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Robustness and Cost Efficiency through User Flexibility in the Distribution Network

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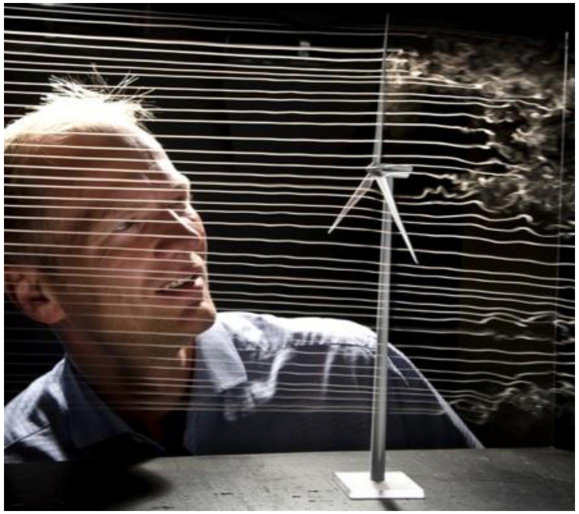
SINTEF is the largest independent research organisation in Scandinavia

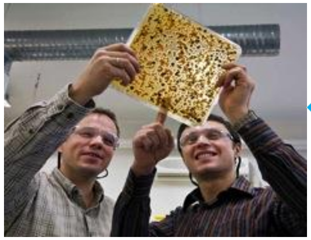
- Leading expertise in the natural sciences and technology, environment, health and social science
- 2100 employees from 70 countries
- Annual sales of NOK 3 billion (EUR 400 mill) – customers in more than 60 countries
- A non-commercial research foundation with subsidiaries



Our partnership with NTNU functions at both strategic and operational levels

SINTEF

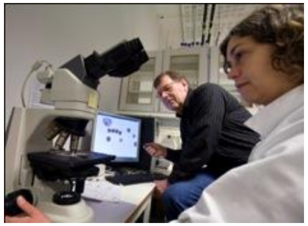
NTNU
Det skapende universitet



Strategic coordination

NTNU personnel work on SINTEF projects

SINTEF staff teach at NTNU



Joint use of laboratories and equipment

Cooperation between SINTEF and NTNU has developed over 60 years

We are among Europe's largest contract research organisations

Fraunhofer

TNO

VTT

SINTEF

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY

SP

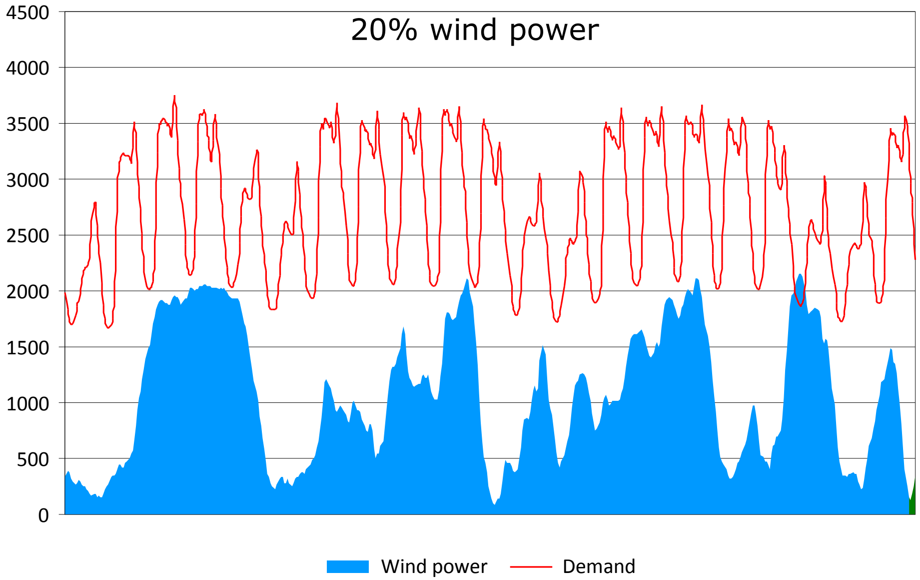
tecnalia Corporación Tecnológica

DANISH TECHNOLOGICAL INSTITUTE

cea

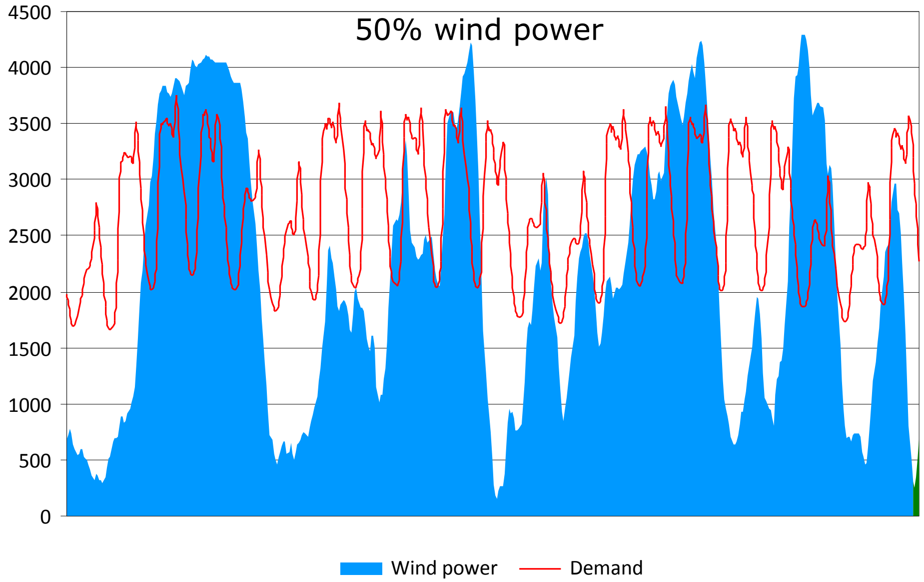
In times with uncertainty increasing – the need for flexibility is apparent.

Today (2008)



Wind power covers the entire demand for electricity in 200 hours (West DK)

Tomorrow (2025)



In the future wind power will exceed demand in more than 1,000 hours

The Wind Power Challenge - An illustrative case from Denmark

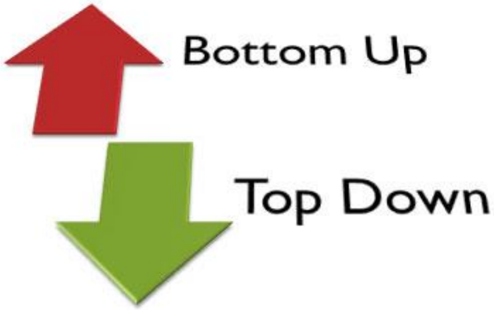
The philosophical view

Philosophy: "*the most basic beliefs, concepts, and attitudes of an individual or group*"

Mirriam-Webster on-line dictionary.

Two archetypes.

1. Smart grids is about designing a power system bottom-up, where all control actions are taken de-centralized by local intelligence in a coordinated manner.



2. The widespread penetration of Smart grids functionalities (DG, electric vehicles, demand response, etc) calls for designing top-down centralized control actions ensuring reliability and security of supply.

SINTEFs' view on Smart grids

It's not a matter of choice, but of coordination.

1. To be able to control, we need to be able to observe.

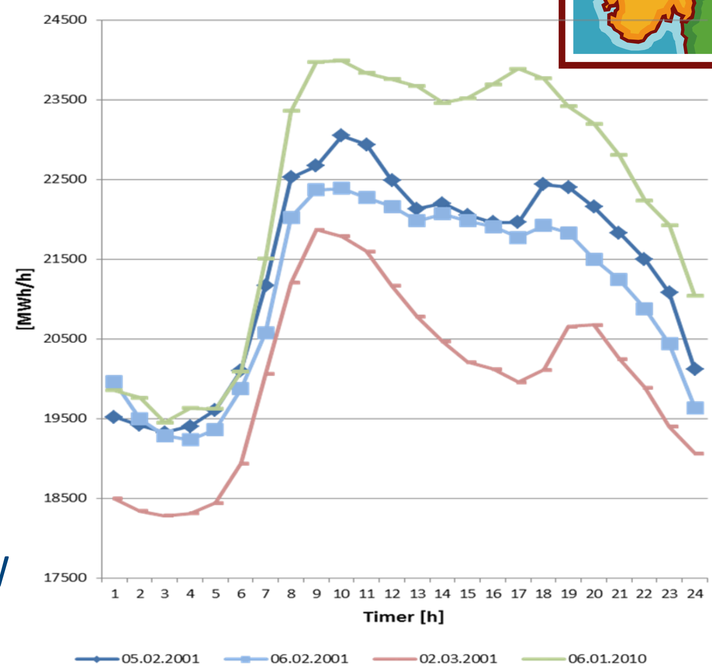
2. To be able to act upon observations we need to have control actions at hand.

3. To be able to have control actions at hand, inherent power system flexibility must be designed for.

   In a smart grid, observations and control actions can be put in place at every level, and **coordination must ensure that the most adequate resources are brought into play** when needed – regardless of it's "distributed" or "centralized" nature.

Electricity consumption in Norway

- Total 127 TWh (07)
  - Heating: appr. 35 TWh
  - Large industrials: appr. 40 TWh
- Peak load: appr 24 000 MW (h10)
- A large (theoretical) DR potential
  - Industry ~3 000 MW
  - Residential and commercial: 1 700 MW

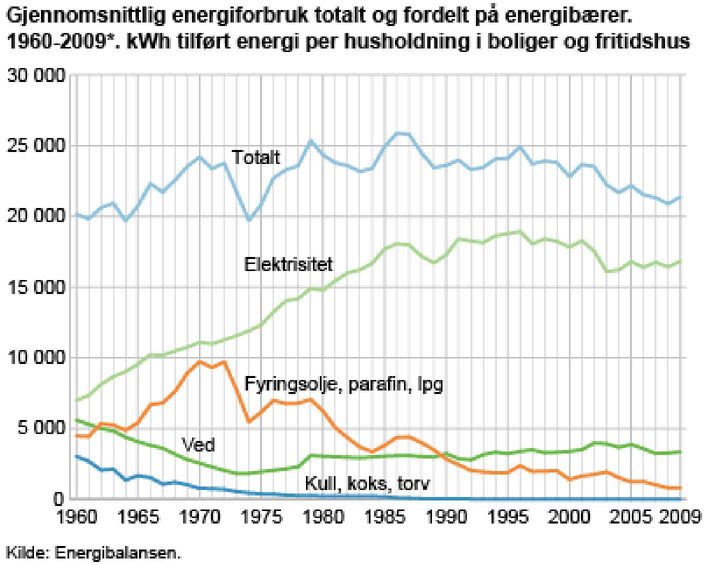


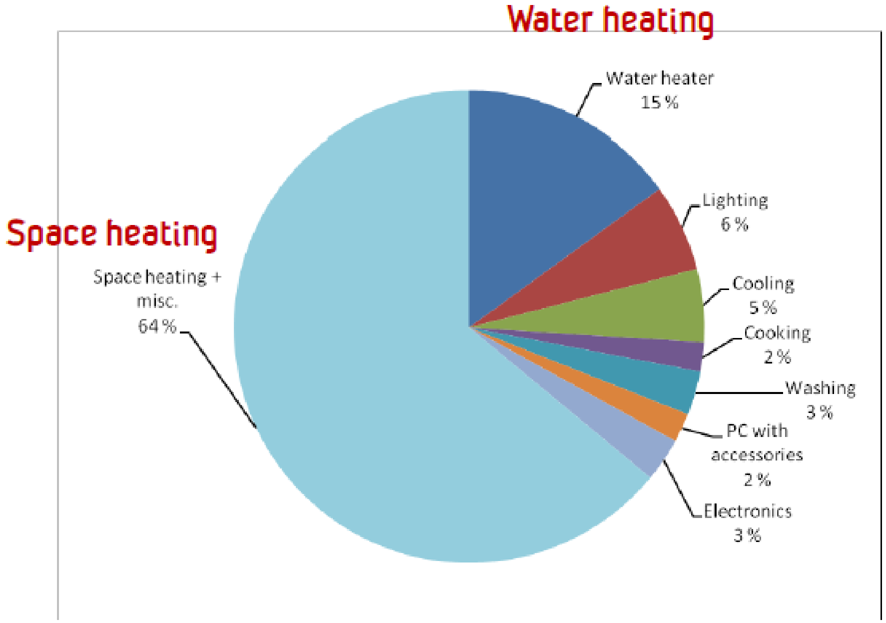
- Production (99 % Hydro): average 130 TWh/Year 50 TWh variation between wettest and driest year

Household electricity consumption in Norway

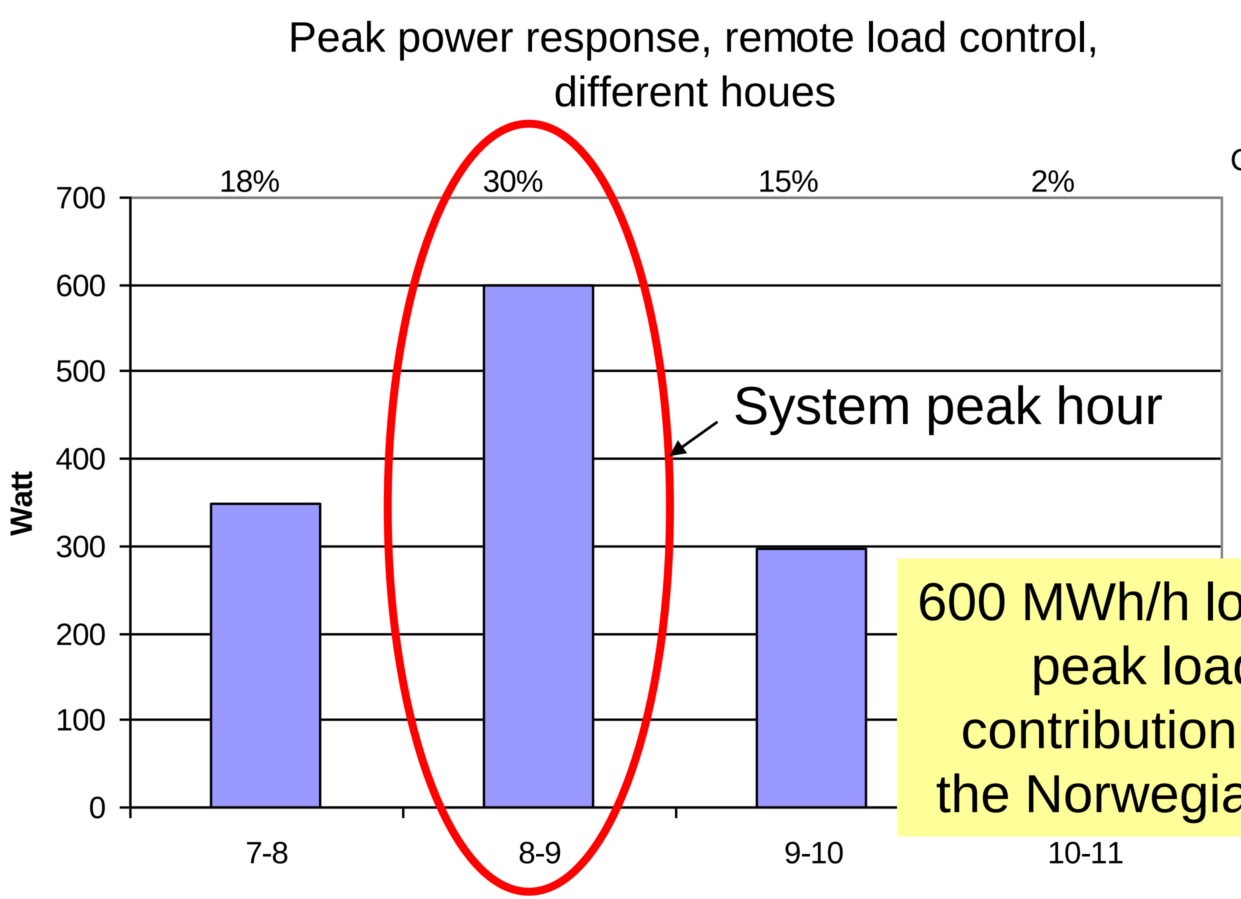
Average annual electricity consumption in domestic sector: 16 000 kWh per household
Source: Statistics Norway

Approx 80% of electricity consumption relates to water and space heating.
Source: : EU/ REMODECE





Empirical load shifting potential from water heaters in Norway



600 MWh/h load reduction in peak load provided contribution from 50 % of the Norwegian Households

Demand response - Situational change in consumption

Research projects at SINTEF Energy Research

The Research Council of Norway

End-user market (1996-2000)
- The customer was ”discovered”
- Mapping of theoretical potential for demand response

Demand response by efficient use of ICT (2001-2004)
- Large scale testing of technology, load control and price incentives

Market Based Demand Response (2005-2008)
- Several smaller pilots related to the power situation and price incentives

Environmental benefits by smart meters (2009-2012)
- Increase customer awareness of electricity consumption (display)
- Smart meters as a part of Smart grids

DeVID (2012-2015)
- Demand Response (load control, storage, PV) in the distribution grid
- Use case-methodology ➔ New data from smart meters and smart substations

EcoGrid EU –

A Prototype for Smart Grids

SEVENTH FRAMEWORK PROGRAMME

- FP7- Energy 2010
- Project period: Mid 2011 – Late 2015
- Total budget: 21 million Euro (EU: 12,7 million Euro)
- Project initiated by Energinet.dk (Danish TSO)
- Project coordinated by SINTEF Energy Research
- 15 partners

www.eu-ecogrid.net

EcoGrid EU in Brief

- A large scale demonstration of a real-time marketplace for distributed energy resources (DER)
- The demo site is the island of Bornholm - a *real* power system with more than 50 % renewable energy – connected to the Nordic synchronous system
- ICT systems and innovative market solutions enable small consumers to offer TSOs additional and more efficient balancing services
- *The EcoGrid EU concept meets the increasing need for balancing services*

Denmark

Østkraft energi til gode oplevelser

Siemens

Landis+Gyr manage energy better

DTU

IBM

Energinet.dk

Netherlands

ECN

TNO innovation for life

Belgium

elia

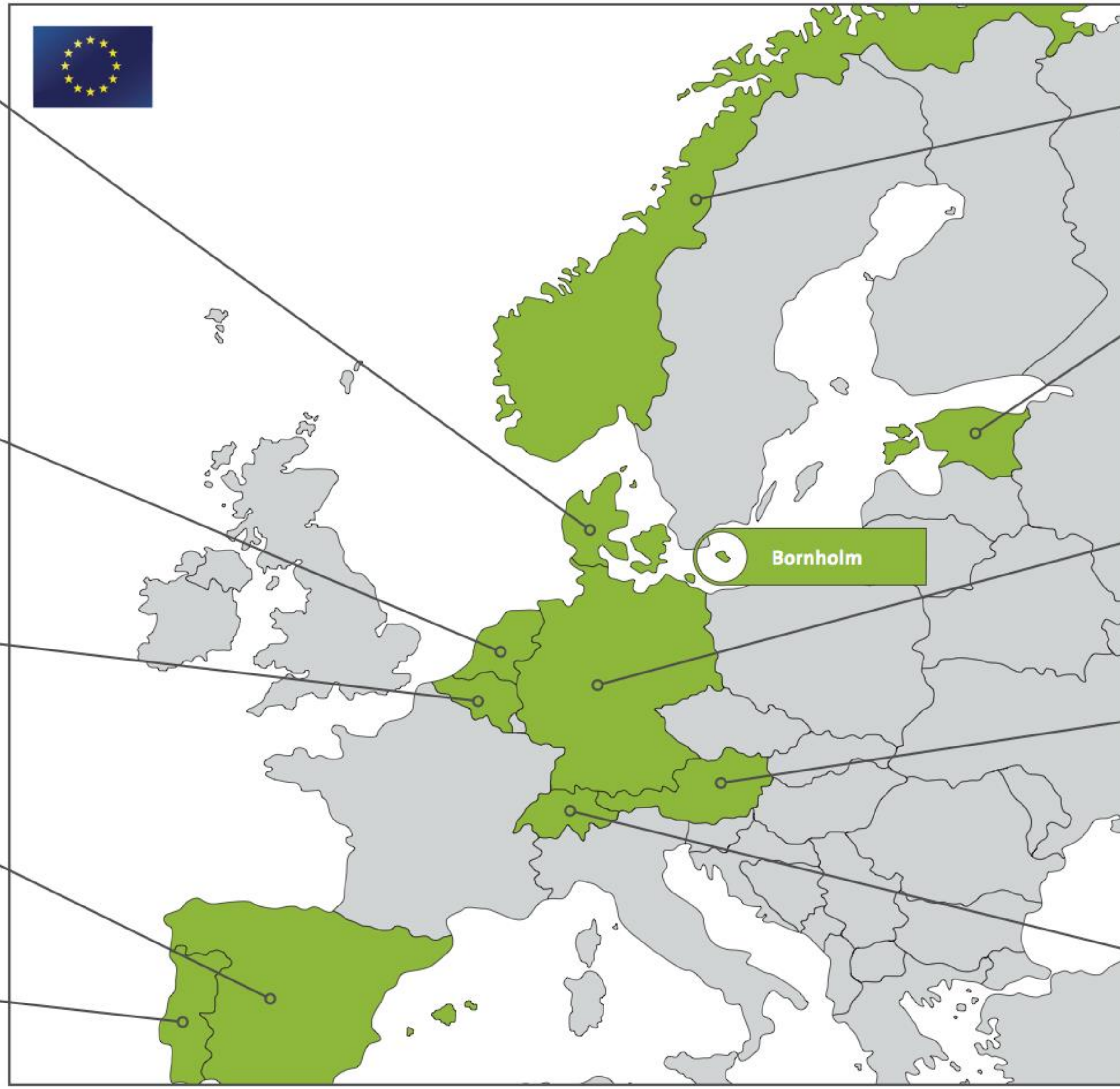
eandis

Spain

tecnalia Inspiring Business

Portugal

edp



Norway

SINTEF

Estonia

Tallinn University of Technology

Germany

Siemens AG*

Austria

AIT Austrian Institute of Technology

* Third party

Switzerland

IBM Zrl*

Siemens CH*

Active use of passive resources

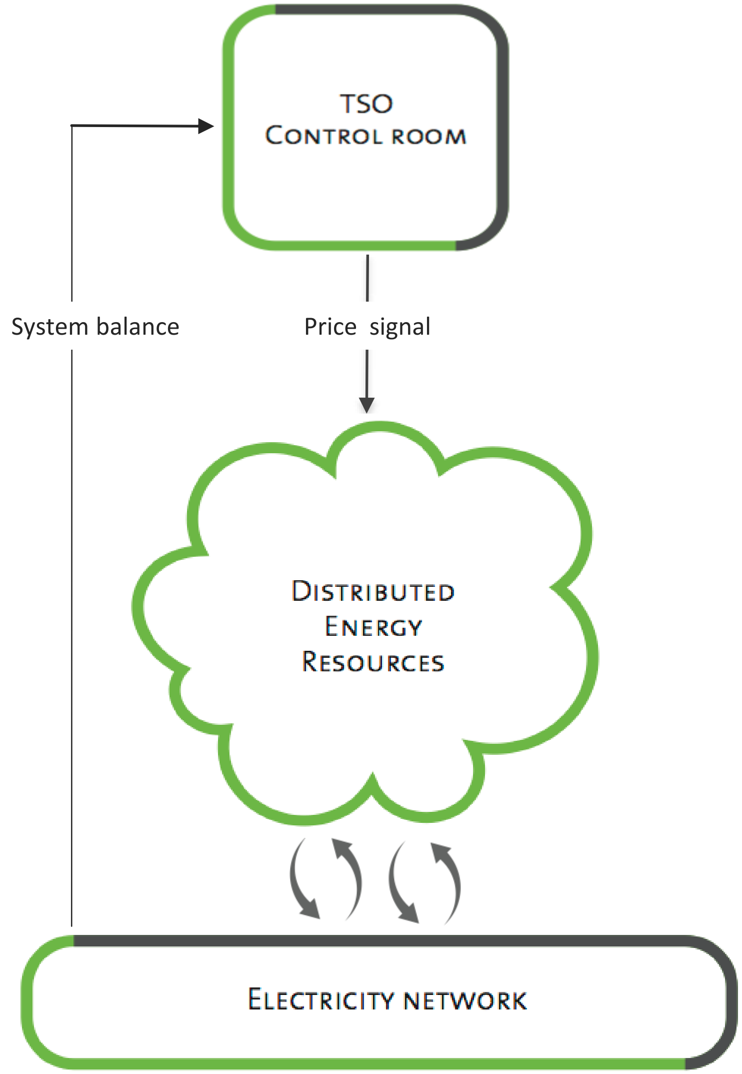
THE REAL-TIME MARKET MAKES ACTIVE USE OF PASSIVE RESOURCES

The development of a real-time electricity market is considered one of the most efficient ways to meet the challenges in operating a power system with increasing shares of renewable sources:

- The EcoGrid EU real-time market has a very high time resolution (five minutes), which improves the capability to manage high amounts of rapidly fluctuating renewable energy sources.
- The market price is set in the very last minute, meaning that very accurate forecasts of wind power and demand can be utilised when determining the market price. It means that problems with forecast errors inherently present in conventional markets are minimised.
- Compensate for traditional balancing resources: The real-time market will increase the demand-side market participation and thereby reduce the need for costly flexibility on the production side and/or compensates for traditional balancing power and services from conventional generation displaced by generation based on renewable energy sources.
- The EcoGrid EU real-time market will improve the utilisation of the inherent (free) flexibility in eg thermal loads (load-shifting potential).
- Activation of a large number of customers will improve the function and competition in the power market through increased market participation and by connecting the wholesale market with the retail market (increase retail competition).

Furthermore, the activation of the demand side, through the real-time market, enables locational pricing for congesting management. This will result in better use of grid capacity, reducing and deferring costs for reinforcements of the distribution network.

The Fundamental Idea of EcoGrid



The Scope of a Real-time Market

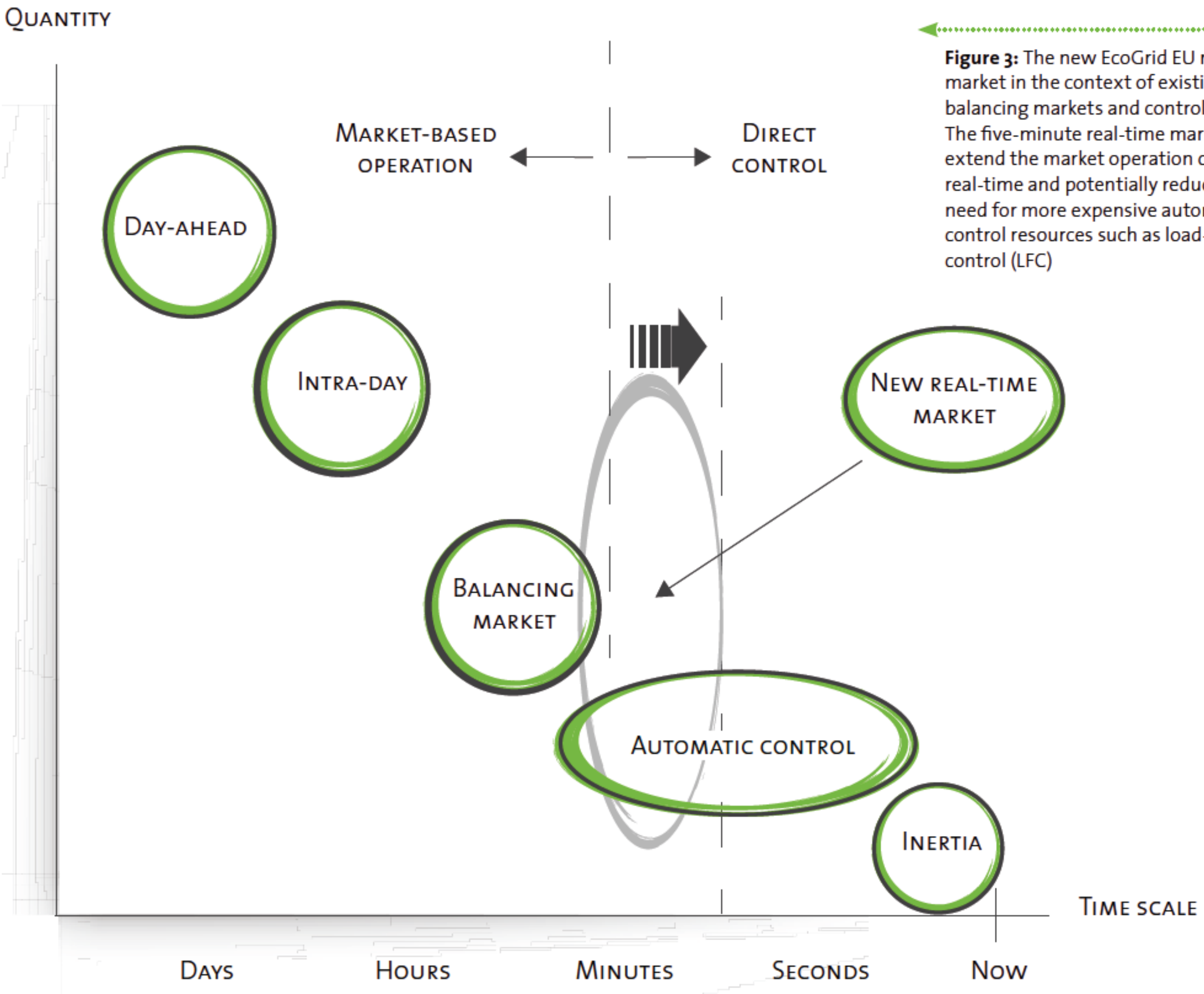


Figure 3: The new EcoGrid EU real-time market in the context of existing power balancing markets and control systems. The five-minute real-time market will extend the market operation closer to real-time and potentially reduce the need for more expensive automatic control resources such as load-frequency control (LFC)

Why a Real-time Market?

- An efficient way to meet the future challenge of balancing
  - High(er) demand for flexible consumption/production
  - High(er) volatility
  - High(er) balancing cost

- An efficient instrument to wide spread adoption of small-scale end-users/ prosumers in the power market(s)

- Increasing competition in the power market(s)
  - Small scale end-users can attain economic benefits
  - TSOs get access to alternative balancing resources

Design of an EcoGrid prototype real-time market place is a realistic approach because it is "just" widening the scope of the existing power market

2000 Participating Customers in the Demonstration

Statistic 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

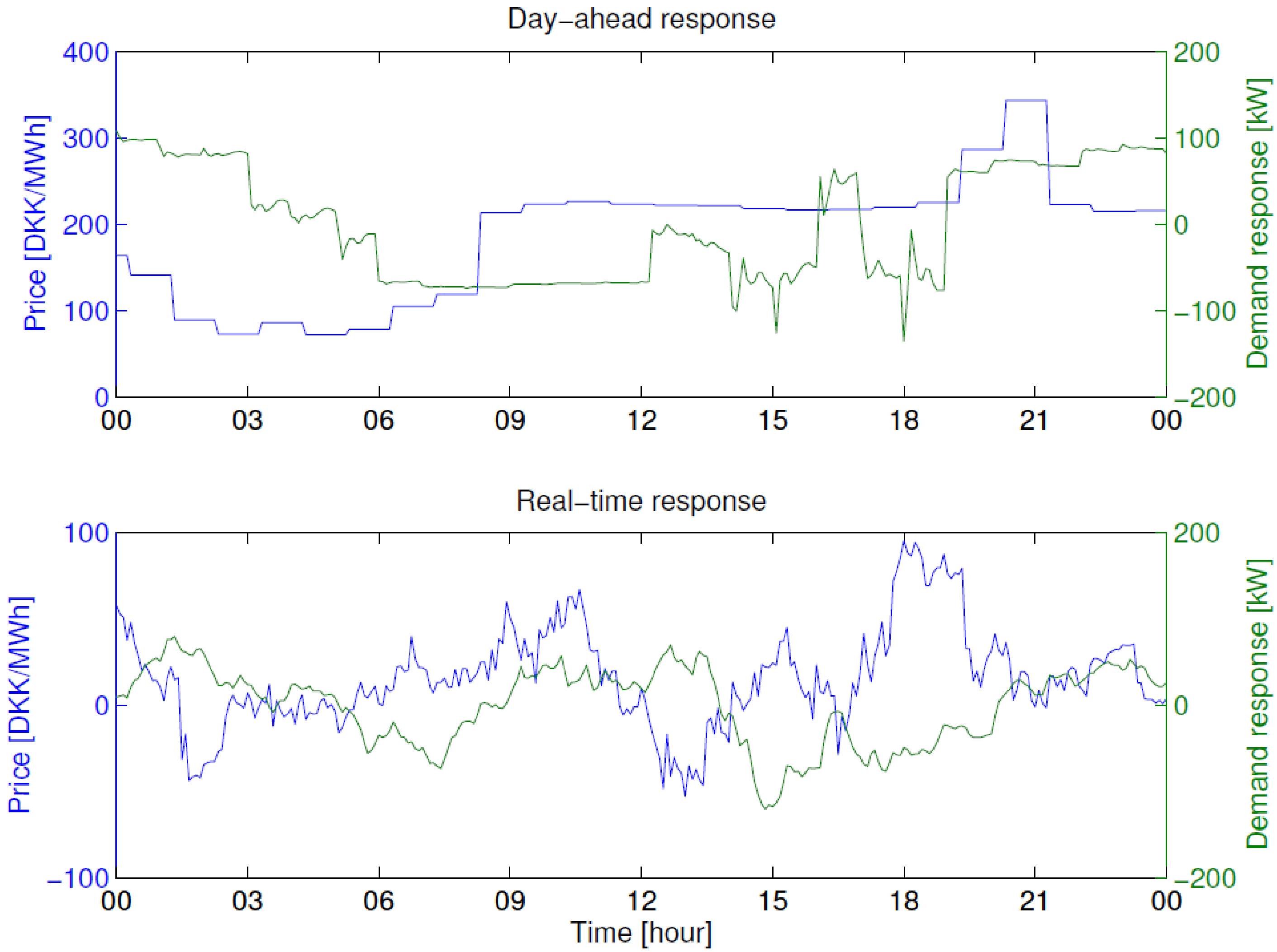
Smart Businesses

Up to 100 costumers with smart meters

Including small business and public customers

Connected smart appliances – responding to control signals

Load response time series



DTU

Conclusions

- The electric energy sector faces **substantial challenges in the coming years** related to the implementation of Smart meters and other Smart grids technologies
  - Peak load and intermittent generation are major challenges to the grid
  - Power driven, not energy driven

- Accumulated **potential for demand response is large** – also from smaller customers
  - Flexibility is a key asset with high responsiveness

- **Demand response can be realized** – if the customers get sufficient incentives

- Demand response…
  - can be integrated into the **power market** – a relative small decline in demand can contribute to substantial reductions in price in shortage situations
  - can also be used to **solve grid problems** (bottlenecks in peak load periods)

Future work

- Past projects: concepts, potential, feasibility
- Current projects: infrastructure, framework, regulatory mechanisms
- Future work:
  - Optimization
  - Automation
  - Formalization

Thank you for your attention!

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