Home EV charging needs smart charge points

Market insight on residential EV chargers and Energy Flexibility - May 2020

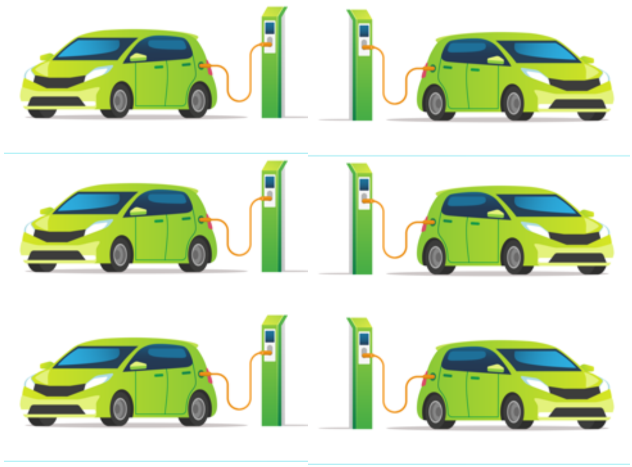
DELTA Energy & Environment

FLEXIBLEPOWER ALLIANCE NETWORK

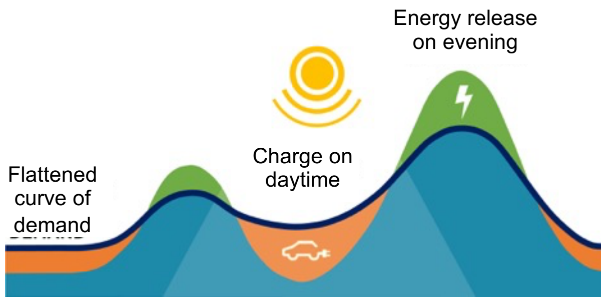
Contents

Goal of research

Evaluate residential Charging Stations current state of affairs in Energy Flexibility .



The EV revolution drives the growth in EV Charge Points in residential space



We risk to congest the enery system if we don't prepare for demand response services

Possibility of smart charging

We need insight developments in technologies and brands of CP's to prepare for the future

Executive Summary 1/2

Total installed base up and thru 2018 (residential)

34% — **~41k units (152 MW)**
NOT Connected EV Chargers

39% — **32k (117 MW)**
Remote monitoring Capabilities only

27% — **47k (175 MW)**
Remote Control Capabilities

~120k units (444 MW)
Total installed base of domestic EV chargers

At the end of 2018, the total installed base of EV chargers in the Netherlands was about 173,000 units, of which **120,000 (70%) is residential chargers.** This is equivalent to ~**444 MW** of capacity. The installed base has 4 main brands: Bosch, New Motion, EVBox and Chargepoint. However, we are seeing more automotive OEM's moving into the market to sell chargers alongside their EVs.

With 66%, connected chargers are already the majority. Yet, most of them are only suitable for monitoring; **only 27% (117 MW) of the total installed base is capable of smart charging.**

EV chargers can be used for a wide range of flex services and the industry is moving towards implementation of Bi-directional power-flow, which will maximize the types of services that they can be used for.

EV manufacturers have an important role towards maximizing the use of EVs for flexibility. Nissan, Renault, Mitsubishi & Toyota have been the most active in participation of trials to prove flexibility service using their vehicles.

Executive Summary 1/2

2018 sales (residential)

15% — **~2,400 units (9 MW)**
<u>NOT</u> Connected EV Chargers

17% — **2,700 (10 MW)**
Remote Monitoring Capabilities only

68% — **10,800 (40 MW)**
Remote Control Capabilities

~15,900 units (59 MW)
Total 2018 sales of
domestic EV chargers

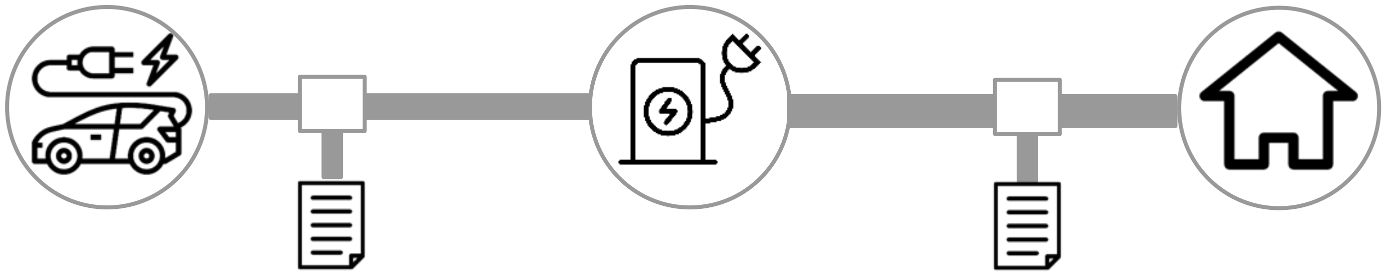
On the positive side: The ratio is increasing in favour of connected charge points every year, as **2018 sales** figures show. Of the total 2018 sales of 15,900 chargers, ‘smart’ EV chargers are the vast majority with **68 % / 10,800 units**. This clearly shows that the market is quickly moving towards smart products, and these will dominate the market in the following years.

EV owners should be able to exchange their Electric Vehicle, or to change of from energy supplier **without hassle**. We currently see a lack of standardization in Home Energy Management systems, which is a risk for utilizing long term benefits of smart EV-chargers. **Vendor lock-in should be avoided.**

Private EV owners may be tempted to buy cheaper charging stations that do not enable smart charging, because they are not aware of the benefits. FAN wants **all new residential charge stations to be capable of smart charging**, to make them ‘energy transition proof’. We see an important role in educating future EV owners, and (European) government policies and regulations.

Fun fact: In 2018, for each 2 sold EV’s, about 1 residential chargepoint was sold.

Smart Charging: Residential ecosystem & requirements



Electric Vehicle

- Smart Charging
- Bi-directional Charging

Charge Point

- Connectivity
- Remote control
- Modulated Charging
- Bi-directional Charging

Home

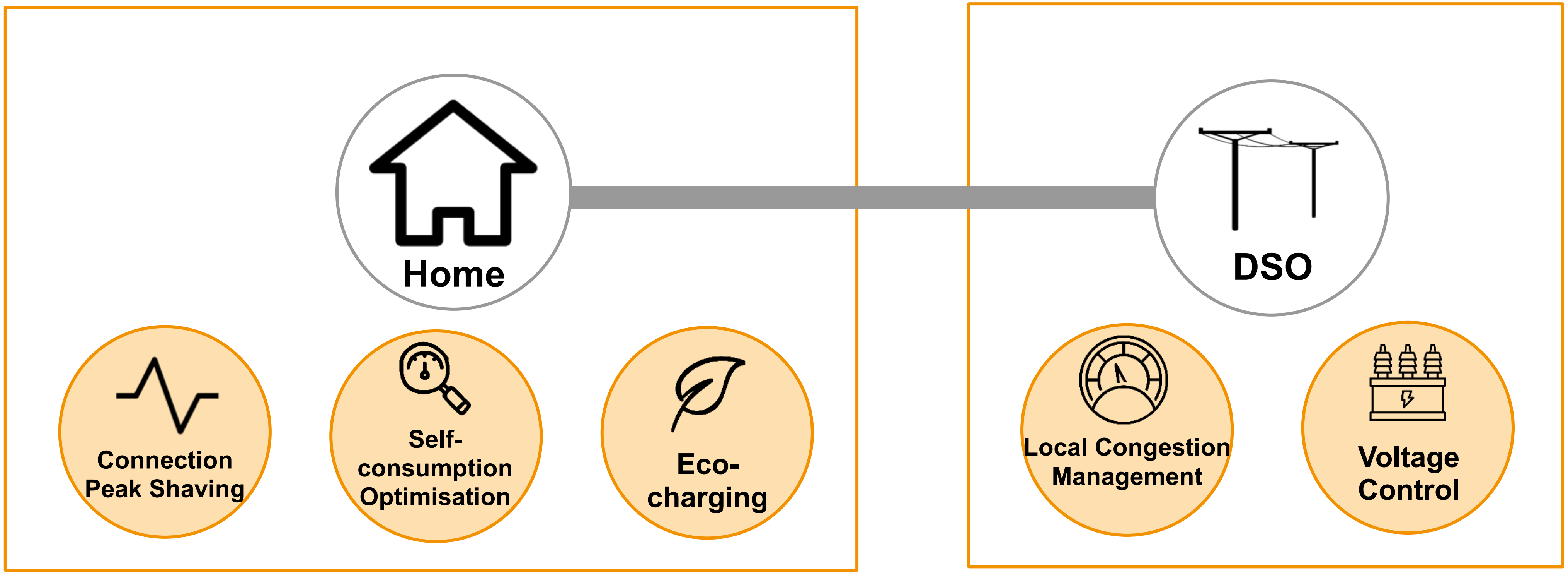
- Internet
- Grid connection
- Aggregator contract
- Aggregator interface

Augmented levels of EV charging:

- Dumb / blind
- Monitoring and Energy insight
- On/of remote control
- Modulating remote control
- VPP / Vehicle to Grid / Bi-directional

5 smart charging main potentials

Bi-directional charging is big promise, but not in the near future



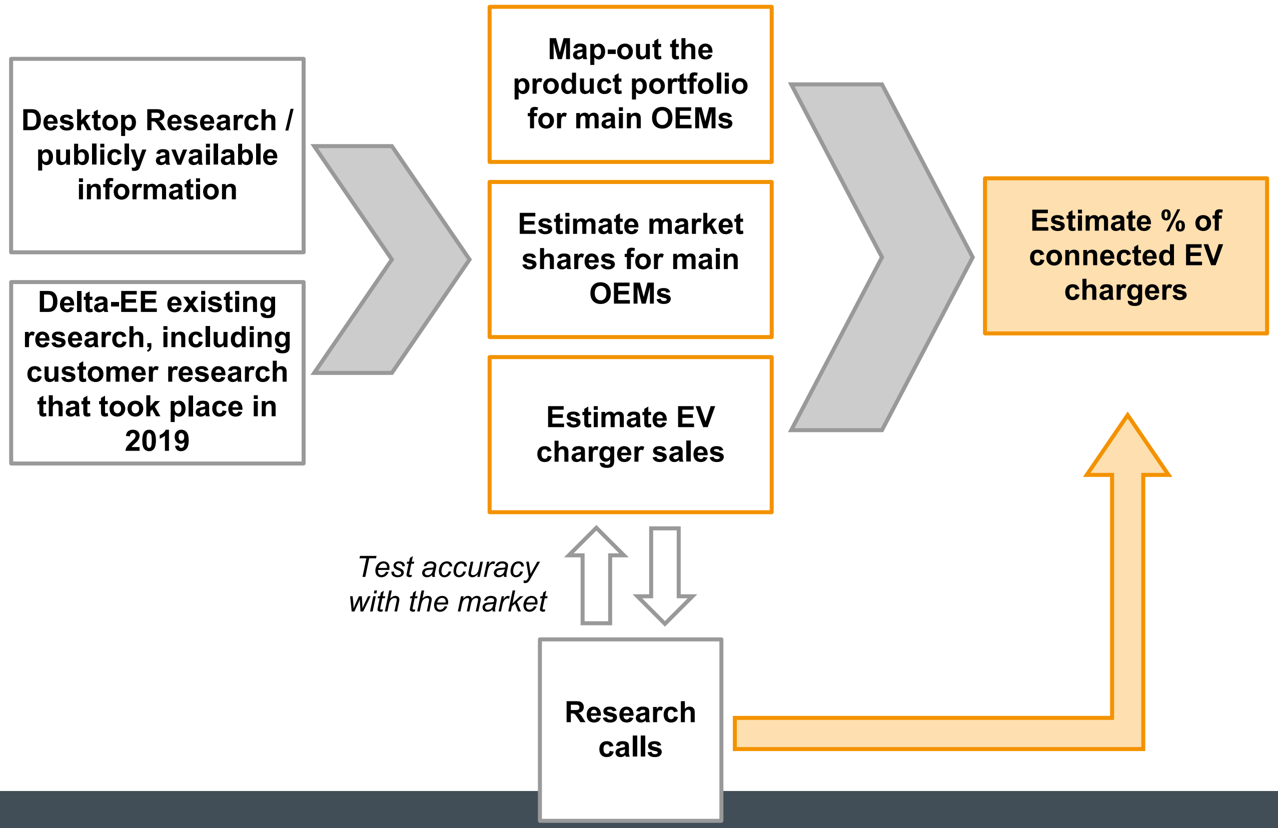
Scope and methodology

Scope

The scope of work is to evaluate the potential for the use of residential EV chargers in demand side response services. Public EV chargers (e.g. in public parking, workplace etc) are not within the project's scope.

Methodology

The graph below shows how we reached to the results seen on the report, and the different types of sources used to collect the information



Assumptions and key definitions

Assumptions

The key assumptions used to reach some of the figures within the report are the following:

- The conversion rate of new EV sales to new connected EV domestic charging points is assumed to be at 50% currently*. This value will evolve in the future and it is just indicative of the current situation.
- To convert the number of connected charge points to equivalent MW, an average value of 3.7kW per charger was assumed. We take 3.7 kW as average since many EV chargers are on 1 phase connection, and many EV's have 1 phase charging, ergo 1 x 16 A = 3.7 kW.

** Based on existing Delta-EE research on the Dutch EV market.*

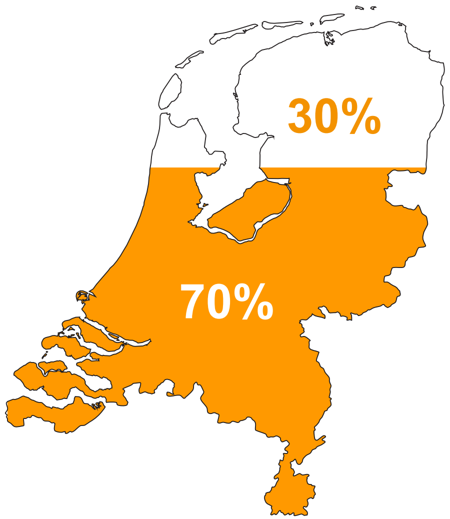
Key definitions

- *Charging point / Charge point / EV charger* **:** an element in an infrastructure that supplies electric energy for the recharging of electric vehicles
- *Connected EV chargers :* EV chargers that are connected to the internet and can be monitored and in some cases controlled remotely.
- *Smart Charging:* Charge EV's at an optimal moment. EV chargers that are capable of remote control are suitable for Smart Charging.
- *"Dumb" charge point :* A charge point that cannot be connected to the internet, as an opposite to a "smart" charge point.

More definitions can be found at the end of the report in the "Glossary" section.

Market size and key manufacturers (total installed base)

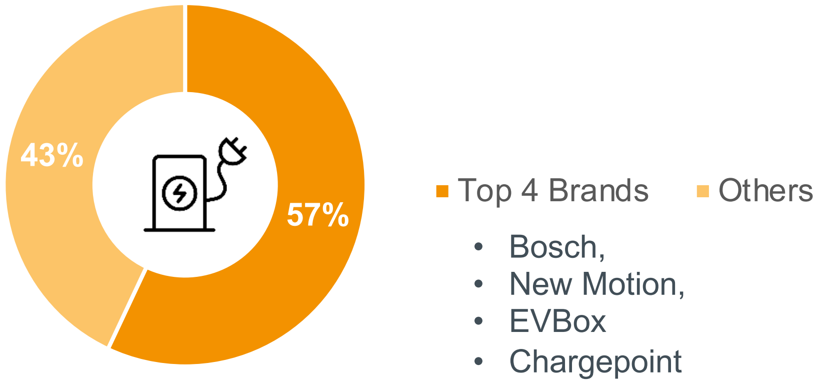
Residential market until and including 2018



Publicly accessible chargers

444 MW

chargers within **private properties / homes** (~120,000 units)



The Netherlands is one of the advanced EV charger markets in EU

A total install base of about 173,000 units, the majority of which are residential.

Market share of Charging Points Residential Market

Market share per year vary strongly, e.g.
heavy changes every in 2 to 3 years.

Connected EV chargers in the Netherlands

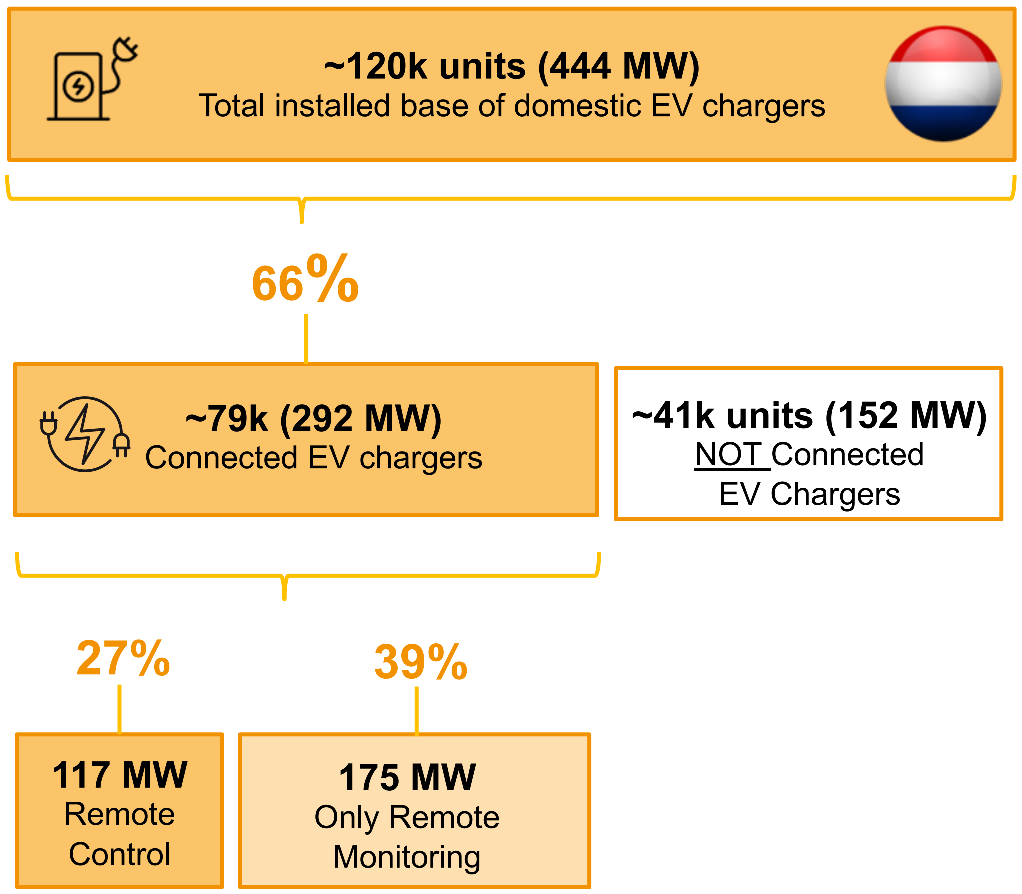
The majority of charging points are connected. Connected charge points figures, also include GPRS-modem connected charge points.

This is a legacy from older models, as new connected EV chargers are basically all Wi-Fi / wired enabled.

We estimate that about 79,000 connected residential EV chargers are installed in the Netherlands, which is an equivalent of ~292 MW

Yet, only 32,000 residential EV chargers (27%) are capable of 'Remote Control', which is an equivalent of ~117 MW

Total installed base (domestic) 2018



2018 Residential EV charger market

The number of connected home charge points in the Netherlands is growing fast

2018 sales

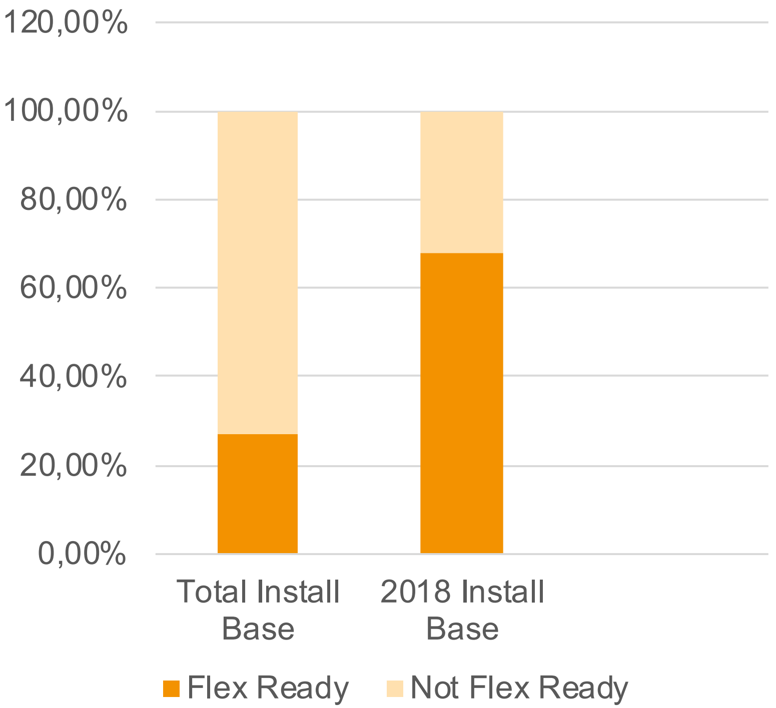
15,900
chargers

In 2018, ±15,900 EV chargers were sold in NL, of which **68% offer monitoring and remote control**.

In the future we expect that the market share of connected charge points will increase to almost a 100% of new charge point sales.

Buyers of 2nd hand EV's may need special attention.

2018 trend



Other market segments

Based on market penetration statistics from previous years, we estimate that about **~2,400** (8.9MW) **"dumb" residential charge points** were sold in 2018.

With regards to **public charge points** installations for 2018, these were about 267 for fast public charge points (>22kW) and another 3,135 for "normal" charge points (i.e. < 22kW).

Future market trend: 2nd hand EV market

We believe that the market penetration of connected chargers may be affected, when second hand EV-market grows – because it will be more price driven. This transition may prompt customers to buy cheaper "dump" products, but we believe it will increase the need to save from energy costs by using more sophisticated charging products and propositions.

What is the flexibility of EV-chargers used for?

Bi-directional applications offer the most potential for flexibility services, however basic services like time of use and peak shaving can be achieved by basic connected chargers

	Basic Connected one way	Sophisticated connected - one way	Bi-directional
Time of Use (financial optimisation)	*	*	*
Time of Use (e.g. carbon optimisation)		*	*
Peak Shaving	*	*	*
Behind-the- meter balancing		*	*
Self Consumption Optimisation		*	*
2-Grid advanced flexibility			*

Basic Connected chargers usually have a time of use setting and a method for communication back to the customer. These may also take inputs from the charge point manufacturer to start, stop or modulate charging based on grid contract signals. These are not bi-directional and usually set up by the end customer for convenience and financial optimisation.

Sophisticated connected chargers are the step on from basic connected chargers, incorporating more features and services (usually provided by the charge point manufacturer and a grid services partner) such as Carbon optimization, behind the meter load balancing and self consumption optimization. These are usually combined with a connected Home Energy Management System (HEMS), renewables (Solar PV) and domestic energy storage where available. Commercially available solutions for these exist today.

Bi-directional applications exist primarily in the trial/proof of concept phase – with some trials taking place with real, private customers but mostly with captive fleets. These services begin providing FFR, Blackstart and peer-2-peer services in some markets. These requests are end customer authorized, but managed by the grid services aggregator in conjunction with the charge point manufacturer.

Who is benefiting from EV flex services?

- ● CAPEX reduction
- ● Direct financial reward
- ● OPEX reduction

Value chain part	Main benefit type	Comments
TSO	●	The TSO benefits from flex services to meet their mandated service standards (e.g maintaining 50hz grid frequency), by reduction of CAPEX.
DSO	●	The DSO benefits from reduced CAPEX to satisfy service agreements (e.g. uninterrupted supply) for an ever increasing demand (as opposed to investing in other alternatives to satisfy the standards).
Energy retailer	●	Energy retailers stand to make a financial reward from being able to work with the aggregator and the EV asset to provide the interface for energy transmission.
Aggregators	● ●	Grid services aggregators stand to make a financial reward from bridging the service contract (from the grid operator/utility) to the asset (the EV).
CPOs	●	CPOs are usually operating grid services with aggregation partners (if not themselves directly). They have a direct financial incentive from each transaction for providing the hardware, that provides the service.
End-customers	● ●	End customers stand to make a financial (& eco-feeling) incentive depending on their end user agreement for providing the flex services. These are usually reflected on their energy bill, or by prior agreement for cashback. This can also be represented by rewards or a fixed monthly payment to satisfy their mobility needs, as long as certain criteria are met.
Car lease company	●	The car lease company may benefit financially from providing the customer, the asset and the CPO with a financial model/backing which allows each part of the chain to play it's part. This depends on how the leasing arrangement and ownership model for the assets (EV, CP) is set up.

EV manufacturers and energy flexibility

What is the current market status?

80 - 100%

Car manufacturers prone to smart charging

45%

Car manufacturers prone V2G on mid-term

Nissan, Renault, Mitsubishi & Toyota have been the most active in participation of trials to prove flexibility service using their vehicles

Manufacturers advanced in the V2G concept:

Nissan have the most prolific operation, with proof of business and proof of concept trials across the EU and the USA for V2G, using their Leaf & eNV200 vehicle ranges. We regard Nissan as one of the leaders in the flexibility and energy services/V2G space.

Manufacturers looking into the flex space, but with no commercial products:

BMW in 2018 announced it's CHARGEFORWARD program, aiming to use smart charging flexibility (but not V2G). They trialled this in the US on BMW i3 models and PHEV products. They also trialled a small fleet of i3 vehicles on V2G applications, as well as releasing details of a AC socket 'energy dispenser' for standard plug and play products.

What about Tesla?

While Tesla is the benchmark for public infrastructure, providing domestic chargers (with some 'smart' functionality) and packaging domestic energy storage with solar PV into the customer proposition, **they are not visibly active in the 'smart' charging and flexibility space as such.** Tesla have claimed that their vehicles could be bi-directional to provide V2G style services, however they have never publicly trialled this. Due to Tesla's proprietary charging protocol, this would likely require bespoke charging hardware. Tesla is currently focussing on meeting demand for ordered vehicles and focussing on quality and cost. It is likely that they will eventually move into the flexibility services space, as they have the building blocks to do so – however not in the short term and likely will do so via trials under their SolarCity subsidiary.

EV manufacturers and energy flexibility

What is their attitude towards flexibility services?

Are EVs ready for modulating / bi-directional charging?

- Practically all vehicles are capable of accepting modulating charge rates, to provide the basic level of flex services – without any inherent concerns about damage or error states to vehicles.
- On the other hand, bi-directional charging is limited to certain manufacturers and their models (Japanese manufacturers, e.g. Nissan). There are no cars yet that offer V2G for AC charging.

> **"EVs are generally capable of accepting modulating charge rates, but bi-directional charging is more limited.**

What are the main concerns?

- There is a concern around **warranty, battery degradation and component durability** – as every vehicle has a bespoke battery, with chemistry suited to the vehicle (with its own ideal operating temperature and voltage), every vehicle will be affected differently.
- For smart charging flexibility services**, the vehicles will have individual cut-offs for charge rate**, if it drops too low or too high dependent on battery state. This is a present value set by the OEM, as a precaution to remove the risk of unnecessary ageing of the battery. Modulation and start/stop charging for flex services are not expected to have any adverse effects on the battery of the vehicle. **Some studies have shown V2G and modulation can help prolong the life of a vehicle battery**, but no OEM is sharing the results of their V2G battery state of health at the end of trial.
- **High voltage systems on vehicles (the charging system) will also be affected by modulation of charge rate and bidirectionality**. No OEM has released statements or published any studies on this currently.

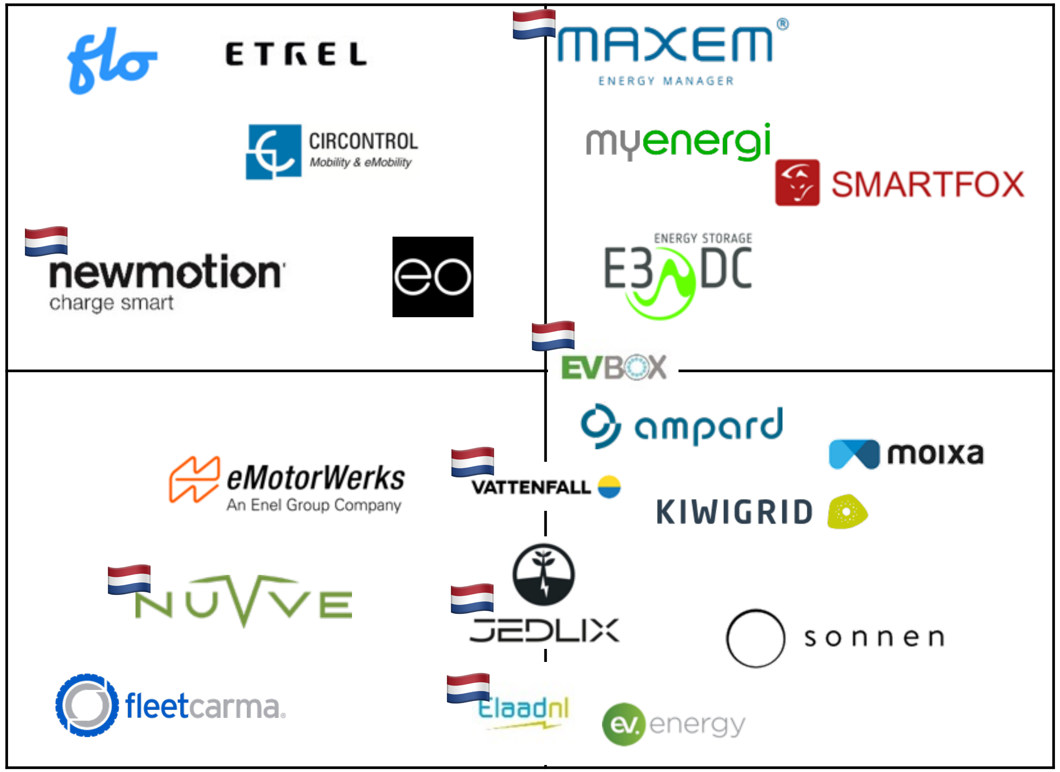
Positioning in the EV space – NL active companies

Local decisions only

Price signals direct to the customer

Local and centralised decisions

Including price signals to aggregators



eMobility driven **Energy business driven**

Focus of companies in the smart charging space is moving towards developing capabilities for providing electricity system services

These include e.g. using TOU tariffs, demand side response, or optimising wholesale trading positions. Whether coming from an eMobility or energy focus, most charge point providers are already developing these capabilities and are searching for partners to help them reach scale and access the value from electricity system services.

This is a European overview – active companies in NL are highlighted with an orange border (not exhaustive).

= available in Dutch market

Attributes of most popular brands of EV chargers

The following table shows the characteristics of the most popular brands of EV chargers and a brief summary of their connectivity:

- **Bosch :** The majority of Bosch chargers in the market today (legacy installs) are ‘dumb’. New products and installs are ‘connected’.
- **NewMotion :** Most domestic products are internet connected, with the ability to load balance and authenticate (if option requested by the customer). They have over the air updates, and can bundle in public charging access for the end customer. Newmotion are running V2x trials in the Netherlands currently.
- **EVBox :** Most domestic products are internet connected, with the ability to load balance and authenticate (if option requested by the customer). They have over the air updates.
- **Chargepoint :** Products with WiFi enabled, tethered cable.

🔵 Commercialised product

🟠 On some variants of the product

⚪ Available on trial

OEM	1 phase or 3 phase	Connected	Smart Charging & Optimisation	Bi-directional	EV communication	OCPI / OSCP
Bosch	Primarily 1-phase	🟠			(Typ1 & Typ2 CCS options)	It’s not 100% clear for all the big brands and makes on their OCPI/OSCP integration – however, it is safe to assume they have them in prototype testing phase and will be available on a commercial B2C product soon.
NewMotion	Both	🔵	🟠	⚪		
EVBox	Both	🔵	🟠	⚪		
Chargepoint	Primarily 1-phase	🔵	🟠	⚪		

EV charger capabilities

EV chargers will be typically connected behind-the-meter and capable of supporting modulation. Connected chargers can unlock some useful grid info.

Modulation capability

Most connected charge points can support some levels of modulation. However, not all vehicles react the same way to having the charge rate fluctuated, some may go into a 'protection' mode as the car may see the spike or drop as an error and subsequently stop charging to protect the vehicle, and may not resume till user/owner intervention.

Bi-directional power flow capability

Currently, only CHAdeMo (DC) & some Typ2 AC wallboxes support bi-directional charging activities. These are on proof on concept trial with fleets and end customers

Are EV chargers behind or in front of the meter?

Almost all domestic charge points are behind the meter and on the same residential tariff (or EV specific) tariff from the same provider that provides energy to the residential property.

Very rarely (about 1% of the cases) charge points may be on a separate meter - dependent on install and provider/tariff.

What useful information can be unlocked from a connected EV charger?

- End-node data for Voltage (reducing capex for communication devices at a transformer level).
- Potential to provide targeted mobility-as-a-service solutions to customers whose vehicles are plugged in and providing flex services.
- A more detailed usage map for different customer archetypes, across different geographies.
- More accurate predictions for nested grid services, as they get developed.

EV Charger communication

Is charger communication necessary to provide some flexibility?

A ‘dumb’ charger is nominally set to charge as soon as a vehicle is plugged in, at the maximum available rate of power transfer to the vehicle, until the vehicle is fully charged (or till the battery % level the vehicle is set to charge till).
This normally requires a handshake operation between the charger and the vehicle to start, confirm charge rate maximum capacity and stop.

A ‘dumb’ charger can be made ‘smart’ – using the vehicle: The vehicle can override this by having it’s own charging schedule set via the in-vehicle menu or via a connected app by the customer (easy to set up) or where the vehicle manufacturer is in partnership with the electricity retailer / grid services aggregator (more complex). This can provide the first level of flexibility services, mostly for financial benefit of the end customer.

How is communication achieved and what protocols enable modular use for flex services?

Charge points with an internet connection (Wi-Fi or captive SIM), will have a back end portal that is manufacturer facing for control & monitoring, and also used for customer information / presentation. This back end portal can be accessed (in partnership with the manufacturer of the charge point), via a grid services aggregator to provide the 1st levels of ‘smart’ charging (time of use optimization, peak shaving, modulation).

If the charge point is capable of **OCPI/OCPP & is ISO15118 enabled, it will be able to do levels of modulation and flexibility with the vehicle.**

Protocols & their characteristics

OCPI (Open Charge Point Interface) & OCPP (Open Charge Point Protocol) enable the support of flexibility, but also lead into the Open Smart Charging Protocol (OSCP) – which will support fitting charge profiles to grid capacity and acts between charge point and energy management system. In summary :

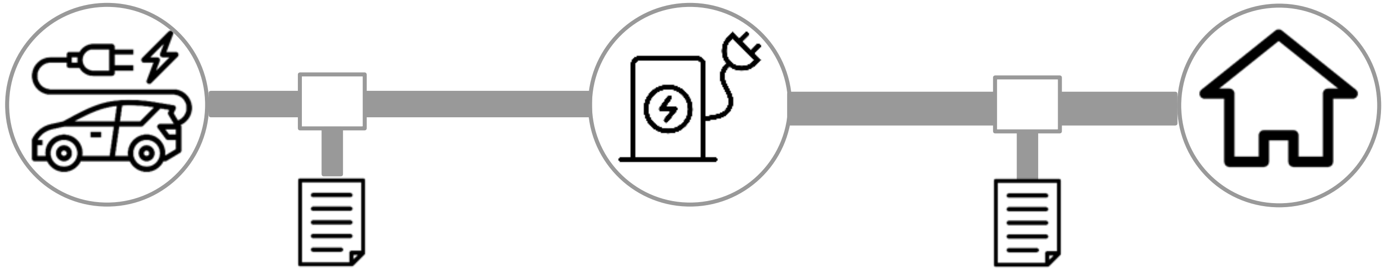
OCPI 2.0

- Smart Charging support for load balancing and use of charge profiles
- Device management
- Improved Transaction handling
- ISO15118 Support
- Additional smart charging functionalities

OSCP 1.0

- Communication of 24hr predicted locally available capacity
- Fitting Charge Profiles to grid capacity
- Acts between charge point and energy management system
- Applicable for site owners & DSO’s

Smart Charging Protocols overview



CHAdeMo :
Japanese standard, designed to be bi-directional. Currently used in many flex trials.

ISO 15118 :
Not common yet, but it is used as a platform to develop CCS V2G capabilities

CCS :
A public charging DC charging standard, applicable for most other EVs. Currently transitioning to fascilitate bi-directional.

IEC 61851 :
Most used protocol between vehicle and charge point for normal (type 2 mode 3) charging

OCPP :
An open standard which describes a method for enabling EVs to communicate with a central system

OCPI :
Interface primarily designed for public charging, but also used at the back end for residential. It improves roaming functionality and transaction handling.

OSCP 1.0:
OCPP leads to OSCP standard, which will support fitting charge profiles to grid capacity and acts between charge point and energy management system

EEBUS:
EVBox announced its participation in the EEBUS alliance in 2019

Protocols used to communicate with the EV

There are 2 core standards found across Europe: CHAdeMO and CCS. These largely affect the car models that can be connected with the chargers.

CHAdeMO

- This is a Japanese standard found almost solely on Japanese designed vehicles (Nissan Leaf, Nissan eNV200, Mitsubishi Outlander etc). It is designed to be bidirectional (i.e. provide power back through the vehicle's high-voltage on board charging infrastructure)
- CHAdeMO is actually being used for flexibility services in a variety of trials in all markets.

ISO15118

- Not a common standard yet, this supports communication between charge point and vehicle – it is being used as a platform to develop CCS V2G capabilities. It is also being used to develop smart charging communication standards, and will likely be the first implementation, as OEM's will have to make their cars compatible.

CCS

- This is more common with all other vehicles (Jaguar, Audi, Mercedes, BMW, Hyundai etc). However at the moment it is applicable for public DC charging.
- The CCS standard is managed by the CHARIN committee – whilst no commercially visible bidirectional capability exists today, CharIn will release a 'Level 2' standard in 12/2019,(bringing it forward from 2025) which will cover bidirectionality & ISO15118 in CCS.
- Type 2 AC – We Drive Solar (Utrecht) & Renault are currently underway on a trail with bi-directional AC hardware fitted onboard the Renault Zoe test fleet to test V2G potential. There is a need to have a compatible AC charge point to support. (Part of the trial)

IEC61851

- Most used protocol between vehicle and charge point for normal (type 2 mode 3) charging

HEMS Integration

Across Europe, EV Charger & HEMS integration is being trialled (and offered commercially in some markets).

- Newmotion & EVBox are in trial, with today's customer available offerings capable of manual load balancing and time of use tariffs.
- Notably, SMA Solar will be offering a Home Energy Management System alongside Audi, with Audi branded EV domestic charge points. It is expected that the VW group products will operate in a similar way under the 'Elli' Brand.
- Myenergi and EO charging (both UK) are also offering branded home energy management control units, which balance peak load, renewable, time of use tariff (or tariff signals where appropriate) and EV charging, via control of the EV charger.
- **EVBox** also announced it's participation in the **EEBUS alliance** – a standardised protocol to link smart home energy devices together to create individual eco systems for customers, without having proprietary closed loop approaches. EVBox have announced that they will work with a number of partners to use EEBUS as 'The Global Language for Energy in the Internet of Things'.

Interoperability & lock-in

Car & EV charger

As long as the vehicle and the EV charger (irrespective of brand) use the same standard (e.g.: Typ1 orTyp2 on AC), they are likely to always be interoperable. It is now possible for an end customer to purchase a converter from Typ1 to Typ2 (and vice versa) for added flexibility. As such, the customer is not 'locked in' to a vehicle brand/type or charger if they choose to change.

Interoperability: **High**
Lock-in: **Low**

Customer & Aggregator / Energy Provider

The answer depends on the business model behind the vehicle and charger install – currently aggregators active in trials package themselves together with the energy supply and the charge point manufacturer. As long as the EV is capable (smart charging: most, V2G: less so), the 'lock in' only applies to the Energy Supply + Aggregator Service + Chargepoint (unless the EV is a part of this bundle).

Interoperability: **High/Medium**
Lock-in: **Medium**

EV charger & HEMs

This is dependent on the HEMS package, and whether it was designed to work directly with an EV charger, or is a retrofit CT-clamp based solution.

Designed together:

Interoperability: **Low**
Lock in: **High**

Retrofit Solution:

Interoperability: **High**
Lock-in: **High**

Glossary

***BEV :** Battery electric vehicle, a type of electric vehicle*

***Charging point / Charge point / charger :** an element in an infrastructure that supplies electric energy for the recharging of electric vehicles*

***Connected EV chargers :** EV chargers that are connected to the internet and can be monitored / controlled remotely.*

***"Dumb" charge point :** A charge point that cannot be connected to the internet, as an opposite to a "connected" charge point.*

***Eco-charging :** controlling charging in such a way that it takes place using on-site renewable energy (PV), instead of injecting this energy into the grid*

***EV :** Electric Vehicle*

***FFR :** Firm Frequency Response - the firm provision of dynamic or non-dynamic response to changes in frequency*

***Mode3 cable:** The cable that connects the EV charger to the vehicle, usually a Typ2 connector standard – they are designed to handle 7.4kW to 22kW charge rates.*

***OEM :** Original Equipment Manufacturer*

***PHEV :** a hybrid electric vehicle whose battery can be recharged by plugging it into an external source of electric power, as well as by its on-board engine and generator*

***Typ1 charger :** 1-phase plug for AC power levels up to 7.4kW. Primarily an asian AC charging standard, not very common in Europe.*

***Typ2 charger :** 1-phase and 3-phase charging plug for AC power levels (domestic) up to 22kW. Supports 3.7kW, 7.4kW, 11kW and 22kW charging. Most common form factor in the EU & USA for AC charging.*

***V2G :** Vehicle to grid - a system in which EVs, communicate with the power grid to sell demand response services by either returning electricity to the grid or by modulating their charging rate.*

***Wallbox :** see charging point*

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FAN partners