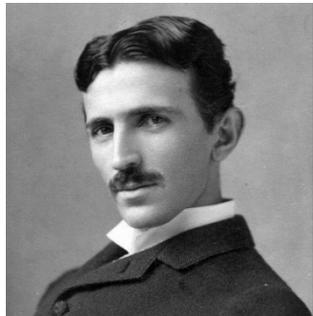


# Introduction to the Nikola project

The solar and electric mobility revolution conference

Amsterdam, 2015-03-31

Peter Bach Andersen, Postdoc, Technical University Of Denmark



NIKOLA

INTELLIGENT ELECTRIC VEHICLE INTEGRATION

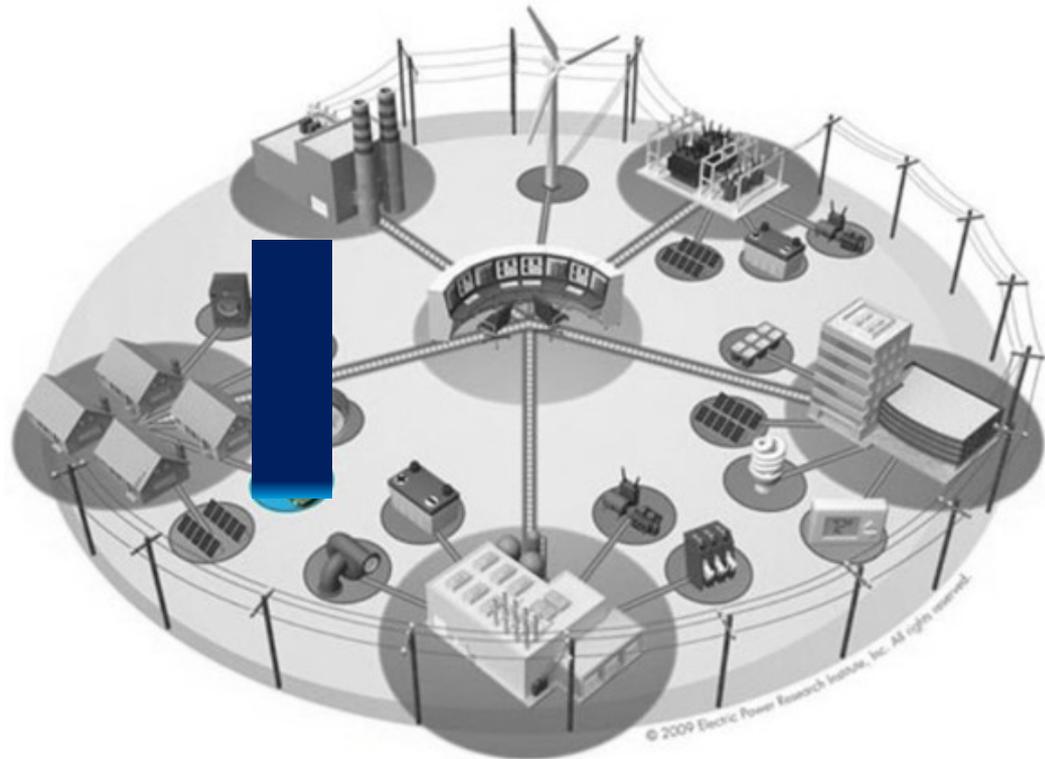


# Challenges

A change in how energy is **produced** and **consumed**

## Consumption

- Flexible
- Increase

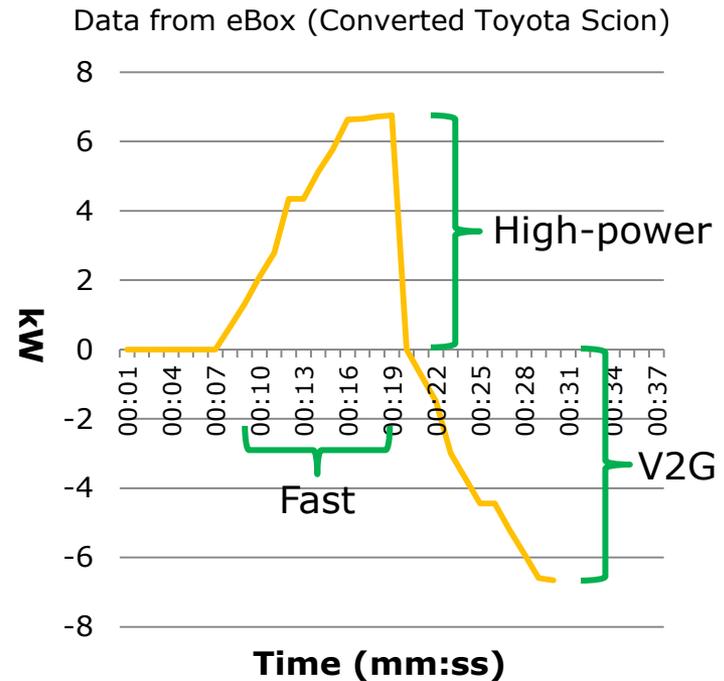


# The Electric Vehicle



## Special properties:

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

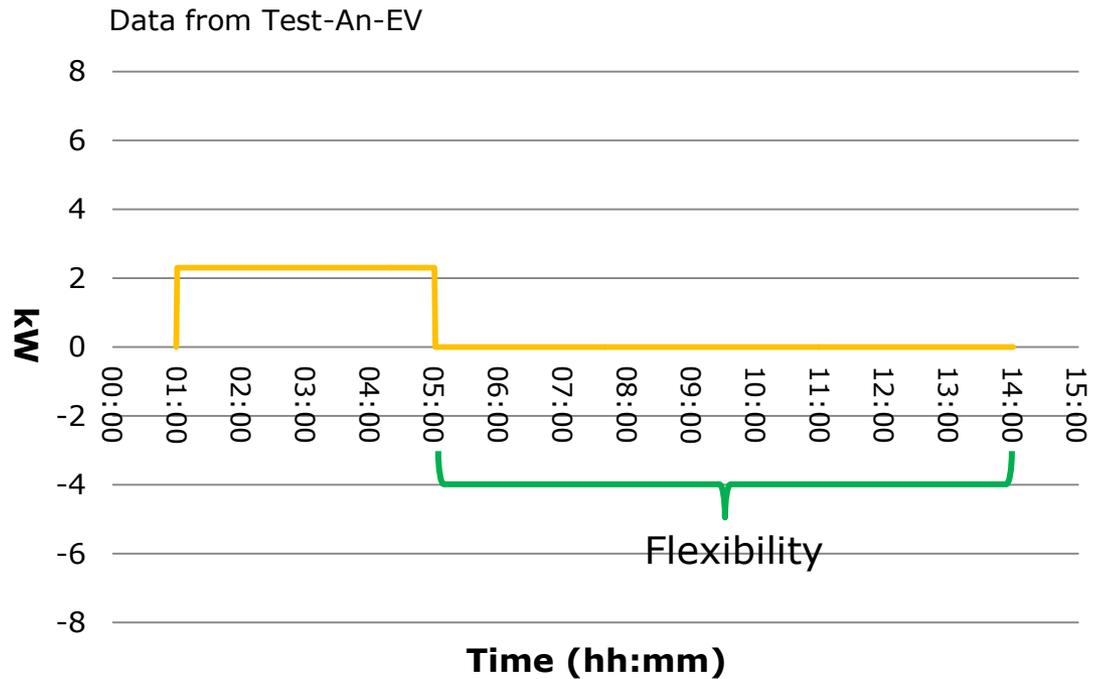


# The Electric Vehicle



## Special properties:

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



# The Electric Vehicle

*"...If this intelligence is not developed in the communication between power system and the new flexible demand, the socio-economic benefit of electric vehicle and heat pump integration will be reduced by approximately DKK 1.7 billion per year."*

Energinet.dk report "Smart Grid i Danmark"



**NIKOLA**

INTELLIGENT ELECTRIC VEHICLE INTEGRATION

## **Description:**

Nikola is a Danish research and demonstration project with a focus on the synergies between the electric vehicle and the power system.

## **Goal:**

Realize the EVs potential in supporting a stable and economic power system based on renewables and thereby reducing costs of the energy consumer and electric vehicle owner.

**Timing:** 2013 to 2016      **Budget:** € 2 million      **Funding:** ForskEl

**Partners:** SEAS-NVE, EURISCO, NUVVE, DTU

## Service definition

*"The act of influencing the **timing, rate and direction** of the power and energy exchanged between the **EV battery and the grid** to yield benefits for **user, system and society.**"*

# Structure and approach

System-wide services —

— Distribution grid services

User added services —

— Enabling technologies

**NIKOLA**

INTELLIGENT ELECTRIC VEHICLE INTEGRATION

# Structure and approach

## Work package 1



Bjørn  
Christensen

System-wide services

User added services

## Work package 2



Mattia  
Marinelli

Distribution grid services

Enabling technologies

## Work package 3



Peter Bach  
Andersen

## Work package 4



Claus  
Amtrup



# Nikola service catalog

Systematically gather and list power and energy services relevant for electric vehicles.

## System-wide Services



Market Integration



Renewable Integration

- Frequency regulation
  - Frequency regulation - very fast
  - Secondary regulation
  - Tertiary regulation
  - Synthetic inertia
  - Adaptive charging
  - MORE\*
- \* **Mother of all regulation services**

## Distribution Grid Services



Grid Services



Local DER Mix

- Islanded microgrid and black start
- LV network balancing
- LV overvoltages management
- MV-LV transformer and lines overloading
- LV congestions due to fast charging station

## User added Services



Usage Patterns



Added Value Service

- Charging management
- Charging flexibility assessment
- Charging information
- Vehicle-to-X

# Nikola service catalog

## Academia

### System-wide Services



**Pierre Pinson**  
Professor  
DTU Elektro

### Distribution Grid Services



**Samuele Grillo**  
Researcher  
Politecnico of Milano

### User added Services



**Michael Kai Petersen**  
Associate professor  
DTU Compute

## Industry



**Preben Nyeng**  
Senior engineer  
Energinet.dk



**Henrik Weldingh**  
Engineer  
Former Danish Energy  
Association employee



**Ole Alm**  
Business developer  
SEAS-NVE

# Nikola service catalog

## Service Evaluation

### System-wide Services



Market Integration



Renewable Integration

- Frequency regulation
  - Frequency regulation - very fast
  - Secondary regulation
  - Tertiary regulation
  - Synthetic inertia
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### Distribution Grid Services



Grid Services



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### User added Services



Usage Patterns



Added Value Service

- Charging management
- Charging flexibility assessment
- Charging information
- Vehicle-to-X

- **Value proposition and economics?**
- **Technical feasibility and standardization support?**
- **Market or regulatory challenges?**



# WP 1 – System-wide services



**Bjørn C.**  
NUVVE



**Ole J. O.**  
DTU

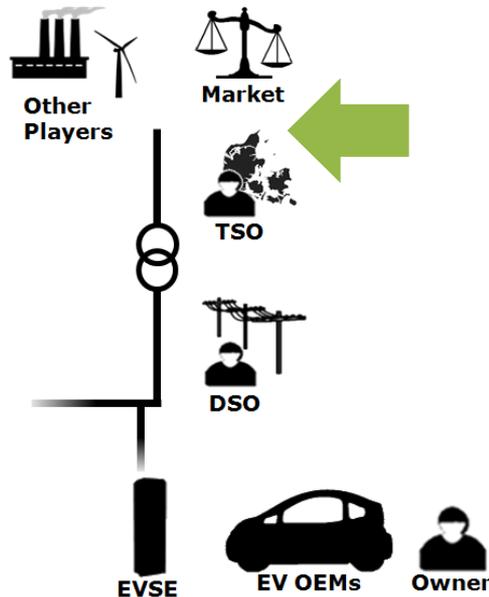


**Gregory P.**  
NUVVE



**Willett K.**  
NUVVE

## Current activities – WP1 System-wide services



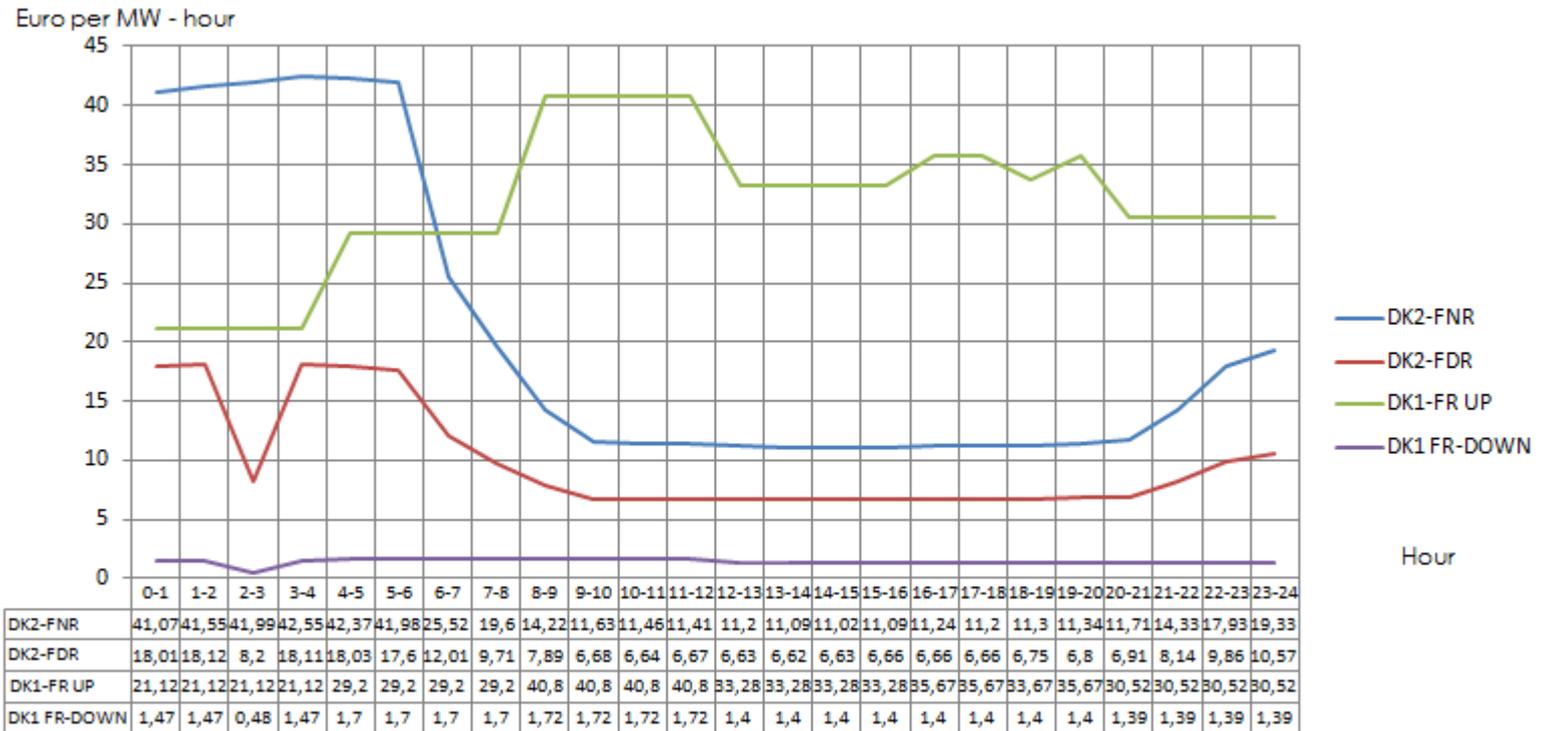
**WP1** focuses on operational and strategic targets typically managed by a transmission system operator on a system-wide ( $\geq 132$  kV) level.

In other words: maintaining a **cost-efficient** and **secure** power system with a high degree of **renewable** production.

# Current activities – WP1 System-wide services

Initial analysis indicates great technical, market, economic and user potential for service to be introduced into the *existing* Danish Ancillary Services

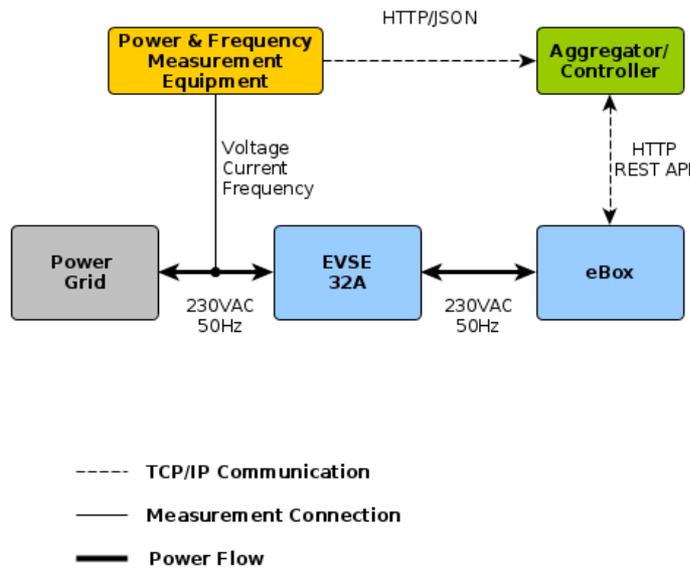
I



B E Christensen

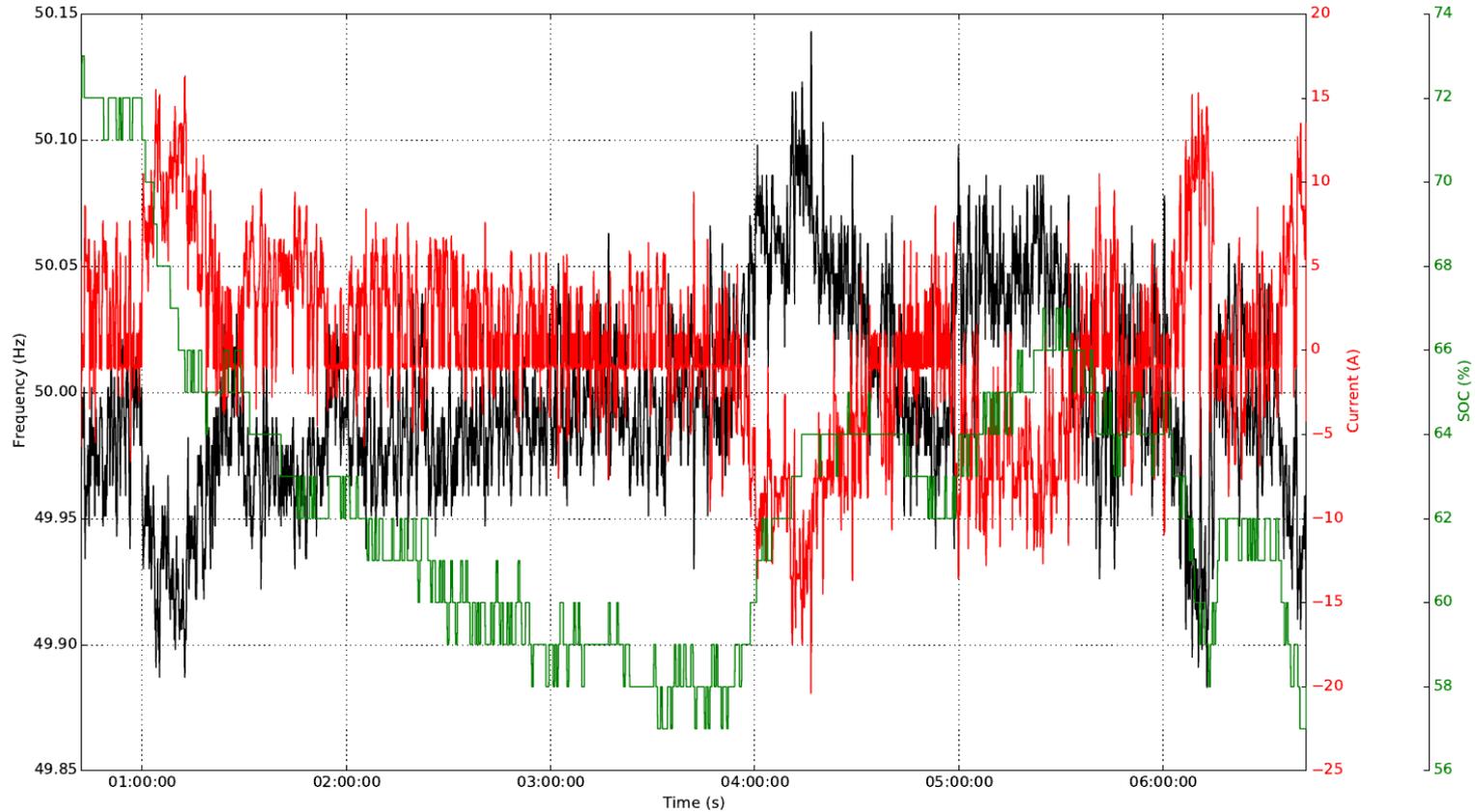
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# Current activities – WP1 System-wide services



**Source: Sergejus Martinenas**

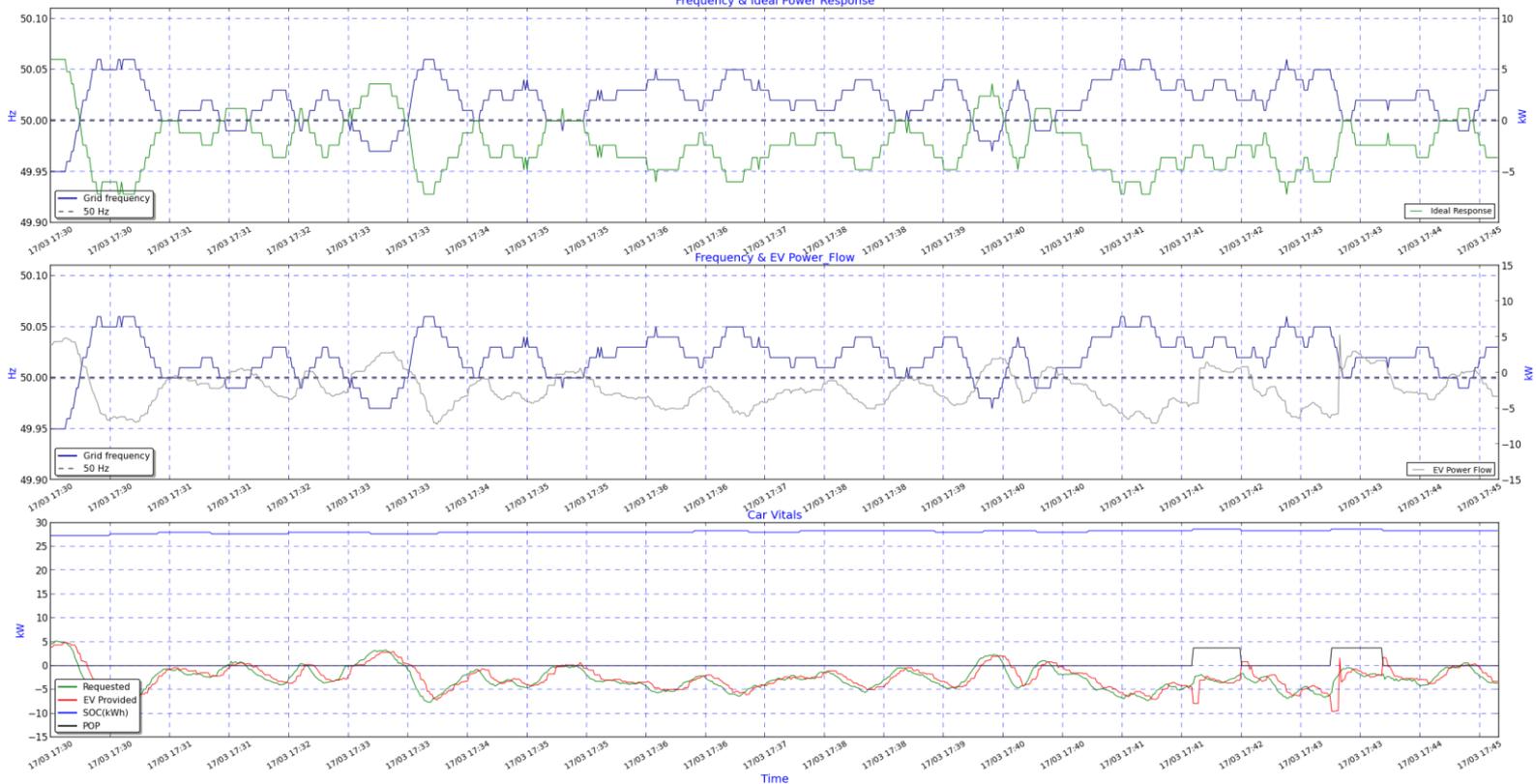
# Current activities – WP1 System-wide services



**Source: Sergejus Martinenas**

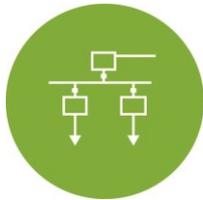
# Current activities – WP1 System-wide services

2015 NIKOLA & ENERGINET.DK - FNR Service  
RE-01  
Hour based From 17/03/2015 17:00:00 to 17/03/2015 18:00:00 Hour period = 17 to 18, No. of hour periods = 1, Samples in time window = 3,600  
Report id.: SYSVIEW - March 26, 2015 09:38:44



## Current activities

# WP 2 – Distribution grid services

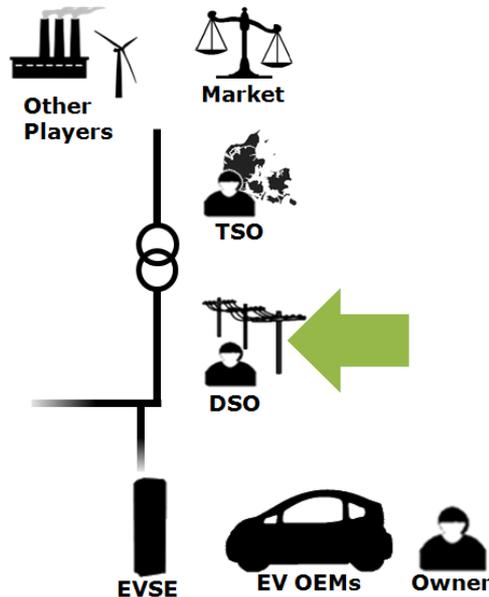


**Mattia M.**  
DTU



**Katarina K.**  
DTU

## Current activities – WP2 Distribution grid services



**WP2** focuses on operational and strategic targets typically managed by a distribution system operator on a distribution ( $\leq 132$  kV) level.

Parameters addressed include voltage, thermal and reactive power limits.

This topic also investigates **mixed-DER**, **islanded** and **microgrid** scenarios where EV services are used to maintain a **stable** and **secure** operation.

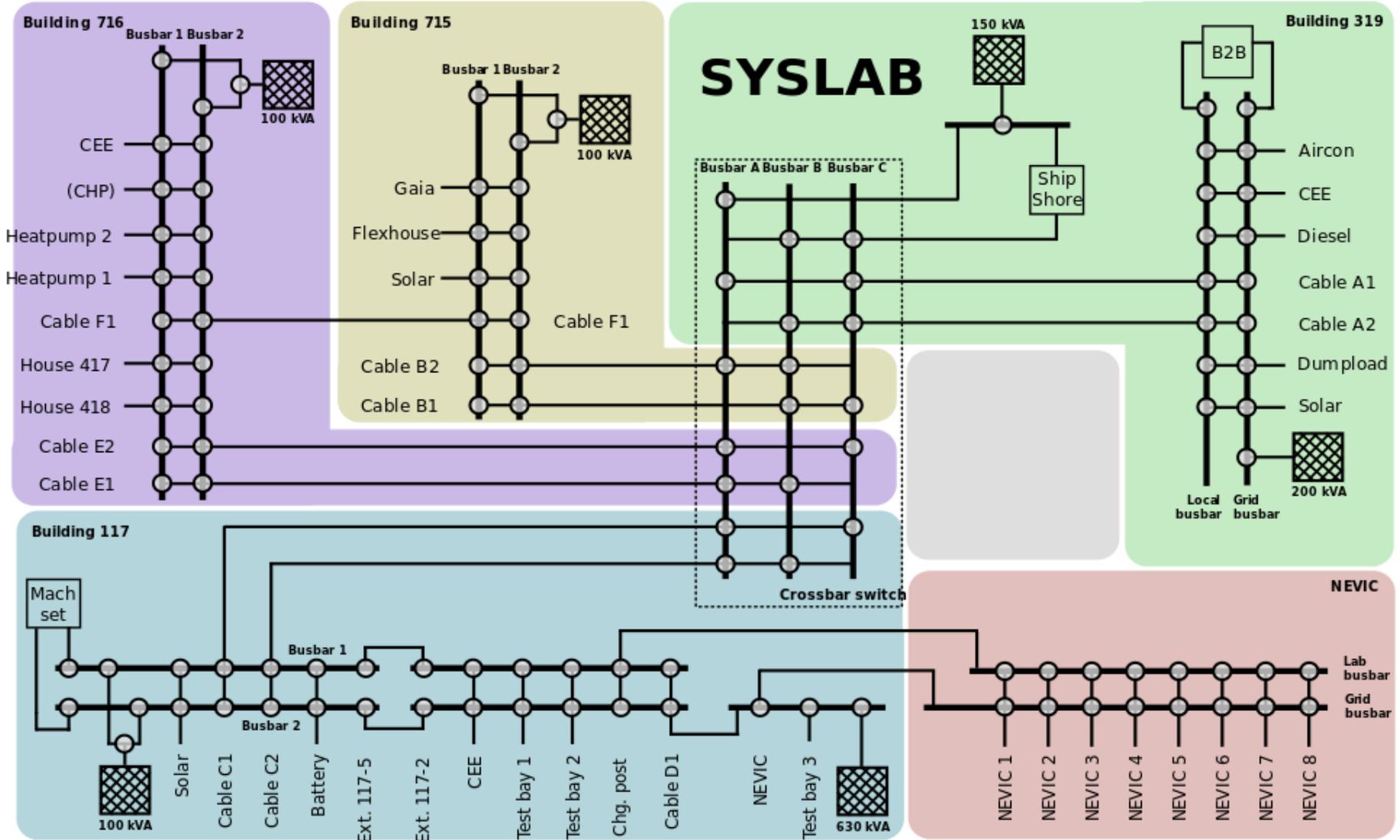
## Current activities – WP2 Distribution grid services

### Syslab

Large microgrid with renewable energy technologies and a novel distributed control system



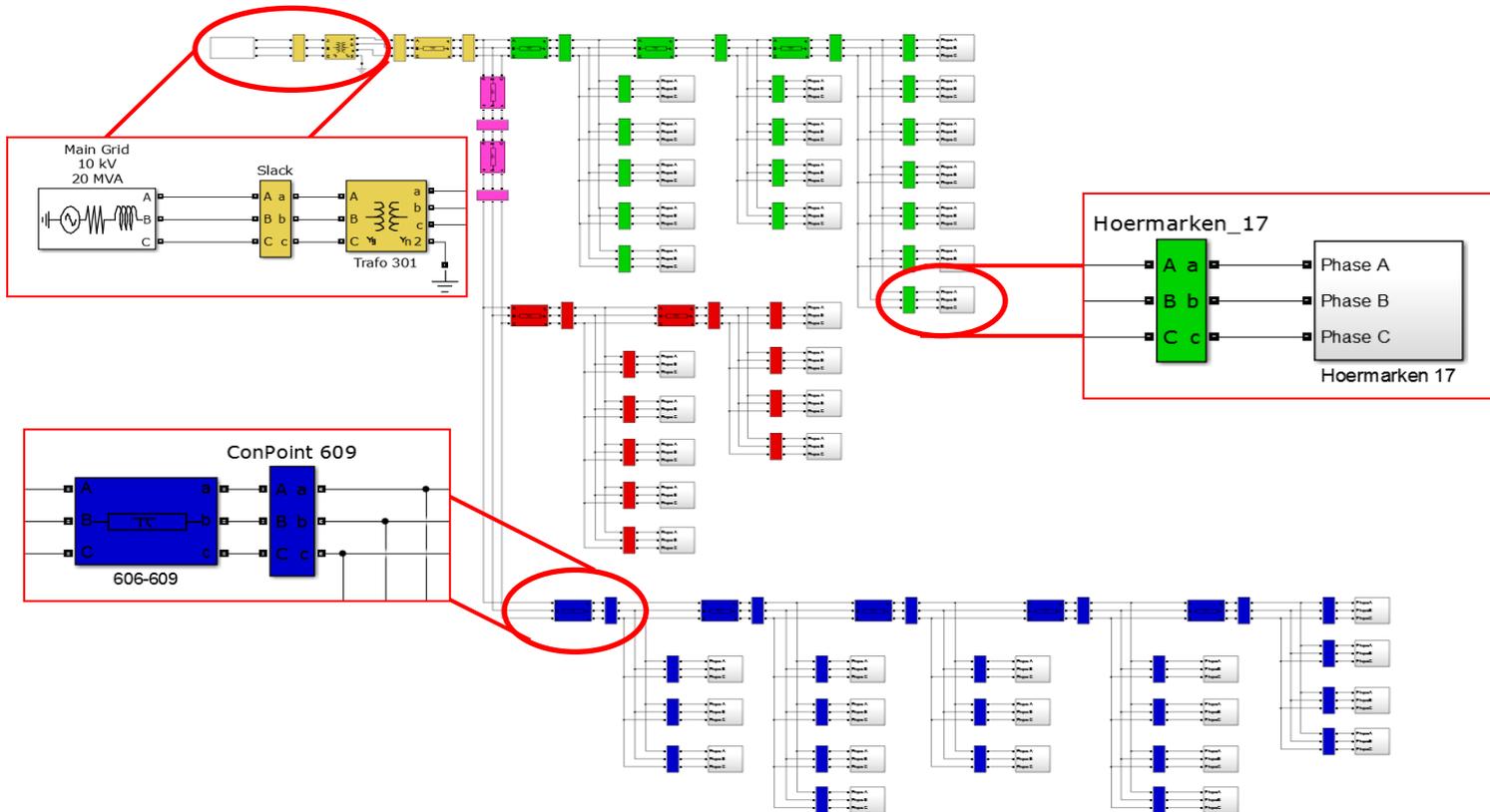
# Setup for congestion/voltage experiments



## Current activities – WP2 Distribution grid services



# Current activities – WP2 Distribution grid services

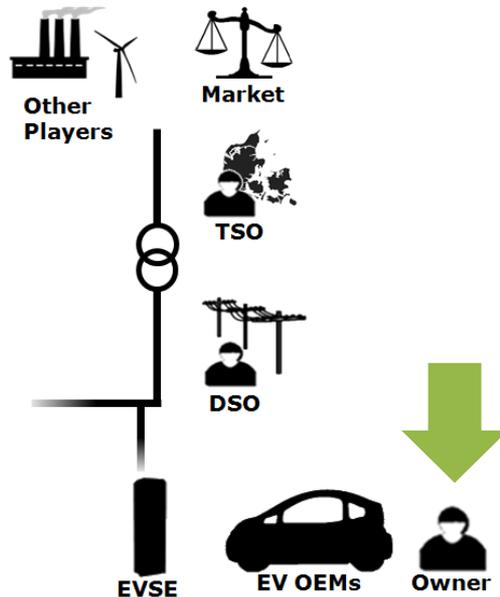


# WP 3 – User-added services



**Peter B.**  
DTU

## Current activities – WP3 User-added services



**WP3** services describe how to understand, inform and empower the EV user before altering the (dis-) charging behaviour of the electric vehicle batteries.

Nikola touches upon how service participation by the EV owner will yield a sufficient economic incentive while providing a convenient and easy solution.

## Current activities – WP3 User-added services

The EVs qualities as a resource to the power system mean little, however, without the EV owner's **ability** and **willingness** to participate in such schemes.

Learnings from other projects: **ELVIIS, Victoria's smart grid, Test-An-EV**



1. Economic and "feel-good" incentives.
2. Convenience and ease-of-use.
3. Transparency, information and sense of control

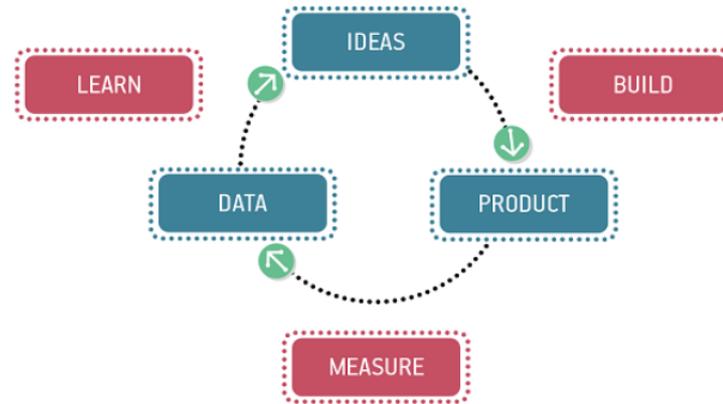
What service-enabling functions should an interface implement to support the above requirements?

## Current activities – WP3 User-added services

### Key service enabling functionalities

- 1. Charging status and management** What is the current charging status?
- 2. Scheduled charge windows** When is charging influenced?
- 3. Spend and earned so far this month** What do I gain?
- 4. Subscriptions** What services is the EV used for?
- 5. Notifications** What information do I want and how do you want to get it?

# Current activities – WP3 User-added services



← → ↻ [arcane-escarpment-9983.herokuapp.com/dashboard](http://arcane-escarpment-9983.herokuapp.com/dashboard)

Charging Management UI

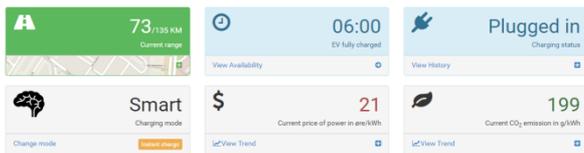
## Charging status and management

<ul style="list-style-type: none"> <li>Status</li> <li>Scheduling <span>2</span></li> <li>Saved and Earned</li> <li>Settings &lt;</li> <li>My Electric vehicle</li> </ul>	<p><b>73</b> / 135 KM Current range</p>	<p><b>06:00</b> EV fully charged</p> <p><a href="#">View Availability</a></p>	<p><b>Plugged in</b> Charging status</p> <p><a href="#">View History</a></p>
<p><b>Smart</b> Charging mode</p> <p><a href="#">Change mode</a> <a href="#">Instant charge</a></p>	<p><b>\$ 19</b> Current price of power in øre/kWh</p> <p><a href="#">View Trend</a></p>	<p><b>258</b> Current CO<sub>2</sub> emission in g/kWh</p> <p><a href="#">View Trend</a></p>	

**NIKOLA**  
INTELLIGENT ELECTRIC VEHICLE INTEGRATION

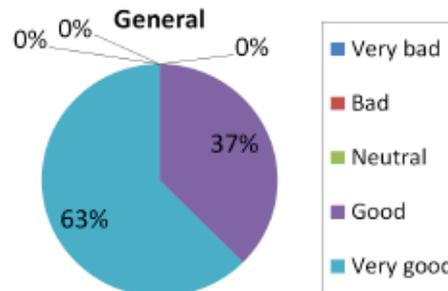
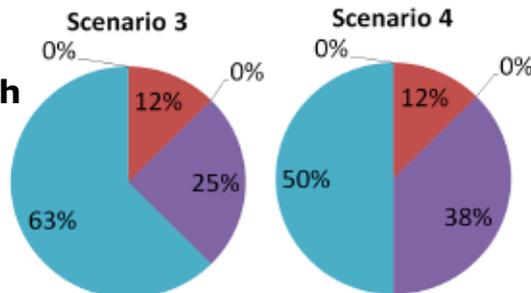
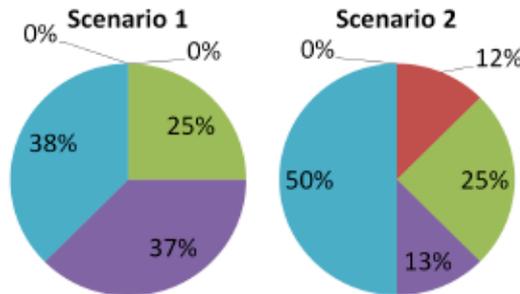
# Current activities – WP3 User-added services

## Charging status and management



## Spend and earned so far this month

Spend and earned so far this month.



## Scheduled charge windows

Mon	Tue	Wed	Thu	Fri	Sat
06:00	06:00	06:00	06:00	06:00	09:00

Mon	Tue	Wed	Thu	Fri	Sat
	07:50	07:50			

## Subscriptions



<http://goo.gl/6Hvp9L>

(press "sign up")

# WP 4 – Enabling technologies and standards



**Claus A.**  
DTU



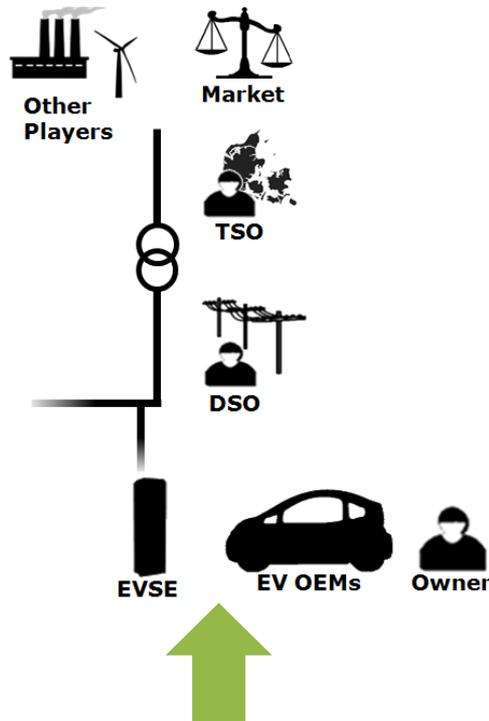
**Jacob D.**  
DTU



**Sergejus M.**  
DTU



**Thomas M.**  
DTU



**WP4** describes the technologies that need to be developed for electric vehicles (EVs), charging spots and backend systems to enable EV services.

Special attention is given to the intelligent controllers that will influence the (dis-)charging of EV batteries, their soft- and hardware and the communication between them.

## Current activities – WP4 Enabling technologies

Identify technology, standards and informatics that will enable the services.

### Project vehicles

Upgrades:

- Performance
- Reliability
- Monitoring and control

Technology:



EURISCO  
RESEARCH & DEVELOPMENT



## Current activities – WP4 Enabling technologies

Standardization-related work:

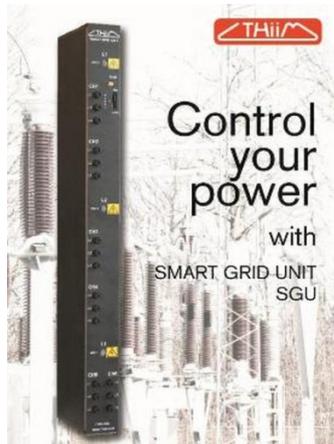
- IEC/ISO 15118
- IEC 61850-90-8
- IEC 61851 ED3 Annex D
- OCPP

# Cooperation

Market integration program



Power measurements



V2X demonstrations



Definition							Initial priority
Type	Groups	Name	Short description	Power & energy behavior	Stakeholders & potential benefits	Existing Danish Market/incentive?	
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	Yes	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	No	High
		Secondary regulation	Replaces frequency regulation and restores the frequency to 50 Hz	Balancing***	Aggregator/EV Owner: Market earnings TSO: Larger, more competitive market	Yes	High
		Tertiary regulation	Replaces secondary regulation and fulfills a higher requirement to energy capacity and delivery timescale	Balancing***	Aggregator/EV Owner: Market earnings TSO: Larger, more competitive market	Yes	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	No	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	Yes	High
		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	No	Medium
	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
		LV network balancing	Mitigates unbalances between phases of LV network	Balancing***	Aggregator/EV Owner: Unknown DSO: New service	No	Medium
		LV overvoltage management	Mitigates overvoltage of LV feeders	Balancing*** Adaptive*	Aggregator/EV Owner: Unknown DSO: New service	No	High
		MV-LV transformer and lines overloading	Mitigates overloading of transformers and cables of LV network	Adaptive*	Aggregator/EV Owner: Unknown DSO: New service	No	High
		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	No	Medium
ICT Services	User added services	Charging management	Simplifies EV service participation for the EVowner by using historical data.	NA	Aggregator/EV Owner: Added simplicity for service participation	-	High
		Charging flexibility assessment	Estimates whether sufficient charging flexibility exists in order to participate in services.		Aggregator/EV Owner: Knowledge on charging flexibility	-	High
		Charging information	Presents to the EV user the information that is most relevant when controlling (dis)charging of the EV		Aggregator/EV Owner: Improved information service	-	Medium
		Vehicle-to-X	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



# Questions?



*More info:  
[www.nikolaproject.info](http://www.nikolaproject.info)*