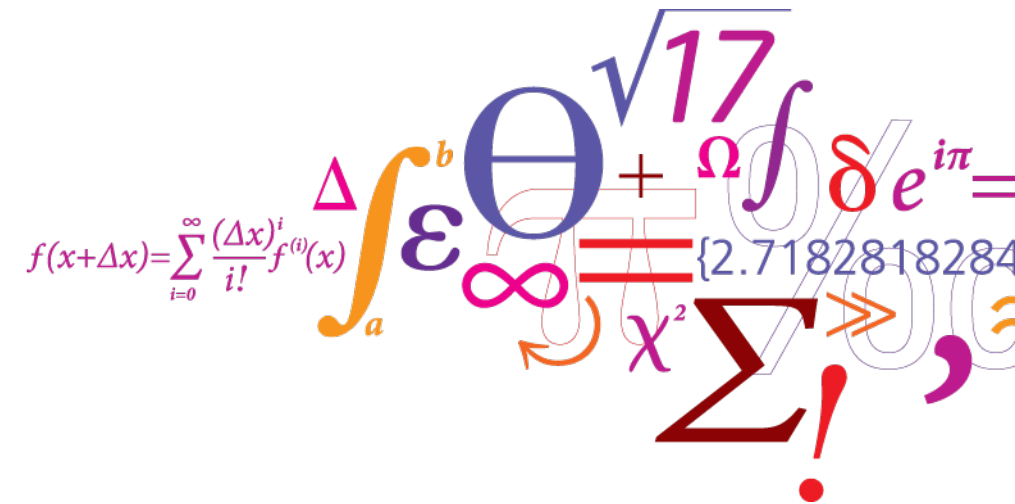


Living Lab for New Energy Technology : Bornholm, Denmark

Professor and head of centre Jacob Østergaard
Center for Electric Power and Energy (CEE)

IEA EGRD meeting
Berlin, 22-23 October 2018



New Danish Energy Policy Agreement

28 June 2018

2020

30 percent of the energy needs covered by renewable energy

50 percent of the electricity needs covered by wind power

2030

55 percent of the energy needs covered by renewable energy

Three new offshore wind farms of total capacity 2400 MW

100 percent of the electricity needs covered by renewable energy

2050

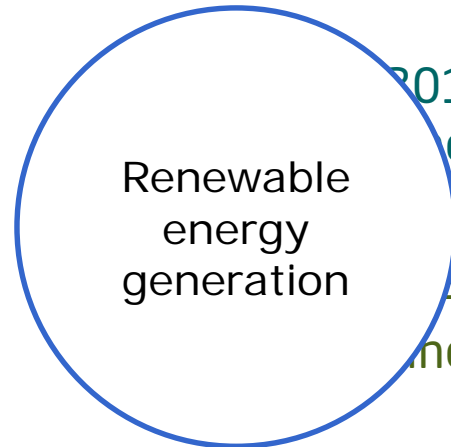
Low emission society independent of fossil fuels

80-95 percent reduction of GHG emissions

Wind power in Denmark



In 2017 Denmark achieved a wind energy world record: **43,4 %** of the Danish power was produced solely by wind



Renewable energy generation

Efficient utilization of the energy (smart energy system)

2014:
Wind power generation: 63.3% of the electricity consumption

21th 2013:
Wind power generation: 102% of the electricity consumption

Single hour July 9th 2015:
Danish wind power generation: 140% of the electricity consumption

2014:
Wind power generated out of installed 4,900 MW

Ref.: Energinet.

Living Labs for New Energy Solutions

- Brings solutions closer to market by demonstrating its applicability in an operational environment (~TRL6-7)
- Solutions are exposed to 360° real-life challenges in all its aspects
 - Operation as part of a coherent energy system
 - Exposed to all aspects of implementation and operation - including aspects not foreseen
- Platform for collaboration and innovation between stakeholders
 - Academia, industry, authorities, end users
 - Knowledge flow from academic to industry
 - Transfer of problems from industry to academia



You have wind and I have sun – shall we trade?

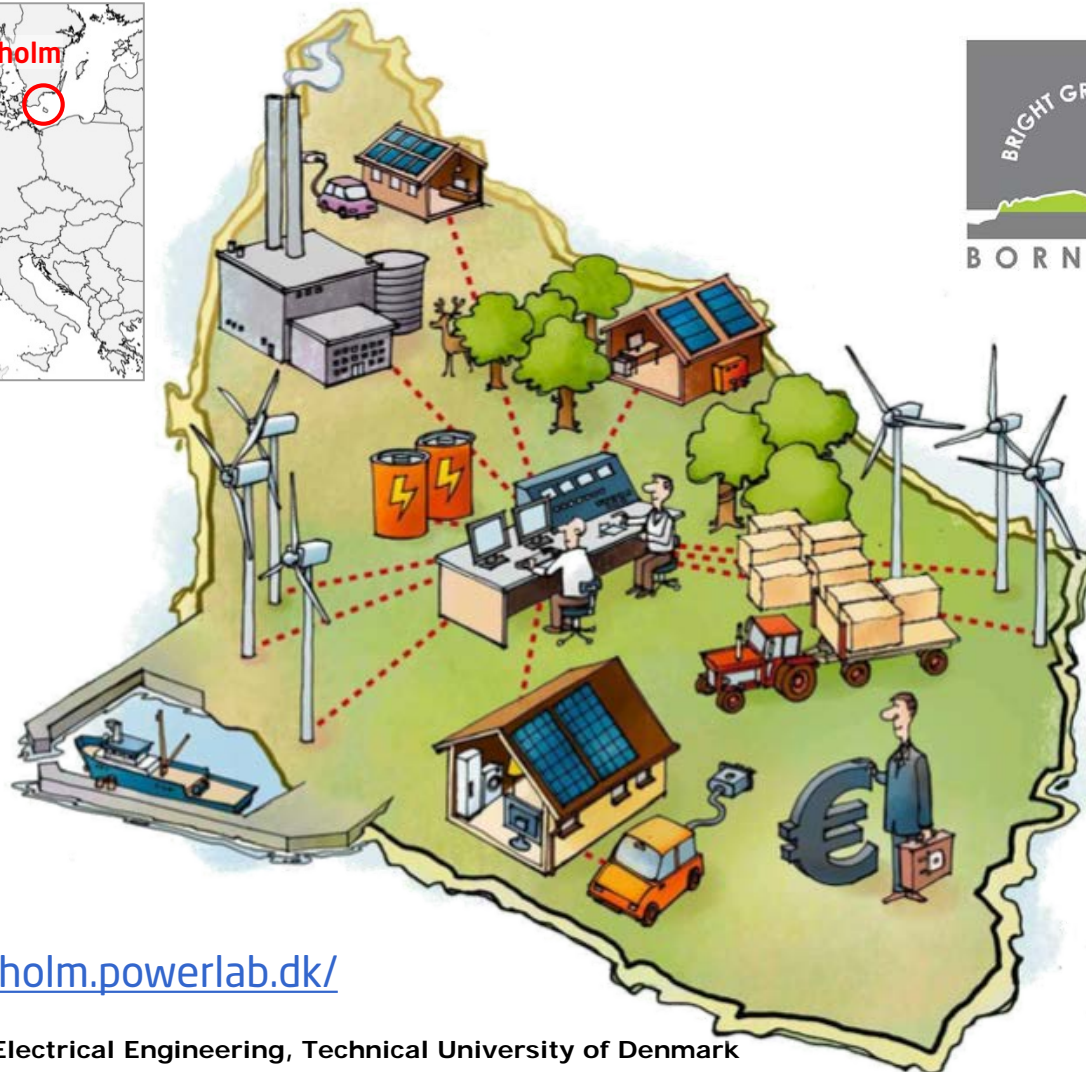
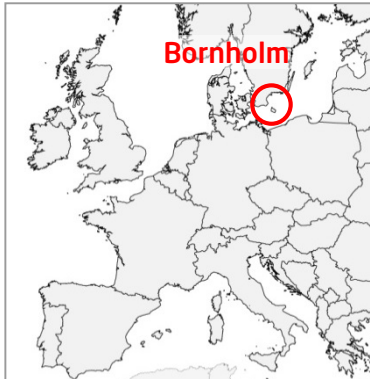
Co-housing scheme : community spirit built into the foundations

Development of a peer-2-peer sharing economy-system for energy exchange



Bornholm Island

~ 1% of Denmark // 40,000 people // 100% renewable power and DH



Bright Green Island strategy (since 2008) -> Engaged community

100% renewable power generation

- Wind power, 34 MW
- Solar PV, 18 MW
- Biomass-fired/CHP, 25+16MW
- Biogas, 2 MW

100% renewable district heating systems

*A single cable to the Nordic power system (can be disconnected)
Part of Nord Pool market*

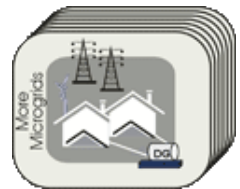
100% smart meters roll-out

Part of PowerLabDK

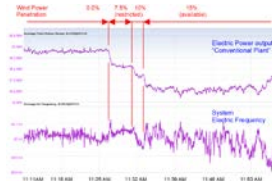
Live data:

<http://bornholm.powerlab.dk/>

Bornholm as platform for energy research, innovation and demonstration



Grid automation



Island operation



Link to control center at DTU



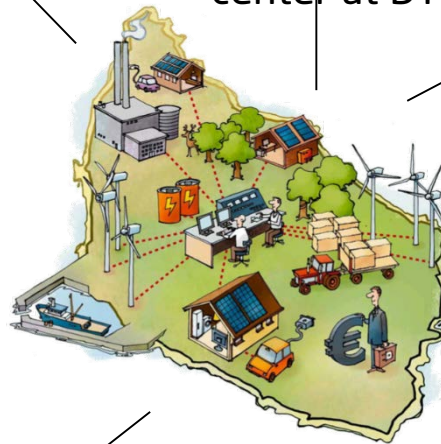
Frequency services from demand



Solar PV integration



Advanced wind turbine control



iTM Energy Roof



Demand response and flex-markets

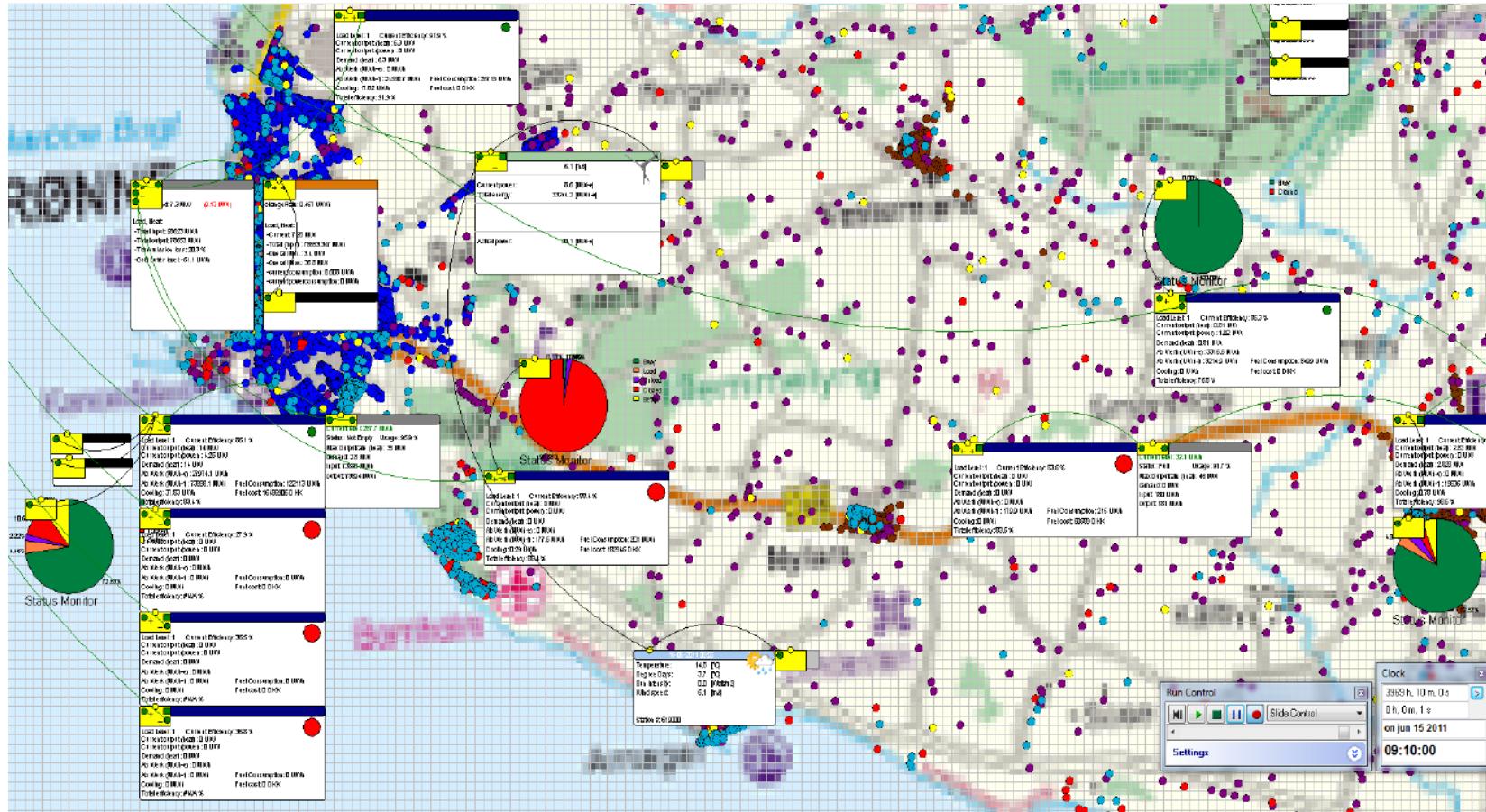


Grid integrated vehicles incl. V2G



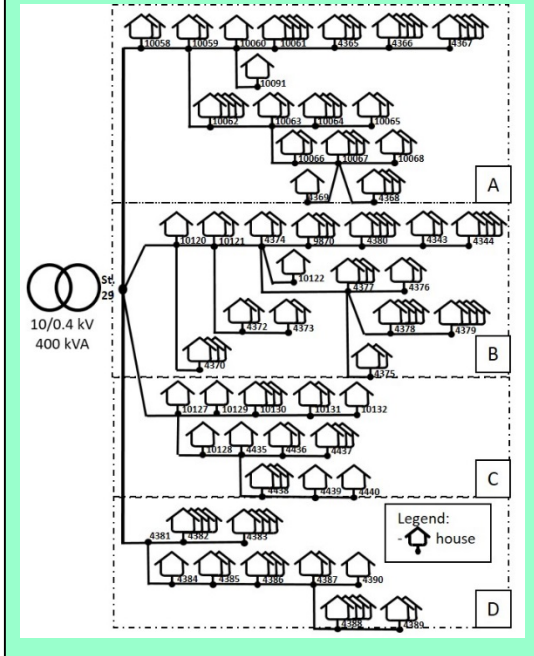
Consumer behavior

High-Fidelity Simulation Models and Data of Bornholm



Models at level of individual buildings

- LV grid: 400 V
- 10/0.4 kV 400 kVA distribution transformer
- 4 subfeeders: 127 known load consumptions

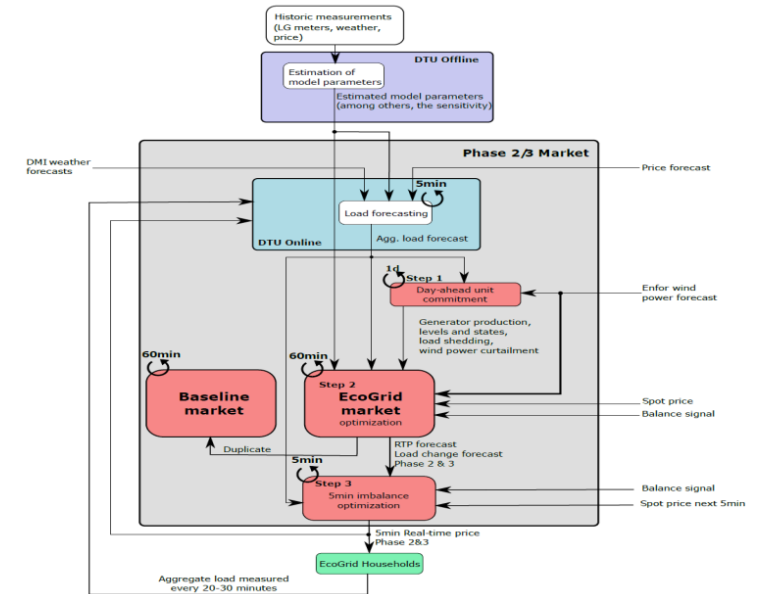
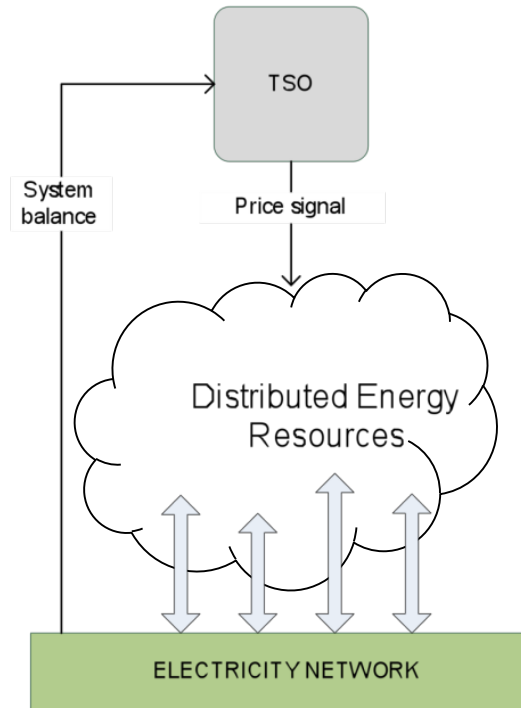
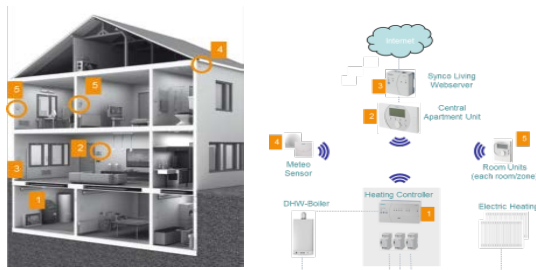


Realistic grid models

EcoGrid EU

EU fast-track to a smart energy system

- Integrated research and demonstration
- Novel 5-min market empowering 2,000 private and commercial customers managing their energy
- Smart meters and automation equipment installed in buildings and processes



EcoGrid EU

Cutting-edge experience with flexible customers

- Awards



EU Sustainable Energy Award 2016; most outstanding and innovative energy project with consumers.



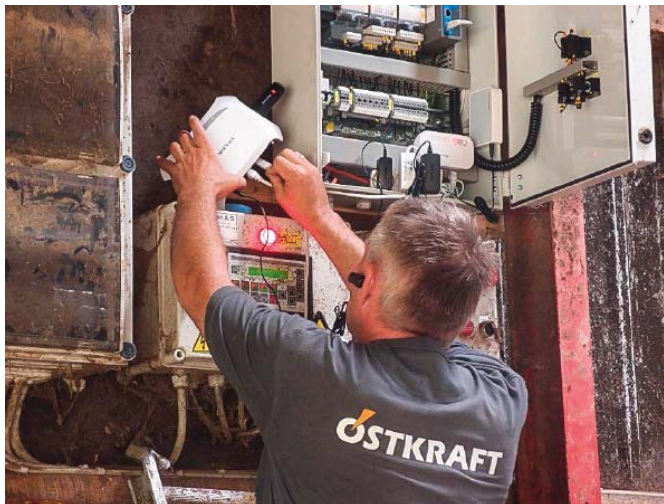
IEA ISGAN Award of Excellence in smart grid systems 2014, "Consumer Engagement & Empowerment"



Best Sustainable IT-project 2012, awarded by Sustainia 100 (Arnold Schwarzenegger et. al)

- Multiple customer motivations

- Lower electricity bill by smart control
- Knowledge about own energy use
- Using green electricity
- Possibilities with new technology
- Being part of a community(!)



A new market framework for exchanging flexibility

MARKETS FOR FLEXIBILITY

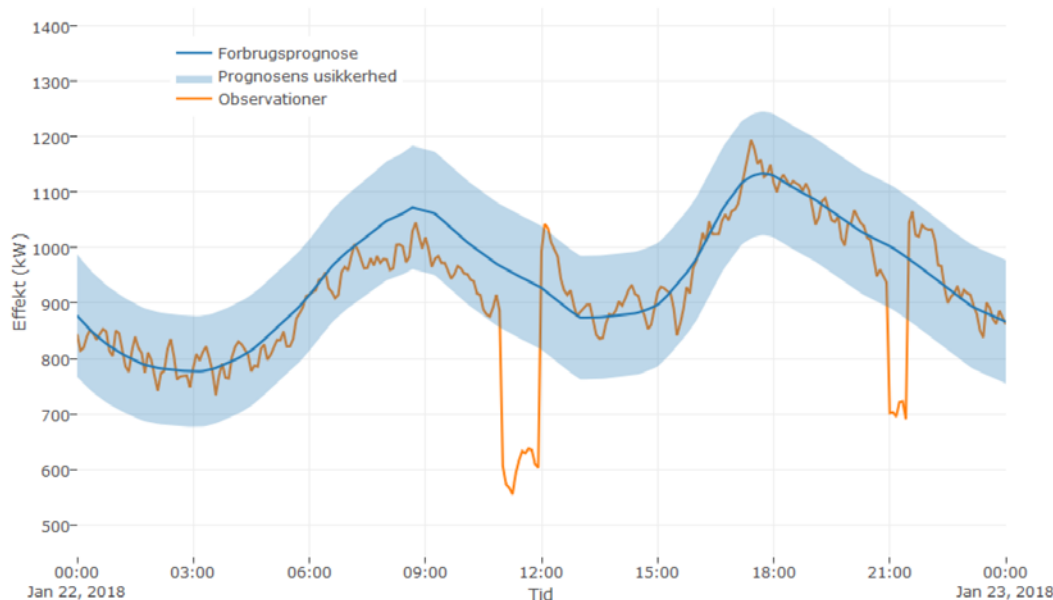


Flexibility market design in EcoGrid 2.0

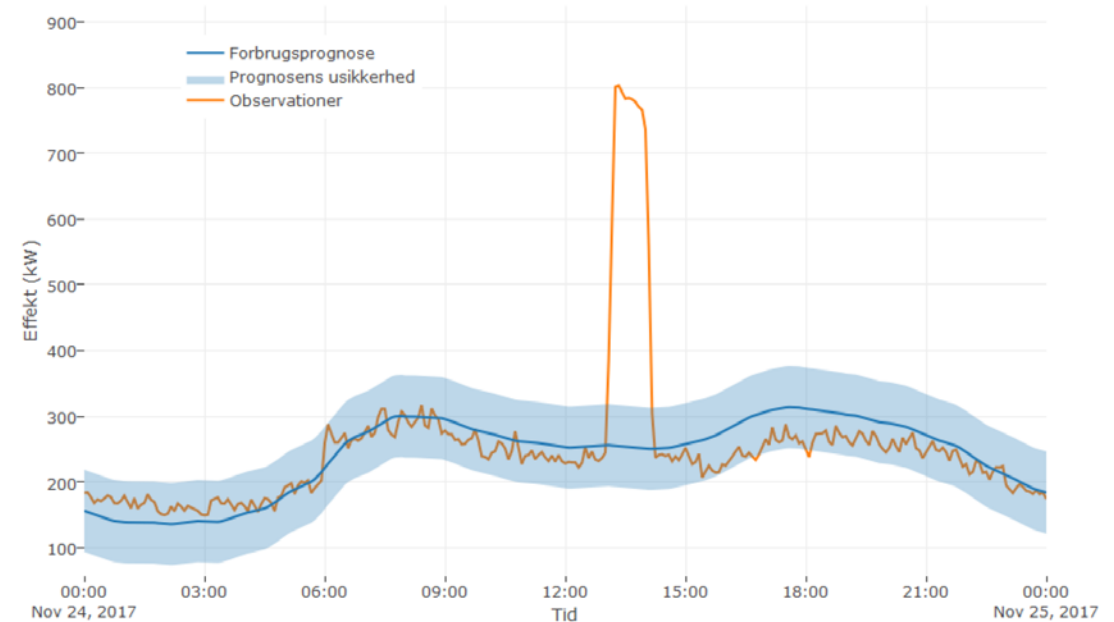


Test of demand response from two aggregators at Bornholm

22 January 2018: Response due to turn-off of 450 heat pumps at 11AM and 9PM. Demand is reduced by $>1/3$ in both cases.



24 November 2017: Response due to turn-on of electric heating in 350 houses. Demand increased by 2.3 times compared to the baseline.



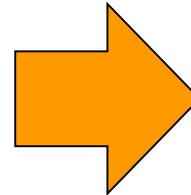
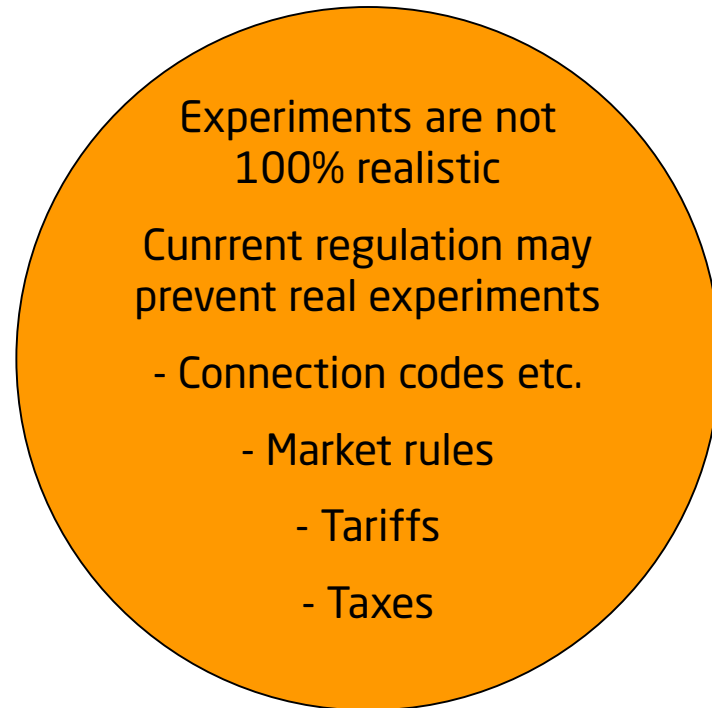
Based on ~200 tests we in winter time can:

- Reduce the demand with 30%
- Double the demand with 100%

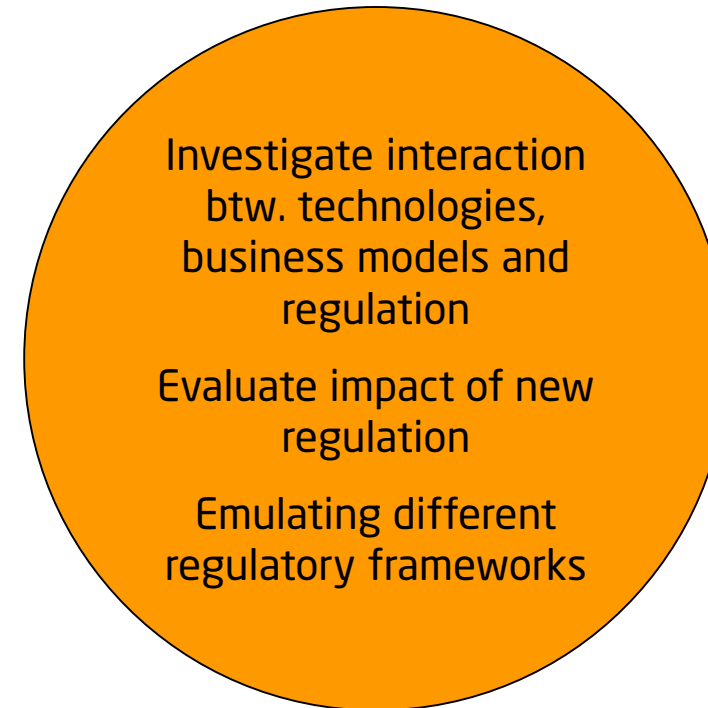
Ref: www.electricitybaseline.com

Extended use of demonstrations...

*Limitations in
current demonstration*



*Potential of allowing
alternative regulation*



Energy Communities

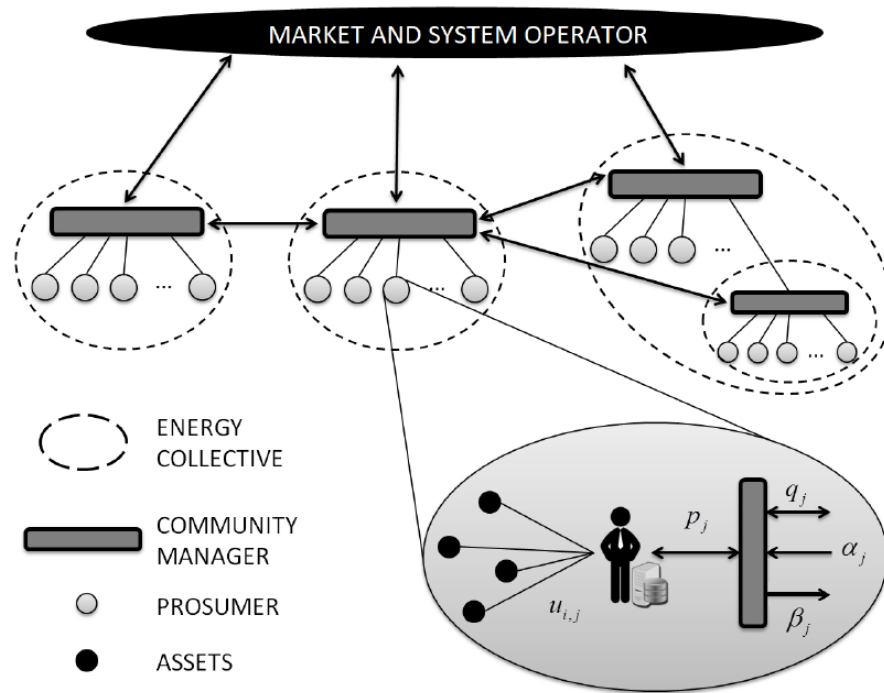


Fig. 1. Organization of an energy collective and its interactions with system operator and other collectives.

- Consumer-centric market
- A community of prosumers that operates in a collaborative manner, optimizing usage of resources
 - the members can trade their lack or excess of energy
 - all prosumers are in charge of optimizing their assets individually
 - a non-profit virtual node, that we call community manager simplifies interface with the market and system operator

Ref.: Moret, F., & Pinson, P. (2018). Energy Collectives: a Community and Fairness based Approach to Future Electricity Markets. *IEEE Transactions on Power Systems*. DOI: 10.1109/TPWRS.2018.2808961

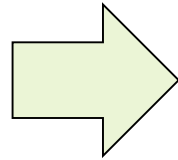
Need for test-zones for new business models and digital energy solutions



Smart Energy
R&D strategy
(2016)



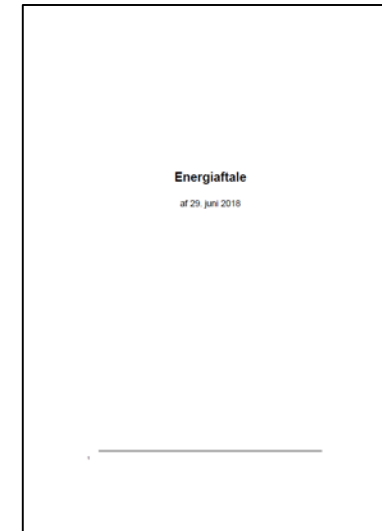
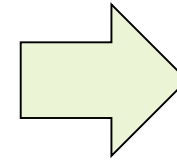
Test under realistic conditions of technologies and business models.



Danish Energy
commission
(2017)



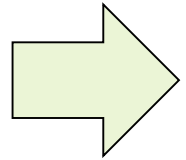
Test-zone with alternative regulatory frameworks for test of alternative solutions and business models under realistic conditions.



Danish energy
policy 2020-
(2018)



Test-zones with alternative regulatory frameworks (limited in time and space) in relation to better utilization of data and digitalization.



Bornholm as national test zone for Smart Energy



Idea?

- Open platform with open access
- Demonstration of interaction of technology, market and control



How?

- Possibility for experiments with alternative regulatory framework (tariffs, market rules, energy taxes)
- Tax neutral



Why Bornholm?

- Full model of the future energy system with scalability
- 100% renewable energy (power generation and district heating systems)
- Isolated area which is easy to monitor



Conclusions

1. Living labs are important for maturing solutions, collaboration, and innovate
2. Clustering activities leads to synergy, efficiency and added-value in the activities
3. The regulatory framework is probably the most important barrier for new innovations of smart energy systems (digitalisation, new business models and new marked designs).
4. Test-zone with alternative regulation will accelerate the new solutions and thereby the green transformation (push regulation).
5. We should not forget traditional (non-living) labs in large scale, where failures are allowed and solutions can be tested beyond their normal operational limits

Questions...

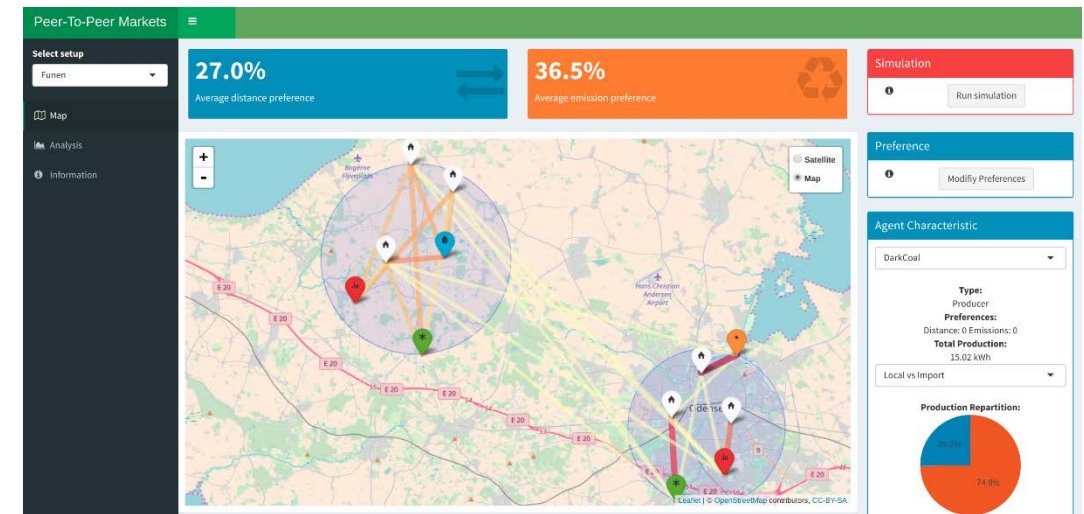


Jacob Østergaard

Professor, Head of Center
Center for Electric Power and Energy (CEE)
Department of Electrical Engineering
Technical University of Denmark
Web: www.cee.elektro.dtu.dk

Tel: +45 45 25 35 01
Email: joe@elektro.dtu.dk

Peer2peer markets in action...



https://p2psystems.shinyapps.io/ShinyApp_Project/