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Promoting Vehicle to Grid (V2G) in the Nordic region: Expert advice on policy mechanisms for accelerated diffusion

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ABSTRACT

Vehicle to Grid (V2G) holds the promise of cheap, flexible, and fast-responding storage through the use of electric vehicle batteries. Unfortunately, infrastruc.ture, battery degradation and consumer awareness are only some of the challenges to a faster development of this technology. This paper offers a qualitative comparative analysis that draws on a subsample of 227 semi-structured interviews on electric vehicles with both transportation and electricity experts from 201 institutions and 17 cities within the Nordic region to discuss the reasoning and arguments behind V2G incentives and policy mechanisms. A frequency analysis of the most coded V2G responses favours an update of the electricity market regulation – in particular in relation to electricity taxation and aggregator markets – and support for pilot projects. However, the analysis overall implies that V2G, in contrast to EVs, is a technology for the market and by the market. One that will develop on its own over time. More in-depth, our analysis shows the debates around V2G and how its perspective differs per country, pending available frequency capacity and flexible production (hydro power). The paper calls for a further development of flexible electricity markets, support for pilot projects, and attention to information and planning.

1. Introduction

With the increasing uptake of electric vehicles (EVs), which follows from technological development and cost reductions in battery technology and management systems, other business models are opening up that make use of the electric storage and power train of EVs. This includes Vehicle to Grid (V2G), a technology that allows for the retrieval of stored electricity in electric vehicles for the benefit of the electricity networks (Kempton and Tomić, 2005b). Beyond smart charging (load control), V2G offers electricity grid services (e.g. frequency control, spinning reserves, peak shifting), a potential reduction of the investment costs for further grid capacity, the possibility of creating new revenue streams for utilities and vehicle owners (private and fleet), a mitigation of emissions (better optimization of electricity production) and a more efficient integration of renewable energy sources (Kempton and Tomić, 2005a, 2005b; Lund and Kempton, 2008; Niesten and Alkemade, 2016; Noel et al., 2017; Sovacool et al., 2017a).

Irrespective these benefits, the technology remains in its infancy although the number of pilot projects is growing and some of these are commercially active, such as in Frederiksberg, Denmark (NUVVE, 2017). These and other pilot projects are carried out around the world, with more and more research institutes, OEMs and grid companies showing interest and a willingness to invest (Sovacool et al., 2017a). Consequently, the literature around these projects is rapidly generating insights into the barriers to a further uptake, including communication complexity, costs, battery degradation, and competition from other flexible storage technologies (Bailey and Axsen, 2015; Parsons et al., 2014; Sovacool et al., 2017a; Turton and Moura, 2008). Consumer acceptance is another important barrier, as V2G is seen to impede on the 'freedom of the car' (Parsons et al., 2014) and the privacy of consumers (Bailey and Axsen, 2015).

In response to this growing body of literature, this paper draws on 227 expert interviews with 257 respondents involved in electric mobility (from the car industry, electricity sector, academia and government) from all five Nordic countries (Iceland, Sweden, Denmark, Finland and Norway) to see what kind of policy mechanisms could help promote V2G. As such this paper offers a more qualitatively focused examination of policy mechanisms in contrast to the more technical in-depth analysis of Knezović et al. (2017) or Uddin et al. (2018). Our aim is to use these expert interviews to identify and prioritize the list of policies that would best address the barriers facing V2G.

Unfortunately, V2G remains a relative unknown technology even among experts working with or around electric mobility. A clear indication of this is that although 85% of the interviews were willing to

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Table 1
Overview of semi-structured research interview data.
Source: Authors. Focus represents the primary focus area of the organization or person in question, sector represents the sector the company was working in (semi-public referring to commercial companies owned by public authorities, like DSOs).

Classifications	Interviews (n = 227)	Respondents (n = 257)	% of respondents	% of interviews discussing V2G	% interviews offering specific V2G recommendations
Country = Iceland (Sept-Oct 2016)	29	36	14.0%	7%	0%
Country = Sweden (Nov-Dec 2016)	42	44	17.1%	15%	2%
Country = Denmark (Jan-Mar 2017)	45	53	20.6%	18%	5%
Country = Finland (Mar 2017)	50	57	22.2%	18%	7%
Country = Norway (Apr-May 2017)	61	67	26.1%	25%	8%
Gender = Male	160	207	80,5%	61%	19%
Gender = Female	40	50	19.5%	14%	4%
Gender = Group	27			8%	1%
Focus = Transport or Logistics	73	81	31.5%	25%	7%
Focus = Energy or Electricity System	63	75	29.2%	26%	11%
Focus = Funding or Investment	10	12	4.7%	3%	0%
Focus = Environment or Climate Change	12	16	6.2%	4%	1%
Focus = Fuel Consumption and Technology	22	23	8.9%	8%	0%
Focus = Other	13	14	5.4%	4%	1%
Focus = EVs and Charging Technology	34	36	14.0%	14%	3%
Sector = Commercial	68	70	27.2%	26%	8%
Sector = Public	37	46	17.9%	12%	3%
Sector = Semi-Public	40	51	19.8%	13%	5%
Sector = Research	37	39	15.2%	15%	4%
Sector = Non-Profit and Media	12	13	5.1%	4%	1%
Sector = Lobby	23	25	9.7%	8%	1%
Sector = Consultancy	10	10	3.9%	4%	1%

discuss the benefits and downsides of V2G, only 23% of the interviews offered concrete policy related suggestions. The results are of interest however and include a need for public support to help restructure the electricity markets, further incentivize innovation and business development, create the facilitating conditions that V2G needs, fill the knowledge and information gap for consumers, EV experts and small distribution system operators (DSOs) lacking the expertise and manpower to study this thoroughly, and support V2G capable charging infrastructure. Interestingly, these suggestions are mainly focussed on the electricity sector and ignore the automobility sector or consumers. Simultaneously, 5% of the experts believe that public authorities cannot do much, or actually already have done plenty, and that it is just a matter of time for V2G to find its place in the electricity markets. In the following sections, this paper discusses these policy mechanisms in more detail.

2. Method

As our primary method, the authors conducted 227 semi-structured interviews with 257 participants from over 200 institutions across each of the five Nordic countries from September 2016 to May 2017. Table 1 provides an overview of this method. The goal of the interviews was to get a state of the art overview of the challenges and expectations that people involved in electric mobility have about electric mobility. The choice for semi-structured interviews follows the complexity and fast changing nature of the topic of electric mobility (including V2G) as they allow for a timely and in-depth discussion of such a complex issue where a lot of elements are connected, political choices are needed and individual perceptions and values play an important role (Harrell and Bradley, 2009; Yin, 2013).

Unfortunately, semi-structured interviews are open to three biases. First, interviews are open to self-selection biases when only those interested accept the invitation. Second, interviews are open to interviewer biases, as the follow up questions are the prerogative of the interviewers. A third bias relates to the level of expertise of the respondents. In certain instances, experts only mentioned more common points after a follow up question, stating that those were common knowledge, or vice versa, primarily focussed on what they felt knowledgeable about while ignoring other aspects.

To explicitly minimize these limitations with an interview approach, we utilized a research design that was large, reliable, verifiable, and triangulated. To minimize self-selection bias, we relied on a substantially large number of interviews—more than 225—when most studies in the energy field and the social sciences rely on fewer than 15–50 (Baker et al., 2012; Galvin, 2015) especially when interviews are with elite respondents such as experts. To minimize interviewer bias, we relied especially in the beginning on varying two person teams of interviewers. We also recorded and fully transcribed all interviews, making them both more reliable and verifiable. To minimize expertise bias, we triangulated the interviews both with each other (internal validity) as well as the relevant peer-reviewed literature (external validity). We would also add that interviews come with their own set of strengths, which can counter potential weaknesses: interviews can and should explore the full range of views or arguments available on a certain topic (Glaser and Strauss, 2006), thereby offering more complex responses when compared to more static methods such as surveys or diaries.

In terms of our specific interview sample, those interviewed in Denmark, Finland, Iceland, Norway and Sweden were selected to represent the diverse array of stakeholders involved with electric mobility, from both a transport and an electricity side, and include:

- National government bodies, including the Ministry of Industries & Innovation (Iceland), Ministry of Environment and Energy (Sweden), Ministry of Finance (Finland), and Ministry of Taxation (Denmark):
- Local government ministries, agencies, and departments including the Akureyri Municipality (Iceland), City of Stockholm (Sweden), Aarhus Kommune (Denmark), City of Tampere (Finland), City of Oslo (Norway), and Trondheim Kommune (Norway);
- Regulatory authorities and bodies including the National Energy Authority (Iceland), Danish Transport Authority, Helsinki Regional Transport Authority (Finland) and Trafi (Finland);
- Universities and research institutes including the University of Iceland, Swedish Environmental Institute, DTU (Denmark), Aalborg University (Denmark), VTT Technical Research Centre (Finland), NTNU (Norway), and the Arctic University of Norway;
- Electricity industry players such as ON Energy (Iceland), E.ON

(Sweden), Vattenfall (Sweden), Energinet (Denmark), DONG (Denmark), Fingrid (Finland), Elenia (Finland) and Statnett (Norway);
- Automobile manufacturers and dealerships including the BMW Group (Norway), Volvo (Sweden), Nissan Nordic (Finland), Volkswagen (Norway), and Renault (Denmark);
- Private sector companies including Siemens Mobility (Denmark), Nuvve (Denmark), Fortum (Finland), Virta (Finland), Clever (Sweden), Nordpool, (Sweden), Norske Hydrogen (Norway), Microsoft (Norway) and Schneider Electric (Norway);
- Industry groups and civil society organizations such as Danske Elbil Alliance (Denmark), Finnish Petroleum and Biofuels Association, Tesla Club (Finland), Power Circle (Sweden) and the Norwegian Electric Vehicle Association.

These institutions where primarily important for sampling, which was done through personal email and phone calls and a snowball question at the end of each interview. Participants were guaranteed anonymity, answered on personal title and were not prompted for responses, except for the follow up questions that were adjusted to the background of the respondent and the direction of the interview. On average, the interviews lasted between thirty and ninety minutes and the interviewees were asked, among others: "What policy mechanisms can further speed up the transition of EVs and V2G?"[1] Each interview was recorded and then fully transcribed, coded in NVIVO with a grounded theory approach in mind and subsequently analysed. As some interviews included multiple respondents, each participant was given a unique respondent number. We refer to this respondent number whenever presenting raw interview data (n = 257), but overall analyses are conducted on an interview level (n = 227). Due to the qualitative nature of semi-structured interview data, this paper relies on inductive and abductive forms of analysis rather than extensive statistical assessment.

3. Background

This section offers a brief background of the Nordic electricity and car markets, and a discussion of the challenges around vehicle to grid.

3.1. Nordic electricity and car markets

At first glance the Nordic countries have quite similar energy and car markets, but this is a bit deceptive as Table 2 summarizes. The Nordic wholesale electricity markets for example are all members of Nord Pool (except Iceland) and have flexible liberalized markets which are harmonized through NordReg, the cooperation of Nordic Energy Regulators (including Iceland). On a consumer level, all countries offer various variable pricing options. However, in Iceland there is basically one variable contract linked to the aluminium price, which implies price differences are very small. In the other countries consumers can choose between various fixed and flexible schemes, including an increasing number of *hourly* flexible plans based on the Nord Pool spot market. Unfortunately, taxation and network costs make up 87% of the Danish consumer price, 70% of the Icelandic, Norwegian and Swedish price and 60% of the Finnish consumer price, so while flexible pricing puts downward pressure on the electricity prices it seems to have little effect on a reduction or shifting of electricity consumption (NordReg, 2017). Simultaneously, the number of consumers entering flexible contracts is increasing, and the Nordic smart meter introduction is hoped to further support these contracts.

Moreover, the countries have strong transmission networks following the high level of international trade (except Iceland). Likewise, they have reasonably modern distribution grids, which our DSO interview partners expect can handle EV loads as long as their introduction does not peak. That said, the first local capacity problems seem to have arrived in Norway following the incredible EV uptake there (Klingenberg, 2017). This uptake strongly contrasts with the weak EV distribution in the other countries. Then again, Norway is weak on V2G compared to Denmark and Finland. V2G is especially actively pursued in Denmark, where the Parker project offers the first European commercial V2G test project with 10 Nissan vans actively delivering frequency regulation (Parker, 2017). While in Finland the internationally active EV charging infrastructure companies are integrating it in their software. This is not surprising if we take into account the strong presence of hydro in Norway, Iceland, Sweden and to some extend Finland. Denmark is the only one without direct hydro, instead depending on an increasing amounts of wind energy. And as Kempton and Tomić (2005a) already argue, V2G and fast responsive hydro compete on frequency regulation markets; which is one of the most likely markets where V2G services are competitive in its current start-up phase (especially with DSOs focussing on stationary batteries to alleviate local grid stress).

The differences on the electricity side continue on the respective car markets. The geography and differing income levels seems to lead to different car turnover rates ranging from 8.5 to almost 13 years. Regarding EVs, the countries have radically distinct levels of EV incentive programs and markets. The all-inclusive programs of Norway are well known, but Iceland is also offering strong tax reductions, Sweden offers a cash subsidy (as it has less car taxes to reduce), Denmark recently halted the phase out of its earlier strong tax reductions for EVs (currently at 40% instead of 150%) in an attempt to reinvigorate its EV sales and consumer trust in EVs, and in the case of Finland the EV incentives are fairly recent in part because Finnish comparative advantage in biofuels. As Fig. 1 shows, these different support schemes are reflected in a different uptake of EVs as they lead to lower – in some cases competitive – consumer prices and time savings. And while Denmark stands out with its wind energy production, Norway stands out with its generous EV incentives, Finland has a large biofuel industry, and Sweden is the only country with a domestic automobile industry. All in all, the Nordic countries are different enough so that many of the major questions around electric mobility and vehicle-to-grid come up, while they simultaneously offer flexible and modern electricity systems and a serious political concern about smog (Norway), oil imports (Iceland), and climate change (all of them) to take these developments seriously.

3.2. V2G: markets and challenges

Vehicle-to-grid stands for the bi-directional use of electricity stored in EV batteries. The technology moves beyond smart charging (flexible load control) and connects travel routines, electricity grid stress levels, and various electricity markets. Its main competitive advantage lies in the dual use of EV batteries, which are bought and paid for with transport in mind, but can be utilized in non-travel hours for grid optimization. As such it fits the rising demand from the grids for flexible storage in line with increasing electricity (peak) loads and growing variable supplies.

Table 3 summarizes four articles which each offer an excellent review of the status of V2G, while highlighting some of the assumed benefits, challenges, markets and policy recommendations. Three remarks are in order regarding this succinct overview. First, the benefits of V2G are expected to encompass multiple stakeholders and V2G will be applicable in multiple regions and competitive for a range of electricity services. Second, the challenges seem to converse around the technology (communication complexity, battery degradation), regulation (dynamic price mechanisms, bidding, aggregation), market (costs and competition from other flexible storage technologies) and end-user

[1] Due to the volume of data collected, the authors decided to split this question in two papers: one detailing the EV policy mechanisms and this one discussing the V2G policy mechanisms.

Table 2
Similar yet different—basic demographic and energy indicators for the Nordic region.
Sources: Authors.

	Iceland	Sweden	Denmark	Finland	Norway
Population (Mln.)[a]	0,35	9,9	5,73	5,49	5.2
Sq. km (thousand)[a]	103,0	447,4	42,9	338,4	385,2
Population density (thousand p/sq km) [a]	3,3	24,3	135,6	18,1	14,3
GNI per capita (Atlas – US $) [a]	56.990	54.630	56.730	44.730	82.330
CO2 emissions (metric tons per capita) [a]	6,08	4,62	6,78	8,51	11,74
Geography	Low population density outside of capital; harsh weather conditions; bad road conditions	Low population density in the North; harsh weather conditions;	Flat, connecting islands, two separate electricity grids	Low population density outside capital region; harsh weather conditions;	Low population density outside cities, difficult terrain between cities; harsh weather conditions
Non-CO2 electricity production (% of total)[b]	99% (hydro 73%, geothermal 27%)	98% (nuclear 35%, hydro 46%, wind 10% and bio & waste 7%)	Over 60% (wind 49%, bio & waste 12%)	78% (nuclear 34%, hydro 24%, bio & waste 16%, wind 3%)	98% (hydro 96%, wind 2%)
Non-CO2 heat production (% of total)[b]	100% (geothermal 97%, electricity / heat pumps 3%)	89% (bioenergy / waste 81%)	61% (bioenergy / waste 60%)	48% (bioenergy / waste 47%)	83% (bioenergy / waste 67%, electricity / heat pumps 16%)
Renewable electricity sources (RES) (% of primary energy supply)[b]	88,5%	45,9%	28,4%	32,3%	44,6%
Relation to EU	EEA member	EU member	EU member	EU and Eurozone member	EEA member
Transport focused climate targets[c]	● 2020: 10% RES share in transport. ● 2050: 50-70% reduction in GHG (comp. to 1990 levels)	● 2030: 63% reduction in GHG (to 1990 levels). ● 2040: 75% reduction in GHG (to 1990 levels). ● 2045: complete carbon neutrality (= 85% reduction in GHG to 1990 levels). ● Transport: 70% reduction by 2030 compared to 2010.	● 2020: 20% reduction in GHG (comp. to 1990 levels) in non-ETS sector (incl. transport), and 40% in the ETS sector. ● 2030: 50% renewable energy ● 2050: complete carbon neutrality. (Copenhagen = 2025).	● 2030: Reduce transport GHG emissions by +- 50% (compared to 2005). First replacing current fuels (with biofuels), then alternative technologies and services, targeting 250.000 PEVs / 50.000 gas-fueled vehicles. ● 2050: 80-95% reduction in GHG (compared to 1990).	● 2025: No new traffic growth in cities and all new passenger vehicles Zero-Emission ● 2030: over 50% of heavy/commercial transport zero-emission and 50% reduction of GHG emissions (Oslo = 95%) ● 2050: 100% reduction
Average age of passenger car fleet[d]	10.6 years	9.6 years	8.5 years	12.7 years	10.6 years
Passenger car taxation[e]	● Excise duty and weight differentiated registration tax. ● Annual ownership tax based on weight	● Primarily CO2 and weight differentiated yearly ownership tax (no registration tax)	● Primarily one-time value-added registration tax ● Annual ownership tax based on fuel consumption	● Annual vehicle tax based on CO2 emissions and weight	● Registration tax based on weight, engine and emissions. ● Fixed annual ownership tax.
EV incentives[c]	● Purchase, VAT, annual ownership tax exemptions ● Support for charging infrastructure	● Subsidy on new BEV (4000e) and PHEV (2000e) ● Company car reduction ● Five year exemption of annual ownership tax	● 20% purchase tax until 5000 cars or 2019 (revising the phase out of tax exemptions (up at 40%) ● Differentiated parking. ● Tax rebates for chargers	● EVs pay minimal technical purchase tax and ownership tax, no other special arrangements. ● As of Jan 2017 5 mln for chargers	● Purchase tax and VAT exemptions; ● 50% company car tax ● Since 2015 local authorities decide on pricing level of PEV parking, toll roads, ferries and HOV lanes (max 50% of highest price). ● Infrastructure support on national and local level.

[a] World Bank (2017);
[b] International Energy Agency (2017);
[c] Based on interviews and respective climate ministries; Nordic Energy Technology Perspective (2016); Finnish Ministry of Economic Affairs and Employment (2017); the Norwegian Ministry of Transport and Communications (2017); European Alternative Fuels Observatory (2018);
[d] Respective national statistical offices;
[e] Based on interviews and respective national taxation offices;

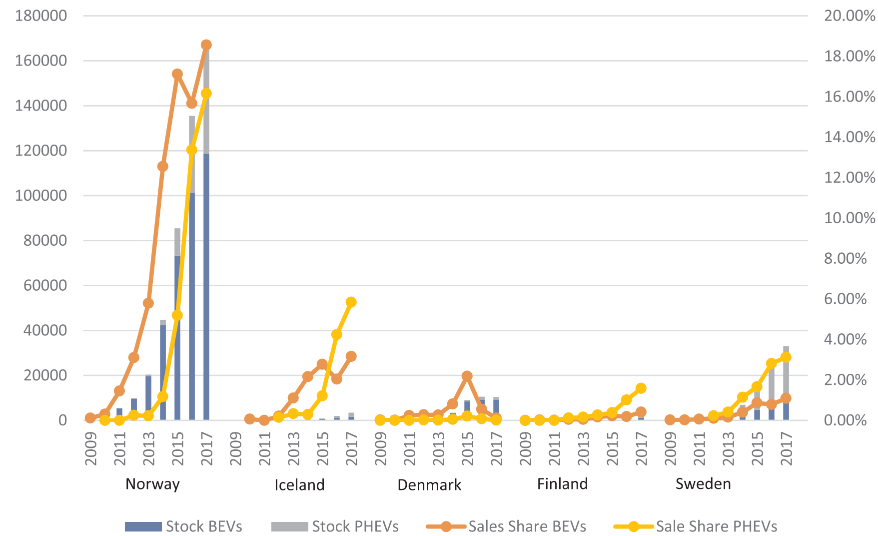

Fig. 1. Nordic stock and sale share of PEVs.
Source: Authors. Based on data from respective national statistical offices, respective EV associations (if applicable), and the European Alternative Fuels Observatory (2018).

(consumer acceptance). Clearly, some reviews pay more attention to the technology and markets (Knezović et al., 2017) while others push for attention to the consumer and social side of this technology (Sovacool et al., 2017b). Third, while these articles seem to take V2G as separate from other flexible storage technologies, this primarily results from the focus on the technology. When considering the regulatory, market and end-user challenges, it is clear that these are quite similar for other flexible storage options, like demand response of electric heating (Nordic Council of Ministers and Nordic Energy Research, 2017, p. 8).

That latter report is actually one of the closest to our study below as it is partly based on 12 interviews with DSOs about demand side flexibility (Nordic Council of Ministers and Nordic Energy Research, 2017). Briefly, the report concludes that Danish, Norwegian, Swedish and Finnish DSOs seem to struggle with the four challenges above. In terms of technical challenges, they highlight a need for standardization and technologies as well as a need for in-house experience with demand response systems and programs. Regarding the regulatory barriers, the DSO representatives in this report are optimistic, stating that these will be resolved, but that capacity tariffs are needed and that the price signals to end-users are extremely weak. In respect of the end-user, the DSOs are sceptical as they see consumer acceptance as a high barrier, especially given the low demand response knowledge and attention to flexibility among consumers (and no need for that without stronger price signals). They feel that this makes the potential of a demand response program highly uncertain, which leads them to argue for the automation of these demand response systems. Lastly regarding the market, the DSOs in this report acknowledge that they themselves need to change their investment culture away from cables, but highlight that there are no commercial market players to fill the resulting gap with little demand for flexibility from the DSOs themselves and few aggregators offering demand response capacity. The discussion below confirms and extents many of these insights as it engages with this discussion more broadly.

4. Results

From the interviews, 26 different policy mechanisms can be identified. After categorizing these suggestions, we are left with 5 categories as shown in Fig. 2. Below this paper will discuss these results, starting with the structure of the electricity market, then discussing the innovation and R&D behind V2G, only to move on to information and awareness about V2G, then discussing some other less frequently mentioned suggestions categorized as general policy advice (on planning, mandates, cost reductions and support for other sectors), only to close with a focus on a set of remarks around the claim that it is just a matter of time for V2G to arrive as most policy actions are already underway.

Before continuing with the analysis, we feel obliged to briefly draw attention to Table 4, which highlights the absence of V2G policy suggestions in our Icelandic interviews. This may be explained through a combination of the general expert ignorance of V2G, a perceived limited value of V2G in some markets, and the question itself (we asked about V2G and EV policy suggestions at the same time) something the interviewers only in later interviews started to counter with specific follow up questions. Together with the earlier mentioned inherent biases of the interview technique this implies that the results are only indicative of the trends around V2G policy suggestions in the Nordic countries.

4.1. Restructuring the electricity market

A large part of the insights from the interviews focussed on the electricity market. Specifically, the experts discussed the place of V2G in the current and future markets, and how this could affect its uptake. Their insights focussed on four aspects: double taxation, dynamic pricing, the organization of these markets (and the role of aggregators), and a need for technical and regulatory guidelines. As an aside, many of these concerns were not about addressing the technology of V2G itself and would likely apply to any actor on the electricity market that wishes to provide some form of flexible storage.

One of the primary concerns related to the payment for the storage service that V2G delivers. Both V2G practitioners and electricity and energy regulators discussed the double taxation that is currently applied to V2G projects when power is transferred to the batteries (buying electricity), as well when withdrawn from the battery (selling it). R179 in Norway draws attention to the fact that normally electricity is taxed when it is used – but storage in the grid is wholesale level trade, not consumption per se. To go about this, and do so quickly so as not to hamper the development of these flexible battery storage techniques, R179 argues:

> *I think there is quite [an] easy solution for that: make an exemption for these [types of flexible] storage. At least at the beginning to put the market in place, and then start to see how it can be done in a better way. That makes clear that we want this storage and simultaneously uses the taxation as an incentive to establish the market here.*

Table 3
Benefits, challenges, markets and policies for V2G.
Source: Authors.

	Benefits	Challenges	Markets	Suggestions
Kempton and Tomić (2005b)	Large aggregate storage capacity and quick responsiveness for the grid; A secondary benefit of a system intended (and paid) for transport; Makes grid management cheaper and power more reliable and stable; Shifts existing peak capacity to baseload.		Regions with fleets of vehicles; Regions that want to avoid copper plating (grid extension); Isolated regions with stressed transmission to that region; Regions with high regulation/spinning reserve costs (e.g. not hydro); Regions with competitive markets that also allow for ancillary services trading; Regions supporting new industries; Regions with strong renewable electricity plans.	Support the transition of V2G beyond demonstration projects first to commercially viable markets with aggregated vehicles, and then learn to handle the saturation of flexible and intermittent markets (expanding V2G to renewable electricity storage).
Turton and Moura (2008)	Accelerate the uptake of new transport technologies; Reduce the installation of conventional peak generation capacity; Support renewable sources; Lower greenhouse gas emissions.	Future costs of technology; Technological uncertainty about the combination and interaction between systems; Consumer acceptance (private consumers, and b2b consumers like electricity retailers and fleet operators); Potential emergence of competitive flexible storage technologies; Potential reduction of automobiles in transport.	Suited for frequency regulation, peak power and spinning reserves, but able to act as baseload as well; Most competitive in relation to infrastructure bottlenecks, generation capacity constraints, high peak electricity markets in sub regions.	Minimize regulatory barriers for flexible capacity; Government procurement to create demand; Fiscal and tax incentives to increase trust in this technology for (private) consumers.
Knezović et al. (2017)	Cope with loads of EVs while making use of its flexibility, capacity and idleness of the vehicle; Providing flexibility (esp. for DSOs).	Unclear regulation of flexibility and the organization of distribution grids, which are historically grid focussed and uni-lateral directed; Missing EV participation and aggregation; Standardization (of measurement, communication and verification); Payment structures; Market programs for ancillary services; Grid codes for EV charging (and reactive power compensation); User privacy.	Load and voltage regulation at DSO level.	Smart metering; EV/EVSE harmonization; DSO regulation (allow DSOs to actively operate within their grids); Flexibility trading (trading platform, products, technical requirements, market participation and payment structures); TSO-DSO collaboration (standards, priorities/roles for emergencies); Consumer (data protection, interfaces, standards).
Sovacool et al. (2017b)	For electric utilities V2G offers: back-up power, supports load balancing, reduces peak loads, reduces forecasting uncertainty, offers greater utilization of existing generation and distribution capacity; For governments V2G offers: help with integration of more intermittent renewable electricity generation and the GHG benefits of electrifying vehicles (energy efficiency, local emissions).	Technical: communication (complexity and costs), strain on the grids, and battery degradation; Financial: initial purchase price of electric vehicle; Socially: negative externalities (increased electricity consumption, impact on water or rare earth minerals); Behaviour: inconvenience (disrupting travel routines, trust to have a full car in case of emergencies), distrust (towards electricity utilities or aggregators), confusion (about types of PEVs/ hybrids and so on), battery degradation, range anxiety.	Applicable segments include fleet operations and potentially car-sharing opportunities; Applicable electricity markets include (by drawing on Habib, Kamran and Rashid (2015)) 'active power regulation, supporting reactive power, load balancing by valley filling, harmonics filtering, peak-load shaving, reduction in utility operating cost and overall cost of service, improved load factors, and the tracking of variable renewable energy resources.'	To overcome consumer resistance: Flexible rates (either by combining time-of-use rates with net metering or by revenue sharing) and education (about environmental value); Broadening the research to other car segments beyond private passenger vehicles; More research on the large-scale transition to V2G; More research on consumer complexity; More interdisciplinary, multi-method research crossing more than two of the challenges.

A more structural alternative was voiced by R163 in Finland who argues to include V2G capable charging stations as ‘part of the electricity grid’ and place them under the wholesale tax regime. R163 main reason for this is not financial ‘as it is not big money’, but administrative, as it removes an administrative burden on the V2G companies. Others similarly prefer the abolishment of one side of the taxation, for instance through some sort of net-metering. R041 in Sweden touches on this when discussing a potential payment system, and sees in net-metering the simplest solution to ‘pay or get paid for storage services’. Basically, net metering and a different tax regime are two ways to decrease the costs of all storage technologies and to allow storage, including V2G, to partake as a commercial technology. Indeed, a recent study suggested to combine these two to give end-users a greater price difference potential (Sovacool et al., 2017b, p. 382).

Continuing on such a price difference, specifically for end-users, a small number of experts prefer to build on a further flexibility of electricity prices in general. One version of this argument entails the suggestion to enhance dynamic pricing for consumers, beyond night-day pricing schemes, building in part on the European distribution of smart meters. Finland has been doing this for quite some time and Norway, Sweden and Denmark are following suit by allowing new consumer contracts based on hourly prices in line with Nord Pool's spot market. R059 felt this would work in Sweden and was confident that with serious flexible pricing the market will quickly see ‘companies and services that give you a lot of possibilities to control it’ which would be economically beneficial for consumers. This sentiment is echoed in Norway by R194 who reflected on the difference between electricity wholesale prices and consumer prices, indirectly pointing to the fact that the wholesale price is only a third of the consumer electricity price (with taxes, VAT and network tariffs making up the rest), which limits the economic impetus for consumers to change behaviour.

Pushing this argument, R083 from Denmark argues not just for dynamic electricity pricing, but also for dynamic network tariffs that better reflect the actual stress on the grid (EUROLECTRIC, 2017). For R083 ‘one of the biggest steps is if you start getting dynamic tariffs’, as these would enhance the wholesale price differences so that the consumer price difference is experienced more fully than it is today. In general, most of the experts discussed flexible pricing in one way or another. Some of them even pushed this dynamism to include flexible taxation tariffs, to further enhance the price differences between stressed and non-stressed grids (R127). As a result, electricity market taxation rules may be an essential aspect to encourage the development of V2G or other forms of storage, particularly from an energy arbitrage perspective. However, this all depends on whether V2G and flexible forms of storage actually are seen as part of the consumer or wholesale market. As EVs in most cases will be privately owned, the push is to change the consumer markets. Yet, currently V2G developments seem primarily focussed on fleet operators or large parking infrastructure, at which point the inclusion of the charger as part of the grid makes sense as well.

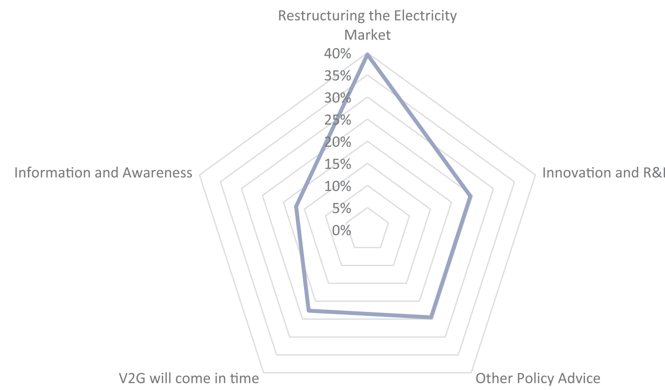

Fig. 2. Categorized V2G mechanisms as percentage of all interviews discussing V2G mechanisms.
Source: Authors.

When it comes to the organization of the electricity markets, the overwhelming advice was to extend their flexibility. Principally, with the government facilitating such a broad flexibility, instead of supporting V2G as a particular storage technology. For some this was based on economic principles, like R050 in Sweden, who argues against ‘too much subsidies and support schemes, because that might distort a functioning market.’ This argument against technology-specific government support is repeated in Finland by R152, when stating that the government actually has no active role anymore in the electricity markets themselves. Or as R152 mentions: ‘they are not on the game table at the moment, at all. And influencing the market in any way would be, I would say, difficult or disruptive.’

Against R050 and R152, the Norwegian R238 offers some thoughts on how the government could still support V2G. R238 points towards the energy regulator's control of the design of the electricity markets and urges them to allow aggregated services to bid in the electricity markets:

> *At least what they should do is make sure that there are markets available for at least aggregated electric vehicles or aggregated anything. Whether that is solar, bio, or a fleet of smaller assets, that doesn't matter …*

Similarly, R129 sees this as the core challenge and argues that authorities could help support V2G primarily by clarifying the role and legal position of aggregators who ‘aggregate the EVs and then trade the energy’ so that it's ‘very clear’ ‘who exchanges what’. A select few of the experts are thus critical of direct public subsidies and instead highlight a specific need for clear market regulations and frameworks for aggregators.

In line with the roles of the market, the experts also discussed the specific parties including other public, publicly owned and private

Table 4
Percentage of interviews weighted per country mentioning V2G mechanisms.
Source: Authors.

	Iceland (n=29)	Sweden (n=42)	Denmark (n=45)	Finland (n=50)	Norway (n=61)	Total (n=227)
Overall number of interviews with proposed V2G Mechanisms	0% (n=0)	12% (n=5)	27% (n=12)	34% (n=17)	31% (n=19)	23% (n=53)
Restructuring the Electricity Market	0% (n=0)	10% (n=4)	11% (n=5)	8% (n=4)	13% (n=8)	9% (n=21)
Innovation and R&D	0% (n=0)	2% (n=1)	7% (n=3)	6% (n=3)	10% (n=6)	6% (n=13)
Other Policy Advice	0% (n=0)	5% (n=2)	4% (n=2)	12% (n=6)	5% (n=3)	6% (n=13)
V2G will come in time	0% (n=0)	2% (n=1)	2% (n=1)	12% (n=6)	7% (n=4)	5% (n=12)
Information and Awareness	0% (n=0)	0% (n=0)	4% (n=2)	6% (n=3)	7% (n=4)	4% (n=9)

actors like transmission system operators (TSOs), energy regulators, DSOs, and so on. Here two issues stand out. First, TSOs and regulators are said to remain reluctant to accommodate new technologies and markets as they are generally conservative 'to change the rules' (R163). For R163, this includes the Finnish TSO and Energy regulator, who R163 simultaneously describes as ahead of their EU counterparts in terms of power aggregation and flexible market structure. Second, R156 remarks how these parties as well as the Finnish Energy Industry lobby should not only install the markets and taxation rules, but also perhaps provide 'the technical guidelines', standardization, and 'terms and conditions' that are needed to construct V2G and other storage techniques as part of the grid. Third, like Knezović et al. (2017), R194 discussed the specific position of DSOs in the market. In particularly, the current EU unbundling regulation which prohibits grid companies to play an active role in decentral electricity markets, but at the same time 'obliges them to utilize local flexibility', without explaining whether DSOs are in charge of setting up local flexibility markets (and how that relates to the TSO) or are able to own and operate flexible storage themselves. It's also not clear whether DSOs are able to organize and especially finance pilot projects. And for R194 this comes on top of another major problem in the current markets, namely the lack of different local pricing zones. It should be noted however that among regulators the official focus seems primarily directed at distribution level grid tariff price signals and the facilitation of subsequent markets (Nordic Council of Ministers and Nordic Energy Research, 2017).

To sum up, the shared vision that experts foresee for V2G and storage technologies in general is founded on a continuation of the current market-based approach that governs electricity markets in the Nordics. However, the interviewees suggest that these markets need to be adjusted so that they facilitate aggregated short-term storage markets. In addition, experts point to the removal of double consumer taxation and the need for guidelines and standards on the technical requirements as well as a clarification of the legal positions of DSOs, aggregators and storage providers.

4.2. Innovation and R&D

Besides the market conditions, experts discussed the phase of V2G development as they recognized the chicken-and-egg discussion between market regulations and the need for pilot projects to see what technical and market arrangements work most effectively. On the one hand, some experts are highly confident about the future of V2G, like R099 in Denmark who confidently remarked that: 'the technology is there, the vehicles are there. So, I think [the goal] is to encourage and support heavy field pilots.' Others are a bit more careful, but similarly support a call for pilot projects. In the words of R222 from Norway: 'I think the first step is to just develop the pilots and learn. And because that could happen anywhere it does not matter [who organizes them or where they take place].' From these and similar remarks, it's possible to draw attention to three aspects of pilot projects.

First, the geographical nature of the pilot projects is of less importance for our experts. It is a global market and for most it does not matter where the pilot projects take place. R222 continues by arguing that perhaps Denmark should take the lead with pilot projects, and that they learn from that. Not because R222 does not believe in V2G, but because 'it competes with other solutions and many other [priorities]' in Norway. In line with the observation from Kempton and Tomić (2005), our experts (R215) saw Norway as an unlikely candidate for V2G. As R196 remarks: 'in Norway, where you have the world's largest renewable batteries installed already, I just cannot see the big need for it here.' That said, R196 immediately points out that while Norway does not need the storage, it does need a strong flexible grid for international and domestic capacity and could still use localized storage to balance out stress levels. The thought that Denmark should take the lead on V2G pilot projects returns in Denmark itself. R099 for example hopes that Denmark 'can be one of the hotspots for sorting out the EV stuff.' Yet, it is also challenged as both R099 and R111 lament recent Danish cuts in fundamental energy technology research. In other words, the argument raised is that V2G needs to fit both the local energy and research systems.

Still, clearly there are countries and regions where V2G offers a better fit and thus a better business model than in other countries. And as R236 argues, finding good business models is a second goal of pilot projects. It is not just about the market where one operates but also how one operates in those markets and how V2G becomes viable for consumers and companies alike. R236 in this sense pushes towards the search for 'business models where you get the benefit of V2G, but where you do not have to worry about your battery.' R236 mentioned V2G structures whereby consumers receive a new battery at the end of its lifetime or a service where they rent a battery.

The third reason for pilot projects touches on the system integration of V2G as the next phase after the technology development itself. Pilot projects, according to R222, first need to show that the technology works (he points to the Danish pilot project doing precisely that), and then need to figure out how they can 'operate in the whole system'. In this respect, an important policy focus here could be the DSOs again, as these need the *institutional* capacity to handle such flexibility and the increasing number of decentralized storage options. However, as R238 argues, currently 'in Norway, we have many, many small distribution companies, and there is an issue with the knowledge of new technologies. […] So, you need to prepare the grid companies for new technologies.' Basically, when it comes to V2G not only the companies constructing and operating the technology need to grow and gain institutional memory, but the companies around them need to grow and learn as well.

Interestingly, during our discussions about V2G and V2G pilot projects, experts often shifted the topic from V2G to the use of stationary batteries in local grids or the options for smart charging with a stationary battery behind the charger. Like R142 who, while discussing V2G, told us about a stationary storage project from two Finnish power companies and how this too 'is not economical and does not make sense right now, but they are looking for experience and how to use it as a part of the grid.' Similar shifts occurred in Norway, where experts pointed us to the Vulcan garage in Oslo that combines controlled charging solutions with battery storage, or the high capacity charging equipment for electric ferries situated at the end of a weak grid connection (R201, R205, R245, R247). Thus, additional research and development was encouraged for various forms of storage technology, including both V2G and stationary storage, even though these could be seen as competitors. At the same time this is a third value of pilot projects: they create local awareness about new technologies.

4.3. Information and awareness

So far, most of the experts seem to agree that V2G technology should be developed by the market with limited government support focusing primarily on regulation and seed-money for pilot projects. Of course, some experts also discussed other aspects of V2G support, including a need for more information and awareness about V2G, as it remains a newly developing and little known technology among consumers, experts and companies alike. As R126 in Denmark reflects 'if you say vehicle-to-grid, less than one percent would understand what it is about.' Not just 'of the Danish population', but 'worldwide it is very limited knowledge.' This sentiment is shared by R171 in Finland, who also argues that training and information sharing are critical at this stage of development in conjunction with the above mentioned concomitant implementation of pilot projects:

> *But of course, there is also always somebody who is reluctant about these developments: "What about my battery?", "What happens to my car?" "Will my car battery suffer from it some way?", "Or who is going to*

Table 5
Summary of V2G policy suggestions and our reflection.
Source: Authors.

Party	Suggestion
Authorities (national governments, energy regulators, TSOs)	Consider whether V2G capable chargers are part of the consumer market or the wholesale market;
	Consider the double taxation on flexible electricity storage (initial temporary exceptions for pilot projects);
	Consider further dynamic pricing options (dynamic pricing with net metering, dynamic tariffs, dynamic taxes; more pricing zones);
	Formulate the role and responsibility of DSOs (how DSOs can actively steer local storage solutions and how this is communicated on a system level, see Knezović et al., 2017 for other specific suggestions);
	Formulate the role and responsibilities of aggregators;
V2G companies	Expand pilot projects;
	Invest in and share information and data amongst B2B contacts;
	Facilitate engagement with demand response companies working on other flexible storage options (to strengthen the lobby for aggregated market regulation);
	Focus on regions without fast responsive hydro (although we strongly believe that there is a role for V2G in the Nordics as well);
	Focus on regions with stressed local grids (but at current stage expect competition from stationary batteries – deemed 'easier');
	Focus on fleet operators with known overcapacity and down time (postal services, neighbourhood nurses, shared car services, and so on);
Lobby of V2G, aggregators, other flexible storage companies	Lobby for fitting ancillary service markets;
	After standardization agreements, generate technical guidelines and share them;
Research and academia	Continue/expand research on flexible storage options across disciplines;
	Participate in pilot projects;
Governments	Support pilot projects / start-up companies on V2G and other flexible storage solutions (financially, but also by temporarily absconding regulatory conditions);
	Create energy strategy;
	Support the sector in generating appropriate aggregation frameworks;
	Consider building regulations;
	Help set up technical/pragmatic guidelines;
	Directly/indirectly support research on these topics;
	Support the sector by supporting EV and RES uptake;
DSOs	Generate institutional capacity about V2G and flexible local storage options;
	Rethink investment strategies;
EV and charging infrastructure companies	Incorporate bidirectionality and payment systems in software and hardware of chargers and cars;
	Sell V2G as an additional selling point to car makers;
General	Clearly differentiate between controlled charging and V2G;

compensate me if that is case?" And definitely somebody will ask those questions! So, training and information exchange definitely would be highly needed at that stage of experiments and implementations.

Lastly, R085 brings up an interesting argument in favour of Danish public support for V2G. Less because of its monetary value, but rather for the marketing value of the incentive itself to make people aware of the development in this field. Or as R085 remarks: to 'get this attention to what it is, and that it is something that the government wants.' The need for information, *from* and *for* both companies and consumers should thus be a focus point for potential policy support and the sector itself.

In order to deal with such questions and inform people about V2G, R126 argues for more 'understandable information' on the effects of V2G in terms of both 'emissions' and 'monetary units'. R126 thus points to a need for the actual data about the costs and benefits of V2G in different markets. Data that subsequently should be used to educate not only consumers, but also experts within the transport and electricity fields. In addition, for consumers specifically, the technology needs to be simple and accessible, or as R104 argues 'it is like buying ecological food, right? If it is there and it is not too expensive, I do it. If it is not there and it is too expensive, I don't do it.'

In sum, V2G would benefit from more and better information on the technology and its monetary and environmental consequences towards both consumers and other involved sectors, including experts within the field. However, while our interviewees acknowledged the role of public authorities to support information sharing initiatives in this regard, the above is as much a call for the sector itself to come up with such data and disseminate it.

4.4. Other policy advice (planning, EV, RES)

Besides these three core mechanisms, experts listed a number of other options ranging from planning, mandates and subsidies to an encouragement of EVs and renewable energy sources (RES). Each of these were mentioned only a small handful of times at most, but indicate other options where the sector and public authorities could focus on.

First planning and visions, as these can both push a market forward and/or create the stability for markets to develop products on their own. For instance, governments could play a role through their long-term electricity (and transport) plans. On a national or system-wide level, when R041 calls for governments to 'devise a strategy how your future electricity system is supposed to look like and what storage demands will come up from that', as this would offer an indication of market potential. Likewise, R099 calls for Denmark to approach EVs and V2G as they did with wind energy: with a vision instead of the current 'focus on cost savings.'

Besides national strategies, local authorities could also offer more strategic visions and better planning. R119 for example connects the local underground electric distribution grid with urban concrete environments in Danish cities and mentions that 'no one has the responsibility for making a strategic energy plan' to prevent a city to 'dig up all the roads again' if it turns out more cables are needed. Similarly, R190 in Finland touches upon the V2G readiness of apartment buildings and how 'it is a policymaker thing' to 'ensure that vehicle-to-grid kind of things' can be implemented in apartment buildings down the road. For both these levels, a set of more practical and officially approved guidelines would support a faster development of V2G, as it informs and guides a wide range of actors who are not directly involved with V2G technology itself.

A second point worth mentioning is that some of our experts – those not directly working on V2G – tend to reason that V2G needs a certain mass penetration of electric vehicles (R179 and R162) and intermittent renewable energy sources (R059). In the words of R158 in Finland (interviewed before recent EV subsidies):

> *The best thing they can do is promote EVs. Because they already subsidise charging infrastructure. But the problem is that we can invest in charging infrastructure as much as we want. But if the EVs are not attractive to people, because they are too expensive or don't have benefits, then this is for nothing.*

While intermittent RES returns in Denmark (in line with the absence of hydropower and its storage and fluctuation control capacity) and Denmark is also home to most activity on V2G in the Nordic region, it is simultaneously a country with a relatively low EV penetration. This dispels the notion that EV and V2G uptake are one-on-one related, a fact well known in the literature (Kempton and Tomić, 2005a) but not in the wider EV sector. Still such calls draw attention to the interplay between EVs, V2G and RES, where each one provides benefits and solutions for the other two, and thus the potential for an exponential development and introduction.

Thirdly, while most of the policy mechanisms so far support V2G indirectly, in some interviews single experts mentioned mandates and subsidies as a way to support this technology directly. These include the earlier mentioned incentives for fundamental research and building regulations, but also subsidies for V2G capable cars or chargers (R085, R157, R127). These subsidies would help bring costs down as it would scale up the individual pilot projects to mass production level and would help 'spread the word' which in turn would create a positive spiral of demand (currently R085 still has to go out 'and pick every customer' individually, which 'takes time and understanding'). Such subsidies could be earmarked (R085) or part of a larger CO2 grant where projects compete based on their contribution (R157). All of these imply ways to support a beginning industry, either by removing potential regulatory barriers or financially supporting research, pilot projects and promising technologies.

In short, authorities can help create stability by offering planning on both a national and local level. These plans should include goals and visions on how to get there, in order to show various actors in society the role that V2G or flexible storage in general is expected to play in both the transport and electricity sectors, as well as more pragmatic guidelines that specifically assist the planning and integration of V2G on a more local level. They can also strengthen the potential business case of V2G by further promoting an overall development of electric mobility and a further increase in solar and wind electricity. Lastly, direct subsidies could be used to speed up momentum in the industry, create economies of scale and help increase the interest and awareness about the technology. While obviously desirable for the companies involved, this seems to go against the principles behind 4.1 and the comments in the next section.

4.5. Determinism and momentum

The last set of remarks came rather as a comment than as a policy mechanism. After the focus on the electricity market, the piloting of the technology, the need for information and information sharing, and other policy mechanisms, our frequency analysis highlighted how experts remarked multiple times that V2G was 'just a matter of time'—that the technology is on a deterministic path to already being diffused. Basically, the experts saying this expressed their trust that V2G and its competing flexible storage options will find their place in the electricity markets; as long as these networks properly accommodate for aggregation services (R121, R136).

Counter to the above, some believe this the case because they feel that the authorities have already facilitated a proper context and either have or are seen to actively look into the aggregation markets. And in line with Section 4.2, they expect an improved business case for V2G as a result from further technology development, like R151 who argues that Finland has 'everything that is needed': that Fingrid is working on the regulations, that the utilities are interested, that Finland is part of Nord Pool, and that it's basically just a matter of trying and developing. For others, it is because they reject excessive command and control forms of government intervention, like building a complete charging infrastructure (as in Oslo or Estonia). Of course, R137 in Finland does welcome financial support: 'we see the charging business as one of the biggest business in the future EV scheme, especially related to the energy sector. So, government should give money but stay away, haha.' Most of the experts talking about this however, just simply state that public authorities have a limited role to play and that the technology will come in time. First in the markets where the business case is optimal, most likely commercial fleets in regions where grids face intermittency and a need for local storage, and then slowly in other regions and different aspects of the electricity market.

Still, the above shows that authorities do play a role in how fast such a technology would come around. And even though our results are indicative and not definitive, the fact that this argument or a variant of it returns in 23% of the interviews that discuss V2G policy mechanisms hints at the established Nordic laissez faire approach to electricity markets and a trust that V2G will find its place even in these markets characterized by hydropower and strong interconnections.

5. Conclusion and policy recommendations

This paper examined how hundreds of experts related to electric mobility reflected on policy suggestions for EVs and V2G in the Nordic countries. As our interview protocol asked open-ended questions across multiple sectors about both EVs and V2G, experts were free to answer as they saw fit and about what they felt comfortable. Our results show that it is indeed a small number of experts in our sample offering specific V2G policy suggestions. From this, three conclusions can be drawn.

First, a lack of awareness and deeper understanding of what V2G is and how it works in the transport and electricity sector, which is evident given the low number of suggested mechanisms and the conflation with smart charging. Furthermore, the results indicate that the advice is primarily focussed on the electricity sector, not the car sector or consumers, even though Table 1 shows that the transport sector does not score radically lower than the electricity sector. This reflects the youth of the technology, as it is not yet at a stage of consumer dispersal, which makes it difficult for those not directly involved in V2G (e.g. those involved in EVs, infrastructure planning, and so on) to imagine how the technology might end up. But it also reflects the type of technology and how those involved construe it. Simply put, V2G is not as alluring as a Tesla Roadster (yet), and the people involved seem to consider it a practical automated solution for the grid. Of course, the challenge is that V2G lifts on the consumer market (with proper compensation, etc.) to benefit the wholesale market. Attention to the former makes no sense without a working integration to the electricity market, and hence our sample was more focussed on the structure of these markets. The order and magnitude of the subsequent V2G policies, as summarized in Table 5, while general can be used or at least calibrated for government and sector wide action.

Secondly, our findings confirm multiple themes offered in the policy literature. Our findings affirm the need for policies targeting aggregators, the position of DSOs, the organization of electricity markets, the need for standardization and guidelines, and a need for information for both consumers and V2G associated industries. They also emphasize the multi-scalar notions of ostensibly successful policy frameworks for V2G, namely the inclusion of actors across the automotive manufacturing industry, charging companies, DSOs, local governments, regulators, companies, consumers, and even universities. This reminds us that the scope of regulation may be just as important as the actors involved in crafting and supporting it.

Third, and lastly, our results do point the way for further research. In line with Sovacool et al. (2017a, 2017b), we call on the research community to better examine whether transportation demands actually pose a barrier to V2G, or an opportunity. Likewise, the main policy recommendations identified are regulatory or financial, calling into light needed research on non-technical or non-policy areas such as social behaviour, cultural norms, and issues of justice and scale (to name a few). Also, although our qualitative method shows promise in relation to the future development of electricity grids as it allows for an in-depth comparative analysis of the arguments in different regions and countries offset against local conditions, it could be supplemented with quantitative designs, especially models or methods more prone to statistical analysis. Furthermore, as the V2G transition bridges transport and power, and in line with recent work, new conceptual frameworks may be needed to fully capture it, including (but also extending beyond) the multi-level perspective (Geels et al., 2017) or strategic action fields (Canzler et al., 2017). Finally, the fairly narrow view of V2G policy reflected in our interviews is due partly to lack of awareness and knowledge. Research could explore why V2G has remained exclusively within highly-technical areas of expertise, even though it is a topic with great potential to impact non-experts (especially automobile drivers and electricity consumers). Perhaps when these avenues are more fruitfully investigated, more effective policy mixes can buttress existing regimes and further accelerate the adoption of V2G in the Nordic region and beyond.

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