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

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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
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

1. Market for flexibility
2. Standardisation of products/services
3. Aggregation
4. Different Control methodologies
5. Available flexibility?
6. Control requirements?
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

Test house at Grundfos: indirect control, price signal, forecast, 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.
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 (case study). Oliver Dufour. Greenwave Systems. iPower rapport. 2013

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

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

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

- 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


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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


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

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Medium temperature display cases

Low temperature display cases
**Chiller with ice storage at Grundfos: direct control via low level controller, PowerMax**

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)

**Agenda**

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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

Aggregated power

Aggregation

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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

Simulation setting

http://orbit.dtu.dk/en/publications/indirect-control-of-flexible-demand-for-power-system-applications(9e8c05c0f-04c2-4366-a36b-8e0c370b8bc).html
**Aggregation – PowerMax**

outwith coordination

with coordination

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**Aggregation of residential DERs – demonstration**

- **PHYSICAL UNITS & LOCAL CONTROL SYSTEM**
  - Power FlexHouse (electric space heating)
  - EV - eBox (Vehicle 2 Grid)
  - PV 10kW installation

- **D/R CONTROL SYSTEM**
  - RA

- **LOW-LEVEL AGGREGATOR**
  - ICF

- **HIGH-LEVEL AGGREGATOR**
  - ICF

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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**

![Graphs showing experimental results and control of heat pumps.](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 customer consumption flexibility with system operator needs?

Proposed solution

FLECH: Flexibility Clearing House

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
file:///C:/Users/sdj/Downloads/FLECH_Market_Regulation_Specifications.pdf
file:///C:/Users/sdj/Downloads/FLECH_Market_and_Service_Specification_Analysis.pdf

Life after iPower

EcoGrid 1.0 and 2.0
http://www.ecogrid.dk/en/home_uk

Danish island Bornholm in the Baltic Sea
Thank you for your attention