SCALE

Report on consumer behaviour (2nd edition)

Project deliverable D1.1

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Project Executive Summary

SCALE (Smart Charging Alignment for Europe) is a three-year Horizon Europe project that explores and tests smart charging solutions for electric vehicles. It aims to advance smart charging and Vehicle-2-Grid (V2G) ecosystems to shape a new energy system wherein the flexibility of EV batteries' is harnessed. The project will test and validate a variety of smart charging and V2X solutions and services in 13 use cases in real-life demonstrations in 7 European contexts: Oslo (NO), Rotterdam/Utrecht (NL), Eindhoven (NL), Toulouse (FR), Greater Munich Area (GER), Budapest/Debrecen (HU) and Gothenburg (SE). Going further, project results, best practices, and lessons learned will be shared across EU cities, regions, and relevant e-mobility stakeholders. SCALE aims to create a system blueprint for user-centric smart charging and V2X for European cities and regions.

SCALE partners

List of participating cities:

- Oslo (NO)
- Rotterdam & Utrecht (NL)
- Eindhoven (NL)
- Toulouse (FR)
- Greater Munich Area (GER)
- Budapest & Debrecen (HU)
- Gothenburg (SE)

List of partners:

- (Coordinator) STICHTING ELAAD NL
- POLIS - PROMOTION OF OPERATIONAL LINKS WITH INTEGRATED SERVICES, ASSOCIATION INTERNATIONALE POLIS BE
- GoodMoovs NL
- Rupprecht Consult – Forschung & Beratung GmbH RC DE
- Trialog FR
- WE DRIVE SOLAR NL BV NL
- UNIVERSITEIT UTRECHT NL
- LEW Verteilnetz GmbH DE
- BAYERN INNOVATIV - BAYERISCHE GESELLSCHAFT FUR INNOVATION UND WISSENSTRANSFER MBH DE
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- L'ASSOCIATION EUROPEENNE DE LA MOBILITE ELECTRIQUE (AVERE) BE
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Deliverable executive summary

Key words

Electric vehicles, EV drivers, smart charging, Vehicle-to-Anything, Vehicle-to-grid.

Summary

This report examines the needs and challenges of electric vehicle (EV) drivers regarding vehicle-to-anything (V2X) technology and smart charging in seven European countries: Austria, Poland, Portugal, Slovenia, Hungary, the Netherlands, and Norway. The respondents generally express a strong willingness to use smart charging, but not all are satisfied with its functionality. This is especially true for Dutch EV drivers. Across all countries, there is a consensus that smart charging should be user-friendly and financially advantageous.

Additionally, control, insight, and financial benefits are key priorities for EV drivers when it comes to adopting smart charging. Trust in handing over control of charging varies, with original equipment manufacturers receiving the highest level of trust. However, many respondents prefer self-control and show low level of trust in third parties, posing a significant adoption barrier.

While most EV drivers see value in V2X technology, they particularly favour vehicle-to-home options like using solar panels and smart house technology. Willingness to participate in vehicle-to-grid increases significantly when participation is made contingent on receiving financial incentives. Moreover, 8 out of 10 EV drivers express concerns related to adoption of V2X technologies. The most common include potential battery degradation, reluctance to cede control, and uncertainty about receiving benefits from using V2X technology.

Expert interviews with representatives from EV driver organizations in the seven countries reveal varying national debates around smart charging and V2X adoption. The literature review also shows a lack of consumer oriented research on smart charging and V2X technology. Differing perceptions, concerns, and interests should be considered in the development and debate surrounding this new technology, as consumer acceptance is essential for its success.

List of abbreviations and acronyms

Acronym	Meaning
EV	Electric vehicle
OEM	Original equipment manufacturer
V2G	Vehicle to grid
V2H	Vehicle to home
V2L	Vehicle to load
V2X	Vehicle to anything
VER	The Dutch Electric Vehicle Drivers Organization

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Purpose of the deliverable

Attainment of the objectives and explanation of deviations

The objectives related to the first edition of this deliverable (consumer behaviour report) have been achieved in full and as scheduled.

The purpose of this deliverable is to illustrate and analyse consumer needs and interests regarding smart charging of electric vehicles. Different studies and surveys show what EV drivers want when charging their car and assess their charging behaviour. This report uses results from research articles, reports and surveys conducted by both external parties and partners within the SCALE project. In this second edition of the consumer behaviour report, the purpose is to provide a thorough analysis of EV drivers' needs and motivations regarding smart charging and vehicle-to-anything technology.

Intended audience

- EV drivers/owners
- EV Fleet Managers
- Mobility Service provider (MSPs)
- Site owner (building, parking, workplace, public)
- Organisations representing the above
- Charge Point Operator (CPO)
- Distribution System Operators (DSO)
- Transmission System operators (TSO)
- Vehicle Manufacturers (OEMs)
- Consultants in EV deployment and energy market,
- Balancing Service Providers (BSP)
- Aggregators
- Policymakers
- Standardisation bodies
- European Institutions (DG MOVE, DG ENER, DG CONNECT, DG GROW, EP, JRC)

Structure of the deliverable

This document is divided into 5 chapters, with relevant subchapters. The first chapter is an introduction to the second edition of the consumer behaviour report and offers relevant definitions and background to the topics discussed in later chapters. The following chapters dive into a survey we did with EV-drivers from seven European countries on their needs and challenges regarding smart charging and Vehicle-to-X (V2X). The following chapter is a literature review, looking at relevant studies on related topics such as EV drivers' perceptions to V2G and smart charging. Then we take a closer look at the specific situations in the different countries through summaries of expert meetings with representatives from all the seven countries surveyed. The conclusion summarizes the findings in the second edition of the consumer behaviour report and elaborates what is needed going forward.

Consumer behaviour report

1 Introduction

While the uptake of electric vehicles (EVs) increases at high speed in Europe, the need to understand EV drivers' expectations, preferences and challenges grows. SCALE is aiming to achieve smart charging alignment for Europe, paving the way for achieving Europe's Fit for 55 ambitions.

This report dives into a brand new European survey conducted as part of the SCALE project about EV drivers' perceptions toward smart charging and Vehicle-to-anything (V2X). The survey was conducted among more than 3000 EV drivers across seven European countries: Hungary, Poland, Portugal, Slovenia, Austria, Norway, and the Netherlands. With a keen focus on the motivations and behaviours of EV drivers, this report offers insights into the prevalence and nuances of smart charging practices, as well as the emerging landscape of V2X technology adoption.

Smart charging is defined as "to control and optimize the time and speed of charging" (de Brey, Gardien & Hiep 2021). V2X can be referred to as Vehicle-to-anything and is a term that describes using the power stored in the EV's battery to power for example a home (V2H), a neighbourhood and so forth (de Brey, Gardien & Hiep 2021). Another part of V2X is called Vehicle-to-Grid (V2G). This means to have your car act as a power supply that can deliver energy back to the power grid. This can also be referred to as "bidirectional charging" or "power recycling" (de Brey, Gardien & Hiep 2021).

The report address questions surrounding the adoption of smart charging practices, with a particular emphasis on whether there are prevailing trends across all surveyed countries. Furthermore, the survey dives into the circumstances under which EV drivers from various countries are open to utilizing their battery's energy for purposes other than charging their own car. The report also investigates concerns related to V2X implementation, acknowledging the diverse perspectives and worries prevalent among EV drivers across these European nations. By comparing the findings across countries, the report unveils both commonalities and differences among EV drivers

This exploration of EV driver perspectives casts a spotlight on the blend of factors that influence charging behaviours and the receptiveness towards innovative V2X applications.

Updated versions of task 1.1

This is the second report on consumer behaviour within the SCALE project. This report will be updated in a third and final version in month 32 (January 2025) of the SCALE project. All SCALE partners are invited to send input on what they deem relevant to include in the third version of the report.

1.1 Survey in seven European Countries

Our journey of exploration across European countries was made possible with the active participation of GEVA (the Global EV Alliance) members (GEVA 2023). Through the collaboration of our partners within GEVA, we reached out to their community of electric vehicle (EV) drivers, inviting them to share their thoughts and insights through our survey. This collective effort ensured that our findings are grounded in real-world experiences and perspectives from a diverse range of EV drivers. The survey was open from March 20th to July 23rd.

The survey aimed to collect insights on motivations related to smart charging and V2X adoption. There were no questions included in the survey to map background information about the participants However, there is other relevant research available that has already mapped out the general characteristics and details about EV drivers. One example is the previous report on consumer behaviour within the SCALE project.

It is highly relevant to map what EV drivers hope to gain from V2X, and which type of V2X they deem as relevant and attractive from their point of view. Furthermore, the survey aimed to collect insights related to V2X barriers and asked for trust levels in terms of handing over control for optimizing charging and discharging cycles to a third party, like an original equipment manufacturer (OEM), energy supplier, grid operator, or charge point provider.

Additionally, we went further than collecting survey responses. We wanted to dive deeper and truly understand what these survey results meant. So, we engaged in insightful discussions with representatives from EV drivers' associations in each country. These conversations added a layer of context and personal experiences.

Moreover, this report includes a literature review with other relevant research and scientific studies of smart charging and V2X. Other research projects and scientific articles might have access to other databases and consumers than partners in SCALE do, therefore the report includes results from other sources when this is regarded as relevant or interesting.

Our approach, blending survey participation, expert insights, and existing research, ensures that our understanding is practical and rooted in the real world.

1.1.1 Countries chosen

In total we got 3246 respondents from more than 20 countries. Seven countries got more than or close to 100 respondents and are thus the countries we chose to focus on in our report. Smaller sample sizes than groups of 100 respondents may not adequately capture the diversity of opinions, attitudes, and characteristics within the larger population they are sampled from.

Country	Number of respondents
Norway	1526
The Netherlands	527
Portugal	247

Hungary	183
Poland	156
Austria	103
Slovenia	68

Table 1: Countries with over or close to 100 respondents

We have included the results from Slovenia in the report, even though there were fewer than 100 respondents from that country. While the absolute values might be less reliable, any consistent patterns or trends observed within the survey responses can still provide valuable insights. However, the survey results from Slovenia, with only 68 respondents, must be interpreted with caution.

Given that respondents from Norway constitute two-thirds of the total participant pool, their presence significantly influences the overall average results. Consequently, our analytical emphasis primarily centres on dissecting the outcomes on a per-country basis, enabling insightful cross-country comparisons. This approach is interesting due to the inherent disparities that can, and indeed do, exist among nations. Notably, Norway, being the most mature market for EVs, stands as an illustrative example of such distinctions.

1.1.2 EV sales in the seven surveyed countries

Country	EV market share new car sales	EV share total fleet
Norway	82.9%	22.9%
The Netherlands	28.5%	3.7%
Portugal	15.7%	1.2%
Hungary	5.0%	0.8%
Poland	3.5%	0.1%
Austria	18.5%	2.1%
Slovenia	2.1%	0.6%

Table 2: EV share in new passenger car market per. 31 July 2023 and EV share of total passenger car fleet per 31 December 2022. Source: ACEA (2023), European Alternative Fuels Observatory (2023), OFV (2023).

As seen in Table 2, the highest market share for EVs is found in Norway. Second in row are the Netherlands and third Austria, with relatively low market shares in Hungary, Poland and Slovenia, making it relevant to refer to EV drivers in these countries particularly as early adopters. The similar trend can be spotted in the fleet numbers. Norway has the absolute highest share of EVs in the passenger car fleet, with the rest of the European countries following with shares from 0.1-2.1 percent share of the fleet.

2 Survey results

2.1 Smart charging

Smart charging is achieved by aligning the time, speed, and charging method with the EV driver's preferences and prevailing market conditions (de Brey, Gardien & Hiep 2021).

2.1.1 How many respondents charge smart?

In the SCALE survey, participants were asked about their car charging habits, specifically whether they have control over the charging process and how they exercise that control. The most commonly selected choice across the countries in the survey, is "I control the charging of my car using the car's app". Following closely are responses for "No, I simply plug in the charger and the car starts charging" and "I control the charging of my car through the home-charging-box." Notably, a minority of 5 percent or fewer in all countries indicated that "The public street charger controls the charging of my car."

However, it is important to note that this question lacked an option for third-party control, such as involvement of an electricity provider. This absence is noteworthy as the Norwegian EV Driver Survey and our SCALE network indicate that this method of charging control is popular. This likely has an impact on the distribution of responses in each category.

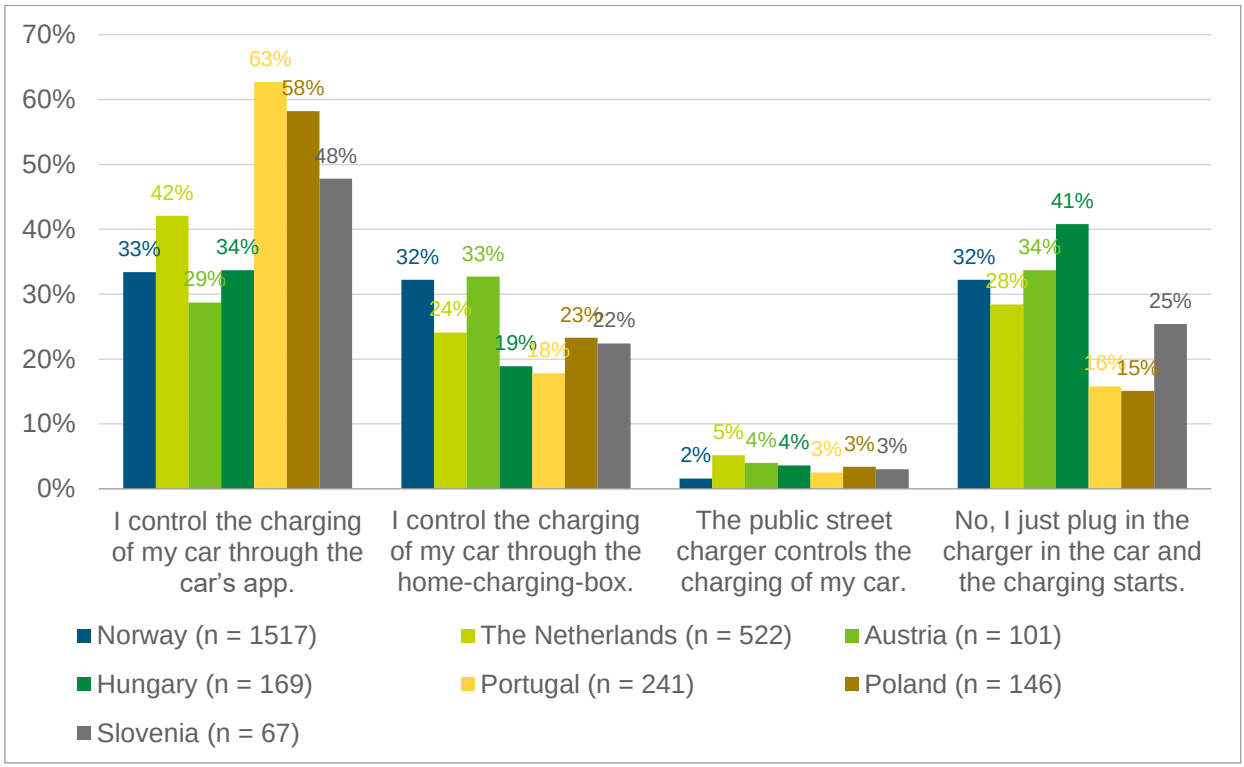

Figure 1: Do you control the charging of your car/do smart charging?

In Norway, the responses are quite evenly spread across the choices of car, charging box, and not using smart charging, with each option accounting for approximately one-third each. Yet, in the Norwegian EV Driver survey (Elbil 2023), which provided more alternative possibilities, only 23 percent reported utilizing the home charger or its associated app for controlling the charging process. A separate 10 percent opted for a third-party app. Additionally, 23 percent mentioned manually plugging and unplugging the charger to

manage car charging, while just 12 percent indicated not having any control over the process. This illustrates how missing alternatives could affect the results.

Moving to the Netherlands, 42 percent of EV drivers exercise control over their charging via the EV's app. Meanwhile, 24 percent prefer using the charging box, and 5 percent let the public street charger take charge of the process. Notably, 28 percent do not engage in smart charging in the country.

Turning our attention to Poland and Portugal, the majority, 58 and 63 percent respectively, rely on the car's app to control charging. These two nations also have the highest overall rates of smart charging adoption. Austria, on the other hand, display a relatively balanced distribution of preferences, with participants opting for the car's app, home charging box, and not smart charging in nearly equal proportions. Hungary emerges as the country where the fewest respondents, at 41 percent, reported controlling their charging process.

Not all countries prioritize smart charging equally, revealing diverse adoption rates and infrastructural priorities. This highlights the need for tailored strategies that consider regional context and local priorities when developing smart charging solutions in the evolving landscape of electric mobility.

2.1.2 Why do EV drivers charge smart?

When asked why they control their charging, in five of the seven countries the most popular answer among the EV drivers was "Because it is greener, I can use my solar panels". Poland leads the charge in emphasizing charging with solar panels, with 47 percent of respondents leaning in this direction. Austria follows closely at 45 percent, trailed by Hungary and the Netherlands, both at 38 percent, while 34 percent of the Slovenians give this answer.

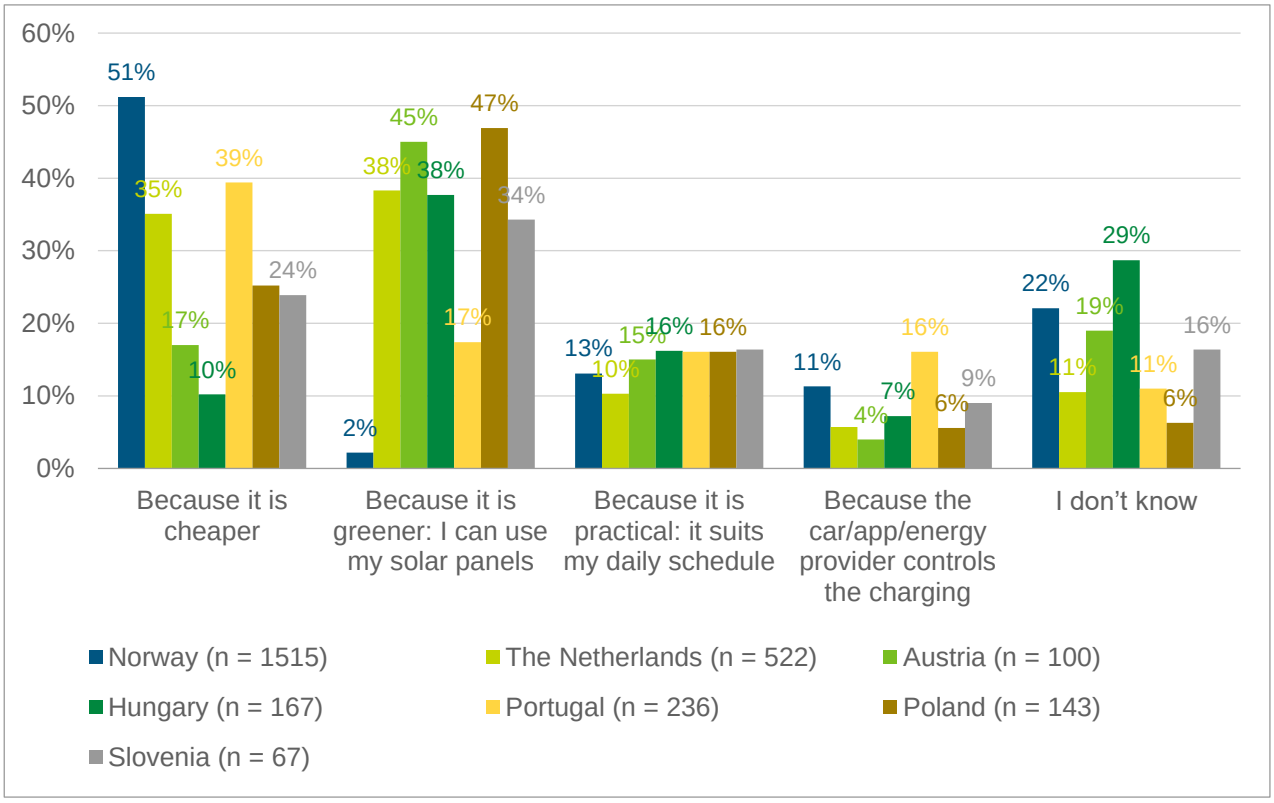

Figure 2: If you charge smart/control the charging of your car, why do you do that?

In the expert meetings with representatives of the different EV drivers Associations we reflected on these figures. Primarily, price emerges as the decisive factor. The utilization of solar panels is often driven by financial considerations rather than an environmental ethos. Using solar panels is in most cases not so much for green energy but more because it's cheaper. So the green option is often also the cheaper one. This was confirmed in the interviews with the representatives of the different countries (see chapter 4).

The respondents in Norway and Portugal, mostly reply "Because it is cheaper". A notable 51 percent of Norwegians opt for smart charging due to its cost-effectiveness. This observation resonates with the findings from the Norwegian EV driver survey, where respondents had the option to provide multiple reasons for nighttime charging. Here, an overwhelming 71 percent indicated cost as the primary incentive. However, a mere 2 percent of Norwegian EV drivers engage in smart charging for environmental reasons. Similarly, in Portugal, the cost holds greater significance (39%) than prioritizing green energy (17%).

The option "Because it is practical" is selected by between 10 and 16 percent of responses across all countries, while the explanation of car/app/energy provider control receives between 4 and 16 percent of responses. There was no option for not smart charging, but respondents had the option to choose "I don't know". Intriguingly, 29 percent of respondents in Hungary and 22 percent in Norway indicated uncertainty regarding their choice to control their car's charging – but this might also be the natural option for those who do not smart charge.

2.1.3 Expectations and willingness to charge smart

In this chapter, we delve into the insights gained from respondents' expectations and willingness to engage in smart charging practices. The respondents were asked to consider statements about smart charging, on a scale from 1 – strongly disagree to 5 – strongly agree.

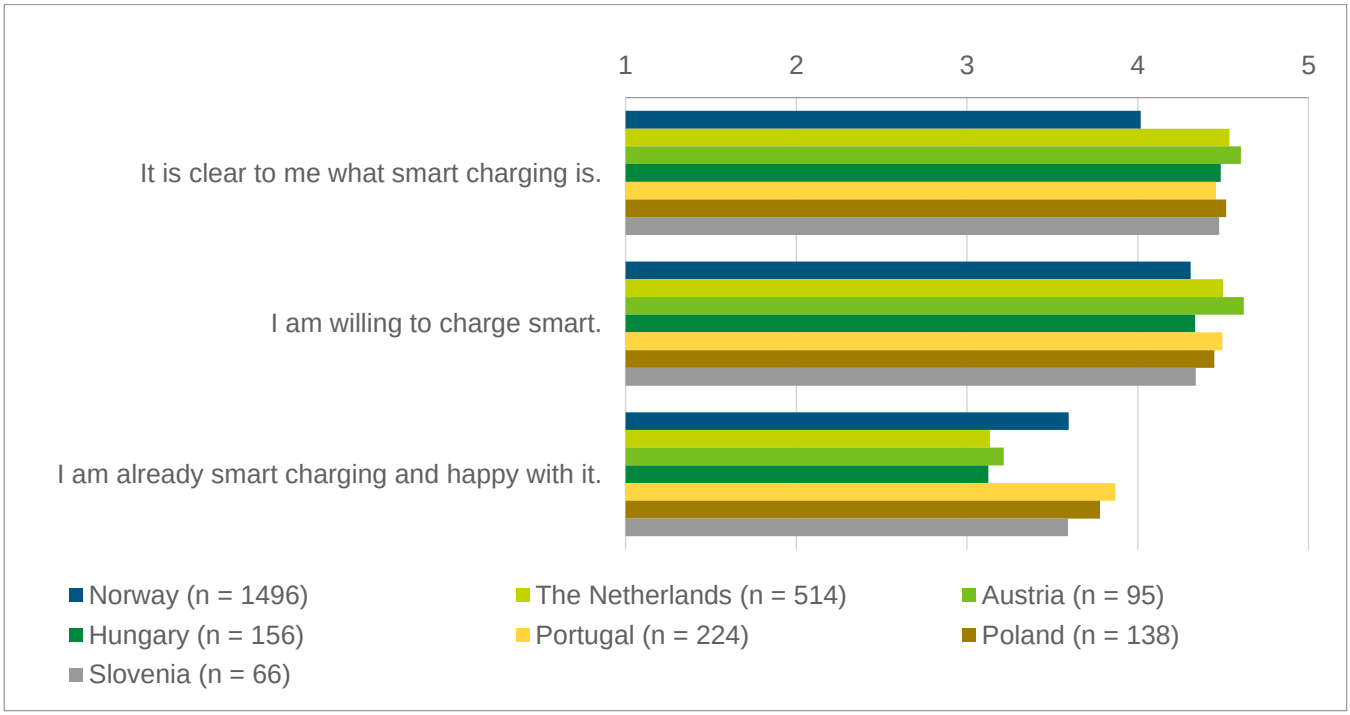

Figure 3: To what extent do you agree with the following statements about smart charging? On a scale from 1 (strongly disagree) to 5 (strongly agree).

The foundation of smart charging adoption lies in the comprehension of the concept itself. Across most countries, a big majority of the respondents agree or strongly agree that they understand what smart charging is. However, this figure slightly dips in Norway where they agree less to this statement. Notably, the Norwegian market distinguishes itself as a mature one, where EV adoption is widespread and not confined to early adopters. This could provide part of the explanation for the dip in results for Norway.

Most EV drivers in all countries agree or strongly agree that they are willing to charge smart. But a lot less are “already smart charging and happy with it”, and the results differs between the countries. Portugal and Poland agree the most, in line with their higher smart charging rates at 84 and 85 percent (see figure 1). In Slovenia, the Netherlands and Norway, where the usage of smart charging is also very high we see interesting differences in level of satisfaction with the technology. While Portugal, Poland, Slovenia and Norway have high rates of smart charging use and are happy with it, the case is different for the Netherlands. In the Netherlands many EV drivers do smart charging (see figure 1) but a minority agree with the statement “I am smart charging and happy with it”.

Participants' desire for control, insight, and ease within smart charging operations provide more information. Most respondents in all countries express a desire for control over their smart charging sessions. Norway and Hungary, however, slightly deviate with lower level of agreement. Similarly, the sentiment towards having insight into charging sessions resonates across the board, again with lower agreement in Norway and Hungary.

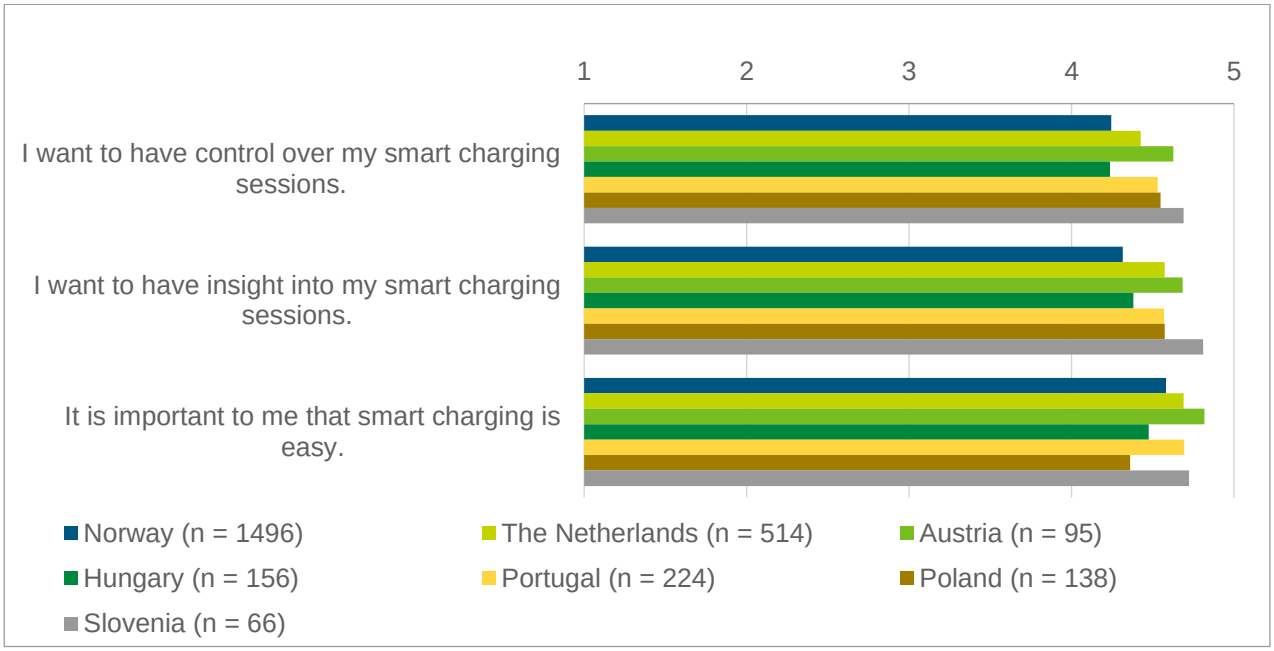

Figure 4: To what extent do you agree with the following statements about smart charging? On a scale from 1 (strongly disagree) to 5 (strongly agree).

A shared consensus prevails across all seven countries that the ease of smart charging is important. Notably, this is the statement with the highest average score among all countries, emphasizing that EV drivers want the technology to be user friendly.

When examining the correlation between green power and willingness to adopt smart charging, Poland and Portugal have the highest levels of agreement, closely followed by the Netherlands. Norway and Slovenia,

however, display lower levels of agreement. Similarly, financial incentives act as a driving force. All the countries have very high levels of agreement, although we see a small dip in agreement level in Austria.

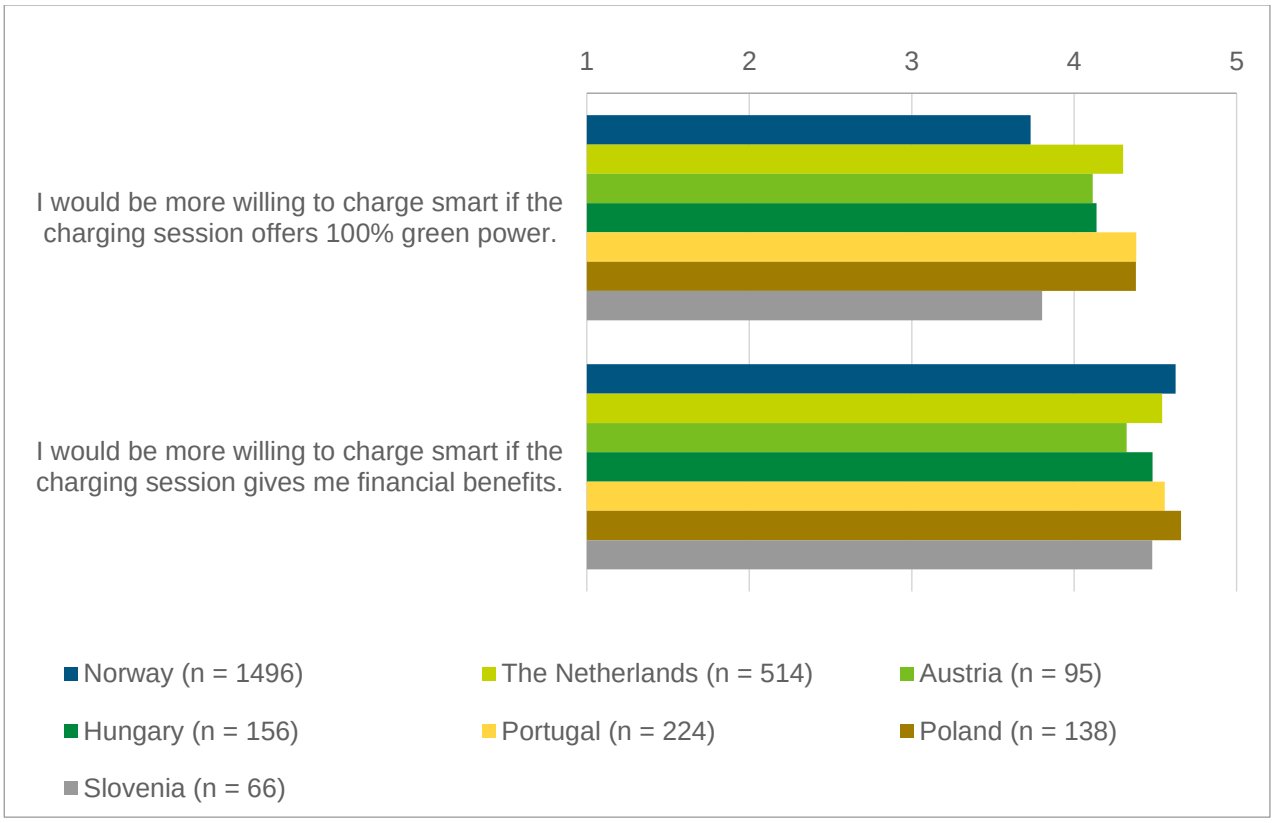

Figure 5: To what extent do you agree with the following statements? On a scale from 1 (strongly disagree) to 5 (strongly agree).

In summary, this chapter underscores the intricate interplay between smart charging adoption, environmental considerations, ease of use, control preferences, and financial motivations. The nuanced responses from various countries offer a multifaceted perspective on what drives EV drivers' decisions to embrace the benefits of smart charging technology. Positivity towards smart charging is evident, but the need for insight, control, user-friendliness, and financial benefits remains crucial for the EV driver.

2.1.4 Control of charging

A closer look at the control aspect of charging reveals interesting insights. When participants were asked about their trust in handing over control of charging, the entity with the highest overall level of trust is the car manufacturer. This sentiment is particularly pronounced in Hungary, Portugal, Poland, and Slovenia.

Subsequently, trust is placed in the grid operator, but differing between countries. Poland, for instance, reflects a lower trust level of just 20 percent in the grid company, while the Netherlands, Hungary, and Slovenia command trust from over 40 percent of respondents. Charging companies has the lowest level of trust, with only 21 percent on average between the countries.

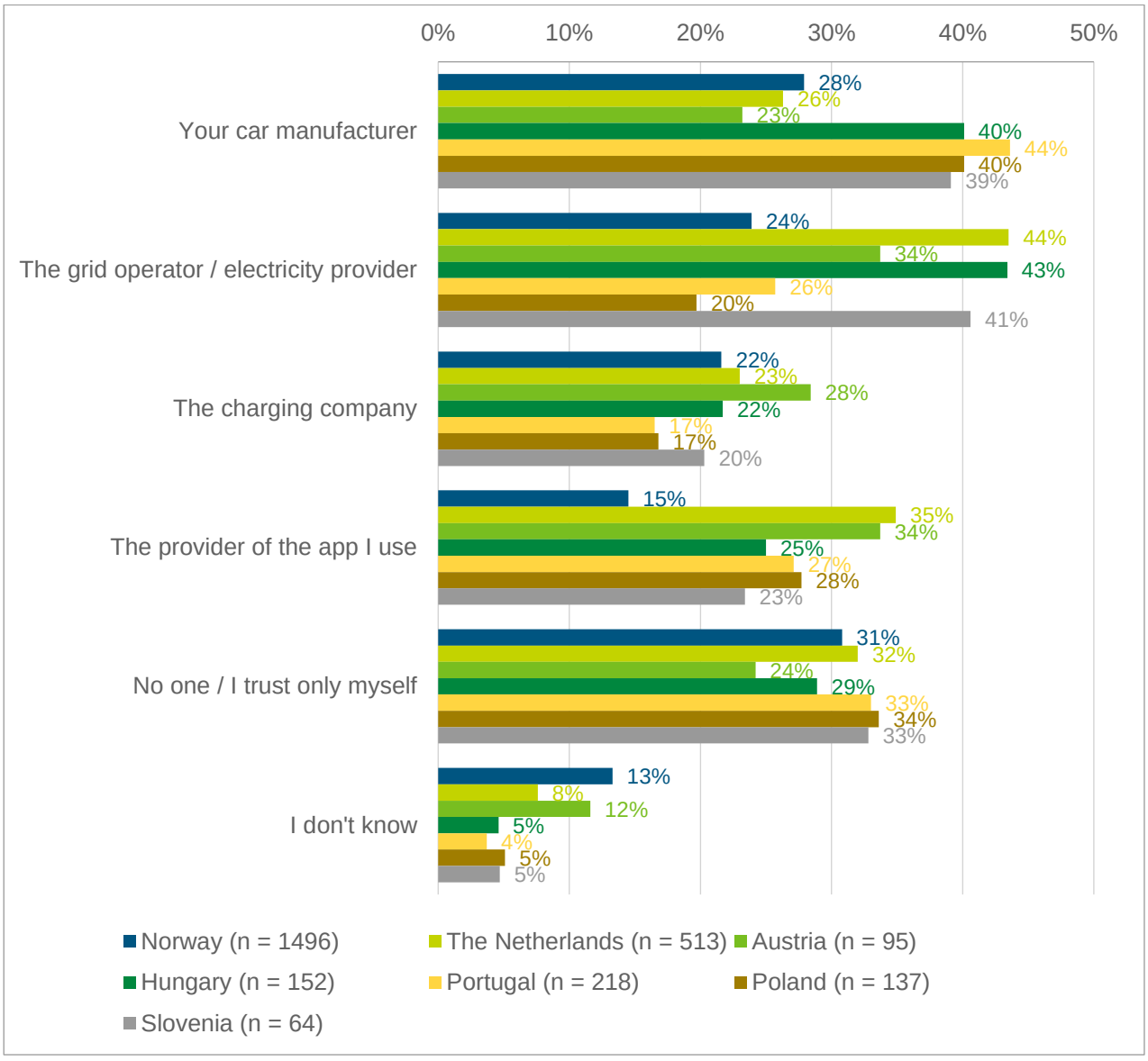

Figure 6: Who would you trust in terms of handing over control for the charging of your car? Multiple answers possible.

The range of respondents only trusting themselves spans from 24 to 34 percent in each country, with Poland boasting the highest percentage and Austria the lowest. Although, interestingly looking at the Norwegian respondents' replies to all the options, the most popular reply is "no one / I trust only myself".

In summary, this analysis of charging control and trust levels highlights intriguing variations across countries. The varying levels of trust show how different each country's context is when discussing new charging technology, and this should be considered when companies develop technology where third parties can apply control of charging.

2.2 Vehicle-to-X (V2X)

Vehicle-to-X can be defined as:

> *The next step in Smart Charging is using the car for energy storage for purposes other than driving. This means that you not only use power as required by the car for driving, but that your car acts as a power supply. This technique is commonly referred to as V2G (Vehicle-to-grid) or V2X (Vehicle-to-anything). Others speak of bidirectional charging or "power recycling". The power stored in your car can, for example, be used to power your own home, the neighbourhood, or even fed back into the grid (de Brey, Gardien & Hiep 2021).*

One of the main aims of the SCALE charging survey 2023 was to map EV drivers' attitudes and potential objections towards the adoption of V2X technology.

The first question on V2X technology in the survey was "If you were able to use the power from your EV's battery for other things than powering your EV (often referred to as Vehicle-to-anything or V2X), what would you use it to?". When looking at all the countries combined, the most popular option is the possibility to power your own home whenever you want to. The second most popular is to power your own home when electricity from the grid is expensive. The least popular V2X option is to power the EV of another person. Although looking at country level, the Polish and Slovenian respondents are more likely than the EV drivers in the other countries to be willing to power the EV of another person.

	Norway	The Netherlands	Portugal	Hungary	Poland	Austria	Slovenia
Power my home when I want to	**15%**	53%	37%	47%	59%	**67%**	58%
Power my home when electricity from the grid is expensive	33%	57%	36%	42%	47%	40%	53%
Power my home when the grid is unstable	19%	35%	21%	51%	54%	46%	**65%**
Power the EV of another person	13%	14%	20%	20%	21%	16%	24%
Give electricity back to the grid to contribute to a stable energy network	11%	**45%**	16%	26%	22%	36%	34%
Give electricity back to the grid if I received financial compensation	29%	50%	36%	40%	32%	49%	55%

Power my caravan, electric BBQ, portable refrigerator, or similar additions I have for my road trip activities	27%	21%	19%	25%	29%	25%	29%
None of these options seem very relevant to me	**35%**	8%	19%	11%	6%	7%	3%

Table 3: If you were able to use the power from your EVs battery for other things than powering your EV (often referred to as Vehicle-to-anything), would you use it to…

Examining the most popular V2X option on a separated country level, most Norwegian EV drivers say that none of the different V2X technology options seem very relevant to them. The Dutch respondents are most eager to have the possibility of powering their home when electricity from the grid is expensive. Austrian EV drivers want most to be able to power their home whenever they want to, while the most popular option among the Hungarian EV drivers is to power their home when the grid is unstable. In Portugal the top three options (with little difference in answering percentage) are to power their home when they want to (37%), power their home when electricity from the grid is expensive (36%) and give electricity back to the grid if they received financial compensation for it (36%). In Poland, as with the Austrian EV drivers, most want to power their home whenever they want to. This is also the case for the respondents from Slovenia, although many of the Slovenian respondents also list giving electricity back to the grid if they receive financial compensation for it, as an attractive option.

Furthermore, looking closer at the results to the option of “give electricity back to the grid to contribute to a stable energy network”. Here the Dutch respondents stood out as very willing (45%), compared to the respondents from the other countries. 36 percent of the respondents in Austria and 34 percent of the respondents in Slovenia also state that they are positive to doing this. In Norway and Portugal only 11 and 16 percent are willing. While in Hungary 26 percent say they can consider doing this and 22 percent says so among the polish respondents.

The willingness to give electricity back to the grid increases substantially in all countries when it is made contingent on receiving financial compensation for doing so. We see the biggest increase in Slovenia with 21 percentage points. There is barely a gap down to the second biggest difference; Portugal has a 20 percentage points increase when participation in V2G is contingent on financial compensation. In Norway there is a difference of 18 percentage points, with 14 percentage points in Hungary, 13 in Austria and 10 in Poland. In the Netherlands, the willingness to participate in V2G only increases with 5 percentage points when the participation is contingent on financial compensation. In other words, financial compensation for V2G participation is least important in the Netherlands and most important in Slovenia, Portugal and Norway.

Then the respondents were asked what their concerns are if they were to use the battery in the car for other things than powering their own EV. The biggest concern when looking at all the countries’ combined is battery degradation. This corresponds interestingly with who EV drivers trust the most in handing over control of charging (see figure 6) which combined was the car manufacturer. It is reasonable that trust is placed in the car company, which could potentially offer new batteries or influence battery performance.

	Norway	The Netherlands	Portugal	Hungary	Poland	Austria	Slovenia
Battery degradation (reduced capacity of the battery)	47%	55%	**70%**	**71%**	**68%**	56%	**68%**
Loss of battery warranty	19%	23%	25%	22%	27%	33%	21%
Loss of data/privacy	4%	8%	5%	7%	7%	5%	10%
Fear that the car won't be charged enough by time of leave	50%	51%	34%	49%	26%	39%	42%
Lack of being in control of the charging process when external control is being applied	26%	29%	21%	27%	19%	30%	23%
That you don't get enough financial compensation for it	13%	21%	18%	**32%**	18%	19%	26%
That EV drivers don't get anything out of it	12%	**4%**	12%	11%	13%	10%	**36%**
I don't have any concerns	19%	15%	13%	9%	11%	21%	16%

Table 4: What are your concerns if you use your battery of the car for other things than powering your own EV?

When looking at country level we find that among the Hungarian respondents a big majority fear battery degradation (71%) and this is also true for the respondents from Portugal (70%). It looks as if in the more mature EV countries like Norway, the Netherlands and Austria, the fear of battery degradation is less than in the newer EV countries.

Approximately one out of four respondents across all the countries fear loss of battery warranty, if using V2X technology. Many of the respondents also fear that the car won't be charged enough by the time of leave. This is the concern with most replies on country level in Norway.

Whether EV drivers will or will not get anything out of using V2X technology is not a big concern in most of the countries. This is different for Slovenia, where the respondents have listed this as their third biggest concern (36%).

The concern regarding whether or not you would get enough financial compensation for using different V2X technology, the country with the highest concern regarding this is in Hungary. The Dutch and the Austrian EV drivers have the highest percentages of concern when looking at the statement "Lack of being in control of the charging process when external control is being applied". Although the differences between the countries are not very big.

Concerns about data privacy are generally low across all countries. However, this does not diminish the importance of data privacy to EV drivers. The introduction of new and stricter data protection legislation at the European Union level is likely to decrease worry in this aspect, as consumers expect companies to follow these regulations. Trust in data processing plays a crucial role in the successful adoption and engagement of V2X systems. The varying degrees of trust EV drivers have in data controllers directly impacts their willingness to embrace these systems, with privacy concerns being one factor. It is essential for companies to recognize that they ultimately bear the responsibility to handle data and privacy correctly. Trust cannot be taken for granted in this context.

Eight out of ten or more EV drivers in all the surveyed European countries have concerns related to using their car battery for other things than powering their own EV. This is important to be aware of when developing and regulating this technology, which is relying on adoption from these consumers.

3 Literature review

In our search for relevant research, we have found that the current research landscape is dominated by a focus on technical aspects. While advances in EV technology are crucial, behavioural research lags far behind. There is a large gap in our understanding of how EV drivers view smart charging solutions and V2X. Identifying the key elements that matter to EV drivers in the context of smart charging and V2X integration can pave the way for more user-centric innovations and increase the likelihood of technology adoption among the users. From this scarcity, we have summarized the most interesting current studies around attitudes and behaviours of EV drivers in this chapter.

In the report “V2G – Value and way forward”, PWC estimates that users can expect a financial benefit ranging from approximately 40 to 750 euros per year by the year 2030, based on research and trials conducted in Germany, the Netherlands, and the United Kingdom (PWC 2021). This information can be found on page 18 of their report. On page 17, there is a discussion about the motivations of electric vehicle owners to participate or not in V2G programs. The key factors influencing their decision are: having control over the charging session, transparency regarding costs and benefits. The motivations to participate include the potential earnings, environmental sustainability, and enhancing self-sufficiency.

Furthermore, Cenex has studied and published the report “Understanding the real value of V2G” (Cenex 2019). To fully capitalize on the benefits of V2G, it is essential for electric vehicle owners to plug in their cars more frequently and keep them connected to chargers for longer periods. This implies a need for more consistent charging behaviour, akin to 'charging station adherents'. On page 14, there's an overview of various electric vehicle owner archetypes and their suitability for participating in V2G programs: not every driver can take equal advantage due to variations in their driving patterns.

An interesting article was published in 2020, and this research investigates the factors that influence people's interest in adopting EVs and how the ability to use EVs for the grid (V2G) affects their preferences (Chien-fei Chen, Gerardo Zarazua de Rubens, Lance Noel, Johannes Kester, and Benjamin K. Sovacool 2020). The study surveyed individuals from Denmark, Finland, Iceland, Norway, and Sweden (4885 participants) and used hierarchical regression analysis to understand the impact of socio-demographics, technical aspects, economics, and behaviour on EV adoption. The findings reveal that younger males with higher income, more children, prior EV experience, and a concern for sustainability are more likely to consider EV adoption. Key factors affecting this decision include the ability to use EVs for the grid and the time needed for charging, as these could generate income for EV owners. People tend to rely on their knowledge of traditional fuel vehicles when thinking about EVs. Factors like fuel efficiency, cost savings, and environmental benefits strongly influence the decision to adopt EVs. Battery life is more important to traditional car users than to current or past EV owners. Former EV owners attach greater importance to vehicle-to-grid capabilities, suggesting this feature could be a crucial incentive tipping the balance towards EV adoption.

A study on factors influencing consumer acceptance of vehicle-to-grid by EV drivers in the Netherlands aims to uncover the factors influencing the willingness of actual EV drivers to adopt V2G charging. The research takes a qualitative approach, delving into the perspectives of actual EV users to understand their thoughts on V2G technology and the reasons driving their acceptance or rejection of it (Koen van Heuveln, Rishabh Ghotge, Jan Anne Annema, Esther van Bergen, Bert van Wee, and Udo Pesch 2021). By conducting twenty semi-structured interviews with Dutch EV drivers – both regular users and those involved in previous V2G projects – key elements fostering acceptance are identified. These include receiving financial compensation, transparent communication and reliable control of the system by the

user. Conversely, negative factors affecting acceptance are range anxiety, discomfort during participation, and battery degradation. The study reveals that most interview participants are open to V2G, albeit with reservations and caution. Notably, the researchers point out that the interviewed EV users are early adopters, so their attitudes might not mirror those of the broader future user base. Nevertheless, the research highlights the presence of EV users willing to engage with V2G charging points, and it provides further details about the reasons driving their acceptance, along with potential areas for future research and insights.

Not surprisingly, but rather intriguing, a presentation by Dr. Susanne Koblitz, an independent EV specialist, in March 2021, highlights the fact that there is no capacity problem on the grid, which remains reassuring especially in the context of a future where electric vehicles become the norm (Koblitz 2021). Instead, the challenge lies in dealing with localized congestion problems. This is where the concept of Vehicle-to-Grid (V2G) technology could potentially play a pivotal role. However, it's fascinating to note that a significant 80% of this issue could be mitigated by employing smart charging strategies alone. This insight underscores the importance of not just advancing V2G solutions but also optimizing the charging behaviour of electric vehicles, suggesting a multi-faceted approach to address the challenges of our evolving transportation landscape.

Another interesting presentation with intriguing insights was given by Mayk Thewessen in October last year (Thewessen 2022). What would be the income generated from widespread V2G integration in the Dutch day-ahead electricity market by 2030? Thewessen calculated that this would be approximately €600 per user per year with intensive usage among 30,000 participants. However, a self-cannibalizing effect emerges: the greater the supply, the lower the earnings per user. With as many as 1.8 million participants, the income per user dwindles to just €180 per year.

4 A closer look at the countries

In this chapter we provide insights from our expert meetings with representatives from different EV associations.

4.1 Norway

Expert meeting with Erik Lorentzen - Head of Analysis and Advisory Services, Norwegian EV Association

Norway has a mature EV market, with a remarkable 83 percent of all new car registrations being electric (see table 2). According to the Norwegian EV Driver Survey, most Norwegian EV drivers have their own parking space (97%), and 95 percent charge at home. Of these, almost 9 out of 10 have a charging box. This has been mandatory for all new EV charging points since 2022. Additionally, there exists a well-established market for charging boxes and the professionals who install them. Notably, only 20 percent of EV drivers charge at home every day. Most charge one to four times a week (69%) and is thus not connected to the charging box the remaining days.

In Norway, the energy landscape is marked by hourly dynamic electricity tariffs and grid fees that fluctuate based on the consumers' highest hourly electricity consumption. Grid fees are also slightly lower at nights and weekends. Smart meters are mandatory. Electricity prices are lower during periods of reduced overall demand, typically at night, and they rise during peak hours of consumption. Consequently, this has influenced the charging habits of EV drivers in Norway. The majority prefer to charge their vehicles during nighttime, with a significant 71 percent citing cost-efficiency as the primary driver for this choice in the Norwegian EV driver survey. Many of the energy companies offer smart charging solutions at no or a low extra monthly cost as a part of your electricity contract. This not only aligns with the financial interests of EV owners but also contributes to grid stability by redistributing energy consumption away from peak times.

Norway has a highly reliable and stable electricity grid. Furthermore, the country's electricity mix is predominately green power, with close to 90 percent of the electricity mix being sourced from hydroelectric power. Wind power also plays a role, contributing around 10 percent. Interestingly, the adoption of solar panels on residential properties remains relatively scarce in Norway. Consequently, the environmental benefit of residential solar panels is less pronounced, as the grid already operates on predominantly clean energy sources.

In recent times, grid operators can be said to have seen a slight decline in their reputation due to the introduction of a new system for and higher levels of grid tariffs, soaring electricity prices, and what is by many perceived as substantial profits to the owners (profits are in fact strictly regulated by the authorities). This might explain why Norway scores lower than the average between countries on trust in grid operators.

Control of charging is widespread, with 87 percent of the respondents in the Norwegian EV driver survey indicating that they control the charging of the car. 64 percent reported utilizing apps and technology to smart charge, while 23 percent reported manually plugging and unplugging the charger to manage charging.

V2X technology, on the other hand, is not much talked about. This technology may be more appealing in contexts where smart home systems and solar panels have gained significant traction— a situation that doesn't align with the Norwegian context. With Norway being a mature market, the majority of EV drivers might be less interested in new technology. Along with the benefit of a robust and dependable energy grid, it is not likely that most EV drivers will prioritize V2G. One relatively common opinion is that the widespread

adoption of smart charging practices effectively optimizes grid efficiency. With EVs strategically charging during periods of lower electricity demand, it is believed that this approach sufficiently fulfils grid stabilization needs without necessitating the implementation of V2G technology.

Given that widespread V2X technology implementation remains a bit distant, and consumer openness to V2X remains low, flexible load management at fast-charging stations might be a good option. This is already applied at several charging stations across the country. Even though this can help facilitate a more stable power grid, it is not noticeable to the consumer if done with care. It is crucial to prioritize consumer perspectives, focusing not only on promoting V2X but also addressing their concerns and needs.

4.2 Netherlands

National Charging Survey 2023, RVO, Elaad and VER – September 2023 (www.evrijders.nl/laadonderzoek2023) summary chapter smart charging

In the Netherlands, electric vehicle (EV) drivers are well-informed about the benefits of charging during off-peak hours and sustainable energy generation. What stands out is the significant enthusiasm among a majority of drivers for the concept of bi-directional charging and dynamic pricing, whether at home or at public charging points. However, the actual adoption of these technologies remains limited. In the latest Dutch National Charging Survey (September 2023) these were the most important conclusions around smart charging and V2X:

- Day or night tariff charging and charging with renewable generated energy are the best known and most used forms of smart charging.
- Bi-directional charging, charging based on dynamic power tariffs and charging based on grid capacity are indicated as desirable. 13% of EV drivers already use dynamic power tariffs. The vast majority of these are home chargers (EV drivers who charge most of their electricity at home). Already 20% of these home chargers use a dynamic power contract.
- Dynamic power tariffs are mainly desired for charging at home, 79% would like or very much like this. About half of EV drivers also see this as a desirable option at the public charging station. Only a small percentage has no interest in dynamic tariffs.
- The most foreseen bottlenecks to charging with dynamic charging rates are less charging security and loss of control over the charging session and less charging security.
- The largest group has charged smartly at the wall box at home in the past year, mainly by charging on the night tariff and using solar panels. The group that does charge smart at a public charging point mostly experiences this neutrally to very positively (86%).
- EV drivers find it desirable to keep the option of 'switching off' smart charging, and would be quicker to opt for smart charging if certainty can be offered about the minimum charging volume.
- The EV driver prefers to choose himself (or via an authorised representative) whether or not to charge smart. After that, the grid operator is most trusted to make this choice, the car manufacturer is at the bottom of the list.
- EV drivers would like to have control over the charging session at the public charging station to guarantee charging security: 47% would like this (very) much, and 33% are neutral. This mainly applies to automatic control of charging capacity from the network company.
- 62% of EV drivers who are familiar with the concept of bi-directional charging would like to use it themselves. Half of EV drivers favour making the option of bi-directional charging mandatory.
- EV drivers consider the main reasons for using bi-directional charging to be more self-sufficiency in power consumption at home and a higher share of renewable energy when charging.

- EV drivers would mainly like to use bi-directional charging to store power from solar panels and use it later, and to power their own homes.
- A quarter of EV drivers do not anticipate any bottlenecks in bi-directional charging. The remaining respondents predict uncertainty about the impact on the battery or battery warranty, and whether the car can cope with bi-directional charging.
- 20% indicate that the EV may be used to balance the grid when charged at a public charging station. 64% find this acceptable provided there is financial compensation in return. Only 16% indicate that the EV should not be used for this purpose.

4.3 Austria

Expert meeting with Christian Peter – Director EMC Austria

In Austria, the landscape of electric vehicle (EV) pricing and charging presents some unique characteristics. Most electricity tariffs are fixed. There are only very few providers offering dynamic household tariffs, such as aWATTar (https://www.awattar.at/) which offers day-in-advance dynamic hourly prices. In addition to mostly fixed household electricity prices, most tariffs offered at EV charging stations are also fixed with the exception of Tesla (offering special off-peak prices) at their Supercharger stalls.

A popular and subsidized wall box, the go-e Charger (https://go-e.com/de-at), can automatically adapt the optimal timing of charging sessions based on aWATTar‘s hourly tariffs. Fixed tariffs are more common, and options like day and night tariffs are limited.

eControl provides a comparison portal for energy tariffs, and thus offers consumers a way to explore new gas and electric options, but the transition to dynamic tariffs is challenging. Negative tariffs, which incentivize power consumption during periods of excess energy production, are not widely adopted. Initiatives like the “digital interface”, which is now mandatory for all EV chargers above 3,7 kW charging power (based on Modbus and OCPI integration (Open Charge Point Interface)) are underway to streamline data management for EV charging, with a detailed implementation guideline from Österreichs Energie (oesterreichsenergie.at) expected to be published late 2023.

Utilities in Austria have shown reluctance toward embracing e-mobility fully. Distribution Network Operators (DNOs) still operate mainly based on evaluating peak power demand. Demand side management (as would be possible with heat pumps and EVs) are not part of their network expansion planning process. The mandatory “digital interface” for charging stations mentioned above could be a first step to change that. Solar panel owners receive compensation for energy fed back to the grid, with the attractiveness of this practice increasing as gas prices rise. When it comes to trust, car manufacturers are viewed with skepticism, while charging companies, particularly those offering public charging options, gain more credibility. Grid operators are trusted for their network-friendly approach and the Austrian grid's reliability, similar to the Netherlands.

V2X (vehicle-to-grid) concepts have garnered attention in Austria, with Power my Home being particularly influential and attracting interest from EMC (Electric Mobility Community) members. Media attention on the possibility of blackouts has stirred discussions about utilizing personal power generation and storage, especially in the absence of dynamic tariffs. However, the financial compensation for energy contribution remains a sensitive topic, particularly given the geopolitical context, such as the Ukraine war. Overall, Austria's EV charging ecosystem is evolving with a mix of fixed tariffs, evolving technologies, and a focus on grid stability.

4.4 Hungary

Expert meeting with Tibor Antalóczy– journalist and board member, The Hungarian Emobility Association

In Hungary, the adoption of electric vehicles (EVs) has been steadily growing, driven by various factors. Home charging from ordinary sockets is a common practice due to its convenience and cost-effectiveness. Many EV owners choose to charge at home to avoid spending extra money on public charging stations. The EV Hungarian association promotes the use of wall boxes for faster charging, although some people have already stretched their budgets after purchasing an EV.

Subsidizing electricity at home have contributed to the affordability of EVs in Hungary. Electricity prices are relatively low, with a flat tariff structure and a separate night tariff, primarily intended for water heaters. Charging your car with that tariff is prohibited. The average price per kWh is 18 cents, and there are two levels, with the lower level being around half of this cost, advantageous for consumption up to 2523 kWh. There is no dynamic pricing for consumers, only for companies.

The country follows a balance system for solar panel users, allowing excess energy to be fed back into the grid at a reduced rate. Despite having only one nuclear power plant providing a significant portion of electricity and a substantial contribution from solar energy, wind power has been restricted due to government policy.

Hungary introduced EV subsidies in 2016, providing substantial benefits to early adopters. Over the years, the subsidy program evolved with changing rules and funding levels. The availability of subsidies was initially generous but became more restricted as the program matured. Tax rebates, reduced taxes, and free parking have remained incentives to drive EV adoption. Green license plates for EVs were introduced in Hungary, and this practice spread to neighbouring countries like Slovakia and Poland.

The strategic importance of a stable grid for Hungary's energy security has led to a level of public trust. However, concerns about battery degradation and lack of charging experience persist, particularly in Eastern European regions. We think it might be fair to say that in countries with less experience with EV’s the fear of battery degradation is higher. Data privacy isn't a top concern, and fears of incomplete charging aren't prevalent.

4.5 Poland

Interview with Lukasz Lewandowski – chair EV Polska

In the world of home electric vehicle charging in Poland we see that wall boxes are promoted, but regular household sockets suffice in a lot of cases. Installing wall boxes costs a lot of money (500-2000) euros. There haven’t been any incidents using normal socket so people consider it as safe option.

Electricity costs are complex, influenced by coal prices exploding in recent years and higher prices of CO2 emission allowances.

Government intervention introduces fixed kWh prices up to 2000 kWh at 18 cents, increasing to 40-45 cents thereafter. There are no dynamic tariffs yet. The discussion about that has already started and a pilot project will be launched in 2024.

Smart charging is not a hot topic for the Polish EV drivers. The cost of implementing such a solution is very expensive and unprofitable for the EV user. The majority of EV-drivers (55-60%) have solar panels (versus

approx. 10% of the whole Polish population) and they use that foremost for cheaper energy. Cost reduction motivations are more important than 'green' motivations.

There are 4 big grid operators, mostly old fashioned companies that are all state owned. Commercial organizations (like for example Tesla) are trusted more than state owned companies.

4.6 Portugal

Interview with Manuel Reis – vice president UVE Portuguese EV drivers' association

Household sockets are popular in Portugal, mostly because of cheaper prices and low daily distance requirements. Looking into available incentives, the government covers a significant 80% of a charging box price (including installation). To access this, the charging box must be linked to MOBI-E, enabling charging through a EMSP rather than your power bill. But electricity through this EMSP is on average 30-40% more expensive in off peak hours (price difference on peak hours is less significant).

Household electric rates stand at around 13 cents per kWh at night and 23 cents during the day, without direct subsidies but with indirect benefits in the electric transport network tariff.

Addressing the environmental aspect, Portugal's electric mix scenario doesn't inherently offer greener energy during the day (although it is quickly improving with new solar installations at a fast pace). Until June 2023, there is 61% renewable energy, mainly from hydro and wind energy sources. Tariffs play a pivotal role in shaping the network usage cost, and despite fluctuations in the price, the monthly tariff remains consistent. Network usage is more affordable during the night, which paradoxically aligns with a greener daytime usage profile, so only dynamic pricing offers can provide advantages when renewables are strong. While dynamic charging by cars is dependent on the EMSP, only two or three providers currently offer this service, predominantly ruling out this possibility at home. This will probably change soon, as the regulator will make it mandatory for providers to offer household dynamic hourly electricity prices.

In terms of trust, Tesla remains a brand that garners faith from users. This sentiment might wane in regions with a greater diversity of EV brands, highlighting the pivotal role that brand reputation plays in establishing consumer trust.

4.7 Slovenia

Interview with Ignac Zavrsnik, president DEMS- Slovenian EV drivers' Association

Slovenia's energy landscape relies on a mix of nuclear, coal, and hydroelectric power plants: Electricity production by energy source in last year (2022) was: Coal plants: 34.8%, Hydro plants: 32.7%, Nuclear plant: 26%, Photovoltaic (PV): 6.3%, Wind: 0.1%. Photovoltaics (PV) are experiencing exponential growth, and Slovenia anticipates reaching a 30% milestone within the next seven years.

The country's historical use of electricity for various purposes is a legacy from its socialist past. The sturdy grid infrastructure, built meticulously over the years, has been instrumental in meeting diverse household energy demands. The first public EV charger was installed in 2009 in Ljubljana and was built in Slovenia by a company called Etrel. Currently, this company is a part of the Swiss company Landis+Gyr.

In Slovenia, the concept of load balancing has gained significant prominence, especially among EV drivers. Over the past five years, the country has been producing its own wall boxes, making home charging for EVs a well-marketed and intelligent option. This strategic approach has contributed to the notable preference for home wall boxes over socket charging. The other reason is that heat pumps are popular in Slovenia. On a survey conducted among EV users and members of DeMS, almost 30% of the people said they had a heat pump. This asks for load balancing if you want to charge your car and heat your house at the same time.

Additionally, approximately 50 percent of EV drivers have embraced solar panels, while only 5 percent of the general population use solar energy for their energy. Surplus energy generated by these panels can even be sold back to the grid, benefitting the grid or other users.

As renewable energy sources like solar panels gradually reshape the energy panorama, Slovenia stands confidently at the brink of an EV and renewable energy revolution. The country's well-established grid stability serves as a solid foundation for this transition. Remarkably, grid companies have officially affirmed their ability to accommodate a substantial EV fleet ranging from 300,000 to 400,000 vehicles, representing a substantial portion of the total car population.

5 Conclusion

This report analyses EV drivers' needs and challenges related to vehicle-to-anything technology and smart charging from seven different European countries: Austria, Poland, Portugal, Slovenia, Hungary, the Netherlands and Norway.

The respondents show very high willingness to use smart charging, but not all consumers are satisfied with how the technology works. This is especially true for the Dutch respondents. Almost all the EV drivers in every country agree that smart charging should be easy and user friendly. Looking at the results even closer, the EV drivers in the countries emphasize the want to have control, insight and that it should be financially beneficial to use smart charging. Addressing user needs and expectations while effectively communicating the benefits of the technology will be key to widespread adoption.

There are varying levels of trust in handing over control of charging. The original equipment manufacturer received the overall highest level of trust in terms of handing over control, but many respondents also stated that they only trust themselves and no third party. This is an important barrier to overcome if smart charging technology (and V2G technology) is to be adopted among the majority of the consumers.

Most drivers recognize the value of V2X, particularly for individual applications, with a strong preference for V2H options such as solar panels and smart house technology. The willingness to participate in V2G is not very high but increases a lot in all the European countries when participation is made contingent on receiving financial benefits.

Furthermore, 8 out of 10 EV drivers have concerns related to V2X adoption. This is especially regarding potential battery degradation, and again the general concern for handing over control of charging, and also whether or not they will receive any benefits from using the technology, like financial compensation for V2G adoption.

The in-depth expert interview with representatives from EV driver organizations in all the seven countries also highlights interesting insights. It has become very clear that the national debates on smart charging and V2X adoption varies a lot among the countries. It is crucial to differentiate between smart charging and V2X, as they represent distinct concepts that require a differentiation of strategies for adoption. In Norway the main focus of EV charging debates has been related to smart charging, avoiding peak hours when electricity prices are high. In many of the countries without a flexible electricity or grid tariffs, many debates revolve around the potentials and challenges of introducing such tariffs. In the Netherlands the charging discussions are already focussed on different potentials and barriers with V2X technology for EV drivers.

The varying perceptions toward V2X adoption, concerns, and interests, needs to be taken into consideration when this new technology is being debated and developed. The consumers are after all the end user of this technology, and the success of these solutions are contingent on the fact that the consumers actually will deem them relevant to use.

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