EcoGrid EU

A Real-Time Smart Grid Demonstration in Denmark

IEA DSM Agreement, Task XVII
Arnhem, 25th April 2012

George Huitema
EcoGrid Coordinator TNO
TNO, The Netherlands

COOPERATION

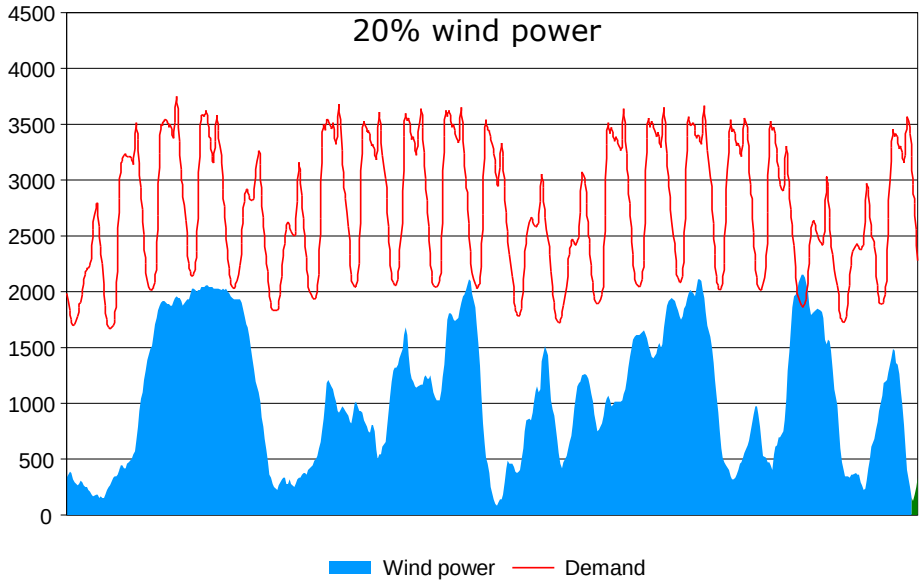
Content

- The Challenges of Tomorrow
- What is EcoGrid EU?
- The Real-time Market Approach
- End-user Involvement
- Conclusion

The Wind Power Challenge

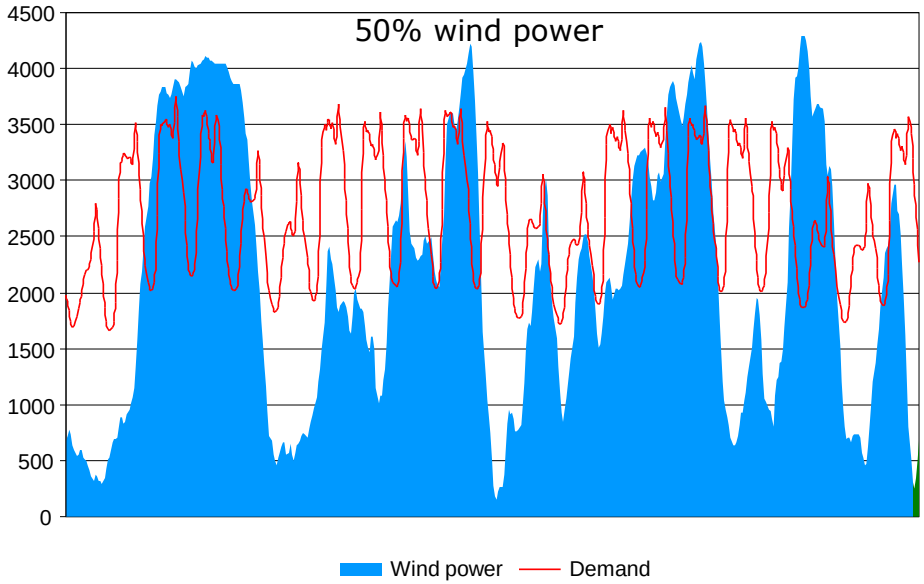
An illustrative case from Denmark

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

Consequence: an increasing need for balancing services

COOPERATION

EcoGrid EU in Brief

- Project:
  - EU FP7 Project
  - Total budget: 24 million Euro (EU funding 12 million Euro)
  - Demonstration > 50 % of budget

- Demonstration:
  - A *large scale* demonstration of a real-time market place for distributed energy resources
  - A demonstration of a *real* power system with more than 50 percent renewable energy
  - *Participation of small consumers and local producers* in the power market

- Preparation for a *fast track* towards European real-time market operation of RES & DR

COOPERATION

EcoGrid EU Partners

DENMARK
Energinet.dk
Østkraft
DTU-CET

BELGIUM
ELIA
EANDES
ORES

GERMANY
Siemens
EnCT

SPAIN
LaBein

NORWAY
SINTEF ER
(Coordinator)

ESTONIA
Tallin University of Technology (TUT)

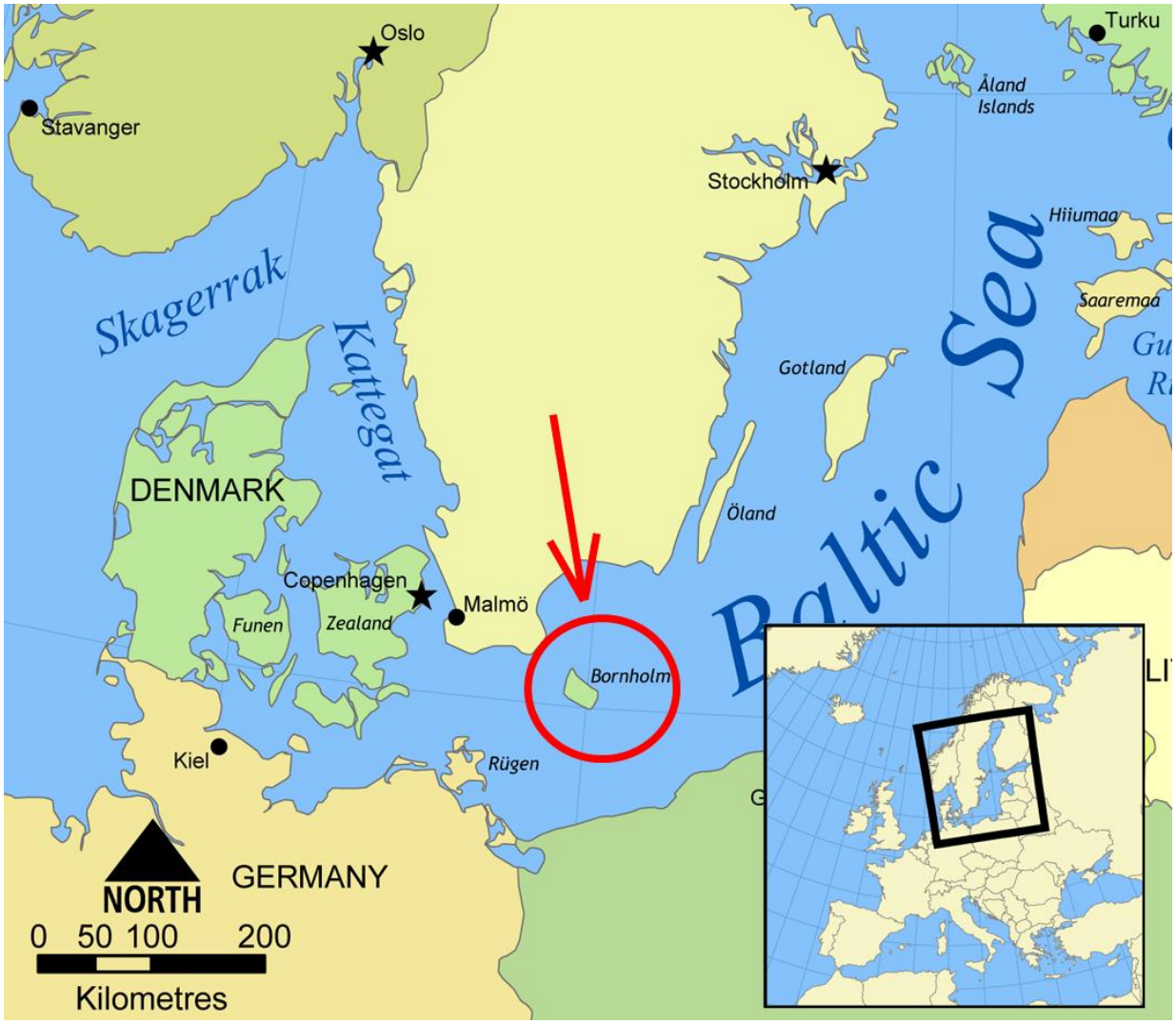
THE NETHERLANDS
ECN
IBM Benelux

AUSTRIA
Austrian Institute of Technology (AIT)

SWITZERLAND
IBM Research

Sweden
Landis + Gyr

Norway
Maj Dang Trong analyse


Oslo
Stavanger
Turku
Åland Islands
Stockholm
Hiiumaa
Saaremaa
Skagerrak
Kattegat
Baltic Sea
Gotland
DENMARK
Öland
Copenhagen
Malmö
Funen
Zealand
Bornholm
Kiel
Rügen
GERMANY
NORTH
0 50 100 200
Kilometres

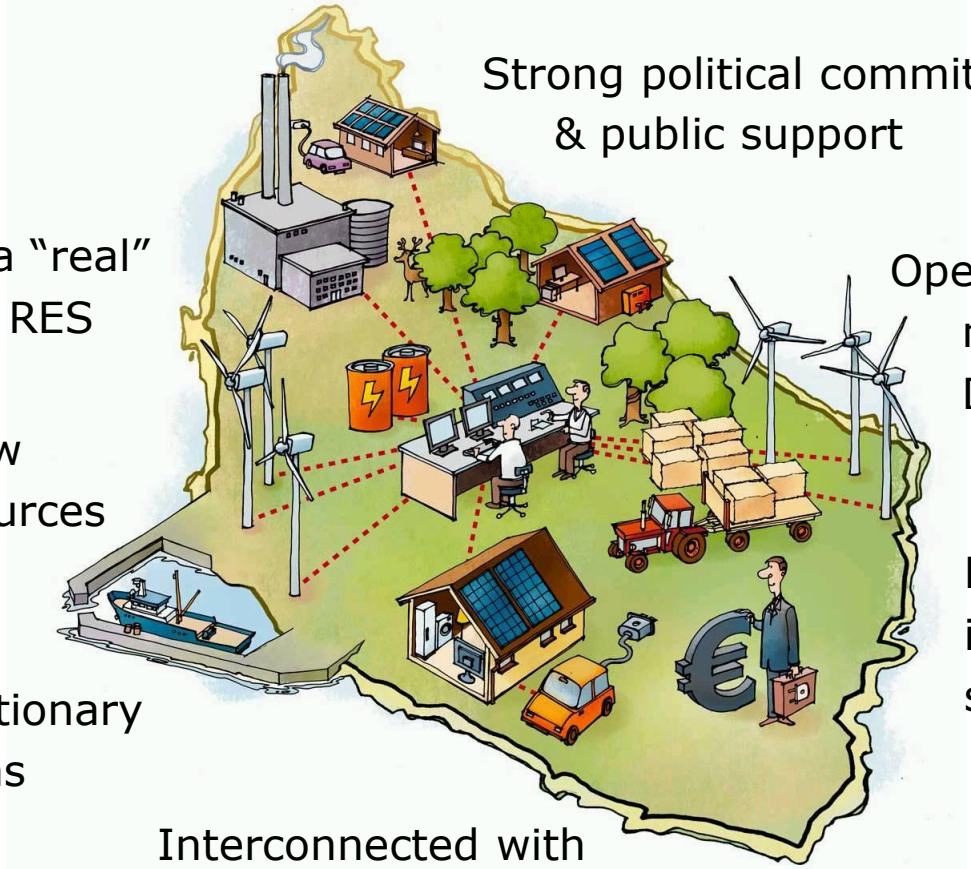
Bornholm – a Unique Test Site

Strong political commitment & public support

Demonstration in a "real" system with 50 % RES

Operated by the local municipal owned DSO, Østkraft

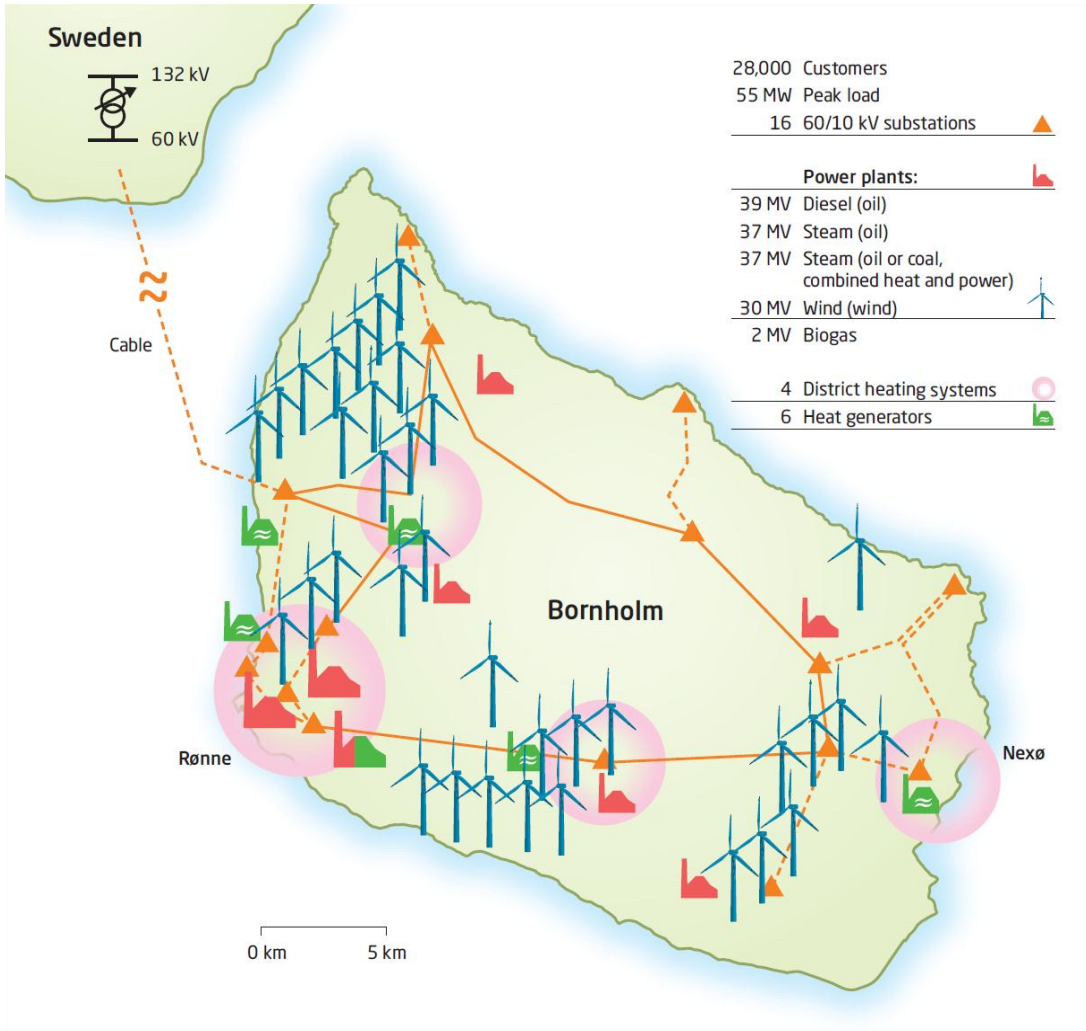
High variety of low carbon energy sources



Eligible RD&D infrastructure & full scale test laboratory

Several active demand & stationary storage options

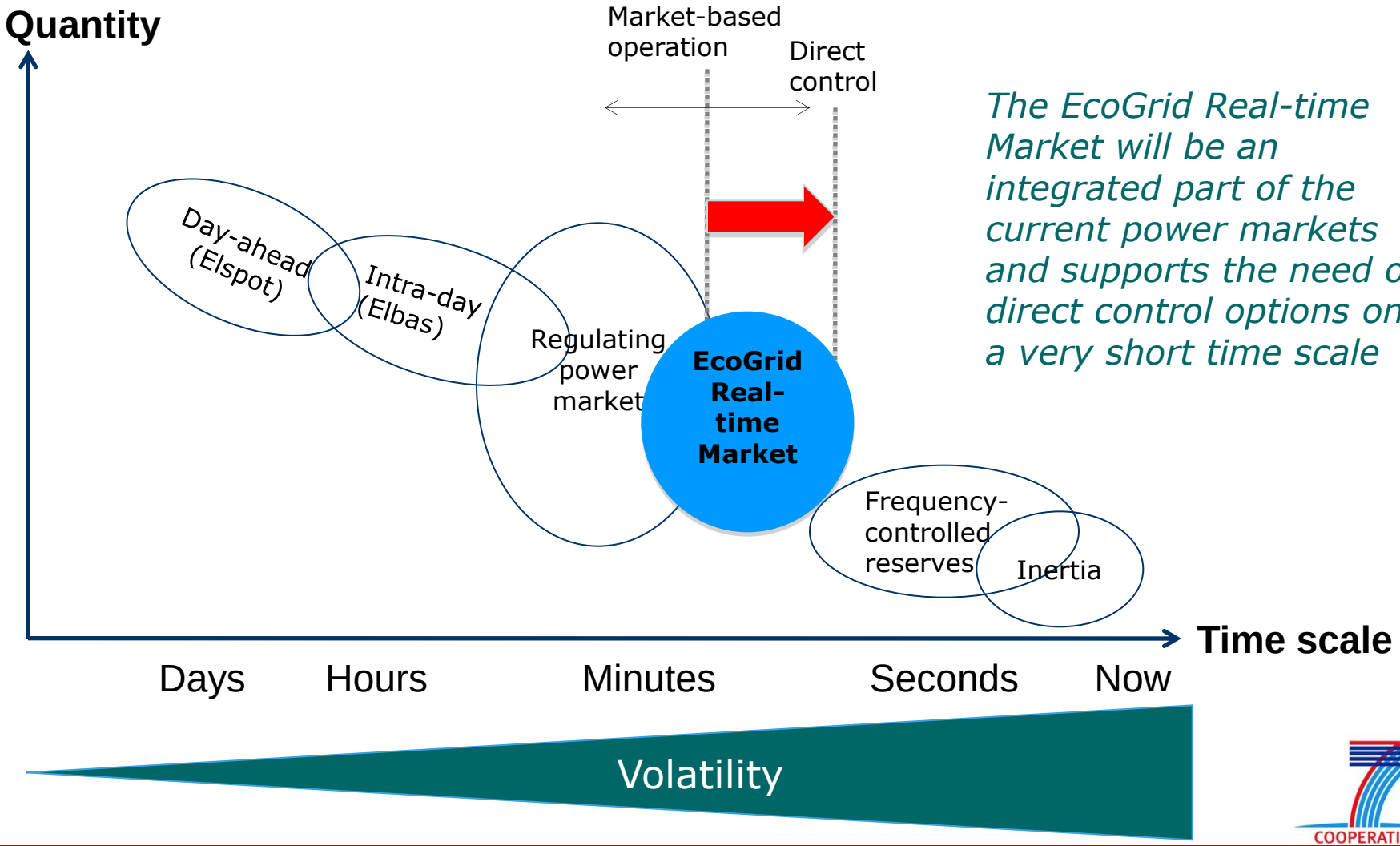
Interconnected with the Nordic power Market


Sweden
132 kV
60 kV
22
Cable
28,000 Customers
55 MW Peak load
16 60/10 kV substations
Power plants:
39 MV Diesel (oil)
37 MV Steam (oil)
37 MV Steam (oil or coal, combined heat and power)
30 MV Wind (wind)
2 MV Biogas
4 District heating systems
6 Heat generators
Bornholm
Rønne
Nexø
0 km
5 km

Key Numbers for Bornholm

Property	Value
Customers	
Number of customers	~28.000
Number of customers (> 100.000 kWh/year)	~300
Total energy consumed	268 GWh
Peak load	55 MW
Low-carbon energy resources	
Wind power plants	30 MW
CHP/biomass	16 MW
PV (roll-out under project)	1.0 MW
Biogas plant	2.0 MW
Electric vehicles (under roll-out)	
Grid	
60 kV grid	131 km
Number of 60/10 kV substations	16
10 kV grid	914 km
Number of 10/0.4 kV substations	1006
0.4 grid	1.887 km
Communication	
Fiber network between 60/10 kV substations	131 km
District heating	
Number of district heating systems	5
Total heat demand (in 2007)	560 GWh
Operation	
Normal operation mode	Interconnected Nordel
Island operation capability	Continuous

The Scope of a Real-time Market



The EcoGrid Real-time Market will be an integrated part of the current power markets and supports the need of direct control options on a very short time scale

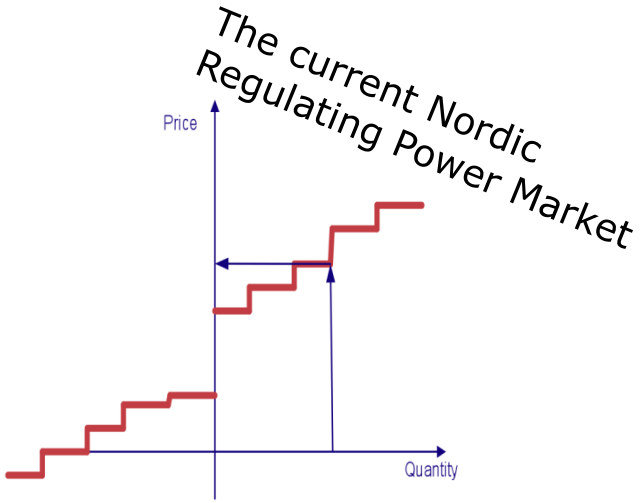
An Additional Source of Regulation Capacity

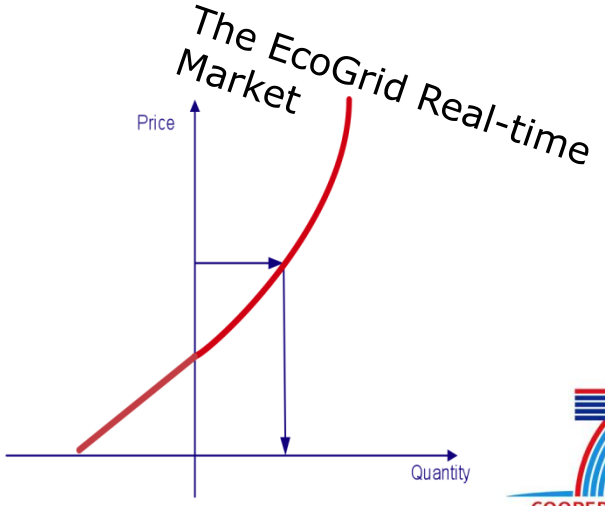
The current system:

- TSOs obtain a certain quantity by selecting/accepting bids
- Include only large producers, large consumers and aggregated smaller units (minimum 10 MW)
- Loads are "updated" every 15 minutes

The new real-time market:

- No restriction on the size of units (MW)
- TSOs *set* a price every 5 minutes that result in a certain quantity of fast(er) response from smaller units



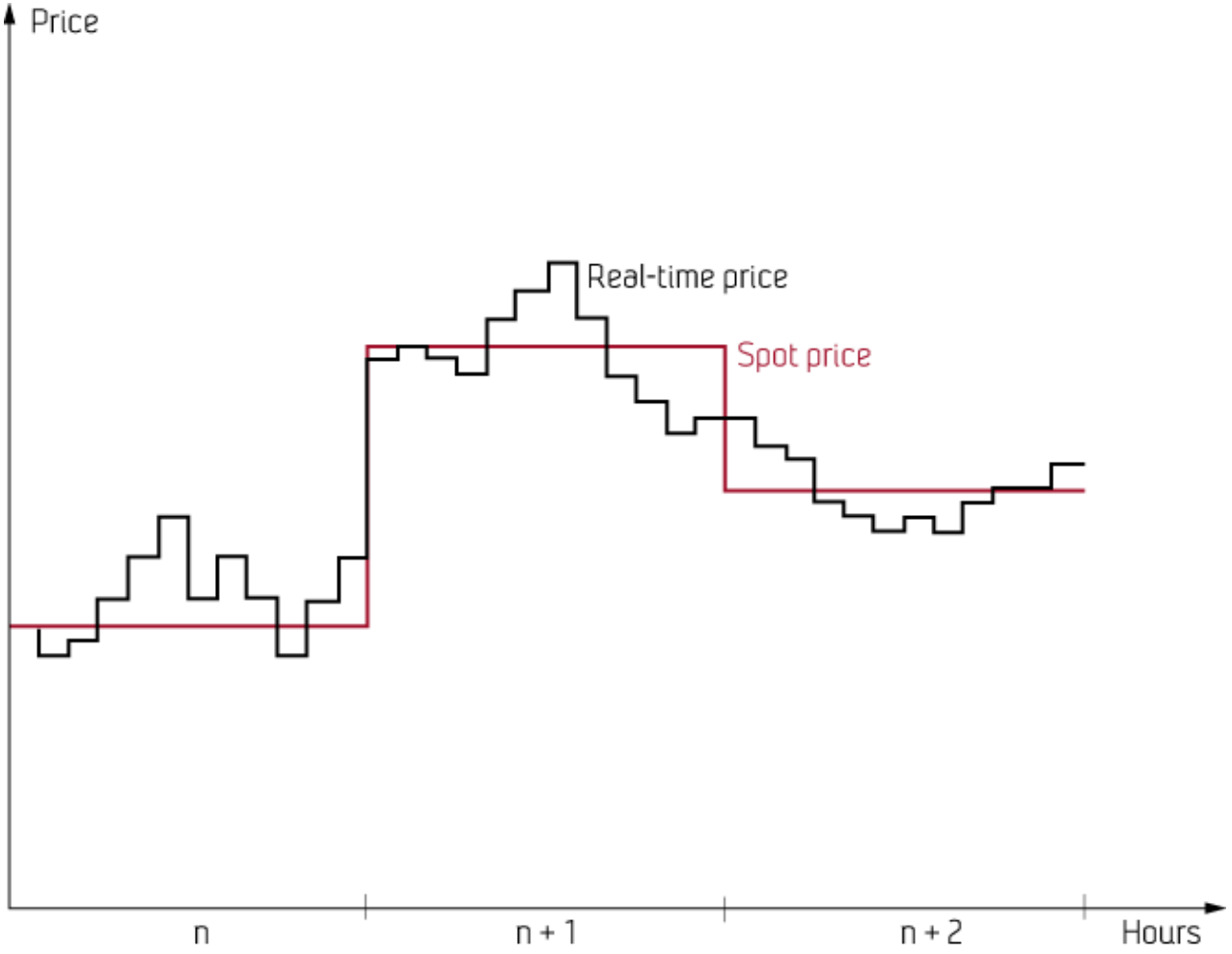


COOPERATION

How does the Real-time Market Work?

- DER and flexible demand will respond to variable electricity prices through *broadcasted* price signals:
  - Step 1: Electricity price from the existing day-ahead Elspot market is sent to the end-user - soon after clearing (= forecast of "real-time" price)
  - Step 2: During the day the price signal is updated in real-time, i.e. every five minutes – to reflect the need for up or down regulation (if no imbalances the real-time price = the day-ahead Elspot price)
- The real-time price is set by a Real-Time Market Operator (RTMO) on the basis of the need for balancing resources
- The RTMO could be the TSO(s)

Day-ahead Market Price (Spot) and Real-time Price

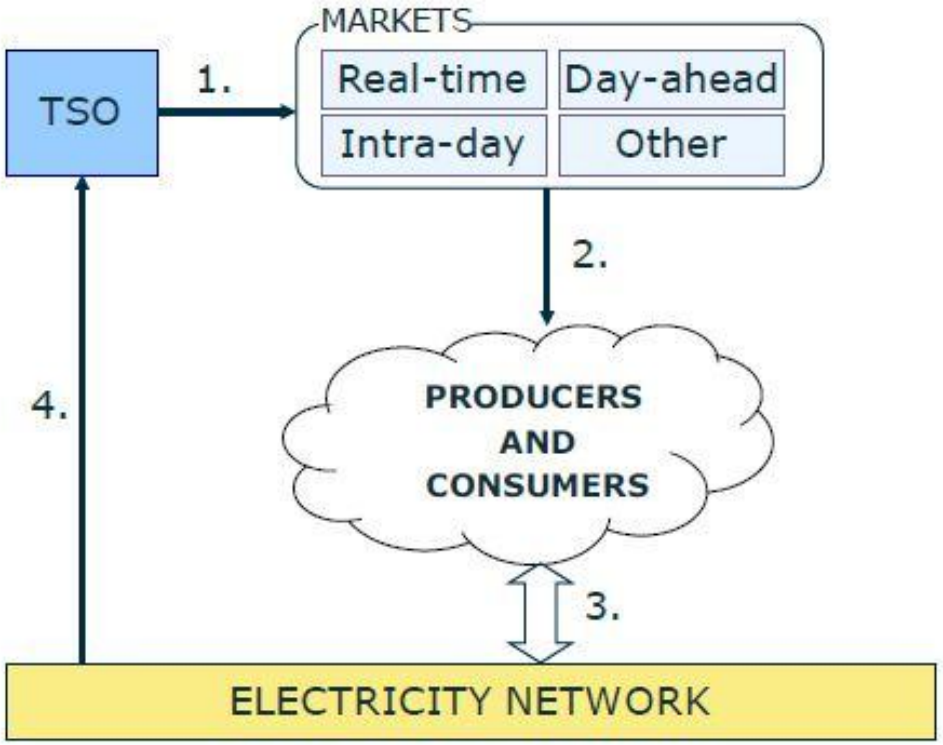


Real-Time Market Process

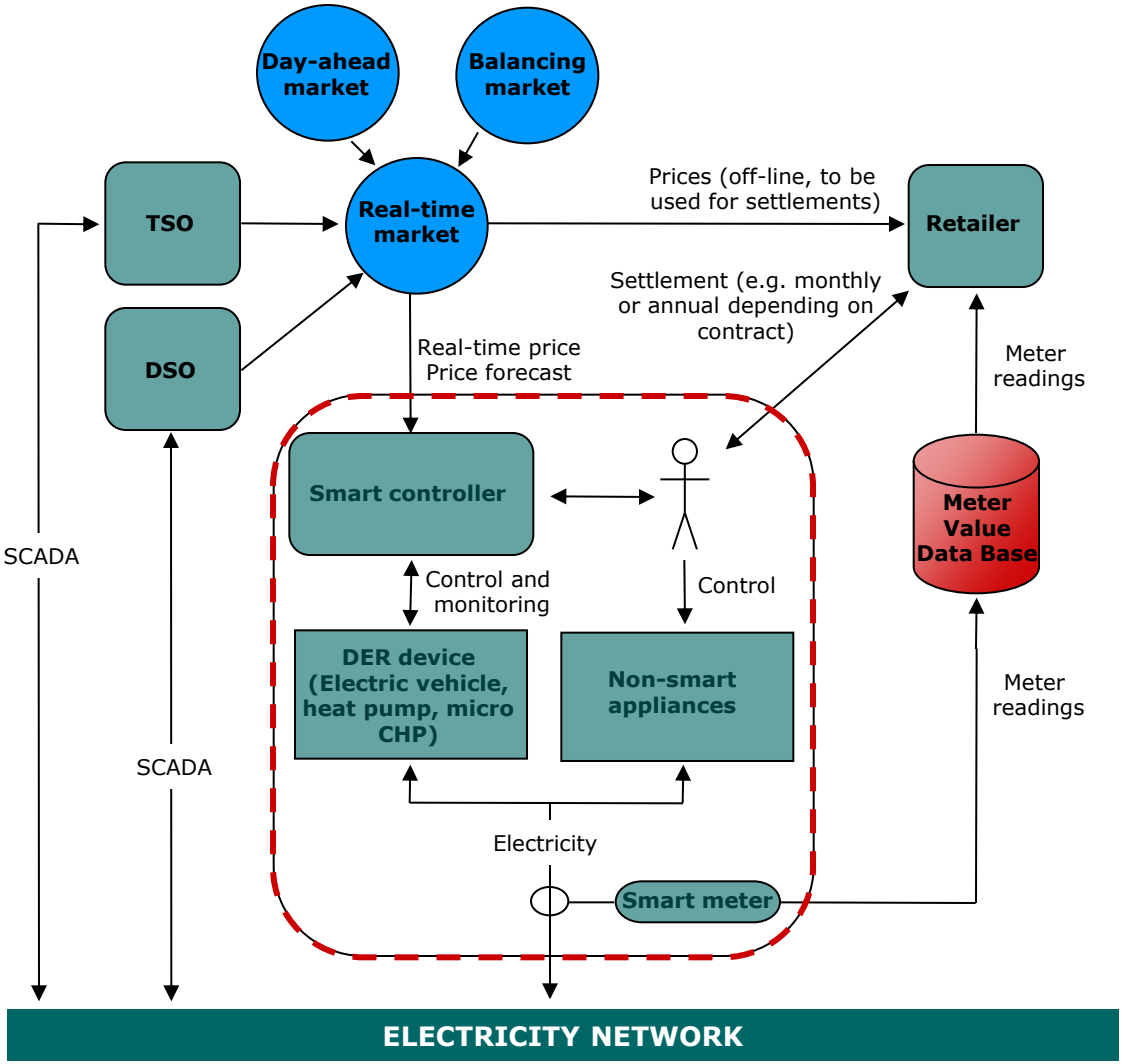
System Balancing

1. Set price based on need for correcting system balance
2. Publish price to users (price is the final settlement price)
3. Production and consumption can choose to react
4. Monitor response, back to 1

- Important: The published price is the final settlement price.



The EcoGrid EU Architecture



New power market architecture requirements:

- Installation of automatic ”smart controllers” in DER devices
- Smart Meters to manage ”real-time” price signals
- Modern ICT infrastructure to transmit price signal to market participants and operational units

End-user Involvement

- Easy for the consumer
  - The price is always known (each five minutes)
  - In principle possible to respond by manually turning off electric appliances, but…

- Appliances equipped with automatic end-user "smart controllers" will do most of the job!

- The requirement of end-user involvement:
  - Understandings of the potential benefits of participation (economical/energy savings/environment)
  - Accept/make contracts based on predefined "preferences"

- ETP Strategic Research Agenda 2035: Alliander/TNO Smart Retail & Consumer Technologies; See http://www.smartgrids.eu/

2000 Participating Customers in the Demonstration

Reference Group

- 200 households with a smart meter
- No access to specific information or "smart" equipment

Manual Control

- 400-500 households with a smart meter
- Receiving market price information
- Must move their energy consumption by themselves

Semi automatic Control

- 700 semi automated households with a smart meter
- 1-2 reactive appliances responding to price signals
- All houses have heat pumps or electric heating

Automatic Control

- 500 fully automated households with a smart meter
- Multiple connected appliances - all responsive to price signals

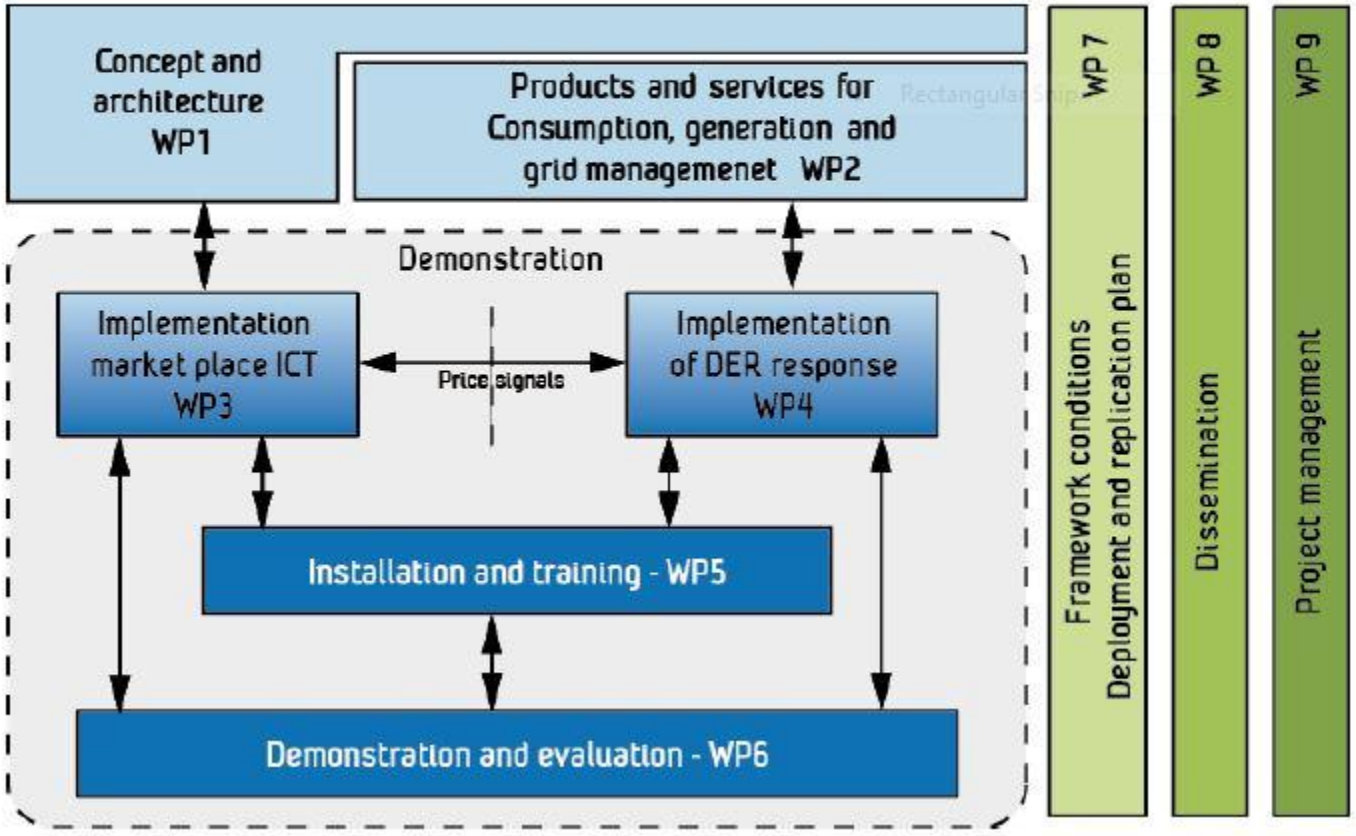
Smart businesses

- 100 commercial/ public customers with a smart meter
- Including small business units and the public customers
- 4 connected smart appliances

PowerMatcher (TNO/IBM)

DEMS (Siemens)

WP structure



Conclusion (1)
New Solutions = New Challenges

- New settlement "challenges" in the real-time market:
  - Meters should handle 5-minutes interval readings
  - Large amount of data should be managed in the settlement process

- Replication challenges:
  - Many countries have deployed meters with 15 minutes/hourly reading
  - The real-time concept must be adapted to those conditions

- End-user acceptance
  - New intelligent home installations are required
  - The concept is based on automatic control (no manual actions required)

- "What's in it for me"?
  - How to make the system attractive for the small consumers/small RES units
  - Keep transaction costs on an acceptable level

COOPERATION

Conclusion (2)

- The PowerMatcher (TNO contribution)
  - Efficient energy management for the smart grid
  - Field-proven technology
  - PowerMatcher: www.PowerMatcher.net

POWERMATCHER
smartgrid technology

- EcoGrid.EU
  - Demonstrates the Smart Grid Future on Bornholm isle
  - Novel real-time market integrates smaller end-users
  - User centric-approach

COOPERATION

Thanks

george.huitema@tno.nl
koen.kok@tno.nl

COOPERATION