The Parker Project: The grid integrated electric vehicle

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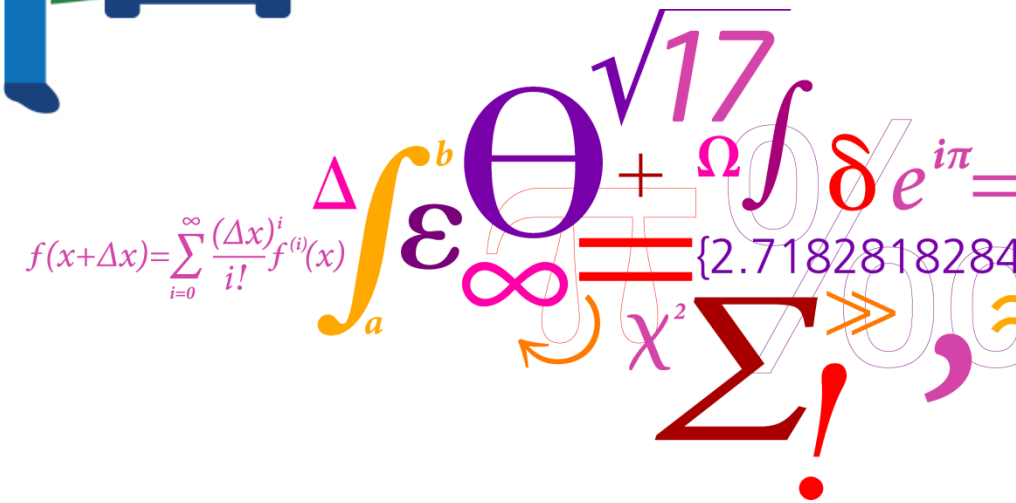
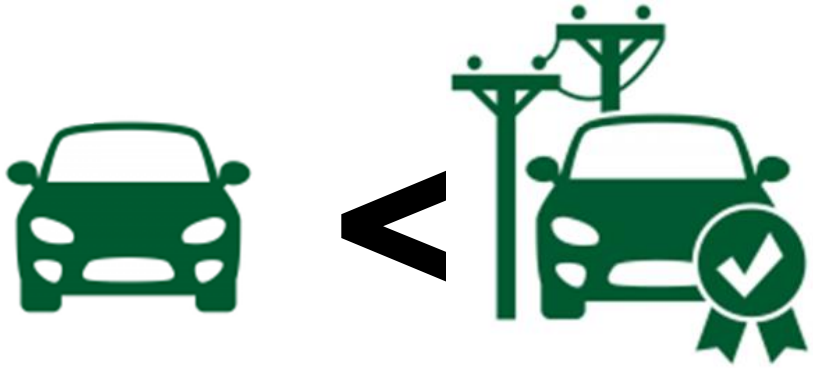


What is a grid integrated electric vehicle?



Agenda:

- Who are we
- Part 1, Background and challenges
- Part 2, Examples US and DK
- Part 3, Our projects and the future
- Questions

Center for Electric Power and Energy
Department of Electrical Engineering

Development of a reliable, cost efficient and sustainable energy system based on renewable energy

Near 100 staff members incl. 30 PhD-students

Research areas

Wind power

Electric component engineering

Electric power system engineering

PowerLabDK

Part 1, Background and challenges

The political agenda – CO2 reduction

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

Paris aftalen

"*Recognizing the need for an **effective and progressive response** to the urgent threat of climate change*"

Source: cop21.gouv.fr/

European Commission

EUs energi og klimaaftale

- Cut non-ETS* CO2 emission by **30%** by 2030 (from 2005)

*Non-ETS sector: transport, buildings, small industry and waste

- Highest potential in the **transport sector***

*1/3 of non-ETS CO2 emissions

A consistent push towards eMobility = a need to prepare for **electrification** and **integration**.

Electrification and integration:

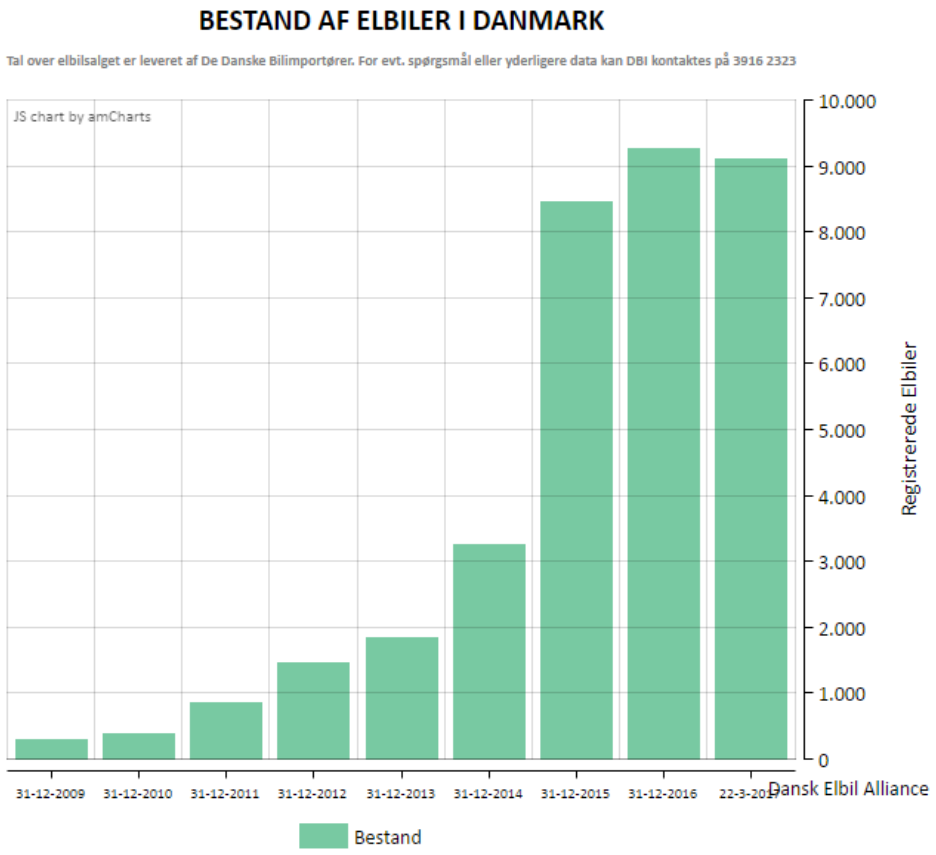
Electrification – a question of quantities

The electric vehicle as a new demand for power and energy that may challenge the existing power system.

Grid integration – a question of qualities

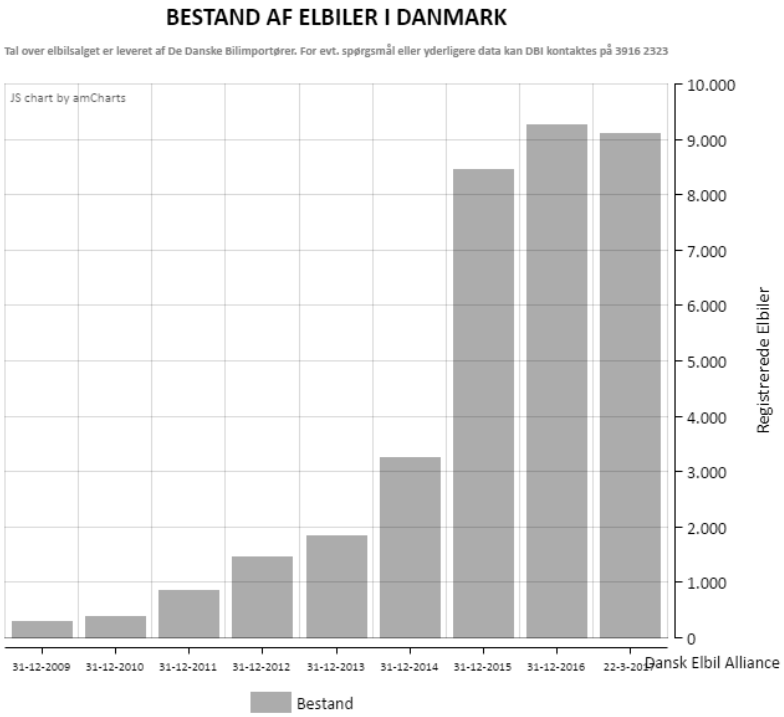
Using the new demand in a way that will actively support the future power system.

Electrification – a question of quantities



Source: Dansk Elbil Alliance

Electrification – a question of quantities



Kilde: Dansk Elbil alliance

9000  **Electric vehicles**

New electric demand

=

~3605  **Three person Family households**

Electrification – a question of quantities

Energy impact of

2.300.000 EVs

=

+ 12,5%*

Energy consumption

* Single EV consumption = 5 kWh/day
National consumption = 92 GWh/day

Electrification – a question of quantities

Power impact of

2.300.000 EVs

=

+ 111%*

Peak consumption

* EV simultaneity = 0.30
EV charging 6-7 PM@10 kW
National Peak demand = 6.2 GW

Grid integration – a question of qualities

Pergamon

Transpn Res.-D, Vol. 2, No. 3, pp. 157–175, 1997

1361-9209/97 $17.00 + 0.00

PII: S1361-9209(97)00001-1

ELECTRIC VEHICLES AS A NEW POWER SOURCE FOR ELECTRIC UTILITIES

WILLETT KEMPTON*
College of Marine Studies and Center for Energy and Environmental Policy, University of Delaware, Newark, DE 19716, U.S.A.

and

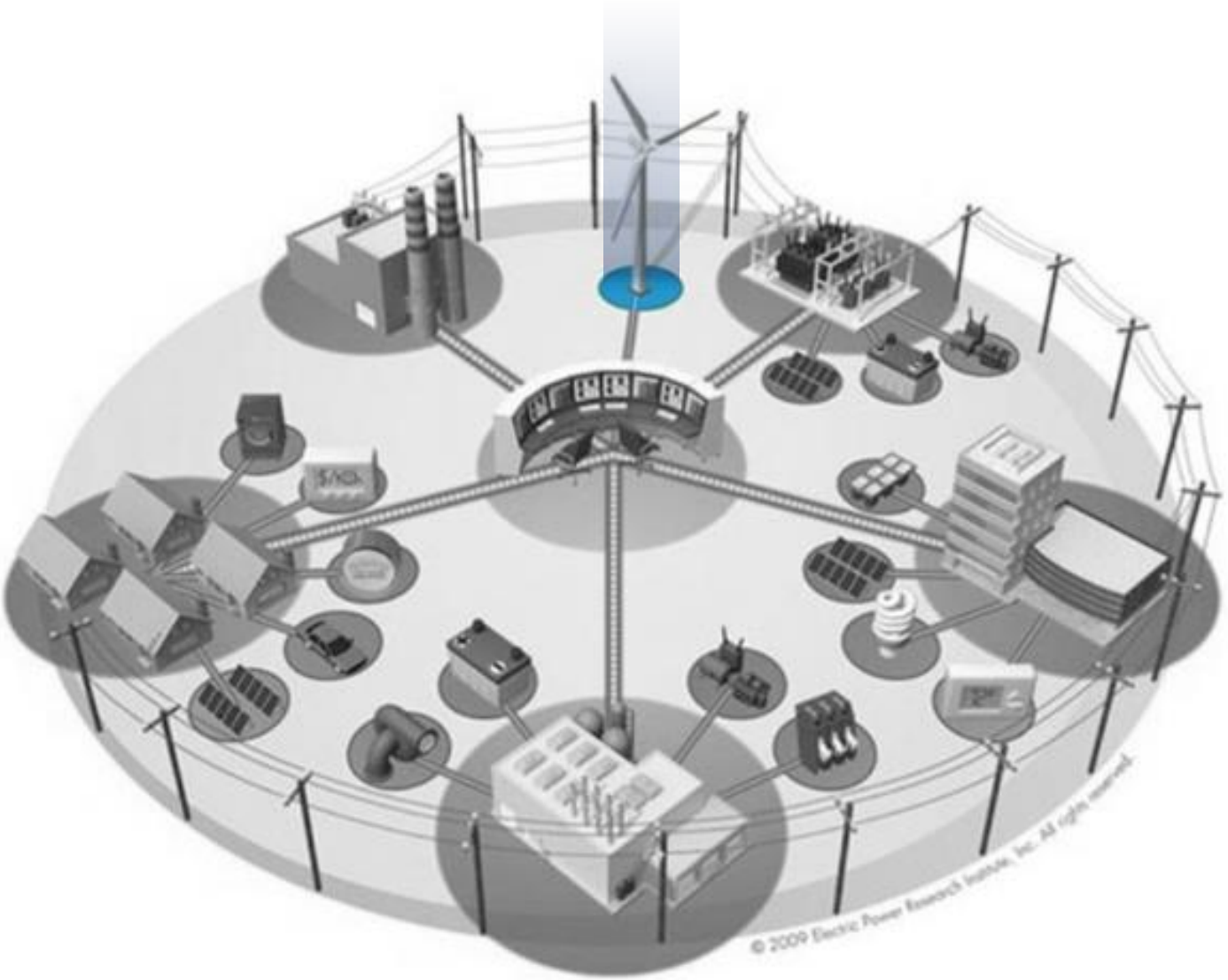
STEVEN E. LETENDRE
Department of Economics and Business, Green Mountain College, Poultney, VT 05764, U.S.A.

(Received 26 August 1996; accepted 18 December 1996)

"I was trying to find an inexpensive way to move the solar peak (at solar noon) to the load peak (typically 4 to 8 pm).

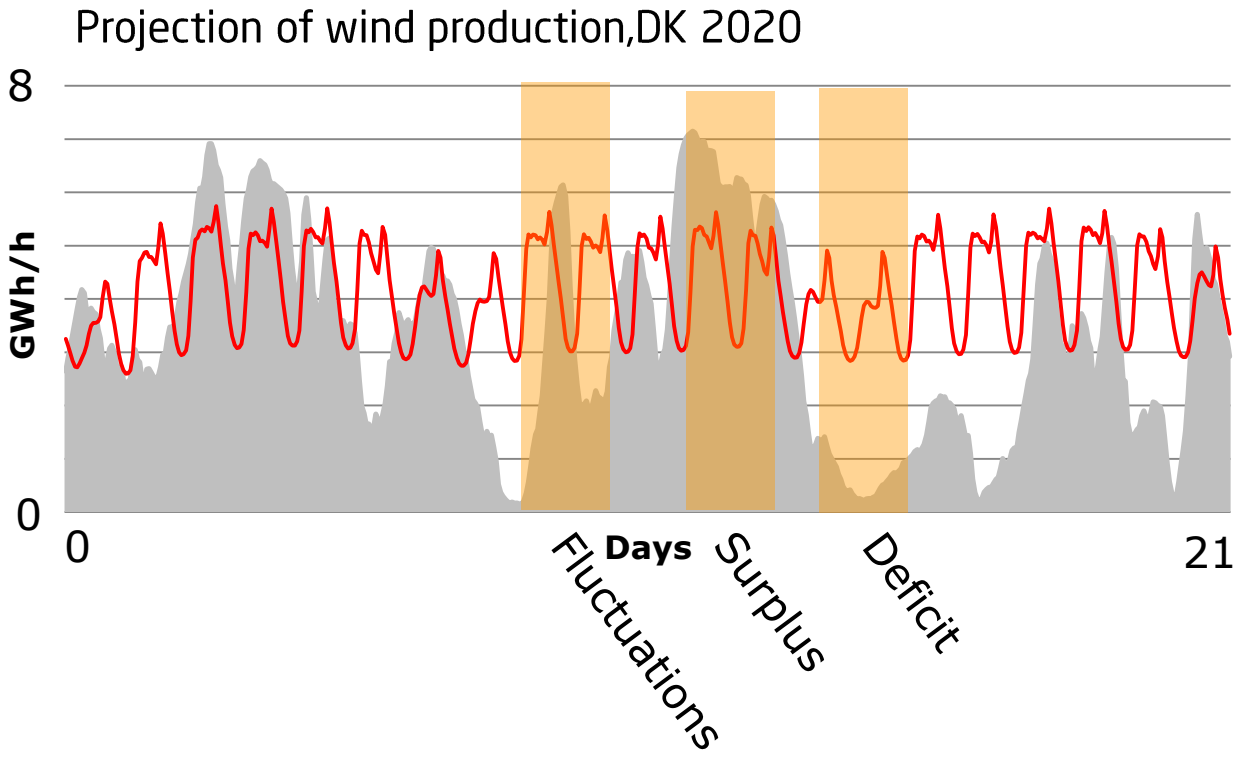
Then I went to an EV conference, and realized that there is going to be a **very big battery** in the garage."

Grid integration – a question of qualities

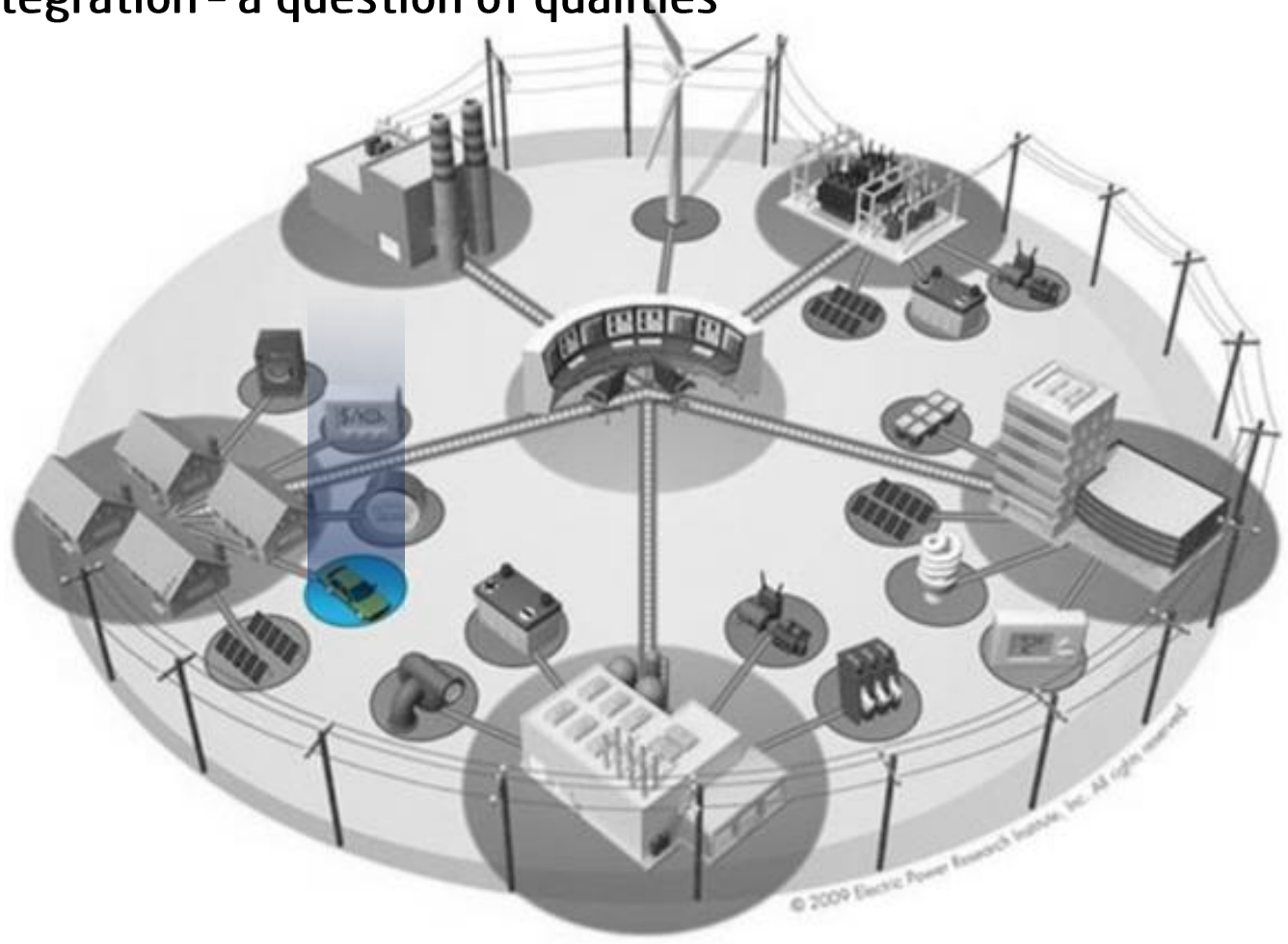


Grid integration – a question of qualities

Danish 2020 target - **50% of electric energy** consumption supplied by **wind power**



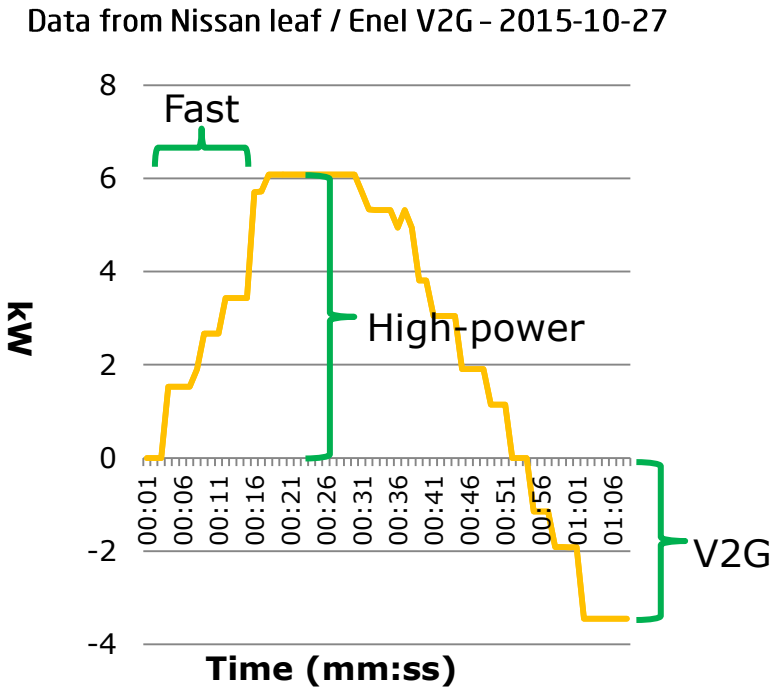
Grid integration – a question of qualities



Grid integration – a question of qualities

Special qualities:

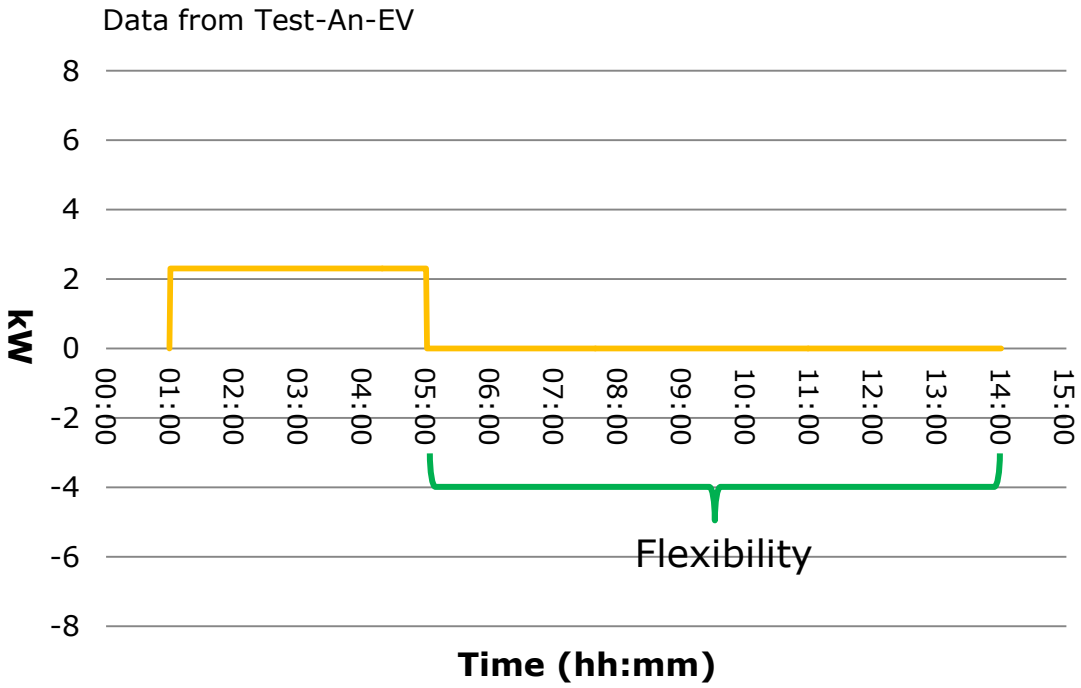
1. Fast response time.
2. High-power load
3. Possibility of V2G support



Grid integration – a question of qualities

Special properties:

1. Fast response time.
2. High-power load
3. Possibility of V2G support
4. High degree of flexibility



Part 2, Examples

Services

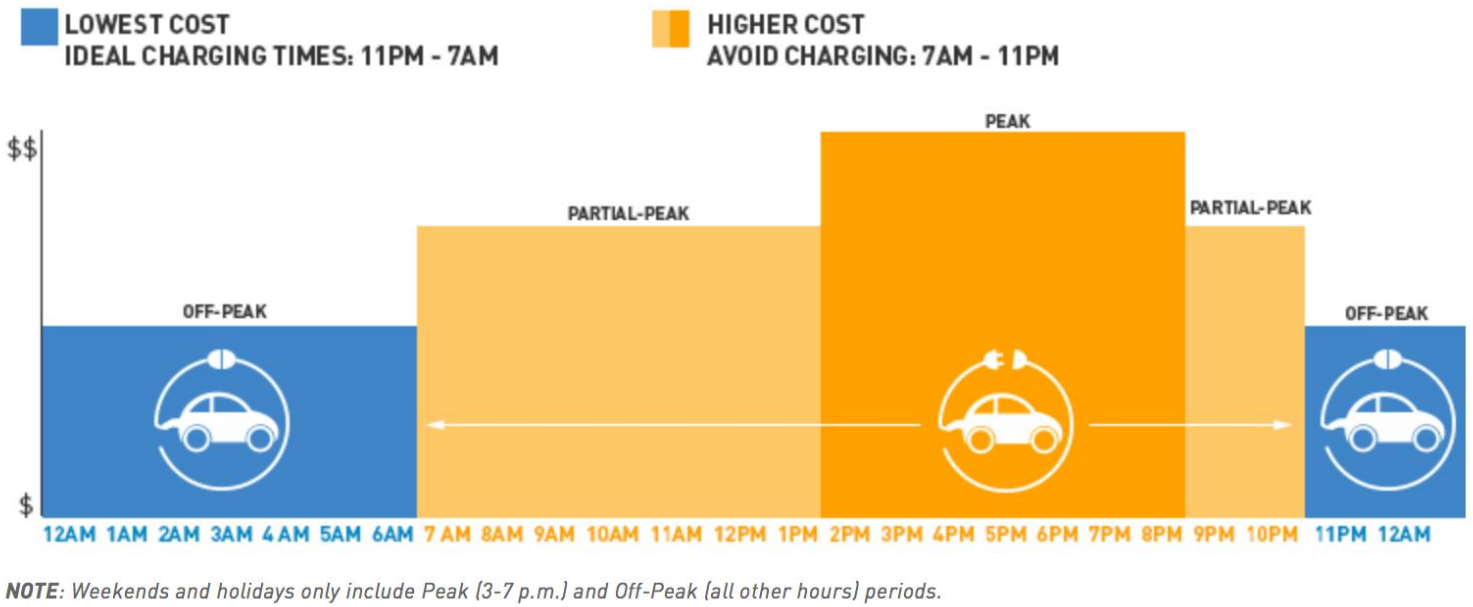
*"The act of influencing the **timing, rate and direction** of the power and energy exchanged between the **EV battery and the grid**"*

Example services:

- Adaptive charging
- Frequency regulation
- V2X

Services – adaptive charging

Charging is delayed in time based on knowledge in the price of energy or renewable content.



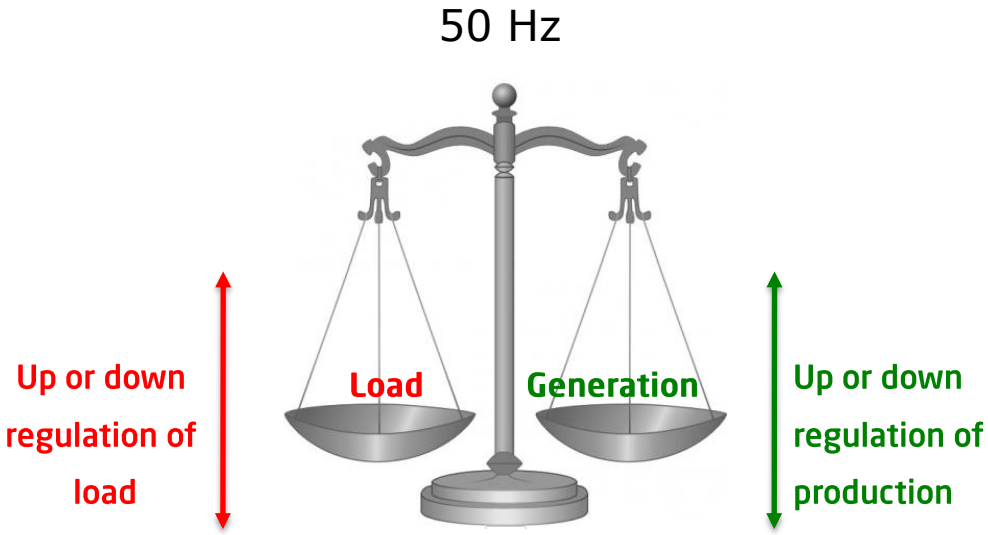
***NOTE**: Weekends and holidays only include Peak (3-7 p.m.) and Off-Peak (all other hours) periods.*

Services – adaptive charging

Charging is delayed in time based on knowledge in the price of energy or renewable content.

Services – Frequency regulation

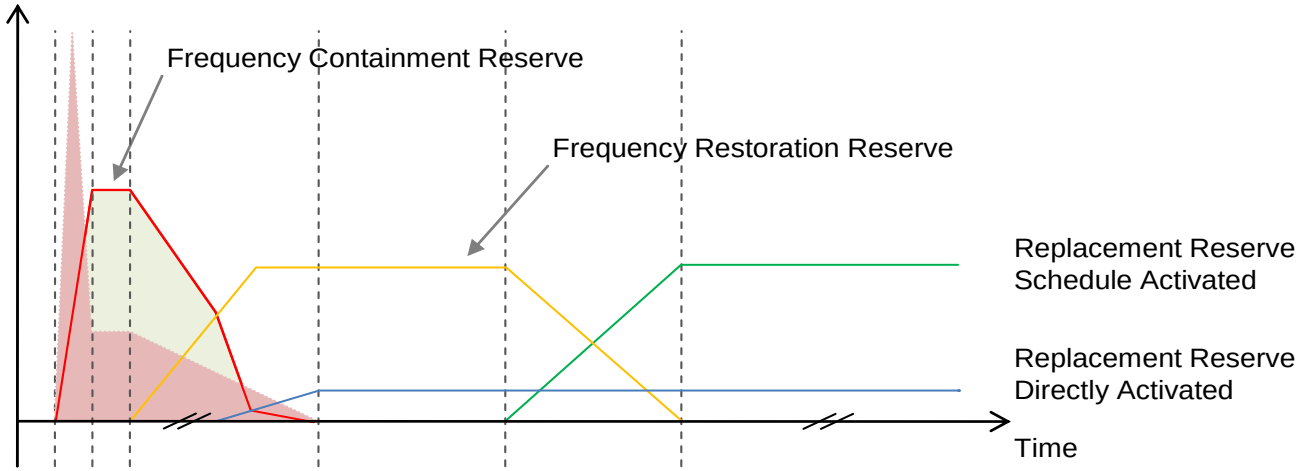
Vehicles charge or discharge to balance the grid



Services – Frequency regulation

3 "waves" of active power reserves:

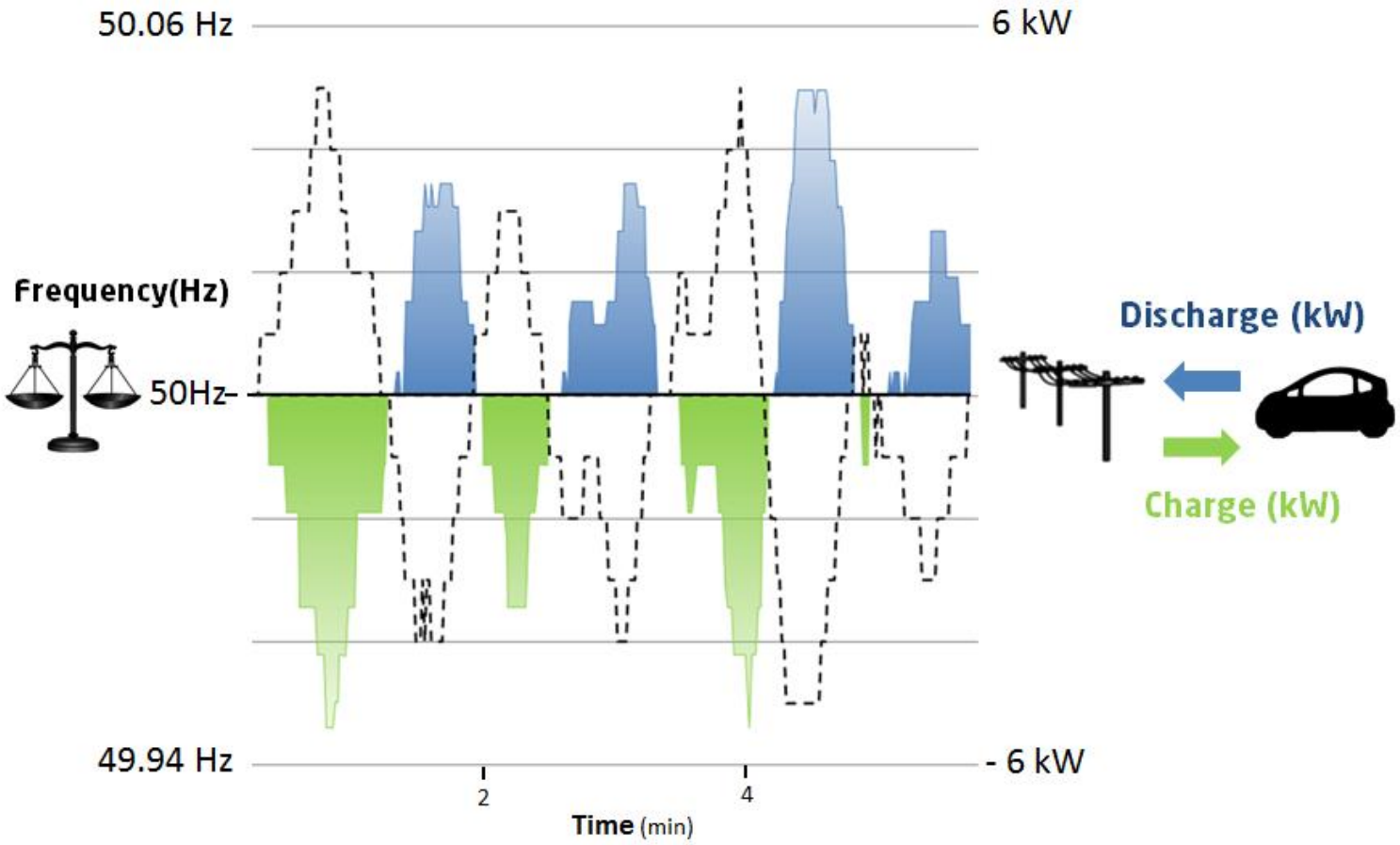
1. Frequency Containment Reserve (FCR, automatic)
2. Frequency Restoration Reserve (FRR, mostly automatic)
3. Replacement Reserve (RR, manual)



Source: Ole Jan Olesen 12-11-2013

* The terminology used here is a new one gaining traction in Europe. Energinet.dk has not yet adapted this terminology.

Services – Frequency regulation



Services – Frequency regulation

Frederiksberg Forsyning

- Utility company – domestic gas, tap water, district heating and sewage
- Approximately 100.000 Residents
- Part of greater Copenhagen

Partner:

NUVVE

NISSAN Innovation that excites

enel

Services – Frequency regulation

- 10x Nissan eNV200 electric Vans
- 10x ENEL V2G units (bidirectional 10 kW)
- Used mainly for maintenance and service tasks.
- Usage hours = Work day 7 AM – 4 PM

Services – V2X

To use the vehicle as a power source where the grid is not available.

Tohoku, Japan, Kilde: CHAdeMO

Heating

Kettle (700-1000W)

Electric blankets
(50W-90W)

Information access

Phone charging
(15W/phone)

Portable PC
(50W-150W)

Recovery support

LED floodlight (70W)

LED electric signs (200W)

Services - V2X

ROSKILDE FESTIVAL

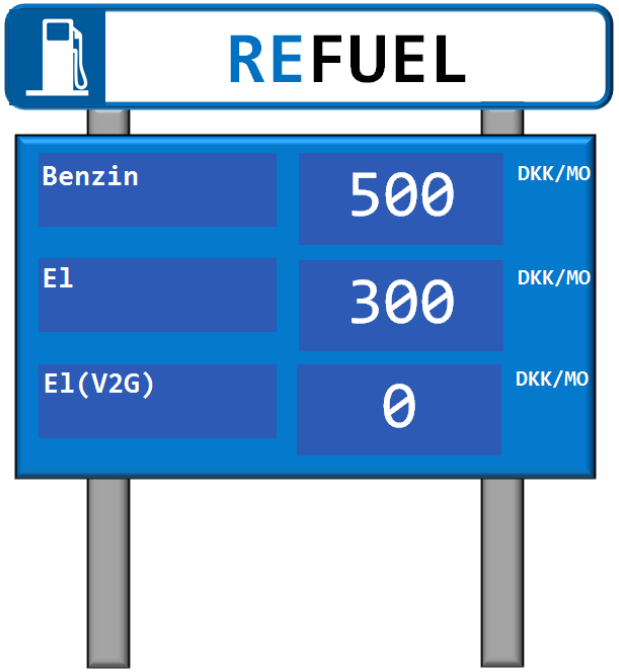
Efficent use of wind power in Denmark Energinet.dk

"Bliver der ikke indbygget denne intelligens i kommunikationen mellem elsystemet og det nye fleksible elforbrug, vil de samsundsøkonomiske gevinster ved at implementere elbil og varmepumper blive reduceret med **ca. 1.7 mia. Kr/år**."

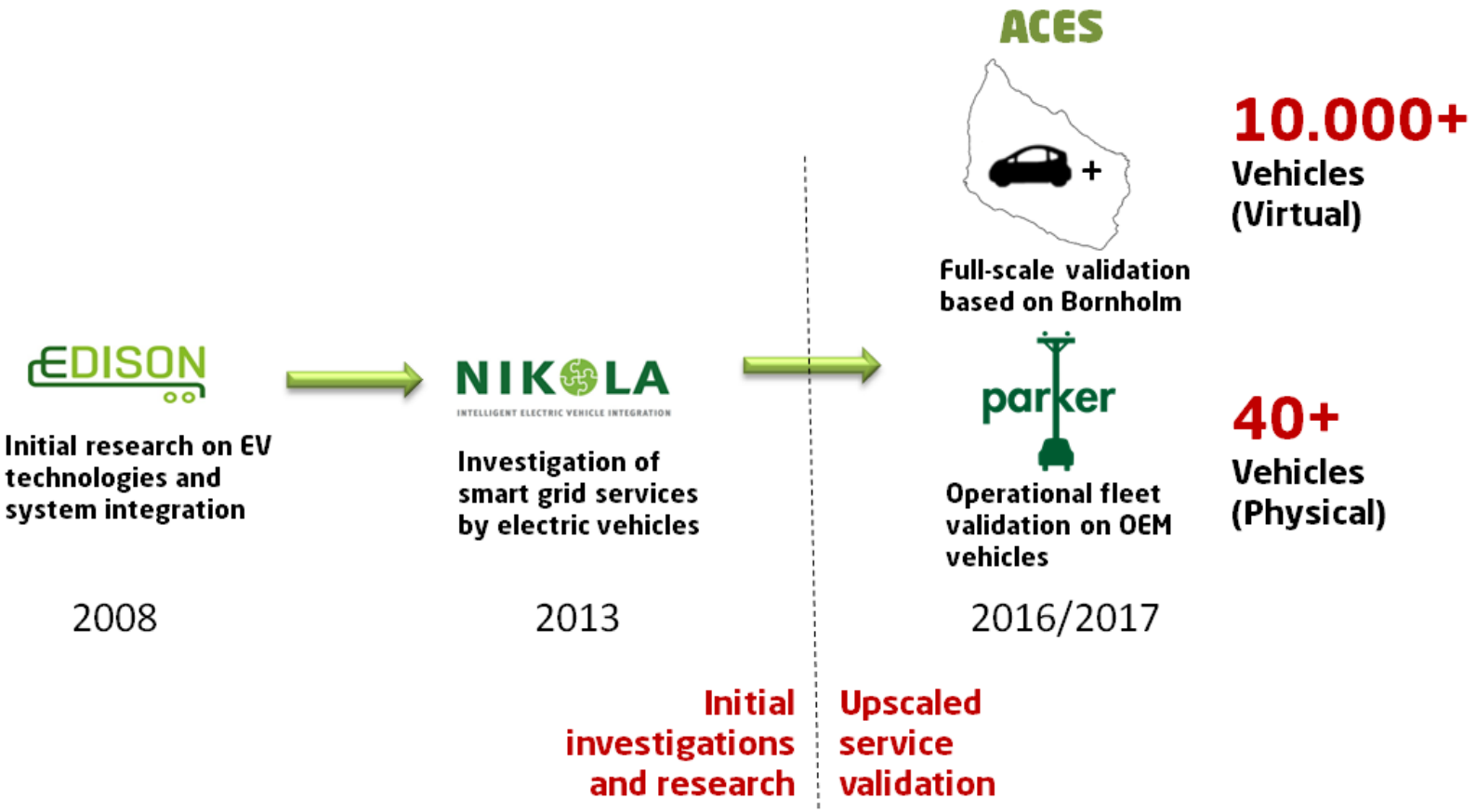
Potential market payment from frequency regulation

811 DKK / Month

(available 16:00-06:00, V2G, 10 kW)



Part 3, Our projects and the future


ACES
10.000+
Vehicles
(Virtual)
Full-scale validation
based on Bornholm
EDISON
NIKOLA
INTELLIGENT ELECTRIC VEHICLE INTEGRATION
parker
40+
Vehicles
(Physical)
Initial research on EV
technologies and
system integration
Investigation of
smart grid services
by electric vehicles
Operational fleet
validation on OEM
vehicles
2008
2013
2016/2017
Initial
investigations
and research
Upscaled
service
validation

Nikola project

Service catalog

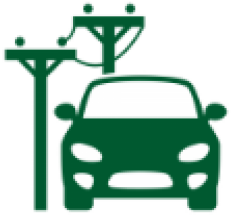
Definition						Evaluation *Danish case, now/near-term (<3 Years)*			
Type	Groups	Name	Short description	Behavior	Stakeholders & potential benefits	Value for system	Value for owner	Tech./ standard support	Market/ regulatory support
Power and energy services	System-wide services	Frequency regulation	Keeps the frequency in an interval around 50 Hz	Balancing***	Aggregator/EV Owner: Market earnings TSO: Larger, more competitive market	High	High	Medium/High	High
		Frequency regulation - very fast	Frequency regulation with ramping times and precision that go beyond what traditional generators can provide	Balancing***	Aggregator/EV Owner: Market earnings TSO: New/Improved service	High	High	Medium/High	Low
		Secondary regulation	Replaces frequency regulation and restores the frequency to 50 Hz	Balancing***	Aggregator/EV Owner: Market earnings TSO: Larger, more competitive market	Medium	Low	Medium/High	Low
		Tertiary regulation	Replaces secondary regulation and fulfils a higher requirement to energy capacity and delivery timescale	Balancing***	Aggregator/EV Owner: Market earnings TSO: Larger, more competitive market	Low	Low	Low	Low
		Synthetic inertia	Mimics rotational inertia by taking advantage of the fast chemical reaction of batteries	Balancing***	Aggregator/EV Owner: Market earnings TSO: New/Improved service	Medium/High	Low	Low	Low
		Adaptive charging	Delays or advances charging in time based on e.g. energy costs or renewable contents	Adaptive*	Aggregator/EV Owner: Energy cost or CO2 savings	High	High	Medium/High	Low
		MORE - Mother of all regulation	Includes all the abovementioned traditional types of regulation in one - assuming a large fleet of EVs.	Balancing*** Energy backup** Adaptive*	Aggregator/EV Owner: Market earnings TSO: New/Improved service + Larger, more competitive market	Low	Low	Low	Low
	Distribution grid services	Islanded micro grid and black start	Enables one or a set of EVs to sustain a small power system	Energy backup**	EV owner: Security of supply.	Low	High	Low	Low
		LV network balancing	Mitigates unbalances between phases of LV network	Balancing***	Aggregator/EV Owner: Unknown DSO: New service	Medium	Low	Low	Low
		LV overvoltage management	Mitigates overvoltage of LV feeders	Balancing*** Adaptive*	Aggregator/EV Owner: Unknown DSO: New service	High	Medium	Medium	Medium
		MV-LV transformer and lines overloading	Mitigates overloading of transformers and cables of LV network	Adaptive*	Aggregator/EV Owner: Unknown DSO: New service	High	Medium	Medium	Low
		LV congestion due to fast charging stations	Manages EV fast charging to keep within operational limits of LV network	Adaptive*	Aggregator/EV Owner: Unknown DSO: New service	High	Medium	Medium	Low
ICT Services	User added services	Charging management	Support EV service participation for the EV owner through interface.		Aggregator/EV Owner: Added simplicity for service participation		High	Low	
		Charging flexibility assessment	Estimates whether sufficient charging flexibility exists in order to participate in services.		Aggregator/EV Owner: Knowledge on charging flexibility		High	Low	
		Charging information	Presents the EV user with the information most relevant when controlling (dis)charging of the EV		Aggregator/EV Owner: Improved information service		Low	Medium	
		Vehicle-to-load	Enables the EV to supply electric energy to the EV user in places where access to the general electric grid is impossible or impractical		EV Owner: New electric energy services		Medium	Medium	

Adaptive Charging* | Energy Backup** | Balancing***

Physical demonstrations

Parker project

Thomas Parker, 1843 – 1915



Explore and **demonstrate** new EV services using state-of-the-art vehicles and chargers.

A **Common definition** of technical capabilities needed to support services

Understand scalability in terms of system and market impacts and **replicability** across users and regions.


ELECTRIC LAB
PowerLabs
V2G
enel
parker
parker


SYSLAB

The grid integrated electric vehicle = An electric vehicle designed to support the power system through services,

- ✓ Move consumption, balance the grid via V2G or act as a power source.
- ✓ Contribute to a more economic power system and lower EV ownership costs
- ✓ Denmark is in a good position to support this development

Twenty years after Willett defined the grid integrated electric vehicle it is being demonstrated in Frederiksberg.

Questions?

More info:

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www.evlab.dk

www.parker-project.com