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The Danish Pilot:
Electrically heated swimming pools as flexible assets

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Agenda

- Challenge:
  - Grid balancing
  - Congestion management

- Pilot case:
  - Case of swimming pools
  - Balancing market design
Challenge: Grid Balancing

- 42% wind power in 2015
- Thermal capacity decreasing
- Currently no demand response
Challenge: Congestion Management

- Photovoltaics (PVs)
- Electric vehicles (EVs)
- Heat pumps (HPs)

**HPs, EVs & PVs**

![Graph showing the growth of HPs, EVs, and PVs from 2016 to 2040. The x-axis represents the years, and the y-axis represents GWh (for HPs and EVs) and MW (for PVs). The graph shows an upward trend for all three categories, with PVs having the highest capacity growth.](Image)
Challenge: Congestion Management

Gorde råd:
Modtageren vil høre din præsentation, ikke læse slides.
Brug notefeltet som hjælp til at huske, hvad du vil sige.
Har du behov for, at modtageren skal huske vigtig information, så lav faktaark og del ud.

EV away from home

- Energikapacitet til elbiler = 13,7 kWh
- Boligforbrug = 11,6 kWh
Pilot case

- 30 summer houses
- Electric heated swimming pools
- Highly flexible consumption
Pilot partners

- Novasol - DER / sub-aggregator
- Eurisco - Control and metering
- Enfor - Forecasting
- DTU - Optimization
- ONE - Aggregator
- BRP - ?
- SydEnergi - DSO
- Energinet - TSO
Balancing market

Goal:

- Activation of DERs
- Optimal dispatch for solving balancing and grid congestion at once

Means:

- Nodal pricing
- Marginal cost of grid use reflected in price formation
- 5 min time slots
- Advanced bid types
- Rolling optimization horizon
Balancing market – 5 mins before operation

Local activation – Central optimization

1. TSO/DSO send current grid load to IMO
2. Aggregators send bids to IMO (MWh, €, node, ...)
3. IMO calculates imbalance and activates necessary bids with the objective of *minimizing activation costs + marginal grid costs*.
4. Activation prices are passed on to DERs
Balancing market – on beforehand

- TSO/DSO sends to IMO:
  - Grid topology
  - Maintenance schedules etc.
  - Marginal costs of use of each line/voltage level
- Aggregator calibrates model of DERs
eMPC modeling
Thank You

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How does it work?

Data measurement and information gathering

SN-10 backend

DTU/ENFOR backend

Heat exchanger

Pool pump

Pool

Temperature sensors:
- Temp A1
- Temp A2
- Temp F1
- Temp F2
- Temp R1
- Temp R2

Relays:
- RELAY1
- RELAY2

Power sources:
- S0 1
- S0 2
- S0 PWR
- S0 PWR
How does it work?

Price based Control
System Interfaces

SYSTEM 1
- Thermostat with actuator
- 230 V Relay
- 24Vac
- Summer house controller
  - 3G
  - Particle io Cloud
  - REST
  - Data gateway Aggregator 1
  - Database
- PT100
- Meter readout
- Temp. sensors (in and out)

SYSTEM 2
- Sub-meter with extended measurements
- RS485 Modbus
- IEC 61850 server
  - 61850/MMS GPRS
  - IEC 61850 client
  - Data gateway Aggregator 2
  - Database

API_1
API_2
SmartNet Pilot B Backend system
Database