EDISON Demo A: Fleet operation for mutual benefit

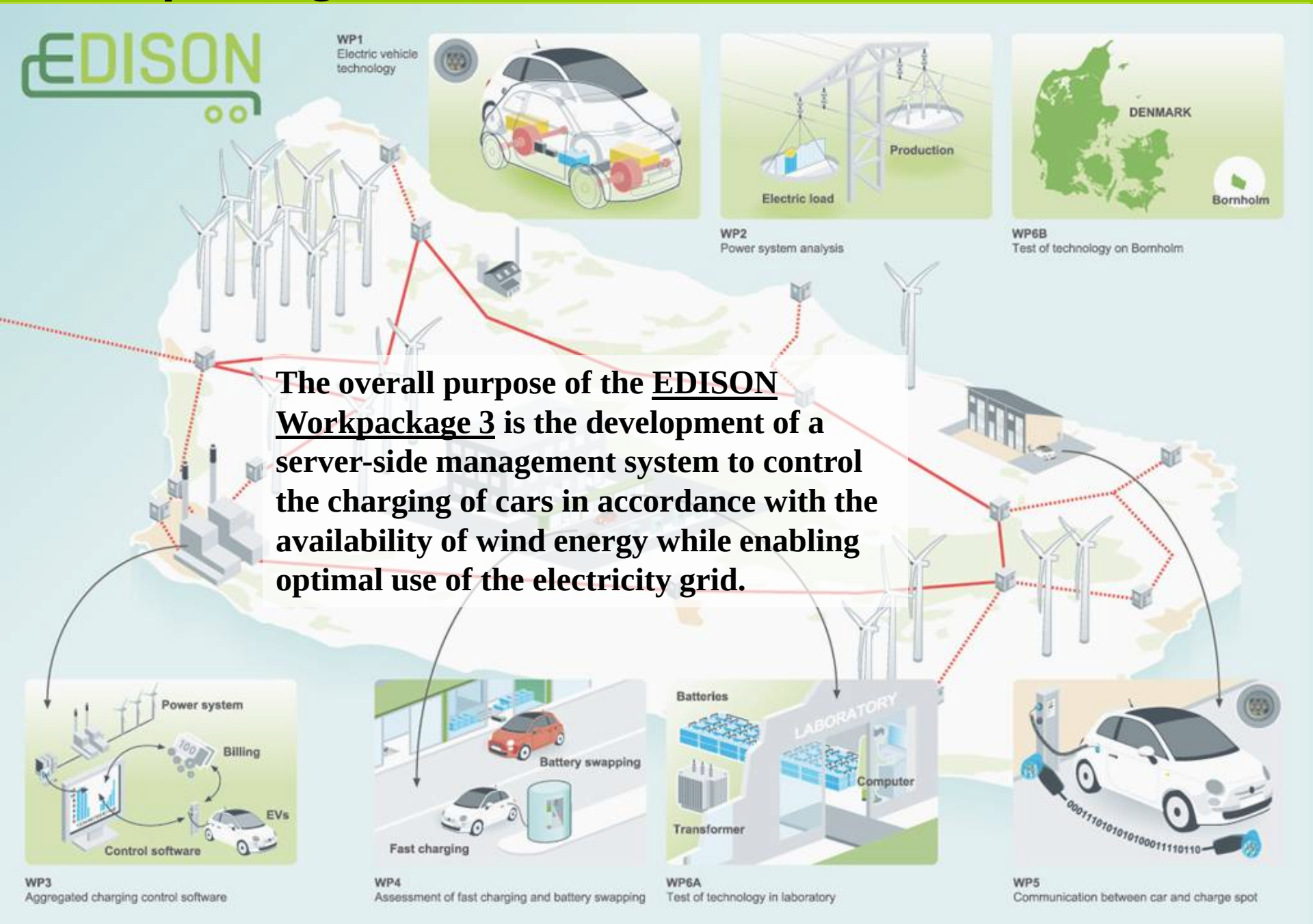
EDISON Workshop, August 18, 2010

Dieter Gantenbein, Bernhard Jansen, Carl Binding, Olle Sundstroem, Nicolas Knaebel, Ulrich Dangel (IBM)

Andreas Bjerre, Lars Henrik Hansen (DONG)

Chresten Træholt, Bjarne Poulsen, Peter Bach Andersen, Einar Bragi Hauksson and Anders Bro Pedersen, Francesco Marra, Qiuwei Wu (DTU)

Work packages and tasks



The overall purpose of the <u>EDISON Workpackage 3</u> is the development of a server-side management system to control the charging of cars in accordance with the availability of wind energy while enabling optimal use of the electricity grid.

Agenda Demo A: Fleet operation for mutual benefit

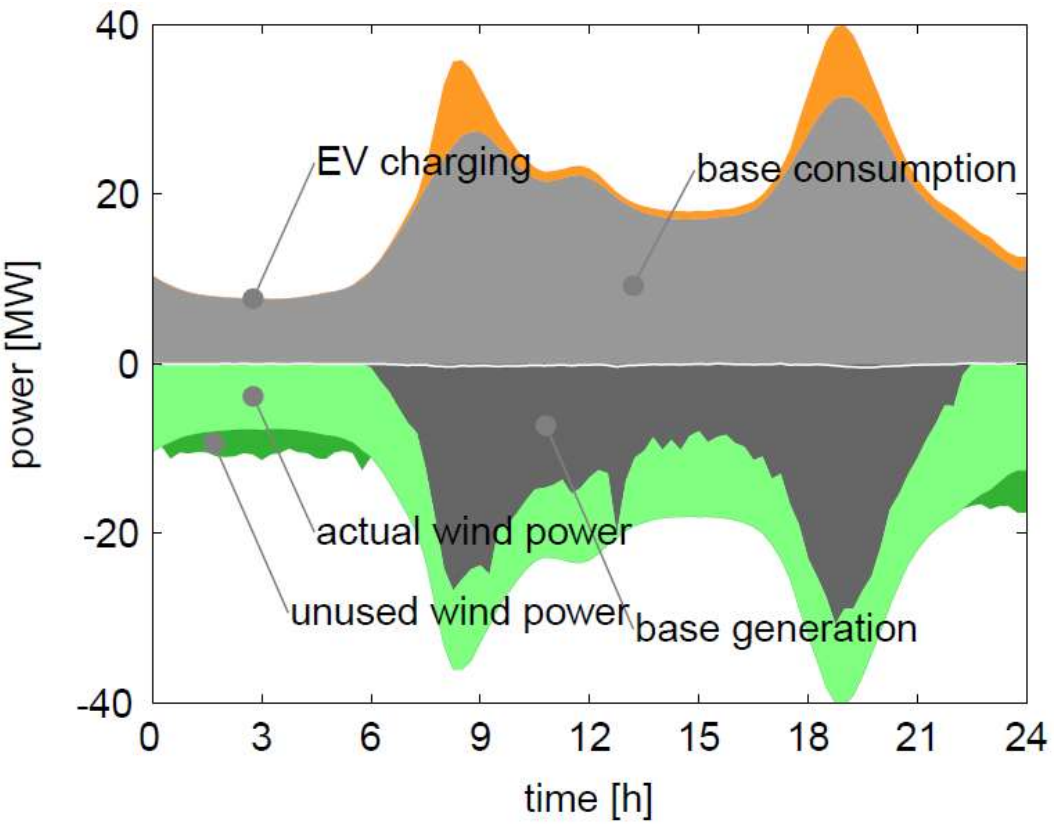
1. **Motivation of Grid-aware Smart Charging**
   a. **Aggregated-level benefits**
   b. **Individual driver perspective**
2. Video of Bornholm Grid and EV Simulation
3. Panel of Fleet Operator
4. Virtual EVs and Archive Visualization
5. EV and Fleet Management - Bornholm

1. With today's flat prices EVs charge immediately

With today's flat prices, EVs will charge immediately after trips. The typical day curve with peaks of power required on "arrival at work“ and “back home” late afternoon / early evening will get even higher as mobility migrates off fossil and onto electricity grid as main energy backbone.

Direct Charging

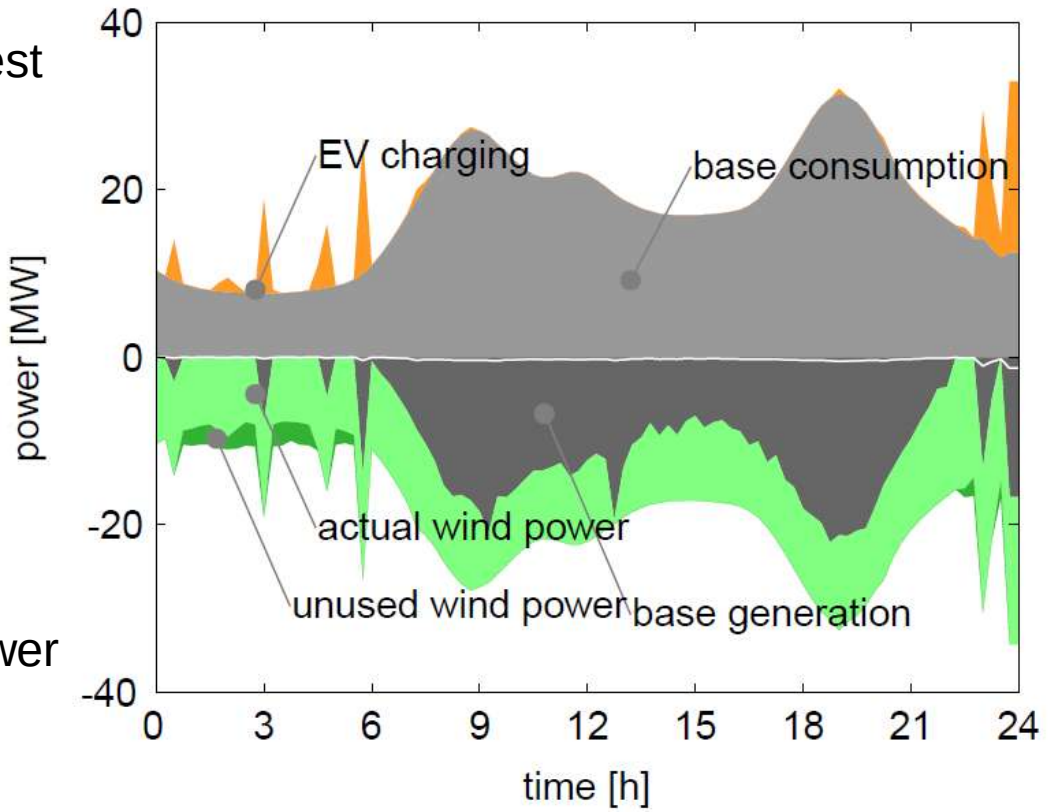
- Marginal power is high in carbon content
- Large impact on grid
- Large variations in base generation, need of balancing power



2. Dynamic electricity prices enable savings

Offering e.g. the dynamic day-ahead prices to consumers and EVs enables savings. But broadcasting dynamic prices is not sufficient and leads to "lemming" effects.

With the pre-announced cheapest price early night, everybody might want to quickly start charging right then. Given large numbers of smart consumers and EVs, this can be very dangerous with worse peaks than ever before with flat prices.



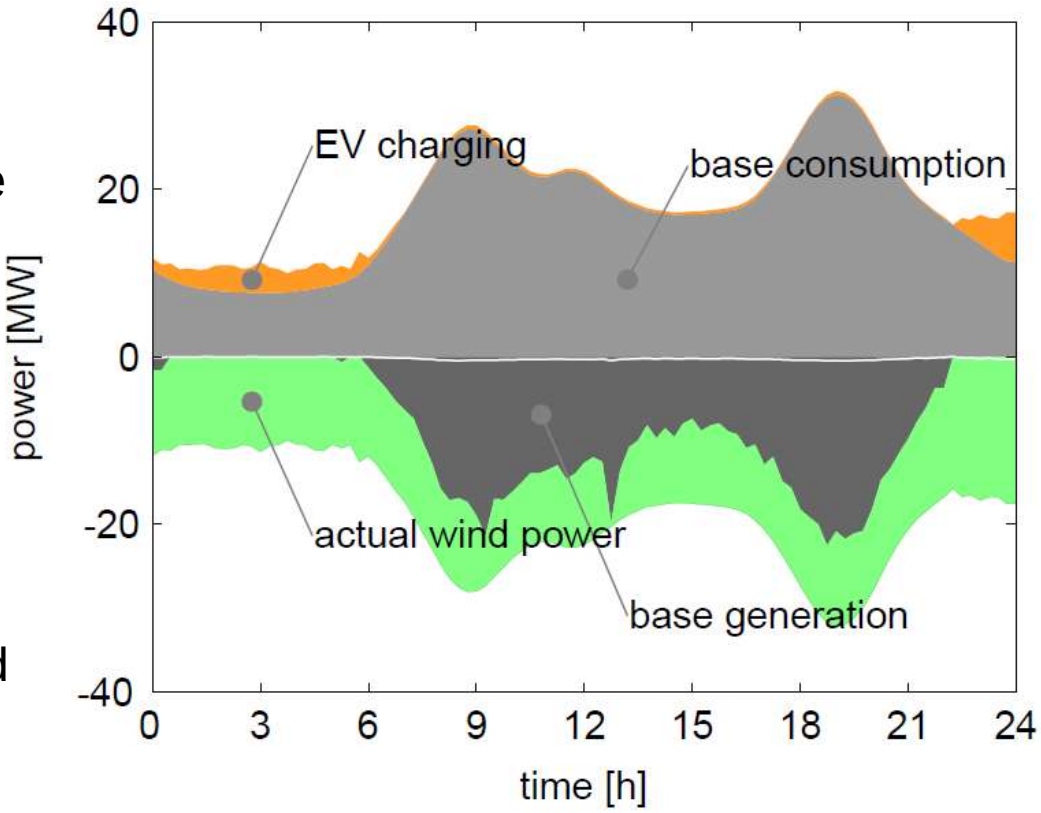
Minimize Cost of Charging

- Price is correlated with wind power
- Lemming-effect, all vehicles charge at low priced slots
- Large impact on grid
- Large variations in base generation, need of balancing power

3. Use excess wind power to increase green content

Offering the dynamic day-ahead prices to consumers and EVs enables savings. The objective to fully use the available wind removes the "lemming" effect.

While the shift of consumption off main load peaks enables savings, this also increases the renewable content. Extra wind lowers price. Of course the charging has to be automatic, at 2AM while we sleep.



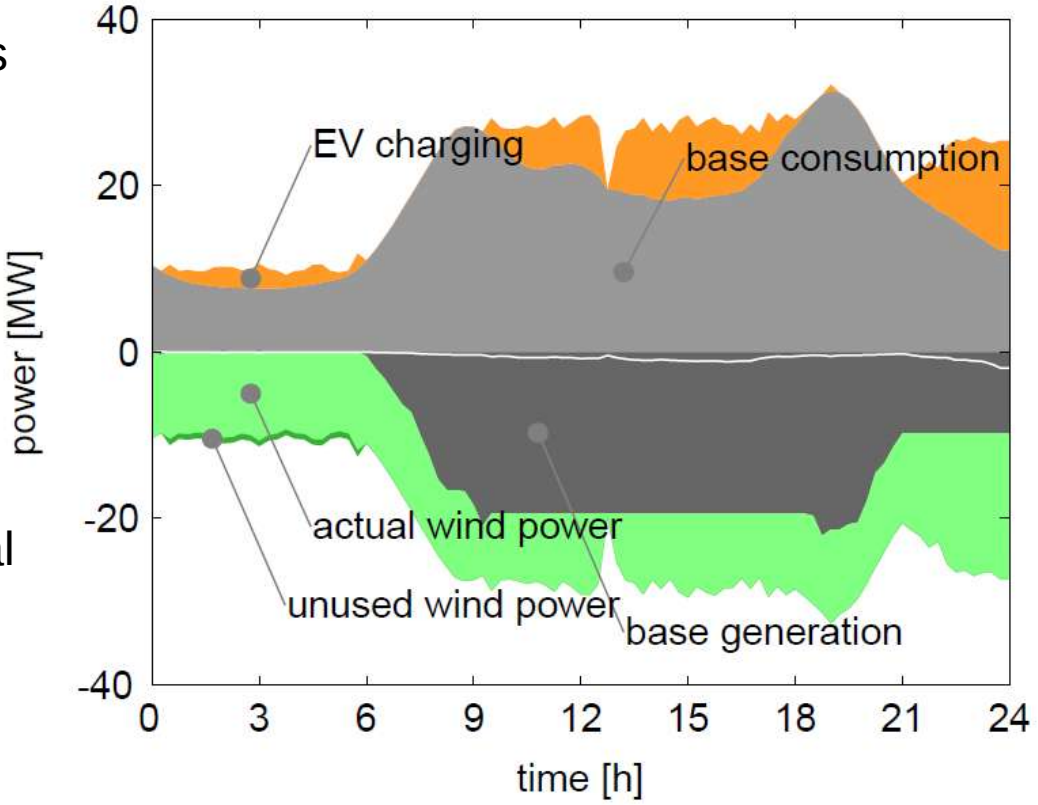
Charge when wind is available
in excess of base consumption

- If necessary charge also if wind power is lower than base consumption
- Still large variations in base generation, need of balancing power

4. EVs can absorb fluctuations for grid operators

Essentially, EVs can easily absorb load and wind fluctuations for grid operators, already by just varying the charging intensity, at the level of the aggregated fleet.

This strategy should be seen as a didactic step to explain the potential but also the potential problem with this.



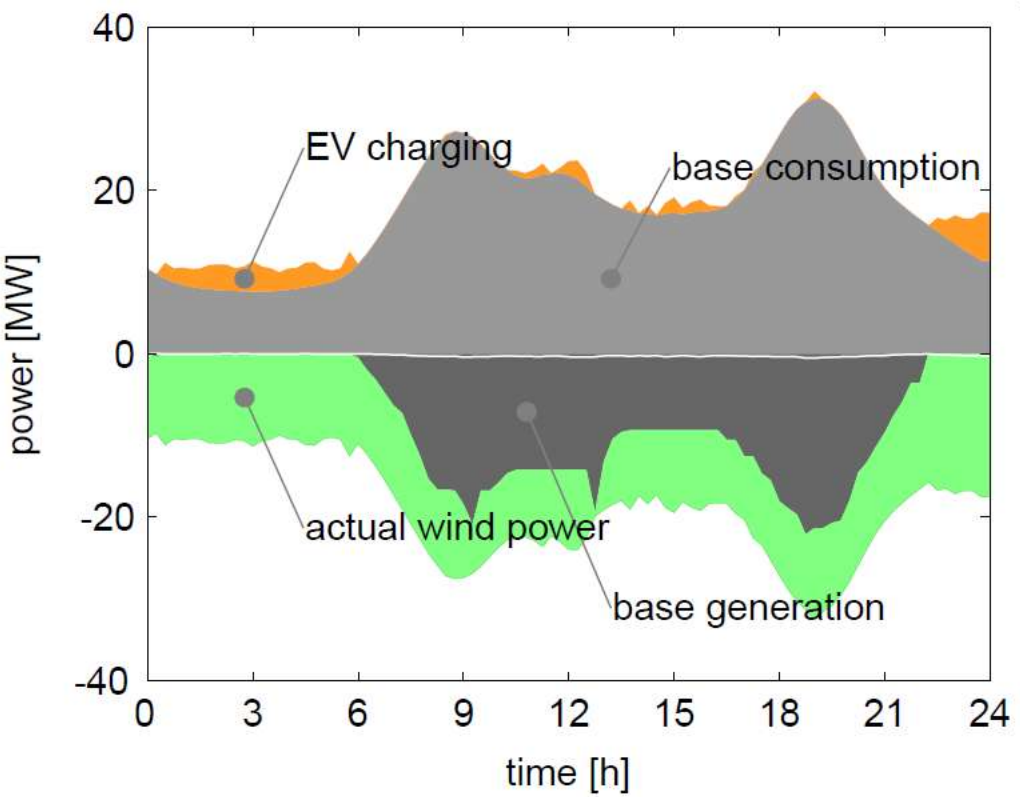
Absorb Fluctuations

- Use EV fleet to level out fluctuations in base generation
- Stable operation of conventional generating units, which leads to the possibility to increase share of wind power
- High cost of charging
- Low green content of energy

5. The optimal symbiosis of fleet & grid operators

Joint analytics and a two-way data exchange on driving predictions, charging requirements, grid state and constraints, and wind and price expectations leads to the optimal symbiotic solution.

The mixed objective is to reduce costs, use green wind energy, and reduce fluctuations.



Mixed Objective Charging

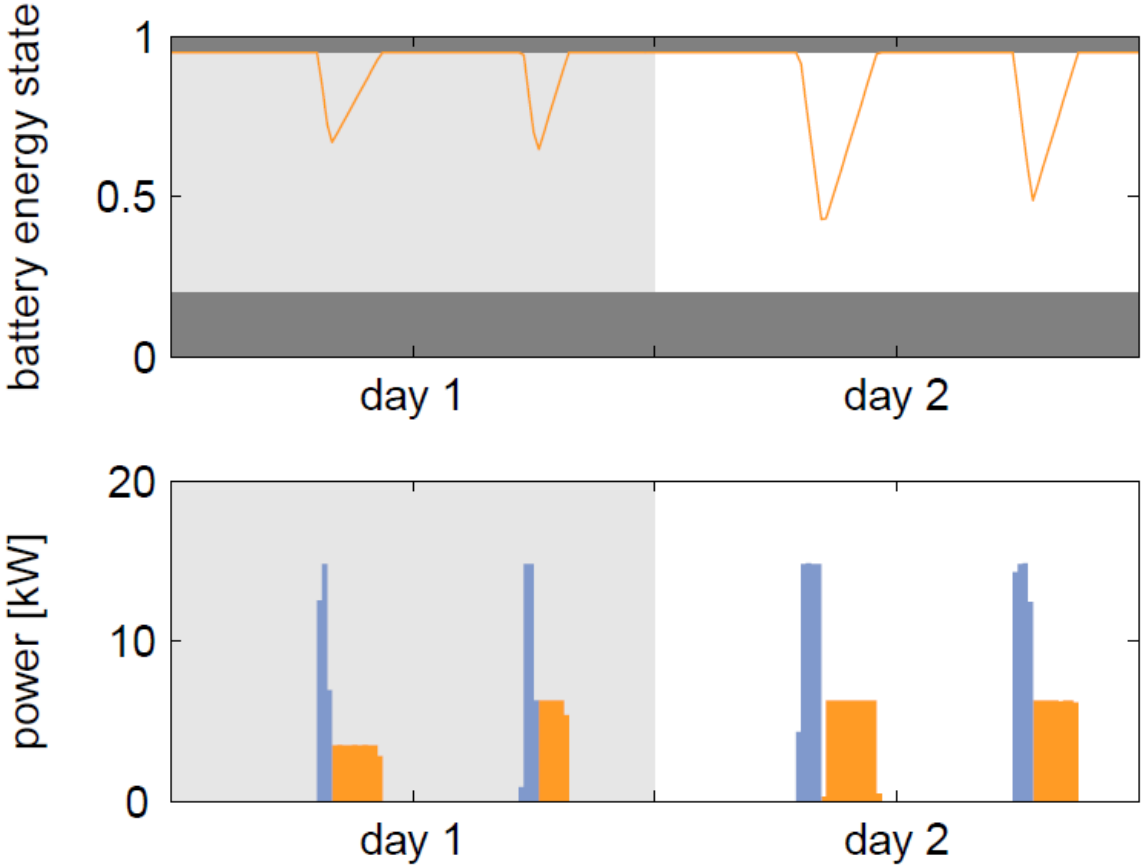
- Minimize cost of charging
- Use of excess wind power
- Absorbing wind fluctuations
- Dampen requirements on base generation dynamics

While the ultimate algorithms and distributed strategies are subject to continued work,

<u>The establishment of a smart-charging enabled infrastructure is a necessary first step.</u>

This ECO mode is for the masses, the individual is always VIP.

6. EV driver can always ask for VIP (direct) charging



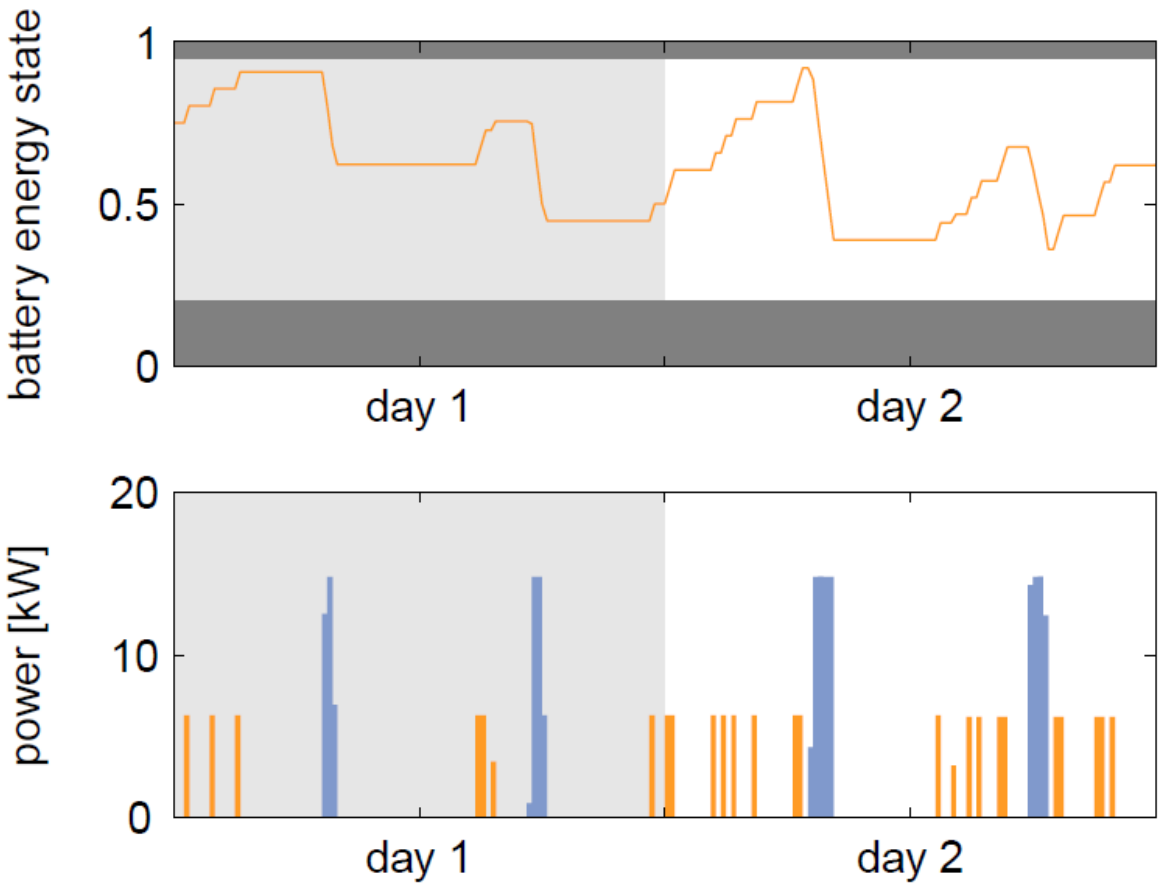
The driver should always
- remain in the driver seat.

Requesting direct charging provides the energy directly after connection to the charging spot.

In general, there is enough time left, to incrementally recharge after trips

if we can assume that not driving means being connected.

7. ECO (smart) charging gives EV driver same range



For a particular EV driver with his/her typical driving patterns, some charging could happen later without violating driver's needs.

With predictable driving patterns for commuters and family cars, there is typically a substantial battery charge left at the end of trip.

Smartly shaping the charging according to wind and price predictions **provides the same energy in ECO mode without any usability penalties.**

Agenda Demo A: Fleet operation for mutual benefit

1. Motivation of Grid-aware Smart Charging
    a. Aggregated-level benefits
    b. Individual driver perspective

2. Video of Bornholm Grid and EV Simulation

3. Panel of Fleet Operator
4. Virtual EVs and Archive Visualization
5. EV and Fleet Management - Bornholm

Agenda Demo A: Fleet operation for mutual benefit

1. Motivation of Grid-aware Smart Charging
    a. Aggregated-level benefits
    b. Individual driver perspective
2. Video of Bornholm Grid and EV Simulation
3. **Panel of Fleet Operator**
4. Virtual EVs and Archive Visualization
5. EV and Fleet Management - Bornholm

Agenda Demo A: Fleet operation for mutual benefit

1. Motivation of Grid-aware Smart Charging
    a. Aggregated-level benefits
    b. Individual driver perspective
2. Video of Bornholm Grid and EV Simulation
3. Panel of Fleet Operator
4. **Virtual EVs and Archive Visualization**
5. EV and Fleet Management - Bornholm

Agenda Demo A: Fleet operation for mutual benefit

1. Motivation of Grid-aware Smart Charging
    a. Aggregated-level benefits
    b. Individual driver perspective
2. Video of Bornholm Grid and EV Simulation
3. Panel of Fleet Operator
4. Virtual EVs and Archive Visualization
5. **EV and Fleet Management - Bornholm**

Summary of
Fleet operation for mutual benefit

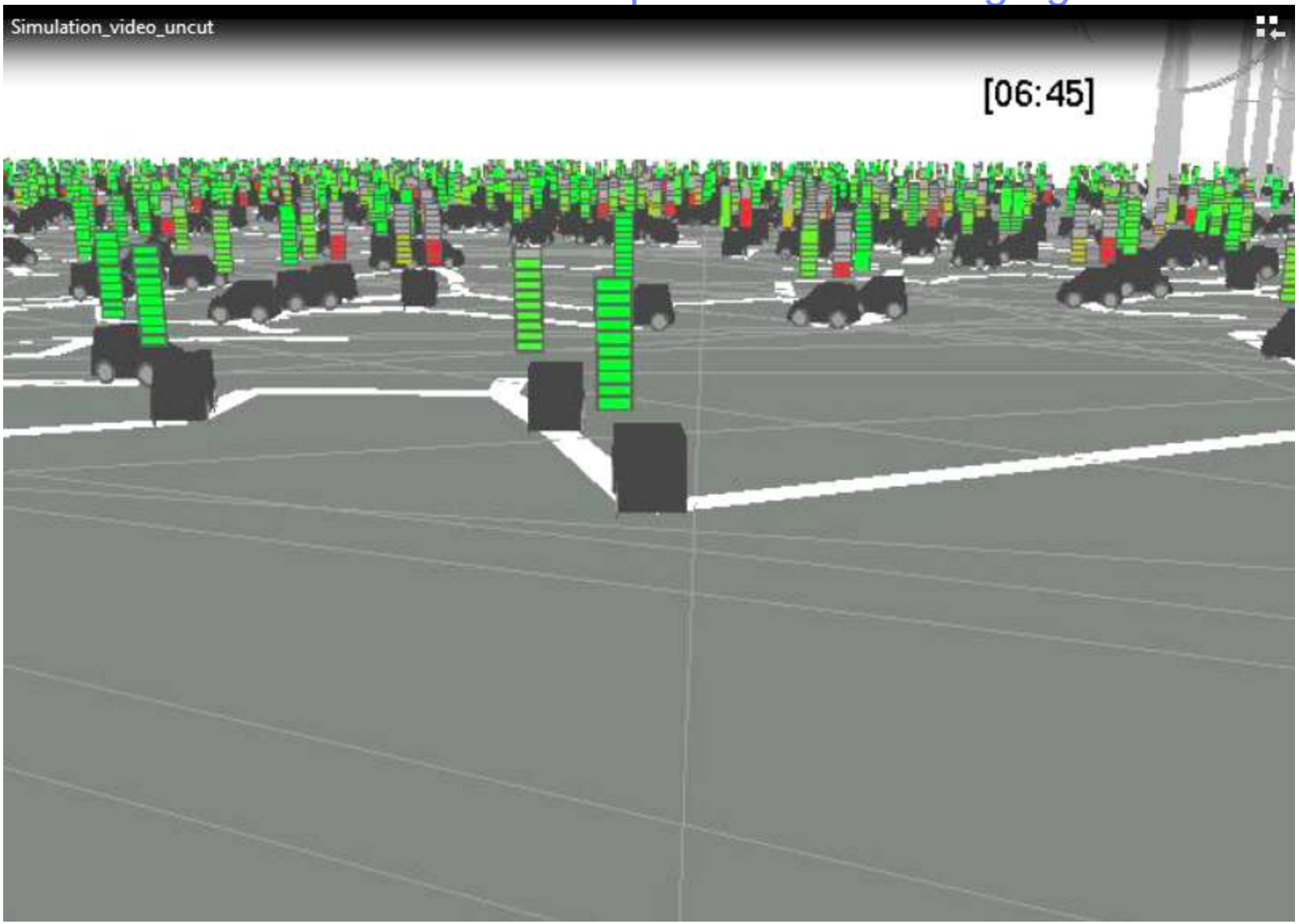
1. **Grid-aware smart-charging leads to enormous benefits for EV owners, Grid operators, and Society as a whole**
2. **Also the individual driver benefits in ECO mode, while direct charging in VIP mode is available as usual**
3. **The establishment of a smart-charging enabled infrastructure is a necessary precondition**
4. **Our ICT platform is ready for a Bornholm demonstration in 2011 !**

Backup and Screenshots

Green power for E-Mobility demonstrator

Source: IBM Forum

Simulation video of Grid-aware optimized EV charging



Source: Olle Sundstroem and Carl Binding, IBM

The EDISON Fleet Operator EVPP Panel

The EVPP Aggregator Panel visualizes the fleetoperators interaction with Grid, Market and Fleet.

Market

The EVPP's operation is based on market prices.

Fleet

The EVPP optimizes the charging of vehicles without limiting driving behavior.

Grid

The EVPP adjusts its optimization to local grid constraints .

EDISON Operator Panel

home fleet market control panel

Location

Total Vehicles
100

Vehicles Charging
5

Vehicles Discharging
2

Total Capacity
24MWh

Current Capacity
23MWh

Current Load
23MW

Static Car Information

ID	License P.	Brand	Model	Batt. Size	Ch. Power	Dch. Power
26	AG12345	Citroen	C1	53,0kWh	2,50kW	0,00kW

State of Charge
59%

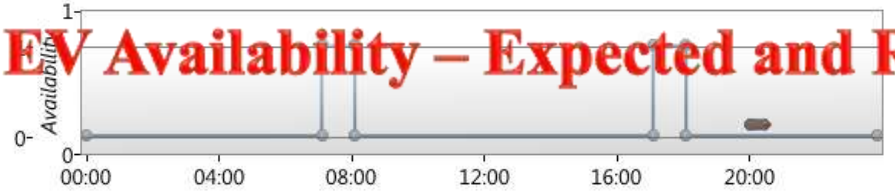
Current Status
Charging

Last seen
17.8.2010 20:27:49

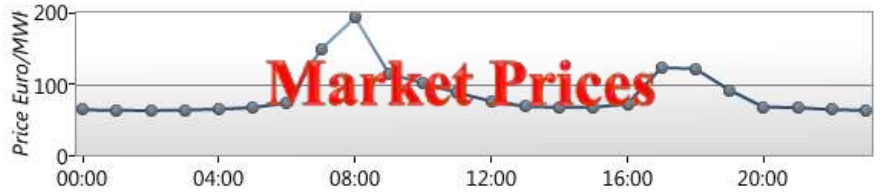
Live EV State

EV status

EV Availability – Expected and Real



Energy Prices (spot)

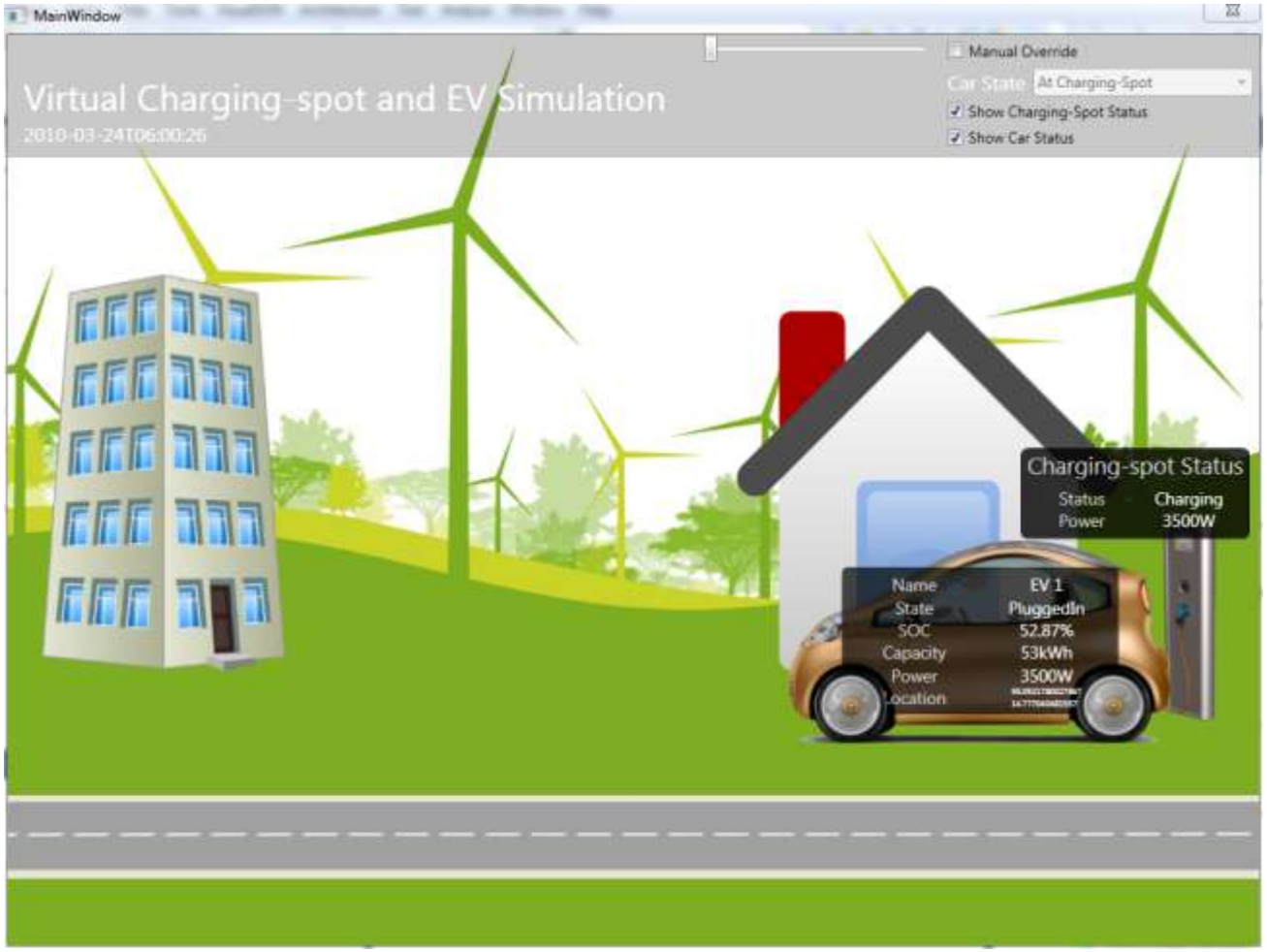


Market Prices

Charging Shedule (load/kW)

Charging Schedules

IEC 61850 based EDISON virtual EV & CS simulator

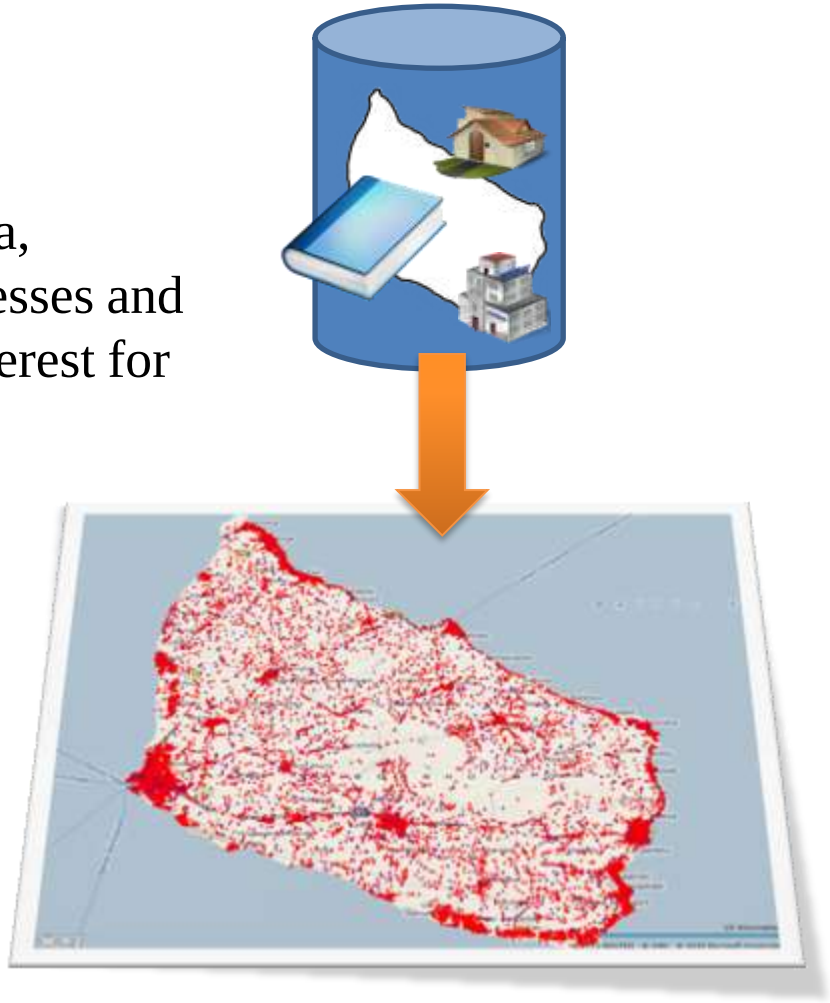


CirroSphere – Fleet operator and EV driving archive interface

Source: cirrosphere.zurich.ibm.com/edison

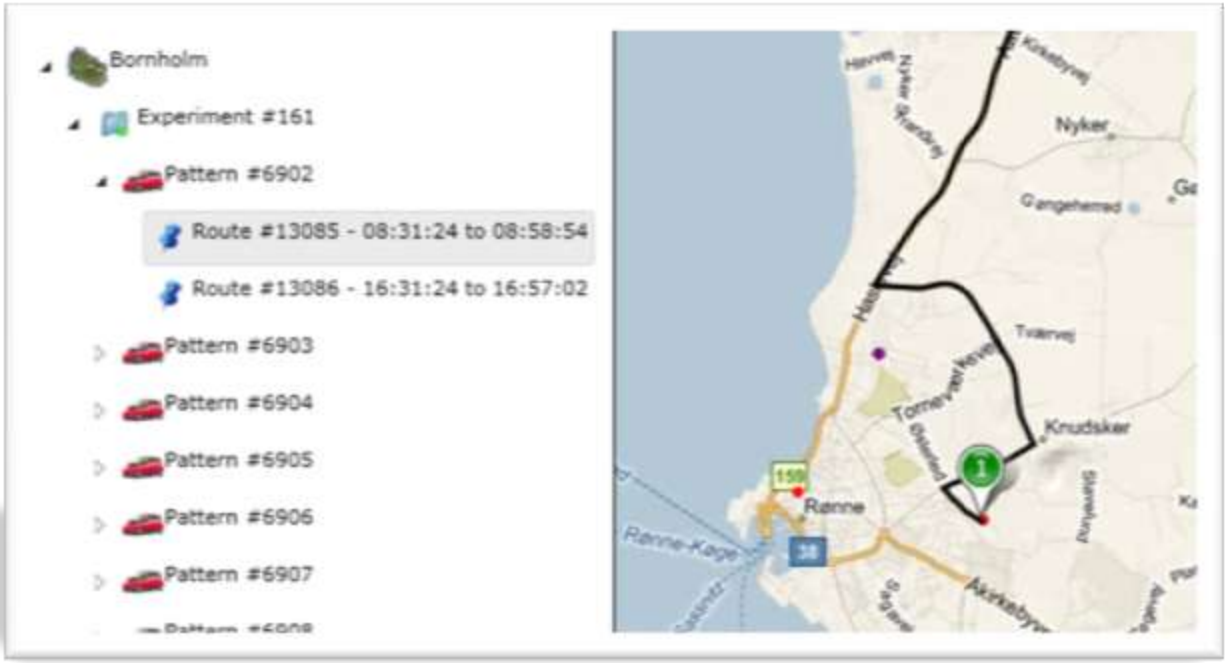
Bornholm infrastructure database

Real-world data, including addresses and locatinos of interest for Bornholm.

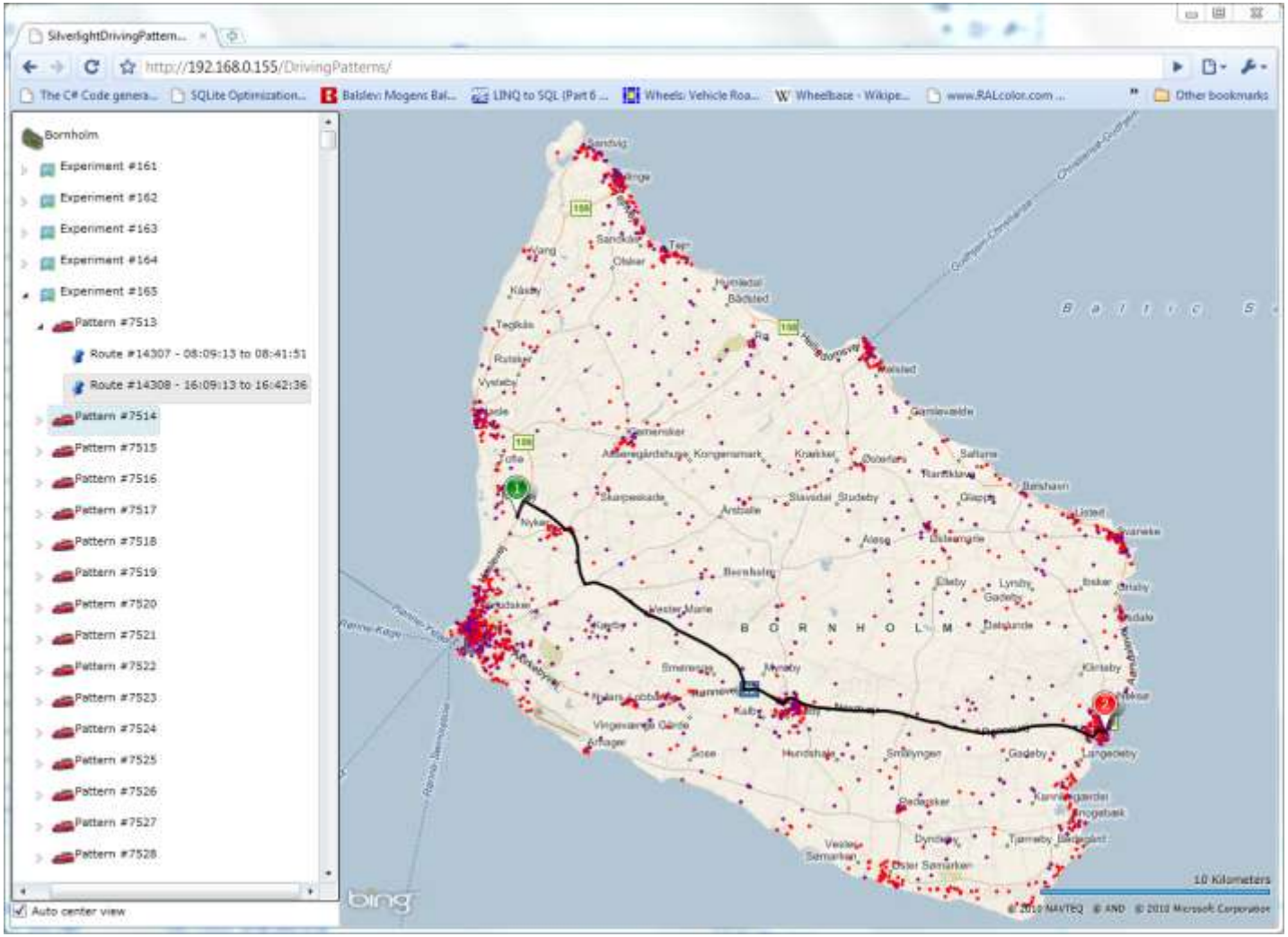


Driving pattern generation

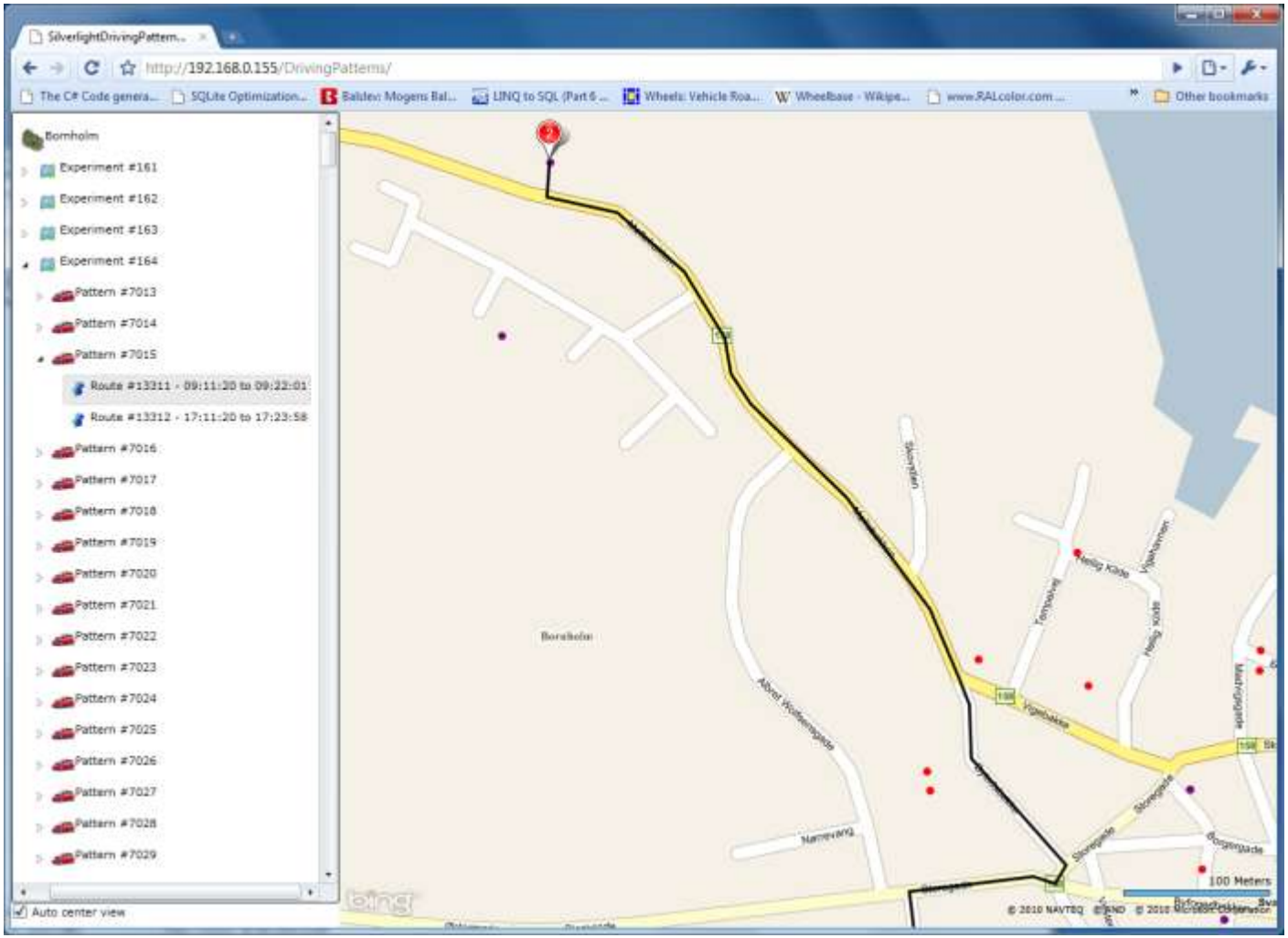
- **Random homes, workplaces and other locations of interest are selected at random.**
- **Interviews with real-life drivers are used to ensure things like realistic departure times and commuting distances.**
- **Using publically availablerouting services, realistic routes are created for the driving patterns.**



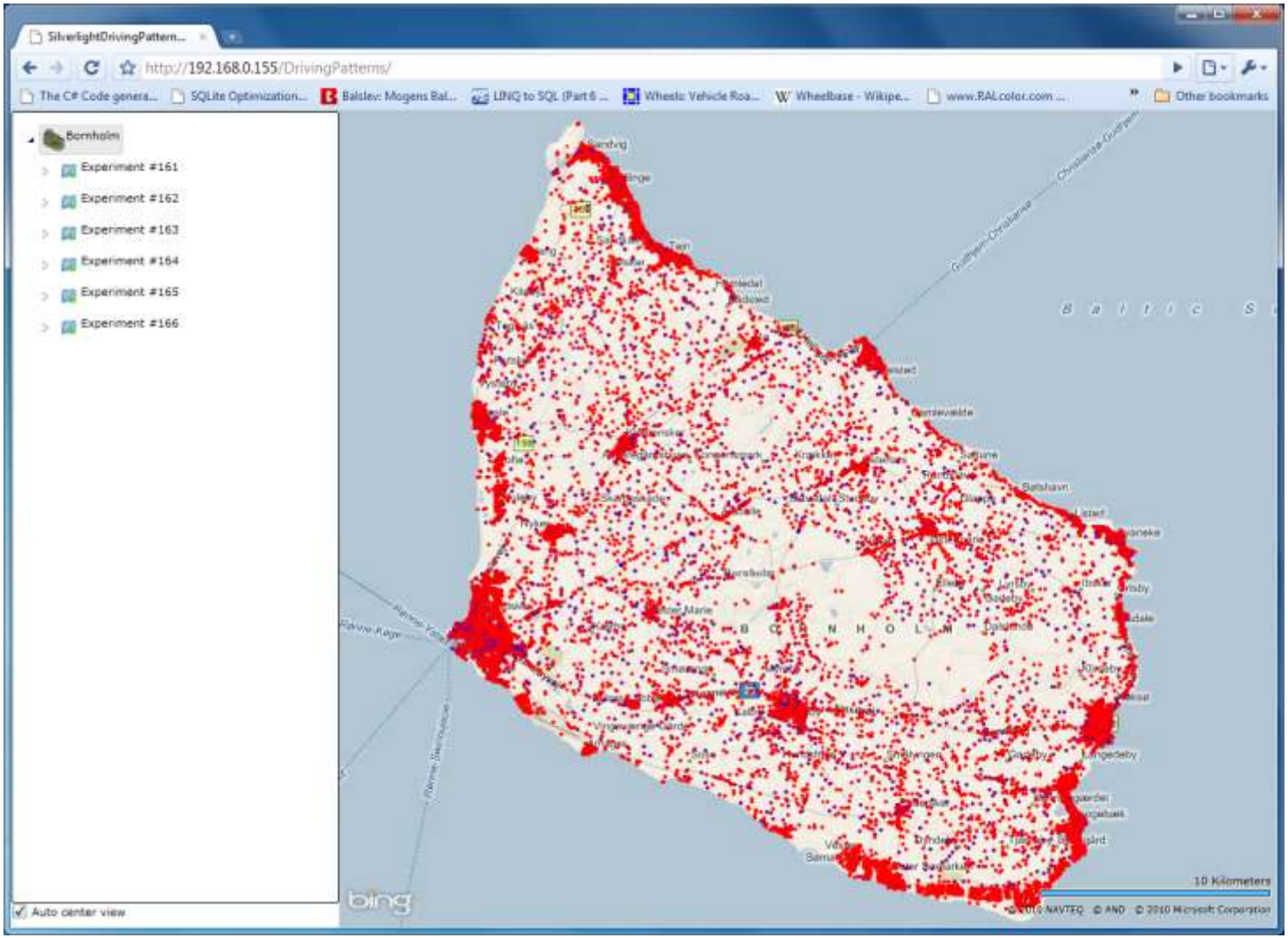
EV Driving Patterns and Fleet Management - Bornholm



EV Driving Patterns and Fleet Management - Bornholm



EV Driving Patterns and Fleet Management - Bornholm



VPP forecasting & power balancing

Historical data:
Trip data
Charging power consumption

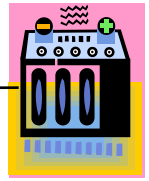
Environmental data (weather, calendar, events…)

Generation schedule(s)

Estimate charging power schedule

$P_{req}(t)$

Accu constraints?



$P_{max}(t) <= P_{req}(t)$

Outlet constraints?

$P'_{max}(t) <= P_{req}(t)$

Feeder constraints?

$P''_{max}(t) <= P_{req}(t)$

Sub-station constraints?

$P'''_{max}(t) <= P_{req}(t)$

Balancing constraints?

Balance EV charging power down/up:

$P_{delivered}(t) <= P'''_{max}(t) <= P_{req}(t)$

VPP data flows to enable smart charging