A 100% Renewable Energy Road with Electric Vehicles

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Centre for Electric Technology
Department of Electrical Engineering

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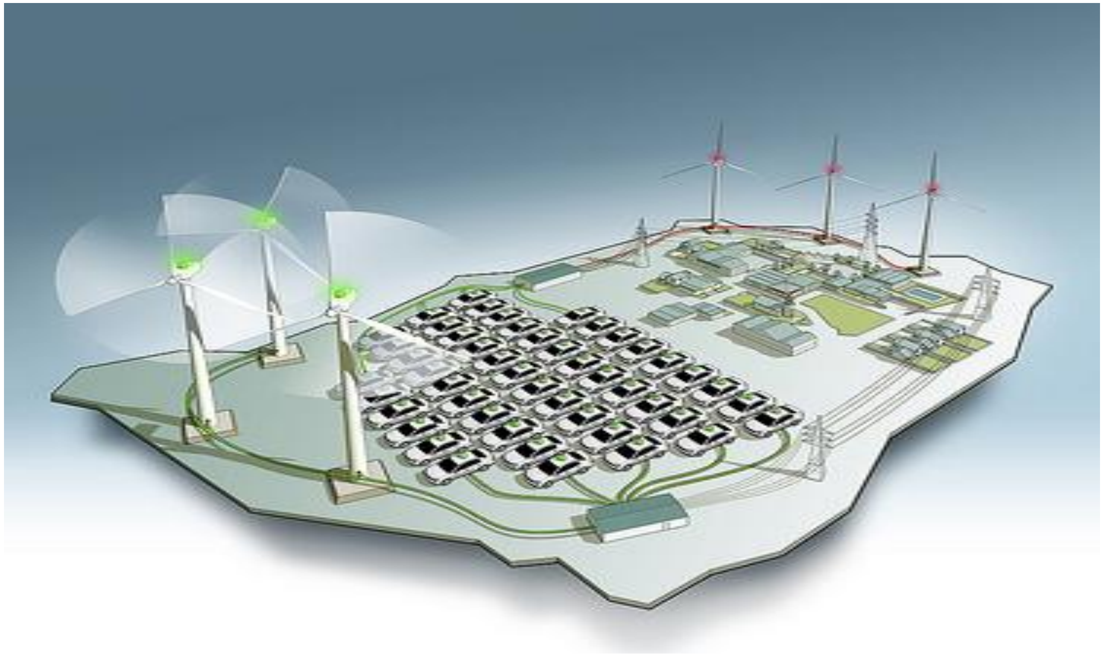
DTU

The EDISON Project

Electric Vehicles in a **D**istributed and **I**ntegrated market using **S**ustainable energy and **O**pen **N**etworks



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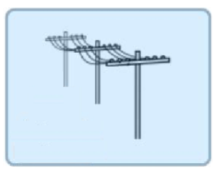
The EDISON Project (ii)

Summary of benefits:

National Level

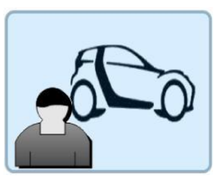
Support an environment-friendly development and increase sustainability

Grid Level



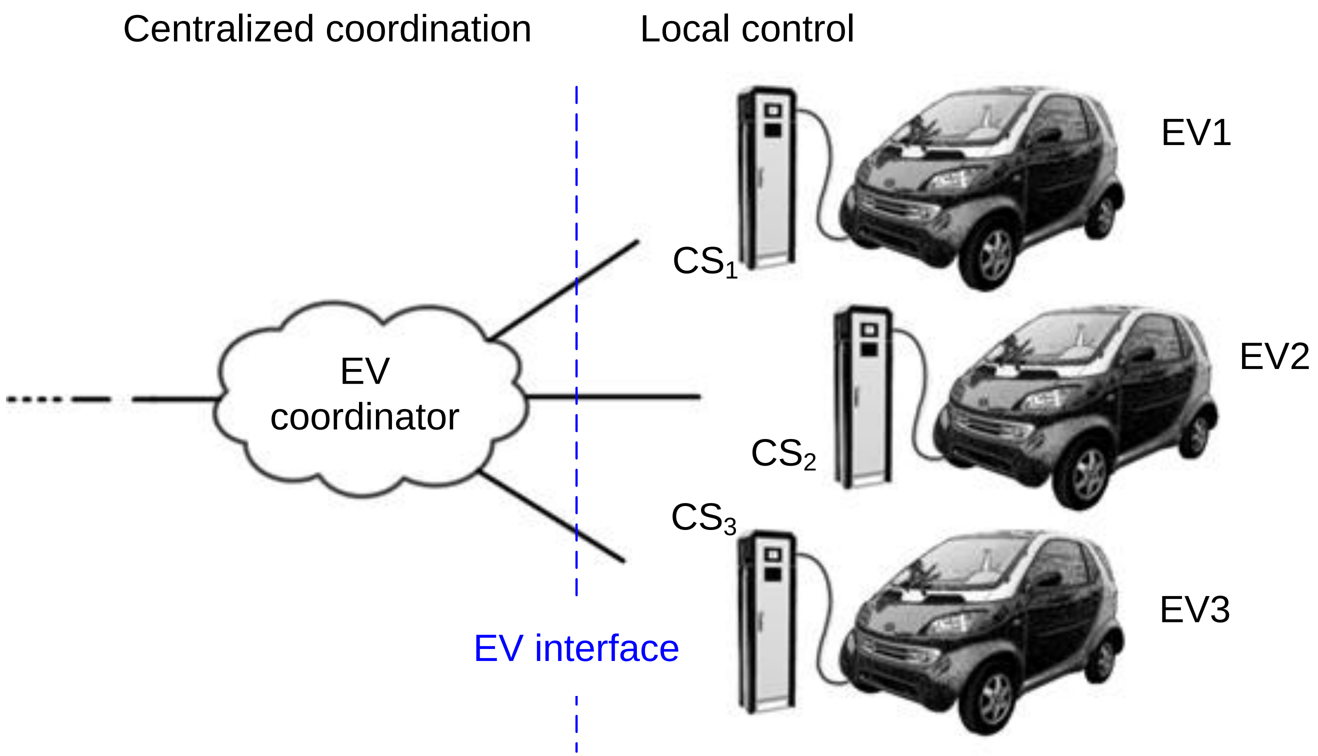
Improve quality of supply and actively integrate distributed energy resources

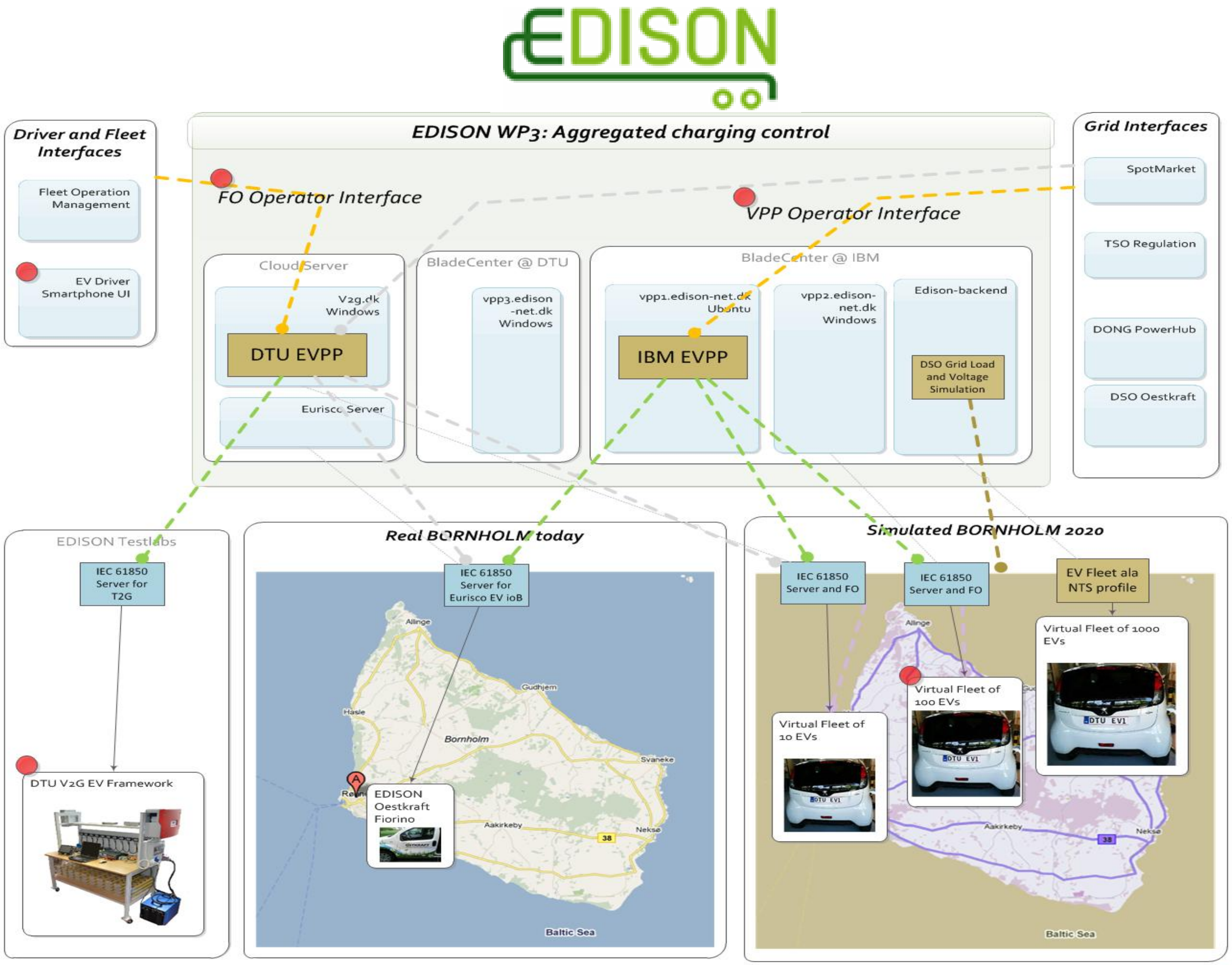
User Level



Economic incentive to contribute to CO_2 reduction, grid support

Concept

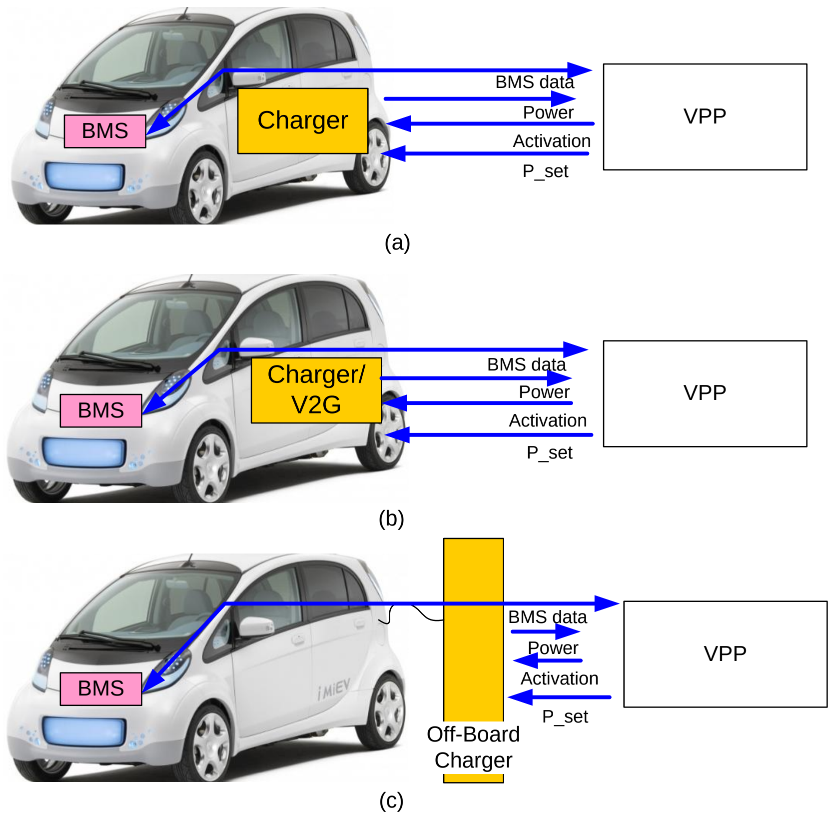

Centralized coordination
Local control
EV
coordinator
CS1
CS2
CS3
EV1
EV2
EV3
EV interface

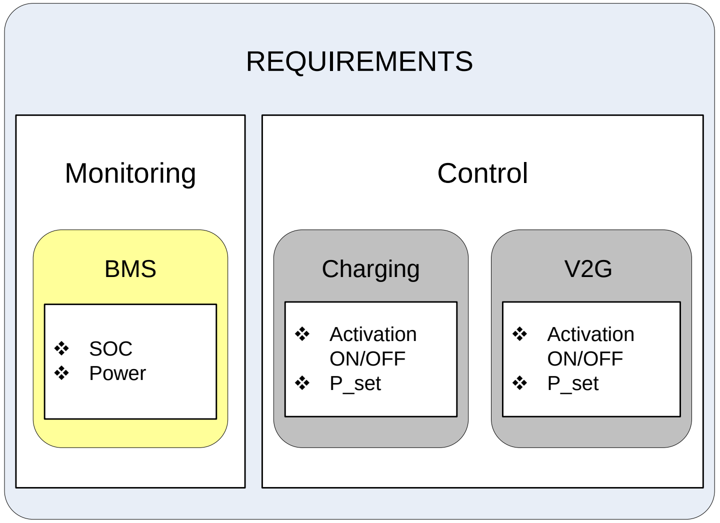


***Courtesy of:* Dieter Gantenbein (IBM Zurich)**

CONNECTIVITY AND CONTROL

Electric Vehicle Requirements for Smart Charging and V2G





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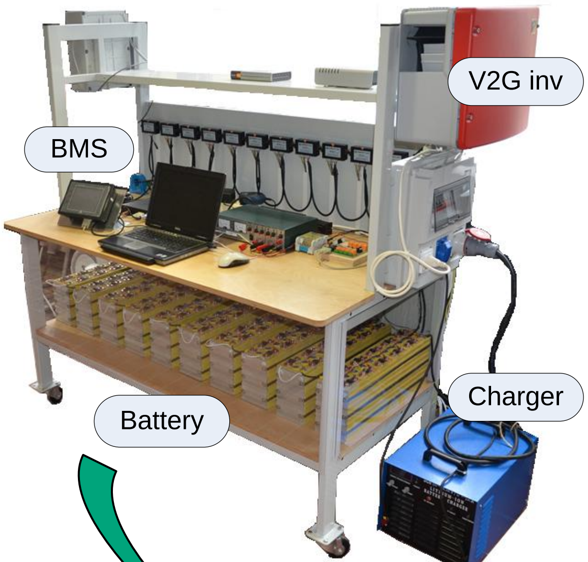
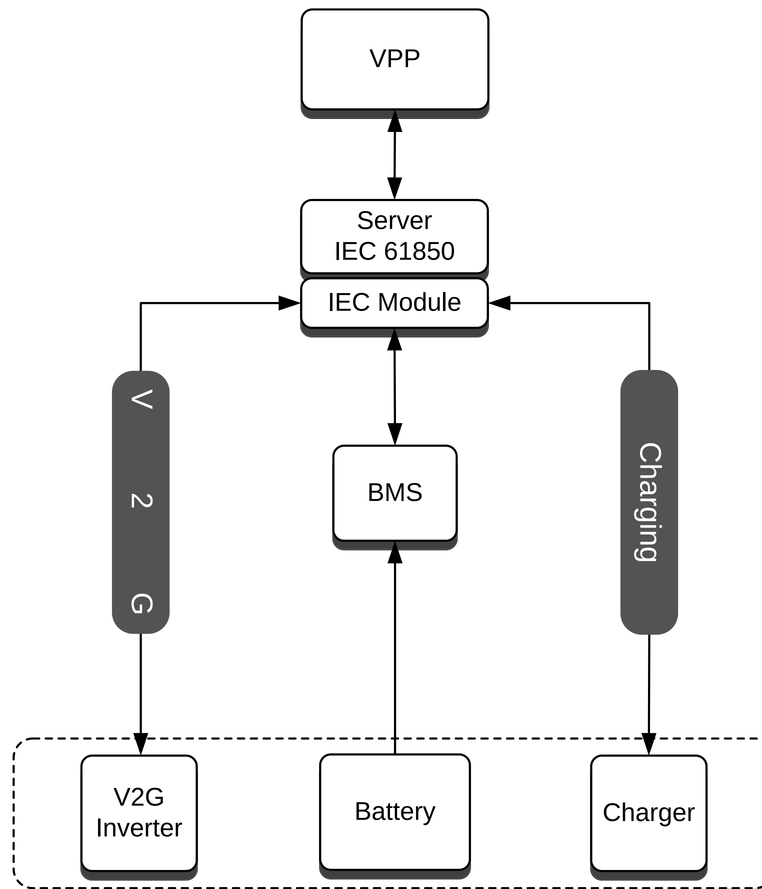
EV Test-Bed



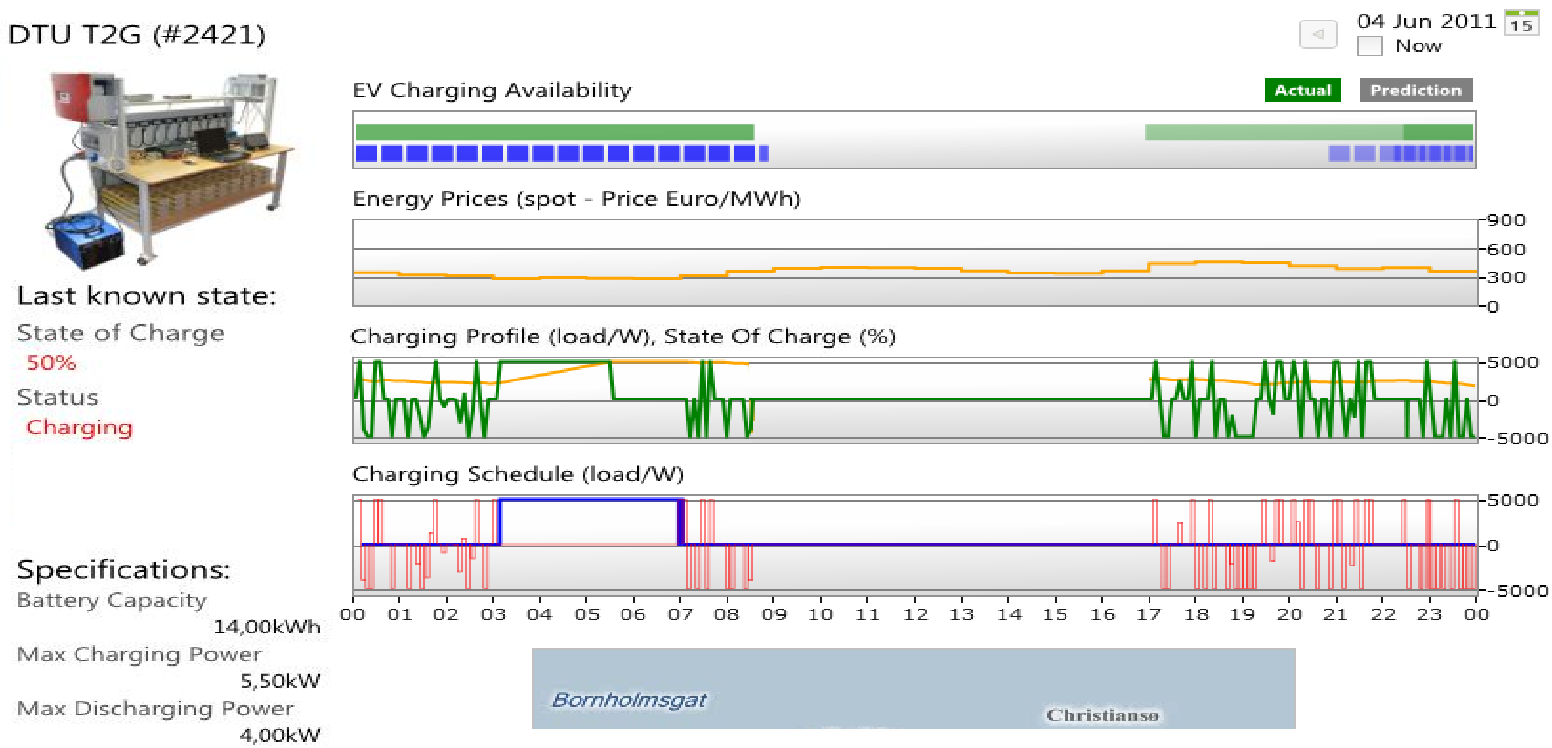
Control and Communication architecture



- Battery pack: V_{pack} = 360 V, C_n = 40 Ah,
- E_n = 14.5 kWh
- Charger: 3-phase, 0-5.5 kW
- V2G inverter: 1-phase, 4 kW
- BMS data: battery voltage, current, power, temperature, SOC, current capacity C, nominal parameters: E_n, C_n
- On-board EV test bed computer for communication with EV-VPP

EV – VPP operation

Operator panel



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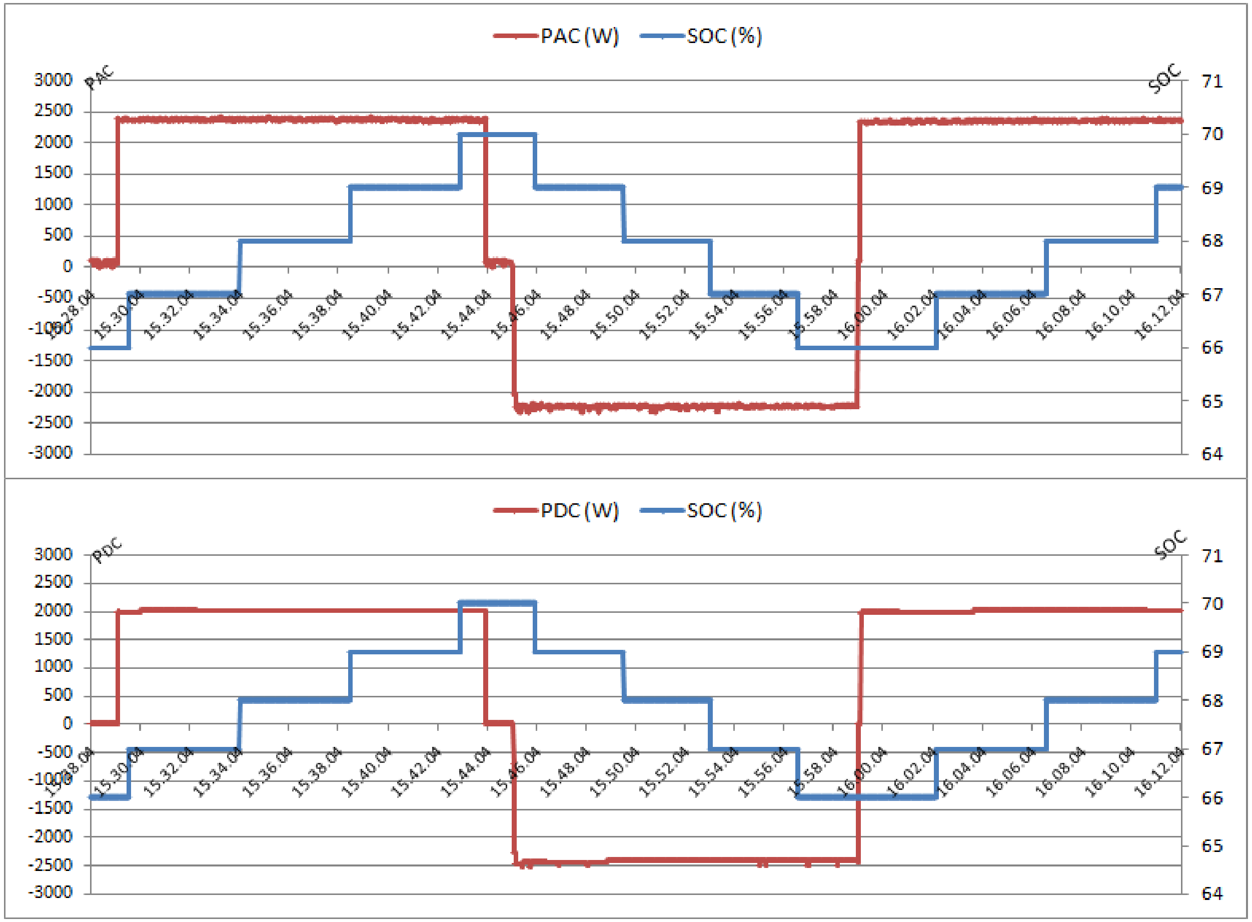
EV – VPP operation

Power measurements during charging/V2G operation



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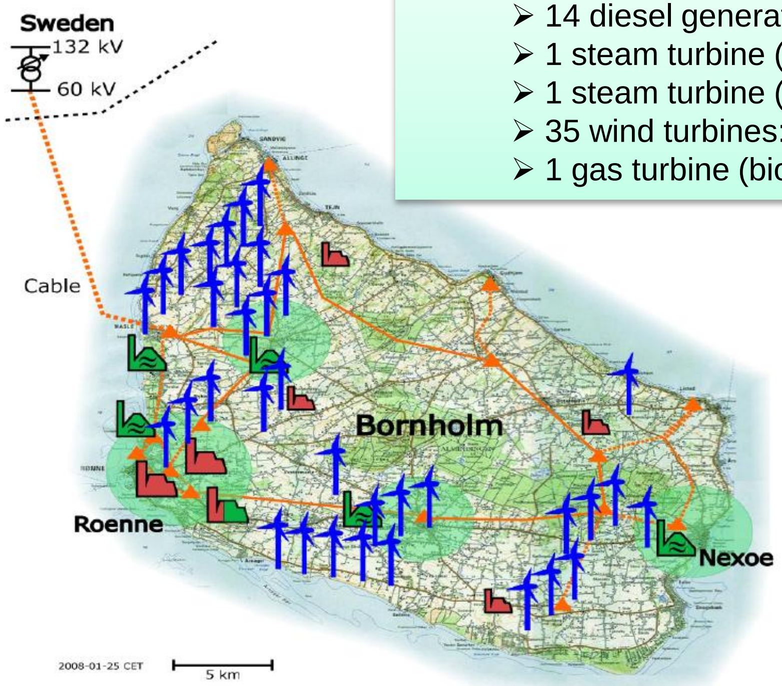
GRID INTEGRATION

The island of Bornholm (Denmark)



The production capacity is as follows:

- 14 diesel generators (oil): 39 MW
- 1 steam turbine (oil): 27 MW
- 1 steam turbine (oil/coal): 37 MW
- 35 wind turbines: 30 MW
- 1 gas turbine (biogas): 2 MW

Distribution grid

1. **60 kV network: the 60 kV network at Bornholm is meshed and consists of the following elements:**
   - **18 substations,**
   - **23 60 kV/10 kV OLTC transformers of a total of 219 MVA**
   - **22 cables and overhead lines, 73 km and 58 km of length, respectively.**
2. **10 kV distribution grid consisting of**
   - **overhead lines with a length of 247 km**
   - **634 km in length of cables**
   - **91 feeders, with an average of 6 feeders per substation**
3. **0.4 kV distribution grid composed of**
   - **overhead lines with a length of 518 km**
   - **1,341 km of cables**
   - **998 10 kV/400 V transformers, with a total of 265 MVA, average capacity of 273 kVA and 29 customers per transformer.**

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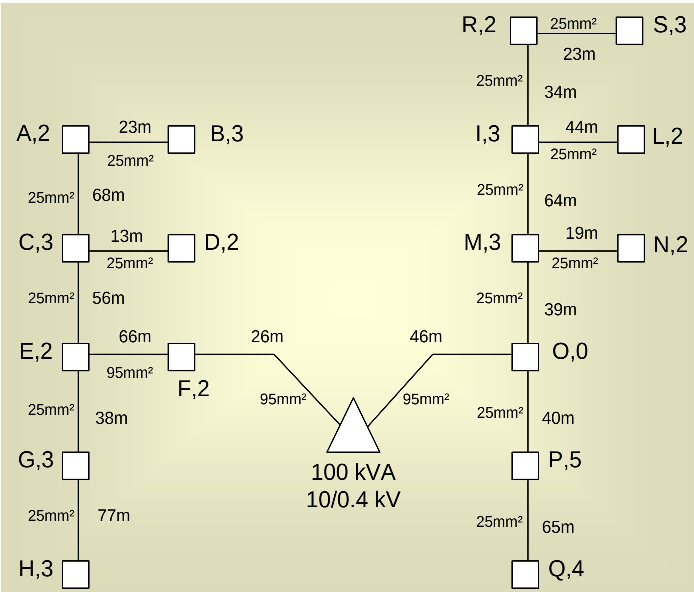
EVs in Distribution Grids



Some distribution grid requirements	
Nominal sec. transf. voltage level	10.4 kV
Lowest primary voltage	9.6 kV
Voltage drop (feeders)	+/- 10% (EN 50160)
Max. cable loading	117%

SUPPLY VOLTAGE VARIATIONS WITH DIFFERENT SHARE OF EVs OVERNIGHT 3.7kW-CHARGING SCENARIO

Penetration Level [%]	Transf. Loading [%]	Voltage at feeder top [p.u.]	Voltage at feeder terminal [p.u.]
100	177	0.945	0.91
80	142	0.955	0.922
50	108	0.972	0.943
20	65	0.989	0.975
10	44	0.99	0.98
5	33	0.992	0.985

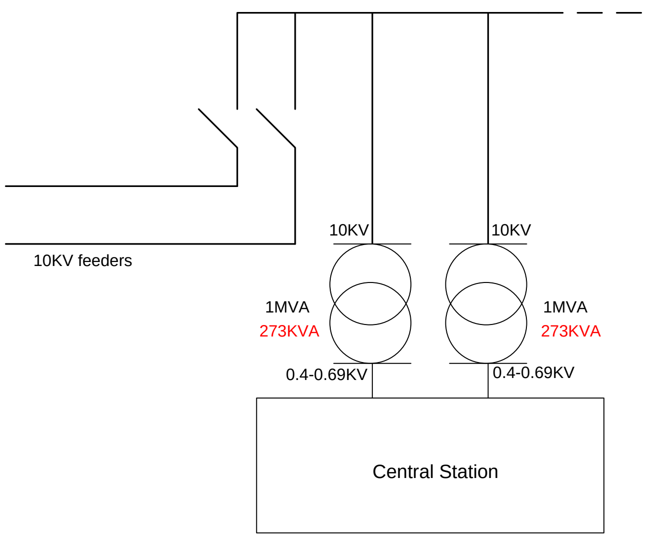
EU Charging Levels

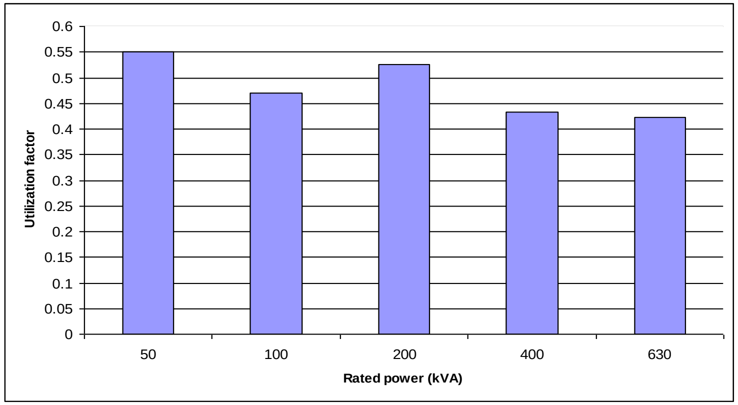
AC current	AC voltage	Grid connection	Power
10 A	230 V	single phase	2.3 kW
16 A	230 V	single phase	3.7 kW
32 A	230 V	single phase	7.4 kW
16 A	400 V	three-phase	11 kW
32 A	400 V	three-phase	22 kW

Fast Charging Stations planning

Bornholm statistics	
Nr. 10/0.4 kV sub-stations	981
Nr. of 10/0.4 kV sec. substations (average for each municipality)	65
Average capacity of each 10/0.4 KVA sec. substation in Rønne	273 kVA
Estimated nr. of cars in Rønne (main municipality)	5400

Transfer Options (kVA)	# EVs (Rønne)	
	FC 120kW	FC 300kW
50	0	0
100	0	0
200	1	0
400	3	1
630	5	1





Conclusions

- RES, solar and wind, should be in a closed loop with EVs. This can increase sustainability.
- From the EDISON project it comes out that controlling EVs turns out beneficial for both achieving the EU targets and for improving the operation of the grid.
- The combination of charging infrastructures and ICT solutions (VPP) is needed to "synchronize" renewable generations with EVs.
- For the coming 10 years, relatively low share of EVs will be integrated (5-10%), no need for grid reinforcement, especially if smart charging is used.
- Fast charging is another option. Its sustainability depends on whether it is used as a range extender or as a standard charging method. It requires local grid assessment prior installation.

THANK YOU!

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