Results from the Danish iPower project – what can we learn for Annex 67?

Søren Østergaard Jensen, Danish Technological Institute
(sdj@teknologisk.dk)

Workshop
Energy Flexible Buildings - Potential and Performance
26th September 2017.

Agenda

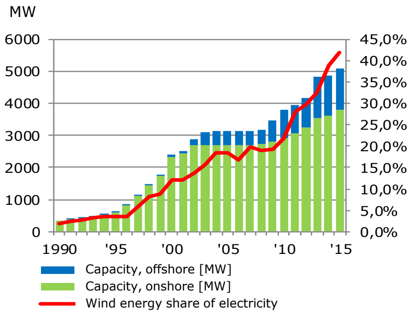
- Why iPower
- Introduction to iPower demos
- Provision of services from DERs – Residential
- Provision of services from DERs – Commercial
- Aggregation of services from DERs – PowerMax and PowerCap
- Lessons learned
- Market for flexibility - FLECH

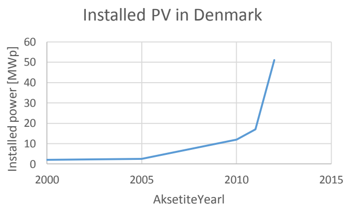
DER: Distributed Energy Resources

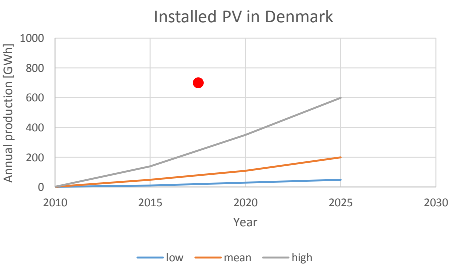
Why iPower

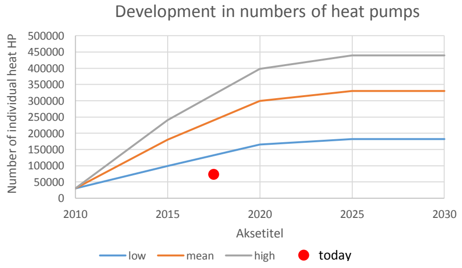
Goal: 50 % wind in power grid by 2020

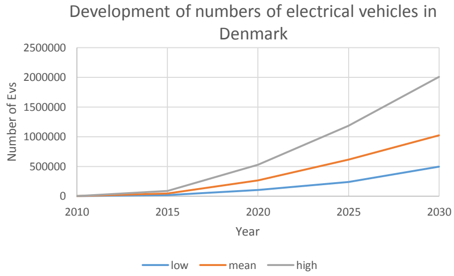
no fossil fuel by 2050











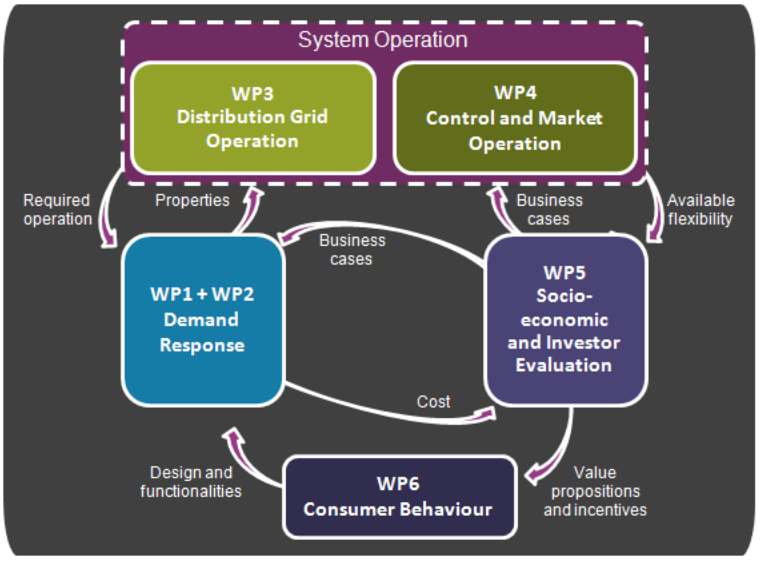
Aim of iPower

Provision of services from DERs for

- Increased utilization of RES and decreased need for fossil fuel
- Reduction of congestion problems in the distributed grids
- Ancillary services for stabilizing the grid

However, flexibility provided by DERs are often too small to be bid into a market

The structure of iPower



Partners in iPower

26 partners, budget 16 MEUR

Project period: 2011 - 2016

http://ipower-net.dk/

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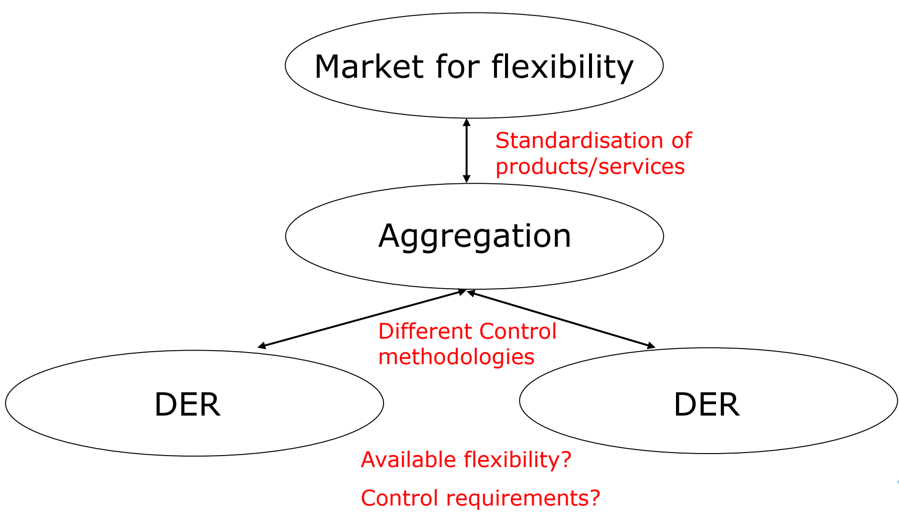
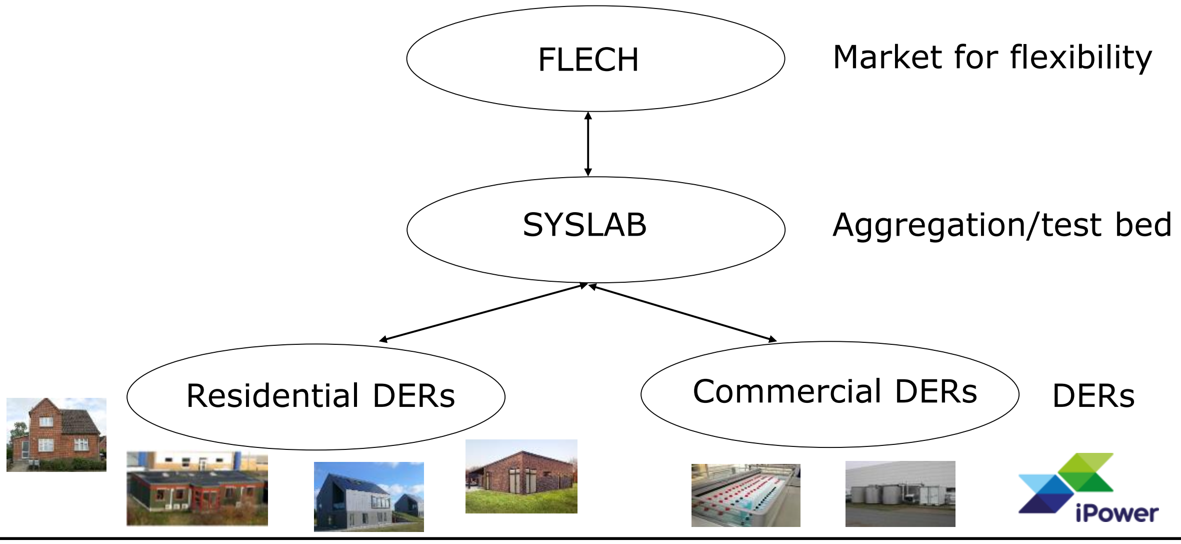
Provision of services from DERs



Provision of services from DERs – in iPower



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Provision of services from DERs – residential

- Test house at Grundfos: indirect control, price signal, forecast, EMPC
- Automatic stop of a heat pump: indirect control, control signal, home automation system
- PowerFlexHouse at Risø: direct control, PowerCap, Home Energy Manager
- EnergyFlexHouse + private house: direct control, no intelligence in the house




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Test house at Grundfos: indirect control, price signal, forecast, EMPC

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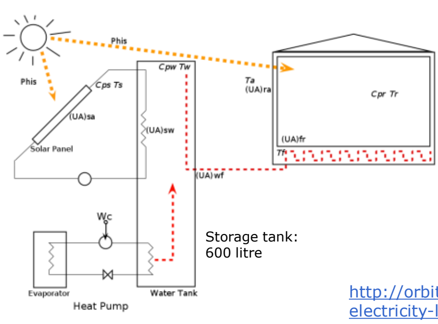

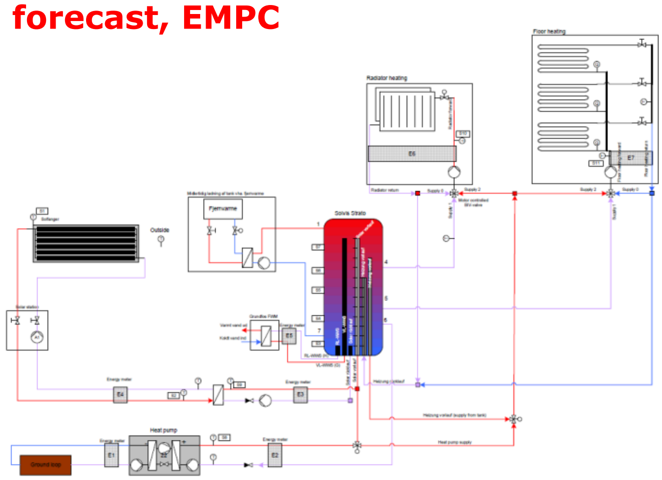

http://orbit.dtu.dk/en/publications/modeling-and-control-for-price-responsive-electricity-loads(7ff027e9-cb51-4baa-b28f-d940a9e94a1e).html

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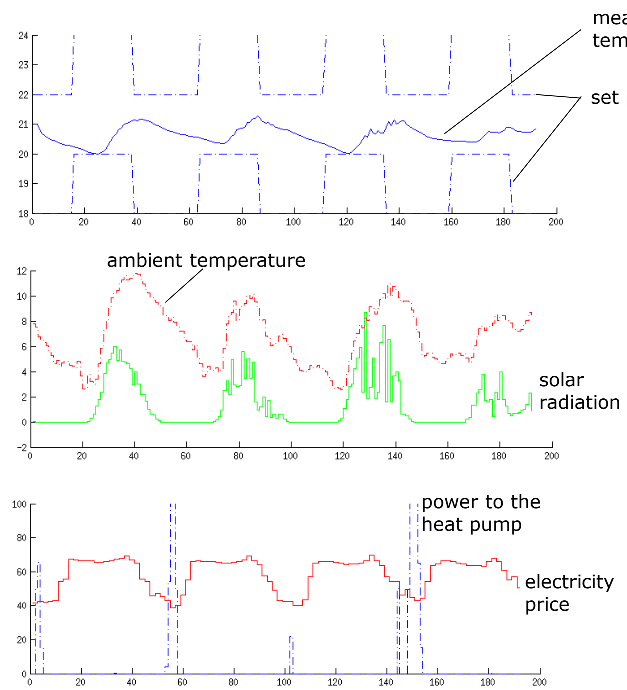

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Test house at Grundfos: indirect control, forecast, price signal, EMPC

Simulation with 48 h prediction horizon using perfect forecasts.

Savings: 30 % in DKK but 8 % larger energy demand.

Results from test in the test house during January-May 2014 utilizing 24 h forecast: 16 % cost saving with dynamic tariffs and 8 % cost saving with flat tariffs.

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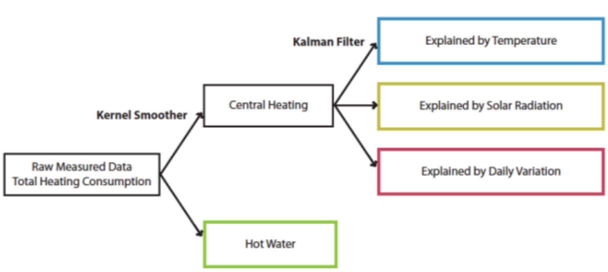
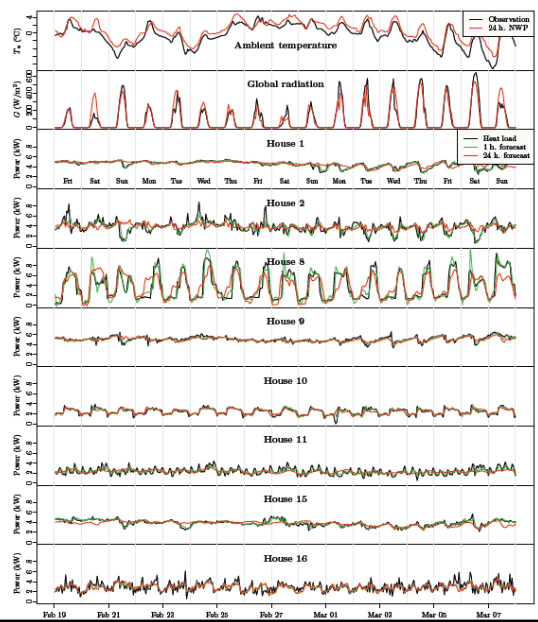
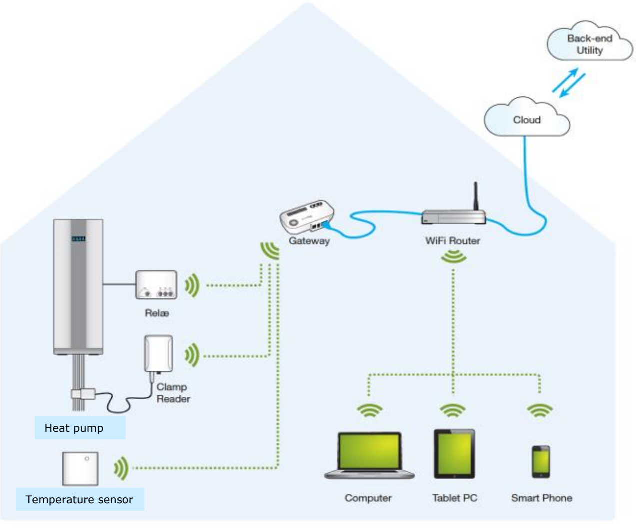
Forecast of the heating demand





http://www.sciencedirect.com/science/article/pii/S0378778816307332

Automatic stop of a heat pump: indirect control, control signal, home automation system



Greenwave Systems:

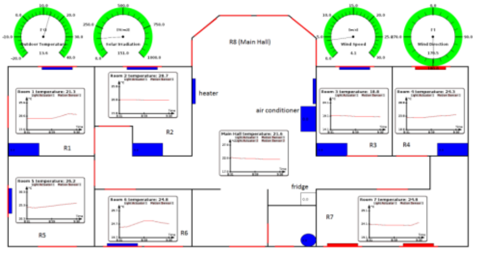
The mean value of the 24 hourly electricity prices for the coming day is calculated.

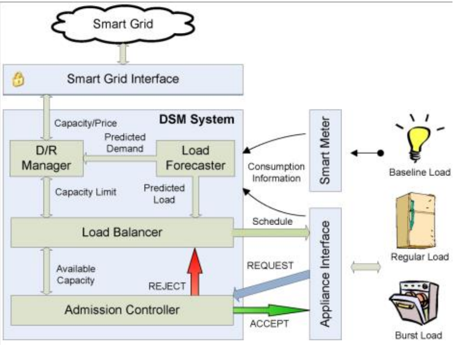
If the electricity price for a given hour is higher than the average electricity price and the room temperature is between the set points defined by the consumer:

the heat pump is switched off.

Define interface between VPP and power plant 8case study). Olliver Dufour. Greenwave Systems. iPower rapport. 2013

PowerFlexHouse at Risø: direct control, PowerCap, Home Energy Manager

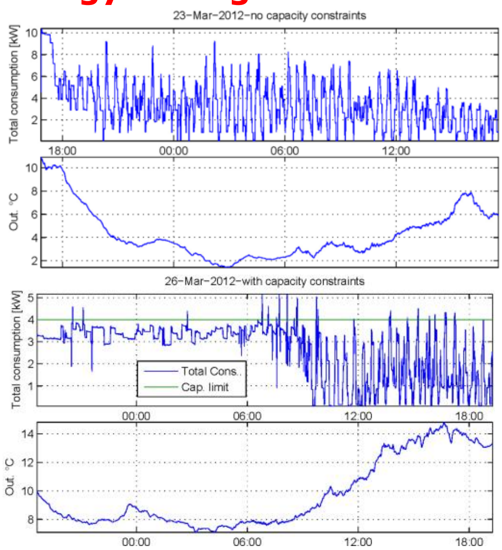


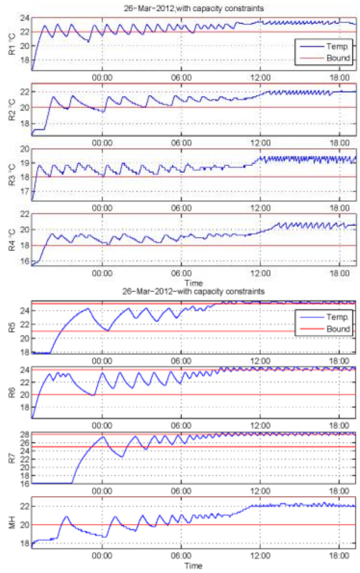


Home Energy Manager

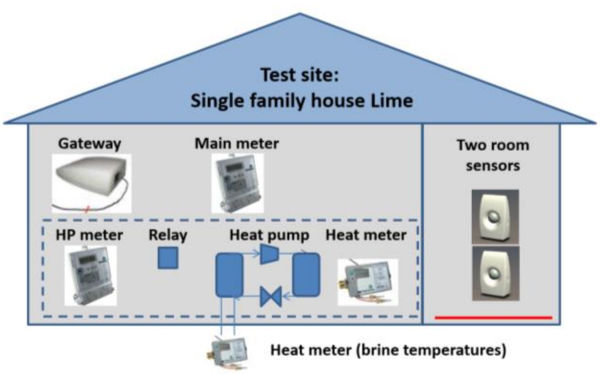
http://ieeexplore.ieee.org/document/7000567/

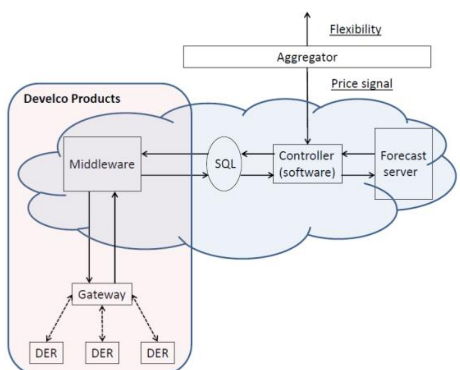
PowerFlexHouse at Risø: direct control, PowerCap, Home Energy Manager





EnergyFlexHouise + private house: direct control, no intelligence in the house





EnergyFlexHouise + private house:
direct control, no intelligence in the house

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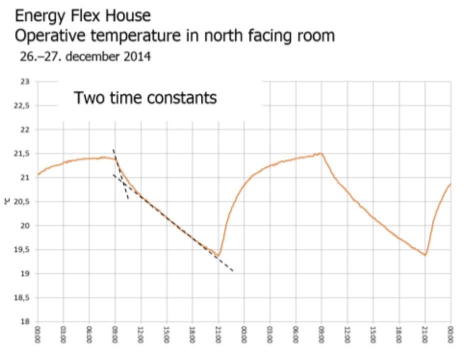
- It is not sufficient only to control the heat pump. Control of the heat emitting system is necessary in order to obtain full flexibility. All thermostats in the system should be controlled
- Need for intelligence in the house
- People seem to accept the fluctuating room temperature
- No need for advanced forecast of heat demand in low energy houses



Smart Meter Case study. Søren Østergaard Jensen, Christian Holm Christiansen, Ditte Marie Jørgensen and Jean-Marc Huet. Danish Technological Institute. September 2016

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Provision of services from DERs – commercial

- Supermarket display cases at Danfoss: direct control via low level controller, PowerMax
- Chiller with ice storage at Grundfos: direct control via low level controller, PowerMax

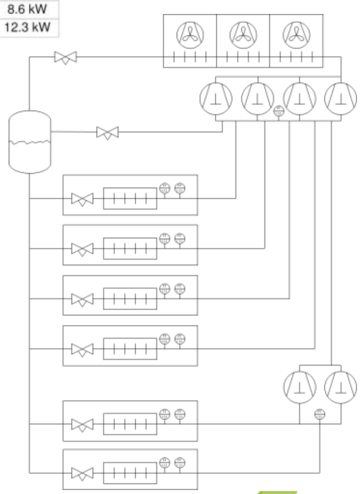
http://vbn.aau.dk/files/218341459/Samira_Rahname_PhD_thesis.pdf

Supermarket display cases at Danfoss: direct control via low level controller, PowerMax

compressors

Compressor	Control mode	Q_0	W_{el}
MTcomp1	Frequency	15 kW	12.6 kW
MTcomp2	Frequency	23 kW	17.7 kW
MTcomp3	ON/OFF	23 kW	17.7 kW
MTcomp4	ON/OFF	25 kW	23.1 kW
LTcomp1	Frequency	12 kW	8.6 kW
LTcomp2	ON/OFF	23 kW	12.3 kW

Medium temperature display cases



Low temperature display cases

Chiller with ice storage at Grundfos: direct control via low level controller, PowerMax

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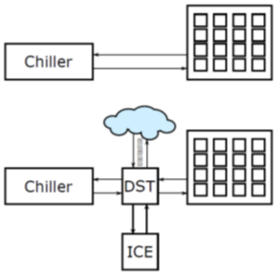
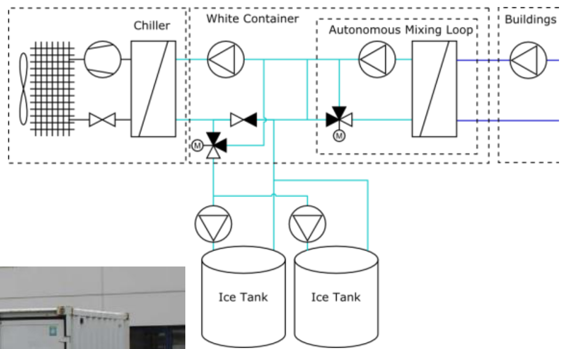


Max cooling power: 300 kW

Size of ice storage: 2 x 6,3 m³

Storage capacity: 1 MWh (75% of peak demand or 4-5 hours)



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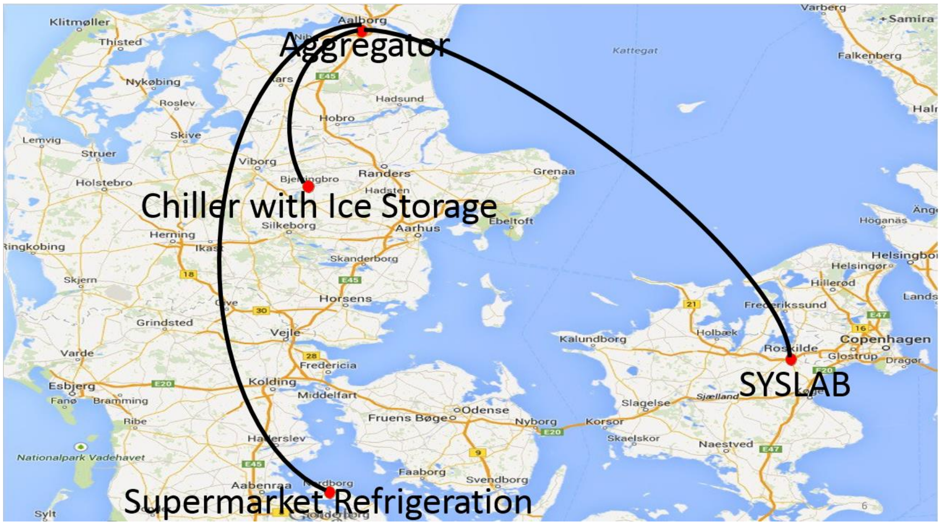
Aggregation of commercial DERs - demonstration



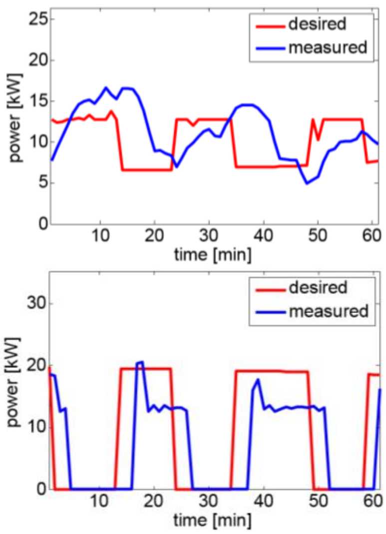
Test bed - SYSLAB

Aggregation of commercial DERs – PowerMax

iPower live demonstration, 18-19 November 2014

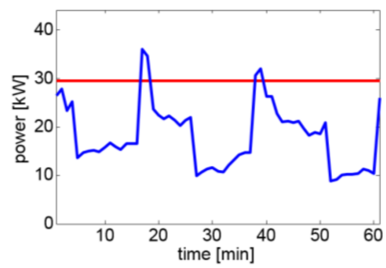
Supermarket

Chiller



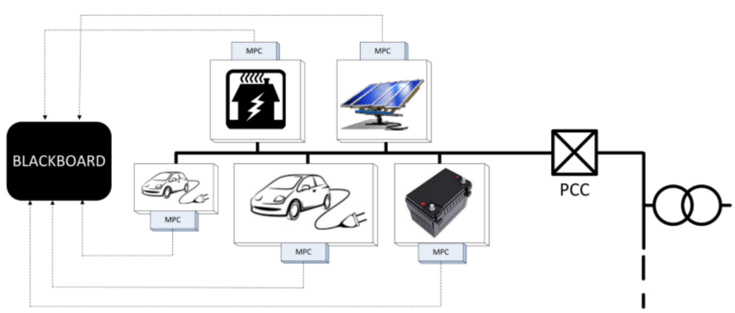
Aggregation

Aggregated power



Aggregation of residential DERs – demonstration/simulation

Sequential Distributed MPC (SDMPC)



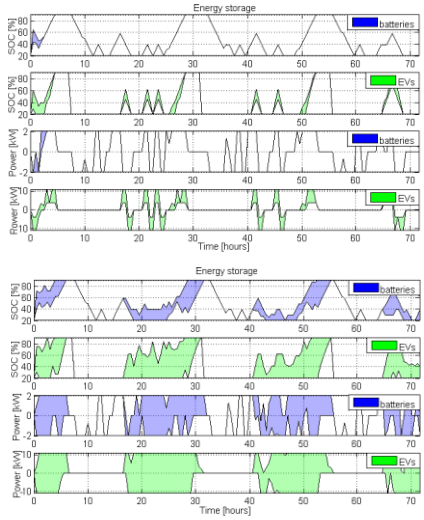
Simulation setting

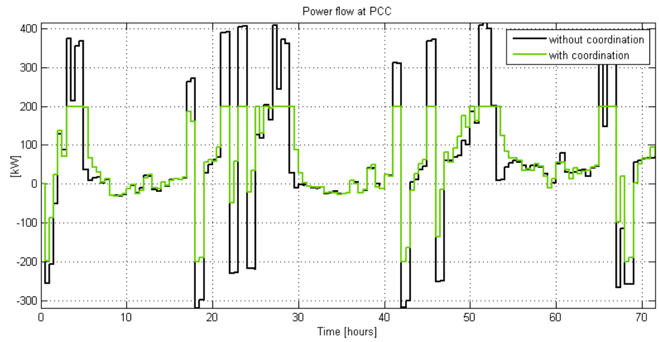
- 100 buildings (Power FlexHouse)
- 10 support batteries
- 20 large EVs
- 20 small EVs
- 10 PVs

http://orbit.dtu.dk/en/publications/indirect-control-of-flexible-demand-for-power-system-applications(f9e8c0cf-04c2-43b6-a3db-8e0c2f7cc8bc).html

Aggregation – PowerMax

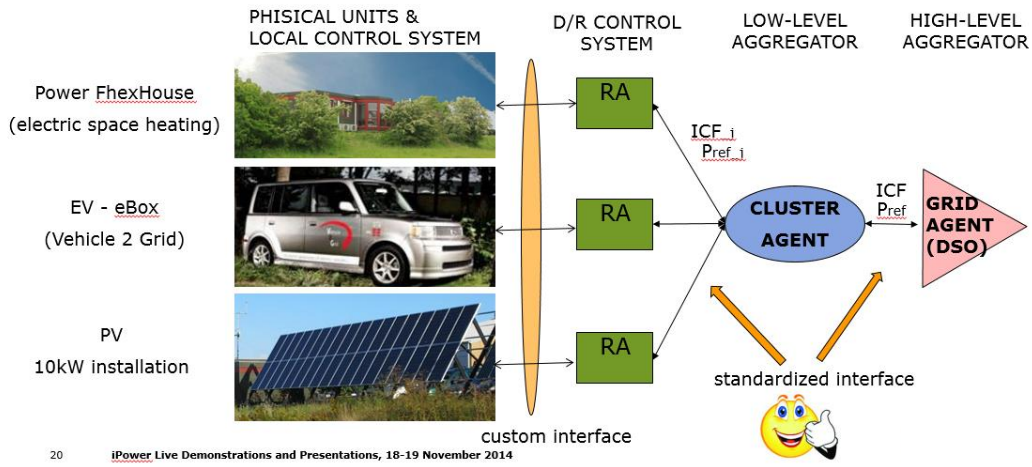
outwith coordination





with coordination

Aggregation of residential DERs - demonstration



iPower live demonstration, 18-19 November 2014

Aggregation and Control of 54 heat pumps – A Real Life Demonstration (AAU, Neogrid, DONG Energy and Neas Energy) - PowerCap

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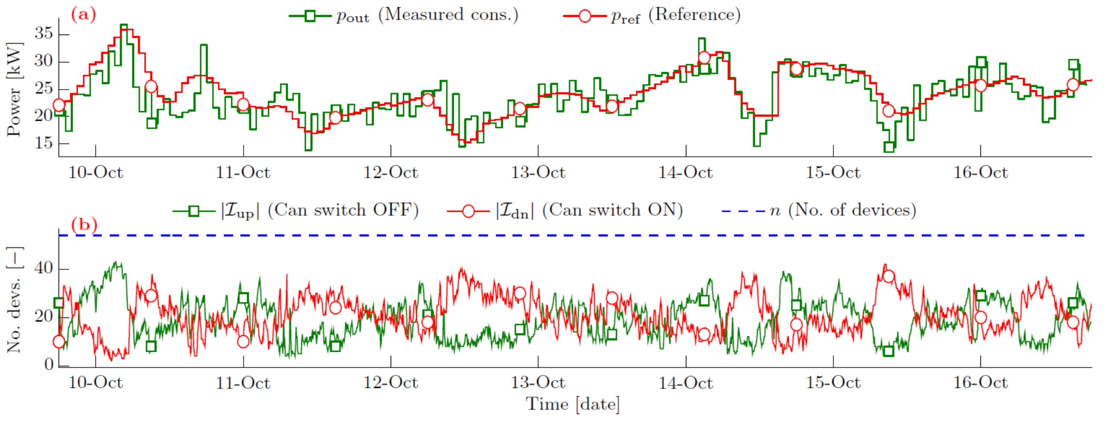

Experimental results. Subplot (a): Tracing ability. Subplot (b): Device available to be turned ON/OFF.

http://www.benjaminbiegel.com/wp-content/uploads/2014/05/HeatPumpDemonstration.pdf

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Lessons learned

- It is possible to control the load of different DERs in different ways
- It is possible to aggregate the above flexible load in order to shape the total power consumption of several DERs
- There is a need for low level controllers at the site of the DERs. Both for residential and commercial DERs
  - If e.g. only controlling the heat pump, only half the flexibility is obtain. It is instead the heat emitting system which need to be controlled
- Forecast will typically increase the available flexibility

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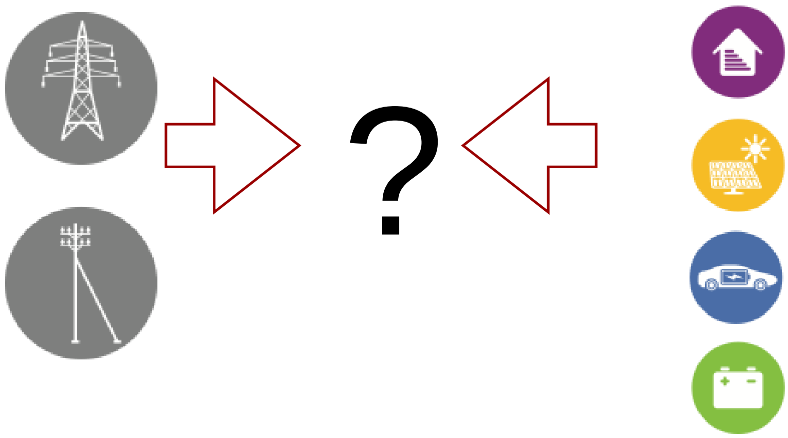
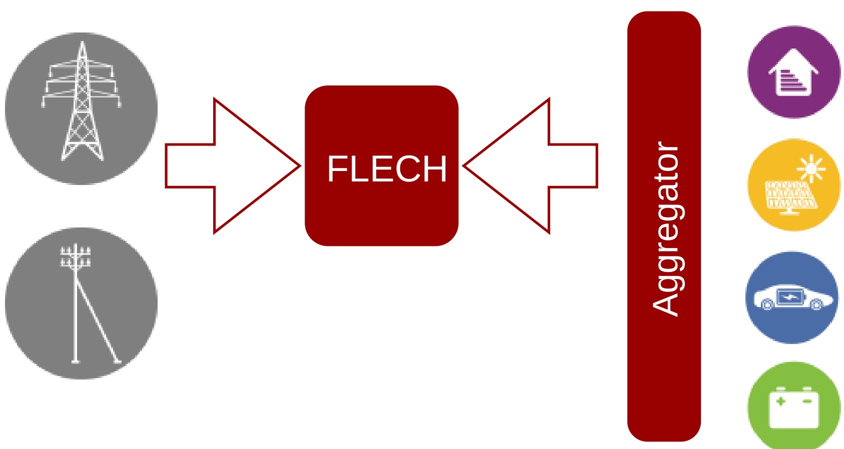
The Problem

- How can we match costumer consumption flexibility with system operator needs?

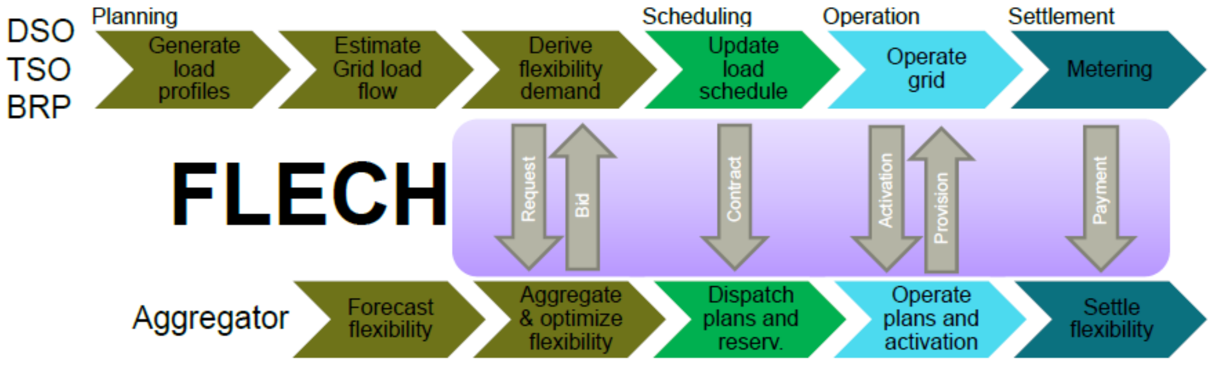


Proposed solution



FLECH: Flexibility Clearing House

FLECH concept: Interaction between DSO,TSO or BRP and Aggregator



https://link.springer.com/article/10.1007/s40565-014-0048-0
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file:///C:/Users/sdj/Downloads/FLECH_Technical_Requirement_Specifications.pdf

Life after iPower

EcoGrid 1.0 and 2.0

http://www.ecogrid.dk/en/home_uk

Danish island Bornholm in the Baltic Sea

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Thank you for your attention

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