Regulatory barriers for Smart Charging of EVs and second life use of EV batteries

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pwc

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Subject: Project "Regulatory barriers for Smart Charging of EVs and second life use of EV batteries" draft Report

17 May 2019

Dear Mr. de Brey,

We hereby present our report on the regulatory barriers for Smart Charging of EVs and second life use of EV batteries. This report is drafted in accordance with our Contract dated 6 November, 2018 ("Contract"). This report provides an overview of the most important barriers that hinder Smart Charging and second life use of EV batteries. Secondly, it provides policy recommendations on how these barriers can be addressed on an EU or Member State level. This reports can provide valuable input for the EU Innovation Deal "From E-mobility to recycling: the virtuous loop of electric vehicle"

Save as described in the Contract or as expressly agreed by us in writing, we accept no liability (including for negligence) to anyone else but you or for use of this report for any other than the stated purpose.

Yours sincerely,
PricewaterhouseCoopers Advisory N.V.

Gülbahar Tezel

Content

Scope of the report

Our scope

Limited | Extensive

The aim of this report is to inform policy makers of the existing regulatory barriers and potential changes needed to stiumulate Smart Charging of electric vehicles (EVs), both during first and second life of the EV batteries. The study aims to serve as a starting point for the design of a better functioning market. It was commissioned by our client Stichting Elaad NL as part of the innovation deal “From E-Mobility to recycling: the virtuous loop of the Electric Vehicle” (with waste regulation being out-of-scope, please refer to appendix 1).

Currently, the transport sector is one of the major emitters of GHG and particulate matter. Hence, policy makers are incentivising the transport sector to move towards more sustainable alternatives like electric vehicles. Within Europe, **Germany, France and The Netherlands** are front-runners in terms of their EV-fleet. In terms of the growth rate over the last 5 years, **Sweden** leads the pack with a CAGR of 88%. As a result, **these four countries are the focus of this study**.

However, the rise of EVs also comes at a cost. For example, the power grid needs to be reinforced with charging infrastructure, and this requires additional investments. Nevertheless, electric vehicles can also help reduce societal cost of the energy transition by providing flexibility through ‘Smart Charging’. The timing, speed and/or the manner of charging (charging/discharging) is geared to an E-driver’s preferences and market conditions (such as availability of renewable energy or peak load on the grid). Due to the life cycle of an EV and the rising fleet numbers, a large amount of car batteries will become available in the future for second-life use or recycling purposes. A second-life car battery could be used as stationary storage to provide flexibility services. Therefore, this is also in scope of the analysis.

For the analysis, **our starting point was a selection of most important barriers for Smart Charging identified in the Netherlands as part of a previous study** conducted for ELaadNL in 2017 (therefore, the list covered herein is not exhaustive). We analysed the applicability of these barriers in France, Germany and Sweden. Furthermore, we identified national solutions that are already in place within these countries, and potential solutions that could be considered at a European level. The goal was to create an overview of best practices or learnings that can be shared across Member States or be stimulated by the EU. Any regulatory developments from March 2019 are not considered within the scope of this report. Due to ongoing discussion and the dynamic nature of the Clean Energy Package, we used the situation as of February 2019 as a basis for our analysis.

Access to and quality of information

Limited | Extensive

Our research was conducted from November 2018 to February 2019 and consisted of:

- Literature review of reports on electric vehicles, Smart Charging, policy documentation on tariffs, market roles, taxation.
- Interviews with participants in electric transport and Smart Charging along the value chain (car manufacturers, energy suppliers, DSO’s, CPO’s/EMSP’s/Aggregators and governments). Please refer to appendix 3 for the participants.
- Workshops with relevant stakeholders to validate the results of the study.

[1]CAGR: Compound average growth rate

Our current electricity system is under pressure due to the energy transition. The intermittency of renewable energy sources is driving the need for flexibility from electric vehicles (EVs)

Our current electricity system is highly regulated due to the need of balancing the grid and avoiding any abuse of market power…

Need for grid balancing:

- EU's energy policies aim to ensure security of supply of affordable and sustainable energy for European citizens. Since storage of power is not economically feasible at a large scale yet, the produced electricity should immediately be consumed. This requires real-time balancing of the grid.
- All market parties have a responsibility to ensure balancing of the grid. For example, the energy suppliers are responsible for informing network operators of their planned electricity production, consumption forecast and transportation needs.

Avoiding market power abuse via regulations:

- In line with EU's policy goals, different market roles are defined. There are electricity producers, energy suppliers (that sell electricity to customers) and grid operators. Grid operators have a natural monopoly, hence their operations are heavily regulated and it is strictly defined which activities are allowed.
- It is legally required to split the ownership over different market roles, as described in the EU unbundling requirements. This helps in avoiding any abuse of market power. As a result for example, distribution system operators (responsible for the regional grid) cannot own or operate storage facilities.

…however the system faces capacity constraints at peak hours due to the rise of intermittent & decentralized renewable energy sources. Flexibility from charging of electric vehicles can be a potential

- By signing the Paris Agreement, European countries have committed to limiting the global average temperature rise to below 2°C compared to pre-industrial levels and have set decarbonisation goals for 2030 & 2050. Therefore, a shift from fossil fuels towards renewable sources is needed from the perspective of electricity production.
- The EU would like to increase the share of renewable electricity (as % of total production) by three-fold until 2050. The generation of wind and locally generated solar energy is expected to play an important role in meeting these ambitious targets set by the EU and individual Member States. However, these renewable sources also lead to volatile production patterns.
- In addition, peaks in the electricity consumption pattern often do not coincide with the peaks in renewable electricity supply. Consumption mostly takes place in the mornings and evenings, whereas the sun shines brightest in the middle of the day.
- Furthermore, there is an expected increase in electricity consumption, driven by the adoption of electric vehicles, electrification of buildings (for heating), and electrification of the industry. This further increases the challenge of balancing supply and demand while avoiding congestions at peak hours.
- Increasing grid capacity is the standard solution employed till date. But, given the high investment costs related to this, there is a need to examine other ways of avoiding congestion in the grid. Electric vehicles can also provide a solution by offering flexibility in their charging patterns as will be explained next.

[1]EC (2017)

Smart Charging of EVs and second life use of EV batteries have the potential to reduce societal costs of the energy transition

Electric mobility is expected to play a vital role in reducing emissions from the transport sector

- Governments are driving the transition to electric vehicles to reduce harmful emissions from the transport sector in Europe. Due to these decarbonisation and air quality policies, the electric vehicle (EV) fleet in Europe has grown fast over the last 5 years (CAGR of ~80% from ’12 – ’17). In order to integrate the EVs into the power system and ensure further growth, charging infrastructure needs to be developed.
- EV charging infrastructure adds new roles to our electricity system, such as charge point operators (CPO) and E-mobility service providers (EMSP). These roles facilitate consumers to charge their vehicle.
- An increased number of electric vehicles leads to more demand for electricity. EV drivers often charge their car when they get home in the evening i.e., when there is already a peak in electricity consumption. Therefore electric driving can add to the grid costs since the grid is built to facilitate peak demand.
- Innovations in charging of electric vehicles can help lower the consumption peaks in the grid. In that way consumption and production can be better aligned and therefore the need for investments might decrease.
- An innovation in electric charging is ‘Smart Charging’ of EV batteries, both in the first life of a battery (in the car) and second life of a battery (as stationary storage).

Smart Charging of EV batteries is expected to reduce societal costs of the energy transition, but some barriers hinder the development of Smart Charging

- Smart Charging can be achieved in two ways: (1) Mono-directional Smart Charging: time and speed of charging is varied (i.e., certain cars are charged faster than other cars or the charging is stopped/ delayed). With mono-directional Smart Charging there is no possibility to feed back into the grid. And (2) Bi-directional Smart Charging: wherein energy from car batteries is fed back into the grid (V2G) and/or back into the house (V2H) using variation in charging time, speed & manner.
- ‘Smart Charging’ of EV batteries can help ensure a positive experience for EV drivers (have their EV battery charged at the time needed) and at the same time help to lower the energy transition cost for society. Smart Charging can provide flexibility services by storing excess renewable electricity and balancing the grids These services can lead to lower grid costs.
- At the moment several regulatory barriers exist for Smart Charging in terms of missing regulation, hindering regulation and tax barriers. Furthermore, regulation differs between EU Member states. Homogeneity in regulation lowers the costs for companies to work cross-border.
- There are several Smart Charging initiatives (both mono- & bi-directional) across Europe, but most are in the pilot phase. Most initiatives have been impacted by regulatory barriers as the incumbent power market and tax rules are not fit for purpose with regards to these innovative solutions.

Several regulatory barriers need to be addressed to enable optimal use of the potential of Smart Charging

Smart Charging initiatives can only be scaled up if several regulatory barriers are removed in the short run…

Most important barriers identified based on The Netherlands, Germany, France & Sweden

	Regulatory barrier	Description	Applicable in	Impact on type of SC[1]
1	**Double energy tax and double charging of variable grid fees**	Each time the EV battery charges, energy tax and sometimes variable grid tariffs are due. This also applies when performing bi-directional Smart Charging for storage services. Double taxation applies, because the activity is classified as consumption from a tax perspective. Additionally, in some countries that have variable grid tariffs (per kWh) double grid charges can apply. Market players indicate this is a showstopper for the development of bi-directional charging. Furthermore, the Impact of the double tax issue differs per location as differences in tax rates apply based on consumption levels of a connection.		*Bi-directional*
2	**Procurement of flexibility services by grid operators**	It is unclear whether grid operators may purchase services from a storage facility. Therefore it is unclear whether a grid operator may purchase Smart Charging services. Even though unbundling regulation in EU countries specifies that DSOs cannot own and operate storage facilities, in NL and SW it is uncertain if flexibility services (service which provides a change in demand or supply) of third parties can be procured by DSOs. Uncertainty in the market can hinder investment in innovation. EU legislation is being developed to solve this issue, but it is not implemented yet (please refer to page 9).		*Bi-directional, Mono-directional*
3	**Lack of coordination between Smart Charging initiatives and the DSO**	Lack of coordination between Smart Charging initiatives and the DSO can lead to congestion within the regional grid because the DSO is unable to plan properly. Even if data is shared with the DSO, there is a risk that data cannot be shared in a safe & secure way because there is no central certificate authority to perform authentication today in Europe. Therefore, coordination is needed to use the potential of Smart Charging to provide flexibility services.		*Bi-directional, Mono-directional*
4	**Grid connection costs**	Lower incentive to roll-out public charge points with large Smart Charging potential due to higher grid connection costs for higher capacities. In (competitive) tenders of public charging stations, often price plays an important role to win the tender. Therefore, operators may choose the lowest capacity connection to reduce costs and win the tender. This limits the Smart Charging potential. This barrier seems to apply in all four countries.		*Bi-directional, Mono-directional*
5	**Netting rule**	Disincentive (due to the netting rule) to optimise a household's own consumption behind the meter by using the battery of an electric vehicle (first or second life). The netting rule only applies in NL and prescribes that energy consumed and produced by a household will be netted by the end of the year. It is a showstopper for using EVs and stationary (second-life) storage to optimise consumption behind the meter. The Dutch government has announced changes to the netting rule by 2023. Most likely a gradual abolishment of the netting rule will be implemented.		*Bi-directional, Mono-directional*

[1]SC – Smart Charging

National governments can help solve these barriers by changing or introducing relevant regulations within their markets. Some countries have already implemented solutions

National solutions to the barriers are possible and even already implemented in some countries

#	National solution	Example of solution currently implemented
1	*Variable grid costs:* Develop or adjust legislation so that the same activity is not taxed twice. This should avoid double grid costs (variable component), in anticipation of implementing the Recast EU Electricity directive (which helps to solve this issue, please refer to the next page). *Energy tax* • Define storage as a separate activity in tax legislation in the energy system with specific regulatory consequences: no (taxable) supply takes place for energy tax purposes if an EV is used as storage (bi-directional charging). • Alternatively, develop policies to facilitate netting of energy tax for charge points or define in law that energy tax is only payable on the net amount of electricity (the balance) charged via a charge point.	In Sweden, for energy suppliers (i.e., tax liable entities e.g. firms that do bi-directional charging via their connection), electricity that is supplied to the grid from the battery will be tax exempt. Non-tax liable entities i.e., entities not supplying energy can potentially receive a refund on the taxes paid. This results in a situation where, in the end, the "same" electricity will only be taxed once.
2	(1) Provide clarity on whether DSOs can procure flexibility (until EU Clean Energy Package comes into force, see next page). (2) Determine if and how costs incurred by DSOs to procure flexibility services should be incorporated in the reimbursement calculation by regulators. (3) Develop remuneration methodologies of DSOs for flexibility services (e.g. introduce a market for grid related services for DSO's; flexible grid tariffs)	In Germany purchase of flexibility by DSOs is happening in projects beyond the pilot phase. Paragraph 14a of EnWG is used as a justification for DSOs to procure flexibility via controllable loads (including EVs).
3	To improve coordination of Smart Charging initiatives and DSO activities, a flexibility market could be used to let the market arrange for prioritization. Data should be shared with the DSO[1].	In Germany, new grid codes are being developed (to be implemented from April 2019) that will allow DSOs the possibility to control charging stations >4.6 kVA. This allows them to manage congestions using mono-directional SC.
4	To increase the incentive to roll out high capacity public infrastructure, further analyse the societal business case of: • A grid connection tariff on the basis of actual consumption • Changing tendering requirements to reward high capacity connections offering Smart Charging solutions • A reduced connection tariff when the connection point is used for flexibility services	No concrete country examples are available. France has implemented a clause[2] that encourages the DSO to take into account the customer's ability to shift consumption from peak to off peak periods while deciding upon the connection capacity needed. However, there is no structural solution providing lower prices to higher capacity charging points.
5	• Ensure the benefit from storing self-produced electricity for later use is higher than the benefit from netting. • This can be achieved by: (1) Replacing net metering with a feed-in tariff scheme; (2) Only netting the tax component.	Only netting of (part of) the tax component applies in Sweden: a tax reduction of 6.3 ct/kWh exists[1] for the electricity fed into the grid[2] (<100A connections). Therefore, the benefit from storing self-produced electricity for later use is higher than the benefit from netting, which provides an incentive to store self-produced electricity for later use.

[1]A national government could impose standards for exchange of data. However, this could also be arranged on a EU level. [2]Clause for incorporating flexibility from connection point: PRO-RAC_03E, §15.5

Three solutions should be considered at a European level. Further analysis is required to determine the societal benefits of EU solutions and the exact changes needed

Some Smart Charging barriers can potentially be solved at a European level

Potential EU solution	Explanation	Regulatory barrier	Next step
1 Implement European tax regulation that bi-directional charging does not qualify as supply for tax purposes, but as (exempt) storage service instead	Double energy taxes are mainly a result of the lack of a definition of storage, as charging and discharging are defined as consumption and supply, respectively. The proposed definition within the Electricity Directive (recast) does not solve the problem, since this directive does not apply to energy tax (the Energy Tax Directive does). A structural and harmonized solution would be to implement changes in the Energy Tax Directive confirming that bi-directional charging qualifies as storage. In that way, it should not trigger double energy taxes.	Double energy tax and grid fees for bi-directional charging	Research and decide which would be the appropriate EU legislation to best implement/drive the solution for double taxation
2 Define regulatory framework to incentivize DSOs to procure flexibility.	The Proposed Electricity Directive (recast) of the Clean Energy Package (which received political agreement after negotiations in December 2018, and now needs to be approved by the European Parliament and Council) clearly mentions (in its 11.01.2019 version, drafted at the same time when this report was developed) that Member States should incentivise DSOs to procure flexibility. The clarity should now be provided by the national regulators, once this directive is approved and put into practice.	Procurement of flexibility services by grid operators	EU can provide further guidance on the design of remuneration mechanisms for DSO's grid investments, incorporating the idea of flexibility provision from battery owners
3 Give guidance on the market design for flexibility	Guidance for market design can be provided by the European Union, but the individual market designs have to be designed and implemented nationally due to differing market structures. The EU could however provide guidance on how to arrange the public key infrastructure to allow standardized and safe data sharing in the Smart Charging value chain.	Lack of coordination of Smart Charging initiatives	Research and learn from frameworks and market designs/platforms like USEF, GOPACS, PKI for ISO15118 etc.

EU solutions can be considered if:

- The regulatory barrier stems from EU regulation
- Barriers apply in all countries
- Cross country harmonisation can be beneficial

This study provides potential EU solutions. However, the costs and benefits of EU intervention (as well as the subsidiarity and proportionality principle[1]) should be further analysed for a specific proposed solution.

Note: [1] Subsidiarity: the objectives of an action can not be sufficiently achieved by Member States and can be achieved at Union Level. Proportionality: action at Union Level should be limited to what is necessary to achieve the set out objectives

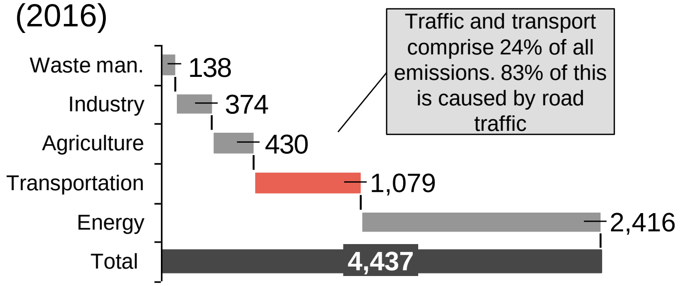
1.

Development of Electric Vehicles: Challenges & Opportunities

To reduce harmful emissions (such as GHG emissions, particulate matter & NOx) from the transport sector in Europe, governments are driving the transition to electric vehicles

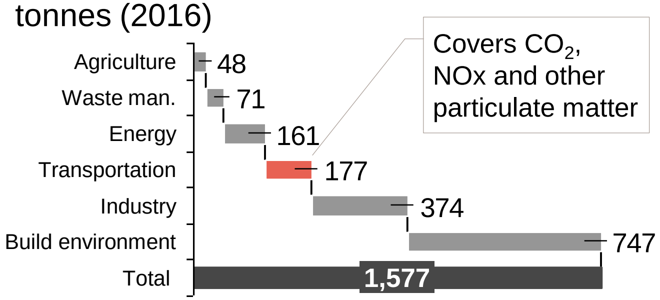
The transport sector accounts for a fourth of the European GHG emissions…

European GHG emissions in million tonnes (2016)



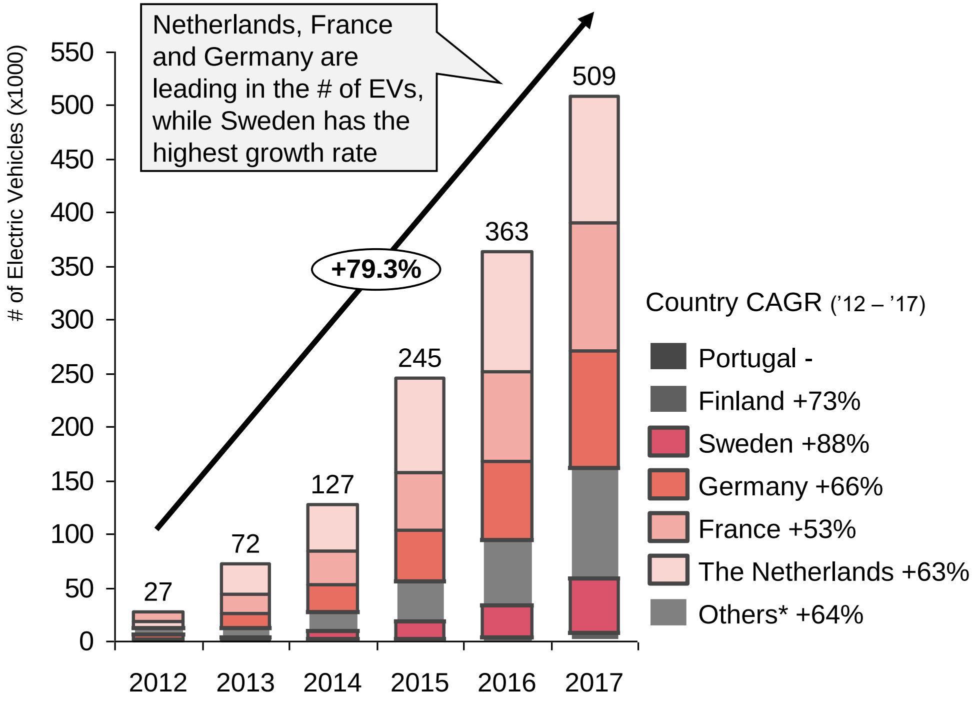
…and over a tenth of the pm2.5 emissions

European pm2.5 emissions in thousand tonnes (2016)



EVs are an essential reduction option for the transport sector, and NL, FR, DE & SE are leading the transition in Europe

The European EV-fleet[1]



Comments

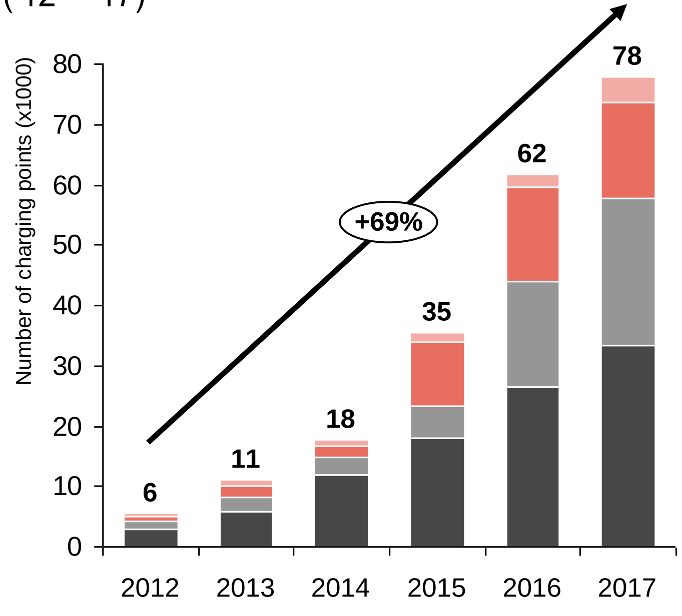
- By signing the Paris Agreement, European countries are pursuing the goal of limiting the global average temperature rise to below 2°C compared to pre-industrial levels.
- Currently, the transport sector is one of the major emitters of GHG emissions and particulate matter. Hence, policy makers are incentivising the transport sector towards sustainable alternatives like electric vehicles.
- Within Europe, **Germany, France and The Netherlands are front-runners** in terms of their EV-fleet. In terms of the growth rate over the last 5 years, **Sweden leads the pack with a CAGR of 88%. As a result, these four countries are the focus of this study.**

Notes:[1]Includes BEV, E-REV, PHEV, FCEV. Excluding Norway and the United Kingdom. *The *others* group contains 32 European countries.

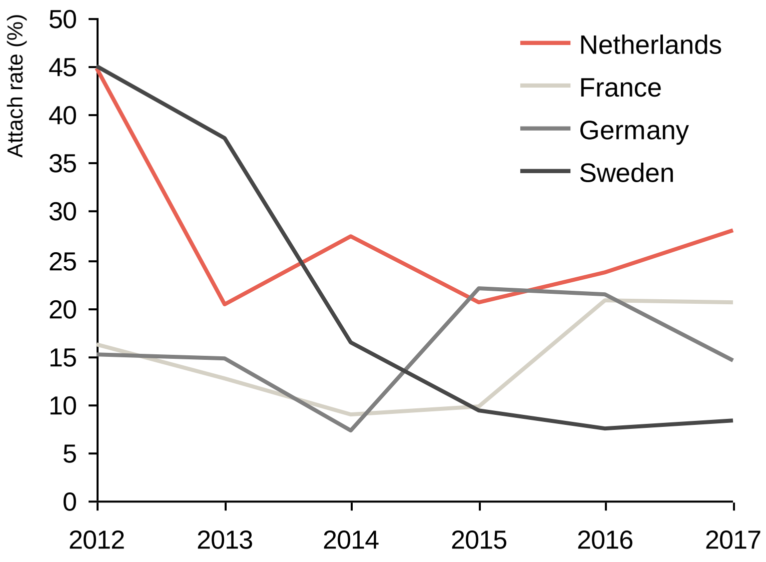
Sources: Eurostat (2018), European Environmental Agency (EEA) (2017), International Energy Agency (2018)

The transition to electric vehicles requires timely adoption of charging infrastructure

All four countries are investing heavily in public charging infrastructure
Public charge points including CAGR ('12 – '17)



However, the attach rate has been declining in Sweden due to a faster uptake of EVs
Attach rate i.e., charging points per car



[1]The attach rate is hereby defined as the number of charge points divided by the EV stock

When deploying charging infrastructure, there are different ownership options with variations in capacity and charging speed

Type	Ownership type(s)	Power output	km/10 min of charging
Home & Street *AC mode 2*	Private and Public	Average 11 kW	1 – 2
Commercial *AC mode 2*	(Semi) Public	Up to 19.4 kW	3.2
Fast charging *AC mode 3 or DC*	Public and Private	20 – 50 kW	21 - 64
Fast charging *DC high power*	Private	100 – 400 kW	90

Private: A charge point owned by an E-driver on his home connection or by CPOs who offer fast charging points

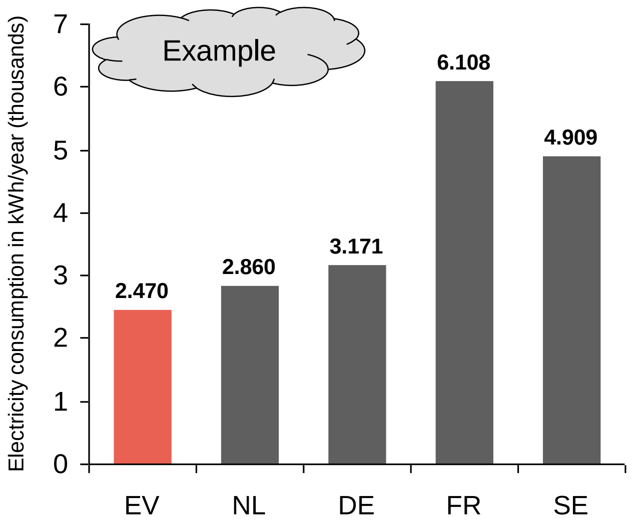
(Semi) Public: A charge point at a bulk consumer (supermarket, gas station etc.) who has installed charge points on his connection

Public: A charge point owned by municipality on streets or highways, installed and operated via a tendering process

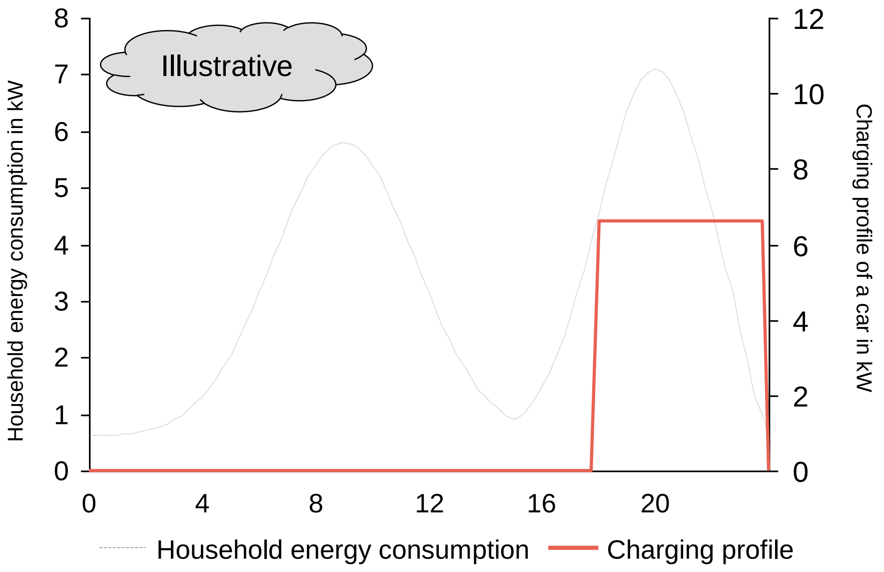
Sources: International Energy Agency (2018), Research for TRAN Committee – Charging infrastructure for electric road vehicles European Parliament (2018), PwC analysis

The growth of electric transport can lead to an increase in peak demand for electricity

The electricity consumption of an average EV is ~75% of a typical household's electricity consumption…
Electricity consumption of an example EV compared to a household in the 4 countries[1]



…with its charging profile possibly coinciding with the peak of household consumption
Household energy consumption and charging profile in kW



…leading to growth in peaks within the grid

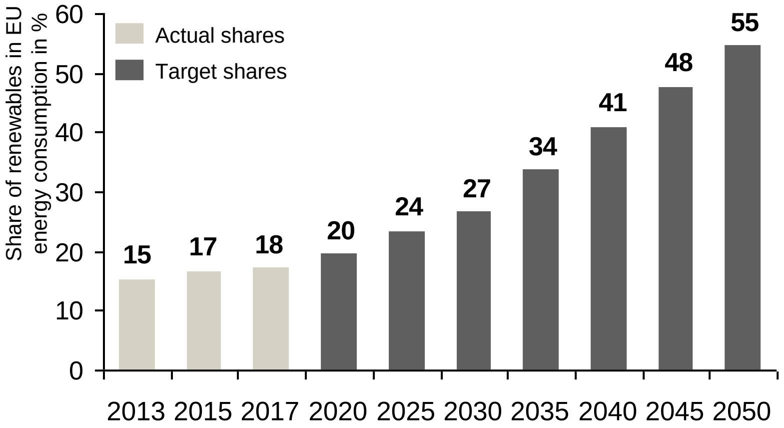
- The energy consumption of electric cars coincides with peak demand and therefore increases the total peak. Consumption often takes place at times when there is already a high peak demand from households (in the morning, when arriving at work or later in the day at home). A household's annual electricity consumption can almost double with the use of an electric car (depending on the use of the car).[1]
- At some locations in for example the regional grids of the Netherlands, peak demand already presents a problem, requiring grid upgrades.
- A 2018 study from a Dutch DSO forecasts an increase in the peak load between 2017 and 2026 by 25%. Electric transport is identified as one of the drivers. In 2026, they predict electric vehicles to be responsible for 3% of the total peak demand.

[1]EV consumption based on average consumption of ~0.19 kWh/km (Tesla model S) and distance of 13,000 km on annual basis (the average in the EU). For France: assuming a total residential electricity consumption of 174 TWh and 28.5 million households (Euro monitor International). For Sweden: 22 TWh electricity consumption from households (Swedish Energy Agency) and 4.48 million households. For Netherlands: CBS (2018). Odysee-Mure (2018)

Sources household energy consumption and charging profile: RDW (2017) & RVO (2017). See also Enexis Group (2019)

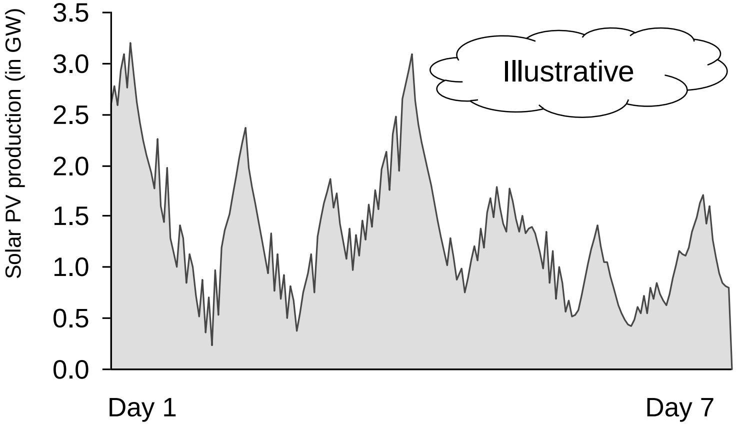
At the same time, the renewable energy transition will lead to increased volatility in the grid

The share of renewable energy is set to increase threefold, in pursuit of ambitious targets
Share of renewable energy consumption in Europe[1]



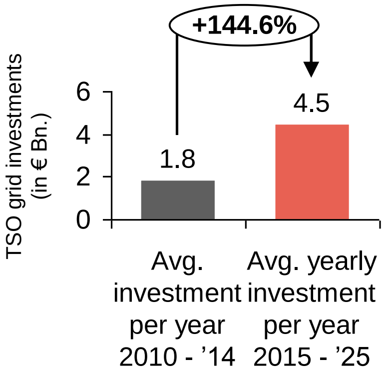
The generation of wind and locally generated solar energy is expected to play an important role in meeting the ambitious targets set by the EU and individual Member States. Over the last years, their shares within the renewable energy mix have steadily increased.

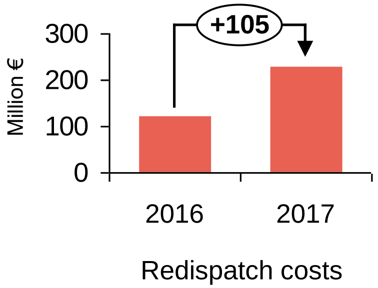
While these energy sources have volatile production patterns…
Germany's solar production during 1 winter week



However, wind and solar energy sources lead to volatile production patterns. The sun intensity can differ from day to day and wind speeds are also highly volatile.

…making new investments in the grid a necessity
TSO fixed investments and redispatch costs in TenneT control area in Germany





Due to an increase of renewable energy and resulting volatility in the grid, grid operators are forced to invest heavily. In Germany, annual fixed investments in the TSO grid had to be doubled since 2015. TenneT also identified wind feed-in as a key driver of congestion management, and consequently rising redispatch costs (as shown in the figure above)

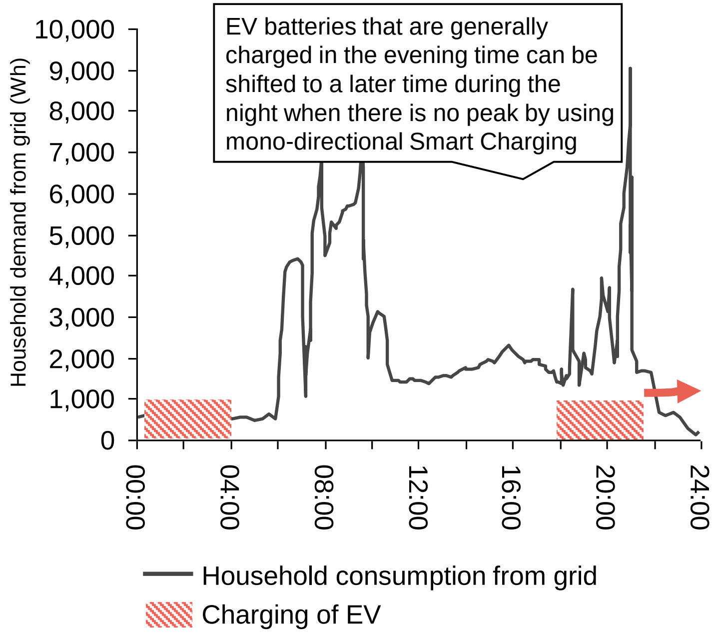
[1]Target values based on the EU target of 27% renewable energy consumption in 2030 and 55% in 2050. Other values are extrapolated

Sources: EnTranCe (2016), EC (2012) & Eurostat (2017)

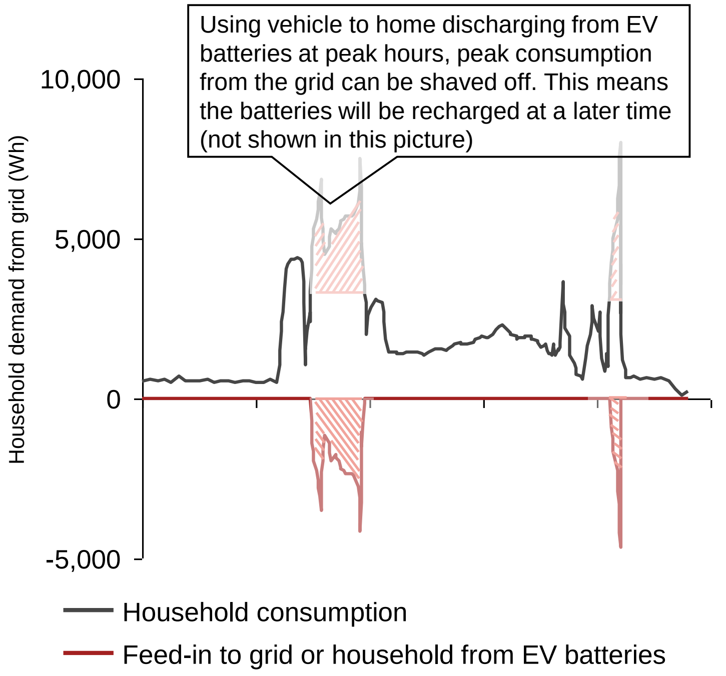
However, electric vehicles can also help reduce the peak in electricity demand because they can provide flexibility via Smart Charging solutions

Two examples of Smart Charging solutions

1 **By delaying charging to non-peak hours, an increase of peak demand can be avoided…**
Time shifting of EV charging to reduce peaks (Mono-directional Smart Charging)



2 **…and/or the peaks can be shaved off**
Peak shaving using stored energy from EV batteries (Bi-directional Smart Charging)



1 Generally, EVs are charged in the evening (after people return home from work). This creates an increase in the peak load i.e., electricity needed from the grid during evening hours. The peak can be lowered if the block of electricity consumed by EVs is shifted to the night. This can be achieved by performing mono-directional Smart Charging (i.e., delayed charging).

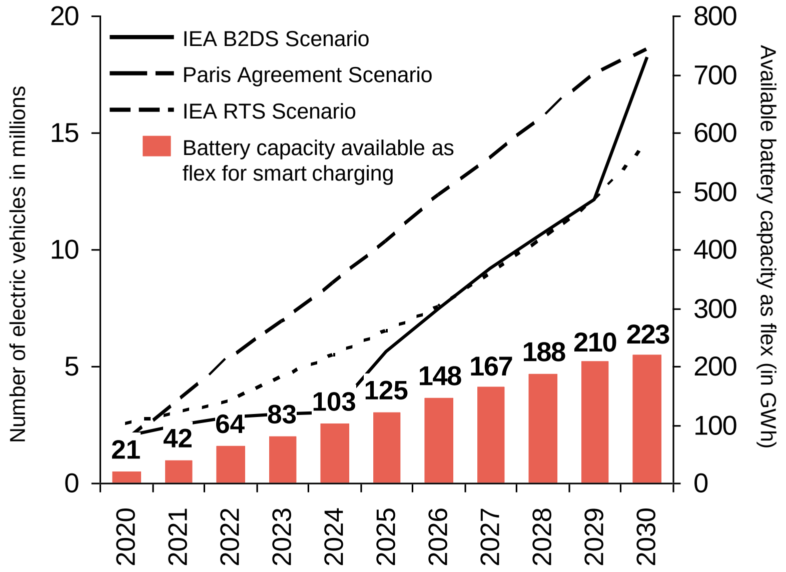
2 As it is expected that there will be a large number of EVs connected to the grid/home in the future, there is a possibility to use the energy from these batteries to power a household during peak hours. This can be done by discharging the stored energy within a battery back into the home. The battery will have to be recharged at a later time, but this can be done during non-peak hours.

Source: PwC analysis, TenneT (2017) & Ensoc (2016)

Moreover, EV batteries can be repurposed for second life use, to offer stationary storage services along the grid

First life of EV batteries (in vehicle)

First life batteries can be used to provide flexibility only for a portion of the time…
Projection of the European EV fleet & (exemplary) available battery capacity for Smart Charging[1]



Via repurposing

Batteries can be re-purposed either at the end of vehicle life or in between while performing replacements etc.
Repurposing can happen in the following ways:

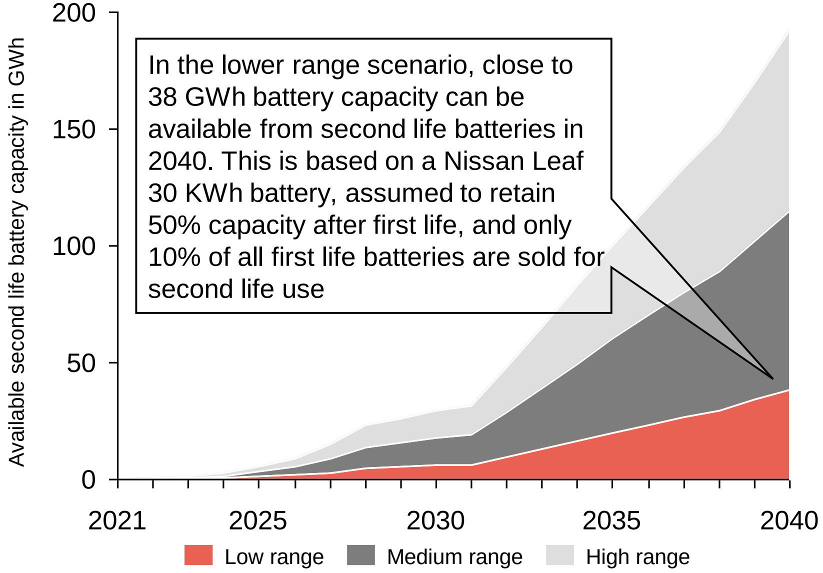
1. Re-use of single original battery pack as a stationary storage system
2. Re-use of various battery packs integrated into multipack stationary storage system
3. Battery pack disassembly and re-use of battery components into a new storage system

Note: For the model on the left, we assume that the batteries enter the repurposing route without any additional costs i.e., mainly the first route (among the 3 routes mentioned above).

Second life batteries as stationary storage

Recycle

…but, if the batteries re-enter the market as stationary storage in their second life, there is a huge potential for flexibility in the system
Projection of potential second life battery capacity in EU[2]



[1]Projection based on the assumption that the market share of Europe in the total EV fleet remains constant at 2017 value. For first life batteries, a Nissan EV battery (30 KWh) is assumed. Furthermore, it is assumed that it can be used for Smart Charging 40% of the time (based on input from LomboXnet). [2]Assuming the following inputs for the scenario's: respectively 10%, 30% and 50% of the batteries can be repurposed (from low to high range) and 50% of the battery's capacity can still be used under all scenarios. Here also, a battery capacity of 30 kWh is used (capacity of Nissan Leaf). *For further details on assumptions, please refer to the Appendix.*

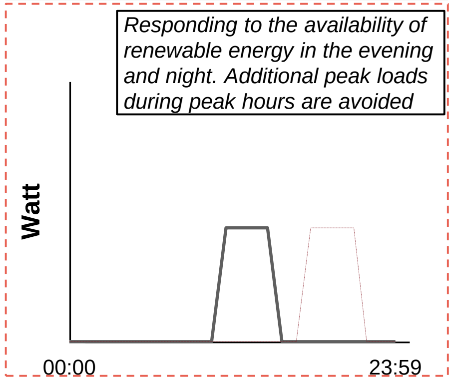
Sources: PwC Analysis based on International Energy Agency (2018). Note: B2DS stands for Beyond 2 degrees scenario, RTS stands for Reference Technology Scenario

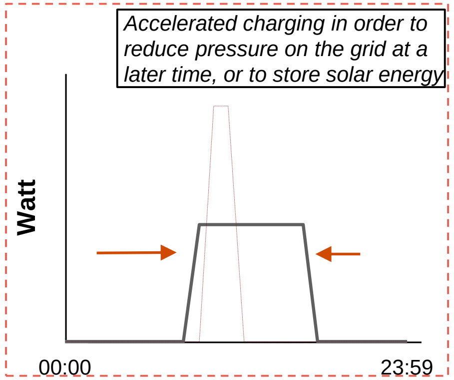
Smart Charging, in essence, enables a battery both in first life (as EV) and second life (as stationary storage) to provide flexibility by controlling the timing, speed, and/or charging method

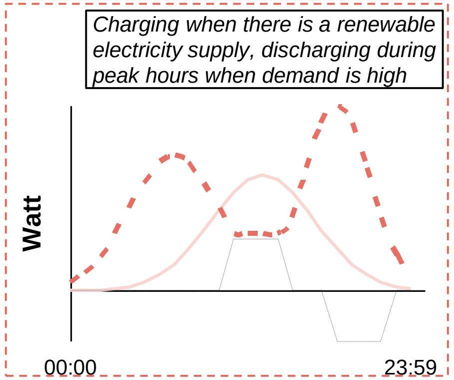
Smart Charging

Time	Speed	Manner
The battery can start charging later (delayed charging). It is thus possible to opt to only charge if specific conditions are met (such as a low retail price for green energy)	The charging speed and the relative power with which two electric cars can be charged at one point can be varied (e.g. one car can be charged faster/slower, or even temporarily stopped)	A storage (battery) owner may both charge and discharge to the grid ('bi-directional charging'). In addition, a user can choose where to charge (public or private)

Example of charging profiles







Mono-directional Smart Charging – variation in time and speed

Bi-directional Smart Charging – variation in time, speed and manner

Charging profile · Sun profile · Desired charging profile · Energy usage household

(1) Mono-directional Smart Charging: This is the most commonly used form of Smart Charging today, wherein the Smart Charging initiatives use variation in time and speed i.e., certain cars are charged faster than other cars or the charging is stopped/delayed in order to limit the impact on grid

(2) Bi-directional Smart Charging: It is expected that battery technology will develop so that energy from car batteries can be fed back into the grid and/or back into the house when there is a need, thus providing an additional lever for Smart Charging initiatives to perform grid balancing

Both mono-directional and bi-directional Smart Charging initiatives are gathering momentum across Europe

ILLUSTRATIVE

Mono-directional use cases

Jedlix uses Smart Charging by temporarily postponing the charging of electric cars and recharging them at a later time, for example when Eneco has generated a lot of renewable electricity. In this way Jedlix helps Eneco to perform its programme responsibility. The driver indicates with the app when the car must be fully charged (‘time of departure’) and what the minimum charge status of the car should be.

MRA-E, Greenflux and the municipality of Alkmaar, among others, are experimenting with variable charging tariffs (in off-peak and peak hours) in a pilot project with 20 charge points.

Daimler, Mobility House, Getec and **Remondis** created the world’s largest second-use battery storage unit to the grid, which has a capacity of 13 MWh. Second-use batteries of EVs were used for the storage unit in order to level out fluctuations in the power grid.

Vandebron and **TenneT** are working together on a pilot project to use the flexibility offered by electric car charging sessions in order to balance the Dutch electricity grid. Vandebron supplies flexibility by starting or stopping charging during the charging session of an electric car at TenneT’s request.

Bi-directional use cases

The GridMotion project is a 2 year demo project of **Groupe PSA**, **Direct Energie**, **Enel**, **Nuvve, Proxiserve** and **the Technical University of Denmark**. Next to mono-directional charging, it tests bi-directional charging with 15 EVs using Smart Charging and V2G services.

INEES project is a V2G initiative from **Volkswagen, Lichtblek, SMA Solar Technology** and **IWES**. For one year, the batteries of 40 EVs were used for both loading electricity and putting surplus energy back into the grid. Participants could use a mobile app to see how their driving behavior and the demand of the electricity market were linked, receiving a bonus when their battery capacity was used for general use.

TenneT, The Mobility House & Nissan launched the **Re-dispatch V2G project, in order to** store locally produced electricity by using the batteries in EVs, and feed it back into the grid to stabilize the grid. In addition, the project will develop and evaluate suggestions for regulatory guidelines for V2G.

LomboXnet and **the municipality of Utrecht** launched a V2G project, called **Smart Solar Charging**. This year, 145 public charging points will be placed to store solar energy in the batteries of EVs. The energy in turn can be discharged into the power grid to avoid peaks in the grid. Also in 2019, 75 smart solar charging points will be added in the region.

Sources: Groupe PSA (2017), Volkswagen (2016), Daimler (2015), TenneT (2018), LomboXnet (2019).

Smart Charging can be beneficial for participants along the electricity to E-mobility value chain

Electricity to E-mobility Value chain	Generator	National (High voltage) grid operator	Regional (Low voltage) grid operator	Energy Supplier/ BRP Charging point operator (CPO)	E-mobility service provider (EMSP) Aggregator	E-Driver	Electric Vehicle Car Manufacturer
Benefits of Smart Charging for each market party	**When there is surplus renewable energy**, a Generator can store energy in the car batteries to **avoid negative prices w**hich the generator would have to pay to supply its electricity to the grid	**Use of the flexibility of electric cars for reserve markets:** Smart Charging initiatives can offer the flexibility of electric cars & second life batteries for balancing the grid close to real-time	**Use of flexibility to avoid grid upgrades:** Smart Charging can help the regional grid operators with both active and reactive power products to avoid congestion in its regional grid (especially at peak times). As a result, there is less need for grid upgrade investments	• **Programme managers** can use Smart Charging to **ensure that their programme is realised**. This will prevent any imbalance costs arising from non-compliance with their programme. • **CPO can optimize the use of his charge point** (load balancing) using flexibility	Aggregators have the **opportunity to create new business models (and revenue streams for E-drivers, battery owners and themselves**) using the flexibility from first and second life batteries	• **Timely charging** so that the e-driver's mobility requirement can be fulfilled • **Optimisation of own consumption** behind the meter i.e., use energy from battery to power the house (by means of bi-directional charging) • **Additional income**	**OEMs can unlock insights from the data of batteries** (regarding State of charge, Charging speed etc.) by offering [or participating in] Smart Charging initiatives. This can also support their R&D activities in the storage domain

Municipality: By installing and enabling Smart Charging points in public spaces, municipalities make EV ownership more attractive and hence are able to meet their decarbonisation & EV uptake targets

Sources: PwC analysis

Traditional and new market parties have to work together to enable Smart Charging in practice. Current regulation is not equipped to deal with these new players and innovations regarding Smart Charging

Electricity to E-mobility Value chain	Generator	National (High voltage) grid operator	Regional (Low voltage) grid operator	Energy Supplier/ BRP / Charging point operator (CPO)	E-mobility service provider (EMSP) / Aggregator	E-Driver	Electric Vehicle Car Manufacturer
Role of each market party in Smart Charging	• Uses the flexibility from batteries at times of surplus or deficiency in renewable energy production	• Designs the prequalification requirements for balancing and control power products in order to incorporate flexibility from EVs and second-life batteries • Procures flexibility from Smart Charging initiatives via the balancing markets	• Provides charge point connection to CPOs • Interfaces with Smart Charging initiatives to exchange grid data in order to manage local congestions using flexibility from charge points	**Energy Supplier:** • Arranges contracting & reimbursement • Sometimes offers Smart Charging initiatives **CPO:** • Installs the charge point based on tender specs. of municipality or its own business case • Optimises use of charge point (load balancing)	**EMSP:** • Provides charging card and arranges settlement **Aggregator:** • Creates flexibility products by using data on batteries charge & participation status and market data on volume & price requirements	• Orders charge point with Smart Charging functionality at home • Selects charging location and charging time according to mobility requirements • Opts for participation in Smart Charging initiative	• Supplies EVs to E-drivers with required convertors and connectors. • Determines whether EV is suitable for Smart Charging • Unlocks data for Smart Charging

Municipality

- Establishes public charging infrastructure for E-driver through concessions & permits
- Determines charge point requirements in invitations for tenders for public charge points

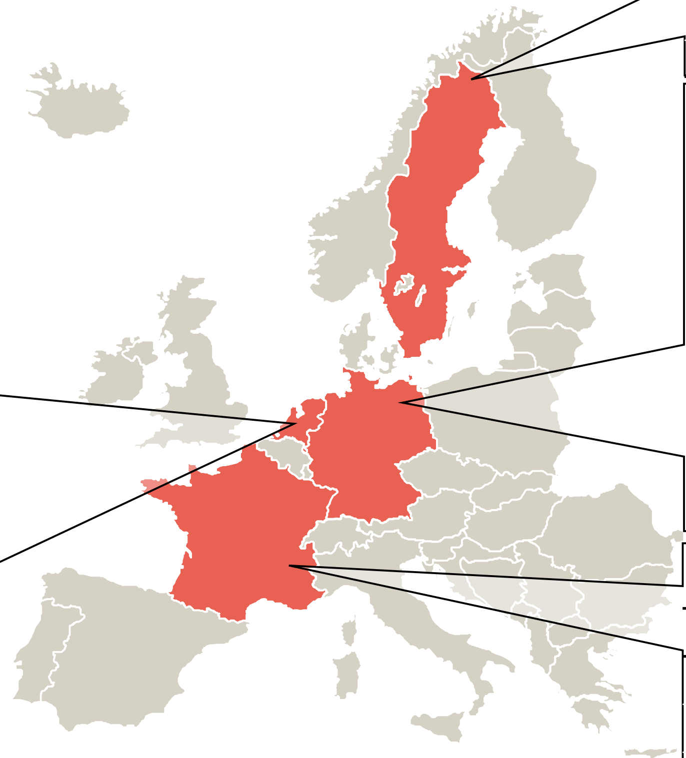
LEGEND Traditional market roles | New market roles

Sources: PwC analysis

With several Smart Charging (esp. V2G) initiatives maturing across the European Union, there is a need to solve regulatory barriers for Smart Charging

The Netherlands, Germany, France and Sweden are all investing in Smart Charging projects

	Smart Charging projects in Netherlands		# charging points
Bi-directional	*Hitachi, Mitsubishi & Engie*	*2018*	**1**
	Nissan NMPC NL HQ	*2017*	**1**
	NewMotion V2G	*2016*	**10**
	Amsterdam Arena battery storage	*2016*	**280[1]**
	Smart solar charging (LomboXnet)	*2015*	**>22**
	Solar-powered bi-directional EV charging station	*2015*	**1**
	City-Zen smart city	*2014*	**4**
	Amsterdam Vehicle2Grid	*2014*	**2**
Mono-directional	*ADO Den Haag stadium*	*2018*	**20**
	Vandebron & TenneT	*2017*	**-**
	MRA-E, Greenflux & municipality of Alkmaar	*2017*	**20**
	Jedlix	*2016*	**-**



Smart Charging projects in Sweden		# charging points	
Kungsbalka pilot with TSO Svenska Krafnet	*2019*	**10**	Mono.
Swedish Electromobility Centre, Uppsala University, Vattenfall AB & CEVT	*2018*	**-**	
ELVIIS	*2013*	**-**	

Smart Charging projects in Germany		# charging points	
i-REZEPT smart communities	*2019*	**20-30**	Bi-directional
Redispatch V2G (Nissan, TMH, TenneT)	*2018*	**1**	
SonnenCommunity	*2018*	**30,000[1]**	
Nissan Leaf FCR with Amprion	*2018*	**8**	
Honda, Offenbach	*2017*	**1**	
Vehicle-to-coffee	*2015*	**1**	
INEES	*2012*	**40**	
2nd use battery storage (Daimler, Mobility House, Getec, Remondis)	*2016*	**1000[1]**	Mo.

Smart Charging projects in France		# charging points	
Grid Motion	*2017*	**15**	Bi.
Hajime Nissan HQ EDF	*2019*	**10**	Mo.
SMAC V2G Champagne Ardenne	*2019*	**10**	
FlexMob'île	*2018*	**-**	

LEGEND | *Project Name* | *Country* | *Year* | **# charging points**

Sources: V2G Global Roadtrip: Around the world in 50 projects (Oct. 2018), Groupe Renault (2018), Viktoria (2013), Uppsala Univsersitet (2018), PwC analysis based on interviews and desk research

[1]number of charging points not applicable, number of second-use batteries of EVs for energy storage is used

2.

Institutional barriers to Smart Charging & second-life use of EV batteries

We have identified the most important regulatory barriers for Smart Charging (both during first and second life use of EV batteries)

	Regulatory barrier type	Short Description	Impact on type of SC[1]	Impact on Smart Charging along the value chain[2]
1a	**Double energy tax and double charging of variable grid fees**	**Double energy tax and double charging of variable grid fees while performing bi-directional Smart Charging.**	*Bi-directional*	• Since storage is not defined separately as an (exempt) activity in the Energy Tax Directive, an EV driver may have to pay taxes every time he/she charges the car. Therefore, charging, discharging and charging again may result in double taxation. Hence, there is no incentive for an EV driver to join a Smart Charging initiative
1b	**Tax differences for public v/s private**	**Impact of the double tax issue differs per location as differences in tax rates apply based on consumption levels of a connection**	*Bi-directional*	• Different tariff structures apply to the energy consumption at different types of charge points (depending on the consumption levels and the location of connection point where charging takes place). This can increase the double taxing issue in some locations
2	**Procurement of flexibility services by grid operators**	**It is unclear whether storage may be procured as a service by grid operators (i.e., Smart Charging may be deployed or not for flexibility purposes)**	*Bi-directional, Mono-directional*	• Instead of expanding its grid, a DSO might want to use EVs or second life batteries to perform congestion management. However, it is unclear whether it can do so under current regulation. It is clear that ownership and operations is not allowed, but in some countries it is unclear if procurement of flexibility services is allowed.
3	**Lack of coordination between Smart Charging initiatives and the DSO**	**Lack of coordination between the Smart Charging initiatives and the DSO can lead to congestion within the regional grid because the DSO is unable to plan properly. Even if data is shared with the DSO, the authentication mechanism is unclear.**	*Bi-directional, Mono-directional*	• Several parties can experience problems from the lack of coordination of flexibility. • DSOs might experience congestion due to uncoordinated flex initiatives on its grid, resulting in brown outs or black outs, and in turn higher network costs.
4	**Grid connection costs**	**No incentive to roll-out Smart Charging infrastructure due to higher grid connection costs for higher capacities**	*Bi-directional, Mono-directional*	• As higher capacity connections are more expensive, CPOs may not have the incentive to install high capacity fast charging stations, especially when costs are an important element to win a tender for a public charge point. This reduces the potential to perform Smart Charging at public charging stations.
5	**Netting rule**	**Missing incentive (due to the netting rule) to optimise own consumption behind the meter using the battery of an electric vehicle (first and second life)**	*Bi-directional, Mono-directional*	• Limits the uptake of EVs and batteries at household level since there is no incentive for the E-driver to perform mono- or bi-directional Smart Charging behind the meter • Beyond the meter, an E-driver is only incentivised to participate in bi-directional Smart Charging (i.e., V2G) if he/she is given additional compensation

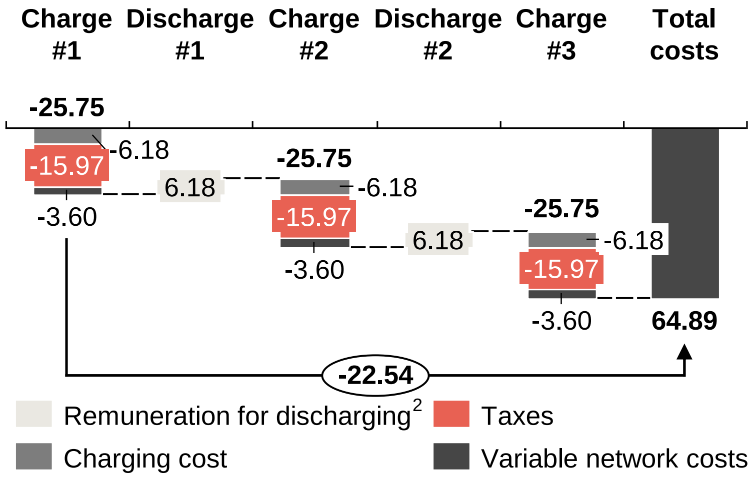
[1]SC – Smart Charging

[2] In general, from the perspective of market players it is beneficial to have harmonized regulatory frameworks across Europe

Bi-directional charging (V2G) is discouraged in most countries due to double energy tax and network fees charged

Double tax can occur since storage is not clearly defined as an (exempt) activity

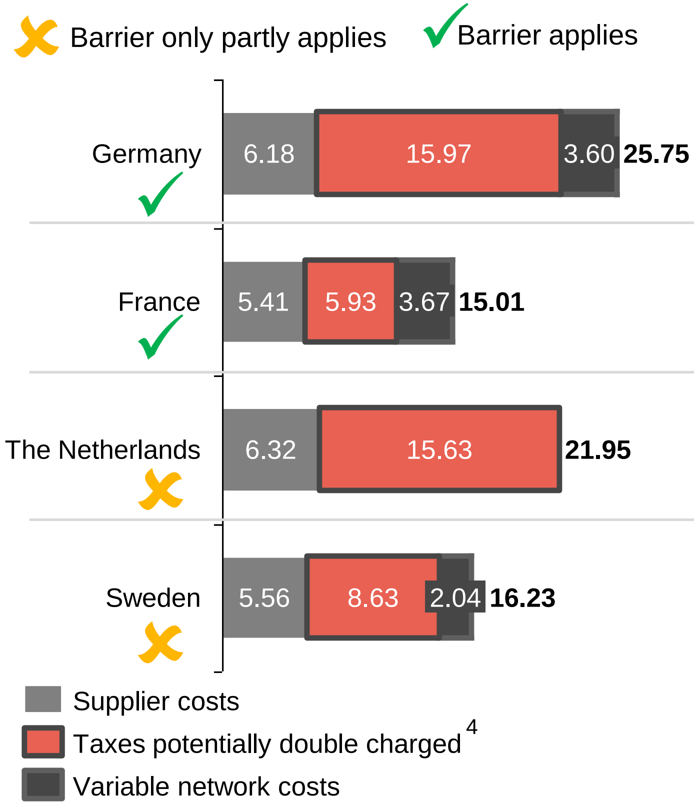
Costs of charging and discharging 1 kWh in Germany in eurocent/kWh[1]



This barrier applies for V2G solutions (not V2H). Two scenario's can emerge where this is applicable when storage is i) charged and discharged multiple times (please refer to figure above) or ii) charged and discharged once, but discharged power is used by another consumer (who again pays taxes)

The size of this problem depends on the tax schemes in each country…

Variable tariff components in Germany, France and The Netherlands in eurocent/kWh[1]



…and in some countries also double grid tariffs or other levies (like costs for electricity certificates) can apply

The potential double taxation is 15.97 ct/kWh, which includes EEG, electricity tax, offshore levy, KWK levy, other surcharges and VAT. The variable network costs included here are a Dusseldorf example and could also be charged double. Storage that is directly and only connected to the grid without the potential of consuming the energy (like is the case with EVs), is exempt from many taxes and grid fees.

The potential double taxation is 5.93 ct/kWh, which includes the CSPE and TCCFE taxes and VAT. CTA tax is not variable per kWh and therefore not double taxed. Also, a double charged variable grid tariff of 3.67 ct/kWh applies.

The potential double taxation is 15.63 ct/kWh, which includes electricity tax, renewable energy surcharge and VAT.[3] Double taxing does not apply with net metering, which is the case for small connections (<3 x 80A).[5]

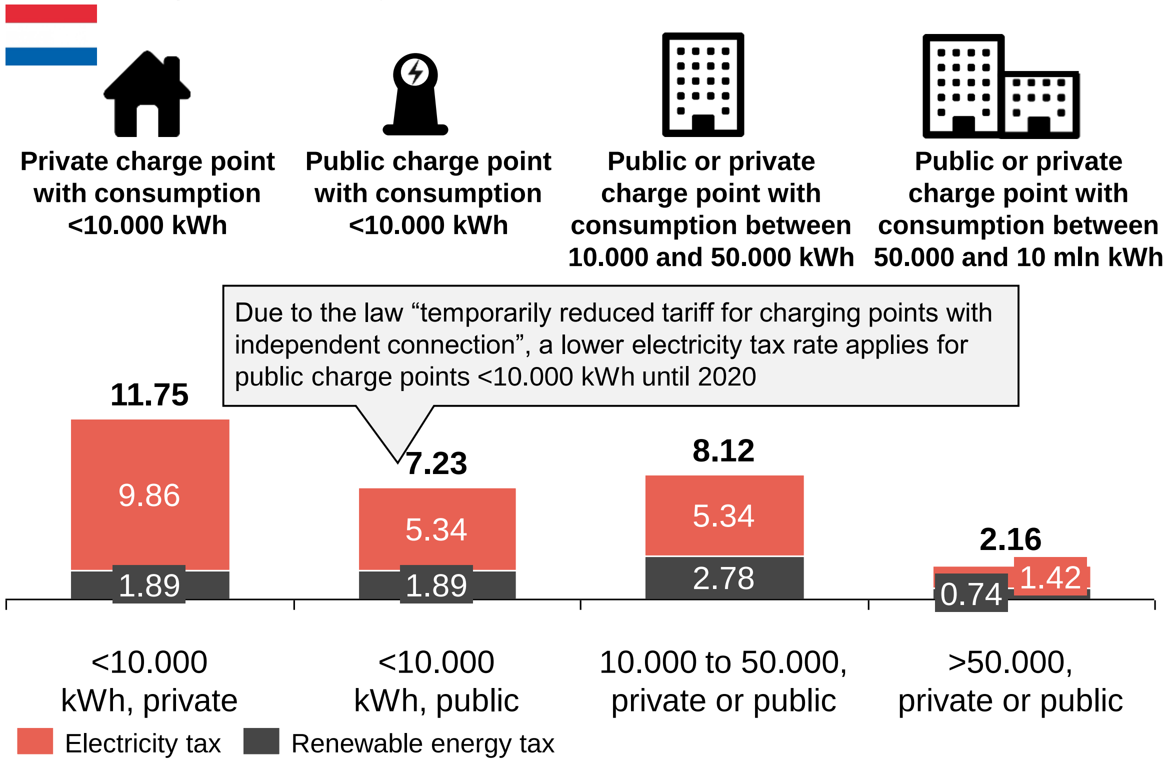
The electricity prices, network costs and taxes vary widely between regions and energy suppliers in Sweden. In the North consumers pay around 1 ct/kWh less taxes. On average 45% of the total price is made up of taxes and VAT. However, in Sweden double taxing is avoided from January 2019 because they implemented a solution (Lag (1994:1776) om skatt på energy, chapter 11). A double charge of cost for electricity certificates can apply in Sweden.

[1]For assumptions, a more detailed taxes breakdown and sources please refer to the appendix (p.54). [2]Here, it is assumed that the flex price for bi-directional charging is equal to the supply component of electricity price. [3]The total electricity taxes in the Netherlands are in fact lower, due to a fixed tax reduction of €257,54 per year for households. [4]VAT is included in the double tax amount, however if an EV driver becomes a VAT taxable person, it won't be charged double. [5]It is unclear if net metering also applies for small public connections.

The double tax issue becomes even more complicated as different tax rates apply to different charge points

The amount of tax per kWh charged depends on the type of charging point

Dutch example of electricity taxes in eurocent/kWh[1] 2019



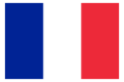
- In The Netherlands, different tax rates apply depending on the ownership and/or location of the charging station. In case e.g. a charging station is located in a building using a lot of electricity, it will be subject to a lower tax rate than a charging station that is connect standalone. This means that an E-driver might pay lower taxes at e.g. a private/(semi) public charging point e.g., at work, when compared to a standalone connected public street charging point (although a lowered tax rate applies).
- In Germany and France taxes do not vary to a large extent[1] based on the location and usage of the charge point. However, if a charge point is behind the meter of an industry, the charge point will benefit from the tax exemptions that apply to the industry.
- In Sweden, taxes vary between the North and South, but these are historically driven locational differences which do not necessarily complicate the double taxing issue.

Source: Belastingdienst (2019)

[1]The energy intensive industries do have some tax exemptions in these countries that could lead to lower taxes for charging at these companies. In France, Article 43 of the finance rectificative law of 2005 refers to the entire consumption of an energy-intensive firm, therefore there is no reason for the electricity use for EV charging to be treated differently.

For DSOs to benefit from Smart Charging they must be allowed to buy flexibility services. It is unclear if this is possible within all Member States

DSOs currently procure storage in several pilot projects, but in order to commercialise, clarity is required from regulators

DSO unbundling elements	Accounting	Legal	Functional	Full ownership unbundling	Flex procuring by DSO allowed?	Does flex procuring by DSO happen in practice?	Example pilot projects where this is happening
					European regulation Due to ownership unbundling[1], the allowed activities of DSOs are limited. Article 32 of the Proposal for a Directive on common rules for the internal market in electricity (recast), 11 January 2019 version, clearly outlines that DSOs should be allowed to procure storage services for grid related activities if this is cost-effective versus grid investments, but at the moment there is no clarity from regulators within member states regarding this.		
 ✓	✓	✓	✓	✓	Owning and operating is not allowed (Wet Vet). Unclear if it is allowed to purchase flexibility services due to the unbundling requirements. DSOs can only apply congestion management temporarily until grid expansion is realised as described in the Netcode Electricity, Article 9.4.3.	Yes, this is happening in several pilot projects across NL. However, the projects are not allowed on a large scale.	1. Stedin (grid operator), MisterGreen (EV lease) and Alfen (energy infrastructure) built a rapid charging station with solar panels and a local energy storage system to show that peak loads can be decreased there. 2. At ADO Den Haag, Stedin & Alfen are setting up a load balancing platform to maximize utilization of the grid
 ✗	✓	✓	✓		Article 199 of the Energy transition Law 2015 (to end in 2019), provides clarity that it is allowed on an experimental basis for four years. Consultations for renewal have started.	Yes, it is happening in pilot projects	Enedis, along with Renault, Morbihan Energies, Les Cars Bleus is introducing a Smart Charging network just off the coast of southern Brittany to mitigate load fluctuations in the grid. The public charging points will use excess energy from rooftop PVs on public buildings for charging EVs.
 ✗	✓	✓	✓		For mono-directional[5] Smart Charging, new grid codes[4] allow DSOs the possibility to control charging stations >4.6 kVA. Furthermore, para 14a of EnWG can be used as a justification for DSOs to procure flexibility via controllable loads (including EVs)	Yes, it is happening in projects beyond the pilot phase and it is even stimulated with SINTEG government funding program	With the Enera project in North Germany, Avacon Netz (DSO), EWE NETZ (DSO) and TenneT are establishing a local market platform along with EPEX Spot and EWE Group, to relieve grid congestions in the regional grid. The platform will be available to system operators and flexibility providers of the consortium.
 ✓	✓	✓	✓		Unclear if this is allowed as a commercial activity i.e., beyond the pilot phase. There seem to be no formal limitations for a DSO to buy flexibility services from markets[3] but no clear regulation was identified	Yes, it is happening in pilot projects	The Swedish Electromobility Centre, Uppsala University, Vattenfall AB and CEVT (China Euro Vehicle Technology AB) are running a pilot for smart EV charging to develop a model that can be used to co-ordinate with the local electricity grid.

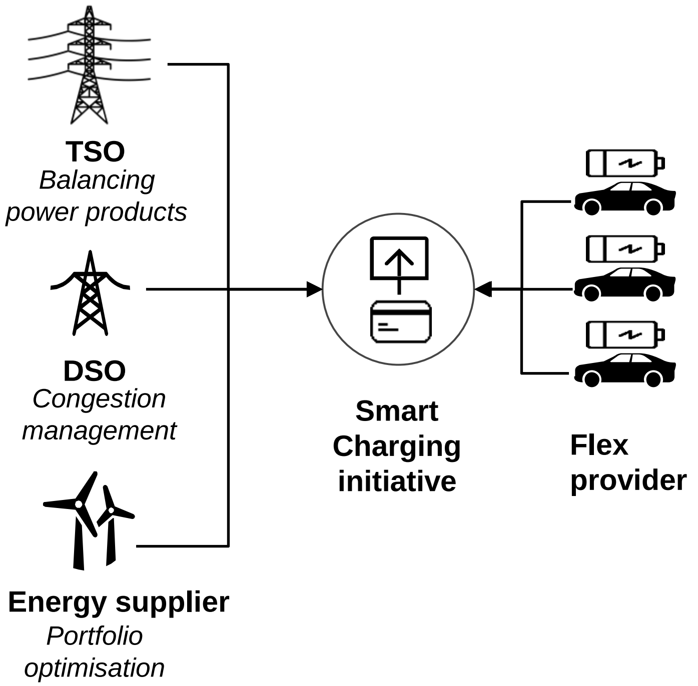
Sources: PV Magazine (2018), Alfen (2018), EPEX Spot (2018)

[1]EU Electricity Directive (2009/72/EC), Article 26.
[2]Proposal for a Directive of the European Parliament and of the Council on common rules for the internal market in electricity (recast), 11.01.2019, ST 5076 2019 INIT, 2016/0380 (COD) articles 32 & 36. This proposal is in the phase of trilogue negotiations at the moment, after which it will be submitted to plenary & subject to vote before being adopted
[3]Nordic Council of Ministers (2017). Demand side flexibility in the Nordic electricity market.
[4] VDE-AR-N 4100, to go live in April 2019; [5] Flexibility from Bi-directional charging is not covered under para 14a of EnWG because there are no defined standards yet for V2G

Lack of coordination between flex initiatives and the DSO regarding the use of flex could lead to congestion within the regional grid

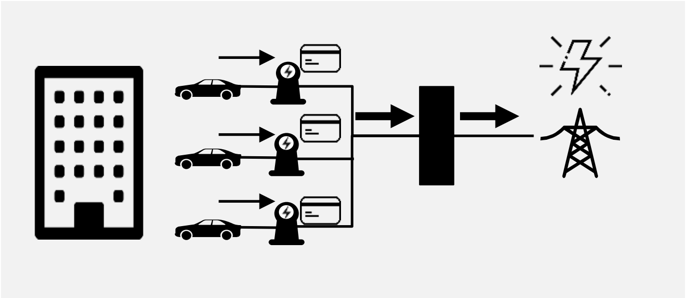
Applies across all 4 countries - **NL** **FR** **DE** **SE**

Several players along the value chain can benefit from controlling the EV or second life battery…



…but if there is no coordination with the DSO, two issues can arise

1. There is a risk of congestion at the regional grid due to strain from uncoordinated flex initiatives



An E-driver can provide flexibility services to several parties. The use of flex by non-DSO players can put pressure on the regional grid if they are not carried out in coordination with the DSO. For example - if a huge amount of positive flex[1] was offered to an energy supplier for a given time (in a specific location) in order to balance his portfolio, there is a risk that this might lead to congestion for the DSO in that area. If the DSO does not know about this beforehand, it can lead to brown outs or black outs.

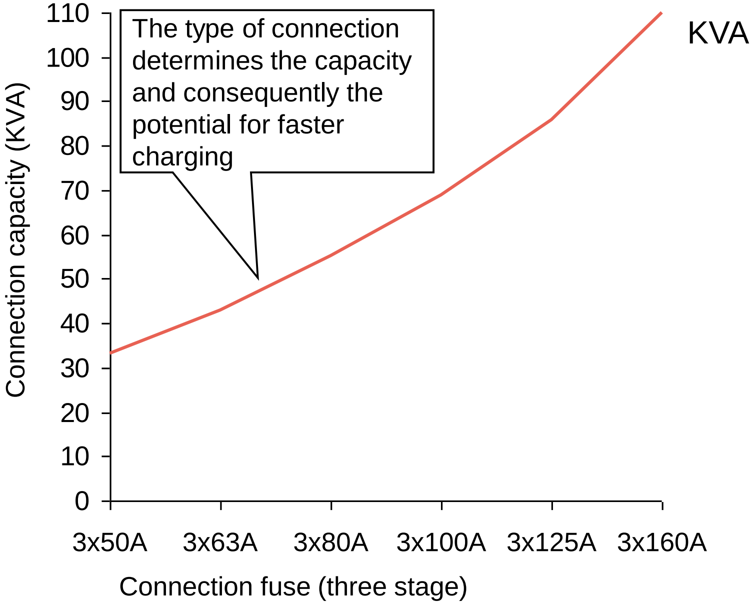
2. Furthermore (even if the DSO is informed), there is a risk that data cannot be shared in a safe & secure way because there is no central certificate authority to perform authentication today in Europe

The ISO 15118 standard (currently being adopted in Europe) provides details on the necessary information exchange between the vehicle & the charging infrastructure. However, the digital certificates that will be used for authentication need to be supported by a public key infrastructure[2] that is provided by an independent certificate authority[3] so all parties can have access to the flexibility market without any discrimination

[1]Positive flex here means the transfer of energy from grid to battery i.e., charging of a car
[2] A Public Key Infrastructure is a collection of hardware, software, personnel and operating procedures that issues and manages digital certificates that are used for securing digital communication. These certificates link public keys to people or systems. The public keys can be used to verify digital signatures that were created with their associated private keys, for authentication and for encrypting data communication.

Smart Charging initiatives that require high charging speed can be hindered by choices of CPOs to roll out public charging points with less potential for increased charging speed (1/2)

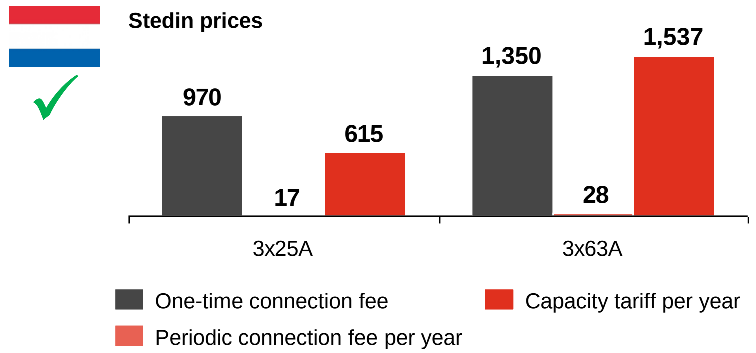
The capacity of the connection influences the possibility to apply Smart Charging



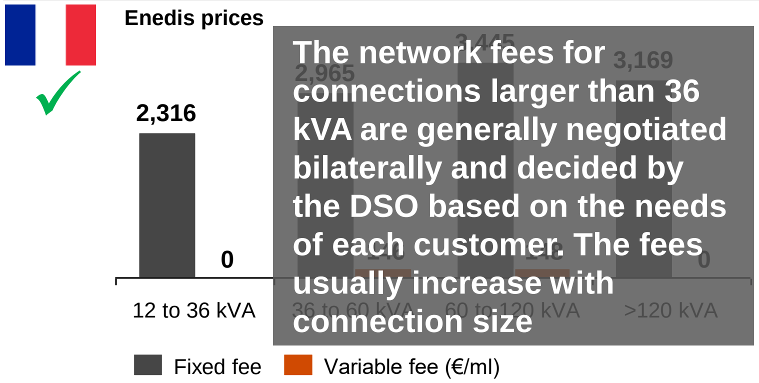
The higher the capacity of a connection, the more flexibility is generated for the deployment of the car for Smart Charging

Tariffs apply for the capacity of the connection, potentially stimulating construction of smaller connections

All tariffs in €



Higher capacity connections are much more expensive. The tariffs for the connection are determined by ACM. Because of these higher costs, mostly low-capacity connections are installed in the (semi-)public domain. This is especially relevant because price is important for winning a tender for a public charge point



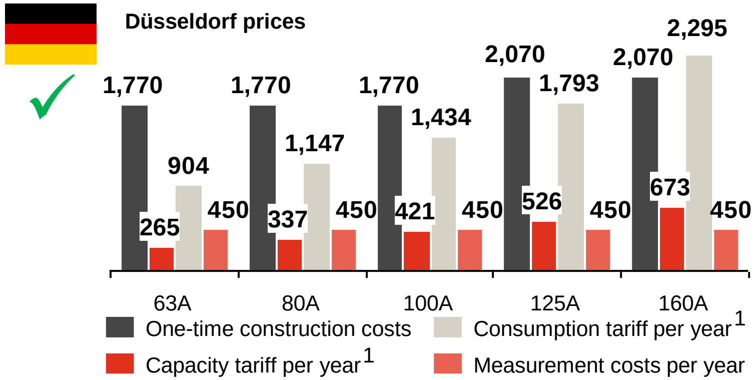
France has implemented a clause that encourages the DSO to take into account the customer's ability to shift consumption from peak to off peak periods while deciding upon the connection capacity needed for that connection[1]. This could result in lower costs for the connection point since a lower capacity connection point will be installed. However, there is no structural solution providing lower prices to higher capacity charging points (by taking into account their ability to do Smart Charging)

Sources: PwC analysis based on tariff decisions from Stedin and Enedis. [1]Clause for incorporating flexibility from connection point: PRO-RAC_03E, §15.5

Smart Charging initiatives that require high charging speed can be hindered by choices of CPOs to roll out public charging points with less potential for increased charging speed (2/2)

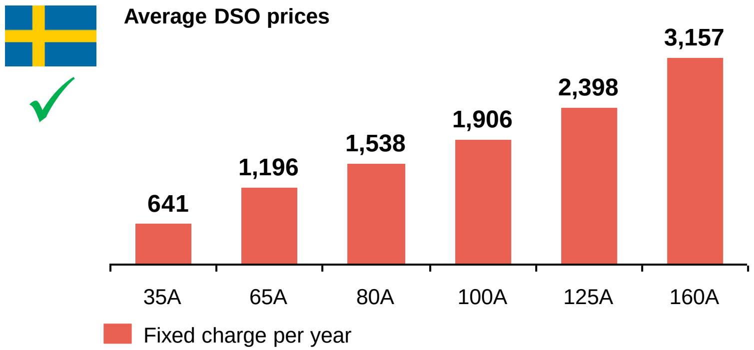
Tariffs apply for the capacity of the connection, potentially stimulating construction of smaller connections

All tariffs in €



The one-time construction costs increase slightly with higher capacity connections. Every connection pays yearly measurement costs that are fixed, and these constitute a large share of total costs for smaller connections.

In Germany, government is providing €200 million funding for the roll out of fast charging infrastructure from 22 kW upwards.



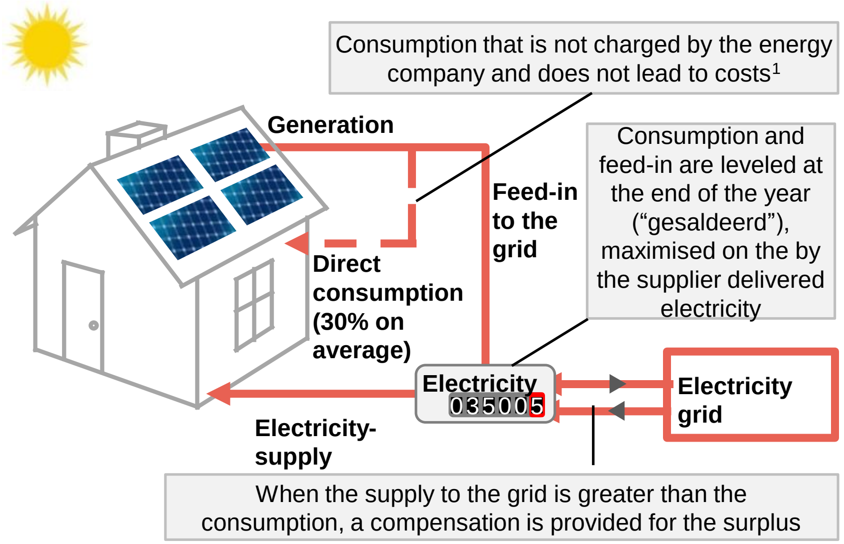
The average fixed network costs per connection increase with the size of the connection. This could negatively impact the incentive to install fast charging stations. In addition to these network costs, there are one-time connection costs that are negotiated between the grid operator and the consumer and therefore are not publicly available. To stimulate fast charging, over 8.800 charging points have been granted support of which one third are fast charging stations as part of a government funding program in place between 2015 – 2020.

Sources: PwC analysis based on Dusseldorf DSO prices, and Swedish Energy Markets Inspectorate (2017). Text: NOW GnbH (2017) and IEA.

[1]Capacity and consumption tariffs transformed to yearly fee. 1000 hours of maximum kW consumption per year assumed.

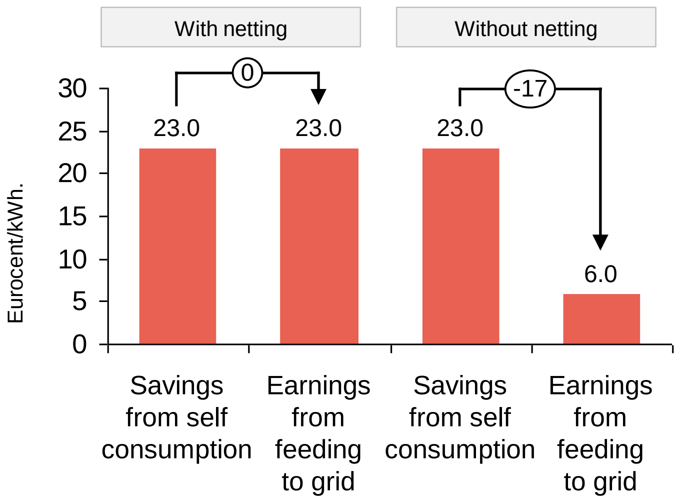
Due to net metering regulation in NL, there is a disincentive to optimise consumption behind the meter (using bi-directional Smart Charging)

Net metering leads to the use of DSO grids without additional costs for the consumer…
Illustration of the use of net-metering for a Dutch household



In Sweden, a different net metering rule applies. Grid connected systems (<100A) that feed into the grid are eligible for a tax reduction of 60 öre per kWh (~6 €cent). So, in effect there is only netting of taxes. For the supply costs, a feed-in tariff may be provided by the supplier, but this varies based on the supplier & offer. Therefore, there may be an incentive for EV/battery owners to optimize behind the meter (depending on the FiT)

…limiting the incentive to optimise behind the meter using bi-directional Smart Charging
Price difference own use and supply to the grid (for The Netherlands)



In the Netherlands, the netting rule applies to the total consumer electricity price, hence there is no difference between feeding into the grid v/s storing in a home battery and consuming at a later time. To incentivize optimization behind the meter, the earnings from/price of feeding into grid should be lower than electricity price

Beyond the meter, an E-driver may participate in Smart Charging if given additional compensation
Impact of net metering on the incentive to do Smart Charging behind and beyond the meter

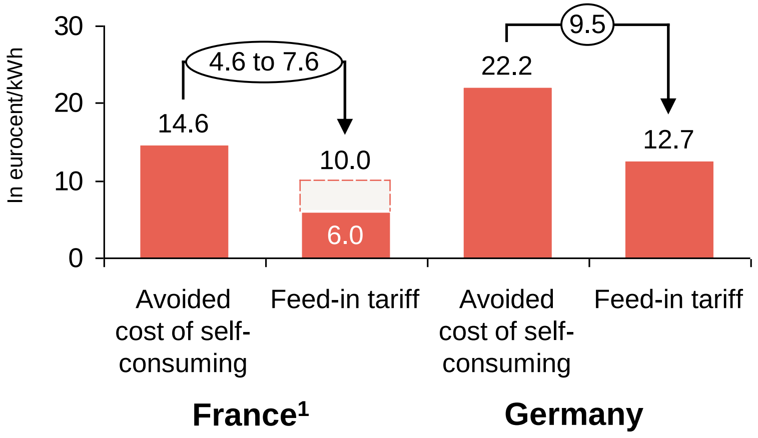
	Behind the meter	Beyond the meter
Mono-directional Smart Charging	Net metering negatively impacts the incentive to adjust speed and timing behind meter	Net metering does not impact the incentive to adjust speed and timing beyond the meter
Bi-directional Smart Charging	Vehicle2Home: Net metering does not provide an incentive to use an EV battery for storing self produced energy and using it at a later time	Vehicle2Grid: Net metering avoids the negative impact of double taxation, so when additionally compensated by a Smart Charging initiative, E-drivers would participate

- Positive impact i.e., encourages Smart Charging
- Negative impact i.e., discourages Smart Charging
- Neutral or No impact

Sources: PwC analysis, Swedish Energy Agency (2018)

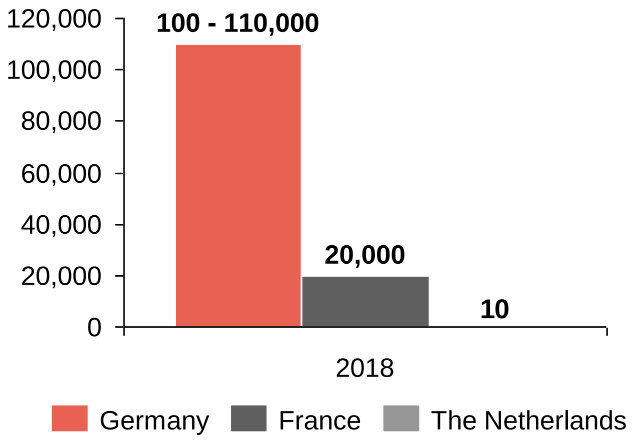
In other countries, the use of feed-in tariffs promotes optimisation of own consumption behind the meter

FiT provides an incentive to store self-produced power and consume at a later time
Price difference between own use and supply to grid



Consumers with solar PV and storage have an incentive to store the excess energy from their solar PV for later use when the feed-in tariff (FiT) they receive for supplying energy to the grid is lower than the (variable) electricity price they have to pay for consumption from the grid. In Germany, the EEG fee is exempted for self consumption in the case of small scale producers with installations <10 kW[3]. However, on self consumption >10 kW, 40% of the EEG levy is applied. In France, self consumption is exempt from the TICFE tax for facilities with a capacity lower than 1 GW

This led to an uptake of storage in DE & FR
Number of household storage facilities installed in Germany, France & The Netherlands[2]



In Germany and France, the feed-in tariff (FiT) schemes have promoted self consumption, and thus led to a higher uptake of batteries. In the Netherlands, household PV storage is barely coming off the ground because the netting rule does not provide any incentive to own batteries.

But, FiT can be beneficial for Smart Charging behind the meter, and not beyond the meter
Impact of FiT on the incentive to do Smart Charging behind and beyond the meter

	Behind the meter	Beyond the meter
Mono-directional	✓ FiT stimulates adjusting timing and speed of charging dependent on the supply from solar PV	◉ FiT does not impact the incentive to adjust speed and timing of charging battery from grid
Bi-directional charging	✓ Vehicle2Home: Since the FiT is lower than electricity price, there is an incentive to store self-produced energy for later use	◉ Vehicle2Grid: Potentially a FiT can stimulate V2G when the FiT > variable supplier price. However, often FiT does not apply to batteries

✓ Positive impact i.e., encourages Smart Charging
✗ Negative impact i.e., discourages Smart Charging
◉ Neutral or No impact

Sources France: FiT: Code de l'énergie (2016). Exemption self consumption: Article 266 quinquies C, 5, 4°, Code of the Customs. FiT Germany: EEG (2017)
[1]In France off peak and peak tariffs apply for supply, so tariffs can differ, and hence the feed-in tariff should always be lower than the tariff in order to incentivise storage behind the meter. Furthermore, the feed-in tariff ranges from 6 to 10 ct./kWh depending on the supplier. [2]Based on estimation from Eneco (2016) for NL, from the BVES (Bundesverband Energiespeicher) Germany and from Enedis (2018) for France. [3]EEG (§61a).

3.

Potential solutions to remove regulatory barriers within Europe

To address the identified barriers, both European and National level solutions should be considered

Why government intervention is needed

New roles emerging that impact a highly regulated market	• New roles are emerging that impact a highly regulated (electricity) sector. These roles need to be described in regulations in order for the new system to function properly.
Old regulation hinders innovation	• Regulations are made for the applicable situation at the time of defining the regulation. This regulation might not be suitable for new developments and even hinder innovation. • Hindering regulation can exist at EU level or national level
A market failure needs to be solved	• Without government intervention, the efficient market outcome is not reached. Certain parties could have market power which could negatively impact total welfare for consumers

Solutions can be taken at an EU or national level

EU level	• To determine the necessity of EU-regulation, two principles are evaluated[1]:
	  • **Subsidiarity**: the objectives of an action can not be sufficiently achieved by Member States and can be achieved at Union Level
	  • **Proportionality**: action at Union Level should be limited to what is necessary to achieve the set out objectives
	• This study provides potential EU solutions. However, the costs and benefits of EU intervention should be further analysed for a specific proposed solution

National level	• Currently, regulatory barriers vary between the four analysed countries as a result of differing national legislation. Some barriers do not apply in all countries, showing the importance of national regulation in addition to EU regulation • Countries that experience certain barriers can learn from other countries where this barrier does not exist

[1]Article 5 of the Treaty on European Union (TEU)

For each of the identified barriers, we also identified potential solutions (1/3)

Summary of solutions (continued on next page). Solutions are described in more detail on pages 36-39

	Regulatory barrier type	Short Description	Impact on type of SC[1]	Applicability in Member States	Description of potential solution
1a	**Double energy tax and double charging of variable grid fees**	**Double energy tax and grid fees for several (or entire) tax/grid fee component(s) while performing bi-directional Smart Charging.**	*Bi-directional*		**EU solution** • Double energy taxes are mainly a result of the lack of a definition of storage, as charging and discharging are defined as consumption and supply, respectively. The proposed definition within the Electricity Directive (recast) does not solve the problem. A structural and harmonized solution would be to implement a European tax regulation providing that bi-directional charging qualifies as storage. In that way, it should not trigger energy tax. This can be implemented via (preferably) the Energy Tax Directive. **National solution** • Storage could also be defined on a national level and made exempt from energy taxes • Alternatively, national policy could be issued to facilitate netting for charge points (netting at the charge point), or a provision that states that energy tax is only payable on the net amount of electricity (the balance) charged via a charge point.
1b	**Tax differences for public v/s private**	**Due to differences in definitions and tax regimes for public and private charge points, E-drivers may experience losses while performing bi-directional Smart Charging**	*Bi-directional*		The different taxes that apply at different types of charge points could be more harmonized, so charging is taxed at several locations in the same way. Defining the best solution will require additional research to identify which solution will be most beneficial. **EU solution** • There are various potential solutions available at a EU level (harmonisation requirement) **National solution** • At a national level, there are other potential solutions such as the Dutch example of a lower tariff for public charging stations, or definition of one tax rate for charging of electric vehicles.

✓ Barrier applies ✗ Barrier partly applies ✗ Barrier does not apply

[1]SC – Smart Charging

For each of the identified barriers, we also identified potential solutions (2/3)

Summary of solutions (continued on next page). Solutions are described in more detail on pages 36-39

	Regulatory barrier type	Short Description	Impact on type of SC[1]	Applicability in Member States	Description of potential solution
2	**Procurement of flexibility services by grid operators**	**It is unclear whether storage may be procured as a service by regional grid operators (i.e., Smart Charging may be deployed or not for flexibility purposes)**	*Bi-directional, Mono-directional*	🇳🇱 ✓ 🇫🇷 ✗ 🇩🇪 ✗ 🇸🇪 ✓	**EU solution** • The Electricity Directive of the Clean energy package mentions that Member States should incentivise DSOs to procure flexibility. Still, Member States or/and National Regulator Agencies are yet to define this in their regulatory framework, including incentives for DSOs and appropriate remuneration. **National solution** • National regulators and policy makers should provide clarity on whether DSOs can procure flexibility, and the costs incurred by DSOs to procure and deploy flex should be incorporated in the reimbursement calculation by regulators, otherwise DSOs will continue to invest in grid expansion instead • A flex market at DSO level can be introduced (following the ancillary services market model of TSOs)
3	**Lack of coordination between Smart Charging initiatives and the DSO**	**Lack of coordination between the Smart Charging initiatives and the DSO can lead to congestion within the regional grid because the DSO is unable to plan properly. Even if data is shared with the DSO, the authentication mechanism is unclear**	*Bi-directional, Mono-directional*	🇳🇱 ✓ 🇫🇷 ✓ 🇩🇪 ✓ 🇸🇪 ✓	**EU solution to coordination issue** • The prioritisation of flexibility can happen via a central flexibility market where each party (i.e., Supplier, DSO or TSO) procures flexibility based on when they need it i.e., following the country market structure & gate closures of their own markets. However, the DSO should have transparency/access to data around flexibility procurement before it is deployed, in order to plan for congestion management effectively

✓ Barrier applies ✗ Barrier partly applies ✗ Barrier does not apply

[1]SC – Smart Charging

For each of the identified barriers, we also identified potential solutions (3/3)

Summary of solutions (continued on next page). Solutions are described in more detail on pages 36-39

	Regulatory barrier type	Short Description	Impact on type of SC[1]	Applicability in Member States	Description of potential solution
4	**Grid connection costs**	**No incentive to roll-out Smart Charging infrastructure due to higher grid connection costs for higher capacities**	*Bi-directional, Mono-directional*	✓ ✓ ✓ ✓	**National solution** (more suitable than EU solution given large grid fee structure differences) • The grid costs could for a larger part be based on the actual consumption instead of the capacity of the connection. • Change tendering requirements to reward parties that install high capacity connections in order to offer Smart Charging solutions. • Grid costs could also be more reflective of the grid stabilizing services that a facility or device provides. In France, there is a clause that states that devices and facilities that allow shifting energy consumption from peak to off-peak periods (in order to limit peak power consumption), have to be taken into account for the choice of the appropriate capacity connection. However, it is unclear how exactly this clause is implemented i.e., there is no structural solution stating that the prices should be lowered for such connection points.
5	**Netting rule**	**Missing incentive (due to the netting rule) to optimise own consumption behind the meter using the battery of an electric vehicle**	*Bi-directional, Mono-directional*	✓ ✗ ✗ ✗	**National solution** To incentivize optimizing behind the meter, the benefit from storing self-produced electricity for later use should be higher than the benefit from netting. There are several potential solutions to this issue: (1) feed-in tariff scheme; (2) Only netting the tax component.

✓ Barrier applies ✗ Barrier partly applies ✗ Barrier does not apply

[1]SC – Smart Charging

To avoid the double energy tax issue, there should be a clear definition for "storage" as a fourth pillar at an EU level and/or national regulators can introduce the Swedish solution of refunding any double tax

Barrier 1: Double taxing and charging of variable grid fees - is the result of the definition of charging (consumption) and discharging (supply) when doing bi-directional charging

EU level

Revised EU directive can help to avoid double variable grid costs

- Article 15, point 5 (b) of the Electricity Directive (Recast) states that "Member states should ensure active customers that own an energy storage facility are not subject to any double charges, including network charges, for stored electricity remaining within their premises or when providing flexibility services to system operators." This still needs to be approved by EU Parliament.

To avoid double taxation EU tax legislation needs to be changed…

- A structural and harmonized solution across Member States is desired. For example, implement European tax regulation providing that bi-directional charging does not qualify as a supply for tax purposes but as a storage service instead. In that way, it should not trigger energy tax. This can be implemented in (preferably) the Energy Tax Directive.

Na-tional level

… but needs to be implemented in local legislation

- The Electricity Directive (Recast) needs to be implemented into national legislation.
- In the meanwhile, in the countries that have variable grid costs that are potentially double charged, legislation can be developed to avoid double grids costs.

… in the meanwhile measures at a national level can be implemented

- Publishing policy on a national level is an easier way to implement to change the definition of storage. This policy should indicate that no (taxable) supply takes place for energy tax purposes if an EV is used as storage capacity (bi-directional charging).
- Alternatively, policy could be issued to facilitate netting for charge points (netting at the charge point) or to define that energy tax is only payable on the net amount of electricity (the balance) charged via a charge point.

Swedish solution to double taxing

Sweden implemented a solution[1] to double taxing:

- For tax liable entities, electricity that is fed into the grid from the battery will be tax exempt.
- Non-tax liable entities can potentially receive a refund on the taxes paid.

This results in a situation where, in the end, the "same" electricity will only be taxed once.

[1] Lag (1994:1776) om skatt på energy, chapter 11

DSOs should be more fit for Smart Charging. Firstly, regulators should be clear on whether DSOs can procure flex. Secondly, DSOs should adjust their grid price structures to accommodate flex

Barrier 2: Procurement of flexibility services by grid operators

Flexibility can help to limit DSO grid investments. Regulators should be clear about whether DSOs can procure flexibility

EU level

- The Clean Energy Package 4, entering into force in 2020, describes that DSOs are not allowed to own or operate storage activities, but member states are encouraged to promote the use of flexibility services by DSOs for grid related activities.[1]
- Still, Member States or/and National Regulator Agencies are yet to define the exact regulatory framework, including incentives for DSOs and appropriate remuneration mechanisms. The EU can provide some guidance on this for national regulators to implement.

National level

- As soon as the Clean Energy Package comes into force, national regulators and policy makers should define a regulatory framework.
- Until that time, they should provide clarity on whether DSOs can procure flexibility, and the costs incurred by DSOs to procure and deploy flex should be incorporated in the reimbursement calculation by regulators, otherwise DSOs will continue to invest in grid expansion instead
- A market for grid related services at a DSO level can be introduced (following the ancillary services market model of TSOs), or incentives can be given through grid tariffs

Barrier 4: Grid connection costs

The societal business case should be studied of grid connection costs better reflecting the grid stabilizing services of connected facilities

National level

Solution 1: Determine grid connection tariff on the basis of actual consumption

- The grid costs could for a larger part be based on the actual consumption (in kWh) instead of the capacity of the connection (in A/KVA). This makes costs reflective of the actual use of the grid.
- This measure reduces the barrier to install a high capacity connection that is needed to charge faster.

Solution 2: Reduced connection tariff when used for stabilizing services

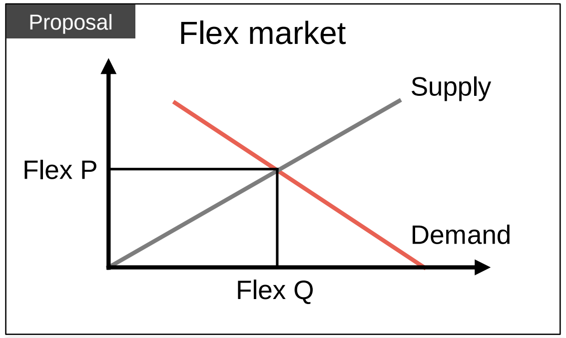
- Grid connection costs can be re-calculated based on the grid stabilizing services that a facility or device provides. This requires regulators to define new calculation models that move away from the grid investment based reimbursements i.e., investing in copper should be less attractive. In France, the network connection tariff codes states that devices and facilities that allow shifting energy consumption from peak to off-peak periods have to be taken into account for the choice of the appropriate capacity connection.[2] However, there is no guidance on implementation.

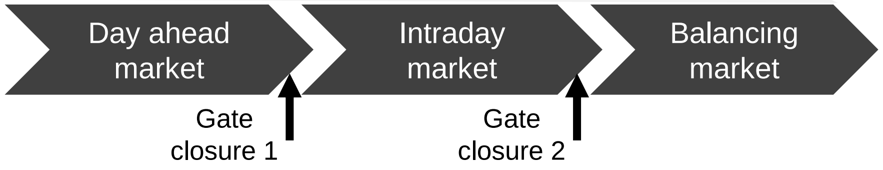
[1]Proposal for a Directive of the European Parliament and of the Council on common rules for the internal market in electricity (recast), 11.01.2019, ST 5076 2019 INIT, 2016/0380 (COD) article 36. This proposal is in the phase of trilogue negotiations at the moment, after which it will be submitted to plenary & subject to vote before being adopted. [2]Barème de raccordement ENEDIS (PRO-RAC_03E, §15)

A flex market could be used to automatically arrange for prioritisation and avoid congestions within the regional grid

Barrier 3: Lack of prioritization of Smart Charging initiatives

Within a liberalised market like the EU, the setting up of a **flexibility market** seems to be the best option in order to let the market **arrange for prioritisation**. Such a market needs to be aligned with the local Member State market structure and gate closures. DSOs will be able to avoid congestion in the regional grid through prior planning, if the **flex market data is continuously shared with the DSO**.





Primary flex buyers

Suppliers/ BRPs	DSOs, Suppliers/ BRPs	TSO

Principles for flex market

- In the intraday flex market, DSO should get priority over Suppliers/BRPs
- The DSO should continuously be informed regarding the procured and (to be) deployed flexibility after each gate closure
- Within the last one hour, i.e. the balancing market, the TSO can procure flex for system balancing purposes
- Ownership of the flex market can depend on the market structure/level of liberalisation within the member state

Data sharing and certificate signing for authentication and security should be secure

Cars and charging stations share data when a car is charging (amongst others about the state of charge of a car, the time of departure, type of car etc.). This data helps in the realization of Smart Charging initiatives. Today, the ISO 15118 standard (being adopted in Europe) gives guidance on what information should flow between different parts of the chain, but there is no clarity around which authority should provide the digital certificates required for securing & authenticating the transmitted data.

In order to facilitate data sharing (for coordination purposes) between the DSO and Smart Charging initiatives, there is a need for a central and independent certification authority to setup a public key infrastructure[1].

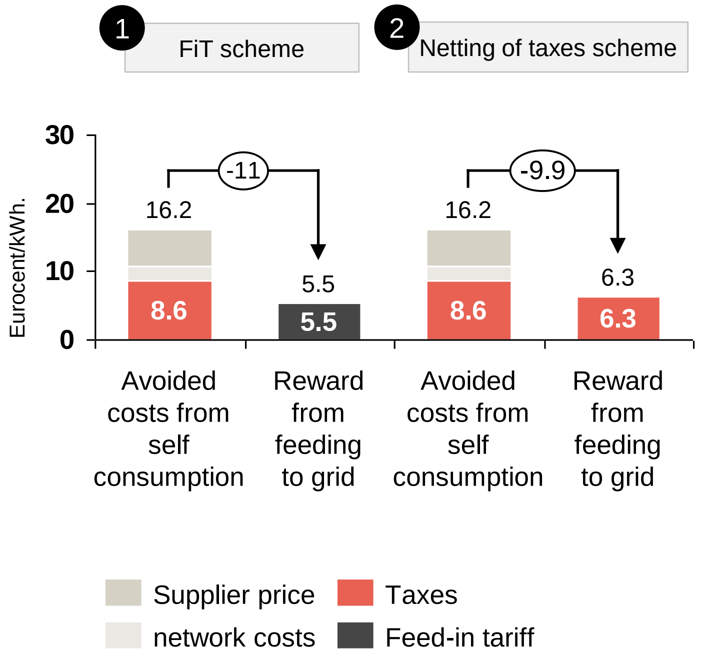
[1]Exploring the Public Key Infrastructure (PKI) for ISO 15118 in the charging ecosystem (ElaadNL, October 2018)

Several potential solutions can give an incentive to optimize energy use behind the meter and solve the issue caused by net metering

Barrier 5: Net metering rule

Due to net metering, there is no incentive to store behind the meter…

Illustration of solution with Sweden as example



To solve this, the benefit from netting should be lower than the benefit from self-consumption which can be achieved with a feed-in tariff or by only netting the taxes

There are several ways to lower the netting benefit:

1. The feed-in tariff scheme as applicable in France and Germany would result in avoided costs from self-consumption of 16.2 ct/kWh in this Swedish example and gives a (hypothetical) compensation from feeding into the grid of 5.5 ct/kWh. This results in an **incentive to store self-produced electricity behind the meter of 11 ct/kWh**. However, the feed-in tariff scheme discourages joining Smart Charging initiatives beyond the meter. This is in part due to double taxes that apply every time a car is charged.

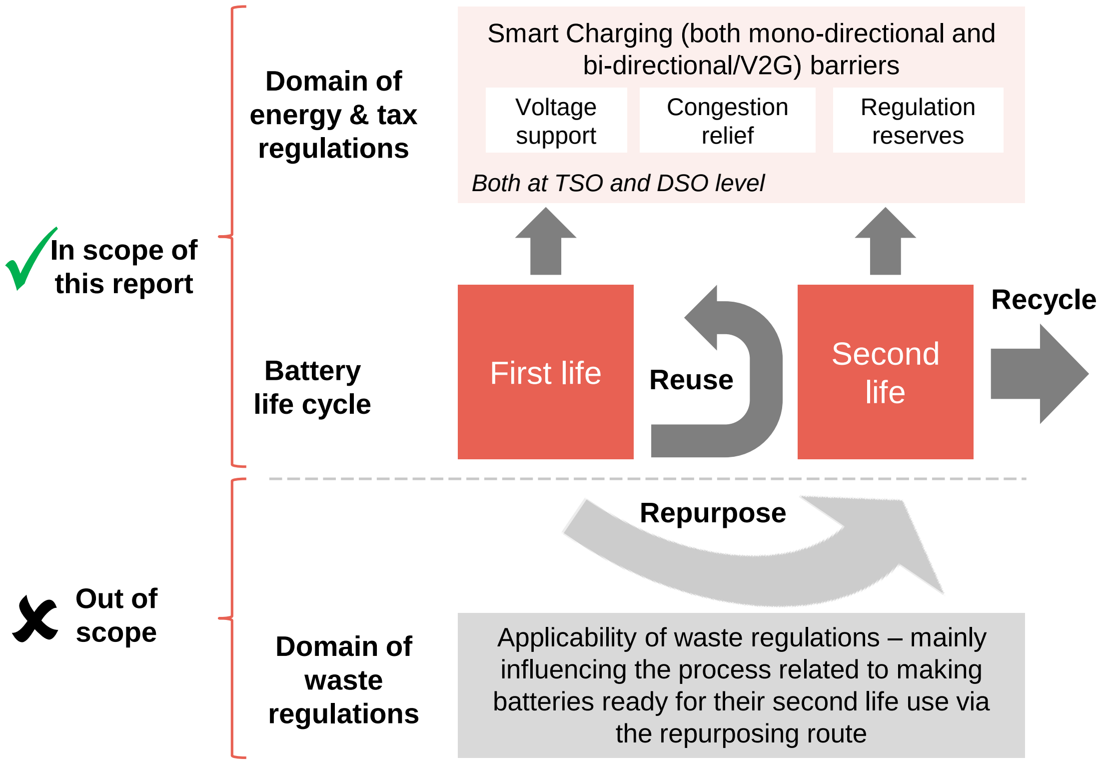
2. Another option is to refund or reduce the taxes on the amount of electricity that is fed into the grid. This means that a household with solar PV receives a tax reduction on the amount of kWh that is fed into the grid, as long as the amount fed into the grid is not larger than the consumption from the grid. This solution is based on the net metering rule of Sweden, wherein a tax reduction of 6.3 ct/kWh exists[1] and any additional feed-in tariffs are not regulated. Therefore, Swedish households with a solar PV have **an incentive to store self-produced electricity for later use.** This solution can be borrowed for implementation at a national level. Note that this solution may not work if the market based feed-in tariff (provided by the supplier) is higher than the supply costs, thus in effect equalizing the avoided costs from self consumption and reward from feeding into grid.

[1]RES legal (2019).

A1.

Scope of the study

In this study we focus regulatory barriers for first-life use of car batteries in EVs as well as second-life use in stationary storage



Scope of the report

Recently, an Innovation Deal (“From E-mobility to recycling: the virtuous loop of electric vehicle") was signed between the European Commission and various market parties, with the goal of identifying whether existing legal/regulatory provisions at EU level and their translation within national or regional law “hamper the use of batteries for second-life applications or otherwise discriminate any technology that might be necessary for second-life applications”.

In the context of this innovation deal, PwC was asked to **research and report institutional barriers and solutions for Smart Charging and Second life storage use of electric vehicles' batteries at a European level**. In order to ensure sufficient representation of diversity in electricity market structures and EV market maturity, **France, Germany, Netherlands and Sweden** are chosen as case study examples.

However, in this study, **waste related regulations are kept out of scope**. Only energy and tax related regulations were explored. It was found that these regulations cover both first and second life batteries since they are applicable for storage in general.

A2.

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A3.

Interviewees

Interviews were conducted with stakeholders across the value chain in Germany, France, Netherlands and Sweden

Sl. No.	Country	Organization
1	France	EVBox
2	France	ENEDIS
3	France	EDF
4	France	Sodetrel
5	France	Renault
6	France	Nuvve
7	Germany	BVES (Energy storage assc.)
8	Germany	Eon & E-E-consult
9	Germany	Mobility House
10	Germany	Getec Energie
11	Germany	Audi
12	Germany	Former CEO Mobility house

Sl. No.	Country	Organization
13	Germany	Eon
14	Netherlands	Lomboxnet
15	Netherlands	Anonymized upon request
16	Netherlands	TenneT
17	Netherlands	Stedin
18	Netherlands	Nissan
19	Netherlands	Ministry of I&W*
20	Europe	European court of auditors
21	Europe	Umicore*
22	Sweden	Volvo Bus Corporation
23	Sweden	Vattenfall

*For Umicore and Ministry of I&W, formal interviews were not conducted. The parties shared their position via legal documents by mail.

A4.

Country analyses

In the Netherlands, almost all of the regulatory barriers are applicable

Regulatory barrier type	Impact on type of SC[1]	Applies?	Dutch situation	Relevant regulation
1a **Double energy tax and double charging of variable grid fees**	*Bi-directional*	✗	• There is a potential to be double taxed for 15.63 ct/kWh[2] • Double taxing does not apply with net metering, which is the case for small connections (<3 x 80A)[3].	• The Environmental Taxes Act (Wbm) and Turnover Tax Act 1968, since the concept of supply in this act is consistent with the Wbm.
1b **Tax differences for public v/s private**	*Bi-directional*	✓	• Different tax rates apply depending on the ownership and/or location of the charging station.	• Article 50 of the Environmental Taxes Act for regulation around private SC. For public SC article 47 para 1f of the Environmental Taxes Act applies.
2 **Procurement of flexibility services by grid operators**	*Bi-directional, Mono-directional*	✓	• Owning and operating is not allowed (Wet Vet). Unclear if it is allowed to purchase flexibility services due to the unbundling requirements. DSOs can only apply congestion management temporarily until grid expansion is realised.	• The relevant regulation for temporarily congestion management until grid expansion can be found in Netcode Electricity, Article 9.4.3
3 **Lack of coordination of Smart Charging initiatives**	*Bi-directional, Mono-directional*	✓	• Several parties can experience problems from the lack of coordination of flexibility. • DSOs might experience congestion due to uncoordinated flex initiatives on its grid. • CPOs and Smart Charging initiatives have conflicting business models and can be affected by rules around the use of flexibility.	• No regulation yet
4 **Grid connection costs**	*Bi-directional, Mono-directional*	✓	• Higher capacity connections have higher one time connection fees, annual capacity tariffs and annual periodic connection fees. This could hamper the installation of high capacity fast charging stations.	• There are 7 DSOs in Netherlands (with three main ones), but the distribution tariffs are determined by the Autoriteit Consument & Markt (ACM) – 'Incentive regulation of the gas and electricity networks in the Netherlands, 2017'
5 **Netting rule**	*Bi-directional, Mono-directional*	✓	• Behind the meter, both mono- and bi-directional Smart Charging is negatively impacted by net metering. Beyond the meter, the netting rule does not impact mono-directional Smart Charging , and positively impacts bi-directional charging.	• Storage behind the meter and the netting benefit relates to Section 50(2) of the Environmental Taxation Act (Wbm), the benefits of self-generated electricity exemption is provided for in Section 50(6) Wbm.

[1]SC – Smart Charging [2]The total electricity taxes in the Netherlands are in fact lower, due to fixed tax reduction of €257,54 per year for households.[3]It is unclear if net metering also applies for public connections

In Germany, half of the regulatory barriers are applicable

	Regulatory barrier type	Impact on type of SC[1]	Applies?	German situation	Relevant regulation
1a	**Double energy tax and double charging of variable grid fees**	*Bi-directional*	✓	• Storage that is directly and only connected to the grid without the potential of consuming the energy (like is the case with EVs), is exempt from many taxes and grid fees. • There is a potential to be charged twice for 15,97 euro ct/kWh	• All taxes can be charged double as described in the Electricity Tax Act (Stromsteuergesetz), there are exemptions possible from paying the EEG tax described in EEG §61.
1b	**Tax differences for public v/s private**	*Bi-directional*	✗	• Taxes do not vary to a large extent based on the location and usage of the charge point.	• No relevant regulation
2	**Procurement of flexibility services by grid operators**	*Bi-directional, Mono-directional*	✗	• For mono-directional Smart Charging, new grid codes allow DSOs the possibility to control charging stations. Furthermore, para 14a of EnWG says that DSOs can procure flexibility via controllable loads (including Evs) and provide reduced network charges in return	• The future grid code for low voltage called VDE-AR-N 4100 is supposed to go life in April 2019 • § 14a of the EnWG regulation
3	**Lack of coordination between Smart Charging initiatives and the DSO**	*Bi-directional, Mono-directional*	✓	• Several parties can experience problems from the lack of coordination of flexibility. • DSOs might experience congestion due to uncoordinated flex initiatives on its grid. • Several players in the Smart Charging value chain can be affected by the lack of standards for sharing Smart Charging data in a secure way.	• No regulation yet
4	**Grid connection costs**	*Bi-directional, Mono-directional*	✓	• Higher capacity connections have higher one time network costs, capacity tariffs and consumption tariff for connecting to the grid than lower capacity connections. This could hamper the installation of high capacity fast charging stations.	• Germany has 879 DSO's that determine their own connection fees. The network fees are also dependent on the size of the connection and there can be a discount for offering flexibility.
5	**Netting rule**	*Bi-directional, Mono-directional*	✗	• Net metering is not applicable in Germany. • Germany has a feed-in tariff scheme which incentivizes households/ EV owners to store self produced electricity behind the meter for self consumption at a later time. But, consumers are made to pay 40% of the grid fee even for self consumption. This effects the business case of EV owners negatively.	• Details described in the Renewable Energy Sources Act (EEG). The duty to pay the EEG and eventual reasons for it to be reduced is given in §61 EEG

[1]SC – Smart Charging

In France, half of the regulatory barriers are applicable

	Regulatory barrier type	Impact on type of SC[1]	Applies ?	French situation	Relevant regulation
1a	**Double energy tax and double charging of variable grid fees**	*Bi-directional*	✓	• There is no clear definition of storage, therefore it is seen as both consumption and production. • All taxes are paid for consumption, therefore taxes could be charged double for every charging session.	• TICFE : Article 266 quinquies C of the Customs Code, TCCFE : L2333-2 & 5 and L3333-2 & 3-3 of the general code of Local Authorities, VAT : Law n°2004-803 of August 9,2004). • The circular of 09/11/2018 on the Internal Tax on Final Consumption of Electricity (TICFE).
1b	**Tax differences for public v/s private**	*Bi-directional*	✗	• Taxes do not vary to a large extent based on the location and usage of the charge point. The energy intensive industries do have some tax exemptions in these countries that could lead to lower taxes for charging at these companies	• Article 43 of the finance rectificative law of 2005 refers to the entire consumption of an energy-intensive firm, therefore there is no reason for the electricity use for EV charging to be treated differently.
2	**Procurement of flexibility services by grid operators**	*Bi-directional, Mono-directional*	✗	• The System Services (Délibération de la Commission de régulation de l'énergie, 2014 portant) are well defined on TSO level, but not on DSO level. • However, an experimental project exists for the DSO. Article 199 of the Energy transition Law 2015 (to end in 2019), provides clarity that it is allowed on an experimental basis for four years. Consultations for renewal have started.	• For TSO - Delibération de la Commission de régulation de l'énergie, 2014 portant • DSO – Article 199 of the Energy transition Law 2015 (to end in 2019)
3	**Lack of coordination between Smart Charging initiatives and the DSO**	*Bi-directional, Mono-directional*	✓	• Several parties can experience problems from the lack of coordination of flexibility. • DSOs might experience congestion due to uncoordinated flex initiatives on its grid. • Several players in the Smart Charging value chain can be affected by the lack of standards for sharing Smart Charging data in a secure way.	• Decret of the CRE 12-01-2017 and Arrêté 19-07-2018 specify that CPO needs systems for load management and that the market should be open for all possible evolutions around ownership of EV flex. But, there is no regulation providing clarity on prioritization in the flex market
4	**Grid connection costs**	*Bi-directional, Mono-directional*	✓	• No particular reductions are provided for higher capacity connections (by taking into account the ability to provide Smart Charging solutions).	• Networks connection tariffs published by Enedis, which is the largest DSO in France (95% of territory) and approved by the French regulator (CRE).
5	**Netting rule**	*Bi-directional, Mono-directional*	✗	• There is no netting rule in France • The optimisation of own-consumption is beneficial as the feed-in tariff is between 6ct/kWh and 10ct/kWh, while the consumption from the grid is at 15 ct/kWh. • Self consumption is exempt from taxes when the electricity is fully self-consumed if the annual power production is <240 GWh. When the electricity is partly consumed, the installation should be <1 GW capacity for the tax exemption.	• Article L315 du code de l'énergie • Délibération de la CRE du 17 novembre 2016 • Arrêtés suivants sur le TURPE

[1]SC – Smart Charging

In Sweden, half of the regulatory barriers are applicable

Regulatory barrier type	Impact on type of SC[1]	Applies?	Swedish situation	Relevant regulation
1a **Double energy tax and double charging of variable grid fees**	*Bi-directional*	✘	• In order to avoid double taxation of electricity that could occur when batteries are charged with electricity from the grid, Sweden has from the first of January 2019 implemented a solution where (1) electricity fed into the grid from the battery will be tax exempt for tax liable entities and (2) for non-tax liable entities a refund is available.	• Solution to double taxing in (Lag (1994:1776) om skatt på energy, chapter 11)
1b **Tax differences for public v/s private**	*Bi-directional*	✘	• Taxes do not vary to a large extent based on the location and usage of the charge point. Taxes vary between the North and South, but these are historically driven locational differences which do not necessarily complicate the double taxing issue.	• No specific regulation
2 **Procurement of flexibility services by grid operators**	*Bi-directional, Mono-directional*	✓	• Unclear if this is allowed as a commercial activity i.e., beyond the pilot phase. There seem to be no formal limitations for a DSO to buy flexibility services from organised markets	• No specific regulation
3 **Lack of coordination between Smart Charging initiatives and the DSO**	*Bi-directional, Mono-directional*	✓	• Several parties can experience problems from the lack of coordination of flexibility. • DSOs might experience congestion due to uncoordinated flex initiatives on its grid. • Several players in the Smart Charging value chain can be affected by the lack of standards for sharing Smart Charging data in a secure way.	• No regulation yet
4 **Grid connection costs**	*Bi-directional, Mono-directional*	✓	• There are around 170 DSOs in Sweden that can set their own prices subject to the rules and the revenue cap set by the Swedish Energy Market Inspectorate (Ei). • Costs of higher capacity connections are on average higher than low capacity connections. • There are construction costs negotiated between the grid operator and consumer and therefore not publicly available	• Role of regulator to ensure reasonable and non-discriminatory tariffs: Electricity Act (1997:857) 4 kap. 1§ • Regulation of network tariffs: Swedish Energy Markets Inspectorate, ”Bättre och tydligare regleringar av elnätsföretagens intäktsramar”, Ei R2014:09, 2014
5 **Netting rule**	*Bi-directional, Mono-directional*	✘	• Grid connected systems (<100A) that feed into the grid are eligible for a tax reduction of 60 öre per kWh (~6 €cent). For the supply costs, a feed-in tariff may be provided by the supplier. Therefore, there may be an incentive for EV/battery owners to optimize behind the meter (depending on the FiT)	• Chapter 67 §§ 30, 31 Act No. 1999:1229

[1]SC – Smart Charging

A5.

Assumptions

The scenarios developed for first and second life battery capacities are based on the following set of assumptions

Assumptions first life projections

- The projection is based on two assumptions:
    - The market share of Europe in the total EV fleet remains constant between 2017 and 2050. This is a market share of ~25%.
    - To determine the available battery capacity as flexibility, a Nissan EV battery (30 KWh) is assumed.
    - Furthermore, it is assumed that it can be used for Smart Charging 40% of the time, since it's primary purpose is mobility. The estimation is based on experiences from LomboXnet pilot projects –
        - Private cars are parked 90% of the time
        - Shared cars are parked 70% of the time
        - All cars are available for Smart Charging 50% of the time
        - Estimation: (0,9*0,5 + 0,7*0,5)/2 = 40%

Assumptions second life projections

- The projection consists of three scenario's, which are different in terms:
    - The percentage of EV batteries that are sold again via the repurposing route for second life use (A1).
    - The percentage of an EVs battery capacity that can still be used throughout the second life use (A2).
- Furthermore, it is assumed that:
    - The average full battery capacity in first life is 30 kWh. Therefore, using the assumption of 50% for remaining capacity, battery capacity in second life is 15 KWh.
    - The average lifespan of a second life battery is 10 years
    - The battery's capacity throughout it's second life remains constant

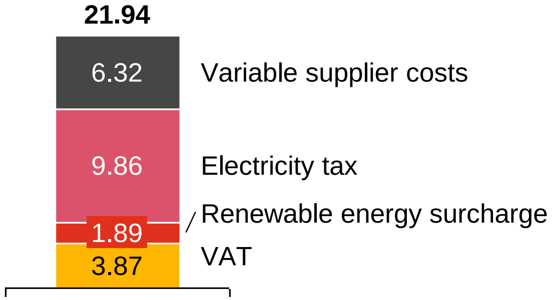
Scenario	A1	A2
Lower range	10%	50%
Medium range	30%	50%
High range	50%	50%

Example for lower range scenario: 10% of the batteries of electric vehicles sold in 2020 are repurposed in 2030. The batteries that are repurposed each can be used at 50% of their original capacity: 15 kWh. They stay in the market from 2031 to 2040. In 2041, these batteries are no longer used and do not contribute any capacity to either the first or second life market.

Household electricity price breakdown in more detail

Netherlands

Variable electricity costs (€ ct/kWh) 2019



Fixed costs and tax reduction

1. Network capacity costs: €208,60 per year[1]
2. Tax reduction: - €257,54 per year

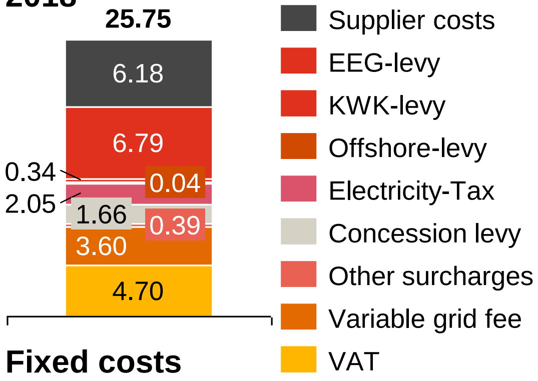
Assumptions:

1. Average household with yearly consumption of 3000 kWh
2. Connections ≤ 3 x 25A

Sources:
Taxes and tax reduction: Belastingdienst 2019
Supplier prices: Essent 2019
Network costs: Liander 2019

Germany

Variable electricity costs (€ ct/kWh) 2018



Fixed costs

1. Grid charges: in total approximately 7,27 €ct/kWh paid annually, including variable costs

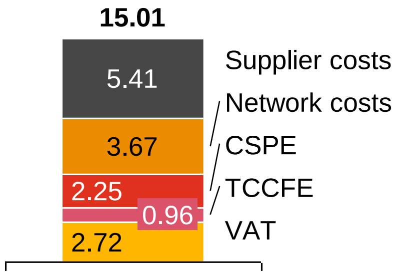
Assumptions:

1. Users >2.500 and <5.000 kWh per year, these ranges can differ per energy supplier
2. Average concession levy, which in fact depends on the size of the town
3. Variable grid fees from Düsseldorf example

Source: BDEW 2018 via Cleanenergywire.org
Network costs: Netzgesellschaft Dusseldorf (2019) (Arbeitspreis)

France

Variable electricity costs (€ ct/kWh) 2018



Fixed costs

1. CTA tax: approximately 0,8% of the total energy bill of a household
2. Network costs power share: €4,80/KVA.

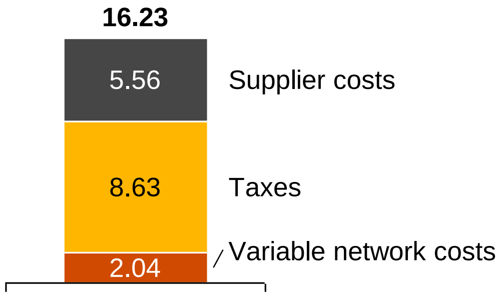
Assumptions:

1. Average household with capacity 6 KVA, regulated EDF tariffs.
2. 11 MWh annual consumption with annual electricity costs of €1800 incl. all taxes
3. Variable network tariff without time differentiation – short time use

Source: taxes: selectra.info (2018)
Network costs: TURPE. CRE (2016)

Sweden

Variable electricity costs (€ ct/kWh) 2018



The above breakdown is an estimation based on an assessment of the Swedish Energy Market Directorate. Prices vary widely between regions and energy suppliers and are often negotiate between consumer and supplier.

For a small house with a 25A connection and a yearly consumption of 20.000 kWh (which is average for Sweden), 59% of network costs were fixed in 2015. The remaining part depends on consumption per kWh.

Sources: EI (2018) & Nordic Energy Regulators (2015)

A6.

Long list of barriers

Long list of potential barriers for Smart Charging of EVs and second life use of EV batteries (1/2)

NON-EXHAUSTIVE

Regulatory barrier type	Short Description	Impact on type of SC[1]	Impact on Smart Charging along the value chain
Metering requirements	To facilitate the correct pricing of Smart Charging from the energy supplier to the CPO, a compatible meter is needed. The current measuring possibilities between the car and the charge point are not accepted for the pricing in the electricity markets. Therefore, either more meters should be allowed, or the existing compatible meters should be implemented in the charge points and EVs	*Mono-directional, bi-directional*	The calibration laws have large constraints/ barriers for Smart Charging or general charging.
Harmonization pre-qualification requirements	The prequalification requirements for bids on the reserve market differ per European country. If a Smart Charging initiative or (second life) storage facility wants to provide capacity to the reserve markets, it has to comply to the prequalification rules of both the country where it is located and the country that buys the storage. Therefore, the differing prequalification requirements make it hard to provide reserve capacity with Smart Charging or small scale batteries (who are already treated unfairly because they are considered the same as large scale producers).	*Mono-directional, bi-directional*	Cross-border trading of flexibility (as part of a Smart Charging or second life batteries initiative) is discouraged because of high administrative costs incurred while trying to comply with multiple prequalification requirement schemes
VAT obligation	It is currently not clear whether an e-driver that supplies energy to the grid needs to pay VAT. The current definitions of 'producer' and 'consumer' do not apply to Smart Charging.	*Bi-directional*	If e-drivers are considered VAT taxable entities, then this might discourage E-drivers to do bi-directional Smart Charging. In this case a change in regulation could only be established by changing the EU VAT guidelines.
DSO compensation	At the moment there is no financial incentive for DSOs to use Smart Charging for congestion management. It is possible to make bilateral agreements, but there is no universal standard. Recently, the Universal Smart Energy Framework (USEF) is developed, but this is not an official standard yet and is only applied in pilot projects. A standard would make this process more efficient.	*Mono-directional, bi-directional*	In most grids, there is no congestion yet. Without a compensation, Smart Charging cannot be used efficiently to avoid congestion in regional grids.

Long list of potential barriers for Smart Charging of EVs and second life use of EV batteries (2/2)

NON-EXHAUSTIVE

Regulatory barrier type	Short Description	Impact on type of SC[1]	Impact on Smart Charging along the value chain
Unit certification	A unit certification of individual EV's is needed for every vehicle and every charging point that is part of a frequency reserve program to qualify for reserve markets.	*Mono-directional, bi-directional*	Smart Charging initiatives have to qualify each and every car in their pool if they wish to join a frequency reserve program. This is an administrative burden that discourages participation.
Potential energy supplier to do Smart Charging	A Smart Charging initiative needs to be connected to an energy supplier. If an e-driver joins a Smart Charging initiative of another supplier than the one that supplies a public charge point, he is not able to do Smart Charging at that charge point. Currently, it is not possible to have a virtual supplier which the e-driver can take to every charge point or to switch suppliers at a public charge point.	*Mono-directional, bi-directional*	If e-drivers cannot do Smart Charging at every charge point, they may be discouraged to do Smart Charging because of the additional effort to find specific charge points.
Standard user profiles	Program managers base their program on standard user profiles. However, whether one neighbourhood has many households with electric vehicles and another neighbourhood has none makes a big difference for the program.	*Mono-directional, bi-directional*	If a program manager would be able to make customized user profiles, then the electricity demand can be much better predicted. This could result in less need for grid reinforcements by the grid operator and therefore reduce costs.

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