EcoGrid EU

Quantitative Results

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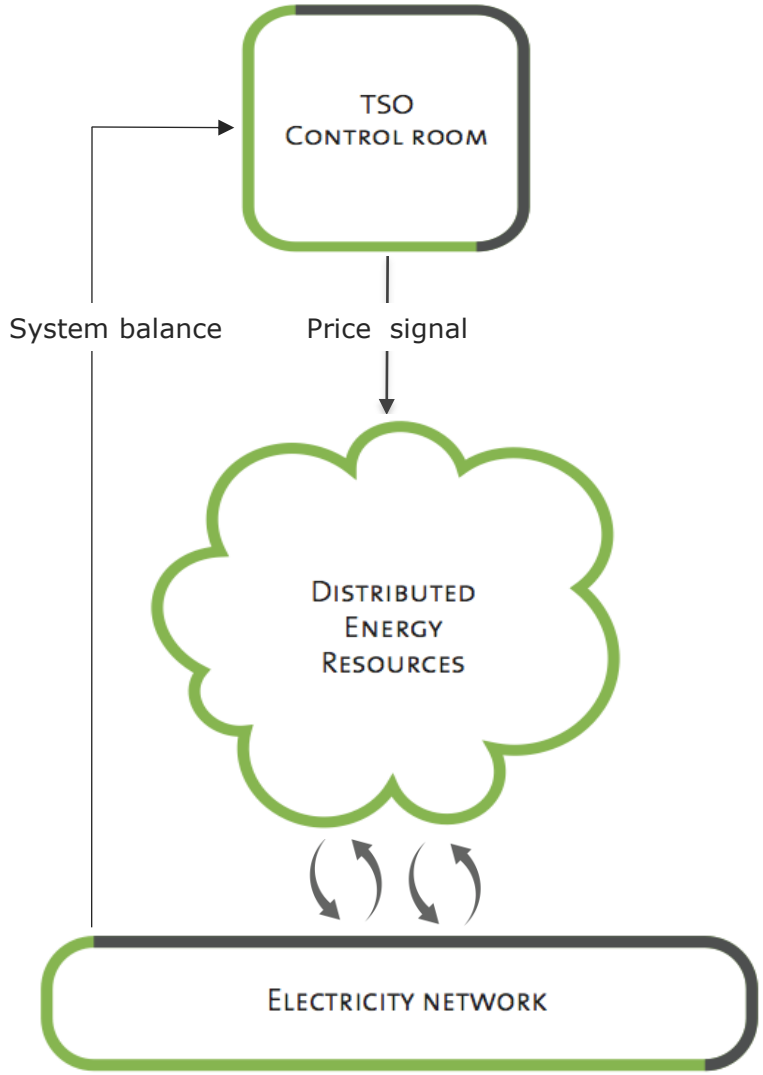
EcoGrid EU in Brief

- EU funded FP7-Energy project (total budget: 21 million €)
- A large scale demonstration of a real-time market place for distributed energy resources (DER)
- ICT systems and innovative market solutions enable small-scale consumers to offer TSOs additional and more efficient balancing services
- A demonstration in a real power system with more than 50 % renewable energy
- Preparation for a fast-track towards European real-time market operation of renewable energy sources and demand response

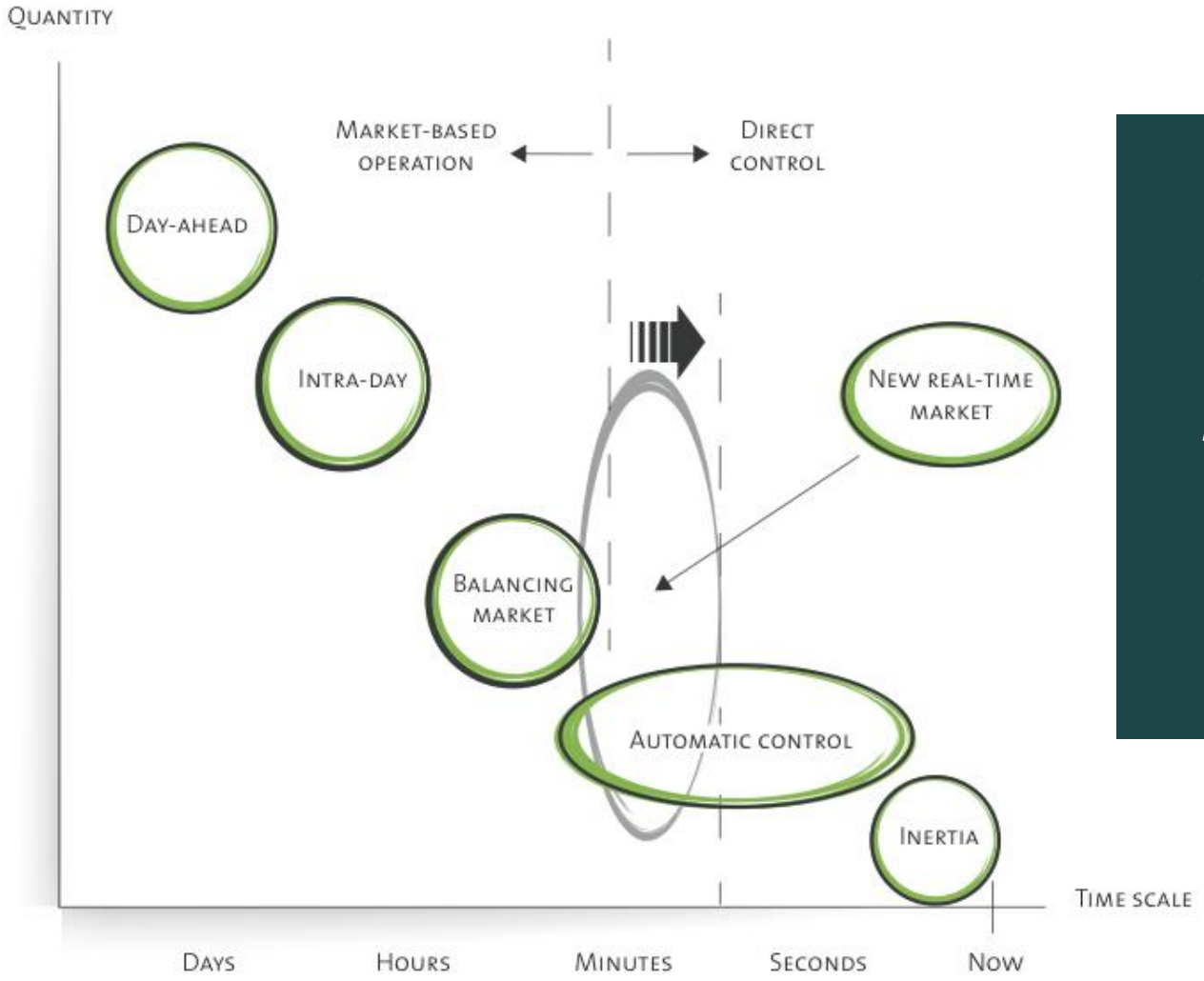
The Fundamental Idea of EcoGrid



The market concept allows regulation of price signals without direct measurement of the individual DER response

*DER = Distributed Energy Resources

The Scope of the EcoGrid Real-time Market



EcoGrid is an example of a real-time market that can be implemented in the context of existing power markets.

EcoGrid supports the need for direct control options on a very short time scale

2000 Participating Customers in the Demonstration

Static Control

200 households with smart meters

No access to specific information

Manual Control

500 households with smart meters

Receiving simple market price information

Must move their energy consumption on their own

Automatic Control

700 automated households with IBM-Green Wave

Reality equipment and smart meters

All houses have heat pumps or electric heating – responding autonomously to price signals

Aggregated automatic Control

500 automated households with Siemens equipment and smart meters

All houses have heat pumps or electric heating

– responding to control signals

Smart Businesses

Up to 100 costumers with smart meters

Including small business and public customers

Connected smart appliances – responding to control signals

Why a new model for evaluation?

- Experimental groups not comparable to the control group due to differences in group composition in terms of
  - Heating systems (type, wood stoves)
  - Usage (Holiday houses)
- Market model is mostly nonlinear
  - Models systems response, but not statistically treatable
- Therefore a purely linear model was used

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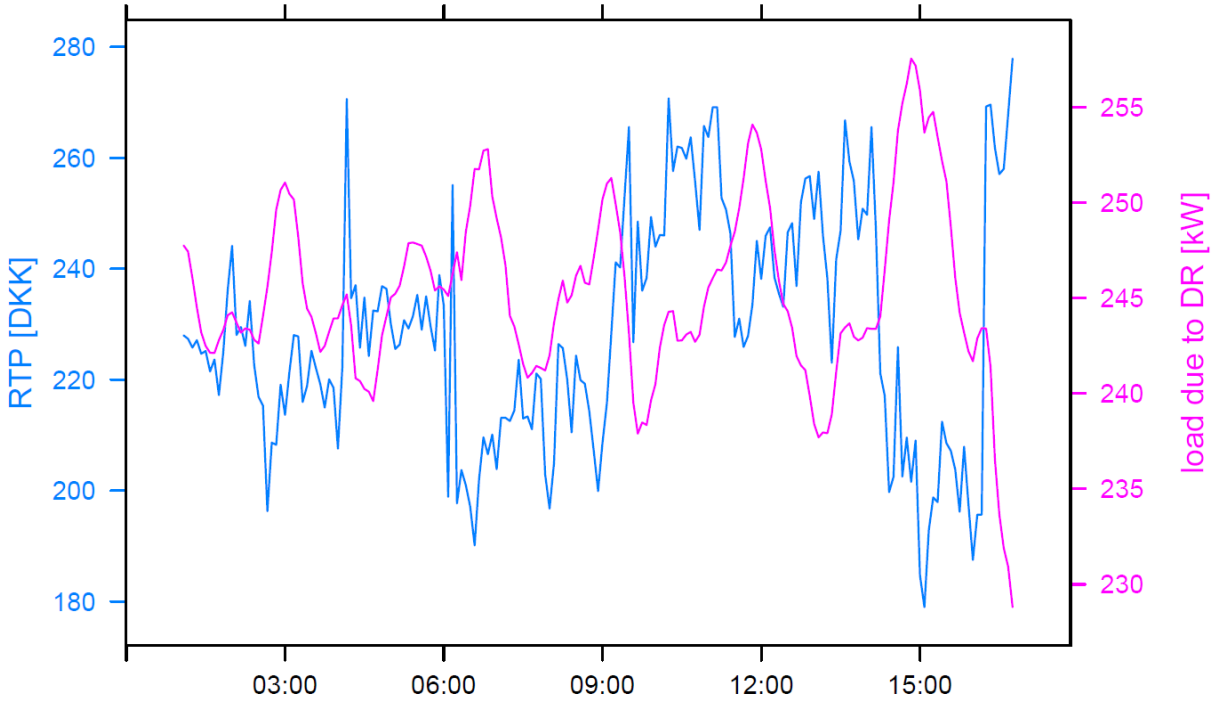
Most important facts about the model

- Differentiated model
  - changes in consumption, not consumption for statistical reasons
- Influence from future and past
  - Day ahead because of the agent listening to forecast
  - RTP up to a certain time back
  - Weather up to a certain time back
- Sample output

	reference	manual	IBM dir.el	IBM HP	Siemens d.e+ HP
rt_lag1	−0.001	0.002	−0.032***	−0.054***	−0.175***
	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)
rt_lag2	0.003	−0.001	−0.083***	−0.074***	−0.183***
	(0.004)	(0.004)	(0.005)	(0.005)	(0.006)
rt_lag3	0.004	−0.004	−0.056***	−0.030***	0.082***
	(0.004)	(0.004)	(0.006)	(0.005)	(0.006)

Sample reaction

- Although linear, not always the same reaction to the same price due to influence from the past



Hourly Response

	Increasing RTP [kW]			Decreasing RTP [kW]		
	Best	Average	Worst	Best	Average	Worst
Reference	0,0306	0,0017	0,0000	-0,0323	-0,0017	0,0000
Manual	0,0166	0,0013	0,0000	-0,0170	-0,0013	0,0000
Siemens	0,3177	0,0147	0,0000	-0,2101	-0,0147	0,0000
All households connected by IBM	0,1413	0,0089	0,0000	-0,1329	-0,0089	0,0000

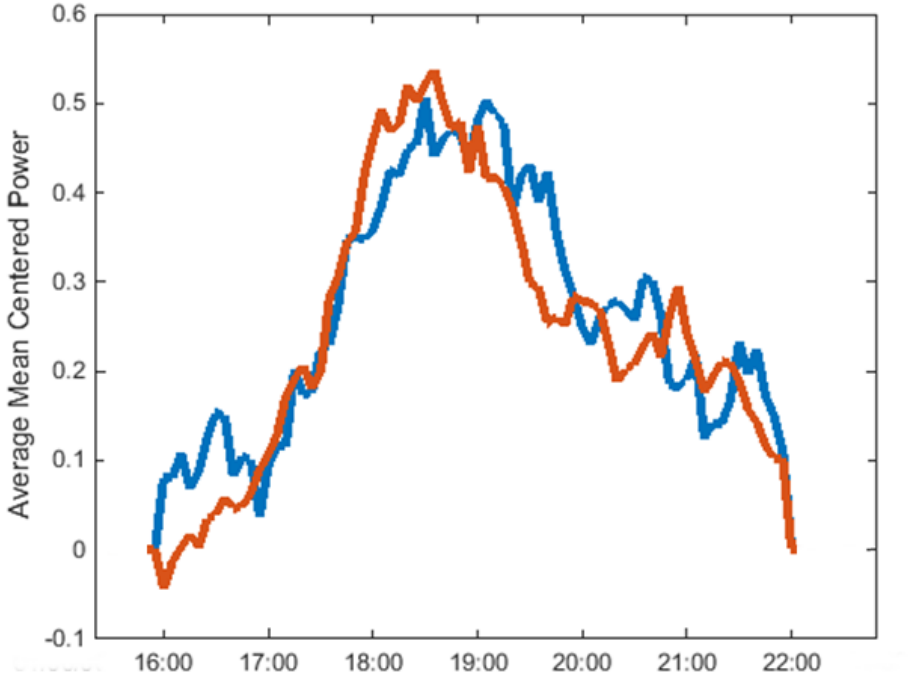
No comparison feasible because of

- Group composition
- Degree of automation (simply blocking heat sources vs. home automation)

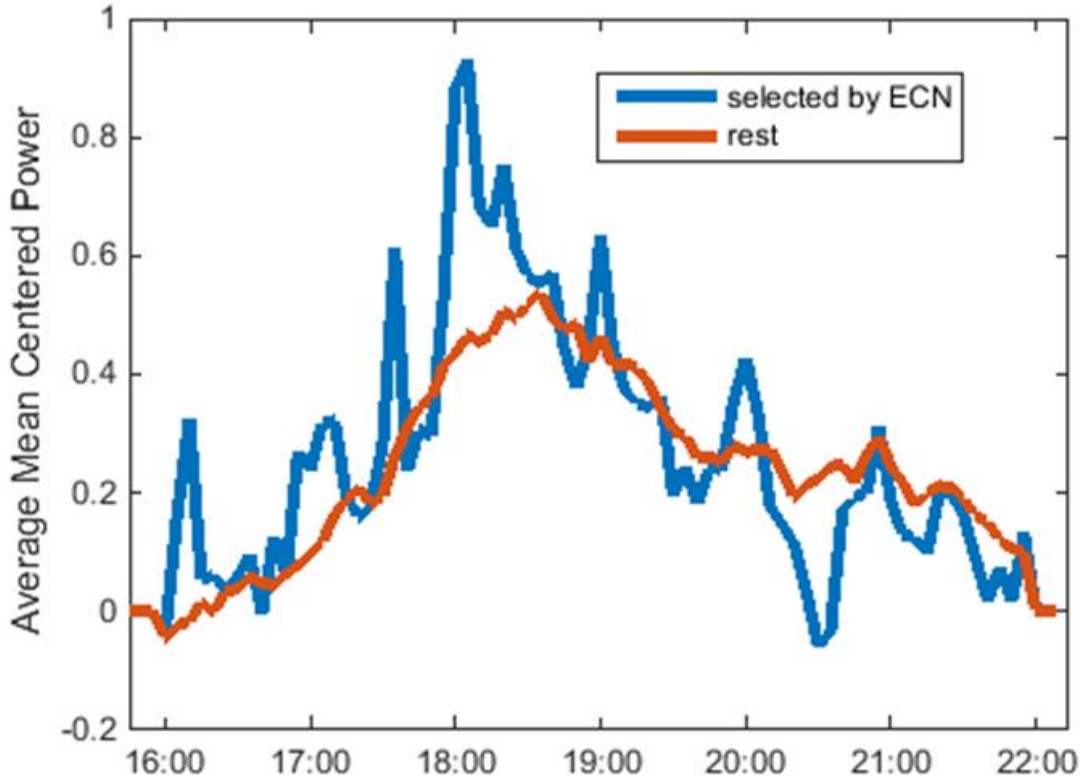
Manual Customers

- Tested in detail with very extreme control signals
- Results for (for high prices)
  - Reference group used for qualitative behavior
  - manual group (red)

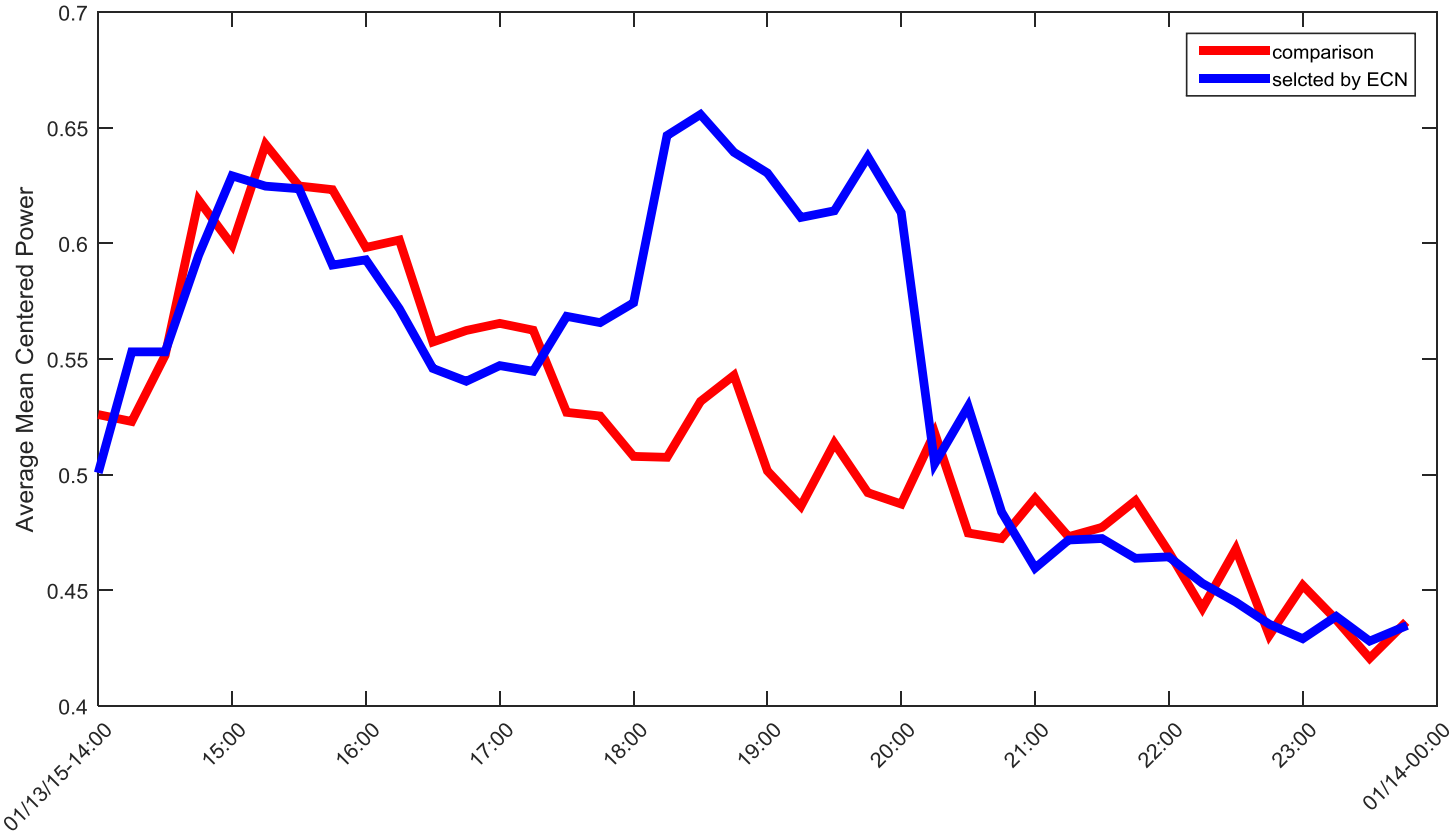
and reference group (blue)



Very high prices – customers claiming to use the FBS



Very low price – customers who claimed to use the FBS



Industrial Customers

- 13 customers
- 11 with more then 50 days of data
- Overall DR

	Max negative DR (KW)	Max positive DR (KW)
Overall Industrial DR	-57,147	61,058

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Industrial Customers

Installation Type	Max negative DR (KW)	Max positive DR (KW)
Manure Mixer	-19,872	19,874
Manure Mixer	-10,799	10,799
Pallet Jack Charger	-1,796	1,792
Pallet Jack Charger	-2,329	4,194
Pallet Jack Charger	-3,746	5,503
Forklift Charger	-4,059	4,932
Forklift Charger	-0,294	0,32
Forklift Charger	-2,602	2,609
Forklift Charger	-7,343	7,299
Forklift Charger	-12,231	12,231
Forklift Charger	-3,569	3,962

Load Reduction (Increase of Energy Efficiency)

- Heating involved
- HDDs in Denmark – bias towards EcoGrid EU

Heating Season	11/12	12/13	13/14	14/15
HDDs	2431	2852	2157	2229

- Therefore linear approach (consistent with e.g. 3e houses)
- Also important as the billing year is not the calendar year and historic data is therefore also aligned

Validation: ANCOVA

- Analysis of Covariance (ANCOVA) tells us whether two linear models are statistically distinguishable or not

- Linear model for
  - Historic data of different groups
  - Experimental data of different group

- Comparisons
  - Time of the experiment with the time before
  - Different groups

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Results (percentages)

Group	Change in Q_{base} [-]	Change in Q_{therm}
All	-3	2.1
Manual	-2.3	2.3
Semi Automated	-3.1	-0,3
Automated	-2.8	-0,1

- But statistically insignificant
- Possible reasons
  - Siemens Hardware in turn used 30W (=~300 kWh/y)
  - Reduction measures in the first half of project (e.g. change to LED) not noticeable here

Thank you for your attention

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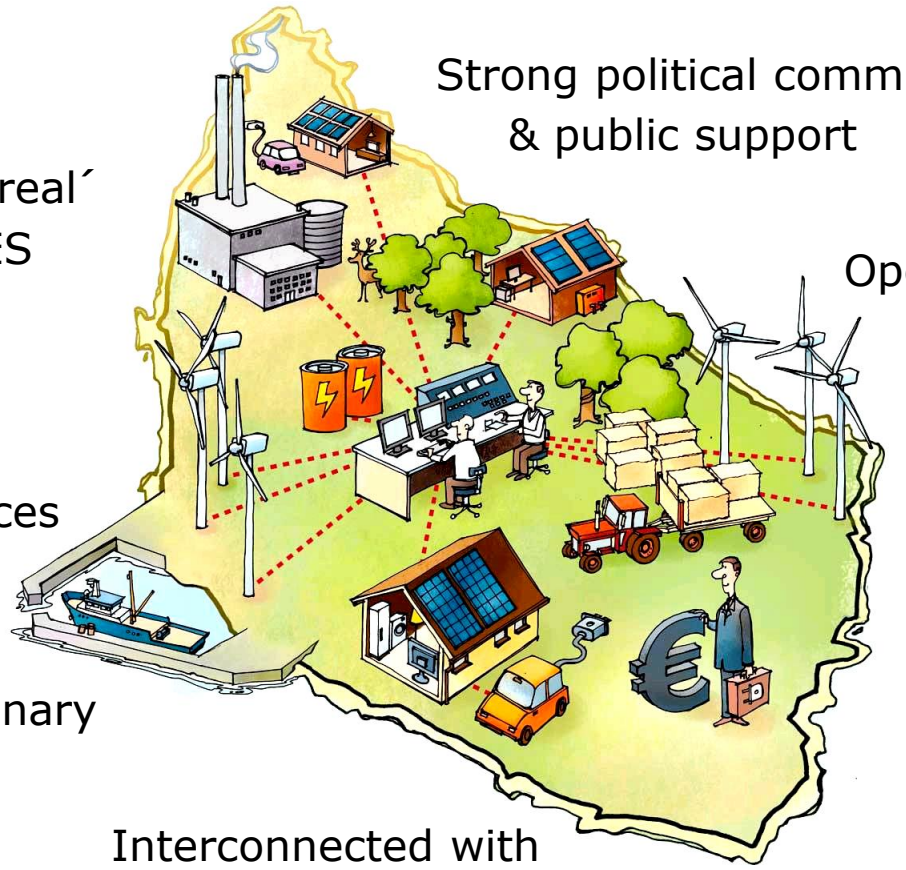
Bornholm – a Unique Test-site

Strong political commitment & public support

Demonstration in a `real´ system with 50% RES

Operated by the local municipal owned DSO, Østkraft



High variety of low carbon energy sources

Eligible RD&D infrastructure & full scale test laboratory

Several demand & stationary storage options

Interconnected with the Nordic power market

Distributed Energy Resources on Bornholm

Power Generation

36 MW Wind Power

16 MW CHP (biomass)

2 MW Biogas

5 MW Photovoltaic (solar)

EcoGrid EU is a large scale demonstration of a real-time market place in a power system with a broad mix of distributed energy resources

Approx. 2,000 pilot test customers

Demand side/Storage options

Intelligent control of household appliances

Heat Pumps with Smart Grids applications

Electricity storage in district Heating