The Crucial Role of Demand Response for SmartGrids' Success

- Dynamic price formation for energy, transport and ancillary services

- Danish demand response pilot projects

Mikael Togeby, Ea Energy Analyses
mt@eaea.dk

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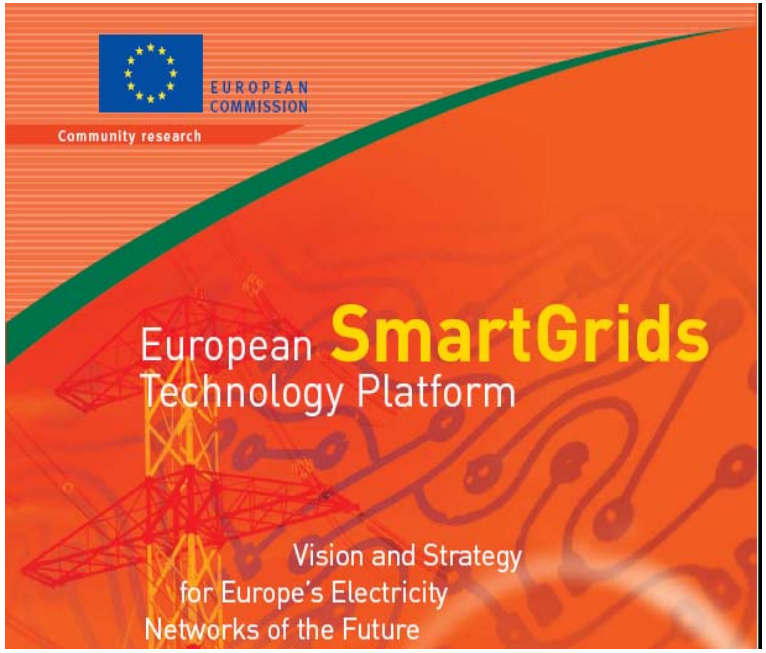
Outline

1. Introduction
2. Marginal prices: Losses
3. Marginal prices: Ancillary services
4. Demand response from households with electric heating
5. Demand as Frequency Controlled Reserve
6. Conclusion

Part 1: Introduction



SmartGrids – Key features

- Much more communication:
  - Every node can interact with every other node
    - A node can be a large power plant, a micro power plant, a transformer, an end-user, an equipment
  - Real-time markets
  - Quality of supply adapted to individual needs
  - Demand and production is optimised to real-time prices
- Focus on end-user
- Similar US vision: GridWise
  - See: Future intelligent power grids: Analysis of the vision in the European Union and the United States. Debora Coll-Mayor, Mia Paget, Eric Lightner, Energy Policy 35 (2007)

Demand response is crucial

- Demand response = Voluntary adjustment of electricity consumption as a reaction to a price signal
- Demand response is NEEDED is the liberalised market as peak power
  - No commercial investment can supply power for a few hours per year
- As the electricity system becomes more dynamic (e.g. due to wind power and due to reduced capacity margins), demand response can be profitable

Dynamic pricing

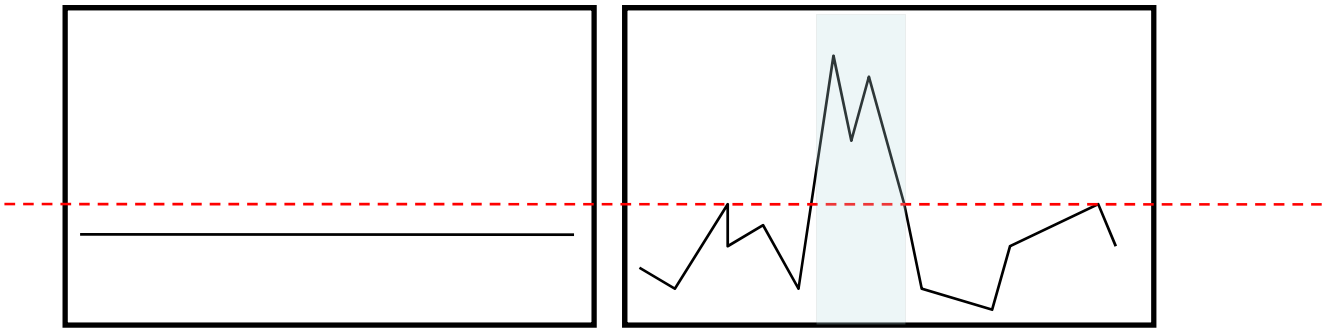
- Retail electricity rate characterised by one or more “dispatchable” prices intended to modify demand (*)
  - Requires an interval meter for accurate billing
  - And a method of receiving the dispatched price, e.g. by internet
- Dynamic tariffs are expected to improve electric system load factors and reduce the costs of producing and delivering electricity (**)

* Introduction to Dynamic Rates. Karen Herter, LBL/CEC September 9th, 2002
** Feasibility of implementing dynamic pricing in California, California Energy Commission, October 2003

Four types of tariffs

	Flat	Time-of-use, TOU	Critical peak pricing, CPP	Real-time
Correct economic signals			(●)	●
Recovery of total cost	●	●	●	●
Ease of computation and transparency	●	(●)		
Dispatched in real-time (day ahead)			●	●
Infinite possible values				●

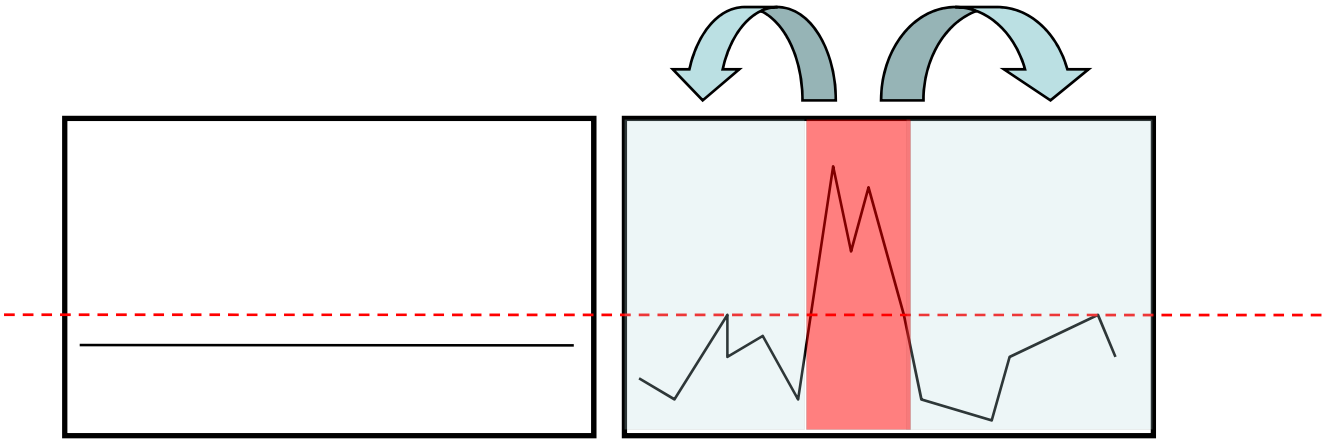
Micro-generation



Flat price:
No production

Dynamic prices:
Production when price is above marginal cost

Demand response



Flat price:
No room for demand response

Dynamic prices:
Demand can be moved to periods with low prices

Correct price (ideal)

- Pay the cost that your action (e.g. demand) causes (marginal pricing)
- Can (in theory) be divided geographically (per node)
- Marginal, nodal prices
  - Prices = function of time and location

Four price components for electricity

	Average cost		Marginal price
60%	~ 35 €/MWh	**Production** Bilateral, day-ahead or hour-ahead	0 to +200 €/MWh
40%	Losses ~ 2 €/MWh (7%) + Grid investment? + Fixed costs	**Transport** Investment in grid, losses	Losses ~ -20 to +40 €/MWh (-10 to +20%) +Grid investment
40%	~ 2 €/MWh + Fixed costs	**Ancillary services** Regulating power, reserves	-100 to +500 €/MWh
		Taxes	

Intelligent prices

- Prices are fair for all technologies
  - Central production
  - Micro-generation
  - Wind power
  - Demand
- Prices are fair for local and foreign trade
  - Trade and transit can bring huge benefits
- Environmental regulation should be carefully designed to respect an efficient energy market

Part 2:
Marginal prices:
Losses

Losses

- Total losses: 5-10%
- Denmark: 7%
  - ~ 1% in transmission
  - ~ 6% in distribution
- Losses proportional to power flow squared
  - Marginal losses = 2 * average losses
- Marginal losses due to a marginal demand can be negative!

Marginal losses due to marginal increased load

Made by Torsten Lund,
Risø National Laboratory, Denmark
in cooperation with BOE Net A/S, Denmark

[next 5 slides]

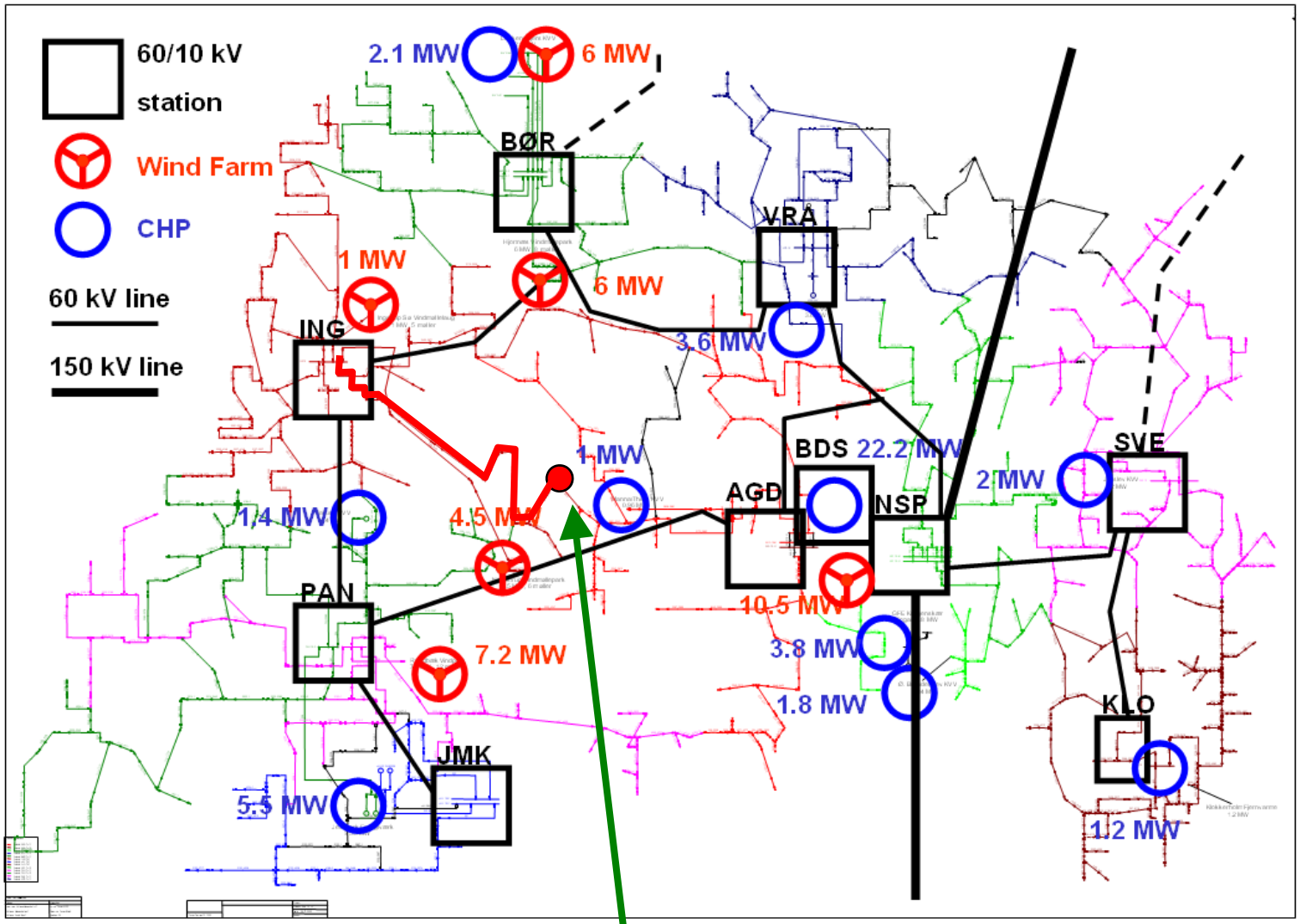
Marginal losses due to marginal increased load

- Analyses based on combination of a detailed load flow model and online measurements
- The model and the measurements have been validated through comparison between the measured and the simulated voltage and active and reactive power flow.
- The production, and the power flow in the distribution transformers have been measured, and the load and the losses have been estimated.
- Load Flow simulations and sensitivity calculations have been made using PowerFactory® from DIgSILENT®

BOE

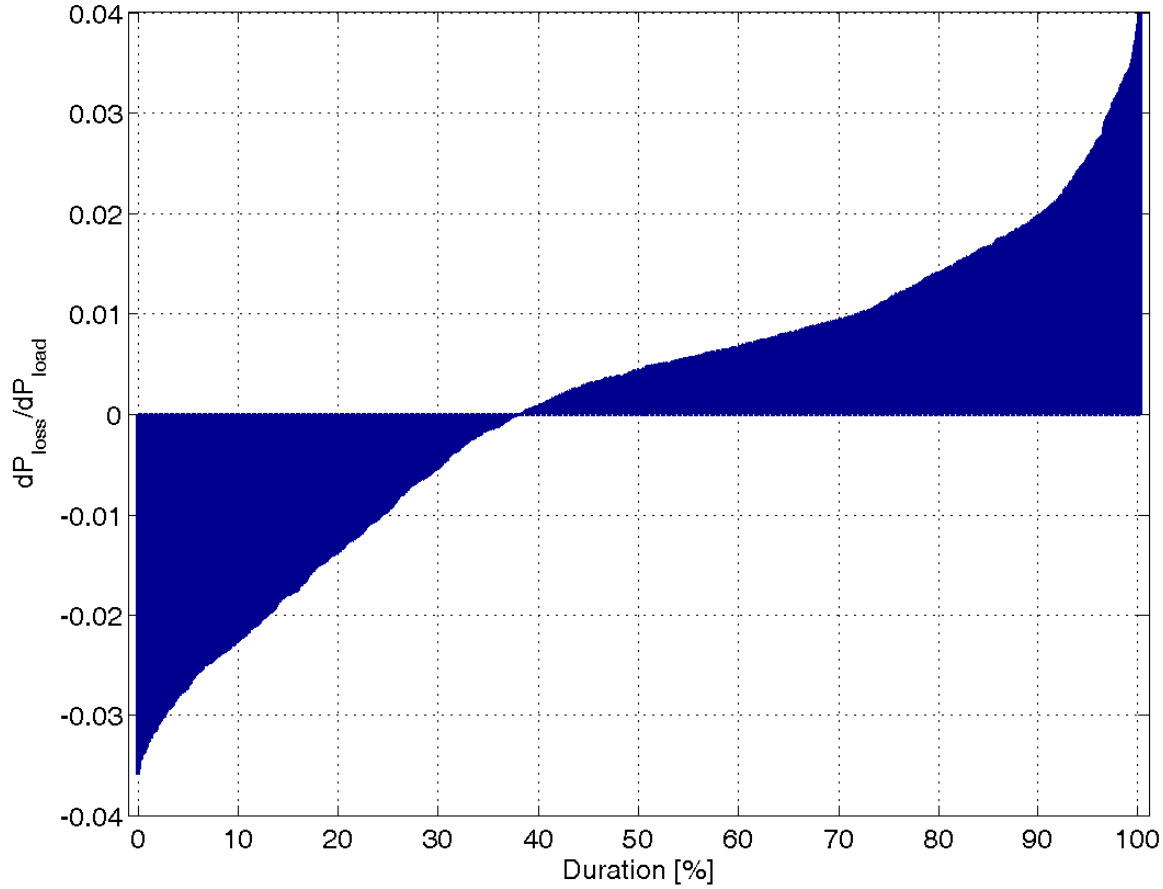
- 29,000 customers, 690 km^2
- 150/60/10/0,4 kV grid
- 65 wind turbine, 40 MW
- 18 Combined heat and power plants, 50 MW
- Load between 15 and 45 MW
- The areas is importing electricity half of the time
  - and exporting electricity the rest of the time

The network of BOE



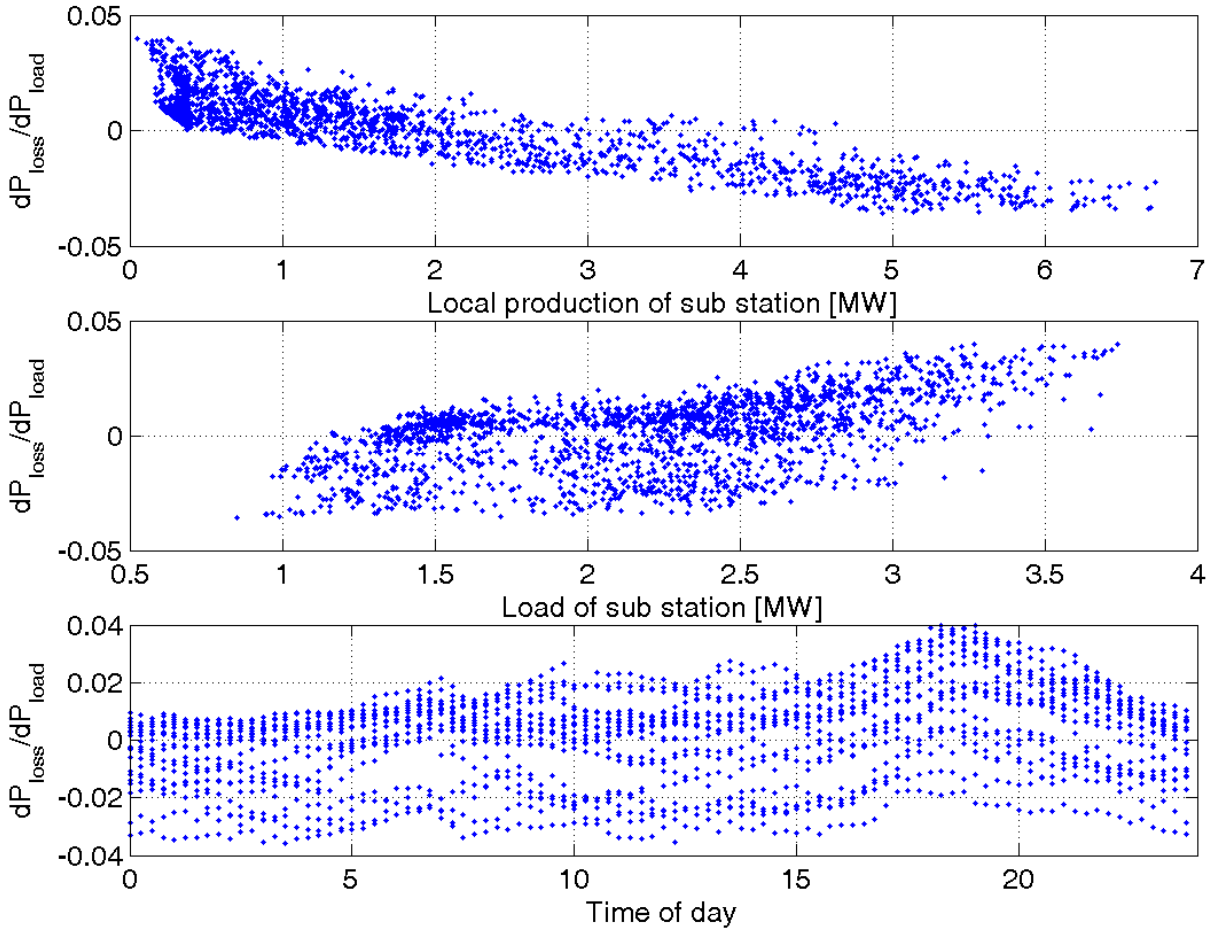
Investigated load bus

Marginal losses due to marginal increased load



Values from 20 August to 9 September 2006

Marginal losses due to marginal increased load



15-minute values from 20 August to 9 September 2006

Part 3:
Marginal prices:
Ancillary services

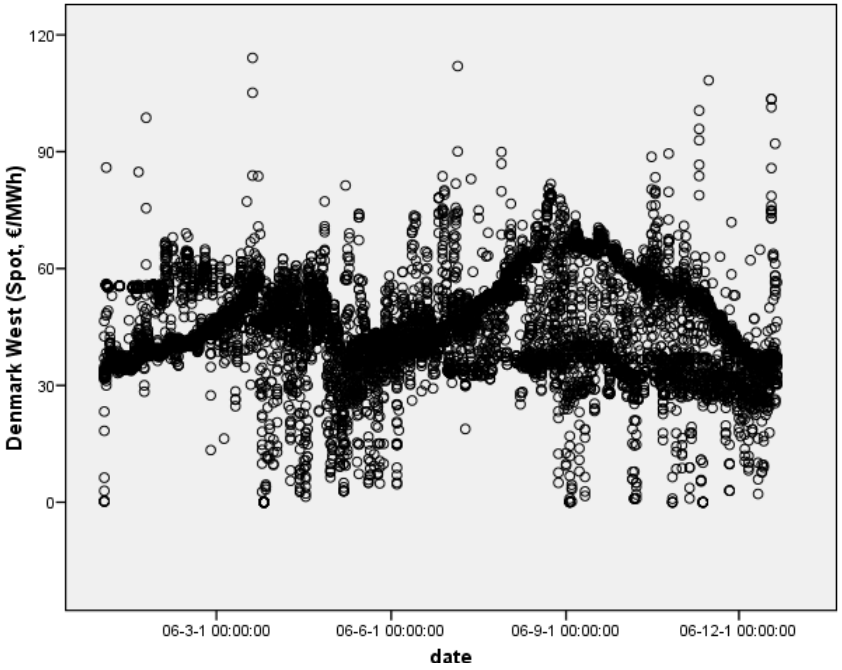
Regulating power

- Manual reserve activated with a 15-minute notice
- Used for balancing the grid in case of deviation from planned operation
  - Prognosis errors
  - Faults

Percentage of average (2006)

	Only spot price			Spot price + regulating power		
	Min	Max	Std. dev.	Min	Max	Std. dev.
Denmark West	0%	359%	30%	-367%	605%	50%
Denmark East	0%	611%	35%	0%	3,200%	72%

Adding regulating power to the spot price increases the price variation.
High incentive for demand response.
Demand is well-suited for the short variation in the regulating power.


Denmark West (Spot, €/MWh)
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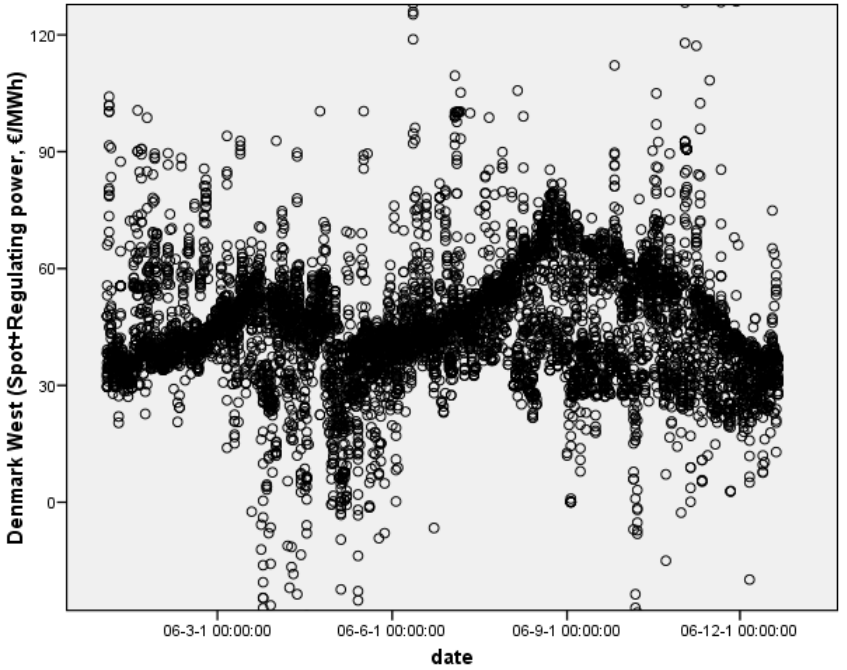
Denmark West (Spot+Regulating power, €/MWh)
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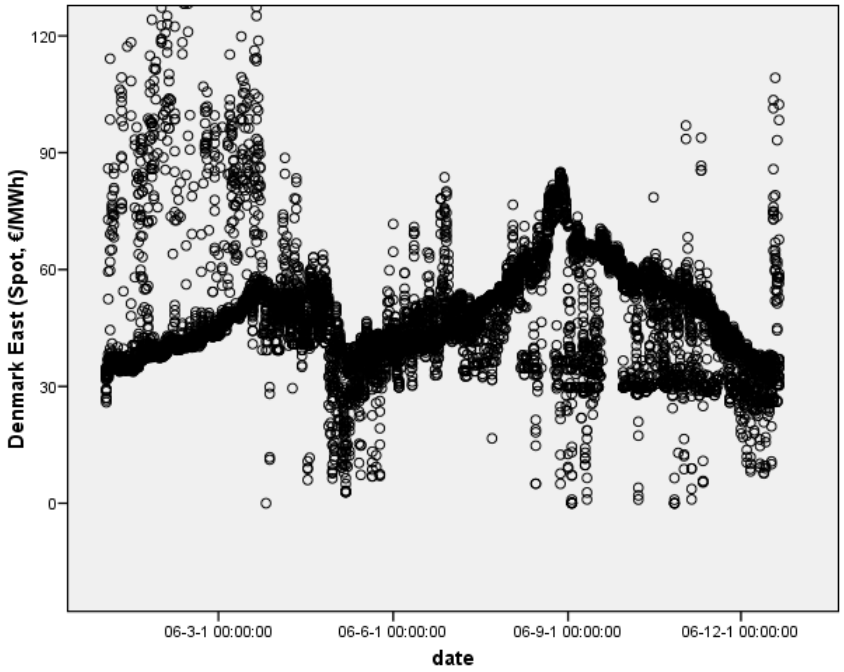
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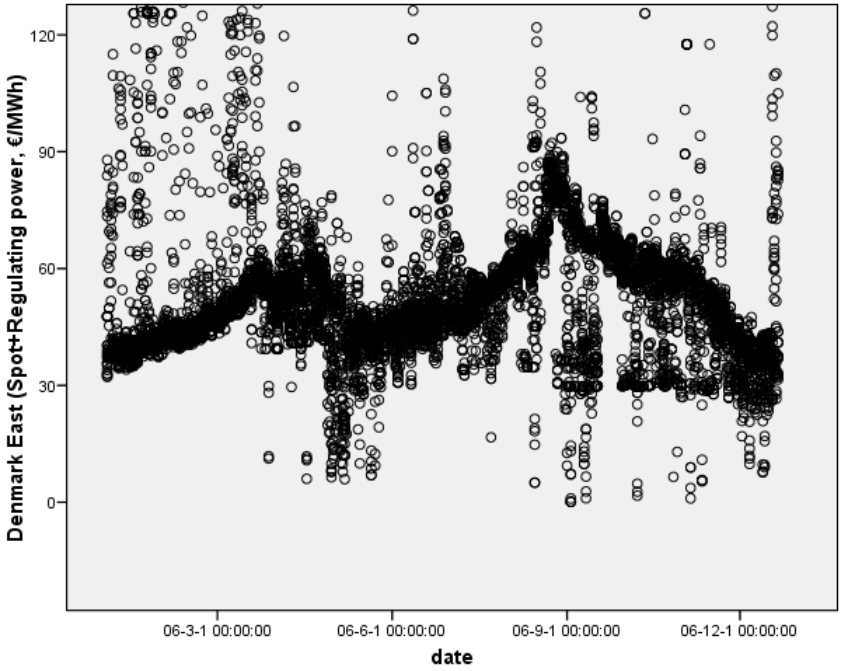
Denmark East (Spot+Regulating power, €/MWh)
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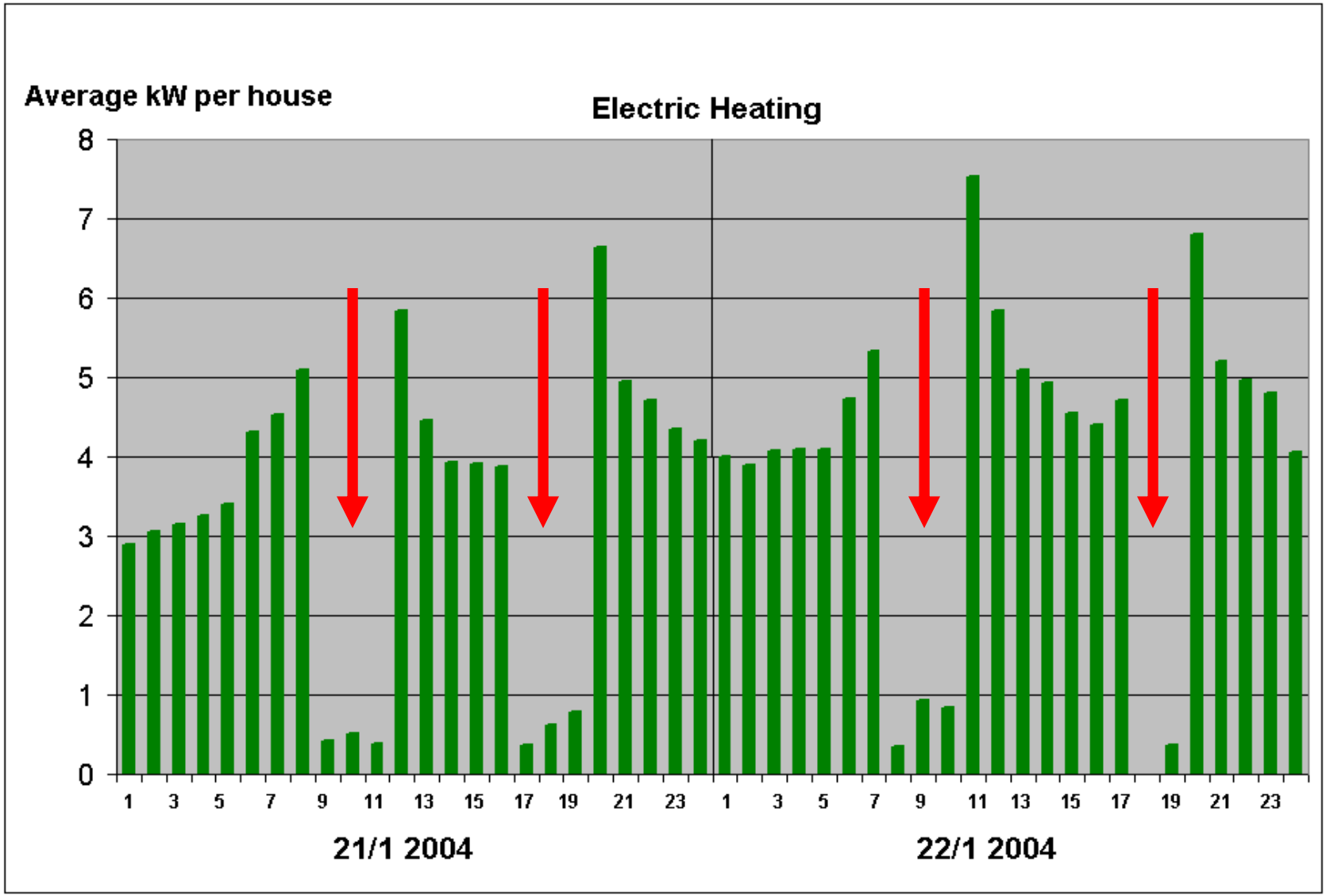
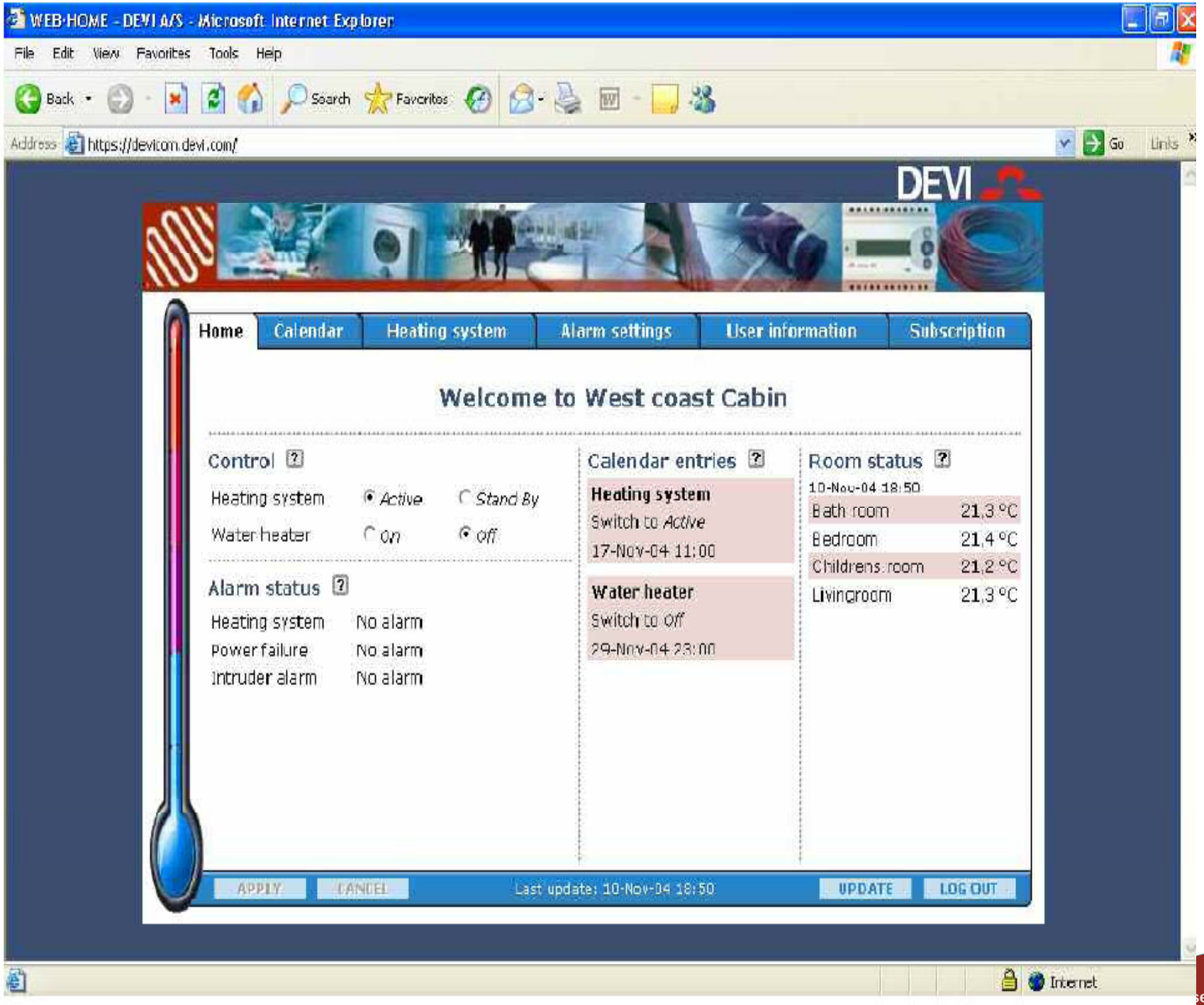
More price variation

- Dynamic prices
  - All reserves can be price-activated
  - Reservation price can be conveted into a higher variation in the real-time price
  - Dynamic prices for losses
- This would improve the potential for demand response
  - And for micro-generation

Part 4:
Demand response from households with electric heating

Pilot project

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Calendar
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Alarm settings
User information
Subscription
Welcome to West coast Cabin
Control
Heating system Active Stand By
Water heater On Off
Alarm status
Heating system No alarm
Power failure No alarm
Intruder alarm No alarm
Calendar entries
Heating system
Switch to Active
17-Nov-04 11:00
Water heater
Switch to Off
29-Nov-04 23:00
Room status
10-Nov-04 18:50
Bath room 21,3 °C
Bedroom 21,4 °C
Childrens room 21,2 °C
Livingroom 21,3 °C
APPLY
CANCEL
Last update: 10-Nov-04 18:50
UPDATE
LOG OUT
Internet


DEVI
Member of the Danfoss Group
Oversigt
Kalender
Historik
Energiprofiler
El-priser
Varmesystem
Alarmindstillinger
Brugerinformation
El-priser
Dato: 12-nov-06
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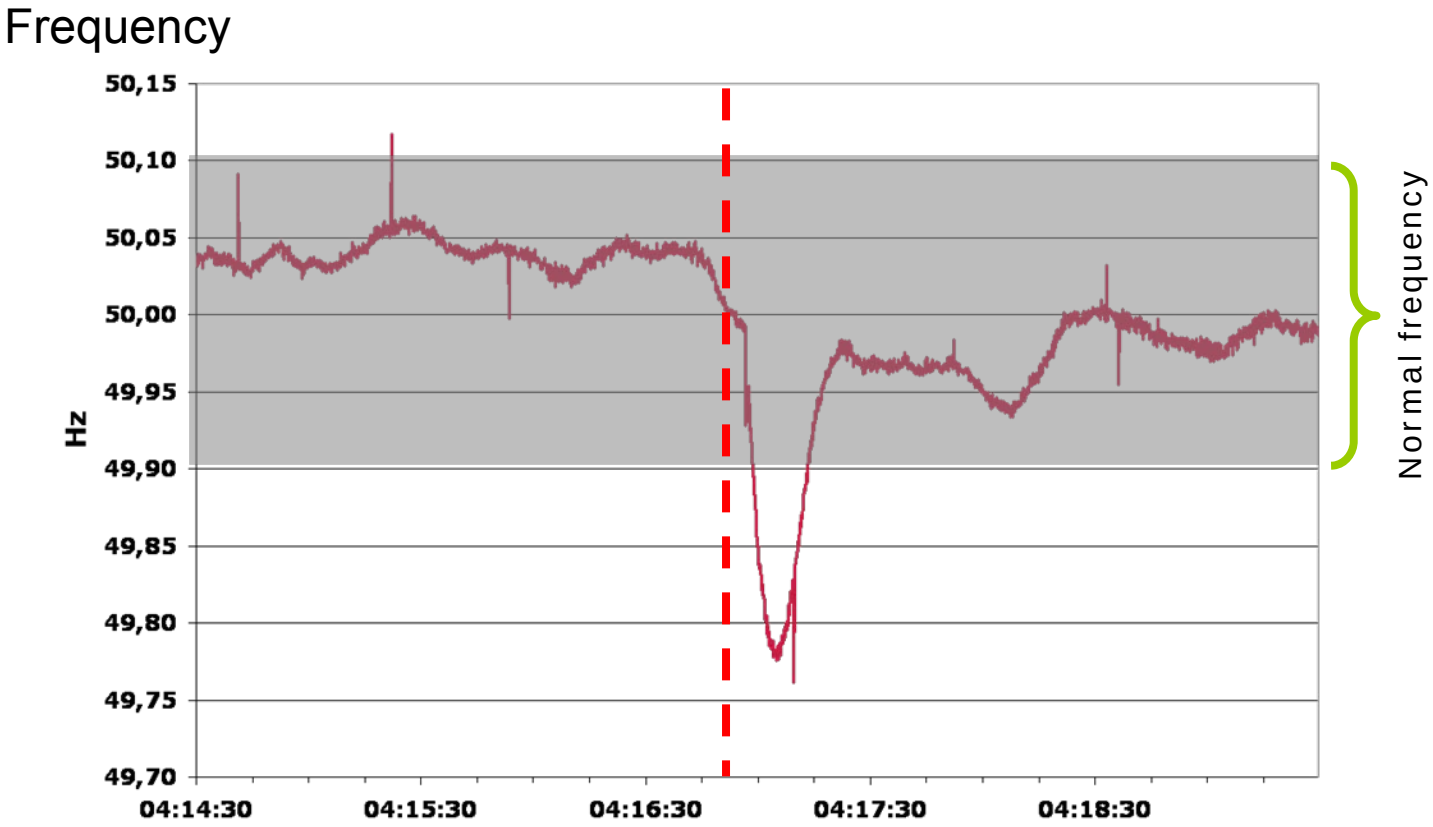
Part 5:
Demand as Frequency Controlled Reserve

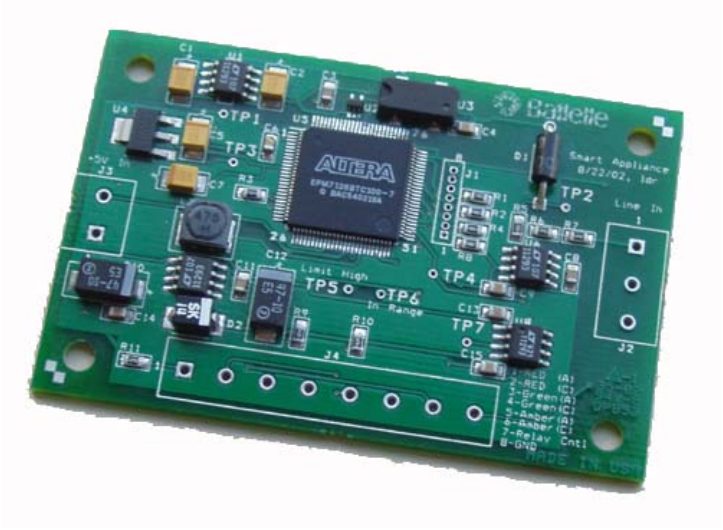
In cooperation with
The Technical University of Denmark

30 October 2005, 04:16: Loss of DC connection between Eastern Denmark and Germany



New electronic provides new possibilities

- The frequency is the same in the whole interconnected power system, e.g. in Nordel or UCTE



- A chip the size of a credit card can measure frequency and disconnect load in milliseconds – far faster than production can be increased
- No communication is needed

Conclusion

SmartGrids, dynamic prices and demand response

- Demand response is NEEDED in the liberalised electricity market
- Current practice with simplified tariffs limits the potential for demand response (and micro-generation)
- Dynamic prices can signal the need for higher or lower demand (or production) in real-time
- Demand can also be used as ancillary services

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Thank you for your attention!

Questions?

Mikael Togeby
mt@eaea.dk