting standardisation of contracts and reporting templates and improving data collection, policy makers can reduce transaction costs associated with investment in sustainable energy.[44]

In the United States, the National Renewable Energy Laboratory's (NREL) Solar Access to Public Capital (SAPC) Working Group was formed to develop standardised contracts for residential solar leases and power-purchase agreements. Their efforts are designed to improve consumer transparency, reduce transaction costs in the solar asset contracting process, and facilitate the pooling of cash flows from solar PV leases so they may be securitised and sold in the capital markets. The SAPC has also developed mock securitisation term sheets for bundled solar PV leases (i.e. legal descriptions of the securitisation structure, managing entities, and cash flow) to illustrate and clarify how solar securitisation works and potentially reduce transaction costs for new securitisations to reach the market (NREL, 2013). Some green investment banks have also shown an interest in standardisation of contracts and reporting processes. For example, NY Green Bank highlights the need for greater standardisation of contracts and the loan underwriting process and improved data collection regarding loan and project performance. Standardisation and greater data availability would then make it much

[44] Standardisation and co-operation could, on the other hand, erode the first mover premium which may be reaped by investors building expertise in new areas.

easier and cheaper for securitisation to occur, for private banks to underwrite and for credit agencies to rate a securitisation (Eklin et al., 2016).

10.3.4 Co-investment, joint-ventures and consortiums

Institutional investors may seek to reduce transaction costs by partnering with other investors through co-investment, joint-ventures or consortiums. Co-investment is a form of direct investing whereby institutional investors partner up with other investors to invest in an asset (OECD, 2014b). Institutional investors are increasingly using co-investment to reduce transaction costs, gain access to more potential investment opportunities as well as build relationships with experienced investors such as infrastructure funds. Co-investments have become common features of the institutional investment landscape with multiple examples to be found in Chapter 13.

In contrast, a joint-venture is a business arrangement where two or more parties agree to pool their resources and establish a new entity for a specific project or business activity in a way that is separated from the participants' other business interests. Relevant examples here are the Aligned Intermediary, the Cubico Fund (a partnership between Santander, OTPP and PSP Investments) and the EDF/Amundi sustainable energy collaborative joint venture.

A consortium is an association of two or more individual companies to pool their resources and participate in a common project or business activity, a good example here is the PRIME coalition in the U.S. In addition to deal-specific co-investment, joint-ventures or consortiums, investors are increasingly organising their own initiatives to support co-investment for a wide range of deals such as platforms.

10.3.5 The rise of co-investment platforms

Co-investing platforms have emerged partly in response to dissatisfaction among institutional investors with respect to high fees associated with infrastructure fund models (OECD, 2014b). The advantages of co-investing platforms include: better alignment of interests with other institutional investors, suitable investment horizons, lower fees, better control of the investment characteristics, larger commitments, local knowledge, and risk sharing (OECD, 2014b). Bachher and Monk (2012) identify additional benefits of collaborating in co-investment platforms including higher returns, access to greater deal flow, greater diversification, improved governance rights, and reduced headline risk.

A number of large pension funds and sovereign wealth funds have looked at pooling their financial and internal resources to invest jointly in infrastructure projects. In Australia, IFM Investors is co-investment platform owned by 30 Australian superannuation funds and collectively represents AUD 52 billion in assets under management across a variety of sectors. IFM Investors invests across a range of subsectors including electricity generation, transmission, and distribution, rail infrastructure, and water (IFM Investors, n.d.; Inderst and Della Croce, 2013).

Co-investment platforms also face a number of challenges. Pension funds often have widely varying strategies, diversification targets, and exposure limits. Differences in governance and compensation structures may also create difficulties. Co-investing using co-investment platforms therefore should not be considered as a ‘short-cut’ to direct investing, as a co-investor still needs some in-house capabilities and execution skills (Bachher and Monk, 2013; 2012).

In order to overcome these challenges, government support may be required to promote co-ordination between the parties or to provide access to attractive investment opportunities. The UK's Pension Investment Platform (PIP), Canada-based Global Strategic Investment Alliance (GSIA) and the Canada Pension Plan Investment Board (CPPIB)-led syndicate model all provide examples of different co-investment structures that may help institutional investors to access infrastructure investment more efficiently than investing through unlisted equity funds by pooling their financial and internal resources (OECD 2014b). See OECD (2014b) for a detailed review of co-investment platforms. In recent years, institutional investors have launched renewable energy platforms geared at emerging markets as well, for instance the Africa Fund with capital from PensionDanmark, PKA and Lægernes Pension.

10.3.6 Co-operation and collaboration, and other informal knowledge-sharing

Co-operation and collaboration are more informal techniques that can facilitate sustainable energy infrastructure investment by institutional investors. Collaboration involves a closer working relationship than co-operation, and involves commitment to a project or projects both in terms of the specification of shared objectives and the means of realising those objectives (Monk, 2013). Institutional investors can collaborate through agreeing on expected outcomes, and setting well-defined mechanisms governing entry and exit from such agreements (Clark and Monk, 2013). While investors may come together informally in various ways to collaborate in investment platforms, there is an opportunity for governments to work with these platforms to better understand investor needs and the key barriers that are reducing or preventing investment in sustainable energy infrastructure.

Compared with collaboration, co-operation is a less formal way of enhancing senior managers' knowledge and understanding of the investment options available and formulating strategies (Clark and Monk, 2013). When investors find deeper engagement challenging, co-operation can be effective as a means of mobilising and sharing resources and capabilities (Clark and Monk, 2013). For example, institutions can establish partnerships when senior managers of smaller institutions wish to establish cost-sharing and service-sharing agreements with larger institutions with the expectation that larger institutions can claim significant discounts from external service providers due to economies of scale.

10.4 Implications for subsequent chapters

In the sustainable energy sector, many risks such as policy risk are not well covered by traditional financial or insurance offerings or are simply too expensive to insure against to attract investor demand. Due to this gap in offerings and the need to scale up investment in sustainable energy infrastructure, there is a clear role for government and other policy actors to develop risk mitigants to promote sustainable energy investments or to pre-commit to reduce these risks.

In order to attract investors, multiple risk mitigants may be necessary given that sustainable energy infrastructure may not be perceived to be able to provide high enough returns to attract commensurate risk-capital. There may well be capital market failures at work here. Risk mitigants can be tailored to the needs and conditions of an individual sustainable energy project if the scale permits.

Risk mitigants play an important role to enhance the creditworthiness of projects by mitigating perceived investment risk. Reducing, re-assigning or re-apportioning

different investment risks, enhance the creditworthiness of projects, de-risks potential investments and increases the attractiveness of investments while stabilising project cash flows. This broadens investment opportunities for institutional investors with long-term investment horizons and relatively limited appetite for risks.

The importance of risk mitigants is magnified within the context of reduced government financing capacity. As risk mitigants mobilise private capital using limited public finance, they are part of a trend where government has less ability to act as a project financier but rather works as a facilitator by reducing risk to encourage private investment. When considering deploying risk mitigants, governments should also examine and carefully evaluate the contingent liabilities that these responsibilities create for taxpayers.

The public sector is increasingly aware of the need to reduce risk and many countries are already using and developing risk mitigants to promote increased sustainable energy investment. Some governments have been particularly active in developing and using these risk mitigants to mobilise greater sustainable energy investment and these examples can potentially be applied to other national contexts. The Danish export credit agency EKF is a particular example of an institution that is using their guarantees to encourage institutional investor participation in sustainable energy finance. Green investment banks and other public financial institutions are also actively working to reduce risk by providing guarantees, loan loss reserves, seeding funds and acting as cornerstone investors.

As most institutional investors have limited experience with direct investment in sustainable energy infrastructure projects, the cost associated identifying, executing and managing investments in-house is often prohibitively expensive, partly due to the costs

of developing and maintaining the human resources of a direct investing team as well as transaction costs and legal fees.

Although many techniques have emerged from the private sector as investors work together to reduce transaction costs, there remains a key role for policy action to reduce costs. For example, while investors may come together informally to collaborate in investment platforms, there is an opportunity for governments to work with these platforms to better understand investor needs and the key barriers that are reducing or preventing investment in sustainable energy infrastructure.

Government should make sure that regulatory frameworks do not prevent techniques such as securitisation from functioning as intended. For example, financial regulations such as Basel III and Solvency II should be carefully considered to avoid unintended consequences of discouraging long-term investment by institutional investors. At the same time, any efforts to kickstart or rejuvenate securitization markets must be done judiciously and transparently, with due consideration for financial stability risks.

The relatively small size of many potential sustainable energy investments is often an investment barrier for large institutional investors, who are looking to invest larger sums of capital (partly to justify the due diligence required and also to have a meaningful impact on their portfolios). Governments can play a key role in reducing these transaction costs through promoting contract standardisation, warehousing and securitisation to facilitate institutional investment in sustainable energy projects, such as has been done for commercial energy efficiency loans by the Connecticut Clean Energy finance and Investment Authority (CEFIA).

Establishing warehousing and encouraging securitisation creates opportunities for the public sector to play an important co-ordinating role in creating platforms that will help to bring small transactions to scale, as well as in mitigating the perceived risks. By pooling small transactions, a collection of projects can then be securitised and sold to institutional investors through financial intermediaries.

11. THE EMERGING GREEN BOND MARKET

> For investors, green bond markets offer a stable, rated and liquid investment with long duration. For issuers, green bonds are a way to tap the huge US$100 trillion pool of patient private capital managed by global institutional fixed-income investors. The shift to the capital markets from banks will also free up limited bank balance sheet capacity for early-stage project financing and other important infrastructure lending…The development of this new global asset class is an opportunity to advance a low carbon future while raising global investment and spurring growth.

Mark Carney, Governor of the Bank of England and Chairman of the Financial Stability Board

Resolving the climate paradox, Arthur Burns Memorial Lecture, Berlin, 22 September 2016

11.1 Introduction

As established in Chapter 7, in the Paris Agreement adopted in December 2015 by the COP21, Parties agreed to hold the increase in the global average temperature to well below 2°C and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels. Parties also agreed to make finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development (United Nations, 2015a).

Following the success of COP21, green finance activities in 2016 advanced significantly, and particularly the issuance of green bonds. The G20 Leaders' Statement at Hangzhou in September 2016 recognised this development by stating:

> We believe efforts could be made to… provide clear strategic policy signals and frameworks, promote voluntary principles for green finance, support the development of local green bond markets and promote international collaboration to facilitate cross-border investment in green bonds (G20, 2016a).

This chapter describes the emergence of a market for green bonds, in the context of broader efforts to finance a low-carbon transition, and examines how the market has evolved. It describes the roles of a range of actors in the market, the continuing evolution of green bond definitions and governance standards. It also provides an overview of the advantages and disadvantages of green bonds as perceived by investors and issuers. This information provides the necessary introduction and context for Chapter 12 which examines barriers to market growth and actions that policy makers are taking to overcome them, and also provides a quantitative assessment of the role of bonds in a low-carbon transition.

This chapter draws on material published in an earlier form, first as a Policy Perspectives on green bonds (Kaminker, 2015) sponsored by Bloomberg Philanthropies in December 2015 during COP21 and subsequently as an OECD book published in 2017 (Kaminker, 2017). Elements of this chapter were also included in two papers that were contributed to the G20 Green Finance Study Group: 'Progress Report on Approaches to Mobilising Institutional Investment in Green Infrastructure' (Kaminker, 2016b), and 'A quantitative framework for analysing potential bond contributions in a low-carbon transition' (Kaminker, 2016a), which was launched in October 2016 at the 3rd OECD Green Investment Financing Forum in Tokyo. Some extracts from this work were included as part of my contributions to several G20 Chinese Presidency Papers: Green Finance Synthesis Report (G20, 2016b) and 'Green Bonds: Country Experiences, Barriers and Options (Ma, et al., 2016).

11.2 The need to mobilise debt capital and bonds

Whilst the scale of investment needs is relatively well known, policy makers need a clearer understanding of whether investment needs could feasibly be financed from private sources of debt and equity capital, and if so, how this might be done. Debt currently finances the majority of infrastructure investment but the challenge will be to shift this debt investment away from emissions-intensive investments while scaling up investment in LCR infrastructure.

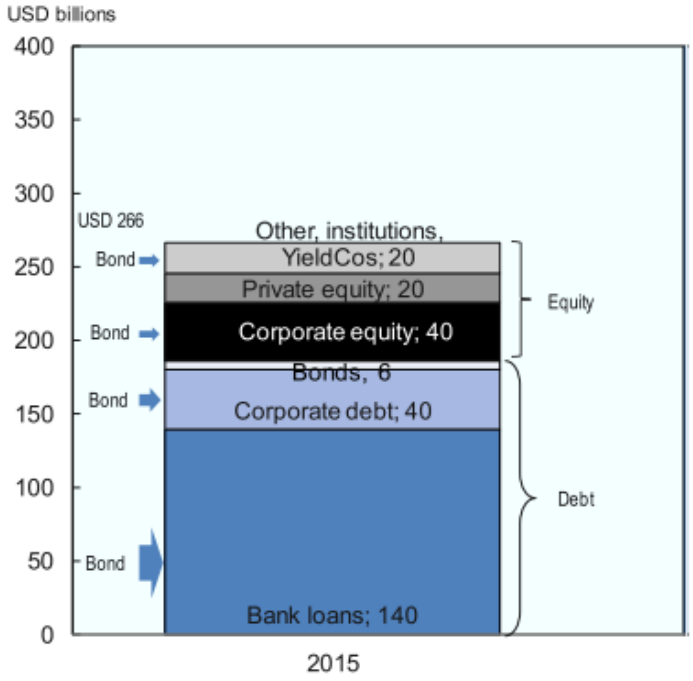
The typical debt-to-equity ratio in overall infrastructure project finance is 70:30 (Dobbs et al., 2013), with either the same ratio of debt in renewable energy financing as estimated by Zindler and Locklin (2016), or a somewhat higher proportion of debt as estimated by McKinsey (75:25). The ratio is approximately 50:50 for financing energy

efficiency and low-emissions vehicles.[45] According to Zindler and Locklin (2016), in 2015 a record USD 266 billion was invested in new renewable power generation (with USD 200 billion in new build asset financing, and the remainder split between refinancing and acquisitions of assets), up from an average of USD 250 billion per year over the last four years.

As illustrated in Figure 11.1 through analysis of the Bloomberg New Energy Finance's (BNEF) database, debt accounted for USD 186 billion of the financing amount in 2015, with the vast majority being provided in the form of loans by financial institutions and on-balance sheet financing from corporates, which is also responsible for half of equity investment. While bonds were used to directly finance or refinance only USD 6 billion out of the USD 266 billion in investment in 2015, corporates and financial institutions routinely call on the bond market to fund and refinance their on-balance sheet investment; although this practice varies geographically. Financial institutions, for instance, rely to a large extent on bonds to raise capital for their lending activities, with US and EU commercial banks currently maintaining a bond-to-loan ratio of 30% (Bielenberg et al., 2016; ECB, 2015).

[45] As context, the global project finance market for all types of infrastructure included USD 298 billion in loans and USD 55 billion in bonds in 2013 (S&P, 2014).

Figure 11.1 Investment in renewable energy in 2015 and the role of bonds



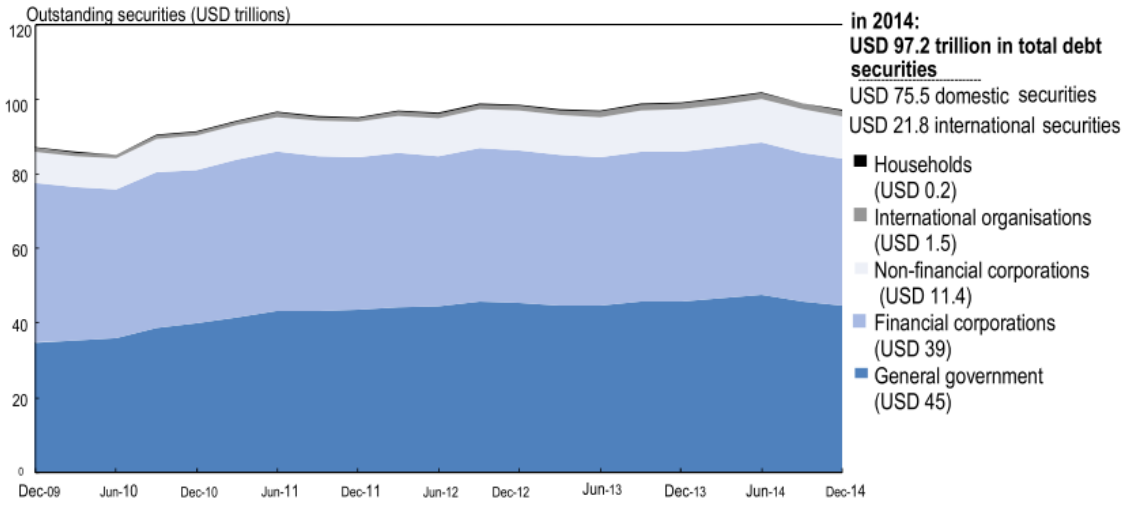
Source: Author based on the BNEF database.

Note: In 2015 YieldCos used bonds to fund wind farm acquisitions and a private equity fund used a bond to refinance a portfolio of wind farms. 'Other' includes institutional investors and other non-bank intermediaries. Bond arrows are not drawn to scale and are provided to illustrate that they are used to raise funding for varying portions of the investment activity.

In 2014 the total amount of capital held in global debt securities (i.e. bonds, notes and money market instruments) markets issued by all types of entities (banks, governments, corporations, etc.) was estimated at USD 97.2 trillion (Figure 11.2). The broader debt capital markets include a further USD 66 trillion in loans outstanding in 2010 (the most recent estimate available) (Roxburgh, Lund and Piotrowski, 2011). Bond finance is a natural fit for LCR infrastructure assets. The case is especially clear for sustainable energy infrastructure, which is characterised by high upfront capital costs and long-dated and frequently inflation-linked income streams. Many cities and municipalities rely on bonds to raise the financing for their low-carbon development plans.

As described by Dewar (2011), accessing the capital markets to fund projects and infrastructure arguably dates to the 1800s with the US railroad expansion. The first modern private sector project bond offerings date to the 1980s and early 1990s, encouraged in part by changes in the US securities regulatory regime that facilitated bond offerings to institutional investors. The first wave of project bonds financed or refinanced independent power projects and quickly evolved to a broad range of electric, oil and gas, water and other power-related assets; as well as toll roads, railways, and eventually social infrastructure such as hospitals, schools and prisons.

Figure 11.2 USD 97 trillion of outstanding global debt securities in 2014



Source: Author based on BIS debt securities statistics

Note: Debt securities include a variety of instruments such as bonds, notes and money market instruments, which have different maturities and intended purposes, most of which are not related to infrastructure finance. There is potential overlap between domestic and international securities.

Banks and corporates will continue to be an important source of direct LCR infrastructure finance, especially at earlier stages of project finance. However, the scale of investment needs along with the 'maturity mismatch' (short-term funding of long-term assets) in asset financing significantly exceeds the capabilities of a post-financial crisis banking sector and an electric utility sector with increasingly constrained balance sheets

(Buehler, Noteboom and Williams, 2013; Alvarez et al., 2013; Gerken et al., 2013). Bond markets, which provide a funding source and an alternative to bank and corporate financing, will need to play a pivotal role.

Given that the cost of project finance debt arranged by banks is higher than the yield for investment-grade project bonds in most jurisdictions at the time of writing[46], it may be possible to achieve a reduction in the weighted average cost of capital (WACC) for LCR infrastructure financed or refinanced with bonds (WEF, 2013), although the cost of capital is usually an inherent feature of the project and its risk, which can have more impact than the financing method used.

Bonds can raise capital directly for LCR projects, or they can refinance existing shorter-term loans potentially at a lower cost. For instance, in 2015, the Blackstone Group refinanced loans to build German offshore wind parks by selling USD 1 billion of green bonds to investors who were prepared to accept a lower interest rate for the investment-grade bonds than Blackstone agreed to pay to nine lenders at an earlier stage in the project's development, when risks were higher. Lowering the cost of capital for renewable energy is important because an estimated 50-70% of the costs of electricity generation are in the financial cost of capital, with only the balance being the physical or operational costs of the installation (OECDa, 2015). Thus, even small changes in the

[46] The spread varies across regions and changes due to economic and market conditions. For instance, as of November 2015 in the United Kingdom (broadly representative of EU and OECD markets as London is the most active project finance lending market globally) the all-in cost of a 20-year project loan compared with a project bond of a similar credit quality (e.g. BBB-) may be roughly as follows: Loan: Libor (~250 basis points (bps)) + ~250 bps credit spread (~5%). Bond: 'mid-swaps' (~150 bps) + ~300bp credit spread (~4.5%). Therefore project loans are more expensive than equivalent project bonds reflecting low yields in the mid-swap market (the benchmark for bond pricing). At the same time, demand for investment-grade project debt in the bank market has been high so credit spreads have been declining, making pricing very competitive with the bond market, but only up to 20 years of loan tenor. Typically banks are not prepared to go beyond 20 years, which is where the bond market is more competitive for project financing and refinancing (Source: S&P, interviews).

WACC can have substantial impact on the long-term levelised cost of capital-intensive renewable energy projects and their competitiveness.

A bond market provides greater flexibility and more options for early project phase capital to be freed up after it has been deployed (an 'exit'), as well as for the longer-term project finance debt held by banks constrained by deleveraging and regulations. In this way, bonds can help to increase the speed at which capital can be 'recycled' back into development, construction and early-stage risk, and also help to attract additional early-stage finance. Investors are more likely to invest their capital in construction if there is a credible and predictable low-cost exit once assets become operational (Caldecott, 2012).

Financial institutions can use bonds to resolve maturity mismatches between loans and liabilities. This is a priority in China, where the average liability maturity in the banking industry is six months. This leads to a maturity mismatch with the need for green infrastructure lending where average loan maturities needed are of five to ten years. To address this issue and promote increased green lending in the banking sector, the PBoC established a green bond system for the inter-bank market which enables the issuance of green bonds with longer maturities, that also help banks to hedge 'duration risk' (PBoC/UNEP, 2015).

Bonds also provide the advantage of already being a well-established asset class in the investment portfolios of mainstream institutional investors that have significant potential to finance a low-carbon transition as analysed by the OECD (OECD, 2015; Kaminker and Stewart, 2012). Institutional investors in the OECD managed USD 93 trillion of assets in 2014, with bonds being the asset class favoured by OECD pension funds and insurance companies, allocating 53% and 64% respectively of their portfolio

to bonds in 2013 (simple average).[47] Bonds with longer maturities are potentially a good fit with institutional investors' long-term liabilities, allowing for asset-liability matching. Green bonds can reconcile the emerging demand from institutional investors for sustainability-themed and environment, social and governance (ESG)-screened investments with infrastructure investment needs.

11.3 Green bonds

As shown in the previous section, the use of bonds to finance large-scale LCR infrastructure directly or to fund lending is not new. However, since 2007-08 a market for bonds specifically 'labelled' or designated as 'green' (hereafter 'green bonds') has emerged. The green bond market has materialised out of a variety of institutional actions, emerging through the first few issuances by multilateral development banks. From 2007-12, the market mainly featured issuance of green bonds by so-called supranational, sub-sovereign and agency (SSA) actors such as the European Investment Bank (EIB), the International Finance Corporation (IFC) and the World Bank, along with a few local government funding agencies, municipalities and national development banks.

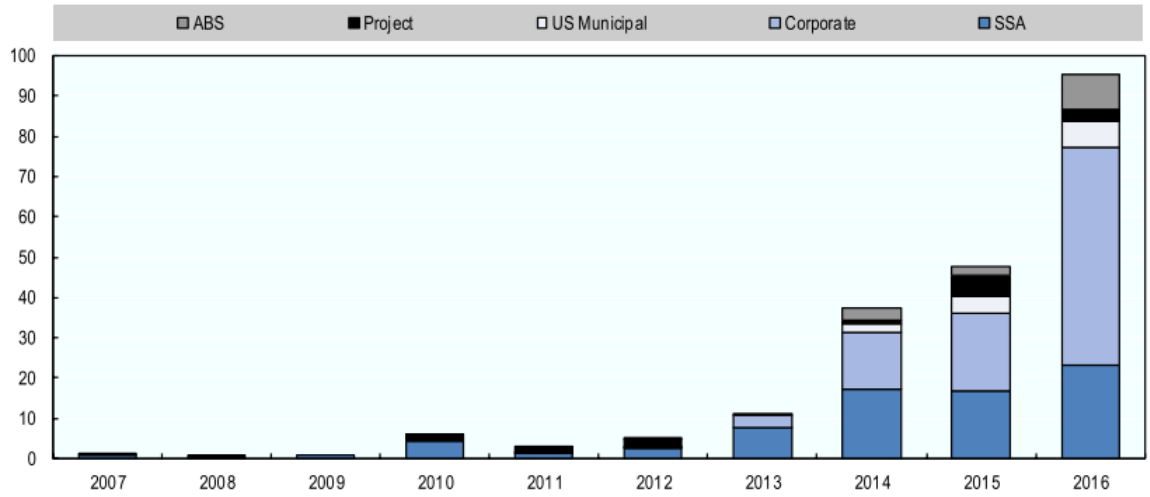
With growing market appetite for such bonds the range of issuers and investors participating in the green bond market expanded significantly with corporates and banks entering the market in 2013. Annual issuance of labelled 'green bonds' rose from just USD 3 billion in 2011 to USD 48 billion in 2015, with issuance occurring in 14 of the G20 markets. Annual green bond issuance continued to grow rapidly in 2016 bolstered by the entrance of Chinese issuers in the market, with USD 95 billion[48] issued. Figure

[47] OECD Global Pension Statistics, Global Insurance Statistics and Institutional Investors databases, and OECD estimates.

[48] SEB analysis provided to OECD based on Bloomberg data.

11.3 illustrates the composition of green bond issuance through to 2016. At the time of writing this thesis, green bond issuance in 2017 had already surpassed 2016 levels and was on track for another record year.

Figure 11.3 Composition of the green bond market USD billion, gross issuance



Source: SEB analysis provided to OECD, based on Bloomberg data.

Note: 'SSA' includes supranational, sub-sovereign and agency issuers such as development banks, local funding authorities, export credit agencies, etc. 'Corporate' includes sectors such as utilities/energy, financials, consumer discretionary and staples, technology, industrials and others. This figure includes project bonds that are 'tagged green' on the Bloomberg Terminal which are not included in other lists such as that of the Climate Bonds Initiative. Note also that 2016 figures include all Chinese green bonds issued in line with the People's Bank of China green catalogue, although some of these do not meet international investor expectations of green bonds due to the inclusion of 'clean coal'.

11.3.1 Defining a green bond

While there is no universal definition for a green bond, stated simply, green bonds are debt instruments used to finance green projects that deliver environmental benefits. A green bond is differentiated from a regular bond by its commitment to use the funds raised to finance or refinance 'green' projects, assets or business activities. Green bonds can be issued by either public or private actors up front to raise capital for projects or for refinancing purposes, freeing up capital and leading to increased lending.

Green bond project definitions and requirements for disclosure of the use of proceeds are the basis for developing a credible green bond market by avoiding 'green washing'. Globally, the most widely accepted standards are the Green Bond Principles (GBP), a set of voluntary guidelines elaborated by key market participants under the co-ordination of the International Capital Market Association (ICMA), and the Climate Bonds Standard, which also includes sector-specific criteria, developed by 'scientific experts under the stewardship of the Climate Bonds Initiative (CBI)'.

The GBP define green bonds as 'any type of bond instrument where the [issuance] proceeds will be exclusively applied to finance or re-finance in part or in full new and/or existing eligible Green Projects' and 'which are aligned with the four core components of the GBP' (ICMA, 2016). The GBP have four core components: 1) use of proceeds; 2) process for project evaluation and selection; 3) management of proceeds; and 4) reporting (ICMA, 2016).

While the OECD has not defined what constitutes a green investment, it has discussed it in its working definitions for 'green infrastructure' and for 'green investments' (OECD, 2013; Inderst et al., 2012) and has provided a general quantitative basis for assessing to what extent infrastructure systems can be considered 'low-carbon and climate-resilient' (Kennedy and Corfee-Morlot, 2012).

11.3.2 Financial characteristics

Green bonds currently have financial features that are identical to conventional bonds. With the exception of the ring-fencing or earmarking of proceeds required by the green label, green bonds have financial characteristics that are identical to conventional bonds from the same issuer, including the credit quality, yield and price at which they are issued.

Like any other bond, a green bond is a fixed-income financial instrument for raising capital from investors through the debt capital market. In line with mainstream bonds, the bond issuer raises a fixed amount of capital from investors over a set period of time (the 'maturity'), repaying the capital (the 'principal') when the bond matures and paying an agreed amount of interest ('coupons') along the way.

11.3.3 The seven types of green bonds

Green bond issuing entities can make use of a variety of structures related to the 'use of proceeds' (according to the GBP, four 'types' of green bond at present, although additional types may emerge). The most common structures used have been standard 'recourse-to-the-issuer' debt obligations (i.e. if the principal is not returned to the investor in full for whatever reason, the investor can recoup unreturned principal from the issuer).

While the use of funds is targeted, the repayment obligation is backed by all of the issuer's assets. Most SSA and corporate green bonds are characterised by this 'plain vanilla' structure.

Green bonds can be structured as asset-backed securities tied to specific green infrastructure projects, but to date have most commonly been issued in the form of 'use-of-proceeds' bonds that raise capital to be allocated across a portfolio of green projects. A green label can also be applied to a bond by another entity via its inclusion in a green bond index or via a 'tag' on analytical tools widely used in financial markets, such as the Bloomberg Terminal.[49]

[49] To tag a bond as 'green', Bloomberg examines bond documentation and official statements for clear indication of an issuer's intention to both label a bond as green and clearly specify that the use of proceeds advances climate change mitigation or adaptation or promotes other environmental sustainability solutions.

Green bonds can also be backed by specific cash flows which are pledged as the basis for repayment (such as the revenue of a project); may be issued by a special purpose entity responsible for a specific project and without recourse to the issuer; or can be a securitisation with collateral from a collection of many assets.

Green bonds can be further classified into seven distinct forms that can be issued by different entities and as different structures.

1. Corporate bond: A 'use of proceeds' bond issued by a corporate entity with recourse to the issuer in the case of default on interest payments or on return of principal. This category includes bonds issued by 'YieldCo' vehicles to finance asset acquisitions.

2. Project bond: A bond backed by single or multiple projects for which the investor has direct exposure to the risk of the project, with or without recourse to the bond issuer.

3. Asset-backed security (ABS): A bond collateralised by one or more specific projects, usually providing recourse only to the assets, except in the case of covered bonds (included in this category). For covered bonds, the primary recourse is to the issuing entity, with secondary recourse to an underlying cover pool of assets, in the event of default of the issuer.

4. Supranational, sub-sovereign and agency (SSA) bond: Bonds issued by international financial institutions (IFIs) such as the World Bank and the European Investment Bank (i.e. 'supranational issuers'). SSA bonds have features similar to a corporate bond relating to 'use of proceeds' and recourse to the issuer. Agency bonds are included in this category (e.g. issuance by export-import banks), as are sub-sovereign national development banks (e.g. the German KfW).

5. Municipal bond: Bonds issued by a municipal government, region or city.

6. Sovereign bond: Bonds issued by a national government. In December 2016, Poland issued the first sovereign green bond, followed by the launch of a sovereign green bond by France in January 2017. A number of other countries also have indicated their intention to issue sovereign green bonds.

7. Financial sector bond: A type of corporate bond issued by a financial institution to raise capital specifically to finance 'on-balance sheet lending' (i.e. to provide loans) to green activities (e.g. ABN AMRO or Agricultural Bank of China). This type of bond is sometimes considered separately, for instance for the purposes of scenario modelling (see (Kaminker, 2016a) to retain a distinction between financial sector bond issuances which finance lending and those which directly finance green investments.

11.3.4 Green bond pricing

The concept of 'flat-pricing' has been central to the rapid, demand-driven expansion of the market. Prices are said to be 'flat' at issuance (relative to most regular, simple and standardised ['plain vanilla'] bonds from the same issuer) because the credit profile of a green bond is the same as any 'plain vanilla' bonds from the same issuer, so no difference in pricing is warranted. This means that issuers have not been able or willing to realise pricing advantages (and a correspondingly lower cost of capital for green projects) through green labelling as investors are unwilling to take lower than expected returns at the primary issuance stage simply for the ability to 'go green' (BNEF, 2014).

At the same time, investors have not been able to realise demand for higher yields to justify supposed additional risk-taking to finance green activities, as in general (with exception for project, covered and asset-backed securities [ABS] bonds) they are

financing the balance sheet of the issuing entity itself (so the credit risk is the same as any other regular bond from the same entity).

Yet, one report has indicated that green bonds trade on the secondary market at a slight premium during certain periods studied (Barclays, 2015). Barclays partly attributes this phenomenon to 'opportunistic pricing based on strong demand from environmentally focused funds faced with comparatively limited green bond supply' along with other factors that are difficult to substantiate empirically at present (Barclays, 2015). The World Bank (2015: 44) reports that 'anecdotally, investors in green bonds have been able to sell at higher prices than conventional bonds because of the rarity of green bonds'. CBI/HSBC (2016) report that anecdotal evidence has emerged that, in some markets at least, green bonds are receiving better pricing than plain vanilla bonds.

A mix of views exists on how market pricing for green bonds will develop. Issuers see strong demand to the point of oversubscription and argue for a pricing advantage relative to vanilla bonds to compensate for green bond-specific issuance costs, while investors are unwilling to accept a materially lower yield (or a higher price) that cannot be sufficiently justified on a risk-adjusted return basis. The green bond market is evolving under pressure from issuers looking to drive the costs of issuance down and investors calling for more supply to meet their demand. CBI/HSBC (2016) takes the view that pricing will (and should) remain tight, but within limits acceptable to the majority of investors. Beyond this, they argue, green investments should and will be preferenced using government policy tools.

Much attention has been focused on the pricing of green corporate bonds, but as discussed above, there are many different types of green bonds. Different levels of

recourse exist, and bonds will price accordingly. For instance, corporate 'use of proceeds' bonds will price differently to project bonds and ABS.

In the emerging market for labelled and unlabelled green bonds, bonds have mainly been used for refinancing (and recycling lending) and for funding on-balance-sheet activity (for existing and forthcoming projects) by corporates, MDBs, and sub-sovereign, municipal and agency issuers. The market has also featured asset-backed securities and project bonds – two bond categories that could (and would need to) play a much larger role in a 2-degree policy scenario, provided the right policies are in place (Kaminker, 2016a). These unlabelled green project bonds and ABS totalled about USD 15 billion in 2014 according to CBI/HSBC (2015). In practice less than USD 2 billion of the USD 15 billion in ABS included as climate-aligned bonds have been self-labelled as green and few project or covered bonds have been labelled as such.

Despite being small currently, the market for sustainable energy project bonds has growth potential. As described by Kaminker et al. (2013), utility-scale sustainable energy projects that are large enough to support the cost[50] of issuing a project bond (mostly for wind and solar) had issued over USD 7 billion of project bonds as of November 2013 to insurance companies, pension funds and other investors. Given the pipeline of 225 large (i.e. 95 megawatts and above) wind and solar projects in the United States and Europe, Bloomberg New Energy Finance estimates a potential clean energy bond market of USD 142 billion, with bond issuances of USD 18-USD 40 billion annually by 2020 (up from roughly USD 2 billion currently).

[50] Smaller projects (unless bundled) in general lack the scale needed to make a listed bond issue viable in terms of cost and market liquidity. However, not all bonds follow the same route; there are numerous listed and unlisted options, depending on the target section of the bond market, and some bond financings can be executed at least as efficiently as on a loan deal (Norton Rose Fulbright, 2012).

To be generally eligible for investment by institutional investors, bonds backed by revenues from sustainable energy projects must be rated as 'Investment-grade' (see glossary). Limited performance history, however, can make this rating difficult for some projects to attain. Policy makers are working to address this problem and accelerate issuance of sustainable energy project bonds by using public funds to provide credit enhancement to such issuances. By reducing the probability of investor losses, publicly funded subordinated debt or loan-loss reserve facilities (as being implemented by the Europe 2020 Project Bond Initiative) can improve the creditworthiness of sustainable energy project bonds and bolster investor demand.

Banks can also issue 'covered bonds', which have been described as a potential middle ground between AAA-rated green bonds issued by multilateral development banks and asset-backed securities relying uniquely on the cash flows from sustainable energy projects (Climate Bonds Initiative, 2014; Fulton and Capalino).[51]

By creating liquid assets with a lower cost of funding, covered bond legislation, which now exists in nearly 40 countries and supports a USD 2.5 trillion global market for all types of covered bonds, has encouraged lending in designated areas such as housing and public infrastructure. To open up this route of financing, policy makers would need to revise covered bond legislation to allow banks to issue covered bonds based on sustainable energy loans. Bondholders have recourse to the bank (which makes them 'covered') that made the loans in the case of default which makes them less risky.

[51] Covered bonds also rely on project cash flows but investors receive the added protection of having recourse to the underlying issuer as well as the projects. For a longer discussion including policy recommendations see Damerow, Kidney and Clenaghan (2012).

Some sustainable energy projects will be large enough to individually issue bonds. Most projects including distributed generation, however, are too small to justify the expense of an individual bond issuance; as a result, the best way to link such projects to capital markets is to pool, or 'securitise,' them into a 'special purpose vehicle,' and then issue bonds backed by the cash flows from this pool (as discussed in Chapter 9).

The US National Renewable Energy Laboratory (NREL, 2013) argues that securitisation is a promising way to provide debt finance for portfolios of rooftop solar PV projects, a recent example being SolarCity's issuance of USD 54 million of notes backed by residential solar leases followed by a USD 70 million issuance and a USD 200 million issuance, each with a lower interest rate and less over-collateralisation.[52]

Because many developers of sustainable energy projects lack the credit rating to themselves issue bonds, securitised bonds – where repayment depends on the quality of the assets rather than the creditworthiness of the issuer – have the potential to lower financing costs.

As described by (Kaminker *et al.*, 2013), government institutions such as the US National Renewable Energy Laboratory are working to scale up the market for asset-backed securities (ABS). The NREL Solar Access to Public Capital (SAPC) Working Group was designed to open capital market investment for solar assets via securitisation and other financial innovations. The SAPC was a three-year initiative that ended in September 2015. SAPC membership included over 440 organisations such as top residential and commercial solar developers, law firms, investment banks and capital

[52] For more see CleantechIQ, "SolarCity Launches S&P Rated Bonds, Plans to Raise $54M," 15 November, 2013

managers, rating agencies, independent engineers, and other key stakeholders in the solar finance space.

Fulton and Capalino (2014, p. 7) recommends that such endeavours must 1) minimise the due diligence burden on buyers of sustainable energy ABS issues (by standardising Power Purchase Agreement terms); 2) make future cash flows from such issues more stable (by strengthening the supply of operations and maintenance providers to keep systems in service); 3) enable more accurate rating and pricing of such issues (via more detailed historical data); and 4) limit downside risk for buyers of early sustainable energy ABS issues (via credit enhancement from banks).

11.4 Investor demand for sustainability and for green bonds rises

Institutional investors have driven the growth of the green bond market, investing in the majority of issuances while working to improve the market's structure and green integrity. Bonds are a core component of pension funds' and insurance companies' portfolios, and bonds with long tenors are potentially a good fit with institutional investors' long-term liabilities, allowing for asset-liability matching. Green bonds fit within the investment portfolios of mainstream institutional investors and can reconcile latent and emerging demand from institutional investors for sustainability- themed, ESG-screened investments. The green bond 'label' serves as discovery mechanism for institutional investors and helps to lower search costs associated with identifying green opportunities in a figurative ocean of fixed-income opportunities.

Assets under management by signatories to the UN-supported Principles for Responsible Investment stood at more than USD 70 trillion in 2017 (according to the PRI), up from USD 4 trillion at the PRI's launch in 2006. So-called sustainably invested

assets increased 61% globally in two years to USD 21.4 trillion at the start of 2014, with half of the assets allocated to bonds (Global Sustainable Investment Alliance, 2015). Socially responsible investors as well as mainstream investors that screen for environment, social and governance (ESG) factors have indicated their demand for green bonds. Pledges have been made to invest a defined amount into green bonds and investor statements supporting the growth of the green bonds market have been released.

In response to the greater availability of green bonds, a dozen institutional investors have made commitments or targets for green bond investments in excess of USD 15 billion to date, and 14 dedicated green bond funds have emerged (with 9 launched in 2015 alone). In 2016, the Swedish pension fund AP2 established a stand-alone green bond portfolio, arguing the market has 'achieved a maturity and size' to justify the fund implementing a separate investment strategy and classifying its green bond holdings as a distinct asset class. Data from the 2016 survey of Large Pension Funds (LPFs) and Public Pension Reserve Funds (PPRFs) (OECD, 2016a) reported an increase in allocations to green bonds in 2014 and 2015, partly due to an uptick in issuance and available supply, but also increased investor interest.

In the margins of COP 21, asset owners, investment managers and individual funds managing over USD 11.2 trillion of assets signed a statement in support of the green bond market. A 2014 investor statement on green bonds signed by investors with USD 2.6 trillion of assets under management was followed in 2015 with another investor statement setting out expectations for the green bond market (Ceres, 2015). The statement's 26 signatories pledged to carry out additional due diligence when evaluating bonds that finance projects whose environmental benefits are marginal. The statement also notes the

expectation of annual impact reporting and the need for independent assurance or auditing of the selection and tracking of green projects.

Table 11.1 Over EUR 12 billion in institutional commitments or targets for green bond investment, May 2016

Green bond commitments or targets			
Actor	Sector	Commitment	Comments
Credit Agricole	Bank	EUR 2 billion	Target by end of 2017
Barclays	Bank	GBP 2 billion	Increased from GBP 1 billion target
KfW	Public financial institution	EUR 1 billion	Within four years
HSBC	Bank	USD 1 billion	No time frame
Zurich	Insurer	USD 2 billion	No time frame
Actiam	Asset manager	EUR 1 billion	No time frame
AXA	Insurer	EUR 1 billion	No time frame
Aviva	Insurer	Increase holdings	No time frame
Deutsche Bank	Bank	EUR 1 billion	No time frame
California State Treasury	Public financial institution	USD 1.1 billion	No time frame
Bangladesh Central Bank	Central bank	Some of its foreign currency reserves	No time frame
AP2	Pension fund	1% of portfolio allocation	No time frame
AP4	Pension fund	Strong commitment and significant allocation to green bonds	No time frame

Source: Author (Kaminker, 2017)

Table 11.2 Fourteen green bond funds manage EUR 1.16 billion, May 2016

Actor	Focus	Assets under management
Storebrand	Green bond fund	EUR 500 million
Foresight	Unlabelled green bond fund	EUR 200 million
Humanis	Green bond fund ("HGA Obligations Vertes")	EUR 125 million
SEB	Green bond fund	EUR 110 million
AXA IM	Green bond fund (WF Planet Bonds)	EUR 80 million
Mirova	Green bond fund	EUR 62.55 million
Calvert	Green bond fund	EUR 61.29 million
Erste Asset Management	Responsible bond global impact fund	EUR 41.6 million
Raiffeisen Capital Management	Green bond fund	EUR 35 million
Allianz	Green bond fund	EUR 20 million
State Street	Green bond fund	EUR 20.34 million
Columbia Threadneedle	Social bond fund	USD 20 million
NN Investment Partners	Euro green bond fund	EUR 20 million
Nikko AM	World Bank green bond fund	SGD 16.46 million

Source: Author (Kaminker, 2017)

11.5 The green bond market

Green bonds are issued on the back of this institutional investor demand into a broader market of USD 694 billion in outstanding bonds,[53] comprising USD 576 billion of 'unlabelled climate-aligned' bonds as designated by the NGO Climate Bonds Initiative (CBI), and USD 118 billion of labelled green bonds (CBI/HSBC, 2016). Unlabelled climate-aligned bonds are bonds whose proceeds are used to finance LCR industries and sectors but do not yet carry the green label (CBI/HSBC, 2015).[54]

For instance, traditional bonds of 'pure-play' wind energy companies qualify as unlabelled green bonds, as do rail bonds in China and France where the use of proceeds have been specified (note that rail bonds where proceeds are used for fossil fuel transport are excluded by the CBI). Most issuers of such bonds may not yet be aware of the potential utility of using the green label; and some issuers may choose not to label bonds as green

[53] i.e. those bonds that have been issued and have not reached maturity or been redeemed.

[54] For instance, traditional bonds of "pure-play" wind and solar energy companies qualify as unlabelled green bonds. Some issuers may choose not to label bonds as green due to concerns over a lack of standardisation in the market, political or stakeholder sensitivities and concerns over restrictions associated with the label.

due to concerns over a lack of standardisation in the market, political or stakeholder sensitivities, and concerns over restrictions associated with the label. Labelled green bonds issued globally in 2015 represented less than 1% of total US bond issuance alone and less than 0.2% of debt securities issued globally.

There are both narrow and broad interpretations of environmentally-themed bonds. The narrow interpretation includes only 'labelled' green bonds, including self-labelled and those labelled by independent reviewers. A broader definition also includes unlabelled 'pure-play' bonds in sectors that are considered as 'green' without controversies.[55] The broadest definition is the aforementioned 'climate-aligned bonds' as defined by the CBI, which includes many unlabelled bonds that are assessed by the CBI to be 'green'.[56]

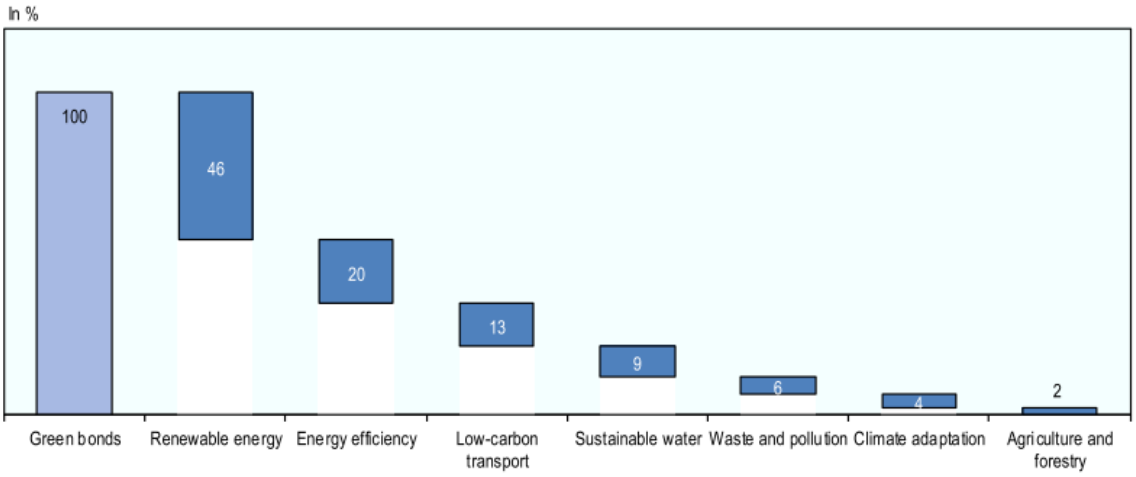
11.5.1 Use of proceeds

As shown in Figure 11.4, in 2015, 46% of proceeds raised from green bond issuance were dedicated to financing renewable energy, followed by energy efficiency (20%), low-carbon transport (13%), sustainable water (9%), waste and pollution (6%), climate adaptation (4%), and agriculture and forestry (2%).

[55] In addition to the USD 42 billion of green bonds issued throughout the course of 2015, the BNEF identified an extra USD 6 billion of such bonds (wind and solar project bonds and asset-backed securities) and designated them as green bonds via a tag on the Bloomberg Terminal.

[56] The GBP recommend that the term 'green bonds' be used only for GBP-aligned bonds while the wider universe should be referred to as climate or environmental themed bonds. For the statistics cited in this report the green bond definition used is cited as well.

Figure 11.4 Green bond use of proceeds raised in 2015 by sector



Source: Author (Kaminker, 2017) based on CBI (2016), 'Final year end green bond market roundup report'

11.6 Promoting environmental integrity in the green bond market through guidelines and standards

The momentum of continued issuance and market demand has led to growing consensus on what constitutes a green bond and progress has been made on standards and criteria for what constitutes a green project or activity. The green bond market is underpinned by voluntary guidelines and standards, as well as more recently by rules and regulations in some jurisdictions such as China, France and India. Market and government-led efforts at standardisation and definition in the green bond market have borne fruit, with the emergence of the Green Bond Principles (GBP, a self-regulatory initiative designed to promote transparency and disclosure in the market).

The GBP, updated in June 2016, have achieved broad market acceptance as well as growing recognition by policy makers and regulators. As of June 2016, over 117 green bond issuers, underwriters and investors had become members of the GBP and in excess of 73 organisations were observers. The GBP outline voluntary guidelines for issuing

green bonds, focusing on disclosure and transparency. They also provide guidance on eligible green project types through key areas of concern and the high-level project categories described below.

There are a number of international and national taxonomies addressing green bond project definitions, including the Climate Bonds Standard issued by the CBI and the Green Bond Endorsed Project Catalogue (2015 edition) issued by the Green Finance Committee (GFC) of the China Society for Finance and Banking. These and other principles and guidelines recognised and backed by the official sector – including public financial institutions and development banks – are discussed below.

However, as previously examined by the OECD (OECD, 2015; Inderst et al., 2012), the lack of universal rules and standardisation of green definitions, reporting and impact assessment is a shared and enduring source of concern cited by participants in the market. According to KPMG (2015), issuers face reputational risk and potential accusations of so-called 'greenwashing' if proceeds are not used for their intended purposes or if issuers are unable to prove that proceeds have funded projects with positive and additional impact.

The risks of greenwashing are legitimate as over the past few years several green bond issuances have proven controversial among stakeholders. In 2015, an open letter signed by a coalition of 17 non-governmental organisations was submitted to the Green Bond Principles calling for them to better address transparency (Banktrack, 2015). The spectre of greenwashing has necessitated focused attention from market participants and stakeholders to safeguard the environmental integrity of the market, with the WWF in particular calling for 'vigorous, credible, fully-developed and widely-accepted industry standards for green bonds being urgently needed to ensure that the market thrives and the

sustainable economy grows' (WWF, 2016). At the same time, there are also concerns among market participants that attempts to establish stringent requirements and standards for bonds to qualify as 'green' could slow, inhibit or derail the growth of a potentially critical source of capital for LCR infrastructure at an early stage of the market's development (Deutsche Bank, 2015; Wilkie, 2015; Gilbert, 2015).

11.6.1 Transparency in the 'use of proceeds' as a key to integrity

In response to these tensions, a significant amount of effort has gone into shaping and cultivating a better-defined market with assurances for the environmental integrity and impact of green bonds while keeping 'green transaction costs' low or seeking to drive them lower. Much of this work has involved determining what investments count as 'green'; enhancing the transparency of the process by which a green bond is issued and how the proceeds are used and managed; and also on improving data and impact reporting.

The foundation of the green bond market lies in the utilisation of the proceeds of the bond which, according to the GBP, should be 'appropriately described in the legal documentation for the security'. The GBP recommend that 'designated green project categories should provide clear environmentally sustainable benefits, which, where feasible, will be quantified or assessed by the issuer'.

The GBP explicitly recognise several 'broad categories' of potentially eligible green projects aiming to address key areas of concern such as climate change, natural resources depletion, biodiversity conservation and pollution. The GBP do not currently define the type of projects under the general categories that qualify as 'green', but point

issuers and other stakeholders to existing, independently developed sets of criteria and standards for defining eligible green projects that can be used as a guide.

For instance, the Climate Bond Initiative's taxonomy specifies the green definitions for the Climate Bond Standards and Certification Scheme and is guided by a panel of climate and energy experts. It is the only current industry effort to address the challenge of green standards within each of the broader asset categories provided by the GBP. The CBI aims to encourage common definitions across global green bond markets based around its taxonomy. As of June 2016, 16 green bonds amounting to USD 6 billion in issuance and 15% of the green bonds issued in 2016 had been certified against the Climate Bonds Standard.

11.6.2 Review and assurance in the green bond market

A key element in the development of standards involves working out exactly how to verify the proper use of proceeds. While shortcomings in the disclosure of information about the use of proceeds may, for instance, be alleviated by the guidelines set out in the GBP, these are voluntary guidelines only, and do not currently spell out material requirements for the type and nature of activities, nor do they mandate a certain threshold of environmental benefits.

Investors need to be assured that the proceeds of the green bonds in which they invest are being allocated to appropriate qualifying projects that generate the desired 'green' impacts. To secure this assurance in the absence of market-wide standardisation, the 'majority of issuers' (CBI/HSBC, 2015) choose to retain specialist service providers and undergo independent review through assurance processes that include second-party reviews and consultation, audits and third-party certifications. These different processes

have been used on their own, or in combination, and serve to elucidate and validate the environmental criteria the issuer will use to select projects for funding, check compliance of the bonds against criteria specified by standards, and provide independent assurance about whether the bond's proceeds have been applied and managed as intended.

An ecosystem of green bond assurance providers has emerged to service this demand. These organisations verify the environmental integrity and impact of green bonds as well as the process by which a green bond is issued, managed and reported on. A number of private and academic organisations provide assurance on alignment with the GBP or on climate bonds certification, as well as on the eligibility of environmental projects. Some are also developing different types of green ratings. CICERO, a second-party reviewer of green bonds, offers a 'Shades of Green' methodology whereby green bonds are graded 'dark, medium or light' green depending on the underlying project's contribution to 'implementing a 2050 climate solution' (Clapp and Torvanger, 2015). Industry-specific guidelines exist, such as those for real estate proposed by the Global Real Estate Sustainability Benchmark.

11.6.3 Review and assurance in the green bond market

The Green Bond Principles (GBP) describe a variety of ways for issuers to obtain outside input to the formulation of their green bond process and recommend several levels and types of independent assurance.

Second-party reviews and consultation. For example, an issuer can seek advice from consultants and/or institutions ('second party') with recognised expertise in environmental sustainability to review or help in the establishment of its process for project evaluation and selection, including project categories eligible for green bond

financing. The reviews and reports of the second party are private and may be made publicly available only at the discretion of the issuer.

Audits. Issuers are encouraged to have independently verified or audited certain aspects of their green bond process, such as the internal tracking method and the allocation of funds from proceeds. The verification can be provided by qualified third parties, or by internal and/or external auditors. These independent reports and audits may be put in the public domain at the discretion of the issuer.

Third-party certifications. Second-party standards intended for use by qualified third parties to certify green bonds are in use or in development. The GBP are supportive of the development of and use of such standards (e.g. the Climate Bonds Standard) for the certification of green bonds as they are defined above.

Ratings agencies are potential players for providing external reviews of green bonds. Certain rating agencies are exploring providing a rating of disclosure and transparency of green bonds. The international ratings agency Moody's launched a green bond rating methodology and service in 2016 – the first from a ratings agency. The Moody's Green Bond Assessment product is an evaluation focused on the issuer's adherence to best practice process – use of proceeds, management of proceeds and reporting rather than a direct evaluation of the relative level of green of assets and projects financed by the bond. For that aspect, Moody's scores a bond based on the green criteria resource that has been used to justify its green status, such as the GBP, the GFC or the CBI. S&P Global Ratings also proposed a new Green Bond Evaluation Tool to analyse and estimate the environmental impact of bond projects or initiatives.

Guidelines specific to municipal issuances have been developed, e.g. the Green Muni Bonds Playbook (Green City Bonds Coalition, 2015), as well as a framework developed by 11 international financial institutions active in the green bond market to harmonise impact indicators and reporting (ICMA, 2015). Several green bond benchmark indices have been launched to track performance and help formalise what qualifies as green by specifying specific attributes as requirements for inclusion in the index.

11.7 The emergence of green bond benchmark indices and exchange listings

As the green bond market has expanded and investor appetite increased, so too has the need for comparable performance data and the need to create benchmarks or reference points for performance. Market indices are broadly defined as metrics, often statistical, that track the performance of a specific group of securities or investment vehicles. In 2014 a range of banks, ratings agencies and service providers launched green bonds indices.

These indices are aimed at lowering information barriers facing investors by providing clear risk-return data for this category of securities. Many institutional investors are required to invest exclusively in 'benchmark-eligible' securities, so having a green bond included in a benchmark index can be an important attribute for attracting these mainstream investors.

As of November 2016, five 'families' of green bond indices were available to investors, each with different methodologies for calculation and with eligibility thresholds for green bonds (including currency, size, rating, and extra-financial characteristics like second-party opinions).

Indices also take a view on what projects and activities are eligible. For instance, to qualify for the Barclays MSCI Index, proceeds must be used for either new or existing

environmental projects in five broad categories: alternative energy, energy efficiency, green building, pollution prevention and control, and sustainable water. Stock exchanges have built on these efforts and have launched dedicated green bond listings which provide added data and trading capabilities for market participants. As of 2016, green bonds were listed on stock exchanges of London, Luxembourg, Mexico, Oslo and Stockholm. The five indices and their green criteria are:

1. Bank of America Merrill Lynch Green Bond Index (complies with Bloomberg green bond definition)

2. Bloomberg MSCI Green Bond Index (complies with the Climate Bonds environmental assessment; unlabelled climate bonds are eligible) taxonomy and MSCI

3. S&P Green Bond Index (complies with the Climate Bonds taxonomy)

4. Solactive Green Bond Index (complies with the Climate Bonds taxonomy)

5. ChinaBond China Climate-Aligned Index (complies with the Climate Bonds Taxonomy and the China Green Bond Endorsed Project Catalogue).

As of October 2015, according to CBI/HSBC (2015), 60% of total green bond issuance to date has officially incorporated a second-party review, and this percentage was stable over the three previous years. ‘Most’ of the remaining 40% of green bonds use a type of proxy for second-party review, including audited assurance reports or benchmark measures related to use of proceeds and impact (e.g. LEED) (CBI/HSBC, 2015).

For instance, the European Investment Bank (EIB), currently the largest green bond issuer, reports in detail on the allocations of its Climate Awareness Bond proceeds in

annual audited sustainability reports and in a dedicated newsletter. According to the CBI, 96% of outstanding green bonds produce annual reports within one year of issuance, with 90% of the reports disclosing proceed allocation and climate impacts of projects or assets financed.

According to Barclays (2015), there is greater investor demand for the bonds of issuers that provide high-quality information about the environmental benefits of the underwritten projects. However, according to Bloomberg (as reported at the June 2016 Green Bond Principles Conference) some 20% of issuers still self-label what constitutes a green bond, foregoing the use of an independent review. This has decreased from 40% in 2014 according to the CBI's figures. This highlights the need for continued attention on promoting transparency and environmental integrity, as discussed in Chapter 11.

Governments have also supported the development of standards and definitions for green bonds. In 2015, the Peoples' Bank of China (PBoC, China's central bank) released the first country-specific green bond issuance guidelines along with a taxonomy in the form of a 'Green Bond Endorsed Project Catalogue' to guide financial sector issuance on green bonds in China (Box 1.6). In January 2016, India issued rules that will govern the issuance of green bonds locally. As part of the French Energy Transition Bill and National Low-Carbon Strategy (SNBC), an 'energy transition for climate' label that is consistent with the GBPs will help identify investment funds that are funding the green economy (French Government, 2015). A methodology for project selection under the Dutch Green Funds Scheme also exists.

11.8 The trajectory of green bond governance

At the EU level, supporting green bond finance through convergence of green bond standards based on market-led initiatives is on the EU's policy agenda under the Capital Markets Union. China and the United Kingdom have also agreed to work towards enhancing consistency of global green bond approaches. Governor Mark Carney of the Bank of England announced in September 2016 (Carney, 2016) that authorities are now working with the private sector to develop a green bond term sheet with standardised terms and conditions to significantly improve the ease and efficiency of green bond issuance and simplify investor access to green bond markets in multiple currencies, thereby moving them into the mainstream of finance.

In October 2016, the Japanese Ministry of the Environment established a discussion group with a view to producing a Japanese green bond guideline by March 2017. The guideline will refer to internationally recognised green bond principles while taking into account the situation of the Japanese market, in order to facilitate issuance of and investment in green bonds in Japan while preventing 'green washing'. Switzerland became the first national government member of the Climate Bond Partners to support the development of the Climate Bonds Standard (Kidney, 2015).

Green bonds were a feature of the Chinese G20 Presidency in 2016. The G20 'Green Finance Synthesis Report' (G20, 2016a) which was welcomed in the Leaders' Statement at Hangzhou, outlined voluntary options to enhance the ability of the financial system to mobilise private capital for green investment developed by the Green Finance Study Group (GFSG). The Leaders' Statement (G20, 2016b) contains language referring to green bonds in paragraph 21: 'We believe efforts could be made to… provide clear strategic policy signals and frameworks, promote voluntary principles for green finance,

support the development of local green bond markets and promote international collaboration to facilitate cross-border investment in green bonds'. The work of the GFSG was informed by a background paper produced by the OECD, the ICMA, the CBI and China GFC (Ma *et al.*, 2016) that outlined suggested improvements on current practice regarding green bond guidelines and standards and can be referred to for a more comprehensive discussion of the issues touched on in this research.

11.9 The growing green bond market

11.9.1 The economic geography of green bond market evolution

In 2007, the EIB launched a structured product 'Climate Awareness Bond'. Instead of a fixed coupon, the bond's returns were linked to an equity index (such a bond is commonly referred to in the bond market as 'structured'). In 2008, the World Bank and Skandinaviska Enskilda Banken (SEB) launched the first labelled green bond together with a group of Swedish investors with mainstream financial mandates to participate in climate financing and raise awareness on climate related risk. The inaugural World Bank Green Bond was the first climate-related fixed income instrument to attract mainstream portfolios in a larger way (World Bank, n.d.).

The identical financial characteristics of green bonds compared to conventional bonds and the relatively simple principle of green labelling and the ring-fencing, earmarking or 'use of proceeds' implied by the label have been catalytic elements in the market's growth. Combined, they have allowed for a wide range of issuers and investors to join the market attracted by the advantages offered by green bonds (see Table 11.3).

The market evolved beyond SSA issuers in 2013, when corporate issuers joined the market, with Vasakronan (a Swedish real estate company), then Bank of America's

‘financial sector’ bond, followed by Électricité de France (EDF) and others. Corporates have also extended the green bond label to asset-backed securities (ABS), with Toyota’s 2014 sale of securities with proceeds used for investment in electric vehicles and hybrids. The deal was backed by leases and loans to non-green vehicles, as the pool of leases and loans to electric vehicles and hybrids was too small.

Municipalities have joined the market, with the issuance by Île-de-France (the Paris region) in 2012 followed by Gothenburg (Sweden) in 2013. The year 2014 also saw the first emerging market municipal issuance, by Johannesburg (South Africa). Export credit agencies and export-import banks have issued green bonds including in India (India ExIM). The first ABS were issued by Hannon Armstrong (a US real estate investment trust providing debt and equity financing to the energy efficiency and renewable energy markets) in 2013 backed by 100 individual wind, solar and energy efficiency infrastructure installations at 20 properties, and the covered bond issuance (Berlin HYP) occurred in 2015 along with further growth in ABS and project bonds.

In 2015, corporate bonds moved beyond the utilities and real estate sectors to include transport and waste, with a GBP 400 million green bond from Transport for London and a EUR 480 million issuance from French recycling company Paprec. In 2016, the first technology company issued a labelled green bond, with Apple’s USD 1.5 billion green bond backing renewable energy for data centres, energy efficiency and green materials. The seven-year security, with a coupon of 2.85%, is the first green bond from the world’s largest consumer electronics company and the largest single issue from a corporation unconnected to electricity generation.

In December 2016, Poland became the first country to issue a sovereign green bond of EUR 750 million to fund renewable energy, clean transportation, sustainable

agriculture, afforestation, national parks and reclamation of heaps (State Treasury of Poland, 2016). In January 2017, France also launched its sovereign green bond following prior announcements in 2016. EUR 10 billion of expenditure has been identified as eligible for green bond allocation based on the 'energy transition for climate' label issued by the French government (French Ministry of Economy and Finance, 2017). The first issuance amounted to EUR 7 billion.

11.10 The benefits of green bonds

Green bonds offer advantages and disadvantages in their use and these are compiled in Table 11.3. At a more general level, the green bond market can offer several important benefits for green investment by the public and private sectors (Ma *et al.*, 2016). These include:

1. Providing an additional source of green financing. Given immense green investment needs, bonds are one appropriate financing instrument to address such projects. As traditional sources of debt financing will not be sufficient in light of immense green investment needs, there is a need to introduce new means of financing that can leverage a wider institutional investor base. The development of the green bond market can provide an additional source of funding to green lending by banks and green equity financing by investors.

2. Enabling more long-term green financing by addressing maturity mismatch. In many countries, the ability of banks to provide long-term green loans is constrained due to the short maturity of their liabilities and a lack of instruments for hedging duration risks. Corporates that can only access short-term bank credit also face refinancing risks for long-term green projects. If banks and corporates can issue medium- and long-term green bonds for green projects, these constraints on long-term green financing can be mitigated.

3. Enhancing issuers' reputation and clarifying environmental strategy. Issuing a green bond is an effective way to develop and implement a credible sustainability strategy for investors and the general public by clarifying how proceeds raised will contribute to a pipeline of tangible environmental projects. Green bonds can thus help enhance an issuer's reputation along with internal sustainable development policies, as this is an effective way for the issuer to display its commitment towards improving environmental sustainability. These enhancements may result in benefits for product

marketing as well as potential government policy incentives for business operations. Setting up a green bond framework also can serve to upgrade issuers' environmental risk management process due to their commitment to 'green' disclosure.

4. Offering potential cost advantages. While the cost advantage is not yet evident in the current nascent green bond market, it is possible that, once the market attracts a wider investor base both domestically and internationally, a differentiated pricing for green bonds vs. regular bonds may emerge provided demand is sustained. According to the CBI, a number of issuers also report a benefit in the increased speed of 'book building' (i.e. the process of generating, capturing and recording investor demand for a bond issue), which translates into reduced costs for marketing and road shows. In some countries, government incentives such as tax reduction, interest subsidies and credit guarantees are also being discussed as options for further reducing the funding costs for green bonds, with the United States having already experimented in this area with green property bonds and municipal bonds.

5. Facilitating the 'greening' of traditionally brown sectors. The aforementioned benefits of the green bond market can function as a transition mechanism that encourages issuers in less environmentally friendly sectors to take part in the green bond market (provided they ring-fence proceeds for green projects) and also to reduce their environmental footprint by engaging in green investment activities that can be funded via a green bond. This complements mandatory 'real economy' policies that lead to changes in business models (such as carbon pricing, waste reduction and recycling targets, policies to promote the circular economy, etc.)

6. Making new green financial products available to responsible and long-term investors. Pension funds, insurance companies, sovereign wealth funds and other institutional investors that have a special preference for sustainable (responsible) investment and long-term investment are looking for new financial instruments to achieve their investment targets. The green label is a discovery mechanism that lowers the 'search costs' for investors looking for green opportunities in a vast ocean of bonds. Green bonds provide these investors with the access to such products and a way for many other investors to diversify their portfolios. At the same time, numerous green bond issuers report an improved diversification of their investor base, thereby expanding their funding sources and potentially reducing exposure to 'funding risk' and bond demand fluctuations.

Table 11.3 Advantages and disadvantages of green bonds as cited by investors and issuers

For investors	
Advantages	Disadvantages
Commonly cited	
– Investors can balance risk-adjusted financial returns with environmental benefits – Satisfies environment, social and governance (ESG) requirements and green investment mandates – Improved risk assessment in an otherwise opaque fixed income market through use of proceeds reporting – Potential use of pure-play, project and asset-backed securities as instruments to actively hedge against climate policy risks in a portfolio that includes emissions-intensive assets (see Annex 1.A2) – Recognised by the UNFCCC as non-state actor "climate action"	– Small and nascent (and potentially less liquid) market, small bond sizes – Lack of unified standards can create confusion and possibility for reputational risk if green integrity of bond questioned – Limited scope for legal enforcement of green integrity – Lack of standardisation can lead to complexities in research and a need for extra due diligence that may not always be fulfilled
Infrequently cited	
– Engagement and private dialogue with issuers on ESG topics related to green bond issuance results in information that enhances credit analysis, through more comprehensive credit profiles of borrowers – Added transparency of use of proceeds and reporting requirements provides informational advantage otherwise unavailable (on spending efficiency, project details and updates, impact performance) which gives green bond investors a significant information advantage (Wong and Eeles, 2014) – Tracking of use of proceeds and reporting leads to improved internal governance structures and a positive feedback loop which improves the overall credit quality of the issuer (Wong and Eeles, 2014)	
For issuers	
Advantages	Disadvantages
Commonly cited	
– Demonstrating and implementing issuer's approach to ESG issues – Improving diversification of a bond issuer's investor base, thereby expanding funding sources and potentially reducing exposure to bond demand fluctuations – Strong investor demand can lead to oversubscription and potential to increase issuance size – Evidence of greater proportion of "buy and hold" investors for green bonds which can lead to lower bond volatility in secondary market – Reputational benefits (e.g. marketing can highlight issuer's green credentials and support for green investment) – Articulation and enhanced credibility of sustainability strategy (putting one's "money where their mouth is") leading to enhanced dialogue with investors – Access to "economies of scale" as majority of issuance costs are in setting up the processes	– Upfront and ongoing transaction costs from labelling and associated administrative, certification, reporting, verification and monitoring requirements (cost estimates vary) – Reputational risk if a bond's green credentials are challenged
Infrequently cited	
– Tracking of use of proceeds and reporting leads to improved internal governance structures, communication and knowledge sharing between project side and treasury side of business (Wong and Eeles, 2014) – For municipalities, a tool to reach constituencies physically located close to the green project they intend to support and provide them with opportunities to invest in programmes that have direct proximal impact (World Bank, 2015)	– Investors may seek penalties for a "green default" whereby a bond is paid in full but issuer breaks agreed green clauses (KPMG, 2015)

Source: Author (Kaminker, 2017)

11.11 The geography of the green bond market

The geography of the green bond market is expanding and diversifying. As of February 2016, green bonds had been issued in 25 jurisdictions, including 22 for domestic and foreign investors, and 3 for foreign investors only. Green bonds have been issued in 23 currencies and in 14 markets of the G20.

Green bonds issued for domestic and foreign investors in Australia; Austria; Canada; the People's Republic of China; Denmark; Estonia; France; Germany; Hong Kong, China; India; Italy; Japan; Latvia; Mexico; the Netherlands; Norway; Peru; South Africa; Spain; Sweden; the United Kingdom; and the United States. They have been issued for foreign investors only: Brazil, Switzerland and Chinese Taipei. G20 markets: Australia, Brazil, Canada, China, the European Union, France, Germany, India, Italy, Japan, Mexico, South Africa, the United Kingdom and the United States. The list of currencies includes: AUD, BRL, CAD, CHF, COP, EUR, GBP, HUF, IDR, INR, JPY, MXN, MYR, NOK, NZD, PEN, PLN, RMB, RUB, SEK, TRY, USD, ZAR.

11.12 Selected case studies on regional experiences with green bonds

11.12.1 China: Greening a financial system starting with bonds

The Peoples' Bank of China (PBoC) has estimated that green development in China will require annual investment of at least CNY 2 trillion (USD 305 billion) in the next years, with 85% of the financing needing to come from the private sector (PBoC/UNEP, 2015). In July 2015, the PBoC launched the Green Finance Committee (GFC), a multi-sectoral group tasked with investigating green finance reforms. The GFC, which is comprised of 85 members representing 65% of China's financial assets, has 6 main areas of research,

with working parties addressing issues such as green banks, green bonds, responsible investment, etc.

In China, the green bond market is regulated by the PBoC, which issued regulations for the issuance and trading of green bonds in China's inter-bank bond market in December 2015. The regulations are broadly consistent with the Green Bond Principles (GBPs). The PBoC also published a Green Projects Catalogue, developed by the GFC and the China Society for Finance & Banking, which defines the assets and projects that qualify for green bond financing. The definitions cover the areas of energy conservation, pollution control, resources utilisation, clean transport, clean energy and adaptation.

A 2016 issues paper by the Climate Bonds Initiative (CBI), the International Institute for Sustainable Development and the UK Foreign and Commonwealth Office (CBI/IISD/UK Foreign & Commonwealth Office, 2016) details the categories of qualifying green projects included in the Chinese guidelines that differ from practices in the international green bond markets, in particular fossil fuel projects, public transport projects that use fossil fuels, and certain supply chain investments, and sets out a roadmap for the next steps of the green bond guidelines in the Chinese domestic green bond market with the aim of harmonising these guidelines with international practice.

In October 2015, the Agricultural Bank of China issued the first Chinese mainland green bond. The USD 1 billion bond, listed on the London Stock Exchange, was given an 'A' rating by Fitch. Following the release of the green bond regulation and as of January 2016, the PBoC had approved RMB 100 billion (USD 15 billion) of green bond issuance by the China Industrial Bank and the Shanghai Pudong Development Bank. Also in November 2016, Bank of Communications issued RMB 30 billion (USD 4.4 billion) of green bonds.

11.12.2 Institutional investment in green bonds: The case of South Africa's Government Employees Pension Fund

The Government Employees Pension Fund (GEPF) is Africa's largest pension fund, with over ZAR 1.5 trillion (USD 109 billion) in assets under management. The GEPF is also the largest investor in Johannesburg Stock Exchange-listed companies, owning on average 10% of companies listed on the Johannesburg Securities Exchange and around half of the government inflation-linked bonds outstanding.

The GEPF, a signatory to the UN-supported Principles for Responsible Investment states in its investment policy that 5% of its portfolio shall be set aside for developmental investments in the areas of economic infrastructure, social infrastructure, green economy projects, and small enterprise or black empowerment initiatives (GEPF, 2015). Over the years, the GEPF has invested in climate-aligned bonds in a number of ways.

In 2012, South Africa's state-owned Industrial Development Corporation issued a ZAR 5.2 billion green bond to finance clean energy projects. ZAR 1 billion of the bond was bought by the GEPF (GEPF, 2012). In 2013, Soitec issued a rand-denominated project bond to finance the Touwsrivier solar power plant using concentrated photovoltaic technology (Soitec, 2013). The unlabelled climate-aligned bond utilised an innovative amortizing repayment structure with a coupon rate of 11% over 15 years. The GEPF bought a 40% equity stake in the project.

11.12.3 United States: Municipal bonds

The American Society of Civil Engineers (2014) estimates that the United States will need to invest USD 3.6 trillion in infrastructure by 2020. Green bonds and other similar financial instruments present an opportunity for US public and private sectors to align their investments with sustainable objectives, without compromising their fiduciary responsibilities. In Q1 2014, the United States' outstanding climate-themed bonds were estimated at USD 35.8 billion. Included in that universe were clean renewable energy bonds, which are tax credit bonds, created as part of 2005 Energy Tax Incentives Act (NREL, 2009). Clean renewable energy bonds are used to finance renewable energy projects, primarily in the public sector, and are nationally allocated and capped in volume. The bondholder receives federal tax credits in lieu of a portion of the traditional bond interest, resulting in a lower effective interest rate for the borrower.

Green municipal bonds in particular have gained traction in the United States since 2013, with activity from a wide array of stakeholders. In the United States, the green muni bond market grew from a single USD 100 million green muni bond issuance in 2013 to USD 2.5 billion of green muni bonds issued in 2014. As of October 2015, green muni bonds have been issued in the United States at the state, county and city levels. To provide clarity and guidance to prospective municipal issuers, the US branch of the Green City Bonds Coalition published the 'Green muni bonds playbook' in July 2015. It contains a five-step guide for issuing a green muni bond, as well as an in- depth analysis of two case studies.

Table 11.4 Labelled green municipal bonds in the United States as of October 2015

State bonds	County/regional bonds	City bonds
– Utah – Connecticut – Massachusetts (through Massachusetts State Clean Water, Massachusetts Development Authority and Commonwealth of Massachusetts) – District of Columbia Water – New York State Environmental Facilities – Indiana Finance Authority – Iowa Finance Authority – Hawaii – California	– Jefferson County, Colorado – East Bay Municipal Utility District, California – Hartford County, Connecticut – East Central Wastewater, Florida – Central Puget Sound Transit Authority	– City of Saint Paul, Minnesota – City of Los Angeles, California – City of Asheville, North Carolina – City of Venice, Florida – City of Chicago, Illinois (through Chicago Met Water and Chicago Board of Education) – City of Tacoma, Washington – Martha's Vineyard Land Bank – City of Spokane, Washington – City of San Francisco, California

Source: Climate Bonds Database

At the individual bond level, different innovative financing tools can be used to invest or refinance in energy efficiency and renewable energy systems. One such tool is Property Assessed Clean Energy (PACE) financing. PACE financing allows property owners to invest in energy efficiency upgrades and renewable energy installations for buildings and to repay these investments over 15-20 years via additional annual payments on their property tax bills. PACE financing removes some of the barriers to investment in energy efficiency and renewable energy, namely large upfront capital costs and lack of accurate information (NREL, 2010). Another innovative mechanism is the Warehouse for Energy Efficiency Loans (WHEEL). Founded in 2014, WHEEL is a public-private partnership that aims to provide homeowners with low-cost financing for residential energy efficiency improvements by creating a secondary market for residential clean energy loans via securitization (Clouse, 2014; Kolstad, 2015). WHEEL purchases and pools small-scale residential energy efficiency loans that are then turned into asset-backed securities. In June 2015, Citi and Renew Financial announced the first securitisation transaction from WHEEL, issuing USD 12.58 million in asset-backed securities backed by pools of unsecured consumer energy efficiency loans (Citigroup, 2015).

12. MOBILISING BOND MARKETS FOR A LOW CARBON TRANSITION

‘Great floods have flown from simple sources’

William Shakespeare

All’s Well That Ends Well (1604-1605)

(Act II, Scene i)

12.1 Introduction

This chapter provides an assessment of barriers to green bond market development and growth, as well as barriers related to: 1) fundamental preconditions for a deep, liquid domestic bond market; and 2) the enabling environment for the development of green infrastructure projects that may be financed or refinanced through the bond markets. The chapter also provides a stock-taking of existing country experiences and actions to overcome barriers to green bond market development. This chapter draws on material published in an earlier form, first as a Policy Perspectives on green bonds (Kaminker, 2015) sponsored by Bloomberg Philanthropies in December 2015 during COP21 and subsequently as an OECD book published in 2017 (Kaminker, 2017). Some extracts from this work were included as part of my contributions to several G20 Chinese Presidency Papers: Green Finance Synthesis Report (G20, 2016b) and 'Green Bonds: Country Experiences, Barriers and Options (Ma, et al., 2016).

12.2 Barriers to green bond market development and growth

The speed at which green bond markets develop and mature hinges on many variables, including policy and regulatory factors (e.g. policies that create the demand for green projects) and market conditions (e.g. interest rate developments and the credit cycle). These conditions will differ across the jurisdictions in which green bonds have been and will be issued.

Many medium and long-term green projects with steady cash flows are good candidates for financing by the bond market. However, the bond market, which currently provides about one-third of total financing for corporates globally (G20, 2016b), has yet to play a comparable role in green financing. The evolving green bond market faces a

range of specific challenges and barriers to its further evolution and growth. Policy makers have a number of options available to overcome these barriers and help to grow a sustainable green bond market with integrity. The OECD's modelling scenarios exhibited later in this chapter suggest that if there is a concerted push by policy makers and market participants to develop the green bond market, it can scale up rapidly to raise and finance the debt capital that will be needed for a transition to a low-carbon economy.

Barriers will differ in importance across jurisdictions. Several challenges are particular to developing and emerging economies, where more fundamental and general actions are needed by governments. For instance, the lack of a domestic debt capital market and other enabling conditions for issuance would need to be addressed in line with longer term financial market development priorities. While this presents a barrier to green bond market growth, it also represents an opportunity for synergy if addressed in tandem with the need for policies more specifically targeted to building a green bond market (CBI/UNEP Inquiry, 2015).

Each country with a bond market will only face a subset of the complete list of barriers that a country starting without a bond market, domestic investor base and framework conditions for long-term investment could face. For any particular emerging green bond market, it is conceivable that a much shorter and more country-specific list of barriers would need to be addressed by policy makers. Accordingly, this chapter aims to provide a comprehensive set of potential barriers that covers a relatively comprehensive set of possible situations at the national level.

12.3 Identifying barriers and challenges to scaling green bond markets

This sub-section identifies several challenges to the growth of the green bond market, recognising that their importance may vary for different markets. A detailed list of barriers of green bond-specific issues and broader framework conditions and factors related to the enabling environment for green infrastructure is given in a later section.

The challenges described herein are supported by the results of a Green Finance Study Group survey that I was involved with (see Ma *et al.*, 2016) on 'barriers to scaling up the green bond market'. The survey received responses from a group of 24 key investors, issuers and intermediaries in the green bond market. According to the survey results, respondents identified the following barriers as being important: 'lack of awareness of green bond benefits' (74% of respondents), 'lack of local definition of green bonds' (43%), 'high cost of meeting green bond requirements' (41%), 'lack of ratings, indices and listings (56%), 'lack of targeted incentives for green bond issuers' (55%), 'difficulties for international investors to access local green bond markets' (67%), and 'lack of domestic green investors' (59%).

12.3.1 General challenges to bond market development

Underlying challenges include the underdevelopment of a domestic institutional investor base, the underdevelopment of the credit rating system, a lack of benchmark yield curves, a lack of risk-hedging instruments and insufficient market liquidity. Many of these fundamental challenges, if addressed in a synchronised way, can be immediately beneficial to the development of local currency green bond markets.

12.3.2 Lack of awareness of the benefits of green bonds and existing international guidelines and standards

For some countries, a lack of knowledge of existing international standards is an important barrier. In addition, in some countries there is a lack of understanding of the potential benefits of the green bond market amongst policy makers, regulators, as well as potential bond issuers and investors. Some finance professionals may simply not have heard of green bonds. In these cases global green bond market participants, for example supranational organisations and multilateral development banks (MDBs), can communicate the benefits of green bonds to these various groups.

12.3.3 Lack of local green bond guidelines

For a variety of reasons, countries may need to develop their local currency green bond markets. For example, in countries where capital investment is not fully open, the local green bond markets will rely on local investors. In some countries, the priorities of their environmental challenges (e.g. air and water pollution being the top priorities) are somewhat different from other countries that focus on controlling greenhouse gas emissions, such as the case is in the People's Republic of China (hereafter 'China') with regards to air pollution. In such countries policy incentives may be used to support the local green bond market. In some of these markets they may require additional definitions and disclosure than the Green Bond Principles require for particular categories. For these countries, the first barrier is the lack of local definitions and disclosure requirements for green bonds.

This barrier may also be relevant in other circumstances, e.g. in countries where capital investment is not fully open and where local green bond markets will rely on local investors.

12.3.4 Costs of meeting green bond requirements

The verification of the 'green bond' status and the monitoring of use of proceeds by issuers for green purposes are performed mainly by second-opinion or third-party assurance providers (such as accountancy firms and specialised research agencies). However, many potential issuers still do not have the knowledge of how such a verification process may work. In some markets, the relatively high cost of obtaining a second-opinion or third-party assurance (ranging from USD 10,000 to USD 100,000) is also a barrier for some small issuers. Some issuers have also complained about the high costs of managing disclosure requirements.

12.3.5 Lack of green bond ratings, indices and listings

Green credit ratings, which incorporate environmental information in the ratings of the bonds, can help the market evaluate the alignment of green bonds with international guidelines and standards such as the Green Bond Principles (GBP) and the Climate Bonds Initiative (CBI) standard, and may also help investors understand the impact of environmental factors in the overall risk profile of issuers. Green bond indices can guide bond investors to invest in green bonds that meet their criteria. This can result in increased fund flows that can also help reduce funding costs for green issuers. Green bond listing criteria implemented by stock exchanges can have similar benefits. However, currently, only a relatively small number of rating agencies, index companies and stock exchanges have promoted such green products and policies.

12.3.6 Lack of supply of labelled green bonds

In some markets, investor appetite for green bonds is relatively strong, as evidenced by significant oversubscriptions of recent issuances. For such markets, the lack of supply of 'labelled' green bonds is a major constraint. At a higher level this reflects the lack of bankable green projects in some markets that can be financed or refinanced through green bonds. This focuses attention on the need to foster robust enabling policy environments necessary for pipelines of green projects to emerge at scale. In addition to the lack of issuance of bonds whose proceeds are spent on green projects, there is also the issue of the relatively low share of potentially qualifying bonds that are actually labelled as 'green'. The number of bonds that meet one of the existing standards (ICMA, CBI or China's definitions) and could potentially qualify for a green label could be many times larger than the number of 'green bonds' that are already labelled as such.

12.3.7 Difficulties for international investors to access local markets

While global green investors exist, they sometimes find it difficult to access certain local markets. One problem here is that green bond definitions and disclosure requirements differ across markets. These differences increase transaction costs as bonds recognised as green in one market need to be relabelled or recertified in another market. Another barrier to cross-border green bond investing is the lack of risk-hedging products (e.g. against currency risks).

12.3.8 Lack of domestic green investors

In markets where green bonds are mostly bought by local investors due either to capital controls or definitional barriers, the existence of institutional investors that have a preference for green assets is important to ensure there is sufficient demand. However,

due to factors such as the lack of disclosure requirements for institutional investors to reveal environmental information of their asset holdings and the lack of capacity to quantify the environmental costs and benefits of their investments, many investors do not have the tools (including indices) to distinguish between green and non-green assets in the domestic bond market.

12.4 The risks, perceived and real, of green bonds

Green bond investors wish to see reductions in risk at the market, project and creditor levels. While institutional investors have driven the growth in the market so far, they prefer commoditised investment products that deliver risk-adjusted returns, with low due diligence costs. Their appetite to invest in green bonds likely will increase over time as projects and markets mature, moving from left to right in Figure 12.1. As markets mature, the volume and liquidity of debt will increase, reducing volatility, reducing uncertainty in performance and reducing issuance costs through standardisation.

In order for the green bond market to reach sufficient scale, a significant portion of the underlying assets will have to achieve mature status. Large-scale 'commoditised' finance requires a high proportion of assets to reach stage 4, that is, to be operating at scale, with standardisation and pooling, credit rating agency 'surveillance', and availability of historical data with correspondingly low technological and market risks.

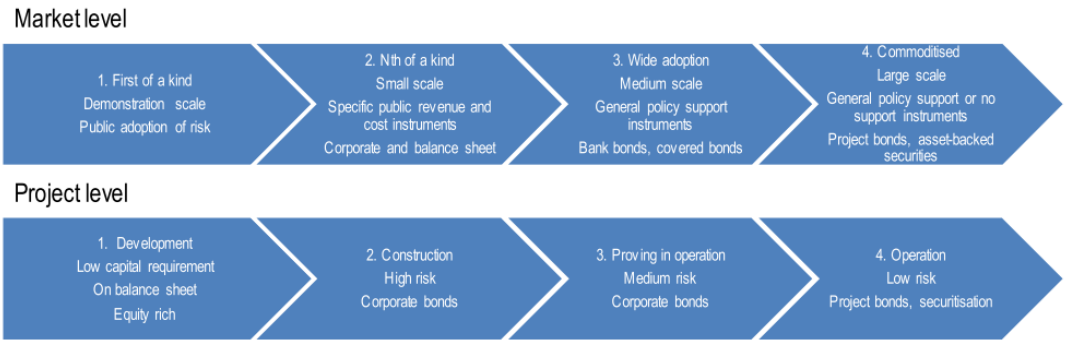
In the transition to a low-carbon economy out to 2030-40, there will be a role for policy makers to play to ensure that policy risks are mitigated and market barriers overcome. For instance, in any scenario with large-scale asset securitisation, policy makers should also be able to consider any adverse effects at a systemic level of policy

reversals, and problems with the underlying assets that only become apparent over time (e.g. technological failures).

At a more granular level, as projects move from development through to operation, and establish a track record, their risks decline and they become more suitable as collateral for securities as well as more attractive to the deeper pools of capital with lower risk appetites (i.e. institutional investors). Not shown in the figure are the changes to the credit risk of the issuer over time.

Currently, green corporate and supranational, sub-sovereign and agency (SSA) bond investors are rarely materially exposed to policy or technology risk because most green bonds issued today provide direct recourse to the balance sheet of the issuer in the case of default, rather than the project. This could change significantly in the future as more project bonds and asset-backed securities are issued, exposing investors directly to project-level risk and commensurate risk-adjusted return. More pure-play corporates specialising in new, green assets may emerge as these sectors grow and generate more visible cash flows that can support debt issuance in public markets, and their green debt will be more closely associated with policy or technology risk.

Figure 12.1 The phases of green infrastructure asset development at individual and market level



Source: OECD (Kaminker, 2017)

12.5 The economic geography of country experiences and actions to overcome barriers to green bond market development

Since the emergence of the green bond market, governments and public financial institutions have moved to address barriers specifically related to green bonds through a variety of actions and approaches, many of them geographically distinct. Government actions that are undertaken as part of broader objectives to develop financial markets have the effect of establishing preconditions for (green) bond issuance.

These preconditions start with the need for established and robust domestic capital markets. Governments already address these issues in line with longer term financial market development priorities. For instance, since 2011, the OECD has been working with the IMF, the World Bank and others on the G20 Action Plan to support the development of local currency bond markets, which could also be applied to green bonds.

Another important aspect of the enabling environment is the presence of domestic institutional investors with the capacity to invest in green bonds. This issue is being addressed through efforts such as the 'G20/OECD checklist and report on effective approaches to support implementation of the G20/OECD high-level principles on long-term investment financing by institutional investors'.

It is also crucial to work towards establishing a broader 'investment grade' enabling environment for green infrastructure investment. These include carbon pricing, fossil fuel subsidy removal and reform and a transparent, stable and credible policy framework for supporting green infrastructure, and are discussed in detail in Chapter 14, and addressed for instance through the OECD's 'Policy Guidance for Investment in Clean Energy', the 'Policy Framework for Investment', and the 'Green Investment Policy Framework'.

If these elements are in place, bankable pipelines of projects that can be financed and refinanced through green bonds can emerge. To date, green bond-specific actions have been taken either after preconditions for a domestic bond market have been met, or simultaneously with actions to put these preconditions in place. Actions specific to green bonds are geared at building the market and stimulating the demand or supply side of the green bond market. They can take the form of government and public financial institution intervention at the project level (e.g. risk mitigation) or at the securities market level (e.g. tax support).

However, each country with a bond market will only face a subset of the complete list of barriers that a country starting without a bond market, domestic investor base and framework conditions for long-term investment could face. For any particular emerging green bond market, it is conceivable that a much shorter and more country-specific list of barriers would need to be addressed by policy makers. Accordingly, this chapter aims to provide a comprehensive set of potential barriers that covers a relatively comprehensive set of possible situations at the national level.

It is also important to bear in mind that due to differences in local conditions, some options that are considered as good practices in one country may not be suitable for another country. This chapter therefore focuses on stocktaking, knowledge sharing, and developing voluntary options for countries to choose from and for bilateral and multilateral collaboration.

12.5.1 Developing a Local Currency Bond Market (LCBM)

A local currency bond market (LCBM) is the cornerstone of domestic financial markets and a necessary foundation for any domestic green bond market. The term LCBMs

encompasses government and corporate (financial and non-financial) domestic debt securities, which are defined as issues by residents in the local market in local currency, targeted to resident investors in the Bank for International Settlements securities statistics. Some foreign currency issues are included in these data, but they are small.

The establishment of a local government bond market alongside issuance of bonds by supranationals targeting investments in a particular country can shape the structure of the corporate segment and lead the development of the fixed-income market more broadly, including subnational government debt and asset-backed securities (ABS) markets. Green bonds can be issued across all of these segments.

A non-exhaustive list of preconditions to the development of LCBMs where green bonds can be issued include the need to develop: a domestic institutional investor base; a suitable issuance framework for a wholesale market; a credible credit rating framework; a long-term yield curve; a robust securitisation framework, including flexible special-purpose vehicles; a robust public-private partnership (PPP) framework; and a pipeline of bankable projects that can be financed or refinanced through bonds.

In response to the 'G20 Action Plan to Support the Development of Local Currency Bond Markets (LCBMs)' (G20, 2011), the International Monetary Fund, the World Bank, the European Bank of Reconstruction and Development, and the OECD produced a diagnostic framework (IMF *et al.*, 2013) that analyses the main elements necessary to deepen LCBMs in emerging and developing economies. The framework serves to analyse the state and efficiency of LCBMs and provides the basis for designing a strategy for market deepening with appropriate sequencing of policy action and delivery of associated technical assistance. As part of the G20's efforts to foster development of LCBMs, a

range of international organisations[57] developed a shared database of advisory operations to help co-ordinate assistance across international institutions and update reports are issued for the G20 on an annual basis.

Policy makers can consult the diagnostic framework to address fundamental barriers to green bond market development and can take actions related to improving the macroeconomic policy framework, composition and needs of the issuer and investor base, primary and secondary market structures and related market dynamics, regulatory and legal frameworks, and market infrastructures.

12.5.2 Unlocking institutional bond investors

Once such preconditions are in place, the key to unlocking the potential of green bonds is to design financial structures that cater to the risk appetite of institutional investors. This is a challenge for both emerging and developing economies as well as for OECD countries. In this context, the availability of risk mitigation mechanisms, such as credit risk enhancements, can be helpful, especially for instruments such as project bonds, which generally struggle to receive an investment-grade rating on their own.

As reviewed by the OECD (Kaminker et al., 2013; Kaminker and Stewart, 2012), and discussed in Chapter 10.2.4, during the previous decade the provision of full guarantees on bond repayments by monoline insurers (see Glossary) was successfully used in the United Kingdom and United States and in selected emerging economies, mainly Chile. One of the developments that facilitated the use of project bonds for infrastructure financing in the United States and other OECD countries was the

[57] The World Bank Group in consultation with the staff of the International Monetary Fund, Asian Development Bank, African Development Bank, Inter-American Development Bank, European Bank for Reconstruction and Development, OECD, and the Bank for International Settlements.

establishment of an insurance market for bond repayments. In particular, the monoline insurance sector offered a product to investors whereby timely payment of interest and principal was guaranteed. However, most monolines stopped issuing financial guarantees in 2008 after their dramatic rating downgrades, including multiple bankruptcies. The challenge in the wake of the global financial crisis has been to develop new business models of risk sharing and credit enhancements, especially for project bonds. Initiatives in this area are at an early stage.

France and the United Kingdom have recently established programmes of government guarantees which operate in a manner similar to a monoline. The Overseas Private Investment Corporation (OPIC) – the US government's development finance institution – offers 'green guaranties': US government guaranties that adhere to the Green Bond Principles. Guaranties, also known as government-guaranteed certificates of participation, are essentially project bonds with an OPIC (US government) guarantee – the investor is paid from project revenues, with an OPIC guarantee that they will be paid. The first-ever OPIC green guaranties were placed with eligible US investors in the domestic debt capital markets in September 2014 to support the construction of the Luz del Norte solar PV project in Chile – which will be, when completed, the largest photovoltaic project in Latin America.

At a regional level, the European Union-European Investment Bank Project Bond Initiative has a good chance of creating an effective substitute for the monoline model for infrastructure financing in Europe by providing up to 20% of first-loss credit protection for senior creditors via a funded or unfunded Project Bond Credit Enhancement mezzanine debt piece for both the construction and operation phases. The Asian Development Bank is currently developing a project bond credit enhancement product,

based on the EU's experience. Larger emerging economies, such as Brazil and Mexico, have established schemes of partial credit guarantees via the domestic development banks. They have not yet been used to support issuance of project bonds (World Bank et al., 2014).

12.5.3 Building the market

Governments are supporting the development and harmonisation of guidelines and definitions for green bonds. Such efforts are taking place in China through the People's Bank of China (PBoC) and in India through the Securities and Exchange Board (SEBI). France has established a green label for investment funds that is aligned with the Green Bond Principles, under the auspices of its Energy Transition Law (Republic of France, 2015). At the EU level, supporting green bond finance through convergence of green bond standards based on market-led initiatives is on the EU's policy agenda under the Capital Markets Union. A group of 11 public financial institutions agreed on a harmonised framework for impact reporting on projects to which green bond proceeds have been allocated.

Countries are active in setting the enabling environment for aggregation and green securitisation. The European Central Bank runs a loan data depository and public green investment banks in the United States are warehousing green loans. For instance, in 2014, the Connecticut Green Bank established a USD 40 million facility for construction-phase lending and loan aggregation for commercial and industrial energy efficiency and renewable energy investments which are sold off to institutional investors, supporting the operational phase.

The US Department of Energy and its National Renewable Energy Laboratory (NREL) backed a solar securitisation initiative (Solar Access to Public Capital) that is now being extended to China (the Chinese PV Alliance) and Europe (RESFARM). In Mexico, a demonstration green securitisation programme for energy efficiency is currently underway, supported by the Inter-American Development Bank.

Legal changes can also support the emergence of green bonds. Germany had its first green covered bond issuance after it extended its dedicated legal framework for covered bond issuances to green projects. In the United States, the establishment of Property Assessed Clean Energy (PACE) bond legislation enables municipalities to raise money for energy-saving retrofits for households and businesses.

As of August 2015, half of G20 countries had a national infrastructure plan and some (less than a third) had a pipeline.[58] The Canadian province of Ontario, which has both, has taken the further step of linking its pipeline of green projects to its municipal green bond programme. The Province of Ontario has formed a Green Bond Advisory Panel, which includes staff from various ministries and agencies, including the Ministry of the Environment and Climate Change and the Ontario Financing Authority. The panel screens and selects projects for use of proceeds that align with Ontario's environmental and climate change policies and pipeline of projects. In October 2014, Ontario successfully launched a Green Bond programme with an inaugural green bond of CAD 500 million. In January 2016, Ontario issued its second green bond, raising CAD 750 million to support low-carbon infrastructure projects.

[58] Infrastructure plan: Australia, Canada, China, Italy, Korea, Mexico, South Africa, Spain, Turkey, the United Kingdom and the United States. Infrastructure project pipeline: Australia, Brazil, the EU, France, Italy and Mexico (G20/OECD, 2015).

12.5.4 Demand-side policies

Green bond investment mandates have been given to various public institutions. Norway's Sovereign Wealth Fund invests in green bonds, as do multiple public pension funds (including in South Africa, Sweden and California), the Bangladeshi central bank and the UN Joint Staff Pension Fund.10 Germany's national development bank, KfW, invests in green bonds on behalf of the German government. Cornerstone investments are also possible for inaugural green bonds as was done by the International Finance Corporation (IFC) for an Indian green bond (issued by Yes Bank) and by Australia's public green investment bank (Clean Energy Finance Corporation) for a local financial sector green bond (issued by National Australia Bank).

National green bond market development committees have been formed in at least seven G20 countries to co-ordinate among key stakeholders such as finance ministries, public issuers and investors.[59] A working group has also been established to promote and develop Shari'ah-compliant financial products (including Green Sukuk) in Islamic jurisdictions to invest in climate change solutions.[60]

12.5.5 Supply-side policies

Public sector issuers have been given 'demonstration issuance' roles for green bonds, and have been a staple of the green bond market, issuing securities in line with their fiscal and debt management parameters. MDBs have been the pioneering and leading issuers, but by 2017, national development banks such as KfW, Export-Import Banks in Korea and

[59] Brazil, Canada, China, India, Mexico, Turkey and California.

[60] Green Sukuk and Working Party (GSWP) established by the MENA Clean Energy Business Council, the Climate Bonds Initiative, and the Gulf Bond and Sukuk Association (GBSA).

India, and export credit agencies in Canada and Sweden, were all active issuers, as well as municipalities and local funding authorities in five G20 countries. In 2015, Poland became the first sovereign green bond issuer, followed soon after by France. These public sector sources (i.e. SSA and municipal issuers) were responsible for almost half of green bond issuance in 2015. After introducing guidelines for socially responsible debt, Malaysia's state-owned sovereign wealth fund (Khazanah Nasional Berhad) issued Green Sukuk. The IFC is also starting to advise potential private green bond issuers in emerging markets on aligning with the GBPs.

As a type of specialist public financial institution, Hawaii's green investment bank capitalised itself through green bond issuance. Responding to the need to make private rooftop solar photovoltaic more accessible, Hawaii's Green Energy Market Securitization programme (GEMS) was designed in 2013 to increase the availability of financing. GEMS issued USD 150 million in green bonds to fully fund its initial capitalisation. The bond will be repaid using funds from an existing consumer surcharge on electrical bills. The GEMS 'green bonds' received an award (the 2014 International Financing Review North America Structured Finance Issue Award) in recognition of the innovation of using a rate-reduction bond structure to finance renewable energy infrastructure.

Governments have provided risk mitigation, credit enhancement and other public intervention in support of green bonds where they deem this support appropriate (see Chapter 13.4). The US government's development finance institution, OPIC, offers 'green guaranties'. One such guarantee is currently supporting a Chilean solar PV project, which when complete will be the largest such project in Latin America. At a regional level the EU/EIB Project Bond Credit Enhancement Initiative provided a credit enhancement for a green project bond backing an off-shore wind interconnector, which

also attracted investment from a Danish pension fund. The Greater Gabbard offshore transmission link thus became the first UK-based infrastructure project to attract finance from institutional investors using the Project Bond Credit Enhancement initiative.

Many governments exempt municipal bond issuances from tax. For example, the United States has a tax exemption for 80% of the USD 3.7 trillion municipal bond market, where bond interest and coupons can be tax-free at federal or state levels. In addition, the United States has offered special tax incentives for bonds financing green buildings as well as renewable energy through the Clean Renewable Energy Bond and Qualified Energy Conservation Bond programmes. Brazil allows tax-free bonds to be issued for large infrastructure investments, construction conglomerates and wind farm developers.

12.5.6 Assessing the effectiveness of policy measures

Assessing the effectiveness of policy measures to advance the green bond market is challenging. The scale of funds flowing through the channel is not a reliable measure of the incremental contribution of green bond-specific policies. Many other policies contribute to the flow, and many other channels also serve green investments.

Keys to evaluating policies for the green bond market may include cost-benefit analysis approaches including an examination of whether green bonds are lowering the cost of capital for green projects, and whether they lower the total social cost of matching investors with investments, thereby incrementally increasing the flow of funds to green investments. Given green infrastructure investments are capital intensive, even small changes in the weighted average cost of capital can significantly improve the levelised costs of green infrastructure compared with carbon-intensive alternatives, and can strengthen the fundamentals for increased deployment.

Policy will have to evolve and respond to a changing context. As the economy grows and changes, as new information and understanding of the climate change challenge develops, as international negotiations take new turns, all governments must adapt their policies accordingly. New green bond policies will be needed in the near future as well, as new types of projects become commercial and available for deployment at scale.

13. MOBILISING FLOWS OF INSTITUTIONAL INVESTMENT FOR SUSTAINABLE ENERGY

‘Stiffen the sinews, summon up the blood’

William Shakespeare (1599)

Henry V

(Act III, Scene i) ‘Once more unto the breach, dear friends’

13.1 **Introduction**

This chapter builds on the previous chapters, and particularly from the Chapter 8 review of institutional investment flows to sustainable energy that is occurring 'organically', where government sets an 'investment-grade' enabling environment and creates the demand for investment, but does not deploy a form of a risk mitigant or transaction enabler to mobilise institutional investors. Informed by the discussions in Chapter 10, this chapter includes an analysis of 33 case studies of institutional investment in sustainable energy where the public or official sector has worked to increase the supply of capital through deploying a risk mitigant or transaction enabler, to facilitate an investment in sustainable energy. The analysis leads to the introduction of a typology of risk mitigants and transaction enablers. A summary with implications for further research concludes.

Parts of the research in this chapter were first published in 2016 by the OECD under the title of: 'Progress report on approaches to mobilising institutional investment for green infrastructure' (Kaminker, 2016b) and provided as an official contribution to the 'Greening Institutional Investors' sub-group of the G20 Green Finance Study Group, co-chaired by the People's Bank of China and the Bank of England. Elements of the sections on green bonds draw on material published as an OECD book in 2017 'Mobilising Bond Markets for a Low-Carbon Transition' (Kaminker, 2017), and as 'A quantitative framework for analysing potential bond contributions in a low-carbon transition' (Kaminker, 2016a), which was launched in October 2016 at the 3rd OECD Green Investment Financing Forum in Tokyo. Some extracts from this work were included in the G20 Chinese Presidency Green Finance Synthesis Report (G20, 2016b).

13.2 Catalysing the supply of institutional capital: A stock-taking of approaches

In locations where sufficient preconditions are in place and other aspects of the enabling environment create demand-side circumstances in which investment demand is generated, investment by institutional investors in sustainable energy will be more likely to occur organically, or without intervention from government or the official sector. These types of organic institutional investment flows are the subject of Chapter 8, where they are described in detail. While some of investment figures and pledges described in that chapter may seem large on an absolute basis, they are still minute compared with the scale of institutional assets under management, and the scale of the investment demand and financing gap for green and sustainable infrastructure. Further, the individual allocations and pledge levels cited are largely exceptions to the rule that institutional investment in sustainable energy projects have been limited to a very small percentage of the portfolio.

The last five policy recommendations from Kaminker et al. (2015) focused on a further element of a strong domestic policy framework, creating the supply-side conditions for scaling up sustainable energy investment by institutional investors. These actions are centred on the establishment of specific policies, instruments, funds, risk mitigants and transaction enablers for mobilising institutional investment, as catalogues in detail in Chapter 10. There is an important role for governments in both reducing barriers to investment and supporting the development of investment channels, such as green bonds, funds and direct investment, which can hold the key to scaling-up institutional investment in sustainable energy. This chapter focuses on such types of 'catalysed' flows, the forms in which they come, and how they can be categorized.

13.3 Research Methodology

The categories of public sector actions considered in the report are informed by the empirical framework laid forth in Chapter 9, which used a base of 67 examples of institutional investment in sustainable energy (companies and projects) to develop a framework that classifies investments according to different types of financing instruments and investment funds, and highlights the risk mitigants' and 'transaction enablers' that governments along with public financial institutions can use to mobilise institutionally held capital.

The scope and data collected (in the 'stock-taking' research) covers sustainable energy sectors for which there are existing examples of and information on investment by institutional investors, where the public or official sector was present in the investment transaction (the 'deal') using some form of intervention to enable or facilitate these transactions and mobilise private financial capital. The specifications and format used for the stock-taking research are given below.

13.3.1 Attributes included in stock taking

Under each sector, examples of 'deals' were included in the form of micro case studies containing key information on the following attributes:

- Physical asset descriptor (e.g. Solar PV installation, [x] MW in [y] Location)
- Channel and financial structure (e.g. direct equity investment; [x] USD)
- Institutional investor (e.g. [name]; public pension fund)
- Stage of the project cycle where investor participated if appropriate (e.g. construction, operation, refinancing, multiple)

- Role and nature of public sector action (e.g. [public financial institution name]; credit enhancement)

13.4 Results of the stock-taking research

13.4.1 Financial geography of results

The research resulted in 33 case studies collected (shown in), which were then divided into eight categories of ‘green infrastructure’ assets in the database. Of the 33 examples, 24 fit within the definition of sustainable energy used in this thesis, however the research here was extended to also include 9 further examples focused on other types of green infrastructure. This was done for two reasons: 1) To better align the research as a contribution to the G20 Green Finance Study Group, which was interested in types of green infrastructure beyond just sustainable energy; and 2) to evaluate the applicability of techniques used for sustainable energy to other types of green infrastructure.

In total, the case studies included 67 examples of the use of risk mitigants and transaction enablers. Investments were logged in 17 countries. It is important here to note that the stock-taking done for this chapter was intended to be illustrative of the types of permutations possible in order to build a typology, and so in fact there are likely to be many more examples of a certain type of technique beyond the 33 deals gathered herein. For instance, there are many countries that provide a public reimbursement for a Feed in Tariff, and it is reasonable to assume that in some of those cases institutional investment will occur, however it was beyond the scope of this research to exhaustively document all such cases. G20 countries hosted the majority of investments observed including multiple deals in Australia, Canada, China, France, India, Italy, Mexico, South Africa, the UK, and the USA.

Examples of institutional investment outside of the G20 were also found, for instance in wind projects in Kenya and Uruguay, a water utility plant project in Peru, a geothermal project in the Philippines, a pan-Asian fund, a pan-African fund, and a fund targeting countries eligible for Official Development Assistance.

Table 13.1 Sectors covered in stock-taking

Sector and Sub-sector	Number of deals	Deal Names
Sustainable energy (power generation and storage) Technologies in sample include: Onshore and offshore wind, solar PV and concentrated PV, solar thermal, geothermal, small scale hydro, bioenergy, fuel cells.	18	GIB Offshore Wind Fund, Greencoat UK Wind, Lake Turkana Wind, Albion Community Power, Crescent Dunes Solar, Bloom Energy, Off Grid Electric Tanzania, Hawaii GEMS, Pampa Wind, ReNew Wind, Hindustan Solar, Tiwi MakBan Geothermal, Montalto di Castro Solar, NTR Wind Fund, Ararat Australia Wind, Cestas Solar, Seine Rive Gauche Wind, Gemini Wind
Green Enabling Infrastructure (Offshore wind interconnectors)	3	Greater Gabbard OFTO, Gwynt y Mor OFTO, Duddon Sands OFTO
Energy efficiency projects (in commercial and residential buildings)	3	Cheltenham Hospital, IDB Efficiency ABS, NY WHEEL
Low-carbon Mobility	2	Quebec Electric Rail, EV Charging China
Green Buildings	1	Hines Poland Fund
Agriculture & Forestry	1	AATIF
Water and Sanitation	1	Consorcio Agua Azul
Mixed Sustainable energy	4	GEEREF, Kommuninvest Aggregator, CT Green Bank C-PACE, Asia Climate Partners
Total	33	

Source: Author (Kaminker, 2016b)

13.4.2 Physical assets

Half of the deals (18) involved sustainable energy assets. Within the other half of the sample, six deals involved energy efficiency and sustainable energy enabling infrastructure such as off-shore wind interconnectors (three each) and two involved low-carbon mobility. Four deals featured multiple types of green infrastructure. As aforementioned, the stock-taking was not intended to be comprehensive and was limited to selected examples to provide a picture of the range of approaches used. Nevertheless,

a fairly thorough search of readily available public information was undertaken. The distribution of samples across the categories reflected the amount of identifiable (and publicly available) institutional investor activity in each sector, with very few examples to be found for some sectors.

For instance, in the green buildings, agriculture & forestry and water & sanitation sectors only one example could be identified per sector. While assessing and explaining the paucity of examples in certain sectors is beyond the scope of this research, the lack of data in itself is a finding which would be worthwhile to investigate in future research.

13.4.3 Public and official sector actors

The results of the research suggest that there are in fact many ways in which governments are already working to help mobilise institutional investment in sustainable energy and green infrastructure, using a variety of approaches. A range of public or official sector actors were involved across the case studies. Six deals featured more than one actor, with the Gemini Wind deal featuring four (EIB and three export credit agencies). Given the relatively recent establishment of public green investment banks (Eklin, Kaminker and Youngman, 2014; Eklin and Youngman, 2016), it is notable that five such institutions, located in three countries, were involved across one quarter (eight) of the deals (UK GIB, Australia CEFC, NY Green Bank, Connecticut Green Bank, Hawaii GEMS). Six multilateral development banks (ADB, AfDB, EBRD, EIB, IDB and IFC/WBG) were involved in 12 deals (36%).

A full third of the deals (11) featured actors related to seven sovereign governments and their ministries or agencies (Danish government; French Treasury; German Federal Ministry for Economic Cooperation and Development; Ireland Strategic Investment

Fund; Japan International Cooperation Agency; UK Department for Business, Innovation and Skills; and the US Department of the Treasury, Department of Energy, and Agency for International Development). Sub-sovereign governmental actors in Canada and the US were also involved in two deals (Government of Quebec and the Delaware Strategic Fund).

Seven public financial institutions (including national development banks, export credit agencies and a local funding agency) were involved in nine deals (27%). These included actors from six countries: Belgium, Canada, Denmark, Germany, India, Italy and Sweden (ONDD, EDC, EKF, KfW, IIFCL, SACE, and Kommuninvest). Two government-sponsored 'blended capital' funds made investments captured in the dataset (Danish Climate Investment Fund and the Africa Agriculture and Trade Investment Fund). The Green Climate Fund was involved with a deal as well, despite only recently becoming operational.

13.4.4 Institutional investors involved

Institutional investors were by definition involved in all of the case studies. As noted earlier, this research focused on deals that featured some type of public or official sector intervention that occurred alongside capital provision by pension funds, insurers and investment managers (that predominantly manage institutional capital), however private equity funds and other forms of investment vehicles that do not disclose what type of investors they have as Limited Partners (LPs) are beyond the scope of the research. Half of the deals featured 'undisclosed institutional investors', whose presence in the deal was mentioned publicly but the actors were not named. Total institutional capital committed across the 33 case studies is approximately USD 8 billion.

Pension funds were the most active type of institutional investor, with 17 different actors named out of a total of 27 institutional investors whose participation in the deals was disclosed publicly. Notably, five Canadian pension funds (AIMCo, CDPQ, PSP Investments, OPTrust and OTPP) were involved transactions domestically as well as in Australia, the UK and the US. Other institutional investors identified in the sample were from Australia (AMP), Denmark (PBU, PensionDanmark and PKA); France (Mirova); Germany (Allianz, Euler Hermes and KGAL); Japan (Nipponkoa Insurance); New Zealand (NZSuper); Sweden (AMF Pensionsförsäkring, AP3 and AP4); the UK (Aviva, Greater Manchester Pension Fund, Legal & General, LPFA, and Strathclyde Pension Fund); the US (CalSTRS, UN JSPF, and the Packard and Calvert foundations).

13.4.5 Towards a typology of risk mitigants

The 44 risk mitigants logged across the 33 deals include an array of targeted interventions generally aimed at reducing, re-assigning or re-apportioning different investment risks using a variety of mechanisms. As described in Chapter 9, by providing coverage for risks which are new and are not currently covered by financial actors, or are simply too costly for investors, risk-mitigating tools increase the attractiveness and acceptability of sustainable energy projects for institutional investors that are particularly risk-averse (e.g. pension funds). These are laid out in a typology and summary shown in Table 13.2.

Table 13.2 A typology and summary of risk mitigants deployed

Risk Mitigant	Short description of public or official sector intervention	Deal Example (Name)	Sector	Financing Channel	Actor that deployed risk mitigant	Institutional investor involved
Credit enhancement[17]	*A credit enhancement is any intervention that improves the chances that financing will be repaid. It is a form of public investment that results in a contingent liability.*					
Layered fund subordination	Taking a subordinated position in a fund to give priority to private investors with regard to claims on assets.	GIB Offshore Wind Fund	Sustainable energy	Intermediated unlisted project equity	UK Green Investment Bank	Strathclyde Pension Fund, undisclosed Sovereign Wealth Fund
		AATIF (Africa Agriculture and Trade Investment Fund)	Sustainable agriculture	Intermediated private equity fund	KfW & German Federal Ministry for Economic Cooperation and Development (BMZ)	Undisclosed institutional investors, Deutsche Bank
Partial credit guarantee	Guaranteeing payments for the principal and interest on debt issuance up to certain percentage.	Hindustan Solar	Sustainable energy	Listed project bond	IIFCL, ADB	Yes Bank and other institutional investors
		Energy Efficiency Securitization by the IABD	Energy efficiency	ABS	IADB	Undisclosed institutional investors
		Greater Gabbard offshore transmission link	Sustainable energy	Listed project bond	EIB, EC	Numerous undisclosed institutional investors
Loan guarantee	A legally binding agreement under which the guarantor agrees to pay any or the entire amount due on a loan instrument in the event of non-payment by the borrower.	Crescent Dunes Solar CSP	Sustainable energy	Direct investment in unlisted equity of a project developer	US Department of Energy	Public Sector Pension Investment Board (Canada) and Ontario Teachers' Pension Plan
Revenue guarantee	Guaranteeing certain cash flows for a project	Consorcio Agua Azul	Sustainable water	Direct investment in listed project bonds	Government of Peru	Undisclosed local pension funds
		Cestas Solar	Sustainable energy	Direct equity co-investment in asset	French Treasury	Mirova, KKB, ACofi, Omnes
Public Investment	*Any form of direct public investment or presence in any deal structure.*					
Cornerstone stake	An investment in an offering that occurs early in the investment process so as to increase chances of success and to play a demonstration role to attract other investors.	Lake Turkana wind farm	Sustainable energy	Intermediated unlisted equity investment in project	Danish government, DCIF (a government-owned fund)	DCIF, Danish pension funds
		Cheltenham General Hospital	Energy efficiency	intermediated unlisted equity investment in project	UK Green Investment Bank	Aviva Investors
		Hines Poland Sustainable Income Fund	Green buildings	Intermediated private equity fund	EBRD	Undisclosed "foreign institutional investor"
Blending	Strategic mixing of concessional, non-concessional and for profit financing to attract risk-capital	Albion Community Power	Sustainable energy	Direct investment in unlisted equity of a pure-play corporate	UK Green Investment Bank	The Greater Manchester Pension Fund, Strathclyde Pension Fund
Grant	Concessional funds allocation	Off grid electric Tanzania	Sustainable energy	Unlisted debt investment intermediated through a debt vehicle	U.S. Agency for International Development	The Packard Foundation, Ceniarth, Calvert Foundation.
Fund seeding	Public investment to help establish private equity funds that specialise in green projects.	GEEREF	Sustainable energy and energy efficiency	Equity: unlisted intermediated fund of funds	EIB	At least 8 private equity funds with institutional investor limited partners

Source: Author (Kaminker, 2016b)

Note: (4) Other forms of credit enhancement are possible but were not observed in this deal sample. These include for instance: Loan Loss Reserves and Insurance, Interest Rate Buy-downs and Debt Service Reserves.

Risk mitigants targeted at credit enhancement (an intervention that improves the chances that financing will be repaid) were deployed 23 times across the sample. The most common technique is the partial credit guarantee which accounted for over half (13) of credit enhancements. Otherwise, five instances of subordination, three revenue guarantees and two loan guarantees were observed.

Public investment as a form of risk mitigant was used 21 times, with cornerstone stakes being the most widespread (10). Cornerstone stakes are public investments made in a structure early in the investment process to increase chances of success and to play a demonstration role to attract other investors. These were followed by grants (six), the 'blending' of concessional and institutional capital to take (four), and one example of seeding fund with public capital.

13.4.6 Towards a typology of transaction enablers

As described in Chapter 10, transaction enablers facilitate institutional investment in sustainable energy projects by reducing the transaction costs associated with these investments, or creating new channels, and also mitigating risk in some cases. As most institutional investors have limited experience with direct investment in sustainable energy projects, the cost associated with identifying, executing and managing investments is often prohibitive.

Such transaction enablers were used 19 times in the sample. Warehousing (pooling small transactions) and securitisation (transforming illiquid assets into tradable securities) were the focus of six transactions. There were six further examples of co-investment and syndication by public actors alongside institutional investors. Public-private partnerships were used on four occasions, and three instances of public actors deploying conduit structures to leverage the capacity and capabilities of a larger or more specialised public institution to access normally unavailable channels. These are laid out in a typology and summary shown in Table 13.3.

Table 13.3 A typology and summary of transaction enablers deployed

Transaction Enabler Type	Short description	Deal Example (Name)	Sector	Financing channel	Actor that deployed the transaction enabler	Institutional investor involved
Securitisation	A technique whereby illiquid or small-scale assets are transformed into securitised products.	Energy efficiency securitisation in Mexico	Energy efficiency	Unlisted debt investment, intermediated	IDB	Numerous institutional investors
Warehousing, pooling	Bundle together smaller projects to get them to a commercial scale that is attractive for institutional investors.	Off Grid Electric	Sustainable energy	Unlisted debt investment, intermediated	Off Grid Electric set up a debt investment vehicle	The David and Lucile Packard Foundation and other family offices
		Greencoat UK Wind	Sustainable energy	Intermediated listed project equity	Greencoat UK Wind (a listed infrastructure fund)	Numerous institutional investors
Co-investment, joint-ventures, partnerships, consortiums and loan syndication	Institutional investors partner up with other investors to invest in an asset.	Ararat Australia Wind	Sustainable energy	Unlisted direct project debt financing (loan) project	Australia Clean Energy Finance Corporation	OPSEU Pension Trust
		NY WHEEL (Warehouse for Energy Efficiency Loans)	Energy efficiency	Direct unlisted debt investment in project company structure	NY Green Bank	Undisclosed Institutional Investors, Citigroup
Co-operation and collaboration	Informal sharing of knowledge and resources between actors.	Electric public transport system in Québec	Low-carbon mobility	Unlisted equity investment	LISEA (a concession company created for this project), EIB	Caisse de dépôt et placement du Québec
Conduit aggregation	Leveraging a larger or more specialised public institution to access normally unavailable channels	Kommuninvest aggregator	Mixed green finance	Intermediated, listed SSA green bond	Kommuninvest (Swedish Local Funding Authority)	Ap3, AP4, CalSTRS, UN Joint Staff Pension Fund
		CT Green Bank C-PACE	Sustainable energy	Intermediated, unlisted non-rated pooled project bonds	Connecticut Green Bank	Undisclosed institutional investors

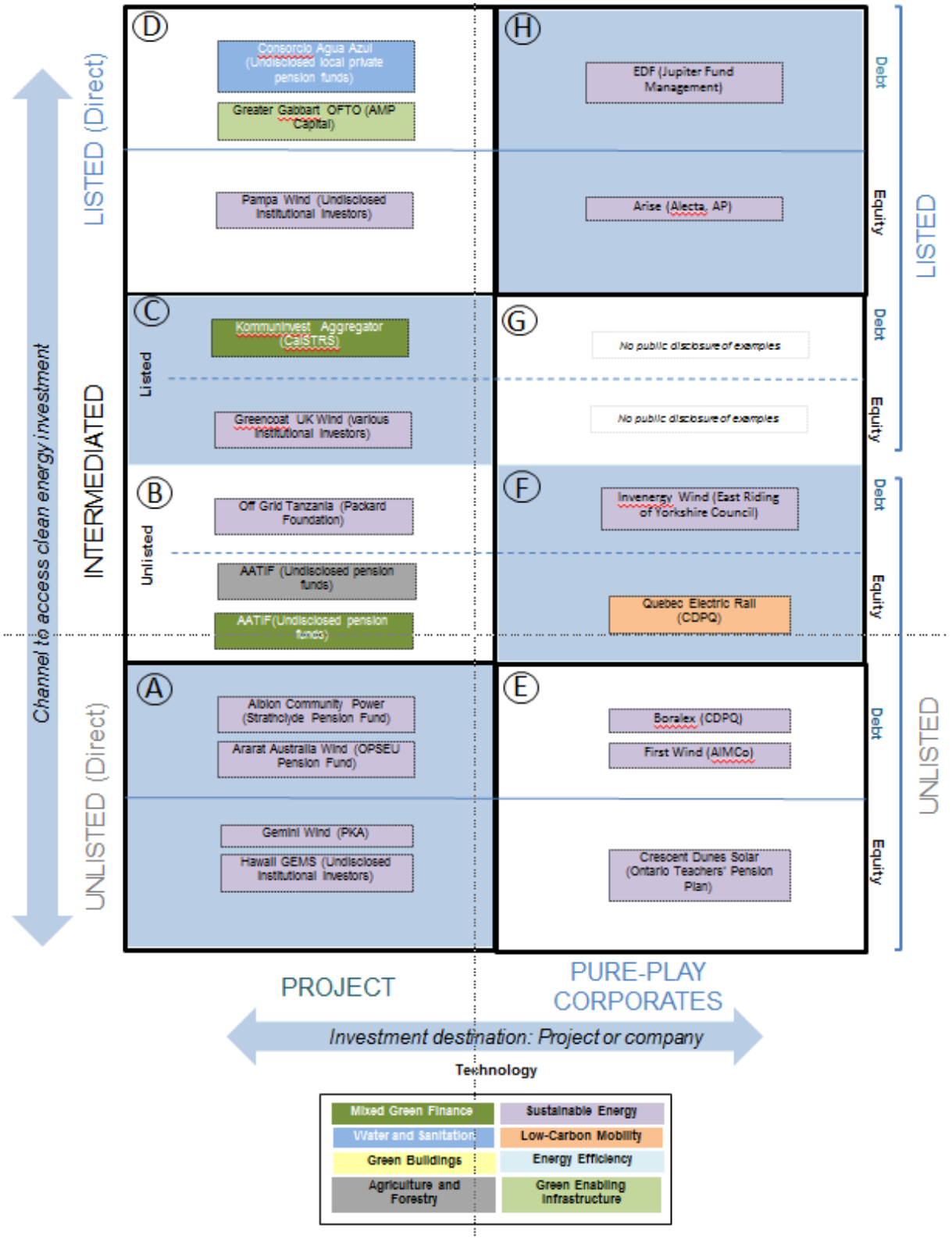
Source: Author (Kaminker, 2016b)

Nearly a third of the 33 deals made use of a risk mitigant as well as a transaction enabler. For example, the Africa Agriculture and Trade Investment Fund involved three risk mitigants including a credit enhancement (subordination) and two public investments (a cornerstone stake and blending), alongside a partnership transaction enabler. On the other hand, CT Green Bank C-PACE featured one risk mitigant (subordination), and four transaction enablers (pooling, warehousing, securitisation and conduit). The Gemini Wind transaction was notable again for its usage of three different partial credit guarantees, as well as subordination and co-investment techniques.

13.4.7 Plotting the stock-taking research examples on a ‘Matrix Frame’ for visualising channels

As shown in Chapter 9, a variety of investment channels are potentially available to institutional investors for accessing sustainable energy, and different channels may be more appropriate when taking into account certain decisions that are routinely made. For example, large institutional investors evaluate prospective investments based on decisions to make the investment directly (‘in-house‘) or to create a contract with an intermediary (‘out-source‘) to make the investment on their behalf. Channels can provide exposure to listed or unlisted debt or equity, a single project asset or company or can bundle multiple smaller-scale projects together.

Figure 13.1 Plotting the stock-taking research examples on a 'Matrix Frame' for visualising channels



Source: Author (Kaminker, 2016b)

As shown in Figure 13.1, in terms of the investment channel used on the equity side (accounting for half of the deals), the most frequent routes to access sustainable energy by institutional investors were unlisted investments in projects made via intermediated funds (8 deals or 25% of the sample), followed by unlisted investments made directly in projects (4 deals, or 13%). There were also two examples each of unlisted direct investments in corporates and listed, intermediated investments in projects.

On the debt side, by far the most frequent channel used a project bond structure, accounting for 41% (13) of all deals. There were 10 examples (31% of the sample) of direct investment in a listed project bond structure, and a further three investments in listed project bonds. Of the project bonds, three quarters benefited from credit enhancement techniques; with 60% (8) credit enhanced through some form of partial credit guarantee. Finally, there were two other examples of debt financing (not in the form of a bond) included in the sample; a subordinated loan as part of the Gemini wind transaction, and an unlisted debt fund.

Interestingly, the majority of case studies in the sample focused on construction stage project investment. This may indicate the importance of public intervention particularly at the construction stage which is riskier. The stage of project development at which investment occurred in the sample diverged significantly from the 'organic' demand side driven institutional investment discussed in Chapter 7, where the clear majority of investment was centred on operational assets.

13.5 Towards a quantitative framework for analysing potential bond contributions in a low-carbon transition

As established in previous chapters, debt currently finances the majority of infrastructure investment. In particular, bond finance is a natural fit for low-carbon and climate-resilient infrastructure assets such as renewable energy infrastructure, which is characterised by high upfront capital costs and long-dated and frequently inflation-linked income streams.

An analysis conducted on behalf of the G20 Green Finance Study Group (Kaminker, 2016a) proposes a quantitative framework for understanding possible directions of bond market evolution and for analysing the potential contribution that the bond markets can make to a low-carbon transition, while mobilising institutional investors. The analysis contains the first quantifications of debt financing, and bond financing in particular, to meet the 2C energy investment scenarios (2DS) set forth by the IEA. While this section summarises the results, the full analysis can be referred to for details, discussion and methodology.

The analysis studies: 1) how much debt finance is needed to meet the IEA's 2oC energy investment scenarios (2DS) between 2015 and 2035 in the four markets studied (the People's Republic of China, the European Union, Japan and the United States); 2) how the bond market might evolve in the same period to account for part of these debt finance needs; and 3) the implications for institutional investors that have driven the growth of the green bond market to date.

The IEA has estimated investment needs in the renewable energy, energy efficiency and LEV sectors to 2035, consistent with an expectation that countries will take policy actions leading to a 2C emissions pathway or scenario ('a 2DS'). Building on these

investment scenarios, this work applies assumptions based on current trends in regional financial markets to synthetically break down the aggregated investment needs by source of finance and type of financial instrument. The analysis converts investments into their constituent equity and debt components. Focusing on debt, the analysis considers the role that the bond markets can play to finance this investment.

13.5.1 High-level results in context

Investment needs over the two decades are considered for renewable energy, the energy efficiency portion of building investments, and low-emission vehicles (LEVs).[61] These three sectors accounted for 75% of outstanding labelled green bonds as of June 2015. For purposes of simplicity, the analysis refers to bonds issued in the renewable energy, energy efficiency and LEV sectors as "low-carbon bonds", and does not speculate on what portion will be labelled green in 2035.[62]

Other segments of labelled green bond and unlabelled climate bond markets relate to low-carbon public transportation, climate adaptation, clean water, waste management, agriculture, land remediation, industrial gas treatment and other key areas of environmentally-related investment. These sectors are beyond the scope of this analysis but are clearly important areas of green finance where the bond markets can (and do) play a significant role. As perspective, in China approximately 40% of "green investment" needs will be for low-carbon projects (including public transport) in the period 2014-2020, with the other 60% being needed in these other sectors such as water (supply,

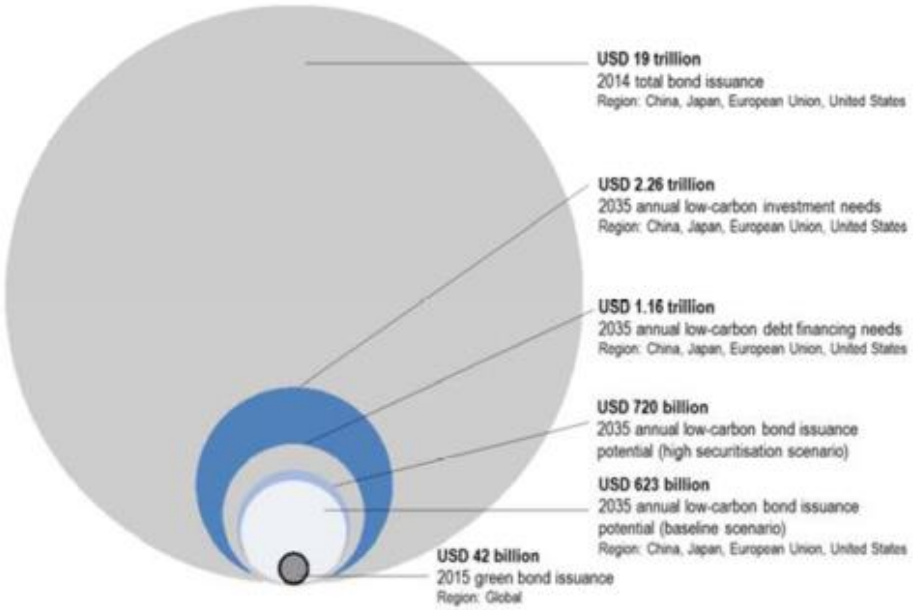
[61] LEV includes hybrid vehicles, plug-in and electric vehicles and fuel-cell vehicles.

[62] In practice as of 2015, 11% of the wider 'climate-aligned' bond market is explicitly labelled as green, and although the green labelled segment has been growing, reaching a conclusion as to the proportion of green labelling in 2035 is beyond the scope of this work.

savings and remediation), waste treatment, sewage, land remediation and industrial gas treatment (PBOC, 2016).

The analysis covers debt securities markets in China, the EU, Japan and the US, which represent almost 70% of the global annual investment needs projected for the next five years. These markets currently have significantly more established debt securities markets than other regions, and are the largest globally, accounting for around 75% of the global debt securities markets valued at 97 trillion in 2014. Debt securities outstanding from all sectors amounted to USD 39 trillion in the US, USD 21 trillion in the EU, USD 9.7 trillion in Japan and USD 4.3 trillion in China. New gross issuance in 2014 amounted to USD 19 trillion in these markets.

Figure 13.2 Scenario results to 2035 compared with low-carbon investment needs and new debt securities issuance (Annual)



Source: Kaminker (2017) citing OECD analysis based on IEA (2014; 2012) Climate Bonds Initiative, BIS, SIFMA, ECB, JSRI, ADB and Goldman Sachs data.

Note: OECD modelling scenarios and annual 'low-carbon' investment needs in the figure cover the renewable energy, energy efficiency and low-emissions vehicle sectors as estimated by the IEA (2014, 2012). The 2015 green bond issuance figure of USD 42 billion is provided as a

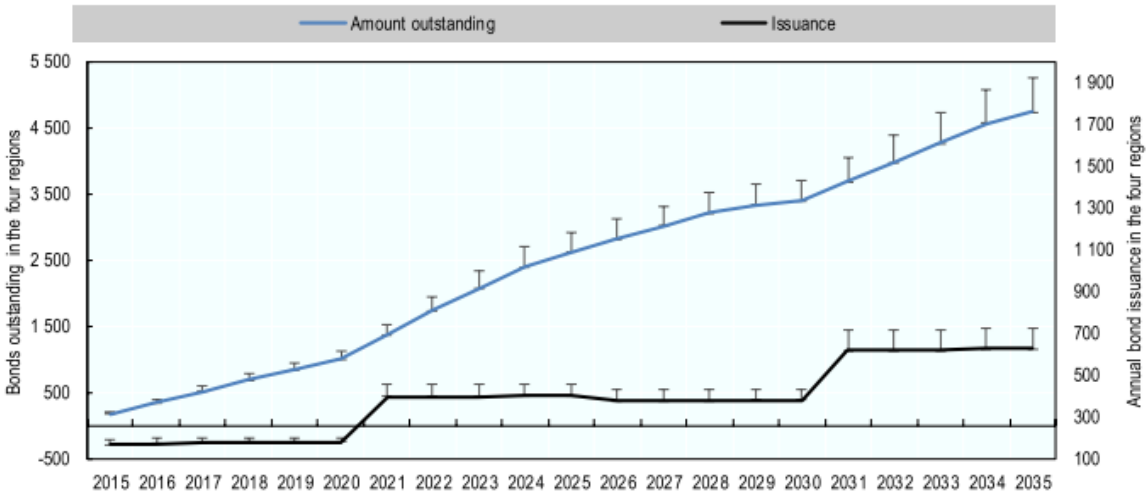
reference point and extends to all sectors included in Climate Bonds Initiative database. No judgement is made as to the percentage of bonds from these 'low-carbon' sectors that will be labelled as 'green bonds'. Annual total bond issuance is provided as an illustration and just as with green bond issuance, reflects 'gross issuance' figures, i.e. does not account for those securities that reach maturity or are redeemed from previous years (termed 'net issuance'). It includes other types of debt securities such as notes and money market instruments.

Debt (lending) and bond financing needs are estimated to continue to grow significantly in capital expenditure terms, while decreasing somewhat as a proportion of investment. Debt is seen as covering 60% of total investment needs between 2015 and 2025, while this ratio decreases steadily to 52% in 2035. The mix of financing types ranges significantly across the types of assets. For renewables, the debt to equity ratio remains about level at 75%.

Current financing and purchasing trends show that a significant proportion of energy efficiency and LEV investment is done through consumer finance or equity. Assuming that this continues to be the case, and given the increasingly large size of LEV and energy efficiency investment needs relative to renewables over the period, equity and self (cash) finance are estimated to continue to make a large and growing contribution to financing low-carbon energy investment.

The role of bonds in financing investment depends on the maturity of the technology, the characteristics of the projects including the scale at project level, as well as the type of investor. The results of the analysis suggest that by 2035 in a 2DS, bonds for low-carbon energy investments have the potential to scale to as much as USD 4.7-5.6 trillion in outstanding securities globally and USD 620-720 billion in annual issuance in the markets studied. While these figures may seem large on an absolute basis, they are small (approximately 4%) relative to the scale of issuance in debt securities markets generally.

Figure 13.3 Potential for low-carbon bond issuance ranges between USD 620 billion and USD 720 billion per year by 2035 (USD billion)



Source: Kaminker (2017)

Note: Error bars represent the enhanced securitisation scenario, based on a 10% increase in asset securitisation rate across all sectors over the baseline scenario, which incorporates a more conservative asset securitisation assumption. 'Outstanding' refers to cumulative amount of bonds issued that have not yet reached redemption or maturity.

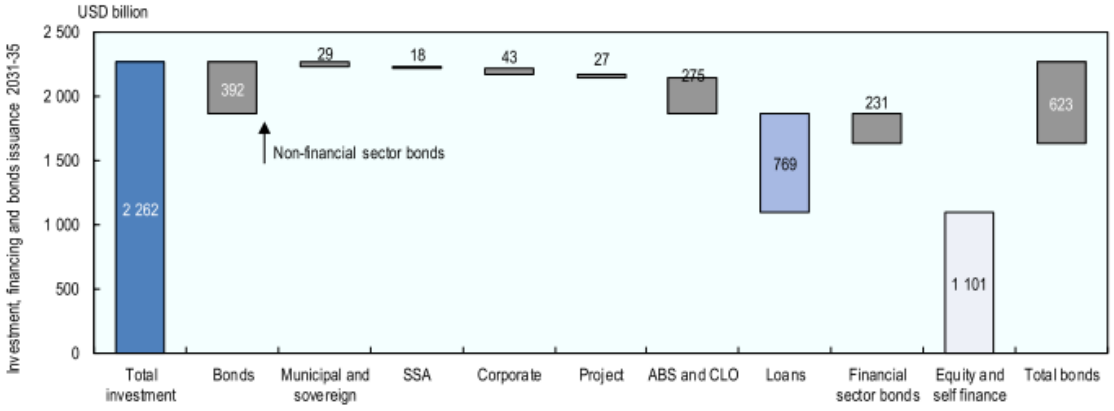
The analysis suggests that the 2020s have the potential to be the beginning of the 'golden years' for bond issuance in the low-carbon sectors. As low-carbon technologies mature, they become more familiar to bond markets which can become substantial contributors to the financing and re-financing of new-build assets. As the costs of assets fall and as policy stabilises, the role played by bonds could expand rapidly. The analysis examines the potential for different types of bond to finance a range of sectors and sub-sectors of low-carbon investments studied; displaying a picture of the volume of outstanding securities through to 2035 and the speed at which they could potentially scale up.

13.5.2 Results by type of bond

Revitalising the concept of securitisation, which was tarnished during the 2007-2008 financial crisis is important to the scaling up of low-carbon infrastructure finance and has emerged as a key area of focus for policy makers generally. This revitalisation may be achieved in large measure by standardising the assets and by making the process, and the market activity it spurs, safer, simpler and more transparent.

Accordingly, a need to activate and scale up issuance of asset-backed securities (ABS) is identified, with solar PV and leases of LEVs being seen as a particularly suitable target; as demonstrated by ABS issued in 2014-2016 from these sectors (e.g. SolarCity and Toyota).

Figure 13.4 Financing in 2035 by type of capital and bond (baseline scenario)



Source: Kaminker (2017)

Notes: SSA: supranational, sub-sovereign and agency; ABS: asset-backed securities; CLO: collateralised loan obligation. Bonds are coloured in grey and financial sector bonds appear after loans to reflect issuance that finances on-lending via banks.

By 2035 in the baseline scenario, almost a third of outstanding bonds from the low-carbon sectors studied could be in the form of ABS. Conservative assumptions used for these scenarios based on the literature available in 2015 suggest there is potential to

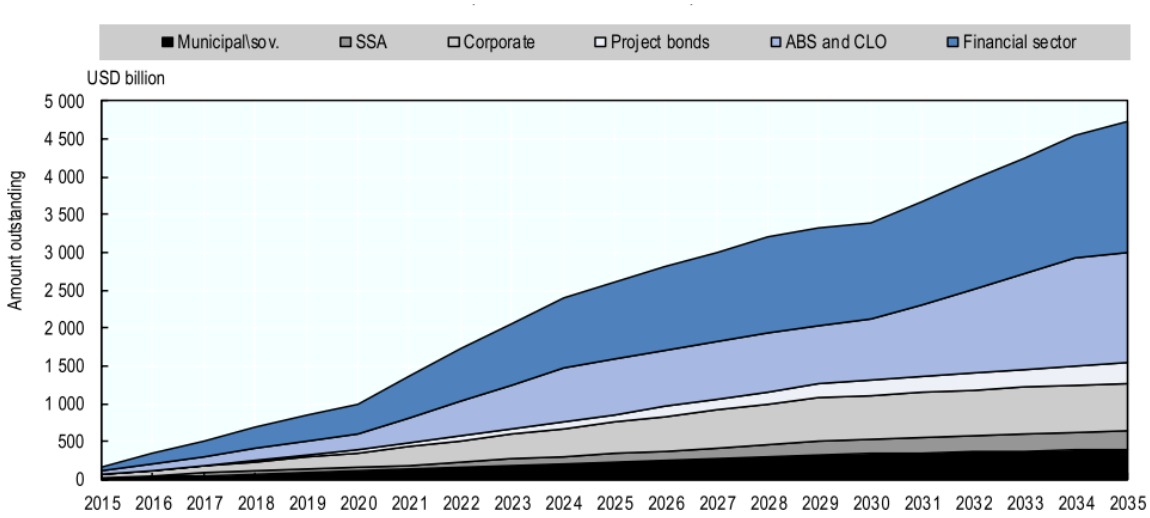
‘surprise to the upside’ based on observed market activity in 2015-16 beginning to diverge significantly from forecasts (e.g. in LEV sales and solar PV deployment).

ABS have a disproportionately large potential to scale since they are less likely to be constrained by government fiscal and budgetary constraints in the case of government (i.e. municipal) bonds, and by balance sheet constraints in the case of corporate and Sovereign, Supranational and Agency (SSA) bonds seen as accounting for USD 240 billion and 640 billion (8% and 14%) of bonds outstanding in 2035. Efforts to support green securitisation must be undertaken in a prudent, judicious and transparent manner so that green ABS markets emerge with integrity and with due consideration for any financial stability issues.

The results also reveal the prominent role loans play in financing low-carbon investment needs to 2035. Financial institutions are expected to continue to be the largest provider of loans to all three sectors given their specific expertise in the arranging of credit for the earlier stages of infrastructure development project cycle through to project operation, at which point other sources of debt capital including bond markets can be called on to re-finance the debt. While financial institutions have a major role to play in arranging the debt financing for low-carbon infrastructure through loans and through underwriting and investing in bonds, they notably also can act as issuers of ‘financial sector’ bonds to raise capital AND fund their lending activities.

Financial institutions are expected to continue to use bond markets to raise capital to finance their low-carbon related lending, which can lead to financial sector issuance of bonds that finance this on- balance sheet lending (e.g. ABN AMRO’s 2015 EUR 500 million green bond). This segment of the market has the potential to add up to USD 1 trillion to the total bonds outstanding in 2025 and over USD 1.7 trillion in 2035.

Figure 13.5 Asset-backed and financial sector bonds have the largest potential to scale up (baseline scenario)



Source: Kaminker (2017)

Notes: SSA: supranational, sub-sovereign and agency; ABS = asset-backed security; CLO = collateralised loan obligation. The figure depicts the base case 'low-securitisation scenario'. Bonds in the People's Republic of China, Japan, the EU and the United States.

13.5.3 Results by geography

The scenarios highlight geographical variations and some similarities. For instance, financial sector issuance potential is seen as strong in all four markets accounting for the largest low-carbon bond sector in China, the EU and Japan.

In the US, a higher share of ABS is possible than in other markets in 2035 representing the largest share followed closely by financial sector bonds. This is due to the higher level of maturity of the financial markets in general and securitisation markets in particular. US utilities are among the most active users of bond finance, and are reflected as such in this analysis. Over time it is assumed that a portion of corporate borrowing by US utilities will be substituted by project bonds and ABS. US municipal authorities are also prominent issuers in bond markets to finance their infrastructure-related expenditure and this is expected to continue.

In the EU, ABS have the potential to be the second largest bond type, with the financial sector playing a more prominent role than in the US. ABS could accumulate a large market share but may cede some of this share over time to corporate and project bonds. The increase in project bonds reflects the Europe 2020 Project Bond Initiative which is targeted at increasing reliance on bond financing at the project level. Corporate bond issuance is likely to be significant given the active role European utilities have played in the EU corporate bond market. There could also be strong involvement of governments in raising funds through the bond market to implement energy efficiency and renewable energy programmes. Many options are possible in Europe and much will depend on the direction policy takes and the strength of corporate utility balance sheets, which have deteriorated in recent years.

In Japan, overall the assumptions drawn from the literature and used to examine the Japanese market's potential result in a low degree of securitisation and bond issuance in Japan. Investment needs for a 2DS in general are lower compared with the other three markets and bond issuance as a percentage of investment needs is also lower. In 2015-2016, a market for low-carbon project bonds emerged in Japan, and this is expected to continue to grow.

In China, corporate and project bonds may take the greater share while ABS expands alongside a maturing debt capital market. China has been largely successful in creating a market for infrastructure bonds. The prospect of participation by financial and corporate entities in China was realised in early 2016 following the release of guidance, regulations and requirements for green bond issuance by the People's Bank of China. As of April 2016, green bond issuance in China had already reached USD 5.3 billion, with

forecasts for annual issuance surpassing USD 46 billion in 2016; a figure already close to that shown in the scenario for 2020 of around USD 52 billion in annual issuance potential.

The current policy push to reduce reliance on the banking sector in China could hasten the development of an ABS market and bond markets in general. Sub-sovereign development banks working in conjunction with policy banks, are seen as having the potential to play a pivotal role in the early development of a low-carbon bond market in China.

13.6 Implications for institutional investor asset allocation

As shown in the previous section, bond finance has the potential to play a significant role in mobilising additional institutional investors to support the low-carbon investment necessary to meet a 2DS by mid-century. However, bond issuance must occur at a scale, and in a format, that such investors are able to absorb. Other sources of potential bond demand exist, such as retail investors, banks and corporations. As institutional investor demand has driven the growth of the market to date, it is assumed that this condition would have to endure in order for much higher levels of issuance to be reached (see Chapter 14 for a discussion, barriers and policy options for mobilising institutional investors).

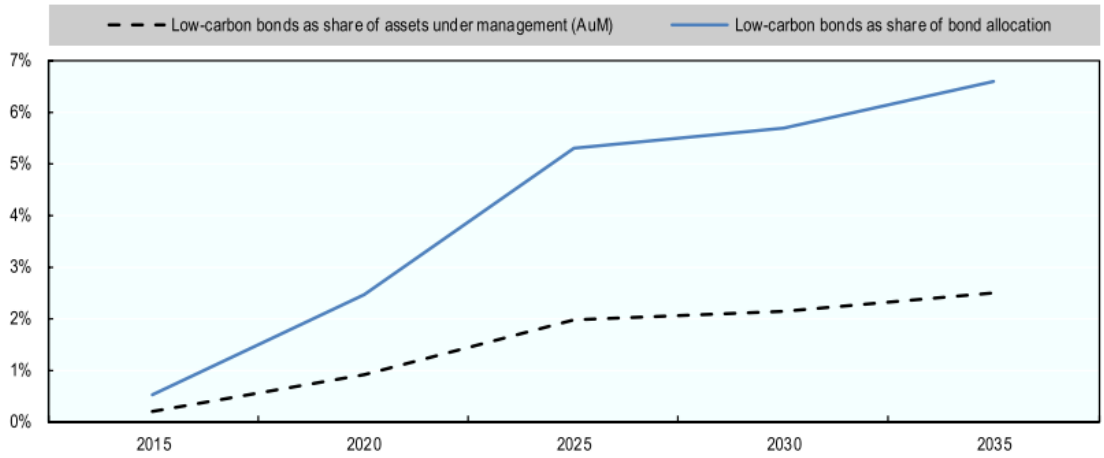
Analysis conducted in (Kaminker, 2016a) uses data and projections on institutional investor assets under management (AuM) to 2035 to assess the potential scale of low-carbon bonds outstanding, relative to total AuM and bond holdings of the three main types of institutional investors, namely pension funds, insurance companies and investment funds.

The results suggest that institutional investors in the OECD have the potential to absorb the increased supply of bonds, through shifting asset allocations in response to the increased percentage of low-carbon bonds as a share of the broader bond markets. This conclusion is based on two assumptions: 1) institutional investors have driven the green bond market growth to date and have shown appetite for low-carbon bonds more generally – this may be expected to grow in light of increasing attention on climate risks and opportunities in investment portfolios; and 2) as institutional investors tend to adopt and reflect broader market trends (given their share of the market), it is reasonable to conclude that they will shift allocations to reflect the increasing share of low-carbon bonds in the market as a whole.

Institutional AuM is projected to grow to over USD 120 trillion in 2019 (OECD, 2015b). Using a projection based on average growth rates adjusted for inflation, institutional AuM could be seen to grow to over USD 190 trillion by 2035. Weighted average allocation to bonds varies significantly by type of investor, with insurance companies allocating 50% to bonds, investment funds 36% and pension funds 24%.

As shown in Figure 13.6 institutional investors would need to allocate between 2.5% of assets in the base case and 2.8% in a high securitisation scenario to absorb the bond supply covered in this analysis in 2035. Correspondingly, within the fixed income bond allocations of institutional investors, these low-carbon bonds would account for 6.6-7.3%. The analysis suggests that as these asset categories develop and mature as a share of the broader market, allocations could plateau in the late 2020s.

Figure 13.6 OECD institutional investor asset allocation to low-carbon bonds as modelled under the base case scenario



Source: (Kaminker, 2016a), asset allocation statistics drawn from OECD Institutional Investor Database.

The OECD has started to collect data on green bond investments and allocations in its annual Large Pension Fund Survey (OECD, 2016b). As context, a noteworthy trend amongst the funds that reported green investments was a general increase in the number of pension funds that invest in green bonds, and also in the relative size of their allocations.

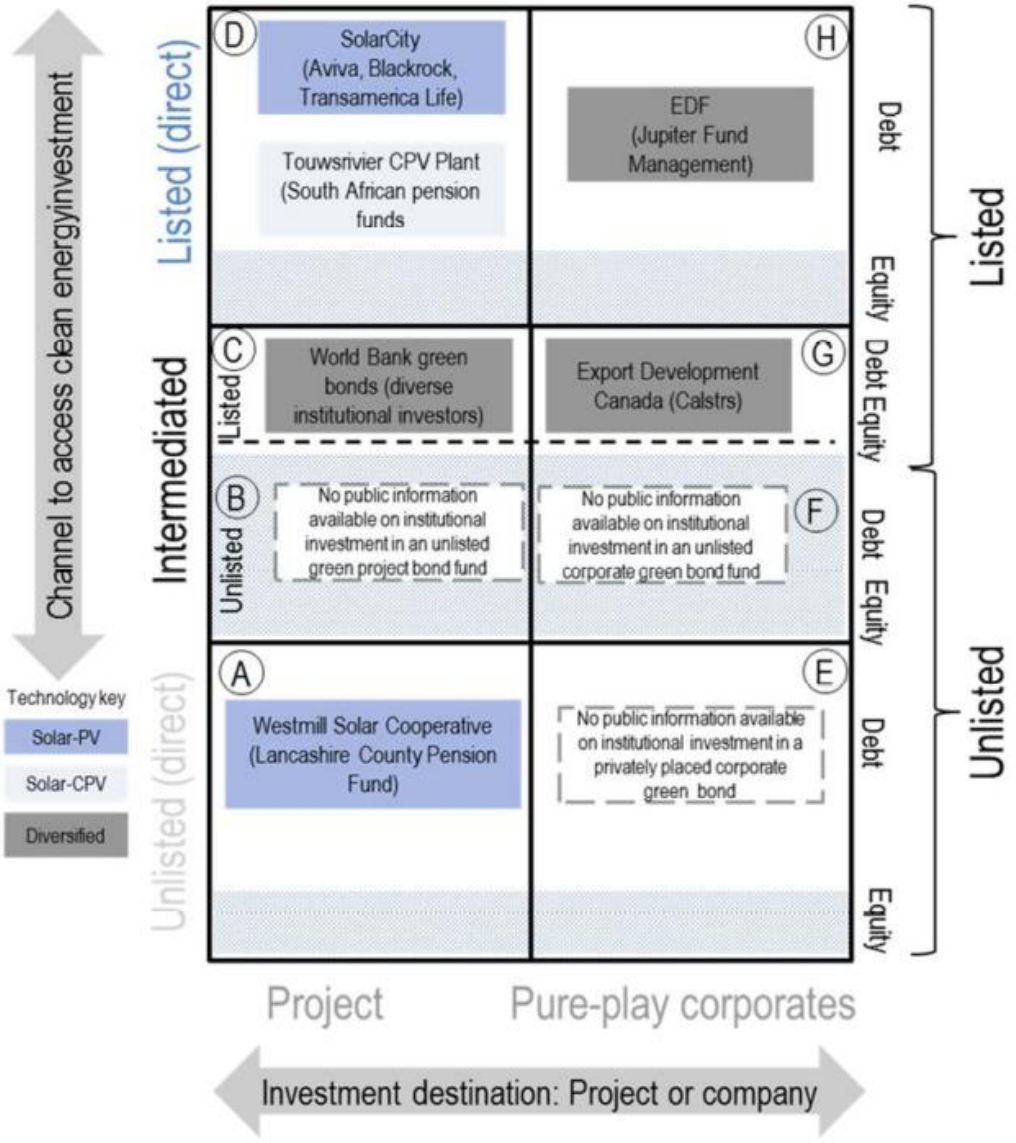
Four funds based in Sweden (Alecta, AP2, AP3 and AP4) all increased allocations to green bonds in 2014. Santander, based in Spain, reported green bond exposure for the first time in 2015, amounting to 1.1% of the total portfolio. AP2 and AP3 allocated 1.1% and 1.3% of their portfolios to green bonds, respectively. Note that these allocation figures can be assumed to underrepresent the exposure of these pension funds to the type of bonds discussed in this analysis, as they are allocations to labelled green bonds, and not to other 'low-carbon' bonds that could be eligible for a green label.

13.7 **Mapping channels for institutional investment in green bonds**

Green bonds, including the low-carbon bonds examined in this chapter, appeal to institutional investors for a number of reasons as discussed in Chapter 11. They also offer the option to access low-carbon investments across a wide variety of channels and asset allocations. Chapter 9 introduced a 'matrix frame' (updated and configured to show green bonds in Figure 13.7), which visualises a range of channels (boxes A-H) that represent typical choices institutional investors need to make when allocating capital to low-carbon investments. Institutional investors consider equity and debt opportunities through a series of lenses (composed of basic investment characteristics).

A first choice is whether the exposure desired is to projects, corporates or both. Institutional investors can make green bond investments directly ('in-house') if they have the capability to do so, or they can outsource these investments via an 'intermediated' channel such as a fund. Investments can be made on a listed or unlisted basis. Green bonds can theoretically be classified into each of these; in practice, however, a lack of publicly available information leads to certain channels appearing unoccupied in the figure (e.g. while institutional investors anecdotally invest in privately placed corporate bonds, no public record is currently available).

Figure 13.7 A 'matrix frame' to map channels for institutional investment in green bonds



Source: Author, analysis based on methodology laid out in Chapter 9

Notes: Coloured boxes are examples of green bond investments by selected institutional investors (named in brackets where information is publicly available – bonds will have more than these listed investors). Annex 3.A4 gives details on the bonds. Colours represent technologies. Although not shown here, diversified corporates can also issue a green bond where the proceeds are reserved for 'green projects or activities. 'Pure-play' refers to entities focused on only one industry or product, e.g. a solar PV company.

13.8 Annotated key for providing detail of transactions and logic for classification

This section details the logic underpinning the categorisations and provides descriptive examples for why deals were classified into each section of the Matrix Frame.

Direct unlisted investments in projects

Direct unlisted project debt

The Westmill Solar Cooperative refinanced its 5 MW Watchfield solar PV plant in Oxfordshire with a GBP 12 million bond privately placed with UK Lancashire County Pension Fund.

Intermediated unlisted investments in projects

Intermediated unlisted project debt

No public information available regarding institutional investment in an unlisted green project bond fund. Intermediated listed project investment Intermediated listed project debt The Nordic Investment Bank (NIB) issued a five-year SEK 1 billion NIB Environment Bond (NEB), the third and largest Swedish krona-denominated bond at the time of issuance in April 2015 (Nordic Investment Bank, 2015). Swedish pension fund Storebrand and Danish pension fund PKA invested in the issuance (Nordic Investment Bank, 2015).

The African Development Bank issued a five-year SEK 1 billion fixed-rate green bond in March 2014. The transaction was placed with 16 investors including AP2, AP3, Landstinget Västmanland, SAAB Pensionsstiftelse, SEB Fonder, SPP/Storebrand, Svenska Kyrkan and Systembolaget AB (AfDB, 2014). The Asian Development Bank

(ADB) raised USD 500 million in its inaugural green bond issuance in March 2015. The ten-year 2.2% coupon bonds will fund ADB projects that promote low-carbon and climate-resilient development in Asia (ADB, 2015). The bonds were sold to 44 investors including: AP2, AP3, AP4, Baloise Insurance, Banque Syz & Co SA, Blackrock, Calvert Investments, Donner & Reuschel Asset Management, Mirova, Nikko Asset Management Europe Ltd, Nippon Life Insurance Company, Omega Global Investors on behalf of Local Government Super, Praxis Intermediate Income Fund, SEB Wealth, State Street Global Advisors, and TIAA-CREF (ADB, 2015).

Bank of America Corporation issued a three-year, fixed-rate USD 500 million green bond in November 2013. Proceeds will be used to finance green investments such as renewable energy and energy efficiency projects. Bank of America viewed this issuance as an opportunity to expand its investor base and participating investors include the following: AP4, BlackRock, Breckinridge Capital Advisors, California State Teachers' Retirement System, Calvert Investment Management, Pax World Management LLC, Praxis Intermediate Income Fund, State Street Global Advisors, Standish Mellon Asset Management Company LLC, TIAA-CREF, Trillium Asset Management, LLC (Bank of America, 2013).

The World Bank issued a EUR 30 million 30-year fixed rate green bond in February 2015 to fund projects that meet low-carbon and climate-resilient criteria (World Bank, 2015). The World Bank issued the bond in response to demand for longer maturities from Zurich Insurance Group and as a 30-year bond it is the longest maturity fixed-rate green bond issued by the World Bank to date (World Bank, 2015).

In 2010, Nikko Asset Management launched two green bond funds, one targeted at Japanese investors and another for international investors, that would invest 100% of its

portfolio in World Bank-issued green bonds in 2010 (World Bank, 2010a). The World Bank issued ten new green bonds for the fund launch denominated in ten different currencies including Australian dollars, Colombian pesos, Russian roubles, Turkish lira and South African rand (World Bank, 2010b). In the two years after the fund launch, Nikko Investment Management raised more than USD 500 million from Japanese retail investors and USD 40 million from European and US institutional investors. Notable investors include Silicon Valley Community Foundation and Truestone Impact Investment Management (World Bank, 2012).

A diverse pool of institutional investors has purchased green bonds issued by the World Bank to fund diverse projects that support climate change adaptation or mitigation. Since 2008, the World Bank has issued approximately USD 4 billion in green bonds (World Bank, 2013). Notable pension fund investors include Sweden's AP Fonden 2 and AP Fonden 3, CalSTRS, New York Common Retirement Fund, and the UN Joint Staff Pension Fund (World Bank, 2013).

The World Bank issued its first AUD-denominated Kangaroo Bond in 2014. Australian superannuation fund UniSuper was the cornerstone investor for the issuance, purchasing AUD 100 million of the total AUD 300 million offering (Fernyhough, 2014).

Direct (in-house) listed project investments

A listed green project bond can provide financing for a single project, a portfolio of similar or standardised projects (such as wind farms or rooftop solar panel installations), or a portfolio of diverse sustainable energy infrastructure projects.

Solar Star Funding, LLC, a wholly-owned subsidiary of MidAmerican Energy Holdings Co., issued a USD 1 billion project bond in 2013 linked to the 580 MW Solar

Star PV project which at the time of the issuance was the largest renewable project bond ever issued (BNEF, 2014). US pension fund CalSTRS invested in the issuance (CalSTRS, 2014).

SolarCity issued a 4.80% USD 54.4 million solar-backed asset-backed security in November 2013. The underlying assets are 44 MW of solar PV across 5 033 projects in the United States, 71% residential (BNEF, 2014). Investors in the issuance included Aviva, Blackrock, Angel Oak Capital Advisors, Transamerica Life, and Accordia Life and Ann (BNEF, 2014).

Toyota Financial Services, the financial services arm of the Japanese automaker Toyota, issued a USD 1.75 billion green bond in March 2014. The bond was the first auto industry asset-backed (ABS) green bond. Proceeds will be used to fund new retail finance contracts and lease contracts for Toyota and Lexus vehicles that meet specific green criteria related to emissions and fuels efficiency (Toyota Financial Services, 2014). The green bonds are a standard auto loan-backed ABS where cash flow is linked to repayments of outstanding loans for the company's cars. Asset managers and pension funds investing in the issuance included TIAA-CREF, Vanguard Group, Northern Trust, SEI Investments and CalSTRS (BNEF, 2014; CalSTRS 2014).

The Soitec project bond was issued to finance the Touwsrivier solar power plant using concentrated photovoltaic technology. The South African bond was issued in local currency and attracted a diverse pool of investors, including South African pension funds and asset managers (Soitec, 2013).

A publically listed solar project finance bond was issued by Solar Power Generation Ltd to fund two 5 MW solar PV plants in England. The UK Pension Insurance

Corporation purchased the entire GBP 40 million offering (Pension Insurance Corporation, 2012).

Direct unlisted investments in pure-play corporates

Direct unlisted (private) corporate debt

No public information available on institutional investment in a privately placed corporate green bond. Intermediated unlisted pure-play corporate investment Intermediated unlisted debt provision for pure-play companies No public information available regarding institutional investment in an unlisted corporate green bond fund. Intermediated listed pure-play corporate investment

Listed pure-play corporate debt Export Development Canada issued its inaugural USD 300 million green bond in 2014, and its second USD 300 million green bond in 2015, to fund loans to companies active in preservation, protection or remediation of air, water and/or soil; creation of renewable energy; and mitigation of climate change (EDC, 2014; 2015). Californian pension fund CalSTRS invested in the issuance (CalSTRS, 2014; 2016).

Direct (in-house) listed corporate pure-play investment

Direct (in-house) corporate pure-play listed debt

In November 2013, EDF issued a EUR 1.4 billion green bond with proceeds used to finance the development or construction costs associated with new renewable energy projects developed by EDF Energies Nouvelles (EDF, 2014). Asset manager Jupiter Fund Management invested in the issuance (Kelly, 2013) and as of December 2014 the funds

contributed to the financing of 13 renewable energy projects (wind, solar PV, biogas) in Canada, France and the United States (EDF, 2014).

PNE Wind AG, a German wind farm project developer, issued a EUR 100 million 8% corporate bond to expand offshore and onshore wind activities. Institutional investors invested EUR 33.7 million in the issuance (PNE Wind, 2013).

14. CONCLUSION: RECOMMENDATIONS FOR POLICY MAKERS

‘Each one already blazing by our meeds, should notwithstanding join our lights together, and overshine the earth as this the world’

William Shakespeare (1599)

The Third Part of King Henry the Sixth

(Act II, Scene i)

14.1 Introduction

To limit climate risks, governments will need to focus attention on the emissions footprint of proposed infrastructure decisions and ensure that the investment environment is one that will enable the allocation of capital to low emission options. Choices made today about the types, features and location of long-lived infrastructure will determine the extent and impact of climate change and the vulnerability or resilience of societies to it. According to the IEA (2012), four-fifths of the total energy-related CO_2 emissions permitted to 2035 in their '450 Scenario', which is consistent with the 2°C emissions path, are already locked-in by existing capital stock, including power stations, buildings and factories. Without further action by 2019, the lock-in would be complete. Given the long lifetime of CO_2 in the atmosphere, stabilising concentrations of greenhouse gasses would then require the costly retirement of infrastructure prior to the end of its economic life, exacerbating stranded assets concerns.

Governments have a central role to play in mobilising capital through the establishment of reform agendas that deliver 'investment-grade policies' (Hamilton, 2009). In most countries, climate and investment policies have to date functioned quite separately and sometimes at cross-purposes, preventing or slowing investment in sustainable energy. Integrating climate and investment policies can help these different policy communities work together to achieve the common goal of achieving low-carbon and climate-resilient (LCR) economy and greener growth (OECD, 2015a).

In view of the diverse and challenging barriers across policy domains to mobilising institutional investment for sustainable energy discussed in Chapter 7.8, an emerging policy priority is to understand what other policy initiatives are needed to reinforce and support efforts to scale up investment by institutional investors. For energy systems, this

implies a more systematic and holistic analysis of the range of policy interventions that are required to undertake this challenge.

A number of efforts are underway, including in the G20 and through the G20/OECD Task Force on Long-Term Investment, to identify approaches for governments to remove barriers to greater infrastructure investment by institutional investors and to address infrastructure funding gaps (G20/OECD, 2014a and 2014b; G20/OECD, 2013; G20/OECD, 2012). There are many other projects focused on the challenge of meeting low-carbon climate-resilient infrastructure investment needs, including sustainable energy investments. These projects have aimed to help policy makers create and improve domestic enabling conditions to shift and scale-up private sector investments and financing, and have identified many elements that together provide a more complete view of a domestic enabling environment for sustainable energy infrastructure investments. These interdisciplinary efforts and their associated policy conclusions and recommendations inform the recommendations for governments made in this chapter.

14.2 Nine high-level policy recommendations to facilitate institutional investment in sustainable energy

Building on findings from previous OECD reports, in particular the policy recommendations of the G20/OECD High-Level Principles of Long-Term Investment Financing by Institutional Investors and based on a review of key trends in institutional investment and investment channels, this section proposes high-level policy options or directions on actions by governments to address barriers and facilitate institutional investment in sustainable energy. These recommendations are presented below, first in abridged form, and then Annex Chapter 16 provides the foundation for this abridged list

with a comprehensive discussion of policy recommendations, annotated and referenced against existing OECD policy guidance and G20 recommendations. These recommendations were also published in 2015 as G20 Finance Minister and Central Bank Governors deliverables under the Turkish G20 Presidency (Kaminker *et al.*, 2015).

1. ***Establish preconditions for institutional investment and favourable framework conditions for long-term investment financing.*** Take steps to: a) improve the business climate, rule of law and investment regime underpinning sustainable energy infrastructure investments; b) strengthen competition policy through designing open and transparent procurement processes; establish a wholesale electricity market; and create a level playing field between independent power producers (IPPs) of sustainable energy and incumbent state-owned enterprises (SOEs); and c) improve the governance of institutional investors, including addressing 'short-termism' and promoting long term investment while prompting disclosure of risks associated with long-term assets.

2. ***Ensure a stable, transparent and integrated 'investment-grade' policy environment addressing key barriers to investment by institutional investors.*** Institute a 'Green Investment Policy Framework'; avoid sudden or retroactive change to support policies in order to provide predictability to investors; examine the case for introducing barriers to policy change through legislation or contractual liabilities that make it unattractive to change retrospectively; address unintended consequences of policies that impede the mobilisation of institutional investment (e.g. 'unbundling' regulation that forces investors to choose between owning transmission or generating assets); and ascertain whether regulatory and other financial market rules (e.g. accounting, solvency and investment restrictions) are unintentionally and unnecessarily hindering investment in sustainable energy.

3. ***Improve risk-return profiles of sustainable energy projects by addressing market failures while improving electricity market design.*** Put an explicit price on carbon; give a clear policy signal of a rising cost for CO_2 emissions over time through explicit and implicit carbon pricing policies; and phase out fossil fuel subsidies. Provide an electricity market context that assures a reasonable and predictable return for investors in power generation and associated enabling infrastructure. Promote well-designed and time-bound sustainable energy support policies, when needed, to improve risk-return profiles. Promote the use of contracts such as Power Purchase Agreements that provide the stable and certain revenue which is instrumental to attracting institutional investors who seek these cash flow characteristics.

4. ***Establish a national infrastructure strategy and road map with project pipeline.*** Develop a sustainable energy plan within a national infrastructure strategy which maps out timing, capacity needs and location for new assets; deployment targets; the duration and level of support policies; and technology-specific considerations. The strategy should be revisited and updated regularly based on periodic reviews to take into account evolving technology developments and views on policy needs. Create a credible sustainable energy pipeline to provide investors with confidence that investable projects will be forthcoming. Create and support facilities focused on improving the 'bankability' of projects through preparation and selection and support initiatives aimed at improving enhanced partnership between the various actors along the project finance chain.

5. ***Facilitate the development of markets for sustainable energy infrastructure financing instruments*** (e.g. for debt in the form of green bonds) ***and funds*** (e.g. for equity in the form of listed YieldCo-type funds) tailored to investor risk profiles across the project lifecycle and developed in co-operation with investors. Evaluate the case for

passing or amending legislation allowing for sustainable energy infrastructure to be included in existing vehicles that appeal to institutional investors (e.g. covered bonds, Master Limited Partnerships and Real Estate Investment Trusts).

6. ***Facilitate the development of de-risking risk mitigants*** where they would 'crowd-in' private investment and result in more appropriate allocation of risks and their associated returns (e.g. credit enhancements and revenue guarantees, first-loss provisions, cornerstone stakes, and risk mitigants targeting different challenges across stages of the project lifecycle).

7. ***Reduce the transaction costs associated with sustainable energy investment***. Support transaction enablers such as channels for securitisation of sustainable energy debt to pool small scale projects using a prudent and judicious approach (e.g. supporting efforts to standardise contracts and project evaluation structures, creating aggregation and 'warehousing' facilities). Develop a sustainable energy project exchange network for large-scale projects; foster collaboration, innovation and knowledge-sharing amongst institutional investors and with other financial institutions.

8. ***Promote market transparency and standardisation, and improve data and disclosures*** on performance, risks and costs of sustainable energy (and fossil fuel) investments across available channels while promoting public-private dialogue. Strengthen, as appropriate, requirements for institutional investors to provide information on sustainable energy investments, following internationally agreed definitions, so as to enhance monitoring and understanding of the risk profile of these investments.

9. ***Consider the case for establishing a special-purpose 'green investment bank'*** (GIB) or refocusing activities of existing public finance institutions to mobilise private

investment for sustainable energy infrastructure. GIBs can facilitate the development of financing instruments and funds, de-risking risk mitigants and transaction enablers to lower transactions costs, and provide technical advice and project preparation and selection.

These policy conclusions address the role of governments because providing policy advice on government priorities is a core function of the OECD. However, it also important to underscore that while policy makers have an instrumental role to play in harnessing the opportunities and overcoming the challenges of institutional investor involvement in sustainable energy infrastructure, the private sector also has a major role to play in addressing the barriers presented and discussed in Chapter 7.8. While it is beyond the scope of this report to describe all the research efforts and recommendations being provided by the private sector and academia, governments should consider the work done on this topic by, inter alia, Clark and Monk (2013a,b), Global Investor Coalition (2013), B20 (2014), Climate Bonds Initiative (2014), Fulton and Capalino (2014), Nelson (2014) and WEF (2014).

To conclude this section, Table 14.1 proposes a map aligning the barriers (discussed in Chapter 7.8) with the relevant recommendations (drawn from the previous section) for government to consider in their efforts to ameliorate or overcome these barriers.

Table 14.1 Barriers to institutional investment in sustainable energy infrastructure and recommendations for government

Barriers			Recommendations
1. Issues with infrastructure investments	1.1 Direct investing challenges	a. Short term investment horizons of investors. b. Need for liquidity with many investors (low tolerance for illiquidity risk). c. Challenges with bidding process for assets on projects and timing; lack of investor best practice and expertise; smaller investors can lose out to more sophisticated, larger investors in bidding. d. Need scale > USD 25-USD 50 bn in AUM and dealflow to maintain costly direct investing team with expertise. e. Min USD 100-200 m deal "ticket" size; expensive and time-consuming due diligence; higher transaction costs.	a. Improve the governance of institutional investors, including addressing "short-termism" and promoting long term investment while prompting disclosure of risks associated with long-term assets. Align long-term interests of institutional investors, asset managers, companies and shareholders, thereby incentivising the latter to become more long-term engaged investors. b. Review financial and prudential regulations to ensure that they are compatible with the goals of financing for infrastructure and continue to monitor the possible effects of regulatory reforms on the supply of long-term financing. Facilitate the development of liquid markets for financing instruments and funds and develop a sustainable energy project exchange network which provides a standardised, consistent marketplace for large scale projects. c. Strengthen competition policy through designing open and transparent procurement processes. Publish an infrastructure roadmap and pipeline. d. Consider initiatives and platforms to pool institutional investor assets and transaction enablers such as securitisation. e. See c) and d)
	1.2 Regulatory and policy issues	a. Regulatory and policy uncertainty. b. Uncertain new policy application e.g. Solvency II for pension funds? c. Illiquidity and direct investment restrictions e.g. capital adequacy rules and higher charges (Solvency II, IORP II Directive). d. Accounting rules e.g. mark to market for illiquid assets.	a. Ensure a stable, transparent and integrated "investment-grade" policy environment. b. See a) c. Review financial and prudential regulations to ensure that they are compatible with the goals of financing for infrastructure and continue to monitor the possible effects of regulatory reforms on the supply of long-term financing. d. See c)
	1.3 Lack of "bankable" project pipeline and quality historical data	a. Few countries publish infrastructure road maps with project pipelines. b. Decreased participation of project finance banks (due to Basel III, deleveraging, structural factors) creates interruptions in project development and construction. c. Little historical pricing data or indices for benchmarking investments such as private placement debt. d. No liquid market to exchange financial stakes in projects.	a. Develop a sustainable energy plan within a national infrastructure strategy which maps out timing, capacity needs and location for new assets; deployment targets; the duration and level of support policies; and technology-specific considerations. The strategy should be revisited and updated regularly based on periodic reviews to take into account evolving technology developments and views on policy needs. b. Create and support facilities focused on improving the "bankability" of projects through preparation and selection and support initiatives aimed at improving enhanced partnership between the various actors along the project finance chain (e.g. to allow banks to offload operating projects to institutional investors and recycle their capital). c. Promote efforts to improve data on performance, risks and costs of sustainable energy investments across available channels. Strengthen, as appropriate, requirements for institutional investors to provide information on sustainable energy investments, following internationally agreed definitions, so as to enhance monitoring and understanding of the risk profile of these investments. d. Support the development of a sustainable energy project exchange network which provides a pipeline and marketplace for investors, improves co-ordination among participants, offers technical advice to local governments to improve identification, analysis, procurement and execution of public-private partnerships and other financing options.[a]

Barriers			Recommendations
2. Issues particular to sustainable energy infrastructure investments	2.1 Risk-return imbalance	a. Market failures: insufficient carbon pricing and incentives; presence of fossil fuel subsidies. b. Insufficient economic business case: cost of capital and perceived risk is too high and return is too low. c. Electricity market challenges (structure and design). d. Low natural gas pricing in some jurisdictions.	a. Put an explicit price on carbon through carbon taxes and emissions trading systems. Identify other cost-effective policy instruments that put an implicit price on carbon. Phase out or reform fossil fuel subsidies and support while addressing potential adverse impacts of subsidies reform. b. Facilitate the development of risk mitigants where they would "crowd-in" private investment and result in more appropriate allocation of risks and their associated returns while lowering the cost of capital across stages of the project lifecycle. c. Provide an electricity market context that assures a reasonable and predictable return for investors in sustainable energy and associated enabling infrastructure and promote well-designed and time-bound sustainable energy support policies when needed. Tackle regulatory and market rigidities that favour unabated fossil fuel incumbency in the electricity sector and which undermine demand-side options that could empower consumers to choose clean energy. Promote the use of well-designed Power Purchase Agreements or similar measures that achieve cash flow characteristics desired by institutional investors, i.e. stable, long-term cash flows linked to inflation. d. See a)
	2.2 Unpredictable, fragmented, complex and short duration of policy support	a. Instances of retroactive support cuts and support switching (FiT to FiP creates cash flow volatility) or start and stop (PTC). b. Unintended consequences of unrelated policies (e.g. can discourage investment by tax-exempt pension funds or EU unbundling preventing majority ownership of both transmissions and generation/production).	a. By better integrating climate and other environmental policy goals into investment policy frameworks and infrastructure planning, establish Green Investment Policy Frameworks in co-ordination with institutional investors, which provide investors with clear and long-term visibility, predictability and incentives. This helps provide the risk-return profile and confidence in future regulatory stability needed for investors to invest in long-term assets. Ensure that support policies are of adequate duration and tied to a technology's level of maturity. b. Analyse, determine and review policy-related barriers to institutional investment and fix unintended consequences of existing policies or issues arising from unrelated policy priorities that impact on the goal of mobilising institutional investment. • Fixes should evaluate the trade-offs between other policy priorities and the benefits of increased institutional investment. Fixes could include, inter alia, regulatory reform, carve-outs (exemptions) for institutional investment or structuring specific policy incentives designed to encourage institutional investment. Review financial and prudential regulations to ensure that they are compatible with the goals of financing for sustainable energy and continue to monitor the possible effects of regulatory reforms on the supply of long-term financing. • Ensure that any restrictions on long-term investment in sustainable energy infrastructure by institutional investors are consistent with diversification and financial regulation objectives. Review restrictions regularly and, where appropriate, ease them subject to necessary safeguards (see Annex 5.A1) being in place, such as strong governance and risk management mechanisms, effective supervision, and appropriate diversification. • Promote the use of well-designed Power Purchase Agreements or similar measures that achieve cash flow characteristics desired by institutional investors, i.e. stable, long-term cash flows linked to inflation.

Barriers		Recommendations
2.3 Potential misalignment with climate change risk and the transition to a low carbon economy	a. Lack of a responsible investment code. b. Lack of clarity on fiduciary duty and stewardship with respect to environmental, social and governance and stewardship (ESG) issues. c. Carbon content of portfolios rarely disclosed.	a. Evaluate the case for establishing a "code for responsible investing" which gives institutional investors guidance on how they may execute investment and risk analysis and conduct investment activities to adequately take into account environmental and social considerations, and exercise ownership rights so as to promote sound governance. b. The governing body of an institutional investor should ensure that the institution can properly identify, measure, monitor, and manage the risks associated with long-term assets as well as any long-term risks – including environmental, social and governance (ESG) risks - that may affect their portfolios. The risks associated with long-term investments should also be carefully assessed, including climate and other environmental risks, and exposure to potential future climate regulation. c. Where appropriate (see Annex 5.A1), institutional investors should disclose with sufficient granularity information on the extent to which their investment strategies are in line with their investment horizon and how they address long-term risks associated with climate change.
2.4 Special species of risk and lack of data on the performance of sustainable energy investments across asset classes	a. Technology and volumetric risk management require expertise and special risk management tools. b. Lack of data.	a. Create stakeholder initiatives to design cost-effective tools to better hedge against technology and volumetric risk. b. Strengthen formal requirements to provide information on investments by institutional investors in sustainable energy, following internationally agreed definitions. This would allow for future monitoring on an international basis. This is necessary for institutional investors themselves to have the necessary data to analyse the performance of these investments and the confidence to then make allocations. It is also necessary for policy makers to be able to understand and monitor such allocations in order to be able to make appropriate policy responses. • Encourage institutional investors to report their recent allocation to and performance of different long-term assets following standardised classifications and methods, while ensuring the confidentiality of any market-sensitive or proprietary information. • Support investor led initiatives such as the Low Carbon Investment (LCI) Registry, a global public online database of low carbon investments made by institutional investors.
2.5 Competition for capital	a. Competition with traditional infrastructure assets and with transmission and distribution infrastructure.	a. No recommendation for government.
2.6 Small scale of assets	a. Distributed and micro-generation assets too small for institutional investors interest and few means exist to bundle them.	a. Support channels for securitisation of sustainable energy debt to pool small scale projects using a prudent and judicious approach (e.g. supporting efforts to standardise contracts and project evaluation structures, creating aggregation and "warehousing" facilities).
2.7 Market perception	a. Negative publicity created by bankruptcies of early-stage companies and poor performance of VC investments due to temporal industry consolidation and macroeconomic factors transfer to projects which were unaffected.	a. Create or support existing platforms for dialogue between institutional investors, the financial industry and the public sector to understand the barriers and opportunities to investment in sustainable energy projects.

Barriers			Recommendations
3. Lack of suitable investment instruments and funds	3.1 Issues with fund and vehicle design	a. High fees associated with fund structures. b. Liquidity trade-off with connection to underlying asset and associated benefits: difficult to offer liquidity without asset disconnect, churn and leverage in fund. c. YieldCos are new innovations for listed equity but depend on bankable pipelines of projects and experienced human resources and may need to evolve further to fulfill their potential.	a. No recommendation for government. b. No recommendation for government. c. Establish a national infrastructure strategy and road map with project pipeline. Support regulatory reforms which impact electric utility business models to accelerate deployment of sustainable energy sources and new financing models such as YieldCos.
	3.2 Nascent green bond markets, few indices/funds	a. Small pipeline of projects, high transaction costs, minimum deal size. b. Definitional uncertainty. c. Few liquid benchmark indices for listed debt and equity as market is still nascent or insufficient demand for products.	a. Establish a national infrastructure strategy and road map with project pipeline. Different levels of government can issue, and support the development of appropriate long-term instruments in line with debt management and capital market development objectives. Such instruments underpin the development of long-dated private sector securities markets and can support asset-liability management by institutional investors and complement long-term investment portfolios. Green bonds and YieldCos are examples of instruments and funds that have the potential to engage institutional investors at scale. b. Support the development of markets for instruments or funds with appropriate risk-return profiles for institutional investors. Such financing options should have an investment horizon in line with those of the underlying projects, should be tailored to investor risk profiles across the project lifecycle, and should be developed in close co-operation with institutional investors. c. Establish the necessary regulatory framework for pooled funds, vehicles and securities channelling financing for long-term investment in a sound and sustainable manner. • Support the development, rigour and adoption of emerging certification standards for green bonds such as the Climate Bond Standard and Certification Scheme and voluntary issuances guidelines such as the Green Bonds Principles. Rigorous standards, guidelines and procedures for verification can allow for straightforward certification and issuance of bond instruments that contribute to a low carbon economy leading to increased market liquidity, comparability and demand from institutional investors. Additionally, they can help prevent risk of so-called "greenwashing" whereby proceeds from bonds issued do not actually contribute to the intended projects or corporate activities.
	3.3 Restricted access to existing vehicles (Covered Bonds, MLPs and REITs)	a. Current national legislation does not enable sustainable energy to qualify for these vehicles.	a. Evaluate the case for passing or amending legislation allowing for sustainable energy infrastructure to be included in existing liquid vehicles that appeal to institutional investors.
	3.4 Challenges with securitisation	a. Lack of standardised project documentation and credit risk assessments. b. Lack of large enough portfolios of loans on bank balance sheets. c. Legacy reputational risk from the GFC.	a. Support channels for securitisation of sustainable energy debt to pool projects using a prudent and judicious approach (e.g. supporting efforts to standardise contracts and project evaluation structures). b. Create aggregation or warehousing facilities (e.g. via a Green Investment Bank). c. Support channels for securitisation prudently and judiciously.
	3.5 Credit and ratings issues	a. Historical lack of ratings data, expensive process. b. Absence of monoline insurers since GFC.	a. Support collection of ratings data and efforts to create "mock" securitisation ratings processes. b. Consider the case for establishing a special-purpose "green investment bank" (GIB) or refocusing activities of existing public finance institutions to mobilise private investment for sustainable energy infrastructure including monoline insurance and credit enhancement.

Source: Author (Kaminker *et al.*, 2015)

Note: Asset-Liability Matching (ALM), Assets under Management (AuM), Institutions for Occupational Retirement Provision (IORP II Directive), Feed-in Tariff (FiT) Feed-in Premium (FiP), Production Tax Credit (PTC), Global Financial Crisis (GFC), Master Limited Partnership (MLP), Real Estate Investment Trust (REIT).

14.3 Emerging options and policy considerations for mobilising the bond markets for sustainable energy and green infrastructure

Drawing on Chapters 11 and 12, and the preceding high level policy recommendations in Chapter 14.1, this section proposes a set of policy considerations for fostering access to the bond markets for sustainable energy green infrastructure. In line with the G20 'Green Finance Synthesis Report' (G20, 2016), this section discusses options that draw on current actions that are being taken discussed in Chapter 12.5, that the public, official and private sectors can consider on a voluntary basis. It is informed in part by the emerging options in (Ma *et al.*, 2016), which can be referred to for further context and explanation.

The diversity that characterises the green and low-carbon bond financing channel means that a wide range of policies can play a useful role, if they are tailored to the specific facts and circumstances in a country and sector (e.g. bond sector or underlying asset sector) and with regard to new technologies that become more available for deployment and bond financing over time (such as solar thermal, energy storage, carbon capture and storage, bio-sequestration and other green innovations yet to be commercialised or even invented).

As established, preconditions exist for the emergence of the green assets that can be financed or refinanced through green bonds and for mobilising institutional investor participation in the green bond market. These are discussed in Chapter 12.5 with respect to fundamental bond market development activities.

14.3.1 Preconditions

Establish an enabling environment for bond issuance and for institutional investors to provide long-term investment financing. This includes taking steps to: 1) improve the business climate, rule of law and investment regime underpinning sustainable infrastructure investments; and 2) strengthen competition policy and level the playing field between the private sector and state-owned enterprises.

Ensure a stable, transparent and integrated 'investment-grade' policy environment for green investment. These aspects are discussed throughout this thesis and further expanded on in Chapter 16.22.

Apart from these, government and the official sector can consider a further range of policy measures that may be warranted, in various areas as listed in the following in terms of general policy considerations (G20/OECD, 2015).

14.3.2 Regulation

Design and oversight. Careful design and oversight of markets for green bonds and securitised asset-backed securities (ABS) in particular, can help to foster the use of alternative financing instruments and provide an avenue for capital recycling, without putting at stake the overall resilience of the financial system (see Nassr and Wehinger, 2015; G20/OECD, 2015).

Regulatory approach. Sensible and balanced calibration [63] of the existing regulatory frameworks affecting different types of green bonds (e.g. covered, ABS, corporate, etc.) should be pursued, particularly given the potential role of institutional

[63] See Nassr and Wehinger (2015) for further discussion.

investors in providing alternative sources of debt financing (G20/OECD, 2015). Regulation should also take a holistic and co-ordinated approach to avoid regulatory arbitrage, in which investors favour specific instruments over others due to differences in regulatory treatment. A co-ordinated regulatory approach would avoid unduly favouring specific instruments over others with similar characteristics and creating associated distortions in risk pricing. Healthy competition should be secured across similar financing solutions, eliminating any imbalances or disincentives that might direct investor and issuer preferences away from some of these instruments (see G20/OECD, 2015).

Create specific market frameworks. Creating regulatory and legislative frameworks for specific asset classes such as ABS and project bonds (e.g. in the United States and the European Union), covered bonds (e.g. in Germany) and private placement bonds (e.g. in the United States and the European Union) at national or broader international levels can open up these green bond channels. Such securities should have an investment horizon in line with those of the underlying assets and should be developed in co-operation with institutional investors.

14.3.3 Market building

Identify project pipeline. The amount of green bonds that can be issued will be determined by market demand and the availability of suitable greenfield and brownfield projects that can be financed or refinanced through the bond markets. China and India have developed pipelines for infrastructure, and Kenya has published a strategic project priority list. The Canadian province of Ontario has linked a pipeline of green projects to its municipal green bond programme. National agencies for infrastructure have been established in Australia, South Africa and the United Kingdom which can co-ordinate and deploy these types of project pipeline plans. Governments can benefit from working more

closely with development banks and investors in this process, who also maintain project pipelines for their green bond issuance programmes.

Develop green guidelines and standards. Scientifically rigorous standards, guidelines and procedures for verification can allow for straightforward certification and issuance of bond instruments that verifiably contribute to a low-carbon economy, leading to increased market transparency, comparability and market integrity. Additionally, they can help prevent the risk of so-called 'greenwashing' whereby proceeds from bonds issued do not actually contribute to the intended projects or corporate activities. Green bonds have developed to date largely thanks to market-led initiatives that have produced international guidelines and standards represented in particular by the GBP and the CBI Standard that aim to promote and protect the integrity of the green bond market. These guidelines and standards may be market-led or developed by governments. Governments can support the development, adoption and harmonisation of emerging certification standards for green bonds such as the Climate Bond Standard and Certification Scheme and voluntary guidelines such as the Green Bond Principles. As a result, they have been recognised by the official sector and have served as a key reference for countries such as China and India that have developed Green Bond Guidelines and definitions to guide the local market, as well as an official evaluation system to ensure that issuers adhere to the guidelines. Further efforts to more firmly anchor the market's 'green' credibility, such as defining international rules, could address uncertainties in the market that could jeopardise its growth, and could help overcome many of the barriers identified earlier in this chapter.

Providing technical assistance for developing local green bond guidelines. As previously described, due to reasons ranging from capital controls to domestic

environmental considerations and other policy preferences, some countries may choose to develop their local currency green bond markets. In these cases, it is important that international lessons and experiences are made available and fully studied when developing their local green bond definitions, taxonomies and disclosure requirements. International organisations with green finance specialisation or capabilities should assist in capacity building for the drafting of key documents as the basis for operating the local currency green bond markets.

The objective of local green bond standards should be to ensure that while the national agenda is met, these local green bond rules do not create unnecessary barriers to or transaction costs for cross-border green capital flows. Local currency green bond taxonomies should reflect where necessary the country's demands for combating its domestic environmental challenges, while remaining as consistent as possible with international guidelines and standards (such as the GBP and the CBI Standard). They should also be simple enough to enable most market actors, who are not specialists in the environmental areas, to comprehend. In such cases where taxonomies will be used by authorities or regulators to approve green bond issuance and to grant favourable policy support (such as interest subsidies and guarantees), these definitions need to be sufficiently specific so that they can form the basis for decision making.

Raising international awareness of the benefits of green bonds. A key lever for green bond market development is effective market education on the benefits of green bonds (for sustainable development, for issuers, and for investors) as well as the awareness of international green bond standards and disclosure requirements. Promotional efforts can be organised by government agencies, regulators, market associations, financial institutions, development agencies, rating agencies, second-

opinion and third-party assurance providers. MDBs and international organisations with a mandate for sustainable investment can also organise dissemination events in countries that they cover.

Centralised data depositories. As a precursor to aggregation and securitisation, governments can start and provide support to initiatives that aim to build up loan-level data, performance track records, definitions and second-party verifications. For instance the European Central Bank set up the European Data Warehouse depository in 2013 for loans underlying European ABS. Pooling this type of data in centralised depositories, set up and maintained through public initiatives, should benefit the functioning and liquidity of the entire green infrastructure financing market through increasing transparency. This will in turn allow for informed decision making by capital holders while facilitating monitoring by supervisors, reducing information asymmetries and reducing transaction costs associated with due diligence. Appropriate balance in the level of disclosure requirements should nonetheless be safeguarded so as to stimulate investor appetite through transparency without rendering such issuance or investment overly costly or cumbersome.

Aggregation. Securitisation is one option to aggregate small-scale green projects to be suitable for green bond issuance. In Mexico, a deal aggregating energy efficiency loans and providing demonstration of green securitisations is currently underway, supported by the Inter-American Development Bank. In the United States, the National Renewable Energy Laboratory (NREL) of the Department of Energy has set up a solar securitisation working group that includes industry actors. Public institutions could also set up a green project warehouse (which includes data as well as the loans themselves) to aggregate small-scale assets across originating entities. In the United States, the state of

Pennsylvania has established a Warehouse for Energy Efficiency loans in collaboration with the commercial bank Citi.

Version standardisation. The development of standardised 'off-the-shelf' versions of green bonds (e.g. for municipalities) and ABS could be pursued with a view to lowering the transaction costs and increasing the efficiency and accessibility of green bonds to issuers and investors. For example, the Basel Committee on Banking Supervision and the International Organization of Securities Commissions created criteria for identifying simple, transparent and comparable securitisations. Support for the creation of indices could be envisaged to enhance liquidity and investor participation in publicly traded green bonds.

Technical assistance for local currency bond market development. Technical assistance for developing local currency bond markets in areas such as the development of benchmark yield curves, ratings, risk mitigation mechanisms and FX hedging products can also be helpful for growing the green bond market. Such efforts should occur in collaboration with any green bond market participants already active in a country. As a considerable amount of the green bond market's growth has occurred as a result of private sector development and innovation, governments should work to support such efforts.

Developing green bond indices, ratings and stock exchange lists. Index companies and other financial institutions can develop green bond indices as a basis for green bond ETFs and other fund products. Rating agencies could further develop or acquire the technical expertise needed to launch green bond ratings that cover the full spectrum of bonds. Securities exchanges could consider green bond listings as a future business driver.

International organisations, public research institutions and non-governmental organisations can provide further support group share tools and systems to make it easier (and less costly) for issuers to manage their green assets, and for second-opinion providers, rating companies and index companies to assess the green impact of the bond-financed projects. These include various analytical tools (such as open source solutions for quantifying the environmental benefits, e.g. emission reductions, energy savings and water savings) and related reporting tools (such as data aggregators that reduce the reporting cost of individual institutions).

14.3.4 Demand side

Strategic public green bond investment mandates. Sovereign wealth funds and public pension funds are well placed to invest in green bonds, playing a demonstration role for private sector investors. Green bonds can represent a form of investment that yields long-term, stable returns that may suit the public mandates of sovereign wealth funds and public pension funds. Public investors can collaborate with governments to grow the green bond market. For instance, the German national development bank KfW has been authorised to act as an 'anchor investor' in a EUR 1 billion portfolio of green bonds on behalf of the German government, backed by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) which jointly with KfW defines a 'minimum quality requirement' for green bonds that are eligible for the portfolio. This type of collaboration promotes the quality-based development of the green bonds market by focusing public demand on green bonds that meet certain standards of transparency in use of proceeds and impact reporting.

The Nordic Investment Bank (NIB) and Brazil's BNDES state development bank are other example of public entities that support green bonds. ***Cornerstone investment***

from public financial institutions can strengthen the market by reducing perceived risk for private investors. The IFC has launched a USD 2 billion Green Cornerstone Bond Fund to unlock emerging market financial issuance, building on its previous expertise in investing in green bonds issued by Indian Yes Bank, using funds raised by its own IFC green bond issuance in the offshore rupee markets.

Incubating local green investors. For markets that rely mostly on local investors, efforts can be made to 'incubate' domestic green institutional investors, via building capacity for them to identify green assets, to improve the transparency of holdings and to adopt environment, social and governance (ESG) principles in investment decision making. Steps that can help incubate a local green investor base include: strong government signals in support of green investment; green finance associations that help raise awareness and provide training for green investment practices; encouragement for institutional investors to examine the environmental performance of their asset holdings; and international collaboration on capacity building.

Collaboration. One collaborative model that has emerged in the market is national green bond market development committees representing various stakeholders, in particular financial regulators, ministries of finance and development banks. Committees are currently being organised in Brazil, Canada, China, India, Mexico and Turkey. Global co-operation between the committees will allow ideas and policy proposals to be shared and activities to be synchronised.

Promoting international collaboration to facilitate cross-border green capital flows. Different markets could collaborate to facilitate the harmonisation of definitions and verification process of green bonds and the development of green asset-backed securities acceptable by foreign investors. These efforts can take the form of bilateral

collaboration between markets, to demonstrate their effect of enhancing cross-border green bond investment flows.

14.3.5 Supply side

Public sector demonstration issuance. Public entities can issue green bonds in line with their fiscal parameters and criteria and priorities for lending and bond issuance. Public financial institutions and MDBs have been pioneering and eading issuers of green bonds, led by the European Investment Bank and the World Bank Group. Sovereign governments, national development banks, public green investment banks, export-import banks, export credit agencies and municipality-linked public entities have all issued green bonds.

Technical assistance for investors. Governments can incentivise and support the deployment of appropriate internal institutional infrastructures (due diligence capacity, models, monitoring systems), which could create efficiencies in investors' due diligence and other procedures and facilitate their participation in a green asset-backed securities market. This is underway for securitisations more generally under certain financial regulations.

Reducing the costs of green bond issuance and reporting. Standardisation of methodologies, as GBP is doing with reporting templates and CBI with green definitions, is designed to lower the cost and effort of verification. Governments, international organisations and non-governmental organisations can sponsor the development and dissemination of tools to support cost-effective analysis of the environmental benefits of green bond-supported projects. Such efforts can contribute to mitigating global market inefficiencies whereby environmental benefits are not adequately priced. The public

sector and MDBs could also consider measures to reduce the costs of green bond verification in early-stage markets (e.g. by covering part of the costs). The IFC has already indicated it is exploring measures to do this in relation to commercial bank green bond issuance in emerging markets.

Labelling qualified 'green bonds'. For bonds that qualify as 'green' but are not yet self-labelled or verified by third-party assurance, financial service providers and non-governmental organisations can consider labelling them as 'green bonds'. Subject to being consistent with accepted practice for new green bonds such as the GBP and the Climate Bonds Standard, such a labelling exercise can substantially increase the availability of green assets, thereby easing supply-side constraints on some markets.

14.3.6 Public intervention

Risk mitigation. Consistent with broader policy, governments can provide risk mitigation and other public intervention in support of green bonds where this would result in more appropriate allocation of risks and their associated returns. Governments may use public financing mechanisms to provide cover for risks that are new to investors and cannot be covered in existing markets. Such mechanisms may include, inter alia, insurance-related options, credit enhancement tools, guarantees and tax options (G20/OECD, 2013; 2014).

Public intervention design. Design should be decided on the basis of identified market failures, and should be selected by carrying out appropriate cost-benefit analysis of such interventions and ensuring that any public support is appropriately priced and is subject to fiscal considerations. Risk mitigants should be designed on a case-by-case basis, according to market best practices, and in such a way that private sector participation is not crowded out. Specific evaluation and control procedures (beyond a

standard impact assessment) would need to be put in place to ensure that the intended (capital, funding) benefit is passed on to the real economy. Some governments do not offer risk mitigation as a matter of public policy, given the risks entailed, which can include potential price and competitive distortions as well as rising contingent liabilities and other budgetary problems. Public financial institutions and development banks can facilitate risk mitigation for green bonds and to the projects underlying green bonds, by providing coverage for government-related, sovereign risks, as well as for specific operational risks including regulatory changes and currency exposure (G20/OECD, 2013; 2015).

Financial stability oversight. While the size of the green securitisation market is small in terms of the wider financial system, it has the potential to grow significantly. Therefore, careful assessment of the riskiness of inappropriate design and use of such instruments should be encouraged in the context of a widely interconnected financial system. The corresponding benefits to the real economy and their materiality to green corporates and projects should be part of such an assessment (G20/OECD, 2013; 2015).

Dialogue. Official support for raising the profile of the public debate on green bond initiatives may help to overcome the barriers to green bond market development identified and encourage the appropriate and safe use of financing instruments such as ABS.

15. CONCLUSION: IMPLICATIONS FOR FUTURE RESEARCH

An egg. An
eye. An egg
at play. A play of
egg. An I. An eye.
An eye is cast. A cast
of I. I eye the egg. A
castaway. Aye, aye. I
aye. I eye the cast. The
I at bay. The eye aghast.
The I to pay. The pay is
vast. The egg is past.
The eye at play.
The I away.
Aye. Aye.

Karin E. Kaminker

Out of the Aviary (2008)

15.1 Overarching research conclusions

15.1.1 Towards an 'investment grade' policy framework

For institutional investors which manage a very large share of national savings, a fundamental pre-condition for investing in sustainable energy is the establishment of appropriate domestic framework conditions, which provide the clear price signals, predictability and policy coherence that investors need. While simple enough in principle, such a framework often proves difficult to achieve in practice, as retroactive policy changes, weak carbon pricing, fossil fuel subsidies and unintended effects of non-climate-related (e.g. financial and investment) regulations can undermine policies that are otherwise supportive of the low-carbon transition.

Even though sustainable energy technology costs are falling fast, policy and market obstacles still constrain overall growth in investment in sustainable energy, limiting the pipeline of bankable projects and affecting the risk-return profile of investments. In addition to insufficiently ambitious climate mitigation policies, the misalignment of other policies and regulations with respect to climate goals can also act to hinder investment. Such misalignments may occur across the general investment environment, for instance in the areas of investment policy, competition policy and electricity market design, trade and financial markets policy.

Whether institutional capital can be mobilised to support infrastructure development – and whether the infrastructure in question is 'green' or 'brown' – will depend on the risk-return profile of infrastructure investments and the regulatory environment in which these investors operate. The costs of sustainable energy are contingent on the cost of capital, which is influenced by the risk perceptions of investors.

Institutional investors have varying risk appetites, liability profiles, investment preferences, illiquidity tolerances and other constraints which will determine the extent to which they will seriously consider investments in sustainable energy infrastructure. Moreover, institutional investors will not make an investment just because it is ‘green’. Their primary concern is the risk-adjusted financial performance of the asset.

Their willingness to finance major investment projects in any given country, including investments in sustainable energy infrastructure, will be heavily influenced by perceptions of the country’s sovereign risk, investment climate, policy settings, and institutions. This is particularly the case in the developing world where much of the infrastructure is likely to be built.

Another consideration that could impact sustainable energy investment by institutional investors as well as their investments in emissions-intensive projects and activities is how investors view ‘climate risk’. In the wake of the Paris Agreement, institutional investors are beginning to perceive that regulatory risks around unabated fossil-related investments can be expected to increase and returns from such investments can be expected to fall.

Such changes in perceptions may be triggered by the expectation of increasingly stringent carbon pricing and climate change mitigation policy, and by an evolving investor governance and disclosure landscape. Climate change itself, policies and technological changes in response to climate change, and green finance all create risks that have various implications for the financial sector and institutional investors. As described by the Bank of England, among these are ‘physical risks’ from climate change. Related are ‘liability risks’ for corporations that may be held responsible for climate-

change related losses or damages and from which affected parties may seek compensation.

There are also risks linked to policy and technological responses to environmental challenges including climate change which can affect the financial sector and institutional investors. These and related 'transition risks' generally result from the adjustment process towards a cleaner and lower-carbon economy that can prompt a reassessment of asset values as their ability to generate returns is impaired and they face pre-mature write-downs or even conversion to liabilities, thus there is a potential for these assets to become stranded ('stranded assets'). These risks mainly affect lenders and (equity) investors in projects concerned, but the re-pricing of assets may have effects that can go beyond the institutions or the sector in which it occurs, including broader economic effects (including for sovereigns and their ratings) and potentially impacts on financial stability.

Despite growing awareness of climate-related risks to the financial sector and institutional investors the understanding of these risks is still incomplete (and may remain so) due to their complexity. Climate-related physical risk management in the insurance and reinsurance sectors is relatively sophisticated, but in other sectors, and regarding other sources of risks (i.e. transition risks), the work is still at an earlier stage in terms of data availability and quality, tools and methodologies as well as capacities devoted to environmental issues impacting the financial sector.

Enhanced transparency and disclosure of climate-related and environmental risk exposures across the corporate and financial sector could help not only to improve understanding and analysis of the risks, but also to improve the decision making of borrowers, lenders and investors alike. This could contribute to improved risk pricing and could support a more orderly transition to a low-carbon economy, allowing financial

market actors to take a view on current as well as future risks, and adjust investment strategies, improve long-run decision making and foster long-term investment in sustainable energy by institutional investors. For such reasons, disclosures with a focus on carbon exposures and their risks may be expected to become standard in the non-financial as well as the financial sector. Efforts to improve disclosure are being undertaken at the OECD, as well as by the FSB's Task Force on Climate-related Financial Disclosures (TCFD).

While there are expanding pockets of institutional investment activity in sustainable energy projects (as opposed to more routine "indirect" investments made in corporate stocks and bonds), investments have been minimal compared with the scale of institutional investors' assets and the magnitude of the investment gap. Looking just at large pension funds, direct equity investment in unlisted infrastructure projects of all types accounted for only 1% of their asset allocation in 2015, and sustainable energy accounted for a tiny fraction of that.

Yet sustainable energy projects have a number of unique cash flow characteristics which can appeal to investors with long-dated liabilities. For example, sustainable energy assets can provide steady, long- term, inflation-linked, income streams with low correlations to the returns of other investments. In a low interest rate environment, and if governments provide an investment grade enabling environment, sustainable energy should in principle be very attractive to institutional investors, and these investors should be able to play a much greater role especially as "recyclers of capital".

This thesis covers the landscape of sustainable energy investment channels and decision-making to shine light on how governments can help shift large capital flows to support the low-carbon transition. It also addresses questions such as: why are green

bonds, YieldCos and direct investment potentially promising channels? Are institutional investors already making such investments? Do all institutional investors view sustainable energy investments in a similar way? What risk mitigants can governments provide to influence investment decisions?

While capital is available to be deployed, it is 'bankable' projects that are lacking. If countries want to significantly augment the flow of capital allocated to sustainable energy infrastructure by institutional investors – particularly in the absence of an unambiguous carbon price signal – they need to consider policy interventions that make that allocation more likely. This thesis suggests ways in which they can.

A list of nine high-level policy recommendations for governments to address the range of barriers and to facilitate institutional investors' investment in sustainable energy is proposed in the preceding concluding chapter. Policymakers can take actions to create an investment environment in which investors have lower risk perceptions and there are significant reductions in the cost of capital, which is fundamental to reducing the costs of sustainable energy. The first four of these policy recommendations were matched against barriers and targeted at creating preconditions and the enabling environment to drive demand for institutional investment.

15.1.2 'Organic' institutional investment in sustainable energy

In geographies where an adequate enabling environment, which may include public support measures, creates demand-side circumstances in which investment demand is generated 'organically', investment will be more likely.

More so than elsewhere, institutional investors have identified sustainable energy assets in Europe as a source of attractive, inflation-linked, long-term and stable cash flows. In the EU, 140 institutional investors have made around 600 investments between 2004-2015, allocating over EUR 30 billion in equity to projects that have a combined debt and equity value in excess of EUR 80 billion. This increased geographic appetite can be attributed to a number of factors including a large contiguous EU umbrella policy framework with carbon pricing in place (albeit at very low levels), ambitious EU-level climate action targets, the presence of policy support mechanisms that create revenue stability (e.g. Feed-in-Tariffs), and a very large, sophisticated, geographically proximate institutional investor base.

Also described is an emerging ecosystem of investment in EU sustainable energy. Early stage risks in developing, building and de-risking projects are the territory of private equity operators with technical expertise, and corporate on-balance sheet financing from project developers and utilities. Once de-risked, such projects become attractive investments for "financial investors" including pension funds, insurance companies, Yieldcos and generalist infrastructure funds seeking stable but lower yields. These operating projects (i.e. post construction phase) are overwhelmingly favoured by institutional investors, accounting for nearly 80% of all institutional equity capital that was invested in sustainable energy projects in the EU since 2011.

Taking a wider view beyond sustainable energy, investment demand for green and sustainable infrastructure by institutional investors is strong and growing and public statements made since 2015 outline how such investors are poised to significantly increase investment in this area. For example, a coalition of insurance companies committed its participants to doubling their USD 42 billion of "green, climate-smart investments" in 2012 to USD 84 billion by 2015 and USD 420 billion by 2020. By July 2015 the figure had already reached USD 109 billion, well in excess of the 2015 target. In 2014, a coalition of three pension funds pledged to increase low-carbon investments across all asset classes to USD 31 billion by 2020, and had already reached USD 29 billion by the end of 2015. A host of other institutional investor initiatives geared at sustainable finance were showcased in the margins of COP21 including, inter alia, the Portfolio Decarbonisation Coalition, the Montreal Carbon Disclosure Pledge, the Divest-Invest Pledge, and the Aligned Intermediary.

Yet while some of these investment figures and pledges may seem large on an absolute basis, they are minute compared with the scale of institutional assets under management, and the scale of the investment demand and financing gap for green and sustainable infrastructure. Further, the individual allocations and pledge levels cited are largely exceptions to the rule that institutional investment in green infrastructure projects have been limited to a very small percentage of the portfolio.

15.1.3 Catalysed institutional investment in sustainable energy

Another element of a strong domestic policy framework is the creation of the supply-side conditions for scaling up 'catalysed' sustainable energy investment by institutional investors. These actions are centred on the establishment of specific policies, instruments, funds, risk mitigants and transaction enablers for mobilising institutional investment. There is an important role for governments in both reducing barriers to investment and supporting the development of investment channels, such as green bonds, funds and direct investment, which can hold the key to scaling-up institutional investment in green infrastructure.

Governments are working to establish specific financial policies, instruments, funds and risk mitigants that provide transitional support for new low-carbon and climate-resilient technologies. There is an important role for governments in both reducing barriers to investment and supporting the development of important investment channels, which can hold the key to scaling-up institutional investment in sustainable energy.

Risk mitigants include a range of targeted interventions generally aimed at reducing, re-assigning or re-apportioning different investment risks using mechanisms such as guarantees and insurance products, public stakes and other forms of credit enhancement. By providing coverage for risks which are new and are not currently covered by financial actors, or are simply too costly for investors, risk-mitigating tools increase the attractiveness and acceptability of sustainable energy projects for institutional investors that are particularly risk-averse (e.g. pension funds).

As a subset of risk mitigants, transaction enablers facilitate institutional investment in sustainable energy infrastructure projects by reducing the transaction costs associated with these investments while also mitigating risk in some cases. As most institutional investors have limited experience with direct investment in sustainable energy infrastructure projects, the cost associated with identifying, executing and managing investments is often prohibitive. Transaction enablers include warehousing (pooling small transactions), securitisation (transforming illiquid assets into tradable securities) in a prudent and judicious way, and co-investment and collaboration among institutional investors.

The results of this research suggest that there are many ways in which governments are already working to help mobilise institutional investment in green infrastructure, using a multitude of approaches. Chapter 13 classifies the different types of approaches into a typology of risk mitigants and transaction enablers, and lays them alongside the channels for investment in different types of sustainable energy and green infrastructure.

Emerging from the list of policy options, considerations and recommendations is a general need to enhance the role of public financial institutions in mobilising institutional investors and developing green bond markets. Given the relatively recent establishment of public green investment banks, it is notable that five such institutions, located in three countries, were involved in one quarter of the 33 case studies in Chapter 13.

Another interesting finding of the stock-taking research in Chapter 13 (which examined a sample of deals collected where the public or official sector was present somehow in the deal structure itself), the majority of case studies in the sample focused on construction stage project investment. This finding is at odds with the finding of Chapter 8 showing that the clear majority of ‘organic’ institutional investment in

sustainable energy (i.e. investments occurring without direct specific public intervention) is centred on lower-risk operational assets. Based on this trend, governments appear to be targeting their public intervention at the construction stage, perhaps to address a perceived financing gap specific to the construction stage.

15.1.4 Mobilising the debt capital markets and scaling green bonds

As debt currently finances the majority of infrastructure investment, this thesis devoted a significant amount of coverage to this asset class. In particular, bond finance is a natural fit for low-carbon and climate-resilient infrastructure assets such as sustainable energy infrastructure, which is characterised by high upfront capital costs and long-dated and frequently inflation-linked income streams.

Since 2007-08 a market for bonds specifically 'labelled' or designated as 'green' ('green bonds') has emerged. A green bond is differentiated from a regular bond by its commitment to use the funds raised to finance or refinance 'green' projects, assets or business activities. With growing market appetite for such bonds, annual issuance of labelled 'green bonds' rose from just USD 3 billion in 2011 to USD 95 billion in 2016.

Institutional investors have driven the growth of this market for green bonds, investing in most issuances while working to improve the market's structure and green integrity. Bonds are a core component of pension funds' and insurance companies' portfolios, and bonds with long tenors are potentially a good fit with institutional investors' long-term liabilities, allowing for asset-liability matching. Green bonds fit within the investment portfolios of mainstream institutional investors and can reconcile latent and emerging demand from institutional investors for sustainability- themed, ESG-screened investments. The green bond 'label' serves as discovery mechanism for

institutional investors and helps to lower search costs associated with identifying green opportunities in a figurative ocean of fixed-income opportunities.

Green bonds can offer several important benefits for green investment including: 1) providing an additional source of green financing; 2) enabling more long-term green financing by addressing maturity mismatches; 3) enhancing issuers' reputation and clarifying environmental strategy; 4) offering potential cost advantages; 5) facilitating the 'greening' of traditionally brown sectors; and 6) making new green financial products available to responsible and long-term investors.

There are several international taxonomies addressing green bond project definitions, including the Green Bond Principles and the Climate Bonds Standard, as well as at the national level in China, and work underway at the European Commission. However, the lack of universal rules and standardisation is a shared and enduring source of concern cited by participants in the market. Convergence towards commonly accepted definitions will be essential to maximise the effectiveness, efficiency and integrity of the market. At the same time, striking a balance between securing market confidence and reducing green transaction costs will be critical.

The speed at which green bond markets develop and mature hinges on many variables, including policy and regulatory factors, market conditions and financing trends. Additionally, the evolving green bond market faces a range of specific challenges and barriers to its further evolution and growth. A key foundation for future market growth is that governments adopt policies supportive of expanded low-carbon project pipelines and bond market development. Banks, corporates and other market participants would then be able to scale up their investments in line with expanded physical asset deployment requirements envisaged under a 2DS. Project bonds and ABS can also play a vital role in

helping to fill investment gaps directly and through capital recycling. The analysis (Kaminker, 2016a) summarised in Chapter 13 suggests that if there is concerted attention by policy makers and market participants, the bond markets can be relied on as a critical foundation for mobilising institutional investors and raising the debt capital that will be needed for the transition to a low-carbon economy.

Institutional investors in the OECD have the potential to absorb the increased supply of such bonds, through shifting asset allocations in response to the increased percentage of low-carbon bonds as a share of the broader bond markets. This conclusion is based on two assumptions: 1) institutional investors' appetite for low-carbon bonds may be expected to grow in light of increasing attention to climate risks and opportunities in investment portfolios; and 2) institutional investors will shift allocations to reflect the increasing share of low-carbon bonds in the market as a whole.

One of the low-cost approaches to developing the green bond market, and leveraging the substantial experiences that have been accumulated by many MDBs, DFIs and public sector entities (such as local governments), is to have them play a more important role in green bond market development.

Through developing green bond markets, MDBs and DFIs can also kick-start the overall growth of a country's bond market. For example, credit enhancement for municipal green bonds can grow a local municipal bond market more broadly. The growth of India's bond market in response to public sector support for infrastructure bond issuance is an example of such an effect. Possible areas drawn from the previous list that MDBs and DFIs can contribute to significantly include: demonstration issuance, including issuance in local currency green bond markets; providing credit enhancements;

providing analytics and tools; setting up vehicles to aggregate investor demand for emerging markets green bonds and serving as an anchor investor for green bonds.

A variety of investment channels are potentially available to institutional investors for accessing sustainable energy, and different channels may be more appropriate when taking into account certain decisions that are routinely made. For example, large institutional investors evaluate prospective investments based on decisions to make the investment directly or to create a contract with an intermediary to make the investment on their behalf. Channels can provide exposure to listed or unlisted debt or equity, a single project asset or company or can bundle multiple smaller-scale projects together. Both institutional investors (and the regulations that govern them), as well as the sustainable energy resources that they seek to invest in are geographically diverse and heterogeneous. This has wide-ranging implications for characteristics such as the scale of both the investors and the physical assets, and means that a diversity of channels will be necessary in practice.

The 'Matrix Frames' proposes in this thesis serve to visualise these different channels and are used three times in the thesis. As such, the Matrix Frame provides an integrated framework that can be used to: 1) understand and compare different instruments and funds available in practice and in theory; 2) illuminate where investment is or is not flowing; 3) highlight potentially promising instruments or funds in which policy makers may consider the use of risk mitigants or transaction enablers to address investment barriers and mobilise flows; and 4) target and undertake data collection on investments in different channels and conduct subsequent empirical analysis.

The absence of observations in certain investment pathways can hypothetically be explained by four reasons: 1) observations exist but adequate data is not available due to lack of publicly available investment disclosure; 2) there is a lack of demand due to reasons such as regulatory barriers, lack of investment experience with a particular type of investment or simply because the investment is deemed uneconomic, not accessible for pension funds (due to restriction or regulation), or impractical; 3) the pathway has not been explored or pursued by the financial community so the investment pathway exists only theoretically but not in practice; 4) there is a lack of mandate for a type of investment as asset allocation or risk management practices may not provide a mandate for a given investment type.

As an example of how the Matrix Frame can be used to theorise and then prove the existence of a potential channel, when these channels were first described in 2015, no individual sustainable energy project had independently listed its equity on an exchange. The following year, a Uruguayan wind farm became the first such project to do precisely that, attracting institutional investors in the process, and filling that channel which had only previously existed in theory, to the best of my knowledge and research efforts. This case study was uncovered in the stock-taking research conducted that same year on behalf of the G20 Green Finance Study Group.

15.2 Implications for future research

15.2.1 Institutional investors

Overall, this thesis endeavoured to map channels and identify areas where both ‘organic’ institutional investment is occurring as well as ‘catalysed’ investment, where the public sector is working to overcome barriers, with a view for laying a foundational framework

for further research and analysis. A first step in determining future avenues for potentially fruitful research is to examine where the research had to draw its boundaries. As such, several areas lay beyond the scope of this report and could usefully be addressed in future research.

While the report focused for the most part on project investment, an analysis of the role of institutional investors in financing corporate investment would be useful to understand how much of the financing gap these sources can realistically fill. Green corporate investment by institutional investors could be useful to examine from several perspectives, from early stage venture capital and growth capital financing to listed equities strategies (e.g. ETF, passive investment and low-carbon index strategies). A deeper inspection of the role of institutions in partnering with corporates on project investments through the project financing cycle, and their role in capital recycling, could similarly be useful.

A number of examples exist throughout the research of small pension fund (less than USD 35 billion in AUM) investment in sustainable energy projects, which may start to challenge the notion that only large pension funds are interested or capable of investing in projects on their own. Examples observed of small pension fund investments for local development of sustainable energy were unexpected (e.g. an example was observed of a local pension fund investment in a local community solar co-operative). As such, analysis of the role of smaller institutional investors aligning with small scale assets could be interesting to explore.

Another area that was outside of the scope of this research was to assess the role of institutional investors in financing different types of green infrastructure beyond sustainable energy. While the stock-taking research conducted in Chapter 13 ventured

beyond sustainable energy, and resulted in a database of 33 case studies (catalogued in Chapter 19: Annex D), it was not intended to be comprehensive and was supposed to be limited to provide a picture of the range of approaches used. However, the distribution of samples across the categories of green infrastructure turned out to reflect the amount of identifiable (and publicly available) institutional investor activity in each sector, with very few examples to be found in some places. For instance, in the green buildings, agriculture/forestry and water/sanitation sectors only one example of institutional investment could be identified per sector. Future research could more systematically examine these important sectors also in need of private capital, to understand the role of institutional investors and what barriers might be specific to them.

The classifications, investment pathways and Matrix Frame establishes a systematic framework for actors to understand the different channels available to institutional investors in practice and in theory, and develops a common language to enable enhanced and aligned communication. They show policy makers where activity is and is not happening. While the research identifies 110 instances of investment, it does not make any comment on the financial performance of these investments. Future analysis could usefully examine the risk and return characteristics of investments and how this is changing over time.

Another future area for research is fundamentally geographical. Green bonds (including corporate, treasuries, project bonds, covered bonds and asset-backed securities), YieldCos, direct investment in projects, and collaborative vehicles are all channels that have experienced growth and innovation in recent years. In the geographies where they have emerged, they all have unique challenges which will need to be surmounted to evolve to a position where they can mobilise institutional investors at scale,

connect directly to projects of all sizes, and contribute to lowering the financing costs of sustainable energy. Uncertainty exists over the scope for these investment channels to emerge and develop in other geographies, especially in emerging markets and developing economies (EMDEs), and much further analysis is needed in this regard.

The cases also highlight the diversity of investments and the channels used to access these investments. Consideration of the geography of institutional investor diversity (form, size, structure, governance) and national regulatory contexts are just as important and will be vital for shaping activity in general. Every country will likely be different. These differences will have implications for which investment channel is most logical or accessible for domestic institutional investors to access. More research is needed to match the geography of institutional investors to investment channels.

To date much of 'organic' institutional investment in sustainable energy projects has occurred in OECD countries. Flows are also found to be largely domestic. For instance, pension funds are investing in local or regionally-relevant projects. There could be information asymmetry reasons behind this, which is an area for potential future investigation and study that already has an established literature base in economic geography. A separate and very important question is how institutional investors approach sustainable energy investments in EMDEs. A quarter (eight) of the case study deals took place in EMDEs, and three further deals involved mandates that extend to EMDEs. Studying the elements that needed to come together to make these deals work and overcome barriers would be important to determine which interventions hold the most promise for catalysing investment in EMDEs, where most investment flows will be needed in coming years.

The results of the research suggest that there are in fact many ways in which governments are already working to help mobilise institutional investment in sustainable energy, using a variety of approaches. Nearly a third of the case studies analysed made use of a risk mitigant as well as a transaction enabler and six deals featured more than one actor. Future research could examine some of the more innovative deals using a more comprehensive and methodical case study approach, to understand what factors were essential in mobilising institutional capital. Assessing empirically the efficiency and effectiveness of different types of risk mitigants and transaction enablers could also hold significant promise for future research, provided the data were of sufficient quality to undertake such a study.

With respect to individual actors, a theme through the thesis is how 'green investment banks' (GIBs) have sought to engage institutional investors. In recent years, at least a dozen special-purpose GIBs have been established. These are domestically-focused public institutions that use limited public capital to leverage or crowd-in private capital, including from institutional investors, for sustainable energy and green infrastructure investment. Given the relatively recent establishment of GIBs, it is notable that five such institutions, located in three countries, were involved across one quarter (eight) of the case studies analysed in this thesis. As such, future research could examine the specific role that GIBs play in catalysing institutional capital.

Another finding of the stock-taking concerned the specific channel used. The most frequent channel to access sustainable energy across the case studies was via a project bond structure (the majority not labelled as green), accounting for 41% (13) of all deals. Of these project bonds, three quarters benefited from credit enhancement techniques; with the majority credit enhanced through some form of partial credit guarantee. This is

consistent with findings in Chapters 11 and 12, which examine the potential for project bonds, among others, to support sustainable energy finance. Given the prevalence of this specific channel, future research could examine these deals in depth and options for scaling-up credit enhancement mechanisms for project bonds.

This thesis did not endeavour to cover all the possible channels for investments in developing countries and the risk mitigants that can be deployed to de-risk those investments to overcome additional barriers. It is necessarily limited in its analysis by the sample of investments covered which focus predominantly on OECD countries. Future work could explore these issues in greater depth, e.g. analysis of the further options that may be unique to Sovereign Wealth Funds and developing country institutional investors.

It follows that it will be very important to explore how institutional investors can interact with international climate finance mechanisms targeted at EMDEs. An examination of the role of institutional investors in the emerging international 'climate finance' architecture was outside the scope of this research but these issues currently arise in discussions around international climate finance and fund mechanisms (see for instance the work of the Global Innovation Lab for Climate Finance).

Moving to a higher level of elevation in terms of the subject area, some other broad questions emerge from this body of research. Given that institutional investment activity has increased during a low-interest rate environment, key macroeconomic drivers for demand could be important to explore in depth, especially in the context of the ongoing global 'search for yield' by institutional investors. Such research could also be geared at improving the understanding on prospects for long-term returns from green infrastructure investing by different types of institutional investor.

More broadly concerning the area of sustainable energy investments, research is needed into what may happen when the low-interest era ends. If the massive investments commensurate with a two-degree scenario are indeed made in sustainable energy, what happens to interest rates and capital markets when effectively hundreds of billions of dollars of annual fuel and energy input costs become transformed into up front capital expenditure?

Other potentially important areas of inquiry include an examination of what is stopping public financial institutions from mobilising institutional investors at a much greater scale? Is it: a) constitutions/terms of engagement; b) balance sheet; c) deal flow; d) institutional inertia, managerial bandwidth, or combinations? How much more institutional investment would flow into sustainable energy if, in each country, it benefited from the most beneficial retirement savings tax treatment available? What might such savings products look like? Finally, as we move to a model of clean digitally-optimised energy, transport and infrastructure, how can institutional investors interact with emerging green digital finance opportunities? Do distributed ledger and blockchain innovations have the potential to unlock new channels and unleash institutional investment in sustainable energy at scale?

15.2.2 Green bonds

Recent history shows many ways in which green bond policies appear to have been effective in lowering costs and expanding the flow of capital to green infrastructure. However, more work is needed in this area to develop and define metrics for evaluating green bond policies as the market grows and matures. The scale of funds flowing through the channel is not a reliable measure of the incremental contribution of green bond-specific policies. Many other policies contribute to the flow, and many other channels

also serve green investments. As such, assessing the effectiveness of policy measures to advance the green bond market is a future research challenge.

Keys to evaluating policies for the green bond market may include cost-benefit analysis approaches including an examination of whether green bonds are lowering the cost of capital for green projects, and whether they lower the total social cost of matching investors with investments, thereby incrementally increasing the flow of funds to green investments. Given green infrastructure investments are capital intensive, even small changes in the weighted average cost of capital can significantly improve the levelised costs of green infrastructure compared with carbon-intensive alternatives, and can strengthen the fundamentals for increased deployment.

Policy will have to evolve and respond to a changing context. As the economy grows and changes, as new information and understanding of the climate change challenge develops, as international negotiations take new turns, all governments must adapt their policies accordingly. New green bond policies will be needed as well, as new types of projects become commercial and available for deployment at scale.

As the green bond market develops and matures, and data on its financial characteristics evolves, research could be targeted at developing increasingly clearer understandings of the financial performance of green bonds, and the economic benefits of the green label that is being applied to bonds. This could also allow for theorising around the evolution of green labelled markets and the efficiency of measures such as ‘back-tagging’. For example, recent public sector-led efforts to grow a green labelled bond market in China and India suggest that in those markets, at the very least, the percentage of bonds potentially eligible for carrying a green label will be higher in the future than at present.

Chapter 11 summarises work that I undertook to develop a framework for understanding possible directions of bond market evolution and for analysing the potential contribution that the bond markets can make to a low-carbon transition. There were several areas that were beyond the scope of the research, but if sufficiently granular data and assumptions were to be made available, the framework constructed could in theory be adapted and applied to these other sectors as well.

For instance, the technological focus of this analysis is on bond financing for the renewable energy, energy efficiency and low-emission vehicle (LEVs) sectors. According to IEA (2014: 199), these sectors are key components of the low-carbon assets included in the 2DS (between 80-90% depending on the scenario as measured by total investment), and were selected because sufficiently granular data and assumptions for these sectors are available [to 2035]. The scope extends only to the energy efficiency portion of building investment though investment in other forms of energy efficiency such as in industry is another integral component of the 2DS pathway. Other elements of aggregate green building investment are also likely to have significant potential for bond financing, but could not be included in the analysis.

Then there are segments of labelled green bond and unlabelled climate bond markets that relate to low-carbon public transportation, climate adaptation, clean water, waste management, agriculture and forestry and other key areas of environmentally-related investment. These sectors were beyond the scope of the analysis (and some sectors like adaptation are not even included in the IEA's 2DS figures) but are clearly important areas of green finance where the bond markets can (and do) play a significant role, and hold potential for mobilising institutional investors. As perspective, the CCICED (2015) estimates that in China approximately 40% of "green investment" needs will be for low-

carbon projects in the period 2014-2020, with the other 60% being needed for sectors such as water (supply, savings and remediation), waste treatment, sewage, land remediation and industrial gas treatment.

The quantification in this analysis of the potential for future low-carbon bond financing covers China, the EU, Japan and the United States, which together represent 68% of the global annual energy sector supply investment needs projected for the next 5 years, and 52% in 2035 in a 2DS according to the IEA. These four markets were selected because they have significantly more established bond markets than other regions (along with sufficiently robust statistics). The analysis of the potential for bond financing in other EMDEs was as such beyond the scope of the analysis and would require enhanced data and assumptions to be made available for a rigorous assessment to be attempted.

16. ANNEX A: BACKGROUND TO THE POLICY RECOMMENDATIONS

In light of the wide body of OECD literature on sustainable energy and private financing (see Literature Review in Chapter 6), Chapter 14.2 presented nine key high level policy conclusions for governments to address barriers and to facilitate institutional investors' investment in sustainable energy infrastructure. In this section, these nine policy recommendations are grouped in 5 categories and referenced according to their roots in the aforementioned OECD policy guidance literature.

16.1 Preconditions for Institutional Investment

Before even considering sustainable energy as a subset of infrastructure investment, investors will only be willing to commit their funds when they have some assurance that financial markets and institutions are safe and sound, and operate according to rules and procedures that are fair, transparent, and free from conflicts of interest and other agency problems (G20/OECD, 2014a). A separate precondition relates to the formation of institutional savings that can be invested in the first place.

1. Establish preconditions for institutional investment and favourable framework conditions for long-term investment financing

- Framework conditions include a stable macroeconomic environment, responsible fiscal management, a strong financial sector, and a well-developed system of channelling public and private savings to longer-term investments (see G20/OECD, 2013, p. 6)
- A favourable business and investment climate and the consistent and effective enforcement of the rule of law are essential for long-term investment. Governments

should create predictable, stable, transparent, fair and reliable business regulation and supervision and administrative and procurement procedures. They should also promote an effective framework for fair competition and sound corporate governance, and clear and reliable creditor rights and insolvency regimes (see G20/ OECD, 2013, p. 6). The investment regime underpinning infrastructure investment should include, inter alia, sound measures for access to land and protection against expropriation, contract renegotiation, settlement of disputes, and tax policy (see OECD, 2015b, forthcoming).

- Steps can be taken by governments to better align long-term interests of institutional investors, asset managers, companies and shareholders, thereby incentivising the latter (e.g. through performance management) to become more long-term engaged investors (see G20/OECD, 2013, p. 7).
- Licensed administrators of institutional investors have a fiduciary duty to members, beneficiaries and other relevant stakeholders to act in their best interests. This duty supports the adoption of a responsible investment approach to deploying capital into markets that will earn adequate risk-adjusted returns suitable for the institution's specific member profile, liquidity needs and liabilities. The implementation of this fiduciary duty can also be supported by appropriate transparency and reporting on financial indicators as well as on environmental, social and governance (ESG) relevant topics (see G20/OECD, 2014a).
- Governments may establish a 'code for responsible investing' which gives institutional investors guidance on how they may execute investment analysis and conduct investment activities, and exercise ownership rights so as to promote sound governance. As such, the 'code' may contain sustainability considerations in addition to many other issues. Such a code may serve as a minimum reference point

for the institutional investor and should not be deemed to preclude higher standards of behaviour. Governments may also assign different definitions of fiduciary duties to different categories of institutional investors (see G20/OECD, 2014a).

- The governing body of an institutional investor should ensure that the institution can properly identify, measure, monitor, and manage the risks associated with long-term assets as well as any long-term risks – including environmental, social and governance risks – that may affect their portfolios (see G20/OECD, 2013, p. 8). The risks associated with long-term investments should also be carefully assessed, including climate and other environmental risks, and exposure to potential future climate regulation (see G20/OECD, 2013, p. 4).
- Where appropriate, institutional investors should disclose with sufficient granularity information on the extent to which their investment strategies are in line with their investment horizon and how they address long-term risks (see G20/OECD, 2013, p. 10).
- When evaluating policies to promote long-term investment by institutional investors, policymakers should ensure its consistency with the best interest of members, investors, beneficiaries, policyholders and other relevant stakeholders, and consider its wider potential public impact (G20/OECD, 2014).

16.2 Investment-grade Policy Environment

The lack of a stable regulatory environment discourages long-term investments. In the case of sustainable energy investment, rapid (and even retroactive) changes to support policies are particularly damaging to investor confidence, especially when they are undertaken without advance notice to allow investors and businesses time to adjust. Existing incentives often provide limited or no pricing of carbon (i.e. the cost of

environmental externalities are poorly reflected or not reflected in prices), subsidise fossil fuel use, or do both. The OECD has developed elements of a 'green investment policy framework' to help governments create and improve domestic enabling conditions to shift and scale-up private sector investments in green infrastructure including from institutional investors (see Corfee- Morlot et al., 2012).

2. Ensure a stable, transparent and integrated 'investment-grade' policy environment addressing key barriers to investment by institutional investors.

- This policy environment may be developed in co-ordination with institutional investors, which provides investors with clear and long-term visibility, predictability and incentives. This helps provide the risk-return profile and confidence in future regulatory stability needed for investors to invest in long-term assets.
- Governments may ensure that policies are of adequate duration, tied to a technology's level of maturity, and matched to the geography and diversity of markets and institutional investors (see Kalamova, et al., 2011).
- Though prudential regulation is important for protecting pension fund members, policy holders and beneficiaries, it sometimes may have unintended consequences, creating barriers to long-term investments by institutional investors which may need to be addressed.
- Governments should review financial regulations to ensure that they do not unduly hamper financing for sustainable energy (see UNEP, 2014) and they should continue to monitor the possible effects of regulatory reforms on the supply of long-term financing (see FSB, 2013).

- Where applied, restrictions on long-term investment in sustainable energy infrastructure by institutional investors should be consistent with diversification and financial regulation objectives. They should be reviewed regularly and, where appropriate, they should be eased subject to necessary safeguards being in place, such as strong governance and risk management mechanisms, effective supervision, and appropriate diversification (see G20/OECD, 2013, p. 9).
- The use of well-designed Power Purchase Agreements or similar measures that achieve cash flow characteristics desired by institutional investors are particularly important and may be considered by governments (IEA, 2014).

3. Improve risk-return profiles of sustainable energy projects by addressing market failures while improving electricity market design.

- Market failures can create risk-return investment profiles that favour polluting or environmentally damaging infrastructure projects over sustainable energy investments.
- Phasing-out inefficient fossil fuel subsidies and implementing regulations that impose a price on environmentally damaging activities (implicitly through standard setting, or explicitly through carbon taxation or emissions trading while providing a clear policy signal of a rising cost for CO_2 emissions over time) are important elements of improving the risk-return profile of sustainable energy investments (OECD, 2013b).
- Provide an electricity market context that assures a reasonable and predictable return for investors in sustainable energy and associated enabling infrastructure by promoting well-designed and time-bound sustainable energy support policies when needed and the use of contracts such as Power Purchase Agreements which provide

institutional investors with revenue stability and certainty (IEA, 2014). Predictability of government programmes is necessary if investors are to initiate a project in clean energy; however, predictability should not be mistaken for permanence. It is important to provide 'sunset clauses' for policies which support investment directly, since over time the financial markets will price risk efficiently and learning benefits will be exhausted (Kalamova et al., 2011).

4. Establish a national infrastructure strategy and road map with project pipeline.

- Develop a sustainable energy plan within a national infrastructure strategy with clear break points where further decisions will need to be made on the basis of technological and other developments, and create a credible sustainable energy road map and pipeline to provide investors with confidence that investable projects will be forthcoming. Create and support facilities focused on improving the 'bankability' of projects through preparation and selection and support initiatives aimed at improving enhanced partnership between the various actors along the project finance chain.
- Governments may develop an infrastructure programme tied to a national strategic vision, which may include a comprehensive infrastructure development strategy based on clearly established guiding principles.
- Strategies and road maps would give confidence to investors in government commitments to the sector and demonstrate that a credible pipeline of investable projects will be forthcoming. This will reassure investors that it is worth building up their investment capability and constructing mandates for investment. Governments may establish, publish and deliver credible national infrastructure pipelines that have been rigorously assessed and prioritised by independent

infrastructure authorities, and which take full advantage of private sector finance and expertise (see B20, 2014, p. 3).

- Where appropriate, governments should provide opportunities for private sector participation in sustainable energy projects via, for instance, public procurement and public-private partnerships. Investment opportunities should enable the different parties to earn returns commensurate to the risks they take. Proper planning and effective management of such initiatives is recommended in order to ensure a regular, coherent pipeline of suitable projects. These initiatives should be supported by a transparent, sound and predictable regulatory framework and subject to effective monitoring and accountability (see G20/OECD, 2013, p. 7).

16.3 Investment Channels

5. Facilitate the development of appropriate green financing instruments and funds:

- Governments should consider issuing appropriate long-term instruments in line with their debt management and capital market development objectives. Such instruments underpin the development of long-dated private sector securities markets and can support asset-liability management by institutional investors and complement long-term investment portfolios (see G20/OECD, 2013, p. 7). Green bonds as a form of long-term instrument have the potential to engage institutional investors at scale.
- Governments can support the development of markets for instruments or funds with appropriate risk-return profiles for institutional investors.
- Governments should establish the necessary regulatory framework for pooled vehicles and securities channelling financing for long-term investment in a sound

and sustainable manner (see G20/OECD, 2013, p. 9). This could apply as well to sustainable energy funds and securities described in this report.

- In markets with limited participation by institutional investors, governments, national development banks, and multilateral development agencies should consider the need for establishing and promoting pooled funds and vehicles for long-term investment, and supporting other instruments for long-term investment such as sustainable energy project bonds and securitised assets. Such financing options should have an investment horizon in line with those of the underlying projects, should be tailored to investor risk profiles across the project lifecycle, and should be developed in close co-operation with institutional investors (see G20/OECD, 2013, p. 9).
- Evaluate the case for passing or amending legislation allowing for sustainable energy infrastructure to be included in existing liquid vehicles that appeal to institutional investors (e.g. covered bonds, Master Limited Partnerships and Real Estate Investment Trusts).

16.4 **Risk Mitigants**

The expected return and risk of investment projects is a core consideration in the effort to attract private financing. Government intervention may be needed in some circumstances, where the rate of return may be insufficient to compensate private sector investors for the perceived level and/or character of risk or to address key market failures that significantly impede the supply of funds (G20/OECD, 2014a).[64]

[64] N.B. The provision of risk mitigation is not universal. Some governments do not offer risk mitigation as a matter of public policy.

6. Facilitate the development of risk mitigants where they would 'crowd-in' private investment and result in more appropriate allocation of risks and their associated returns

- Governments may consider providing risk mitigants to long-term sustainable energy investments projects where it would result in more appropriate allocation of risks and their associated returns. Such risk mitigants may include credit and revenue guarantees, first-loss provisions, cornerstone stakes, public subsidies, and the provision of bridge financing via direct loans (see G20/OECD, 2013, p. 9).
- Governments may use public financing mechanisms to provide cover for risks that are new to investors and cannot be covered in existing markets. Such mechanisms may include loan guarantees, insurance-related options, and other credit enhancement tools to improve flow of financing to projects.
- Governments may use debt instruments such as loan and securities to cover the risks in both construction and post-construction phases of sustainable energy projects, while investment guarantees are provided during the post-construction period.
- Public intervention in sustainable energy projects – selected in light of socio-economic and environmental impact assessments – should be decided on the basis of identified market failures, should avoid crowding-out private investments, and should be selected by carrying out appropriate cost-benefit analysis of such interventions and ensuring that any public support is appropriately priced and is subject to fiscal considerations (see G20/OECD, 2013, p. 9).
- Governments may develop a standard methodology for allocating risks – a set of 'guiding principles' to determine the level of risk allocation optimal to both deliver

value for money and provide investors with an appropriate risk-return (see WEF, 2014, p. 4).

16.5 Transaction Enablers

7. Reduce the transaction costs associated with sustainable energy investment.

- Collaborative actions and resource sharing amongst institutional investors and with other financial institutions should be encouraged and supported in order to facilitate the exchange of expertise, ensure the effective exercise of ownership rights and to allow sufficient scale and diversification to be reached for investment in large, long-term sustainable energy projects. This will also allow for capacity sharing and provide the scale necessary for smaller funds to participate in these projects.
- Support channels for securitisation of sustainable energy debt to pool small-scale projects using a prudent and judicious approach (e.g. supporting efforts to standardise contracts and project evaluation structures, creating aggregation and 'warehousing' facilities).
- Governments can consider creating a sustainable energy project exchange network which provides a standardised, consistent pipeline and marketplace for investors, improves co-ordination among participants, offers technical advice to local governments to improve identification, analysis, procurement and execution of public-private partnerships and other financing options.[65]

8. Promote market transparency and standardisation, and improve data

[65] An example of this type of exchange at a regional level is the West Coast Infrastructure Exchange (WCX), comprising California, Oregon, Washington, and British Columbia (see http://westcoastx. com/).

- Governments may create or support existing platforms for dialogue between institutional investors, the financial industry and the public sector to understand the barriers and opportunities to investment in sustainable energy projects. Institutional investors require support and track records to invest in new asset areas. Learning from leading investors and the experience of peers could assist in building their confidence and the capabilities of other institutional investor service providers (Kaminker et al., 2013).
- Governments may consider conducting 'market consultation' with potential investors. This interactive process is undertaken early in order to generate feedback on a project, learn more about investor preferences and determine refinements needed prior to the tender process. Market sounding must be carefully managed to generate useful information and prevent probity issues (WEF, 2014).
- Governments could, where appropriate and needed, strengthen formal requirements to provide information on investments by institutional investors in sustainable energy, following internationally agreed definitions. This would allow for future monitoring on an international basis. This is necessary for institutional investors themselves to have the necessary data to analyse the performance of these investments and the confidence to then make allocations. It is also necessary for policy makers to be able to understand and monitor such allocations in order to be able to make appropriate policy responses.
- Institutional investors should be encouraged to report their recent allocation to and performance of different long-term assets following standardised classifications and methods, while ensuring the confidentiality of any market-sensitive or proprietary information. The reporting should have an appropriate frequency and should include performance measures calculated over sufficiently long periods.

Such information should be at least available for members, policyholders and other beneficiaries as well as supervisory authorities. To fulfil those reporting requirements, adequate existing reporting sources should be used as far as possible (see G20/OECD, 2013, p. 9).

- Governments may also support investor led initiatives such as the Low Carbon Investment (LCI) Registry, a global public online database of low carbon investments made by institutional investors.
- Governments may support the development and adoption of emerging certification standards for green bonds such as the Climate Bond Standard and Certification Scheme and voluntary guidelines such as the Green Bonds Principles. Rigorous standards and guidelines can allow for straightforward certification and issuance of bond instruments that contribute to a low carbon economy leading to increase market liquidity, comparability and demand from institutional investors. Additionally, they can help prevent risk of so-called 'greenwashing' whereby proceeds from bonds issued do not actually contribute to the intended projects or corporate activities.
- Governments and intergovernmental institutions may organise domestic and international summits and events with the key objective of exchanging ideas and experiences among institutional investors in order to develop best practices for sustainable energy investment.

16.6 New and Existing Public Finance Institutions

9. Consider the case for establishing a special-purpose, domestically-focused 'green investment bank' (GIB) or refocusing activities of existing public financial institutions

- In recent years, at least a dozen special-purpose public 'green investment banks' GIBs have been established. They are domestically-focused public institutions that seek to use limited public capital to leverage or 'crowd-in' private capital, including from institutional investors, for LCR infrastructure investment (see Eklin et al., 2015, forthcoming).
- GIBs can facilitate the development of financing instruments and funds, risk mitigants and transaction enablers, and provide technical advice and project preparation and selection.
- Governments may consider the case for establishing a GIB, which can be a useful entity for governments to mobilise domestic private capital, including from institutional investors. As they are being used in different ways in different country settings, their varying operational models and focuses suggest a potential for their adaptation and replication at the national and sub-national level (G20/OECD, 2014b, p.18).
- To consider the case for establishing a GIB, governments should conduct a market assessment exercise to reveal market barriers, financing gaps and potential offerings and modalities.
- GIBs are making their place within a broader ecosystem of domestic and international public institutions engaged in catalysing private and institutional investment in LCR infrastructure. Such institutions include broader-scoped international financial institutions (including multilateral development banks and bilateral development banks), climate investment funds, national development banks and other public finance institutions. As such, governments may examine the roles played by those institutions and whether mobilising capital from institutional investors for sustainable energy investment has been sufficiently mainstreamed.

17. ANNEX B: FULL LIST OF PUBLICATIONS

The following is a full list of all my publications, including those that I authored before commencing the doctorate. The documents are updated and available on the University of Oxford, School of Geography and the Environment website at: http://www.geog.ox.ac.uk/graduate/research/ckaminker.html

1. Kaminker, C. (2018, forthcoming) 'Institutional investors and green infrastructure'. In Caldecott, B.L. (editor) *Stranded assets and the environment: risk, resilience, and opportunity*. Routledge (London, UK). ISBN: 978-1138120600
2. Kaminker, C. and Majowski, C. (2017) *Green Bonds in G20 Emerging Markets*. Central University of Finance and Economics (CUFE). Available at: http://www.greenfinance.org.cn/
3. Kaminker, C. (2017) *Mobilising Bond Markets for a Low-Carbon Transition*, *OECD Publishing*. Edited by C. Kaminker. Paris: OECD Publishing. doi: 10.1787/9789264272323-en.
4. Ma, J. *et al.* (2016) 'Green Bonds: Country Experiences, Barriers and Options', *G20 Green Finance Study Group*. Available at: http://unepinquiry.org/wp-content/uploads/2016/09/6_Green_Bonds_Country_Experiences_Barriers_and_Options.pdf.
5. Kaminker, C. (2016) *A Quantitative Framework for Analysing Potential Bond Contributions in a Low-Carbon Transition*, *OECD Publishing*. Paris. Available at: https://www.oecd.org/cgfi/quantitative-framework-bond-contributions-in-a-low-carbon-transition.pdf.
6. Kaminker, C. (2016) *Progress Report on Approaches to Mobilising Institutional Investment for Green Infrastructure*, *OECD Publishing*. Paris. Available at: http://www.oecd.org/cgfi/resources/Progress_Report_on_Approaches_to_Mobilising_Institutional_Investment_for_Green_Infrastructure.pdf.
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8. Kaminker, C. (2015) 'Policy Perspectives: Green Bonds - Mobilising the debt capital markets for a low-carbon transition', *OECD Publishing*. Paris, (OECD/Bloomberg Philanthropies). Available at: http://www.oecd.org/environment/cc/Green bonds PP [f3] [lr].pdf
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11. Kaminker, C. and Kawanishi, O. (2013) 'Long-term investors and green infrastructure: Policy Highlights from Institutional Investors and Green Infrastructure Investments: Selected Case Studies', *OECD Publishing*. Paris: OECD Publishing. Available at: https://www.oecd.org/env/cc/Investors in Green Infrastructure brochure (f) [lr].pdf.
12. Kaminker, C. *et al.* (2013) *Institutional Investors and Green Infrastructure Investments: Selected Case Studies*, *OECD Publishing*. Paris. doi: 10.1787/5k3xr8k6jb0n-en.
13. Corfee-morlot, J. and Kaminker, C. (2012) 'Policy Perspectives: Financing Climate Action'. Paris: OECD Publishing. Available at: http://www.oecd.org/environment/cc/49096643.pdf.

14. Hascic, I. *et al.* (2012) 'Recent Trends in Innovation in Climate Change Mitigation Technologies', in *Energy and Climate Policy: Bending the Technological Trajectory*. Paris: OECD Publishing. doi: http://dx.doi.org/10.1787/9789264174573-4-en.
15. Corfee-morlot, J. *et al.* (2012) *Towards a Green Investment Policy Framework*, *OECD Publishing*. Paris. doi: 10.1787/5k8zth7s6s6d-en.
16. Inderst, G., Stewart, F. and Kaminker, C. (2012) *Defining and Measuring Green Investments: Implications for Institutional Investors' Asset Allocations*, *OECD Publishing*. Paris. doi: 10.1787/5k9312twnn44-en.
17. Kaminker, C. and Stewart, F. (2012) *The Role of Institutional Investors in Financing Clean Energy*, *OECD Publishing*. Paris. doi: 10.1787/5k9312v21l6f-en
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18. ANNEX C: LIST OF INVITED PRESENTATIONS

The following is a list of the opportunities I have had to present elements of my research and receive feedback over the course of the thesis period (2013-2016).

1. Kaminker, C. (2016j) '*Presentation: Mobilising Bond Markets and Progress Report on Institutional Investors*', OECD Working Party on Climate Investment and Development, 21 November 2016, Paris
2. Kaminker, C. (2016i) '*Presentation: Mobilising Bond Markets and Institutional Investors*', COP22 session - 7th Annual OECD Institutional Investors High-Level Breakfast, Four Seasons, 17 November 2016, Marrakech
3. Kaminker, C. (2016h) '*Presentation: Quantitative framework for bond contributions in a low-carbon transition*', OECD Green Investment Financing Forum, 14 October 2016, Asian Development Bank Institute, Tokyo
4. Kaminker, C. (2016g) '*Presentation: The role of institutional investors in financing green energy*', APEC Conference on Green Energy Finance, Ministry of Economic Affairs, August 18 2016, Chinese Taipei
5. Kaminker, C. (2016f) '*Presentation: G20/OECD work on institutional investors and green infrastructure*', Oxford Global Infrastructure Conference: Bridging the Infrastructure Gap: Global Integration and the One Belt One Road Initiative, 1 July 2016, University of Oxford
6. Kaminker, C. (2016e) '*Presentation: Mobilising the bond markets for green infrastructure*', Banque de France, 3 May 2016, Paris
7. Kaminker, C. (2016d) '*Presentation: Quantitative assessment of green bond market evolution*', G20 Green Finance Study Group Meeting, IMF/World Bank Spring Meetings, April 12 2016, Washington DC
8. Kaminker, C. (2016c) '*Presentation: Mobilising the bond markets for green infrastructure*', ICMA Public Sector Issuers Forum, March 15 2016, Paris
9. Kaminker, C. (2016b) '*Presentation: Mobilising Bond Markets and Progress Report on Institutional Investors*', OECD Working Party on Climate Investment and Development, 23 February 2016, Paris
10. Kaminker, C. (2016a) '*Presentation: Public sector actions to grow green bond markets*', G20 Green Finance Study Group Inaugural Meeting, Ritz Carlton, January 23 2016, Beijing, China
11. Kaminker, C. (2015n) '*Keynote* p*resentation: Mobilising the debt capital markets for a low-carbon transition*', OECD/Bloomberg Green Bonds Roundtable, December 10 2015, Paris
12. Kaminker, C. (2015m) '*Presentation: green bonds and institutional investors*', UNFCCC COP21 Side Event: Aggregating Finance for Low Carbon Energy
13. Kaminker, C. (2015l) '*Presentation: Institutional investors and green infrastructure*', G20 GreenInvest, 8 October 2015, Annual Meetings of the IMF/World Bank Group, Lima, Peru
14. Kaminker, C. (2015k) '*Presentation: Institutional investors and sustainability*', SEB/Columbia University Earth Institute Capital Markets Symposium, 5 October 2015, New York.
15. Kaminker, C. (2015j) '*Presentation: Institutional investors and sustainability*', Allianz-Oxford Pensions Conference, 1 October 2015, University of Oxford
16. Kaminker, C. (2015i) '*Presentation: Financing the future and balancing sustainability*', Fourth Global Conference on Economic Geography, 22 August 2015, University of Oxford

17. Kaminker, C. (2015h) '*Presentation: Institutional investment in green infrastructure*', Oxford Infrastructure Investment Consortium Workshop: Infrastructure Investment in Emerging Markets and Developing Economies, 2 July 2015, St. Catherine's College, University of Oxford
18. Kaminker, C. (2015g) '*Discussant: Green Securitisation Roundtable*', LSE/Nomura Green Securitisation Workshop, 8 June 2015, London
19. Kaminker, C. (2015f) '*Presentation: Mobilising the Debt Capital Markets for a Low Carbon Transition*', G20/OECD Task Force on Institutional Investors and Long Term Financing, G20 Investment and Infrastructure Working Group 2nd Meeting, 28 May 2015, Singapore
20. Kaminker, C. (2015e) '*Presentation: Institutional Investors and the Low-Carbon Transition*', Meeting of the Portfolio Decarbonization Coalition, 16 May 2015, Villa Medici, Rome
21. Kaminker, C. (2015d) '*Presentation: Green bonds and institutional investors*', OECD/WBG/UNEP Workshop on Green Bonds, IMF/World Bank Spring Meetings, 16 April 2015, IFC, Washington D.C.
22. Kaminker, C. (2015c) '*Presentation: Investment in Energy Efficiency: Institutional investors and Green Banks*', G20 Energy Sustainability Working, Energy Efficiency Financing Task Force Meeting, 13 March 2015, Paris
23. Kaminker, C. (2015b) '*Presentation: Aligning financial and prudential regulations for a low carbon transition*', OECD Aligning Policies for the Low Carbon Economy Workshop, 17 February 2015, Paris
24. Kaminker, C. (2015a) '*Keynote presentation: Long term investment in APEC's green infrastructure*', APEC Seminar on Addressing constraints in Promoting PPPs in Infrastructure, 14 Jan 2015, Ha Noi, Vietnam
25. Kaminker, C. (2014l) '*Discussant: Green Revolution and ESG*', OECD-Euromoney Infrastructure Summit, 26 November 2014, Hotel Collectionneur, Paris
26. Kaminker, C. (2014k) '*Presentation*: *The Potential for Green Bonds*', 4th Annual San Giorgio Group Meeting, San Giorgio Maggiore, 17 October 2014, Venice, Italy
27. Kaminker, C. (2014j) '*Presentation: Mapping Channels to Mobilise Institutional Investment in Sustainable Energy*', OECD Working Party on Climate Investment and Development, 1 October 2014, Paris
28. Kaminker, C. (2014i) '*Presentation: Mapping Channels to mobilise green investment*', Official OECD-IGES Side Event, UNFCCC COP 20, 5 December 2014, Lima, Peru
29. Kaminker, C. (2014h) '*Presentation: IEA World Energy Investment Outlook*', Impax, 12 September 2014, London
30. Kaminker, C. (2014g) '*Presentation: Institutional Investors and Green Infrastructure Investments*', G20/OECD Task Force on Institutional Investors and Long Term Financing, 9 September 2014, Paris
31. Kaminker, C. (2014f) '*Presentation: Financing energy demands by 2035 in the context of climate change,* HSBC/2ii Conference, HSBC France Headquarters, 19 June 2014, Paris
32. Kaminker, C. (2014e) '*Presentation: Mapping Channels for Institutional Investment in Sustainable Energy',* OECD Inaugural Green Investment Financing Forum, 12 June 2014, Paris
33. Kaminker, C. (2014d) '*Presentation: Institutional Investment in Clean Energy',* US Department of Energy Finance Working Group, 23 May 2014, Washington DC
34. Kaminker, C. (2014c) '*Presentation: Institutional Investors and Green Infrastructure: State and Trends',* US Department of the Treasury, 22 May 2014, Washington DC

35. Kaminker, C. (2014b) '*Presentation to the Energy Geography Working Group: Institutional Investors and Green Investments'*, Association of American Geographers Annual Meeting, 11 April 2014, Tampa, FL
36. Kaminker, C. (2014a) '*Keynote presentation: Institutional Climate Investments'*, U.N. Secretary General's Office Working Group on Pension Funds and Climate Change, January 14, Rockefeller Foundation, New York
37. Kaminker, C. (2013j) '*Keynote presentation: Institutional Investors and Climate Resilient Investments in Emerging Markets'*, OECD Ambassador's Informal Working Group on Development Strategy, 9 December 2013, Paris
38. Kaminker, C. (2013i) '*Keynote presentation: Institutional Investors and Green Infrastructure Investments: Policy Perspectives'*, EFFAS European Bond Commission Conference, 14 October 2013, Bloomberg L.P., London, UK
39. Kaminker, C. (2013h) '*Presentation to the Energy Geography Working Group: Greening the Growth Trajectory of the OECD'*, Royal Geographical Society Annual Meeting, 30 August 2013, Imperial College London, UK

19. ANNEX D: 33 CASE STUDIES USED IN CHAPTER 13

19.1 Sustainable Energy

Case Study Number:	1
Title:	GIB Offshore Wind Fund
Sector:	Sustainable Energy
Subsector:	Offshore wind
Physical asset descriptor:	As of February 2016 the fund had five investments o 24.95% in Rhyl Flats (gross 90MW) o 20% in Sheringham Shoal (gross 317MW) o 10% in Gwynt y Mor (gross 576MW) o 61% in the combined Lynn and Inner Dowsing (together gross 194MW) Taken together these assets are capable of producing 3,970 GWh of net renewable electricity annually
Location(s):	UK
Channel and financial structure*:	Intermediated unlisted project equity. The Fund is managed by an FCA registered subsidiary of GIB – UK Green Investment Bank Financial Services Limited
Institutional investor(s):	As of October 2015 the Fund had total committed capital of £818m from UK based pension funds, such as Strathclyde Pension Fund, as well as international institutional investors, including one of the world's largest sovereign wealth funds and Sweden's AMF Pensionsförsäkring AB, a leading European life and pension company
Capital commitment:	GBP 818 million
Aggregate deal size:	GBP 1 billion
Stage in project:	Operational unlevered offshore wind power generation assets
Role and nature of public sector action:	Layered fund subordination; blending; cornestone stake
Deal date(s):	2015

Sources:
http://www.greeninvestmentbank.com/funds/offshore-wind-fund/
Personal communication with UK GIB (Jeremy Burke)

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Case Study Number:	2
Title:	Greencoat UK Wind
Sector:	Sustainable Energy
Subsector:	Wind
Physical asset descriptor:	16 onshore and 1 offshore wind farms, aggregate net installed capacity of 400 MW
Location(s):	UK
Channel and financial structure*:	Intermediated listed project equity, YieldCo fund managed by UK Greencoat Wind
Institutional investor(s):	Greencoat UK Wind itself is a listed infrastructure fund which has a broad investor base including numerous institutional investors such as LPFA
Capital commitment:	n/a
Aggregate deal size:	GBP 260 million (IPO) GBP 50 million, secondary offering
Stage in project:	Operating wind farms
Role and nature of public sector action:	The UK government (Department for Business, Innovation and Skills) provides a cornerstone stake in the Initiatl Public Offering (IPO). The UK Green Investment Bank advises on deals and co-invests with the fund.
Deal date(s):	2014

Sources:
http://www.oecd.org/environment/mapping-channels-to-mobilise-institutional-investment-in-sustainable-energy-97892642245
http://www.greencoat-ukwind.com/

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Case Study Number:	3
Title:	Lake Turkana Wind
Sector:	Sustainable Energy
Subsector:	Wind
Physical asset descriptor:	Onshore wind farm, 310 MW
Location(s):	Kenya
Channel and financial structure*:	Unlisted equity investment in the project intermediated through the Danish Climate Investment Fund (DCIF)
Institutional investor(s):	The DCIF which manages blended capital from the Danish government, IFU (an investment fund owned by the Danish government) and Danish pension funds
Capital commitment:	DKK 107 million for project. DCIF has private fund commitment of a total of DKK 774m contributed by pension funds PensionDanmark, PKA and Pædagogernes Pensionskasse (PBU), the private investment fund Dansk Vækstkapital and Aage V. Jensen Charity Foundation.
Aggregate deal size:	Project valued at EUR 625 million. The DCIF manages DKK 1.3bn of public and private funds.
Stage in project:	Construction
Role and nature of public sector action:	The Danish government and IFU provide cornerstone investments in the DCIF. Denmark's Export Credit Agency also provides a loan guarantee. The Lake Turkana Project itself benefited from a EUR 20 million guarantee from the AfDB.
Deal date(s):	2015

Sources:
http://www.oecd.org/environment/mapping-channels-to-mobilise-institutional-investment-in-sustainable-energy-978926422458
OECD (2016 forthcoming) Danish Climate Investment Fund Case Study
http://www.danishclimateinvestmentfund.com/

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Case Study Number:	4
Title:	Albion Community Power
Sector:	Sustainable Energy
Subsector:	Various
Physical asset descriptor:	Community-scale renewable energy projects including solar PV, hydroelectricity, biogas and onshore wind.
Location(s):	UK
Channel and financial structure*:	Direct investment in unlisted equity of a pure-play corporate
Institutional investor(s):	Greater Manchester Pension Fund and Strathclyde Pension Fund
Capital commitment:	GBP 70 million (50m by UK GIB, 10m each by Strathclyde Pension Fund and Greater Manchester Pension Fund)
Aggregate deal size:	GBP 100 million
Stage in project:	Construction
Role and nature of public sector action:	The UK GIB made a co-investment. Albion Community Power also is supported by policy incentives provided by the UK government: Feed in Tariffs; Renewable Obligation Certificates; and Renewable Heat Incentives.
Deal date(s):	2014-2015

Sources:
http://www.albioncommunitypower.co.uk/sites/default/files/Albion%20Community%20PLC%20Half%20yearly%20financial%2
http://www.greeninvestmentbank.com/news-and-insight/2015/albion-community-power-secures-10m-from-greater-manchester

Case Study Number:	5
Title:	Crescent Dunes Solar
Sector:	Sustainable Energy
Subsector:	Solar power
Physical asset descriptor:	Concentrated Solar Power (CSP), 110 MW
Location(s):	USA
Channel and financial structure*:	Direct investment in unlisted equity of a project-development company
Institutional investor(s):	Public Sector Pension Investment Board (Canada) and Ontario Teachers' Pension Plan
Capital commitment:	The ownership of the USD 2 billion portfolio will be split approximately into thirds between Santander and each of the two pension funds.
Aggregate deal size:	USD 2 billion
Stage in project:	Construction
Role and nature of public sector action:	The US Department of Energy provided a loan guarantee in 2011 of USD 737 million for SolarReserve's project development company, Tonopah Solar Energy which was formed to develop the 110 MW Crescent Dunes Concentrated Solar Power (CSP) project in Tonopah, Nevada.
Deal date(s):	2014-2015

Sources:
http://social.csptoday.com/markets/new-potential-source-csp-finance-pension-funds-buy
http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=60

Case Study Number:	6
Title:	Bloom Energy
Sector:	Sustainable Energy
Subsector:	Fuel cell
Physical asset descriptor:	A manufacturer on-site power generation systems using fuel cell technology
Location(s):	USA
Channel and financial structure*:	Direct investment in unlisted equity of a pure-play corporate
Institutional investor(s):	Morgan Stanley, Madrone Capital, Alberta Investment Management Corp. (Canada), the New Zealand Superannuation Fund and others
Capital commitment:	USD 100 million from NZ Super; undisclosed from others
Aggregate deal size:	The company has now raised more than $1.2 billion as of 2015
Stage in project:	Technologies in development and deployment
Role and nature of public sector action:	The US Department of Treasury provided grant awards totalling $15 million under the 1603 Treasury Program, a technology-neutral finance mechanism that allows solar and other renewable energy project developers to receive a direct federal grant in lieu of the Section 48 Investment Tax Credit (ITC). A $16.5 million loan guarantee from Delaware Strategic Fund was also provided
Deal date(s):	2011-2015

Sources:
https://www.nzsuperfund.co.nz/news-media/nz-super-fund-increases-stake-bloom-energy

Case Study Number:	7
Title:	Off Grid Electric Tanzania
Sector:	Sustainable Energy
Subsector:	Small scale distributed solar and battery storage for households and small businesses
Physical asset descriptor:	Community-scale renewable energy projects including solar PV, hydroelectricity, biogas and onshore wind.
Location(s):	Tanzania
Channel and financial structure*:	Unlisted debt investment intermediated through a debt vehicle
Institutional investor(s):	The David and Lucile Packard Foundation, Ceniarth, Calvert Foundation and other family offices
Capital commitment:	The Packard Foundation, Ceniarth, Calvert Foundation and other family offices will lend up to USD 40 million to the fund.
Aggregate deal size:	Off Grid investment totals USD 70 million including a USD 25 million Series C in October led by DBL Partners along with Western Technology Investment, SolarCity, Omidyar Network, Serious Change LP, Vulcan Capital and the private investment firm of Microsoft co-founder Paul Allen.
Stage in project:	Construction
Role and nature of public sector action:	Grant and partnership: A USD 5 million grant is provided by the U.S. Agency for International Development (USAID). The organising company, Off Grid Electric, has a partnership with the national government.
Deal date(s):	2015

Sources:
http://www.greentechmedia.com/articles/read/Off-Grid-Electric-Raises-45M-in-Debt-For-African-Micro-Solar-Leasing-Platf
http://offgrid-electric.com/#home

Case Study Number:	8
Title:	Hawaii GEMS (Green Energy Market Securitisation)
Sector:	Sustainable Energy
Subsector:	Distributed solar and other technologies that support PV interconnection, such as energy storage, advanced inverters and monitoring devices.
Physical asset descriptor:	GEMS has the ability to finance the installation of over 44 MW of green energy, assisting as many as 30,000 underserved Hawaii consumers
Location(s):	USA, Hawaii
Channel and financial structure*:	Debt: Listed AAA-rated green asset-backed securities in two tranches
Institutional investor(s):	Goldman Sachs and Citi were joint underwriters with a view to selling the bonds to undisclosed institutional bond investors
Capital commitment:	USD 150 million
Aggregate deal size:	USD 150 million
Stage in project:	Construction
Role and nature of public sector action:	Conduit: The Hawaii Public Utilities Commission on Sept. 4, 2014 issued an order permitting the State of Hawaii to issue USD 150 million of Green Infrastructure Bonds to fund GEMS. The PUC on Sept. 30 issued a second order allowing the State Department of Business, Economic Development and Tourism/Hawaii Green Infrastructure Authority to launch the GEMS program.
Deal date(s):	2014

Sources:
http://energy.hawaii.gov/gems-faqs-2
https://www.climatebonds.net/2014/11/aloha-hawaiian-state-govt-issues-green-abs-solar-150m-aaa-two-tranches-50m-8yr-146

Case Study Number:	9
Title:	Pampa Wind
Sector:	Sustainable Energy
Subsector:	Onshore wind
Physical asset descriptor:	On-shore windfarm, 141MW
Location(s):	Uruguay
Channel and financial structure*:	Listed equity investment in a project intermediated through a wind energy trust (Shares issued on Montevideo Stock Exchange)
Institutional investor(s):	Undisclosed institutional investors including pension funds and insurers, as well as retail investors, banks and SOE utility
Capital commitment:	USD 77.6 million
Aggregate deal size:	USD 321 million
Stage in project:	Construction
Role and nature of public sector action:	Cornerstone stake: A state-owned utility power company (UTE) took a USD 19 million cornerstone investment stake in the trust; KfW provided a loan to the project
Deal date(s):	2015

Sources:
http://www.bloomberg.com/news/articles/2015-03-25/uruguay-utility-raises-77-6-million-to-build-biggest-wind-farm

Case Study Number:	10
Title:	ReNew Wind
Sector:	Sustainable Energy
Subsector:	Onshore wind
Physical asset descriptor:	84.65 MW wind power project
Location(s):	India, Maharashtra
Channel and financial structure*:	Debt: Listed project bond refinances project debt
Institutional investor(s):	IDFC and Yes Bank underwrites the bonds in a private placement with a view to selling them to other institutional investors
Capital commitment:	Rs 4.51 billion ($68 million)
Aggregate deal size:	Rs 4.51 billion ($68 million)
Stage in project:	Operational - refinancing
Role and nature of public sector action:	Credit enhancement: India Infrastructure Finance Company Limited (a wholly government-owned company) provides a “first loss” partial credit guarantee to the bondholders. ADB also provides an irrevocable backstop credit guarantee. a CRISIL rating of AA+
Deal date(s):	2015

Sources:
http://blogs.adb.org/blog/first-bond-issue-under-guarantee-facility-can-be-boon-indian-infrastructure

Case Study Number:	12
Title:	Tiwi MakBan Geothermal
Sector:	Sustainable Energy
Subsector:	Geothermal power
Physical asset descriptor:	676 MW power plant
Location(s):	Philippines
Channel and financial structure*:	Debt: Non-recourse listed project bond and loan
Institutional investor(s):	Bank of the Philippine Islands acted as an arranger and an underwriter with a view to selling bonds to other institutional investors
Capital commitment:	PHP 10.7 billion ($225 million) local currency green bond comes in addition to a direct ADB loan of PHP1.8 billion ($37.7 million)
Aggregate deal size:	PHP 10.7 billion ($225 million) local currency green bond comes in addition to a direct ADB loan of PHP1.8 billion ($37.7 million)
Stage in project:	Operational refinancing
Role and nature of public sector action:	Credit enhancement: ADB will provide credit-enhancement to the Philippine firm AP Renewables, Inc. (APRI), a subsidiary of AboitizPower Corporation (AboitizPower), for the Tiwi-MakBan geothermal energy facilities. ADB provides a loan and partial credit enhancement in the form of a guarantee of 75% of the principal and interest on the bond
Deal date(s):	2016

Sources:
http://www.adb.org/news/adb-backs-first-climate-bond-asia-landmark-225-million-philippines-deal

Case Study Number:	13
Title:	Montalto di Castro Solar
Sector:	Sustainable Energy
Subsector:	Solar PV
Physical asset descriptor:	44 MW power plant
Location(s):	Italy
Channel and financial structure*:	Debt: Listed asset backed security (ABS) issued by SunPower
Institutional investor(s):	Half of the EUR 97.6 million Class A1 bonds placed with institutional investors
Capital commitment:	EUR 48.8 million
Aggregate deal size:	EUR 195.2 million
Stage in project:	Development, construction and operational
Role and nature of public sector action:	Credit enhancement and cornerstone stake: The Class A1 benefit from a loan guarantee by SACE (an insurance and financial group controlled by Italy's Ministry of Economy and Finance) and its Aa2 credit rating from Moody's. The class A2 bonds were rated Baa3 from Moody's and were purchased by the European Investment Bank.
Deal date(s):	2010

Sources:
http://www.oecd.org/finance/private-pensions/49016671.pdf

Case Study Number:	14
Title:	NTR Wind Fund
Sector:	Sustainable Energy
Subsector:	Onshore wind
Physical asset descriptor:	270 MW of onshore wind farms
Location(s):	Ireland and the UK
Channel and financial structure*:	Unlisted equity investment in projects intermediated through a fund
Institutional investor(s):	NTR, Legal and General Capital, Strathclyde Pension Fund, Ireland Strategic Investment Fund
Capital commitment:	EUR 50 million from Strathclyde Pension Fund, EUR 35 million from Ireland Strategic Investment Fund, EUR 118.5 million from Legal & General
Aggregate deal size:	EUR 250 million
Stage in project:	Construction
Role and nature of public sector action:	Cornerstone stake: Public investor, Ireland Strategic Investment Fund made a cornerstone investment in the fund
Deal date(s):	2016

Sources:
http://www.legalandgeneralcapital.com/media-centre/press-releases/NTR-wind-fund-close.pdf

Case Study Number:	15
Title:	Ararat Australia Wind
Sector:	Sustainable Energy
Subsector:	Onshore wind
Physical asset descriptor:	240MW (75 wind turbines)
Location(s):	Australia, south-west Victoria
Channel and financial structure*:	Equity: Direct co-investment
Institutional investor(s):	OPSEU Pension Trust (OPTrust - Canadian Pension Fund) 30% equity stake in project
Capital commitment:	AUD 135 million
Aggregate deal size:	AUD 450 million
Stage in project:	Construction
Role and nature of public sector action:	Co-investment: Australia's public green bank, Clean Energy Finance Corporation (CEFC) committed $67 million as part of a five-year, $276 million senior secured debt financing
Deal date(s):	2015

Sources:
http://www.cleanenergyfinancecorp.com.au/media/releases-and-announcements/files/cefc-finance-contributes-to-ararat-wi

Case Study Number:	16
Title:	Cestas solar
Sector:	Sustainable Energy
Subsector:	Solar PV
Physical asset descriptor:	Solar PV power plant, 300 MW, estimated production of 350GWh/year in permanent regime
Location(s):	France, Cestas
Channel and financial structure*:	Direct equity co-investment in asset
Institutional investor(s):	The company called Neoen (renewable energy producer) owns 40 % of the PV installation; the rest is split between 8 private equity co-investors including infrastructure funds managing institutional capital (Mirova, KKB, Acofi, Omnes)
Capital commitment:	EUR 360 million
Aggregate deal size:	EUR 576 million
Stage in project:	Construction
Role and nature of public sector action:	French Treasury input describes a public intervention through a public revenue guarantee involving reimbursement of feed-in-tariff. EDF buys the produced electricity at 105 €/MWh and public authorities then reimburse EDF.
Deal date(s):	2015

Sources:

Private input and communication via French Treasury (Gildas Lame)

Case Study Number:	17
Title:	Seine Rive Gauche wind
Sector:	Sustainable Energy
Subsector:	Onshore wind
Physical asset descriptor:	On-shore windfarm, 75 MW, estimated production of 183 GWh/year in permanent regime
Location(s):	France, Chartres
Channel and financial structure*:	Direct intermediated project equity
Institutional investor(s):	German investment fund KGAL, managing institutional capital
Capital commitment:	EUR 120 million
Aggregate deal size:	EUR 220 million
Stage in project:	Construction
Role and nature of public sector action:	French Treasury input describes a public intervention through a public revenue guarantee involving reimbursement of feed-in-tariff. EDF buys the produced electricity at 82 €/MWh and public authorities then reimburse EDF.
Deal date(s):	2015

Sources:
http://www.engineeringnews.co.za/article/seine-rive-gauche-nord-wind-farm-project-france-2014-04-18
Private input and communication via French Treasury (Gildas Lame)

Case Study Number:	18
Title:	Gemini Offshore Wind
Sector:	Sustainable Energy
Subsector:	Offshore wind
Physical asset descriptor:	600 MW offshore wind farm (EUR 2.8 billion)
Location(s):	Netherlands
Channel and financial structure*:	Direct subordinated debt
Institutional investor(s):	Danish pension fund PKA
Capital commitment (USD):	EUR 120 million
Aggregate deal size (USD):	EUR 2.8 billion
Stage in project:	Construction
Role and nature of public sector action:	Cornerstone investment and Syndication: EIB provided €587 million of the senior debt, through direct cornstone stake of €200 million and funding for public export credit agencies EKF (Denmark), ONDD (Belgium). Export Development Canada and two institutional investors participated in the syndication. PKA invested €120 million and Allianz-backed Euler Hermes guaranteed senior debt worth €350m (not included in capital commitment)
Deal date(s):	2015

Sources:
https://finance.siemens.com/financialservices/global/en/press/sfs-in-the-press/documents/2014_06_pfi_gemini-closed.pdf
https://www.environmental-finance.com/content/deals-of-the-year/wind-project-gemini.html

19.2 Energy Efficiency

Case Study Number:	1
Title:	Cheltenham Hospital
Sector:	Energy Efficiency
Subsector:	Combined Heat and Power (CHP)
Physical asset descriptor:	Installation of a 1.3 MW combined heat and power unit at Cheltenham General Hospital
Location(s):	UK
Channel and financial structure*:	Unlisted equity investment in a project intermediated through an infrastructure fund
Institutional investor(s):	Aviva Investors
Capital commitment:	GBP 1.1 million from Aviva
Aggregate deal size:	GBP 3.1 million
Stage in project:	Construction and operational
Role and nature of public sector action:	Cornerstone stake and grant: The UK GIB made a cornerstone investment in the infrastructure fund. This project also received a grant from the Department of Health.
Deal date(s):	2014

Sources:
http://www.greeninvestmentbank.com/news-and-insight/2014/uk-green-investment-bank-announces-programme-of-support-

Case Study Number:	2
Title:	IDB Efficiency ABS
Sector:	Energy Efficiency
Subsector:	Energy efficiency projects for Mexican SMEs (purchased through a warehouse facility)
Physical asset descriptor:	Contribution towards $125 million in financing for energy efficiency projects developed by Mexican energy service companies (ESCOs)
Location(s):	Mexico
Channel and financial structure*:	Debt: Listed green bond (ABS)
Institutional investor(s):	IDB structures the ABS with a view to selling to institutional investors
Capital commitment (USD):	USD 50 million
Aggregate deal size (USD):	USD 50 million
Stage in project:	Implementation
Role and nature of public sector action:	Credit enhancement and warehousing: USD 50 million green bond backed by energy efficient projects by Mexican SMEs (purchased through a warehouse facility) - Up to USD 56 million of partial credit guarantees for the subsequent securitization of the pool of energy efficiency loans. The project also benefits from USD 19 million partial credit guarantees from the Clean Technology Fund.
Deal date(s):	2014

Sources:
https://www.climatebonds.net/2015/11/first-round-un-green-climate-fund-projects-kick-starts-green-securitisation-markets-la
http://www.iadb.org/en/projects/project-description-title,1303.html?id=ME-L115

Case Study Number:	21
Title:	NY WHEEL
Sector:	Energy efficiency and Renewable energy (solar)
Subsector:	Energy efficiency and Renewable energy (solar)
Physical asset descriptor:	Statewide energy efficiency and renewable energy improvement loans of up to USD 20 000 with a duration of up to 10 years for up 12 000 owner-occupied NY residences.
Location(s):	New York, United States
Channel and financial structure*:	Debt: Energy Efficiency Loan Asset-Backed Security
Institutional investor(s):	Undisclosed institutional investors
Capital commitment:	USD 20 million
Aggregate deal size:	USD 100 million
Stage in project:	Construction (the portfolio of loan receivables is expected to be securitized within approximately 18 months of September 2015)
Role and nature of public sector action:	Subordination: Public-private partnership with Citi: NY Green Bank provided USD 20 million of subordinated capital to RF Finance, which, together with a warehouse line of credit provided by Citi, will finance the purchase of New York State residential energy efficiency receivables, as well as a small portion of renewable energy receivables. These will be pooled with other receivables from FR Finance programs. This pool of underlying assets will back the EE ABS.
Deal date(s):	2015
Sources:	
http://greenbank.ny.gov/-/media/greenbanknew/files/Residential-Energy-Efficiency-October-2015.pdf	

19.3 Low Carbon Mobility

Case Study Number:	1
Title:	Quebec Electric Rail
Sector:	Low-carbon Mobility
Subsector:	Electric public transit systems
Physical asset descriptor:	67-km light rail transit (LRT) system
Location(s):	Canada, Quebec
Channel and financial structure*:	Unlisted equity investment in an infrastructure company
Institutional investor(s):	Caisse de dépôt et placement du Québec (CDPQ : a public pension and insurance fund)
Capital commitment (USD):	TBD
Aggregate deal size (USD):	CAD 5.5 billion
Stage in project:	Construction
Role and nature of public sector action:	Innovative PPP and collaboration: New business entity established between the Québec government and CDPQ. The government sets broad project parameters and approves solutions presented by CDPQ. The proposed financial structure also requires investments by the governments of Québec and Canada.
Deal date(s):	2015

Sources:
http://www.cdpqinfra.com/en/the-model

Case Study Number:	23
Title:	EV Charging China
Sector:	Low-carbon Mobility
Subsector:	Electric Vehicle Re-charging Infrastructure
Physical asset descriptor:	Nationwide station-charging network to fulfil the power demands of anticipated 5 million electric vehicles. In addition to the 12,000 chargers, 4.8 million power poles, 3,850 charging stations for public buses and 2,500 for taxis will be built in the same period.
Location(s):	China
Channel and financial structure*:	Potentially listed or unlisted corporate debt or equity financing
Institutional investor(s):	Undisclosed Chinese pension funds and other institutional investors
Capital commitment (USD):	TBD
Aggregate deal size (USD):	TBD
Stage in project:	Design and development
Role and nature of public sector action:	TBD: to finance the project, “the [Chinese] government will encourage private investment, allow charger manufacturers to issue corporate bonds and seek investment from pension funds.”
Deal date(s):	2016

Sources:

Automative News (2015), “China’s Basic pension funds expected to invest in EV charging infrastructure”, 28 September, ht
http://www.eco-business.com/news/china-to-build-12000-nev-chargers-by-2020/

19.4 Green enabling infrastructure

Case Study Number:	1
Title:	Greater Gabbard OFTO (Offshore Transmission Owner)
Sector:	Green Enabling Infrastructure
Subsector:	Offshore wind transmission link operator
Physical asset descriptor:	Transmission co links to the Greater Gabbard 504 MW offshore wind farm (GBP 1.5 billion)
Location(s):	UK, England, Suffolk
Channel and financial structure*:	Direct Debt: Listed project bond
Institutional investor(s):	AMP Capital, as part of a consortium with Balfour Beatty and Equitix, other undisclosed institutional bond investors from UK, Canada and EU
Capital commitment (USD):	GBP 305 million
Aggregate deal size (USD):	GBP 1.5 billion value of whole project including offshore wind farm
Stage in project:	Construction
Role and nature of public sector action:	Credit enhancement: EIB provided a GBP 45.8 million guarantee, representing 15% of the bond issued, as a credit support under the Project Bond Credit Enhancement model that allows a one notch upgrade in the project's rating provided by Moody's (A3).
Deal date(s):	2013

Sources:
http://europa.eu/rapid/press-release_BEI-13-204_en.htm
http://www.ampcapital.com.au/article-detail?alias=%2Fsite-assets%2Farticles%2Fmedia-releases%2F2013%2F2013-11%2
https://www.climatebonds.net/2014/05/uk-greater-gabbard-wind-grid-bond-19yr-%C2%A3305m-496m-3-x-oversubscribed-

Case Study Number:	2
Title:	Gwynt y Mor OFTO (Offshore Transmission Owner)
Sector:	Green Enabling Infrastructure
Subsector:	Offshore wind transmission link operator
Physical asset descriptor:	Transmission co. links to the Gwynt y Mor 576 MW offshore wind farm (GBP 2 billion)
Location(s):	UK, England, Liverpool
Channel and financial structure*:	Direct Debt: Listed project bond
Institutional investor(s):	Undisclosed institutional bond investors from UK, Canada and EU
Capital commitment (USD):	GBP 352 million
Aggregate deal size (USD):	GBP 2 billion value of whole project including offshore wind farm
Stage in project:	Construction
Role and nature of public sector action:	Credit enhancement: EIB provided a GBP 51 million guarantee, representing 15% of the bond issued, as a credit support under the Project Bond Credit Enhancement model that allows a one notch upgrade in the project's rating provided by Moody's (A3).
Deal date(s):	2015

Sources:

http://www.eib.org/infocentre/press/releases/all/2015/2015-030-gbp-51m-eib-backing-for-gwynt-y-mor-offshore-transmission-link.htm

Case Study Number:	3
Title:	West Duddon Sands OFTO (Offshore Transmission Owner)
Sector:	Green Enabling Infrastructure
Subsector:	Offshore wind transmission link operator
Physical asset descriptor:	Transmission co. links to the West Duddon Sands 389 MW offshore wind farm (GBP 1.6 billion): 108 wind turbine generators
Location(s):	UK, England, West Duddon
Channel and financial structure*:	Direct Debt: Listed project bond
Institutional investor(s):	Undisclosed institutional bond investors from UK, Canada and EU
Capital commitment (USD):	GBP 254 million
Aggregate deal size (USD):	GBP 1.6 billion value of whole project including offshore wind farm
Stage in project:	Construction
Role and nature of public sector action:	Credit enhancement: EIB provided a GBP 51 million guarantee, representing 15% of the bond issued, as a credit support under the Project Bond Credit Enhancement model that allows a one notch upgrade in the project's rating provided by Moody's (A3).
Deal date(s):	2015

Sources:
https://www.moodys.com/research/Moodys-assigns-PA3-rating-to-WoDS-Transmission-plcs-senior-secured--PR_327815
https://www.ofgem.gov.uk/publications-and-updates/ofgem-grants-licence-west-duddon-sands-offshore-wind-farm-s-269m-t

19.5 Agriculture and Forestry

Case Study Number:	1
Title:	AATIF (Africa Agriculture and Trade Investment Fund)
Sector:	Sustainable Agriculture and Forestry
Subsector:	Sustainable Agriculture
Physical asset descriptor:	Sustainable Agriculture projects that lead to better food security outcomes (landmark transaction Wienco Ghana USD 21 million)
Location(s):	Pan Africa (Sierra Leone, Kenya, Ghana, South Africa, Zambia,
Channel and financial structure*:	Equity: intermediated private equity fund investment
Institutional investor(s):	Multiple undisclosed pension funds and other institutional investors
Capital commitment:	USD 54 milllion
Aggregate deal size:	USD 141 million
Stage in project:	Construction, operational
Role and nature of public sector action:	PPP, cornerstone stake, first loss (subordination), layered fund, blending: PPP with KfW and the German Federal Ministry for Economic Cooperation and Development (BMZ). The fund is administered by Deutsche Bank. Through KfW, the BMZ has invested in C-shares. This provides public 'first loss' capital, which serves as a risk buffer to encourage private investment of capital by institutional and private investors through more senior share classes. KfW and Deutsche Bank are investors in the mezzanine B-shares and several private investors have invested in the A-shares.
Deal date(s):	2014

Sources:
https://www.db.com/cr/en/concrete-Africa-Agriculture-Trade-and-Investment-Fund.htm
https://www.convergence.finance/knowledge-detail/1ooKOJJFKwwSu68gI8ESYI

19.6 Green Buildings

Case Study Number:	1
Title:	Hines Poland Sustainable Income Fund
Sector:	Green Buildings
Subsector:	Real estate sustainability improvements e.g. energy efficiency and water saving technologies
Physical asset descriptor:	Office and warehouse real estate
Location(s):	Poland
Channel and financial structure*:	Equity: Intermediated private equity fund
Institutional investor(s):	Undisclosed "foreign institutional investor" is a partner in the fund
Capital commitment:	EUR 50 million
Aggregate deal size:	EUR 155 million
Stage in project:	Development and implementation
Role and nature of public sector action:	Cornerstone stake in fund: EBRD takes EUR 50 million equity stake matching the largest private institutional investor's stake.
Deal date(s):	2015

Sources:
http://www.ebrd.com/work-with-us/projects/psd/hines-poland-sustainable-income-fund.html

19.7 Water

Case Study Number:	1
Title:	Consorcio Agua Azul (CAA)
Sector:	Sustainable Water and Sanitation
Subsector:	Sustainable Water
Physical asset descriptor:	Water utility plant (SEDAPAL)
Location(s):	Lima, Peru
Channel and financial structure*:	Debt: listed USD 45 million bond
Institutional investor(s):	Undisclosed local private pension funds
Capital commitment:	USD 18 million (by local private pension funds in 2003)
Aggregate deal size:	USD 45 million
Stage in project:	Implemented
Role and nature of public sector action:	The Peruvian government encourage pension fund involvement by underpinning CAA's concession contract by a "take or pay" agreement backed by a sovereign guarantee—thus effectively assuring a certain cash flow for the project and encouraging both the pension funds and CAA to take risk. Other forms of credit enhancement included debt seniority and the creation of an escrow account controlled by CAA's creditors.
Deal date(s):	2001

Sources:
www.wsp.org/sites/wsp.org/files/publications/WSP-Research-Brief-Leveraging-Public-Funds-to-Attract-Commercial-Financ

Note:
CAA is a SPV which signed a 27-year contract with SEDAPAL, the SOE responsible for Lima's water services.

19.8 Mixed green finance

Case Study Number:	1
Title:	GEEREF (Global Energy Efficiency and Renewable Energy Fund)
Sector:	Sustainable Energy and Energy Efficiency
Subsector:	Sustainable Energy and Energy Efficiency
Physical asset descriptor:	Small to medium-sized projects
Location(s):	Multiple: projects targeted in emerging markets that qualify as recipients for Official Development Assistance
Channel and financial structure*:	Equity: unlisted intermediated fund of funds
Institutional investor(s):	Undisclosed institutional investors, at least 8 private equity funds with institutional investor limited partners
Capital commitment:	EUR 110 million
Aggregate deal size:	EUR 222 million
Stage in project:	Implemented
Role and nature of public sector action:	Public stake in fund seeding other private funds: EIB capital mobilises private capital including from institutional investors and through GEREEF committed for instance EUR 10 million to the Armstrong S.E. Asia Clean Energy Fund.
Deal date(s):	Launched in 2008

Sources:
http://geeref.com/about/what-geeref-is.html

Case Study Number:	2
Title:	Kommuninvest Aggregator Green Bond
Sector:	Sustainable Energy, Energy Efficiency, Low Carbon Mobility, Green Buildings, Sustainable Water
Subsector:	Wind, waste-to-energy, solar, wave, geothermal, hydro and bioenergy, electric public transport (rail, trams, buses etc), energy efficiency (primarily in district heating and buildings) water management and green building retrofits and installations
Physical asset descriptor:	Proceeds will finance eligible loans across all five areas
Location(s):	25 investment projects in 18 Swedish municipalities (and growing)
Channel and financial structure*:	Debt: Intermediated, listed Municipal and Local Funding Authority Green Bond
Institutional investor(s):	Central banks and official Institutions accounted for 37%, asset managers 29%, banks 19%, pension and insurance funds 12%. Notable institutional investors: AP3, AP4, CalSTRS and UN Joint Staff Pension Fund.
Capital commitment:	USD 600 million bond issuance
Aggregate deal size:	By early March 2016, Kommuninvest's Green Loan portfolio was USD 1.1 bilion.
Stage in project:	All
Role and nature of public sector action:	Aggregation and Conduit: Kommuninvest, the Swedish local government debt office, obtains economies of scale by aggregating local government funding needs through a joint funding vehicle, supported by an unlimited, joint and multip guarantee from the owners (Swedish local governments with tax-raising capabilities). By combining single Green Loans into an aggregated Portfolio of Green Loans, Kommuninvest can enable and empower the smaller municipalities with green financing opportunities. This would otherwise not be feasible for a number of reasons, primarily due to insufficient volume and lack of skills and resources. The smallest project funded by Kommuninvest has a Green Loan amounting to SEK 5 million (USD 0.6 million). The largest project is for SEK 2.5 billion (USD 300 million).
Deal date(s):	2016

Sources:
Input from Swedish Prime Minister's Office (via Nannan Lundin)
http://kommuninvest.se/wp-content/uploads/2016/03/Kommuninvest-press-points_160315.pdf

Case Study Number:	3
Title:	CT Green Bank C-PACE (Commercial Property Clean Energy)
Sector:	Sustainable Energy
Subsector:	Distributed solar, energy efficiency and CHP (combined heat and power) for commercial and industrial buildings and multi-family dwellings
Physical asset descriptor:	C-PACE is a security and collection mechanism developed in the USA which places a lien / security interest on the property enabling long tenor (20/25 year) financings that are collectred through the property tax systems and stay with the property regardless of ownership.
Location(s):	USA, Connecticut
Channel and financial structure*:	Debt: unlisted / non-rated pooled project bonds in three tranches: 80% senior A bonds, 10% mezzanine B bonds, 10% junior C bonds
Institutional investor(s):	The Public Finance Authority was the conduit bond issuer and Clean Fund was the purchaser of the senior bonds
Capital commitment:	USD 30 million
Aggregate deal size:	USD 30 million
Stage in project:	Projects fully completed and bonds issued in 2 stages (2014 & 2015)
Role and nature of public sector action:	Conduit, subordination, warehousing: The Connecticut Green Bank co-structured the transaction with the bond purchaser (Clean Fund) and credit enhanced the transaction by retaining ownership of the subordinated bond tranches
Deal date(s):	2014 & 2015

Sources:

http://resources.ctgreenbank.com/Portals/0/board-materials/6c_Sale%20of%20C-PACE%20Transactions.pdf

http://www.prnewswire.com/news-releases/cefia-announces-sale-of-commercial-property-assessed-clean-energy-benefit-a

Case Study Number:	4
Title:	Asia Climate Partners
Sector:	Various
Subsector:	Various
Physical asset descriptor:	Various
Location(s):	China, Hong Kong (investment will take place throughout Asia)
Channel and financial structure*:	Intermediated project equity
Institutional investor(s):	Asia Climate Partners (private equity investment fund), Robeco, Sompo Japan Nipponkoa Insurance etc.
Capital commitment:	USD 400 million (initial capital)
Aggregate deal size:	TBD
Stage in project:	Construction
Role and nature of public sector action:	ADB provided cornerstone investment. Also JICA and the UK Government participate as co-investors.
Deal date(s):	2014

Sources:

http://www.adb.org/news/new-joint-venture-established-private-equity-investments-climate-related-transactions

http://www.jica.go.jp/english/news/press/2015/151211_02.html

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21. GLOSSARY

‘Forsan et haec olim meminisse iuvabit.’

Virgil

The Aeneid, Book 1 (29-19 BC)

Explanations of these terms are very condensed and may not be complete, and are not considered to necessarily reflect the official position of the OECD. Sources used include, inter alia, Duke University's Hypertextual finance Glossary; Brealey, Myers and Allen (2014) and Investopedia.com.

450 Scenario: A scenario presented in the IEA's *World Energy Outlook* that sets out an energy pathway consistent with the goal of limiting the global increase in temperature to 2°C by limiting concentration of greenhouse gases in the atmosphere to around 450 parts per million of CO_2.

Alpha (α): A measure of risk-adjusted performance. Some refer to the alpha as the difference between the investment return and the benchmark return. However, this does not properly adjust for risk. More appropriately, an alpha is generated by regressing the security or mutual fund's excess return on the benchmark (for example S&P 500) excess return.

Annuity: A regular periodic payment made by an insurance company to a policyholder for a specified period of time.

Asset-backed security (ABS): A financial security backed by a loan, lease or receivables against assets other than real estate and mortgages.

Asset and Liability Management (ALM): The task of managing the funds of a financial institution to accomplish two goals: *1)* to earn an adequate return on funds invested and *2)* to maintain a comfortable surplus of assets beyond liabilities.

Asset liability matching: Process of managing investing, purchasing, and selling activities to ensure that cash is available for meeting the obligations as they fall due.

Bankable: Projects that have sufficient collateral, probability of success, and predictability of future cash flow, to be acceptable to prospective financiers.

Basel III: The third version of the Basel Accords agreed upon by 27 countries on 12 September, 2010. Among the highlights was the increasing of Tier 1 capital from 2% to 4.5% and the addition of a buffer of 2.5%. The assets that qualify for capital were also redefined. The full implementation of the accord is not due until 2023. Basel I is the Agreement concluded among country representatives in 1988 in Basel, Switzerland to develop standardised risk-based capital requirements for banks across countries. The Accord is also known as the 1988 Basel Accord and it primarily focused on credit risk and is now viewed as outdated. Basel II is currently in the process of implementation.

Bellweather stock: A stock in a well-known or highly-regarded company in a given sector. The performance of a barometer stock is considered to be an indicator of the performance of its particular sector or industry.

Benchmark: The performance of a predetermined set of securities, used for comparison purposes. Such sets may be based on published indexes or may be customised to suit an investment strategy.

Beta (β): The measure of an asset's risk in relation to the market (for example, the S&P500) or to an alternative benchmark or factors. Roughly speaking, a security with a beta of 1.5, will have moved, on average, 1.5 times the market return. According to asset

pricing theory, beta represents the type of risk, systematic risk, that cannot be diversified away.

Break-even level: A level at which the volume of sales or revenues exactly equals total expenses, therefore there is neither a profit or a loss.

Capital recycling: Providing refinancing once a project is at the operational stage so that early-stage investors have an 'exit strategy', allowing them to free up capital to invest in new projects – i.e. to 'recycle' their capital.

Churning the portfolio: Trying to buy projects when they are cheap and sell when they are expensive – enhancing returns, but also increasing risk and distorting the underlying cash flows.

Co-investment: A form of direct investing whereby institutional investors partner up with other investors to invest in an asset.

Corporate bond: Debt obligations issued by corporations.

Cost of capital: The cost of funds used for financing a business. Cost of capital depends on the mode of financing used – it refers to the cost of equity if the business is financed solely through equity, or to the cost of debt if it is financed solely through debt. Many companies use a combination of debt and equity to finance their businesses, and for such companies, their overall cost of capital is derived from a weighted average of all capital sources, widely known as the weighted average cost of capital (WACC). Since the cost of capital represents a hurdle rate that a company must overcome before it can generate value, it is extensively used in the capital budgeting process to determine whether the company should proceed with a project.

Coupon: The contractual interest obligation a bond or debenture issuer covenants to pay to its debtholders.

Covered bonds: Debt securities backed by cash flows from mortgages or public sector loans. Covered bonds employ a 'dual recourse structure' where bond investors have a claim over *1)* a 'cover pool' of assets, the quality of which is strictly regulated; and *2)* a general unsecured claim against the issuer. This dual recourse structure enables covered bonds to enjoy superior credit ratings and lower funding costs compared with unsecured debt issued by banks. At the same time, because of strict oversight for what can go into the 'cover pool,' they generally carry less risk than pure asset-backed securities.

Credit enhancement: Reducing the credit or default risk of a debt, thereby improving its credit-worthiness and increasing the overall credit rating

Credit rating: Credit rating refers to an evaluation of individual's or company's ability to repay obligations or its likelihood of not defaulting. If credit rating is downgraded, it would increase the cost of capital due to the extent that the reward for such risky assets would be necessary as risk-premium.

'Crowding-in': Occurs when public investment increases the marginal productivity of private capital or labour, or reduces the costs that investing firms incur and induces greater private investment than would have occurred otherwise. '

'Crowding-out': Occurs when a public intervention directly displaces the efforts of the private sector by undertaking projects the private sector would have otherwise done. Crowding out can also occur indirectly if governments use distortionary taxes to fund public investment.

Crowdsourcing: The process of obtaining ideas, content or funding, usually online, from a large group of people. In the context of this report crowdsourcing refers to attracting small unaccredited investors to provide funding for clean energy projects.

Defined benefit: A defined benefit pension plan refers to a type of plan in which certain benefits are guaranteed when you retire.

Deleveraging: The reduction of the ratio of debt in the balance sheet of an economic entity. In this report, deleveraging refers to the attempt to decrease its financial leverage ratio (value of firm's debt to the total value of the firm). Banks have been lowering their high pre-crisis leverage levels and are preparing for stricter regulatory capital requirements, and in the process have been reducing their lending.

Diversification: Dividing investment funds among a variety of securities with different risk, reward, and correlation statistics so as to minimise unsystematic risk.

Dividend yield: Annual dividends divided by current stock price or return on a share of a mutual fund held over the past 12 months.

Due diligence: An investigation or audit of a potential investment prior to signing a contract.

Economic infrastructure: Internal facilities of a country that make business activity possible, such as communication, transportation, and distribution networks, financial institutions and markets, and energy supply systems.

Endowment (funds): Investment funds established for the support of institutions such as colleges, private schools, museums, hospitals, and foundations. The investment income may be used for the operation of the institution and for capital expenditures.

Feed-in tariff (FiT): A fixed price per kWh of electricity which is paid to the producer by the system operator.

Feed-in premium (FiP): A premium which is paid to the producer on top of the electricity market price.

Fiduciary duty: The fiduciary concept for institutional owners generically means that the institutions shall serve the interest of the beneficiaries, rather than their own immediate interest. A common and implicit interpretation of this fiduciary duty is that institutions should monitor and engage with investee companies.

Financialisation: The process by which financial institutions, markets, etc., increase in size and influence.

Financing instrument: A financing instrument is a tradable asset of any kind; either cash, evidence of an ownership interest in an entity, or a contractual right to receive or deliver cash or another financing instrument

Fund: An investment company that invests the funds which are aggregated and pooled from individual investors for a fee. Investment fund gives individual investors access to a wider range of financial products than investors themselves would have been able to access.

Green investment bank: Broadly defined as a public entity established specifically to facilitate and 'crowd-in' domestic private low-carbon climate-resilient infrastructure investments through different activities and interventions.

Grid-parity: Grid parity refers to 'an energy source can generate electricity at a levelised cost that is less than or equal to the price of purchasing power from the electricity grid'.

Headline risk: The risk that a major event or story will spread throughout the media and will negatively impact a company's stock price or reputation.

Illiquid: In the context of investments the term illiquid describes a thinly traded investment such as a stock or bond that is not easily converted into cash. Illiquid securities have higher transactions costs.

Infrastructure fund: Investment fund that is established to invest in infrastructure assets.

Institutional investor: Institutional investors are usually synonymous with 'intermediary investors', that is to say, an institution that manages and invests other people's money. The term institutional investor can be used to describe insurance companies, investment funds, pension funds, public pension reserve funds (social security systems), foundations and endowments among others.

IORP II: IORP comprises solvency rules applicable to Institutions for Occupational Retirement Provision. IORP II is widely known as Solvency II for occupational pension funds.

Investment bank: An investment bank traditionally facilitates transactions of all types in the wholesale financial markets (transactions conducted by corporations, businesses, institutional investors, and high net worth individuals) including mergers and acquisitions (the purchase and sale of businesses and their assets), capital raising or 'underwriting' (of equity, debt, etc.) on behalf of corporations or their shareholders. They may provide ancillary services such as market making, trading of derivatives, securities, and other financial instruments, investing and lending, asset management, and FICC services (fixed income instruments, currencies, and commodities). This excludes retail brokerage, retail lending, or any other practice that centres on 'unaccredited investors'

Investment-grade: In the context of bond ratings, the rating level above which institutional investors have been authorised to invest. Investment-grade bonds are those that are assigned a rating in the top four categories by commercial credit rating companies. S&P classifies investment-grade bonds as BBB or higher, and Moody's classifies Investment-grade bonds as BAA or higher.

Leverage: The use of debt financing, or property of rising or falling at a proportionally greater amount than comparable investments.

Liquidity: In context of a corporation, the ability of the corporation to meet its short-term obligations. In context of securities, a high level of trading activity, allowing buying and selling with minimum price disturbance. Also, a market characterised by the ability to buy and sell with relative ease.

Long-dated liabilities: A section of the balance sheet that lists obligations of the company that become due more than one year into the future.

Market capitalization: Market capitalisation refers to the total value of all outstanding shares of a company. This is calculated as the number of shares outstanding multiplied by the current market price per share.

Mark to market: The practice of valuing an asset or a liability, using current market prices. 'Mark to market' is referred to as 'fair value accounting' and is the practice of updating the value of an asset or a liability to reflect its real market value rather than the initial cost of the asset or liability.

Maturity transformation: The process of converting short-term sources of finance (e.g. deposits from retail savers) into long-term borrowings (e.g. loans, mortgages, etc.).

Mezzanine financing: Mezzanine financing is senior to common shares (equity) (i.e. mezzanine investors receive returns from the investment before equity holders) but junior to secured debt or senior debt. Mezzanine financing normally includes subordinated (i.e. junior) debt or preferred equity (i.e. equity shares that provide dividends before common stock dividends are paid out) and is usually more expensive than senior debt. It can be used as the stage of financing that follows venture capital.

MLP (Master Limited Partnership): A publicly traded limited partnership that includes one or more partners who have limited liability.

Monoline insurer: Monoline insurers are financial institutions focused solely on insuring bond issuers such as municipal governments against default. Bond issuers buy this insurance to upgrade the credit-worthiness of their bonds, making the overall cost lower by giving confidence that the insured security would be paid in full. The first monolines were set up in the US in the 1970s, covering municipal and corporate bond issues. These insurers suffered when the financial crisis hit, as some lacked sufficient capital to cover their liabilities adequately.

New Policies Scenario: A scenario in the IEA's World Energy Outlook that takes account of broad policy commitments and plans that have been announced by countries, including national pledges to reduce greenhouse-gas emissions and plans to phase out fossil-energy subsidies, even if the measures to implement these commitments have yet to be identified or announced. This broadly serves as the IEA baseline scenario.

On-bill finance (OBF): OBF allows utility consumers to invest in energy efficiency improvements and repay the funds through additional charges on their utility bill. Under this approach, a third party (such as an energy provider) provides upfront funding for energy efficiency improvements to an investor (e.g. a tenant in a residential or commercial building). The investor pays back the loan via its energy bill. In many cases, repayments are structured in such a way that the monthly energy savings achieved

through the investment equal or outweigh the loan repayments. If structured properly, an OBF programme can substantially reduce the cost of and improve access to financing.

Ownership unbundling: Ownership unbundling is one of the core elements of the European Union's Third Energy Package, which is a legislative package for an internal gas and electricity market in the EU. Its purpose is to further open up the gas and electricity markets in the EU. Ownership unbundling is designed to split generation (production of electricity) from transmission (of electricity from electrical generating station via a system to a distribution system operator or to the consumer).

Parametric insurance products: Parametric insurance products are a type of insurance product that pays out when the coverage is triggered by a particular variable, such as the number of inches of rain over a designated time period.

Pledgeable future income: The maximum amount of income that a firm or project can credibly promise to repay to investors.

Private equity fund: A fund which use their own capital or capital raised from investors (or both) to take companies private with the aim of running them better and later taking them public or selling them at a profit.

Private placement debt: A type of debt that is generated when a bond or some other type of security is sold directly to a limited number of investors in a non-public offering.

Project bond: Private debt issued by a project company to finance a specific off-balance-sheet project. Project bonds are an asset-based form of financing.

Prudent person principle: A principle set forth in the Uniform Prudent Investor Act that states that a fiduciary trustee has the legal obligation to invest and manage trust assets as a prudent person would, taking into account, among other factors, general economic conditions, risk, and liquidity requirements in an attempt to create a portfolio or investment strategy with objectives suited to the trust.

Public finance institutions (PFIs): Publicly created or mandated financial institutions that have often been created to correct for the lack of market-based finance through the provision of missing financial services.

Pure-play: In financial management, 'pure-play' entities are focused on only one industry or product.

Real Estate Investment Trusts (REITs): A corporation or trust that uses the pooled capital of many investors to purchase and manage income property or mortgage loans. REITs invest in real estate or loans secured by real estate and issue shares in such investments. A REIT is similar to a closed-end mutual fund.

Revolving debt: A type of debt that typically has a variable interest rate, an open-ended term and payments that are based on a percentage of the balance.

Ring-fencing: Practice of financially separating a portion of a company's assets or profits without necessarily being operated as a separate unit. Ring-fencing may occur for regulatory, financing or taxation purposes.

Risk-adjusted return: A measure of valuing return on investment calculated in a way that takes into account the risks associated with the investment. Being able to compare a high-risk, potentially high- return investment with a low-risk, lower-return investment helps to answer a key question that confronts every investor: is it worth the risk? There are several ways to calculate risk- adjusted return. Each has its strengths and shortcomings. All require particular data, such as an investment's rate of return, the risk-free return rate for a given period, and a market's performance and its standard deviation. Risk-adjusted returns can apply to individual securities and investment funds and portfolios.

Risk mitigant: A targeted financial intervention that is aimed at reducing, re-assigning or re-apportioning different investment risks.

Risk-profile: An assessment of the degree to which an investor is prepared to accept losses at the expense of potential gain.

Securitisation: The process of transforming illiquid financial assets into tradable products.

Special purpose vehicle: Legal entity created to fulfil a specific and well-defined financial or regulatory objectives. For project finance, a SPV may be created to hold the assets associated with a project therefore keeping the investment off the balance sheets of project developers. Within the securitisation framework, an SPV can be a legal entity which may issue securities or other debt instruments, may legally or economically own assets underlying the issue of the securities mentioned above and be financially and legally isolated from the originator.

Solvency II: A directive developed by European Commission for the European insurance industry. It aims to establish a revised set of EU-wide capital requirements and risk management standards that will replace the current solvency requirements. Solvency rules stipulate the minimum amounts of financial resources that insurers and reinsurers must have in order to cover the risks to which they are exposed. The rules also lay down the principles that should guide insurers' overall risk management so that they can better anticipate any adverse events and better handle such situations. The original Solvency I rule was introduced in 1973. According to the Commission, Solvency II will introduce economic risk-based solvency requirements across all EU Member States for the first time and these new solvency requirements will be more risk-sensitive and more sophisticated than in the past, thus enabling a better coverage of the real risks run by any particular insurer. The Commission also states that Solvency II will also be more comprehensive than in the past, in the sense that whereas at the moment the EU solvency requirements concentrate mainly on the liabilities side (i.e. insurance risks), Solvency II takes account of the asset-side risks.

Superannuation fund: The superannuation system (in Australia) refers to the arrangements of a compulsory occupational pension system which was introduced in 1992. Superannuation systems now have 11.6 million members with a coverage rate of 71% of workers. Total assets have grown to a level of AUD 1.4 trillion (Inderst and Della Croce, 2013).

Transaction enabler: A process or technique which facilitates investment by reducing the associated transaction costs or otherwise enabling the investment to be made.

Term loan: Loan payable in a fixed number of equal instalments over the term of the loan. Term loans are generally short-term (between one and five years) and are usually provided as working capital for acquiring income-producing assets (machinery, equipment, inventory, etc.) that generate cash flows to repay the loan.

Underwriting: In the case of loans, underwriting is the process by which a lender decides whether a potential creditor is creditworthy and should receive a loan. For securities issuances, underwriting is the procedure by which an underwriter, such as in investment bank, brings a new security issue to the investing public in an offering. In such a case, the underwriter will guarantee a certain price for a certain number of securities to the party that is issuing the security (in exchange for a fee). Thus, the issuer is secure that they will raise a certain minimum from the issue, while the underwriter bears the risk of the issue.

'Valley of death': This term has been used to refer to the situation in which many seemingly promising renewable energy technologies do not progress along the innovation chain towards commercialisation and diffusion. The 'valley of death' has more recently been described as 'the place where a technology is too capital intensive for a venture capital firm to continue investing, but too risky for a project financier to bring it to scale' (Lacey, 2010). It has also been described as a scenario in which 'investment in renewable productive capacity is required well before the energy price is sufficient to cover the full long run cost of that capacity' (Hartley and Medlock, 2013: 42).

Venture capital: An investment in a start-up business that is perceived to have excellent growth prospects but does not have access to capital markets. It is also a type of financing sought by early- stage companies seeking to grow rapidly.

Volumetric risk: A cash flow risk caused by deviations in delivered volumes compared to expected volumes. The primary cause of these deviations is weather and economic conditions.

Wholesale funding: A method of funding used by banks through short-term borrowing from other banks and financial institutions.

YieldCo: A publicly-traded company that is formed to own operating assets that produce cash flows. The cash is distributed to investors as dividends