

The Development and Adequacy of the Recharging Infrastructure for Electric Vehicles in Europe

Paris, October 17th, 2016

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Plans for an electric car charging point in every new home in Europe

Tuesday 11 October 2016

Every new or refurbished house in Europe will need to be equipped with an electric vehicle recharging point, under a draft EU directive expected to come into effect by 2019.

In a further boost to prospects for the electric car market in Europe, the regulations due to be published before the end of the year state that **by 2023, 10% of parking spaces in new buildings in the EU zone will also need recharging facilities.**

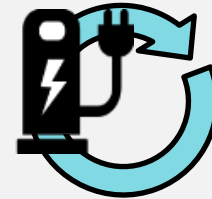
The EU initiative is intended to **lay the infrastructure for the sort of electric car boom envisaged by Norway and the Netherlands**, which both plan to completely phase out vehicles with diesel engines by 2025.

...

Agenda

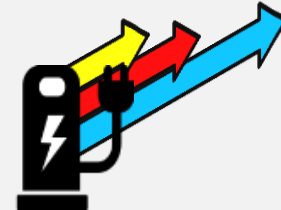
Electric Vehicle Supply Equipment

Basic and value added services, tariffs,
eRoaming



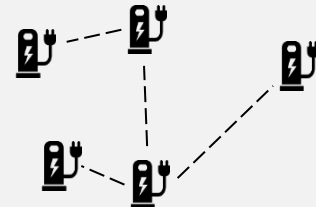
Development of the EVSE Network

Trends, targets and policies



Adequacy: Where, when and how?

Slow charging: Loadshifting
Fast charging: Technical mitigating measures,
Location planning, Time signals & monitoring





EVSE - Electric Vehicle Supply Equipment

- Conductors, connectors, attachment plugs, and all other fittings, devices or power outlets installed
 - **Delivering energy from the on-site wiring to the electric vehicle.**
- Wall-charger or charging station device and the protocols that
 - enable two-way **communication**
 - allow **safe** electricity flows (e.g. safety **lock-out**)
 - ensures that the current passed to the vehicle has to be within the **limits** of the charger and the maximum charging capacity of their onboard chargers.



[evconnectors.com]



[renault.fr]

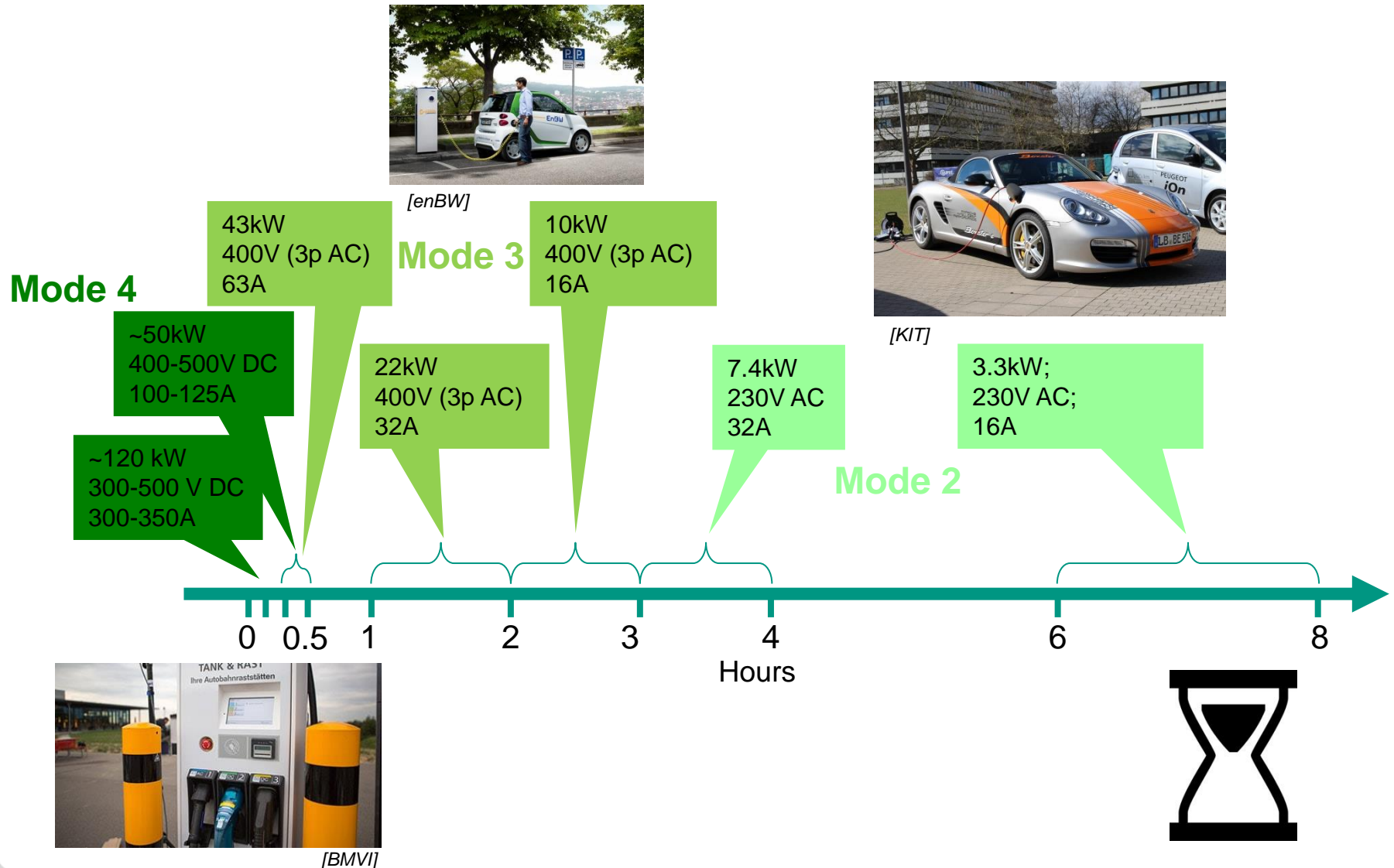


[enbw.de]



[tank.rast.de]

Charging durations for ~100 km of range



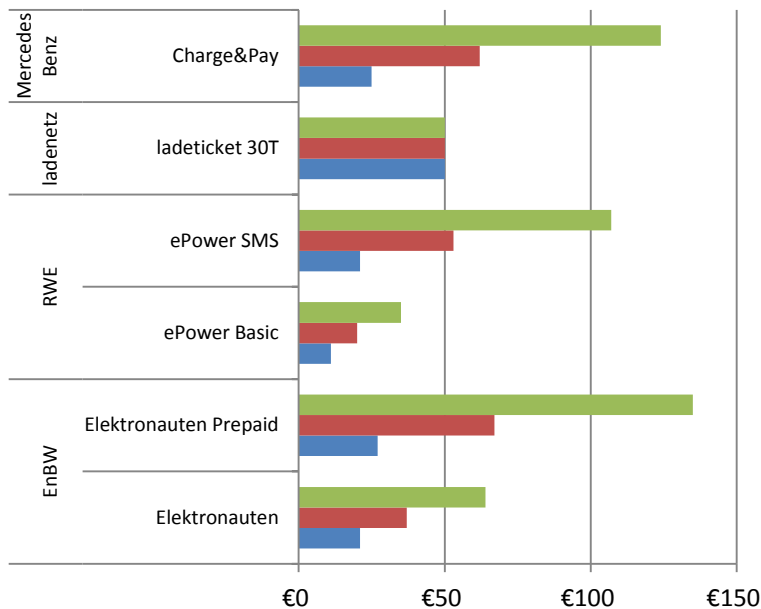
EVSE electricity tariffs

- Free (SuperCharger, Supermarkets, ...)
- By the hour (to avoid blocking)
- By the session (e.g. included in parking)
- Time-of-Use (TOU) rates

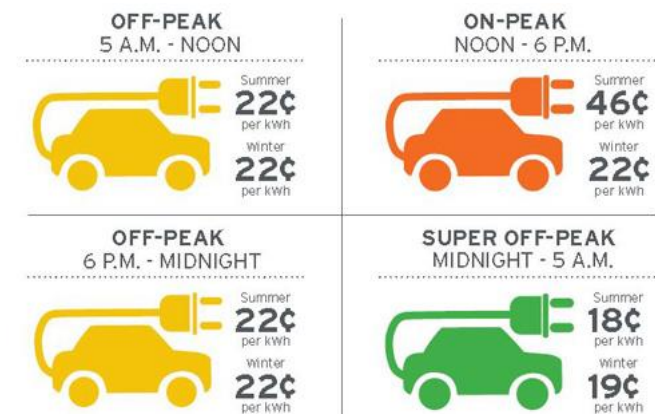


[eon]

- Higher prices for public charging, but usually cheaper than gasoline
- Public charging will rarely compete with home charging on an economic basis



[mobilityhouse.com], Data from 23. January 2015



Prices represent the EV-TOU2 rate* as of May 1, 2016.

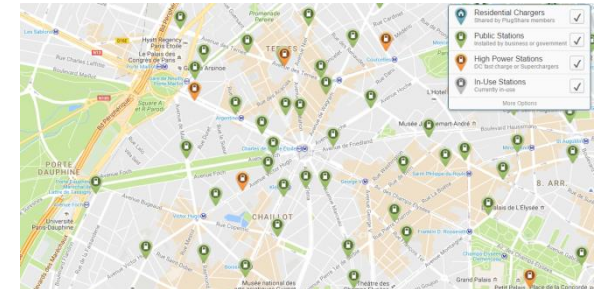
Learn more about our rates at sdge.com/evrates.

Summer rates run May - October. Winter rates run November - April.

*The EV-TOU2 rate uses your existing household smart meter to track electricity used by both your home and EV.

Value added services for EVSE infrastructure

- Navigation, trip planning
- Information on plug type, availability, etc.
- Reservation
- Examples: plugshare.com, ChargePoint.com, evchargehub.com, *[plugshare.com]*
chargepoint.com, sodetrel-mobilite.fr, ...



Prises

Informations Détails des prises

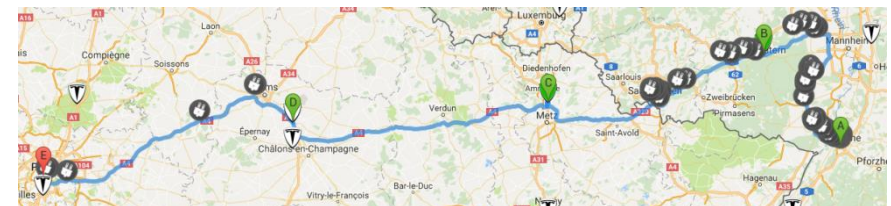
Total de prises	Type de prise	Type de prise	Type de prise
13	T3	Domestique	Combo T2
Disponibilit�			
13 / 13			
Statut : Disponible	Statut : Disponible	Statut : Disponible	Statut : Disponible
Vitesse de charge : Acc�l�r�e	Vitesse de charge : Normale	Vitesse de charge : Acc�l�r�e	Vitesse de charge : Acc�l�r�e
Mode sortie : socket	Mode sortie : socket	Mode sortie : outlet	Mode sortie : outlet
Type de courant : AC1 AC3	Type de courant : AC1	Type de courant : DC	Type de courant : DC
Tension maxi : 400 Volt	Tension maxi : 220 Volt	Tension maxi : 400 Volt	Tension maxi : 400 Volt
Courant maxi : 32 A	Courant maxi : 16 A	Courant maxi : 120 A	Courant maxi : 120 A
Puissance maxi : 22000 W	Puissance maxi : 3000 W	Puissance maxi : 22000 W	Puissance maxi : 22000 W
Nombre de prises : 2	Nombre de prises : 5	Nombre de prises : 2	Nombre de prises : 2

Type de prise	Type de prise
ChaDeMo	T2
Statut : Disponible	Statut : Disponible
Vitesse de charge : Acc�l�r�e	Vitesse de charge : Acc�l�r�e
Mode sortie : DC	Mode sortie : socket
Type de courant : DC	Type de courant : AC1 AC3
Tension maxi : 400 Volt	Tension maxi : 400 Volt
Courant maxi : 120 A	Courant maxi : 32 A
Puissance maxi : 22000 W	Puissance maxi : 22000 W
Nombre de prises : 2	Nombre de prises : 2

[sodetrel-mobilite/]



[enBW]



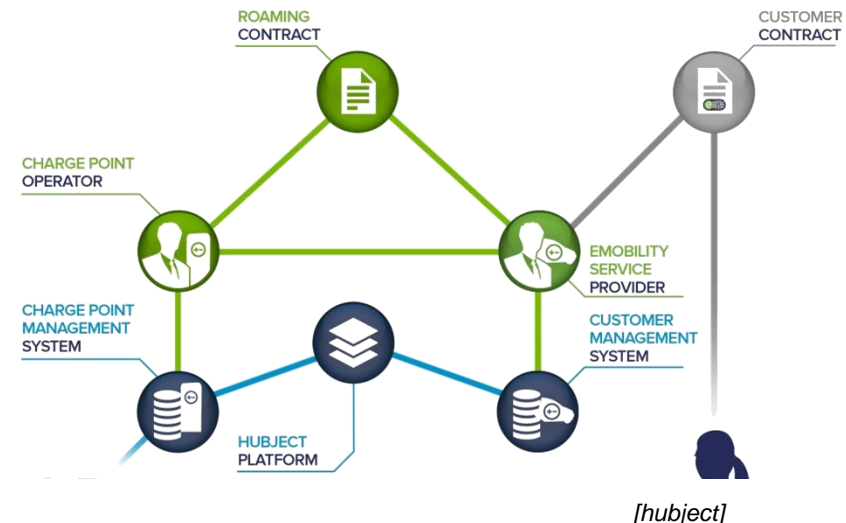
[evtripplanner.com/]

eRoaming Platforms

- Proprietary billing systems lead to **limited circles of customers**.
- eRoaming...
 - A market model for the **contractual relationship** and the resulting **interaction of the market participants**.
 - Allows **billing** via the customer's own contractual partner.
 - A **business and IT platform** that connects electric mobility market participants.
 - Basis for a **cross-provider charging infrastructure**.



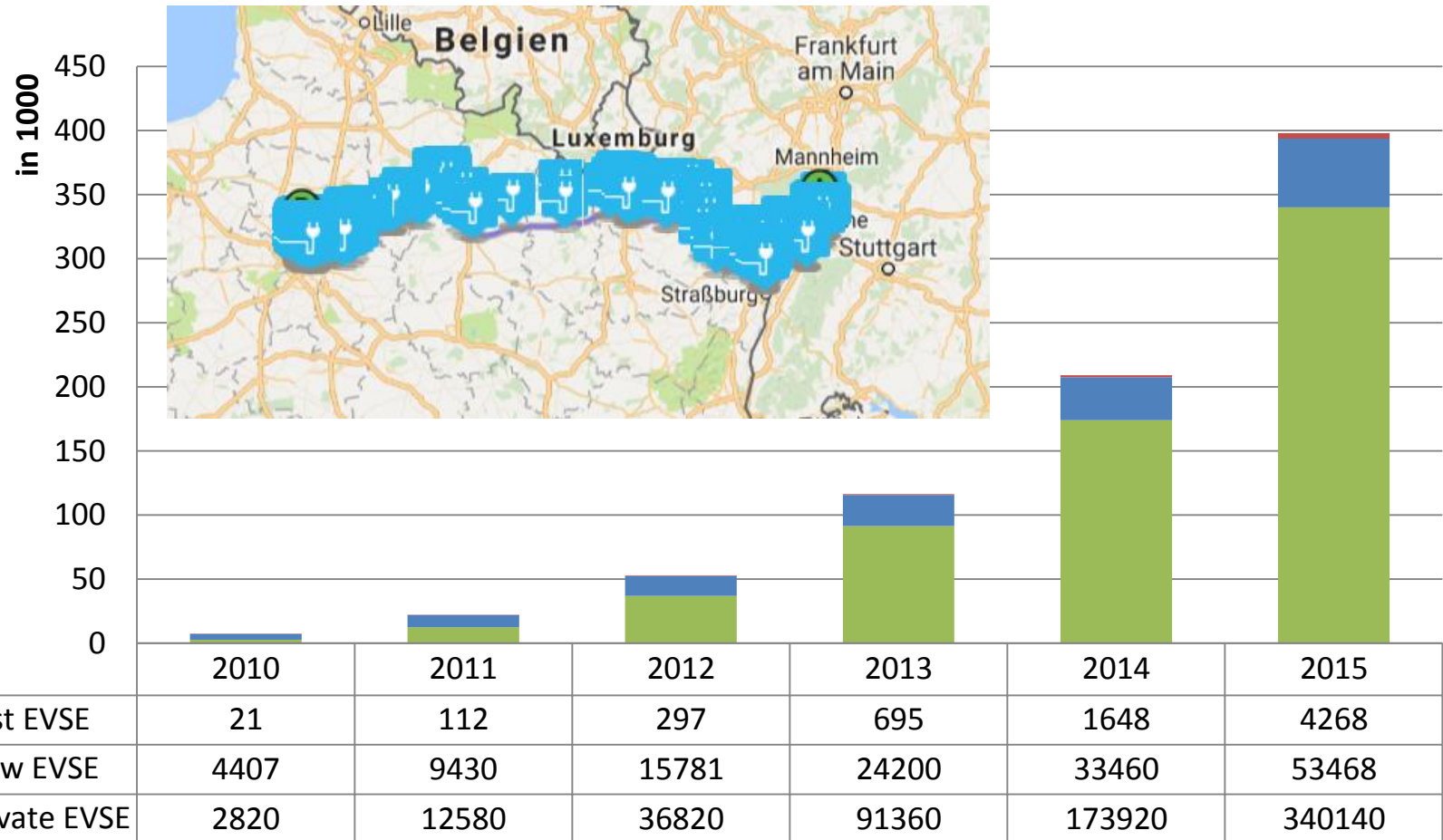
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DEVELOPMENT



Charging network in the EU in numbers



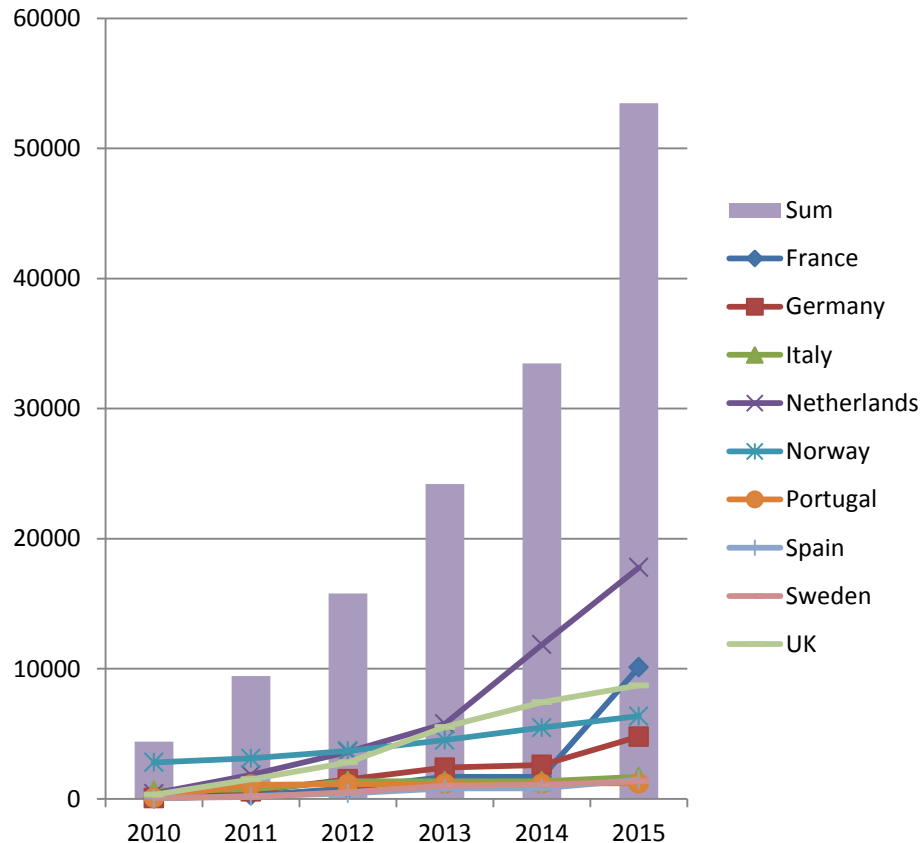
*Assumption: Each EV is coupled with a private EVSE

[IAE, EVI, EAFO 2016]

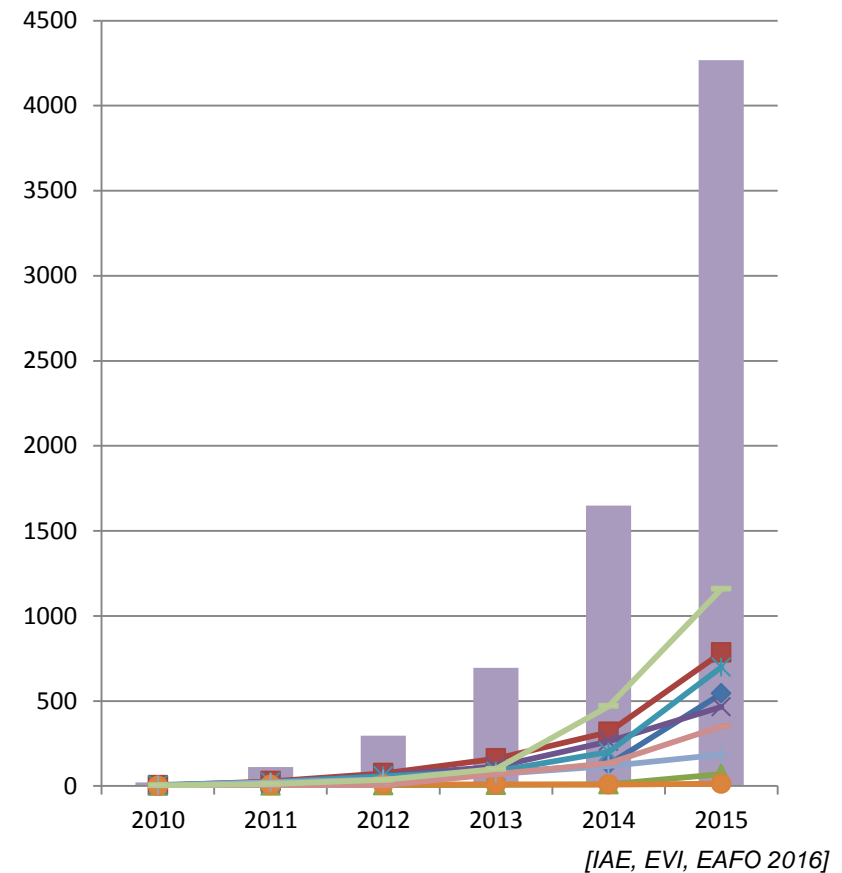
■ Public EVSE follow the growth trend of the EV stock (71% vs. 78%, '15)

Slow and fast charging EVSE stock in the EU

SLOW EVSE (AC 3.7 kW - 22 kW)

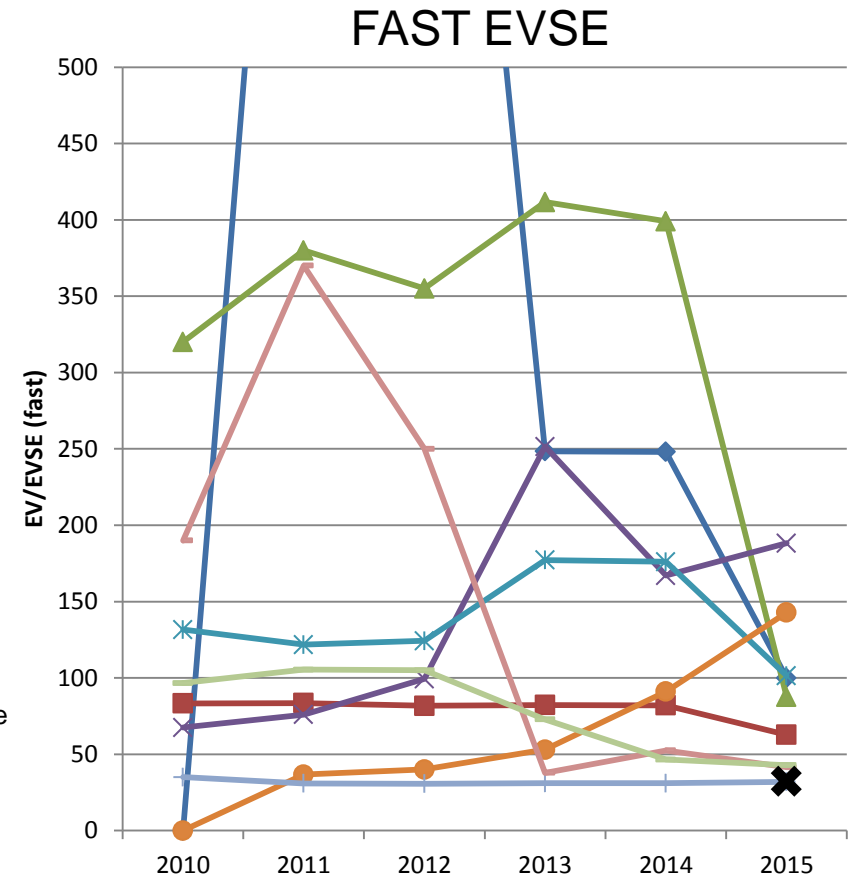
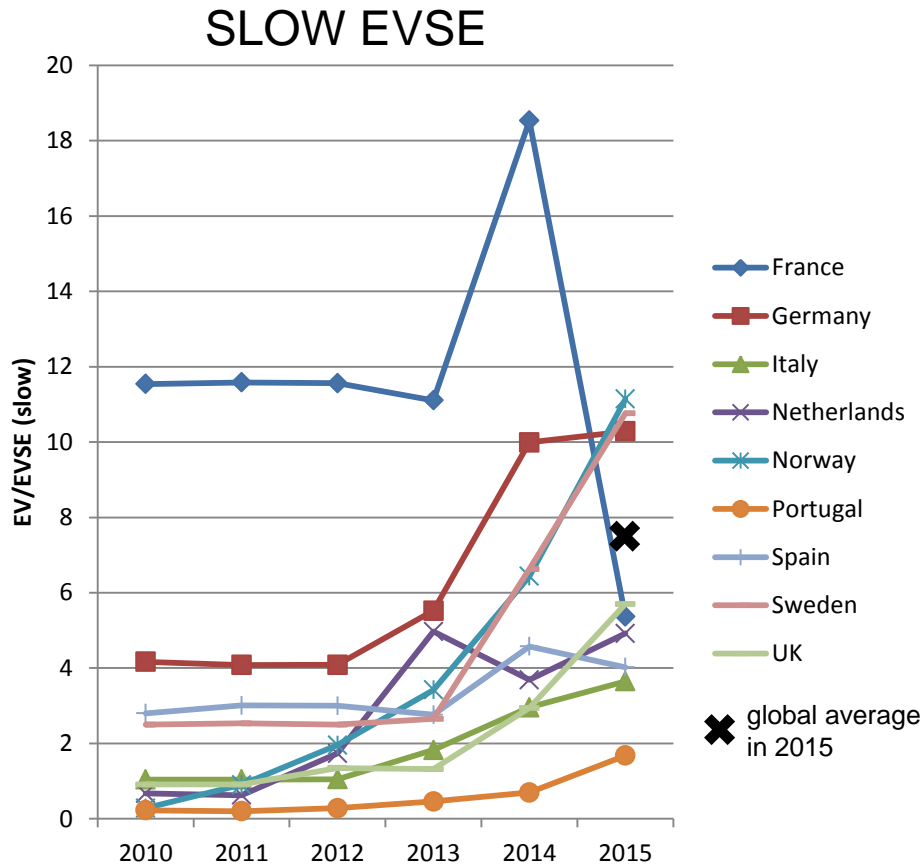


FAST EVSE (AC 43 kW, DC, Tesla Superchargers and inductive chargers)



■ Both more than doubled on an annual basis in the past five years

EV per EVSE (indiv. public outlet)



[IAE, EVI, EAFO 2016]

■ EVSE/unit land area

→ low in countries with low population density

■ EVSE/capita

→ low in countries with low vehicle ownership rates

Future Developments: Targets

- Earlier proposals for EU-wide **EVSE target** for 2020 (EC, 2013)



- **0.8m** public EVSE
- A total of **8m** EVSE

- **EU Directive** “Deployment of alternative fuels infrastructure 2014/94/EU

- Member countries have to define **EVSE targets** for 2020 by November 2016 (EC, 2014a)
- **No metric** or a numerical **indicator** suggested
- EV should **be able to circulate** at least in urban and suburban agglomerations (EC, 2015, 2014b)
- Ideally a minimum of **1 EVSE per 10 EV** (EC, 2014b)

- **Worldwide EV Stock objectives**

- ...add up to **13m** EVs by **2020** for 14 countries
- EVI **2020** target: **20m** EV (IEA, 2016b).

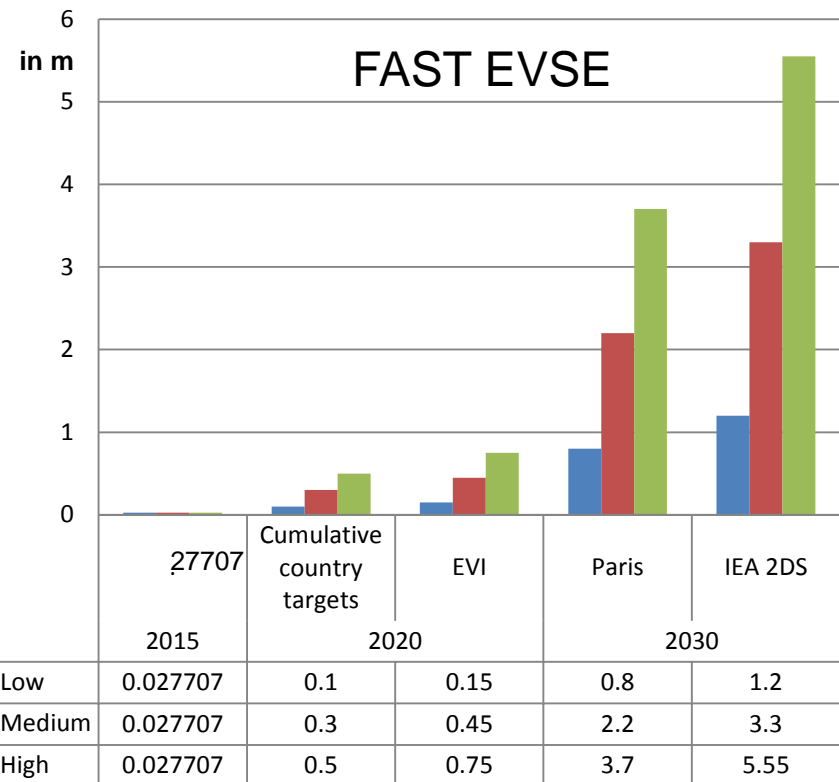
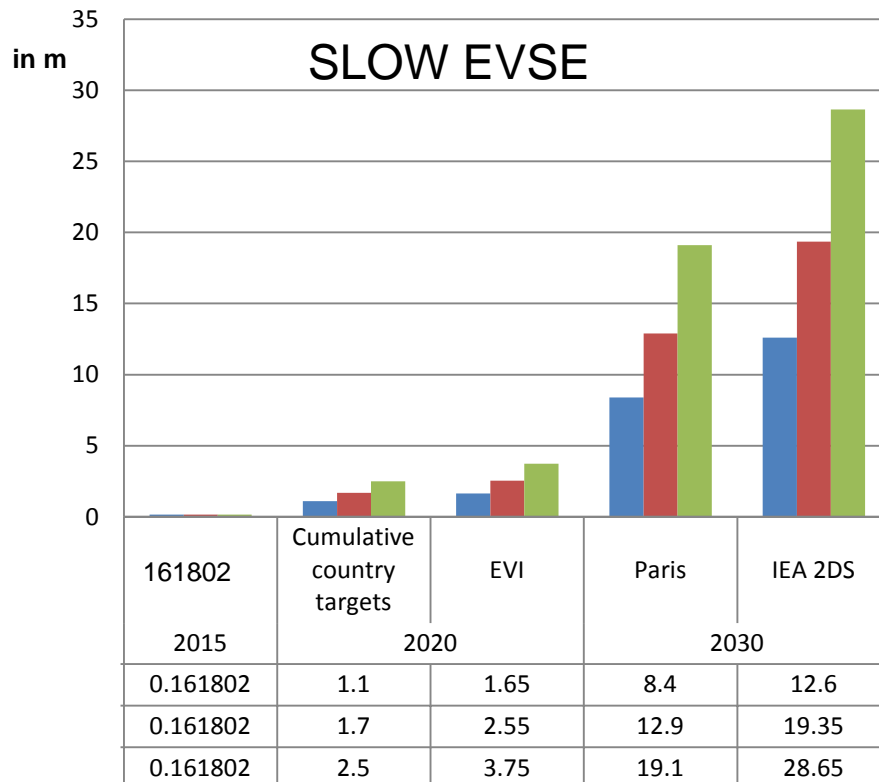


- Paris Declaration on Electro-Mobility and Climate Change and Call to Action: **100m** electric cars by **2030** (UNFCCC, 2015b).
- IEA 2°C Scenario (2DS): **140m** EV by **2030** (10% of the total stock of passenger light-duty vehicles)

Estimated increase for EVSE in the EU

■ Estimation based on historical EV/EVSE average ratios (high/medium/low)

- more than a factor of 10 from 2015 to 2020,
- and by a factor of 80 to 120 by 2030.



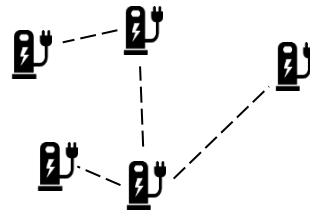
Early Findings of the EVSE Development

- EV markets and EVSE networks are still in early development phase
 - High variability in the EV/EVSE ratio
- Positive relationship between the adoption of EV and the deployment of the public EVSE infrastructure
- Optimal balance for the EV/EVSE ratio difficult to determine



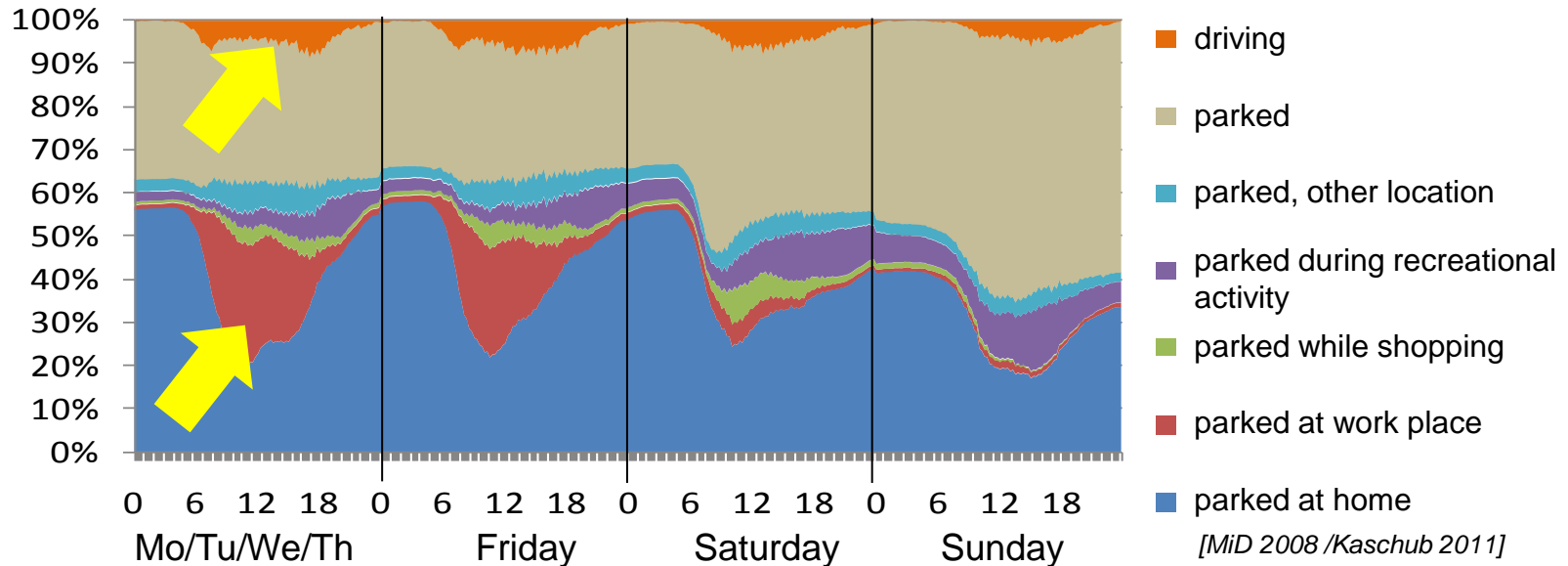
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ADEQUACY



Slow Charging at home and at work

- In Germany **85%** of those possessing at least one car also own private parking ground or a garage



- By far, most parking occurs **at home, secondly at working place.**
- A charging infrastructure at home and at work **seems to be sufficient.**
- Possibility to modulate charging time and power
 - → **Load shifting potentials** (Aggregation at higher voltage levels)
 - → **Flexibility resource** for integration of high shares REG

Fast Charging

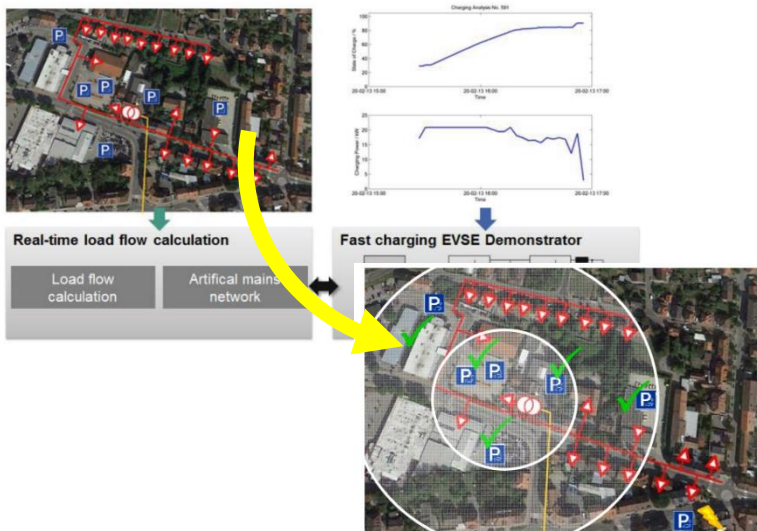
- Fast Charging and a future High Power Charging (up to 0.4MW with 1000 V, 400 A) are a **concern for distribution networks**.
- Challenges:
 - **Reinforcements of the electricity grid** may be needed
 - Difficult to provide **demand side management (DSM)**
 - May be **underutilized at night**.
- Possible solutions:
 - Implementation of **technical mitigating measures** (e.g. voltage control technology, active power control,...).
 - Proactively and **optimally size and locate**.
 - Time signals in **electricity pricing**.
 - Active **monitoring and control**.



[tank.rast, nissan, newatlas]

Technical mitigating measures

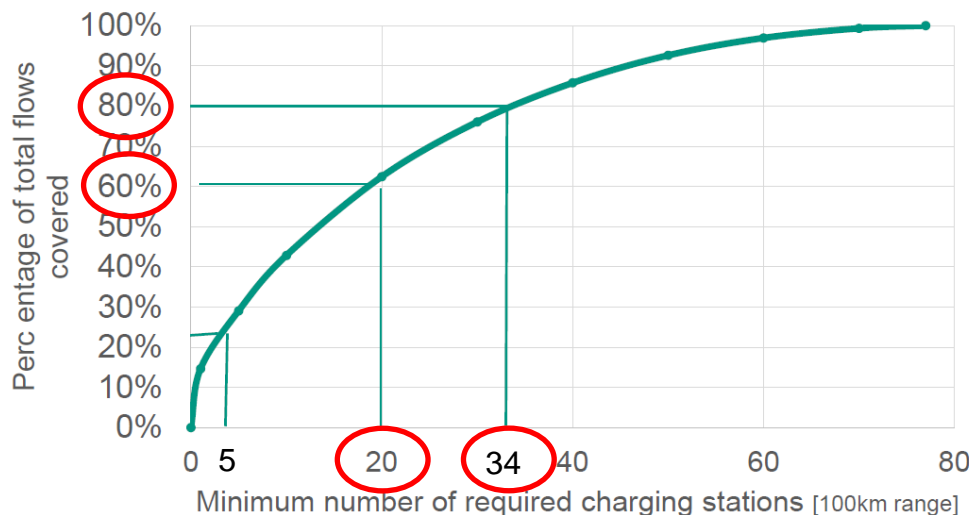
- Inclusion of technical components in some fast EVSE for additional grid services → **Increases distance** between EVSE and transformer.
- **Reactive power compensation** also favorable for the local grid environment (e.g. inclusion of photovoltaic systems).
- Due to very **heterogeneous low voltage grid architectures** analysis (simulations) have to be accomplished for the individual grids (e.g. REG).



[Krasselt 2016]

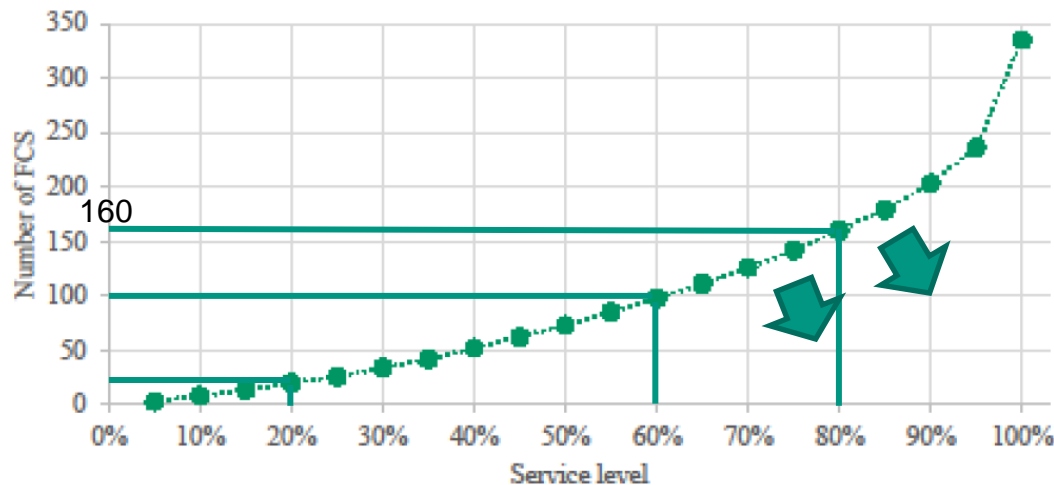
Location Planning: Case-study South-Germany

- **Flow Refueling Location Model** that locates a given number of stations on a network to maximize the covering, based on Caparelli et al. (2013), 100km EV range
- Input: Road network, Origin-Destination(OD) flows, distance data
- Potential locations: existing service stations or all exits

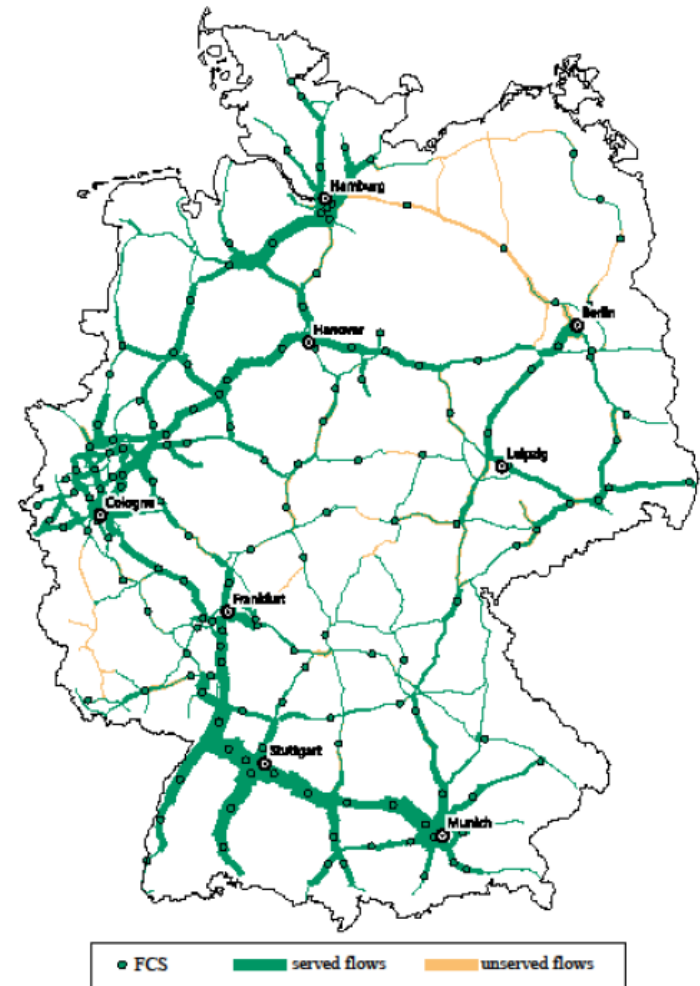


[Jochem et al. 2015]

Location Planning: Case-study Germany

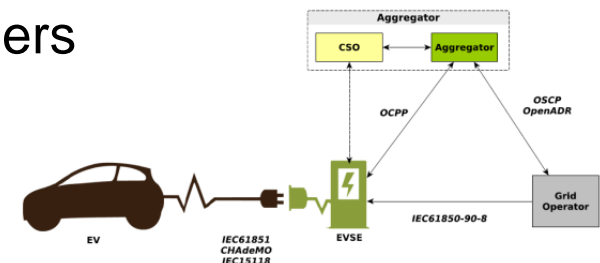


- If potential locations include all exits
→ 80% coverage at 120 fast EVSE
- EV range of 150km,
→ 80% coverage at 99 fast EVSE



Adequacy of the deployment: Early findings

- High power requirements of the EVSE will have a **sizeable impact on the load profile and distribution**.
- Effects occur at lower voltage levels and are **mainly local**.
- Charging can be a **major strain or potential on system flexibility**
- To leverage the potential the following is required:
 - **Interconnection** of EV, EVSE, DSO and aggregators
 - Implementation of **attractive dynamic electricity pricing** mechanisms instead of weak price signals for individual consumers
 - **Overcome the barriers** of a lack of standardization, interoperability, on board IT and regulatory frameworks.
 - **Improvement of the coordination** of car manufacturers, network operators, regulators and consumers





- **Building an international charging Infrastructure** requires ...
 - comprehensive **knowledge** of the necessary EVSE physics,
 - its **harmonization** with the help of international standards,
 - elaborate **tariffs** and
 - basic and meaningful value added **services** as well as their connection via eRoaming.
- EV markets and EVSE networks are still in **development phase**, however
 - an **increasing tendency** can be observed in the deployment of publicly accessible charging infrastructure
 - national **frameworks** and local **policy** support will push market shares
 - the optimal **balance** for the EV/EVSE ratio remains difficult to determine.
- **Charging will mainly be performed at home and work**
 - Load shifting potentials have to be leveraged to avoid problems
- **Fast charging infrastructure has to be allocated optimally**

Thank you for your attention

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