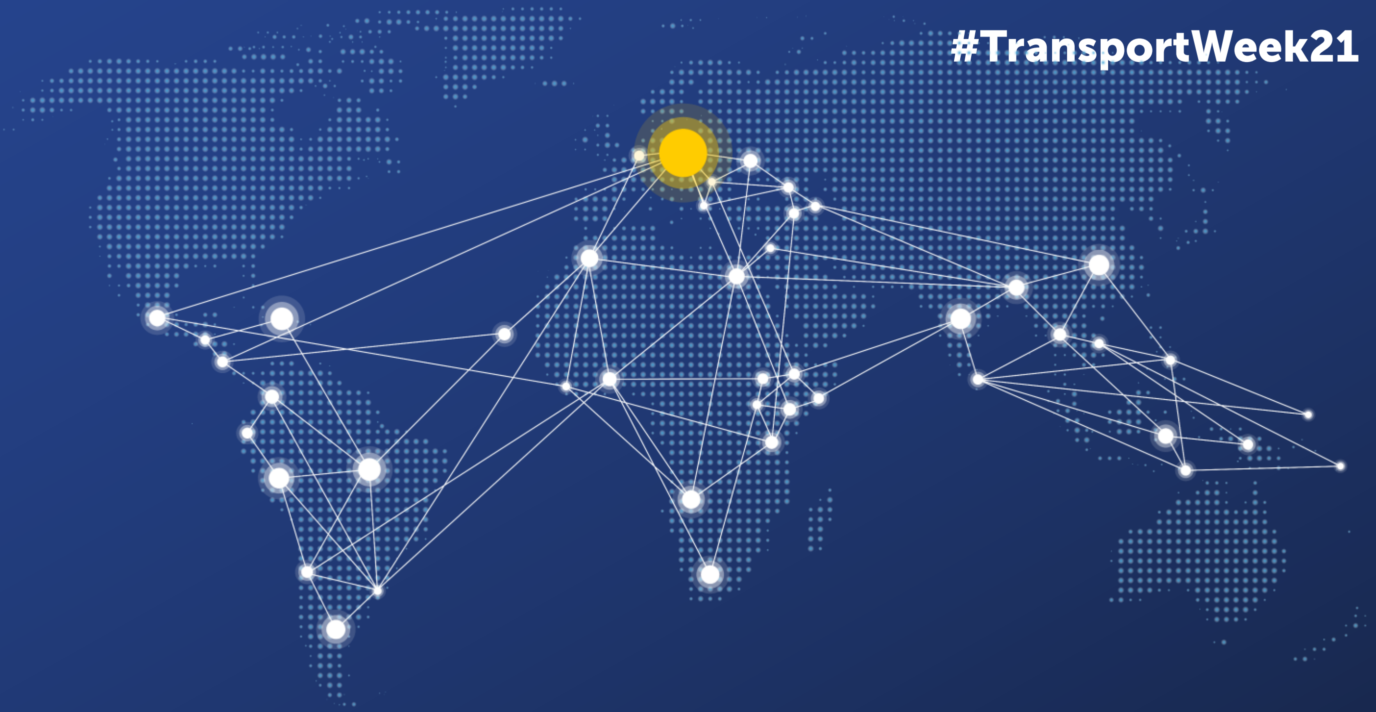
Transport and Climate Change Week

#TransportWeek21



International Experience on EV Integration

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CHANGING TRANSPORT Facilitating climate actions in mobility
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
On behalf of: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety of the Federal Republic of Germany

Contents

01 EV Integration in UK

02 EV Integration in Stromnetz Berlin GmbH, Germany

03 Impacts of EV Integration in Norway

04 Time based EV tariffs, California, USA

05 Power Quality Issues due to EV Integration

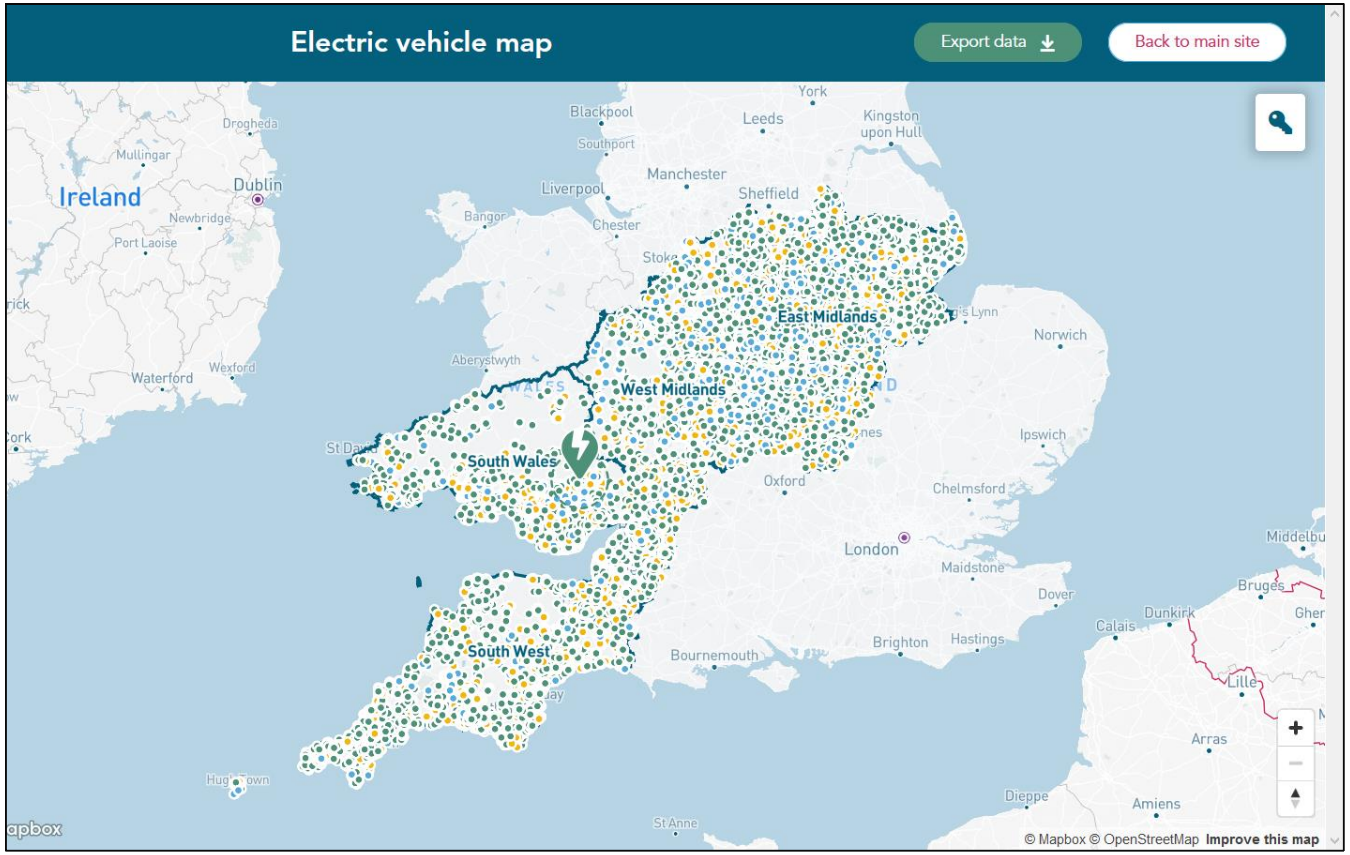
06 V2G Regulations, Netherlands & Denmark

07 Barriers for V2G

08 Parker Project

EV Integration in UK

- To accommodate EV charging the UK system operators are playing an active role.
- Installation of each EV charger (residential/commercial) in UK's Northern PowerGrid must be approved by their respective utility operators, prior to their installation.
- The utilities determine the headroom availability in the distribution network and check for upgradation requirements
- The utilities have also created publicly accessible maps for their respective regional zones, showing the headroom availability in the distribution substations



Interactive map released by WPD showing the capacity available in each distribution substation for placement of EV chargers (Source: Western Power Distribution)

"Your Guide to Electric Vehicle Charging." 2019. Northern Powergrid. https://www.northernpowergrid.com/asset/0/document/5486.pdf

Requirements for Consumers - Stromnetz Berlin, Germany

The following requirements are set for the users that are served by Stromnetz Berlin

- Newer houses in Stromnetz Berlin's territory generally have enough available contracted power capacity to be able to accommodate a 11kW EV (3 x 16A) charger.
- There is an obligation for all users to register their charging unit with their network operator.
- Each connection point must have its own Residual current device (RCD)
- EV chargers connected to the German low voltage grid has to comply with VDE-AR-N 4100 standard.

Stromnetz Berlin, https://www.stromnetz.berlin/elektromobilitat/ladeinfrastruktur-fuer-elektromobilitaet

Charge Management Schemes - Stromnetz Berlin, Germany

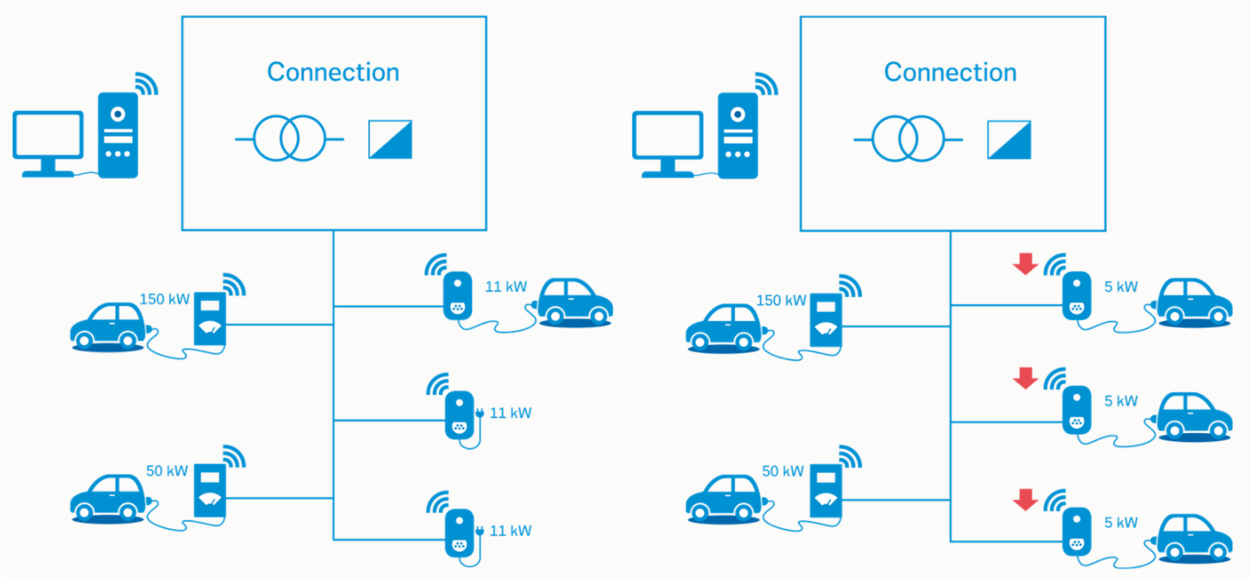
The DSO also has charge management schemes in place

Passive Charge Management

This is dumb charging, and the vehicles are charged at their maximum power capacities

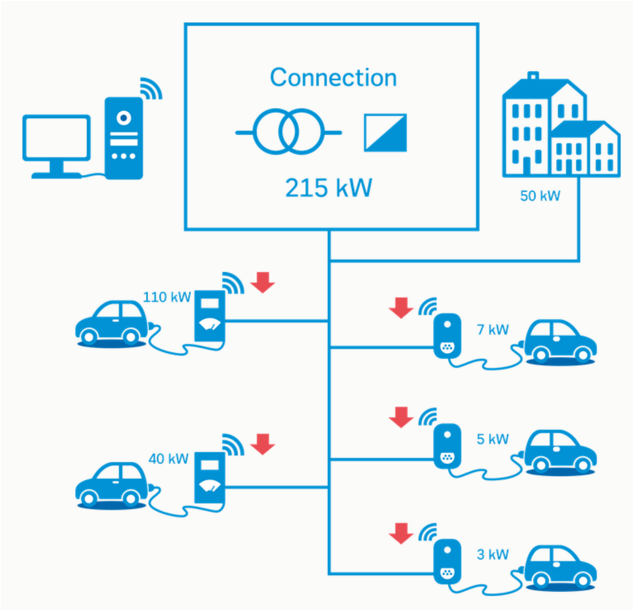
Static Charge Management

The available charge margin is shared between all the charging points



Active Charge Management

The available power margin for charging is distributed proportionally to the maximum power capacities of each EV



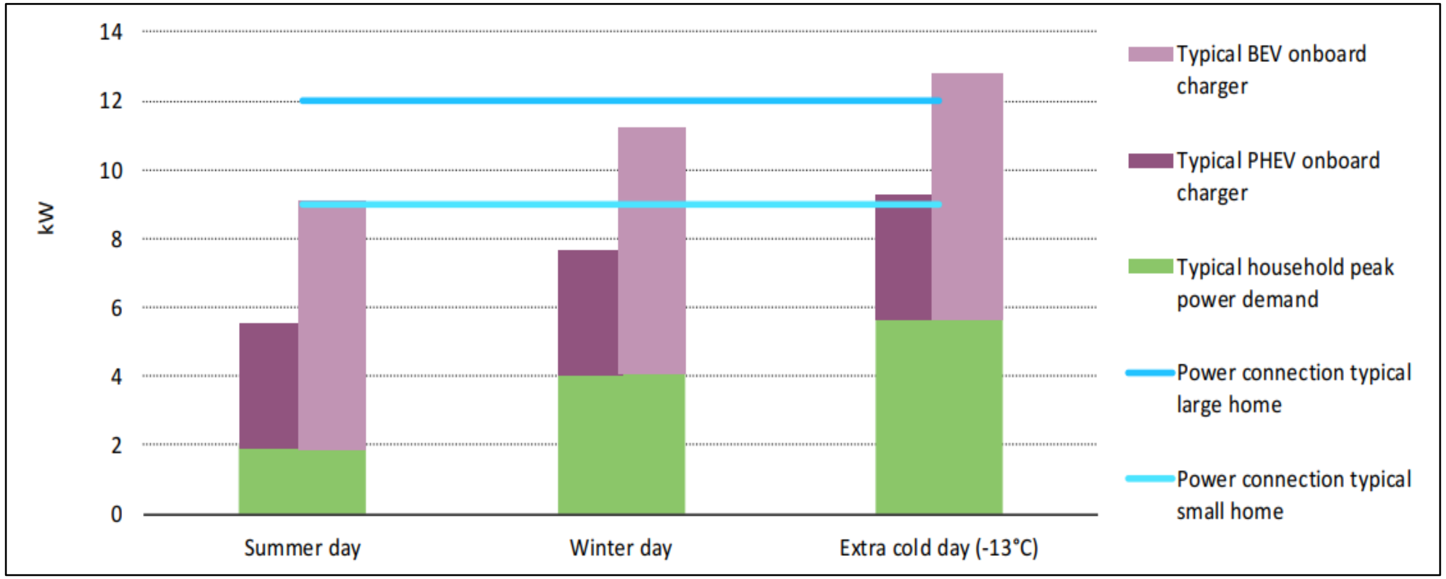
Dynamic Charge Management

The overall performance of a grid parameter such as loading of distribution transformer, loading of transmission cables etc. is monitored and based on the current status of the observed parameter the charging power is allocated to each EV

"Charging Management System." Stromnetz Berlin. https://www.stromnetz.berlin/en/electric-mobility/charging-management-system.

Impacts of EV Integration, Norway

- In 2017, the electricity demand due to EVs in the Nordic countries was 500 GWh, which was negligible compared to its total annual electricity demand (393 TWh in 2018)
- In Norway, the demand from EV only accounted for 0.14% of the country's annual electricity demand in 2017.
- In the case all of 2.7 million passenger electric vehicles were to be electrified, the additional energy demand in the system due to vehicle charging requirements would about 6.5 TWh, which is 6% of the country's total demand
- An increase in power consumption by 1-2 kW per household would lead to overload in nearly 10% of all transformers of Norway.



Peak electricity demand of detached Norwegian houses with home charging

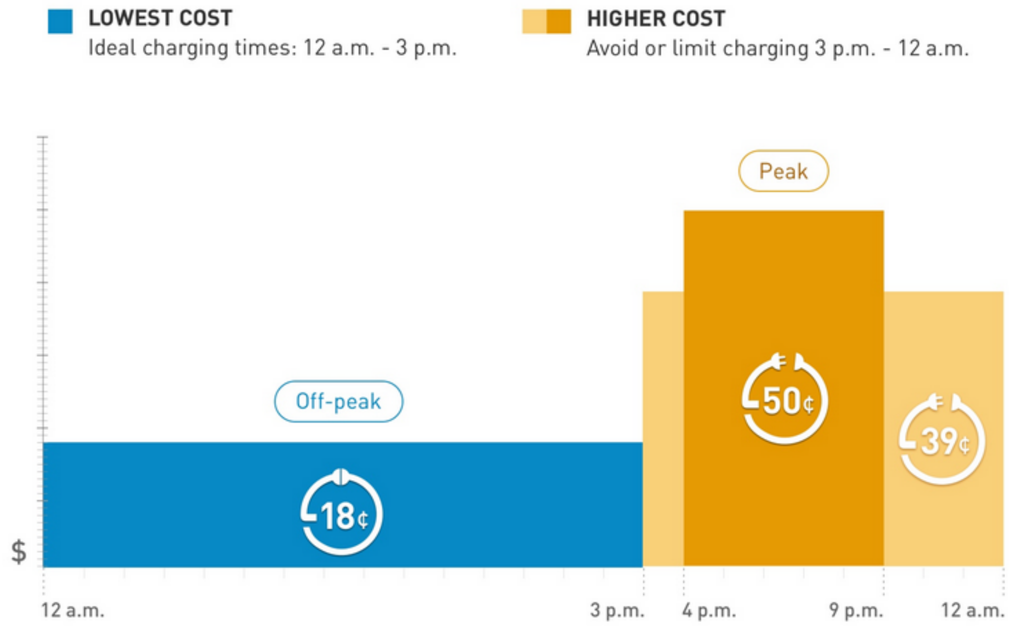
Time-based tariffs for EV charging: California, USA

All the three major utilities in California, Pacific Gas & Electricity Company (PG&E), South California Edison Company (SCE) and San Diego Gas & Electric Company (SDG&E) have ToU tariffs structured specifically for EVs.

PG&E also has two EV specific tariffs for the residential users

- EV2-A: This plan applies to the net energy usage of the household. So it is generally more beneficial to the users who have battery storage along with an EV, so that the energy usage maybe shifted to the low priced off-peak periods.

- EV-B: This plan needs an additional meter to record the energy needs for EV charging and the other customer load, so that the utility can track their EV charging separately from their home energy consumption.

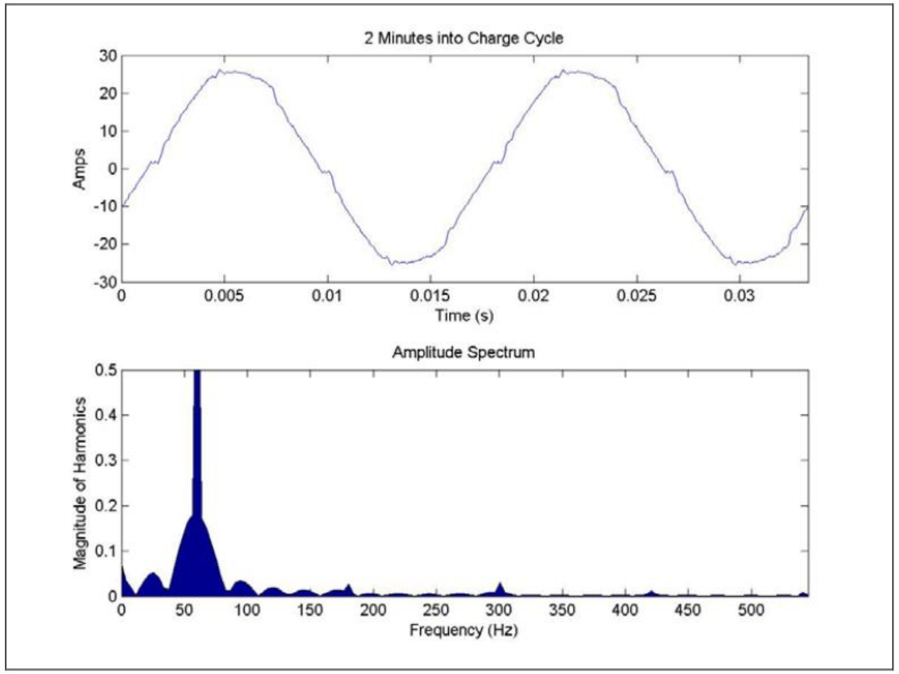


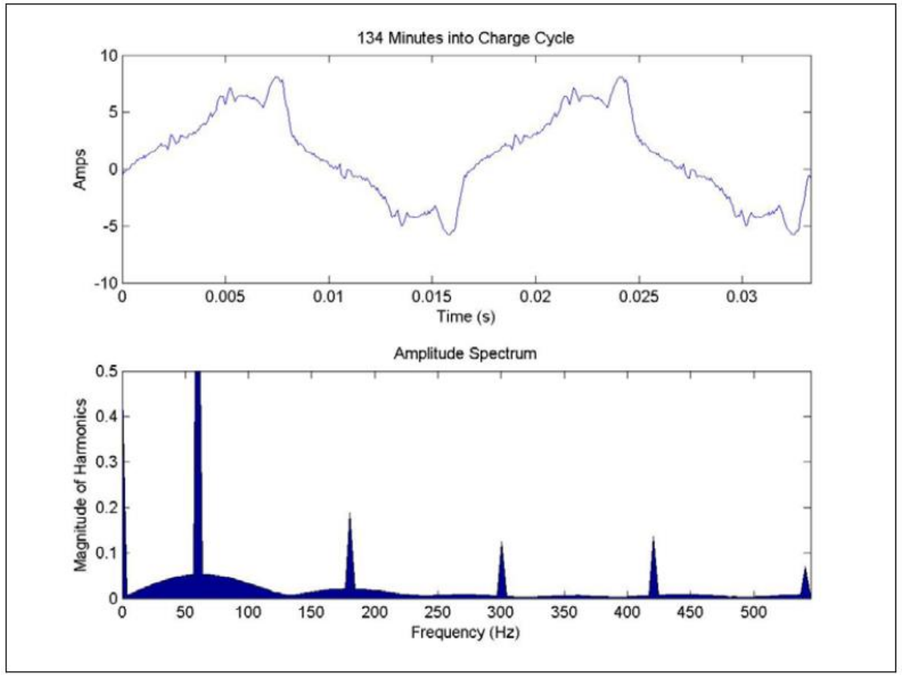
PG&E EV Tariffs, https://www.pge.com/en_US/residential/rate-plans/rate-plan-options/electric-vehicle-base-plan/electric-vehicle-base-plan.page

Power Quality Issues

The THD varies with the course of the charging cycle, with generally low THD seen during the initial phase of charging however worsening towards the end of the charging cycle.

Single Phase Charger

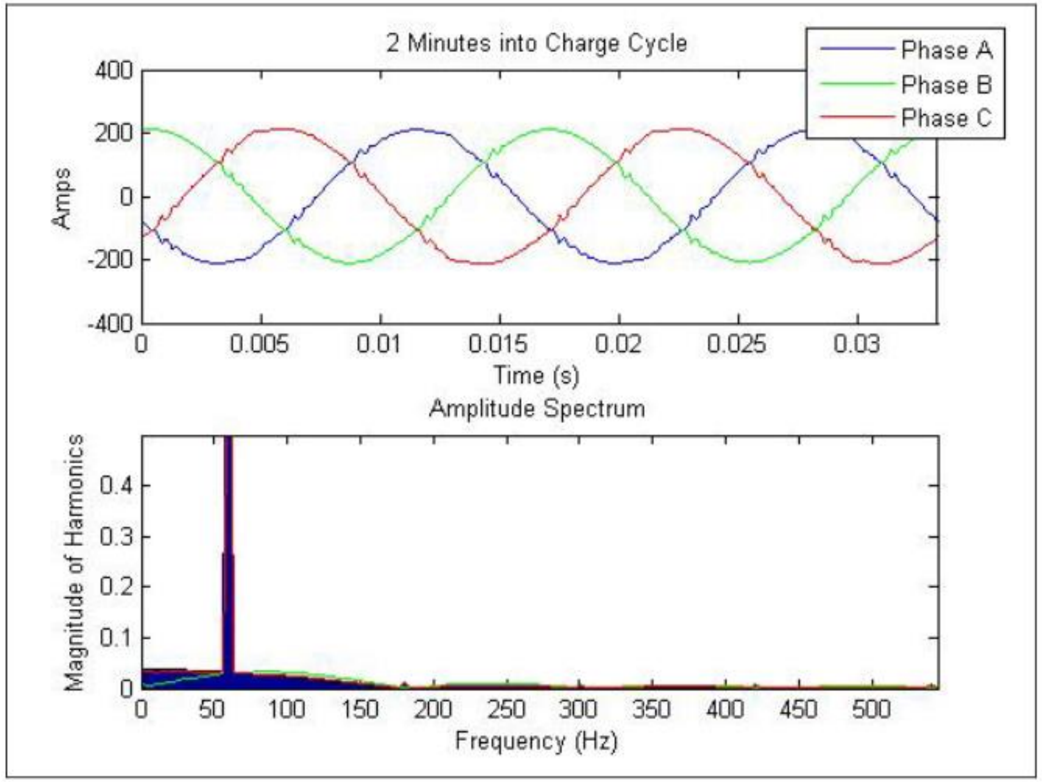


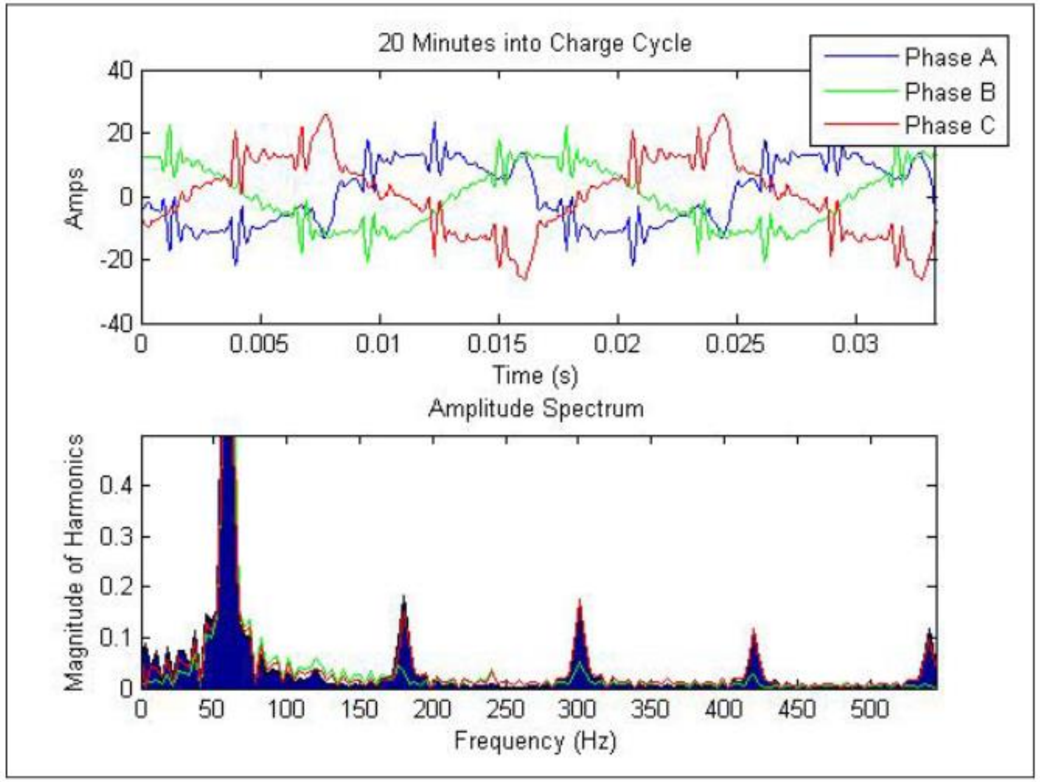


Bass, Robert, and Nicole Zimmerman. 2013. "Impacts of Electric Vehicle Charging on Electric Power Distribution Systems." OREGON TRANSPORTATION RESEARCH AND EDUCATION CONSORTIUM.

Power Quality Issues

Three Phase Charger



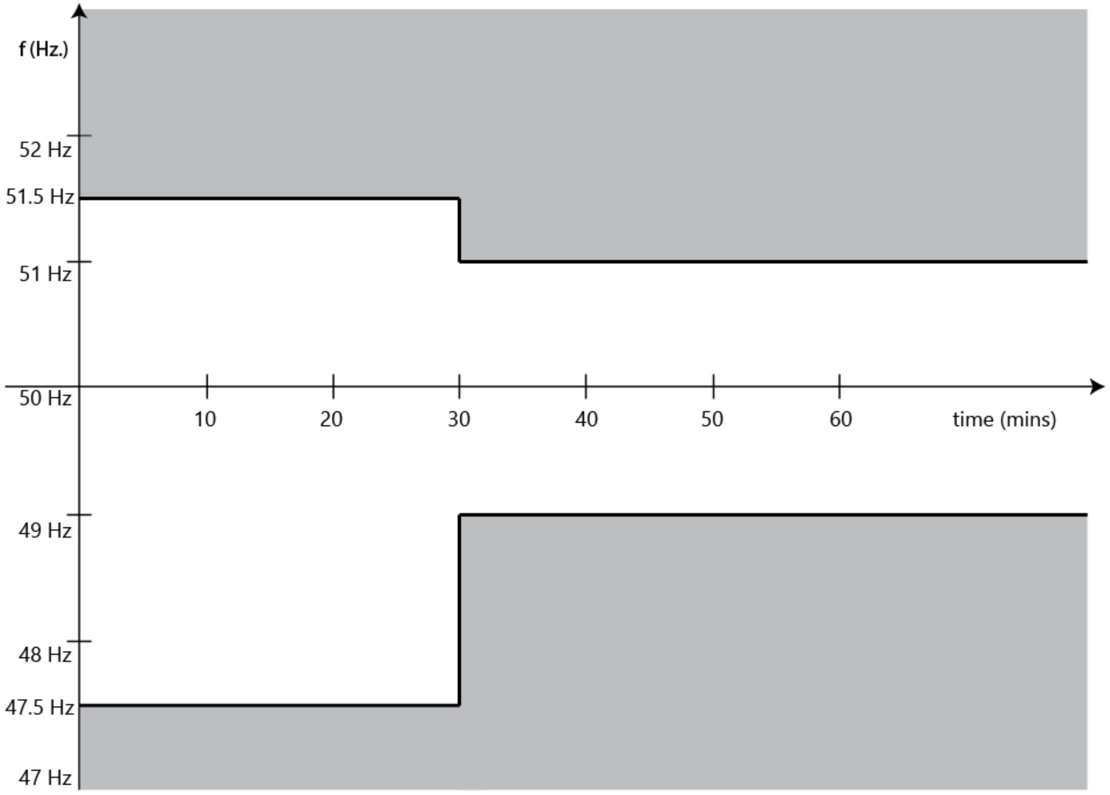


Bass, Robert, and Nicole Zimmerman. 2013. "Impacts of Electric Vehicle Charging on Electric Power Distribution Systems." OREGON TRANSPORTATION RESEARCH AND EDUCATION CONSORTIUM.

Requirements for V2G (Draft Regulation) 2019, Netherlands

ElaadNL has issued a draft for the general requirements for implementation of bidirectional charging

- The CPO which has bidirectional chargers installed should report the location of the V2X chargers to the local DSO via the platform www.energieleveren.nl/ .
- Unbalanced phase supply should be avoided.
- The V2X system must be equipped with means to automatically disconnect from the grid during power outage (anti-islanding).
- Grid code requirements for performance of V2X chargers during frequency and voltage events have also been mentioned.
- The communication between EVSE and EV for bidirectional charging should be conformity of the following standards
    - CHAdeMO
    - ISO/IEV 15118-20 (draft)
- The communication between EVSE and the central system is in conformity with the OCPP 2.0 specification
- The data to be provided consists of at least
    - Meter readings (every 15min), including current and voltage per phase
    - Location data of charging points
- The data is to be transmitted via
    - API
    - OCPI



The V2G charger (>800 W) is only allowed to disconnect from the grid in the shaded region

"CHARGING STATIONS Requirements for Bidirectional Systems." 2019. ELaadNL (December). http://electricvehicles.caa.ca/types-of-electric-vehicles/charging-stations/.

Grid Code Requirements for EVs, Denmark

Category	Rated Power
A1	$x \leq 11\ kW$
A2	$11\ kW < x \leq 50\ kW$
B	$50\ kW < x \leq 1.5\ MW$
C	$1.5\ MW < x \leq 25\ MW$
D	$25\ MW < x$

Minimum control functionality requirements

	A1	A2	B	C	D
Frequency Response (Over frequency)	Yes	Yes	Yes	Yes	Yes
Frequency response (Under frequency)	-	-	-	Yes	Yes
Frequency control	-	-	-	Yes	Yes
Absolute power limit	Yes	Yes	Yes	Yes	Yes
Ramp rate limit	Yes	Yes	Yes	Yes	Yes
Q Control	Yes	Yes	Yes	Yes	Yes
Power Factor Control	Yes	Yes	Yes	Yes	Yes
Automatic Power Factor Control	Yes	Yes	-	-	-
Voltage Control	-	-	-	Yes	Yes

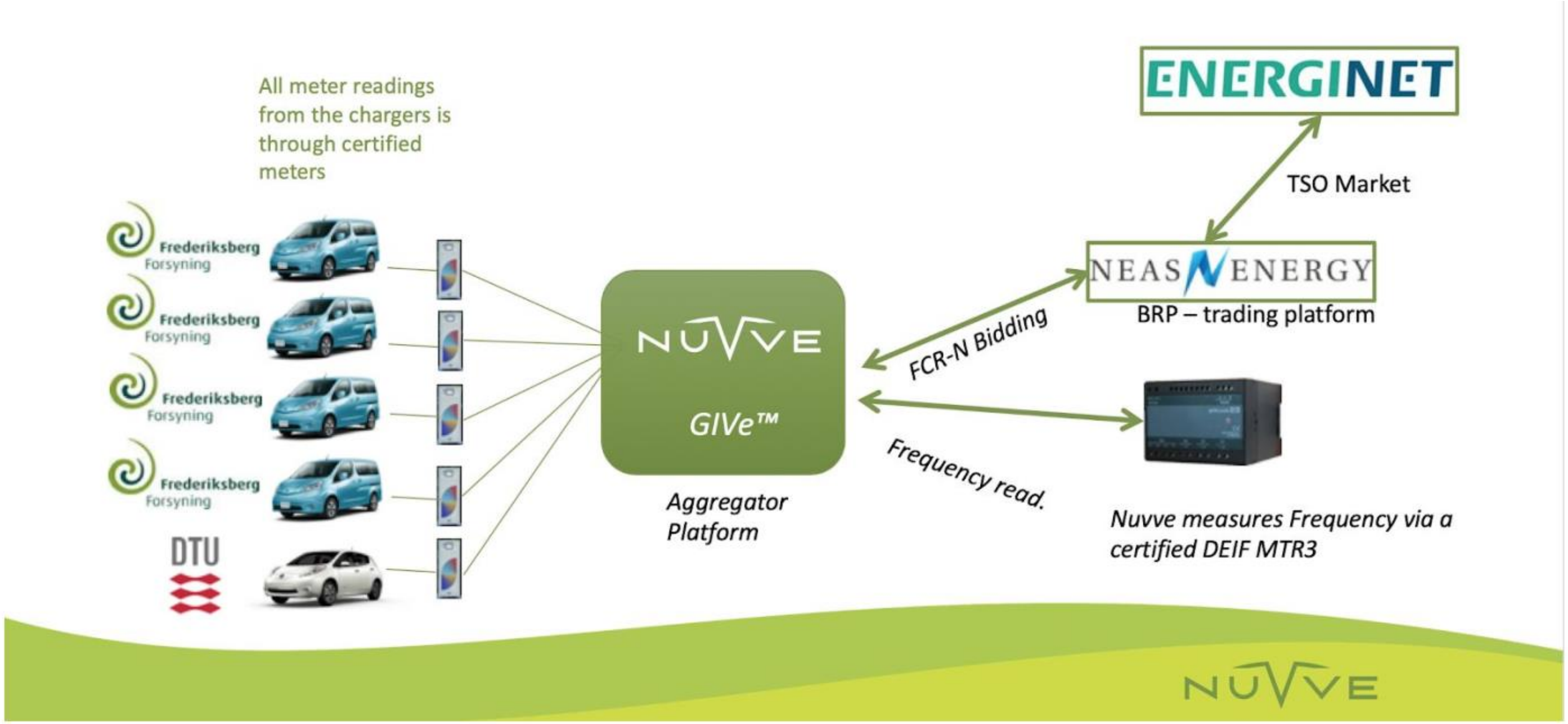
"Technical regulation 3.3.1 for battery plants", Energinet.dk, 2017

Barriers for V2G

Economic Barriers	Market reform	Current bidding rules are not effective for small scale fleet aggregators
	System investment	There is significant cost associated with the upgradation of monitoring and metering systems
	Dual taxation	High tax rate for both V2G charging and discharging limits V2G cost effectiveness.
Technological Barriers	Discharging capability	All the EV models are not designed to provide bidirectional power flow
	Emerging market	Public distribution level market is necessary to realize various V2G services for DSOs
	Battery lifetime	Insecurity about battery degradation due to V2G
	Small market	The limited number of EVs on the street that can provide bidirectional power
Social Barriers	User behaviour	Consumers need guidance and directions to make them acceptable of the new technology
	Trust in technology	The technology must be able to give customers the confidence that their travel needs would be not be affected
	Complexity of business models	The customers are also not likely to participate in V2G services if the terms and conditions of the business models are too complicated.
	Financial incentive	Participation in V2G services must give the customers a minimum amount of financial incentive in order to motivate them
	Lack of government support	Lack of communication about V2G and its opportunities for the society
	Lack of communication	Lack of Danish subsidy for purchase of EV results in lack of public support

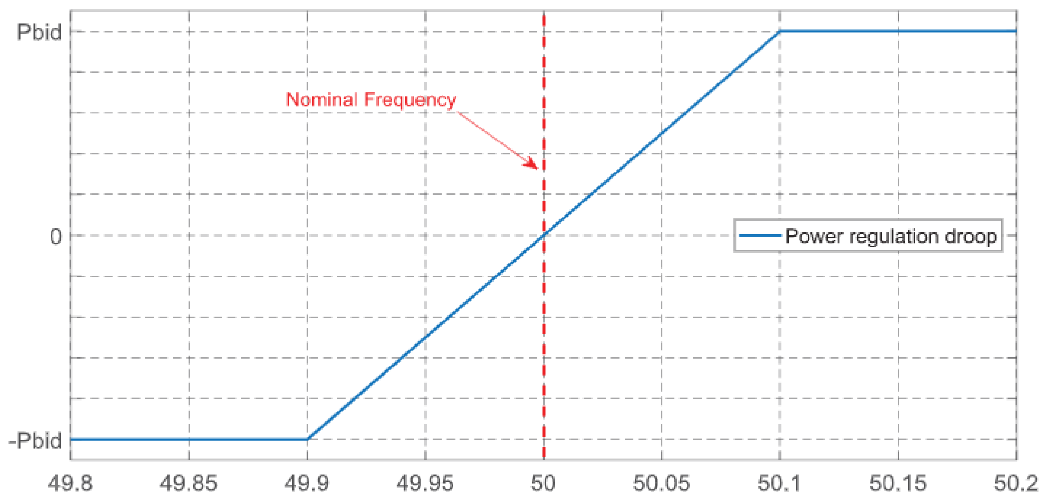
Parker Project, Denmark (2016-2018)

This project demonstrated the potential for EVs to provide grid frequency response services. 50 charging points were provided by ENEL and the aggregation software by NUVVE

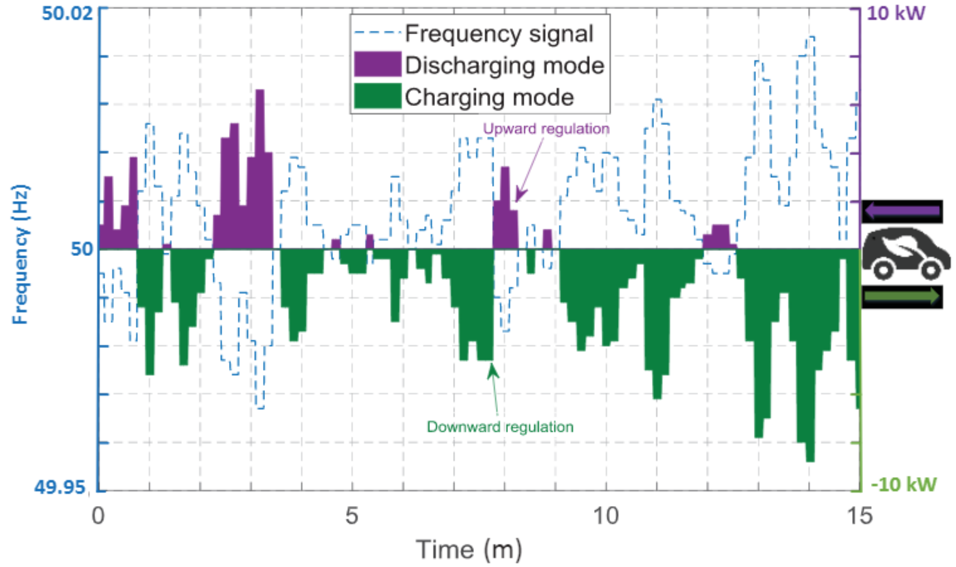


Andersen, Peter Bach et al. 2019. "Parker Project Final Report. Energy Technology Development and Demonstration Program (EUDP)."

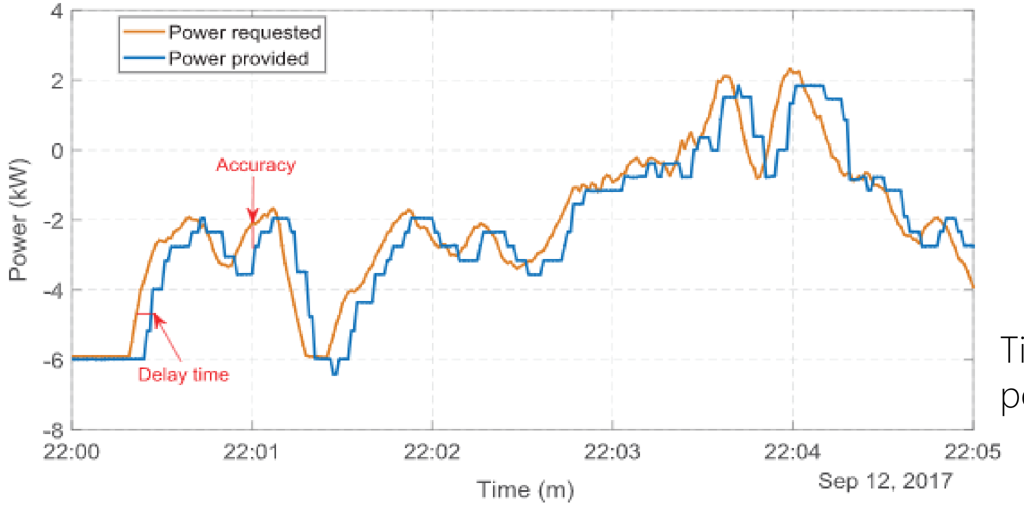
Parker Project, Denmark



Droop control for Regulation service



Regulation service provided by an EV



Time difference between power requested and power provided for one EV

Andersen, Peter Bach et al. 2019. "Parker Project Final Report. Energy Technology Development and Demonstration Program (EUDP)."

Conclusion

- The distribution network operators are generally playing an active role in monitoring the number of EV chargers connected to their system.
- The impact of EV is more significant for local distribution systems.
- Impact of EV load on annual energy requirement is minimal.
- Smart charging is one of the key technologies that needs to be enabled for future high EV penetration scenarios
- Time-based EV tariffs can be used to indirectly dictate the EV charging load and can help in peak load management as well as increased RE integration.
- Countries have started utilizing grid support services from EV.