

# The Crucial Role of Demand Response for SmartGrids' Success

- Dynamic price formation for energy, transport and ancillary services
- Danish demand response pilot projects

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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 in 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 (\*\*)

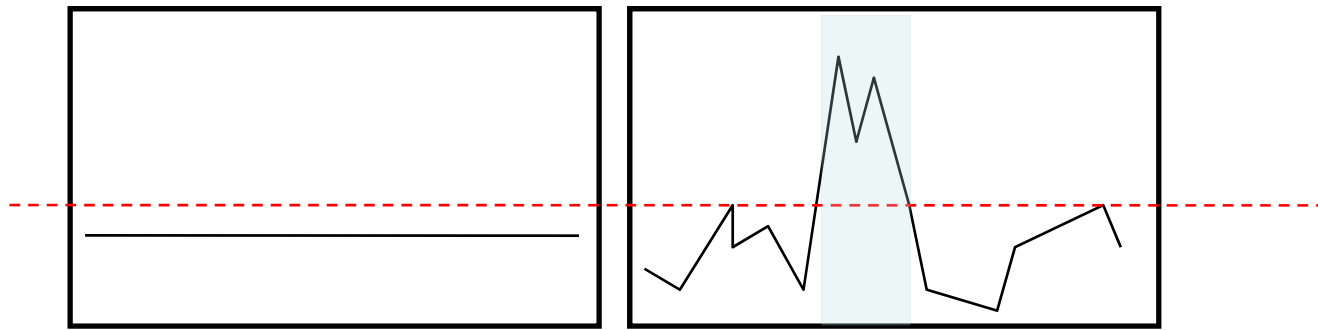
\* Introduction to Dynamic Rates. Karen Herter, LBL/CEC September 9th, 2002

\*\* 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

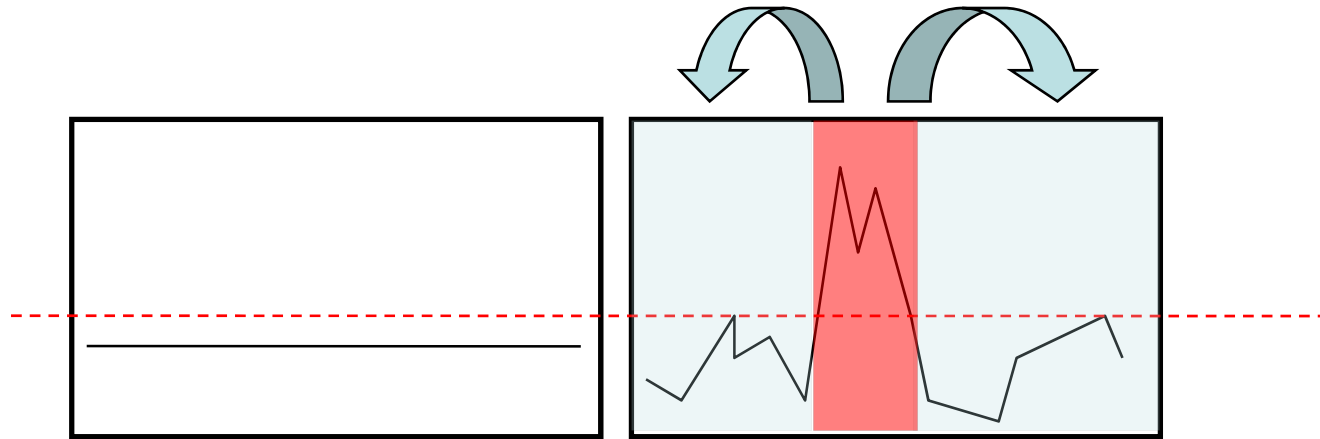


Flat price:  
No production

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

# 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*

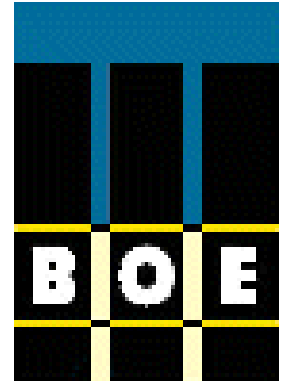
*[next 5 slides]*

# 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 DlgSILENT®

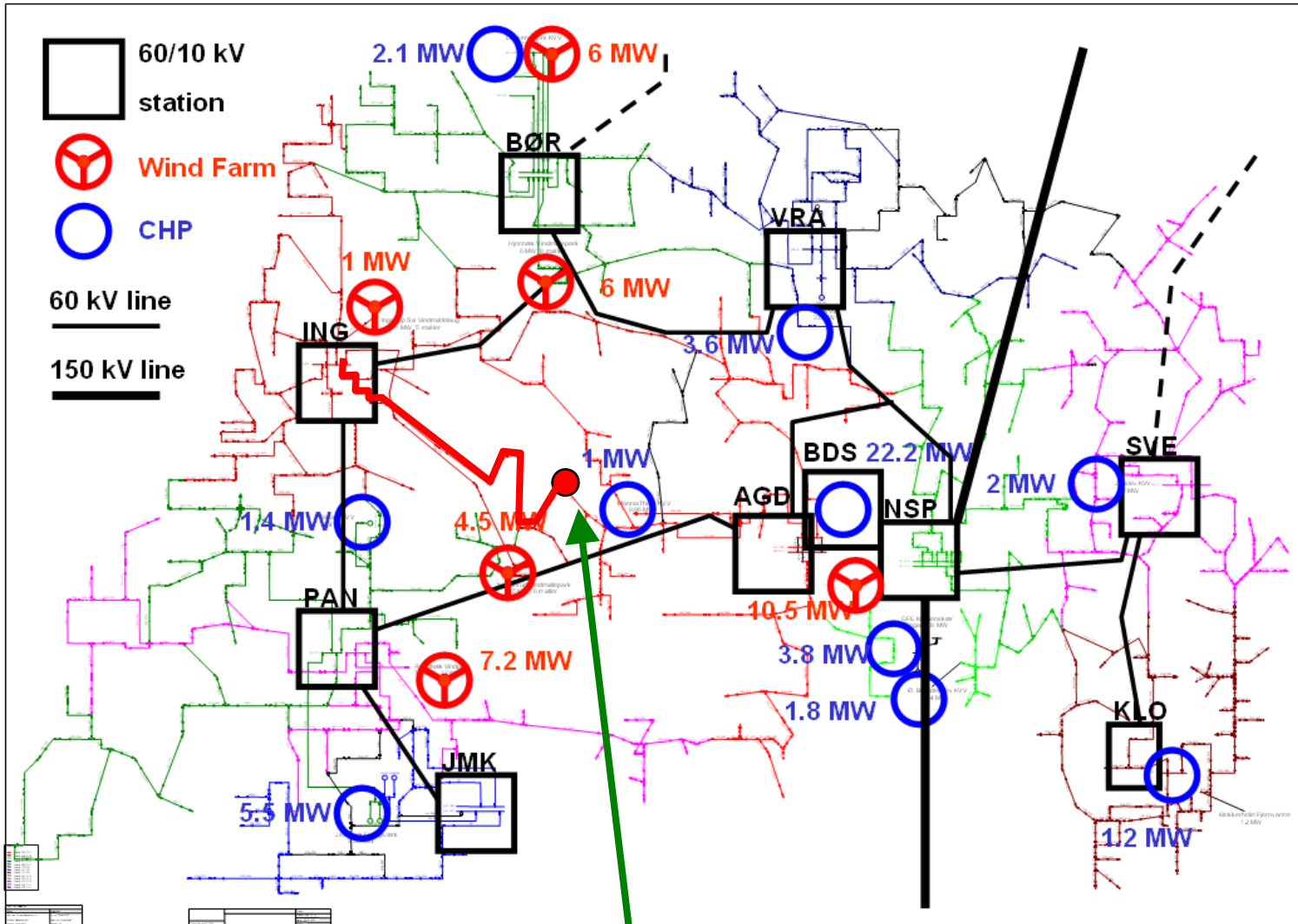


# BOE



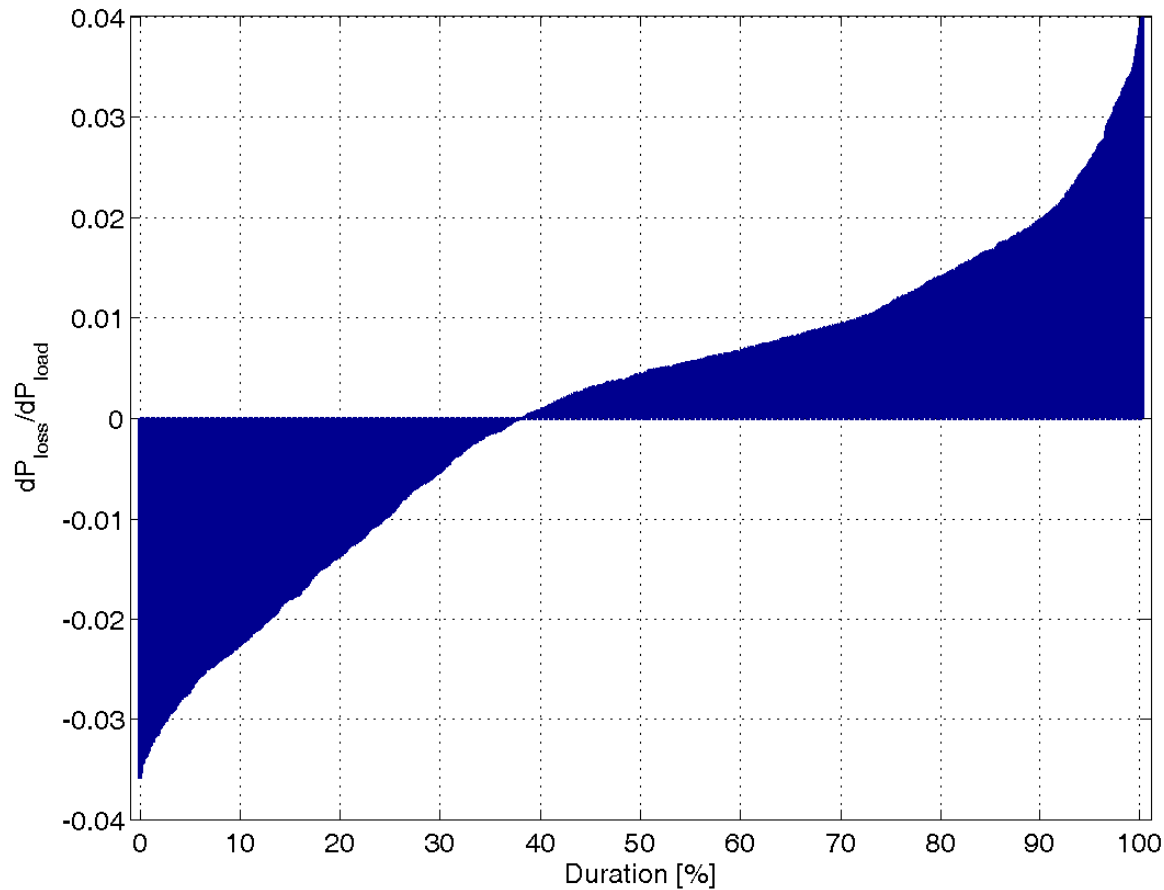
- 29,000 customers, 690 km<sup>2</sup>
- 150/60/10/0,4 kV grid
- 65 wind turbine, 40 MW
- 18 Combined heat and power plants, 50 MW
- Load between 15 and 45 MW
- The area is importing electricity half of the time
  - and exporting electricity the rest of the time

# The network of BOE



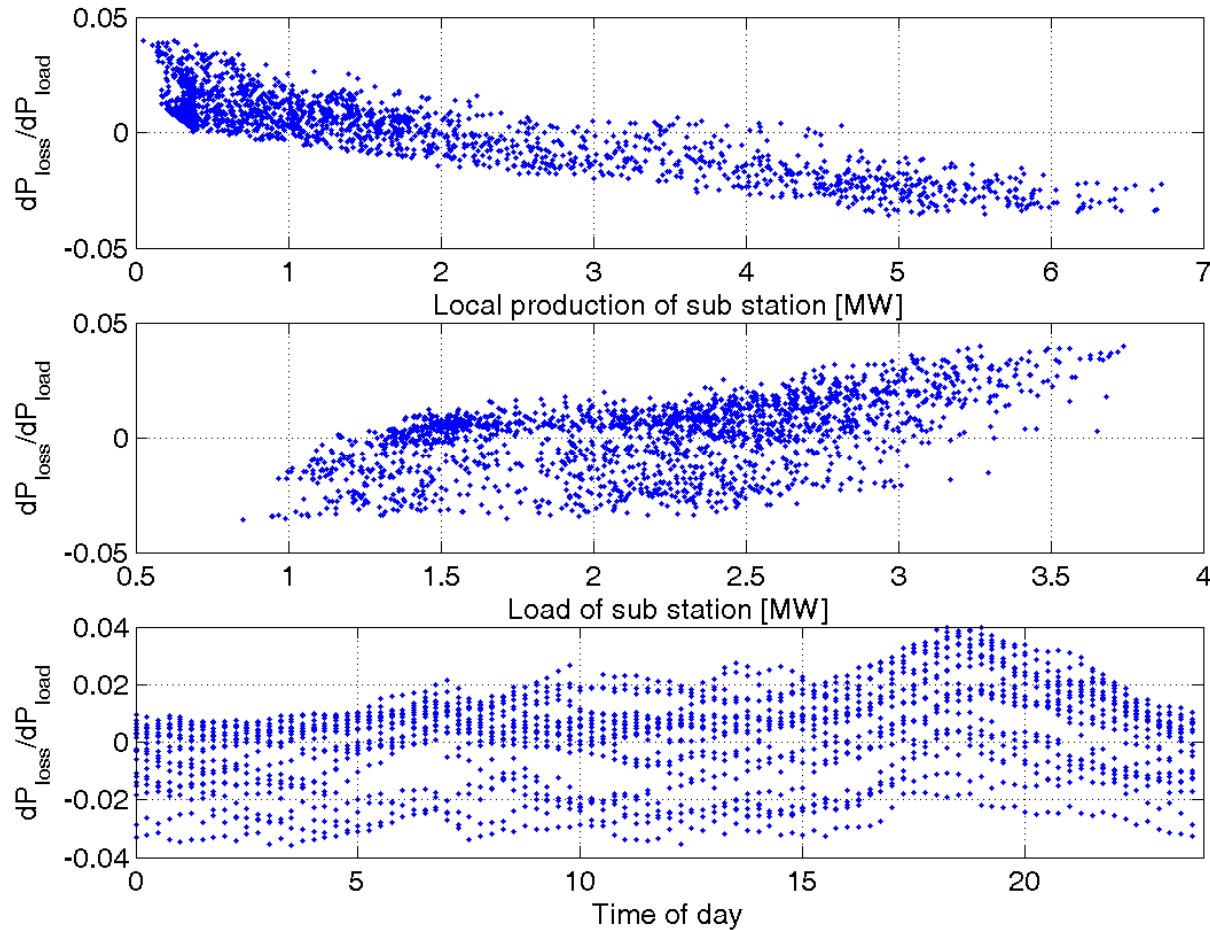
Investigated load bus

# 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

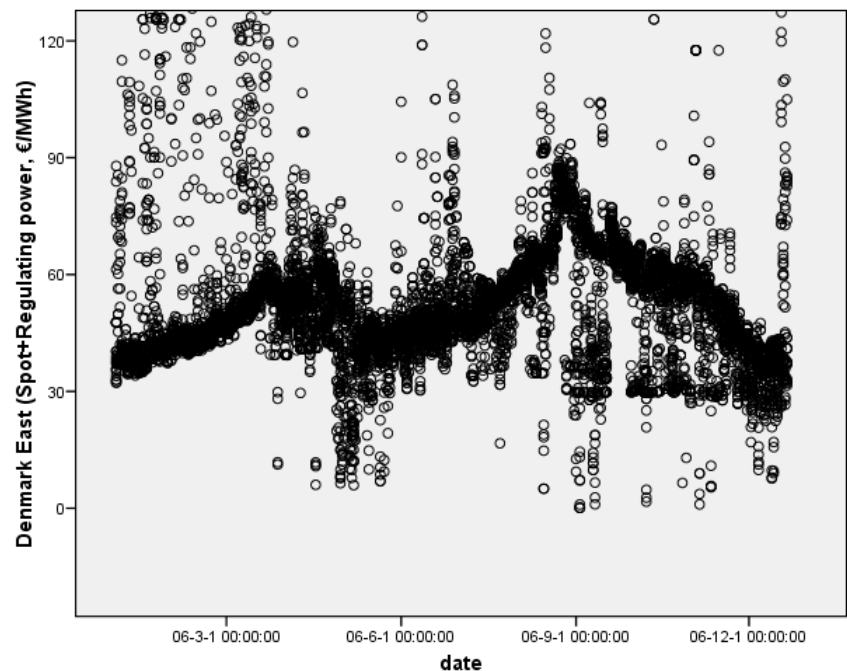
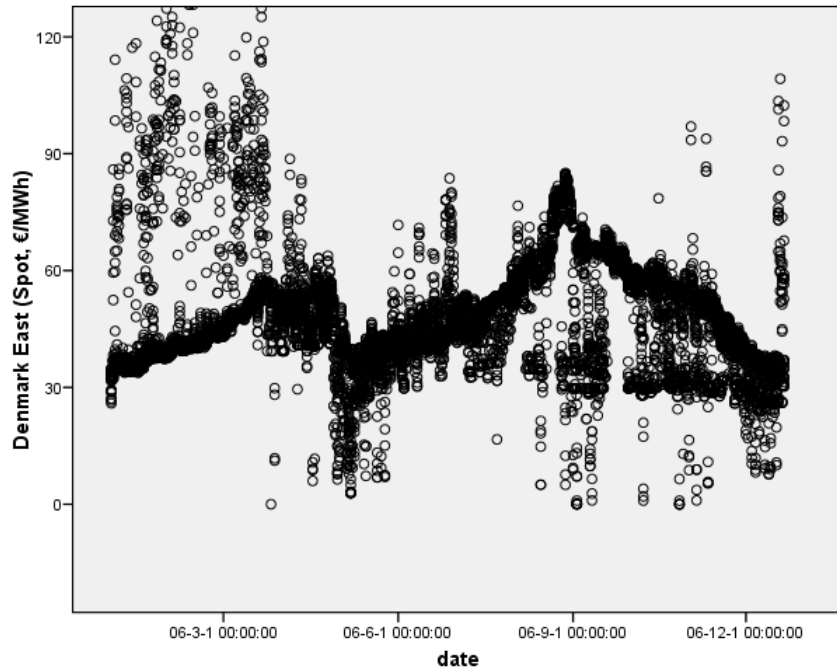
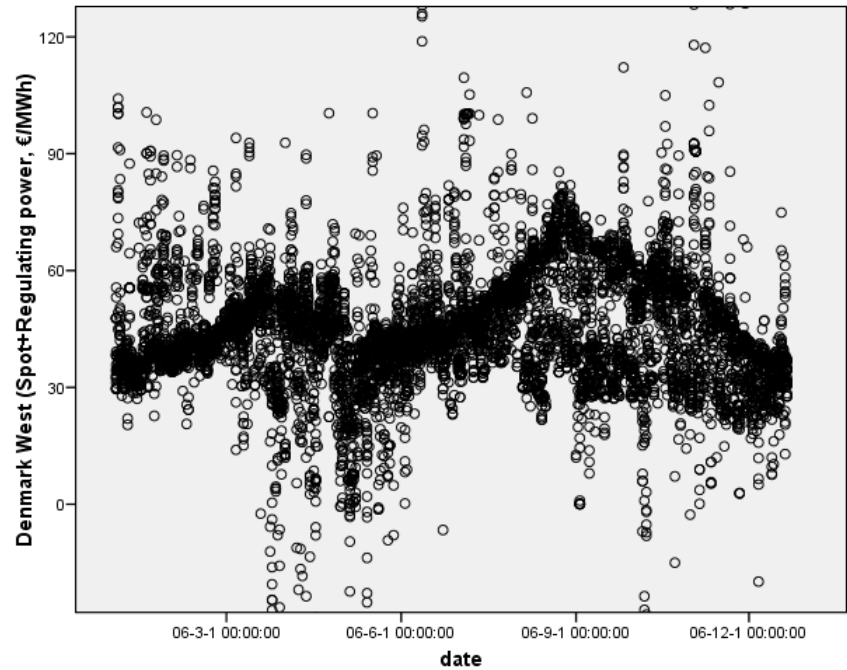
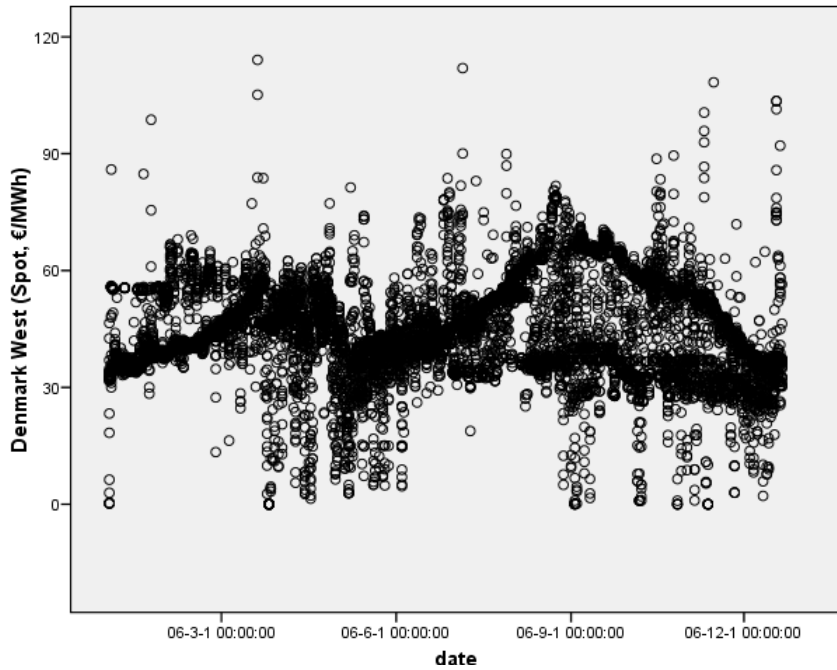
# Regulating power

- 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.





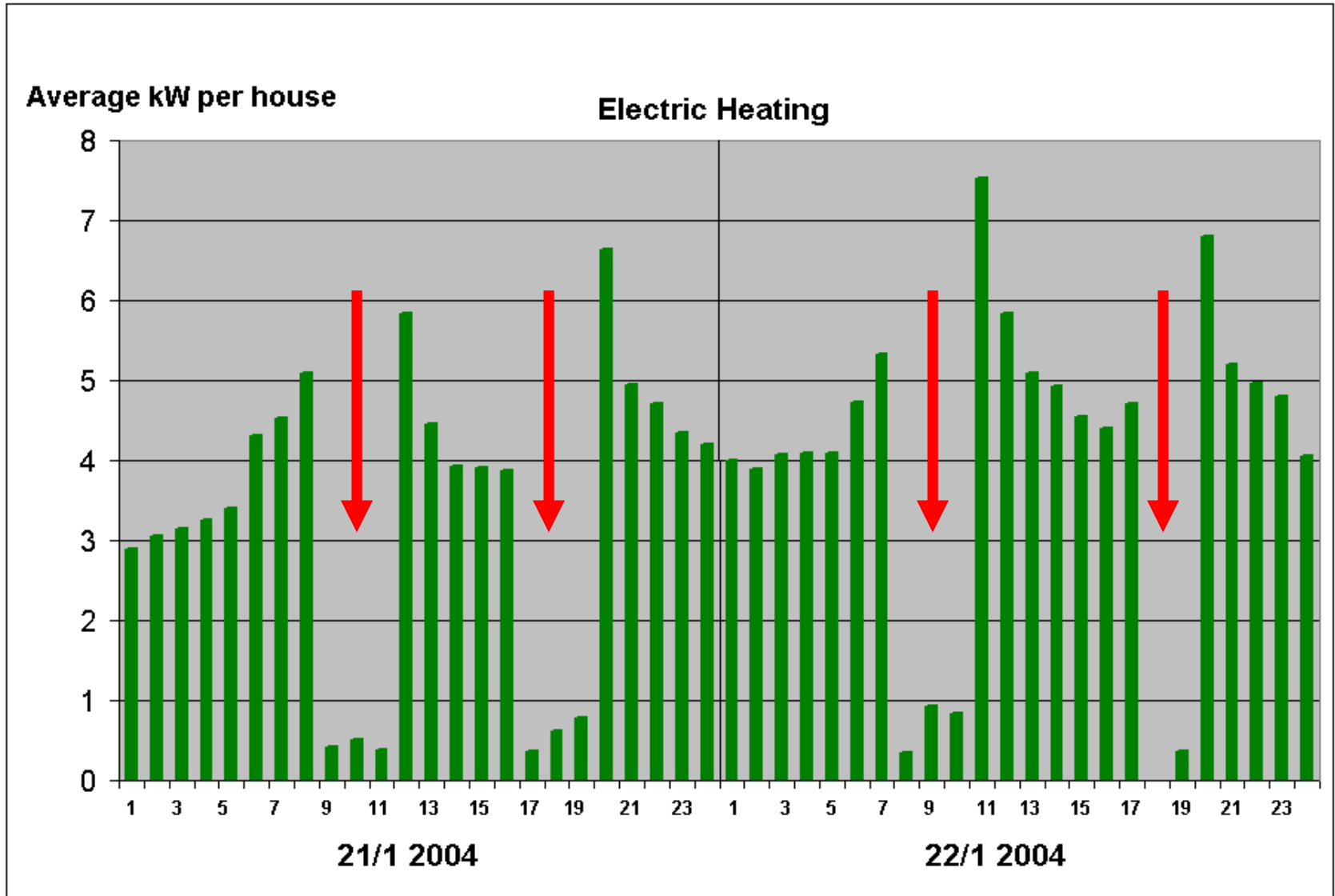
# More price variation

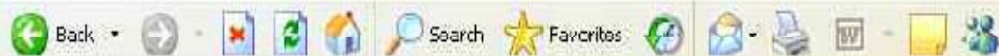
- Dynamic prices
  - All reserves can be price-activated
  - Reservation price can be converted into a higher variation in the real-time price
  - Dynamic prices for losses
- This would improve the potential for demand response
  - And for micro-generation

# Part 4:

## Demand response from households with electric heating

# Pilot project





- Home
- Calendar
- Heating system
- 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

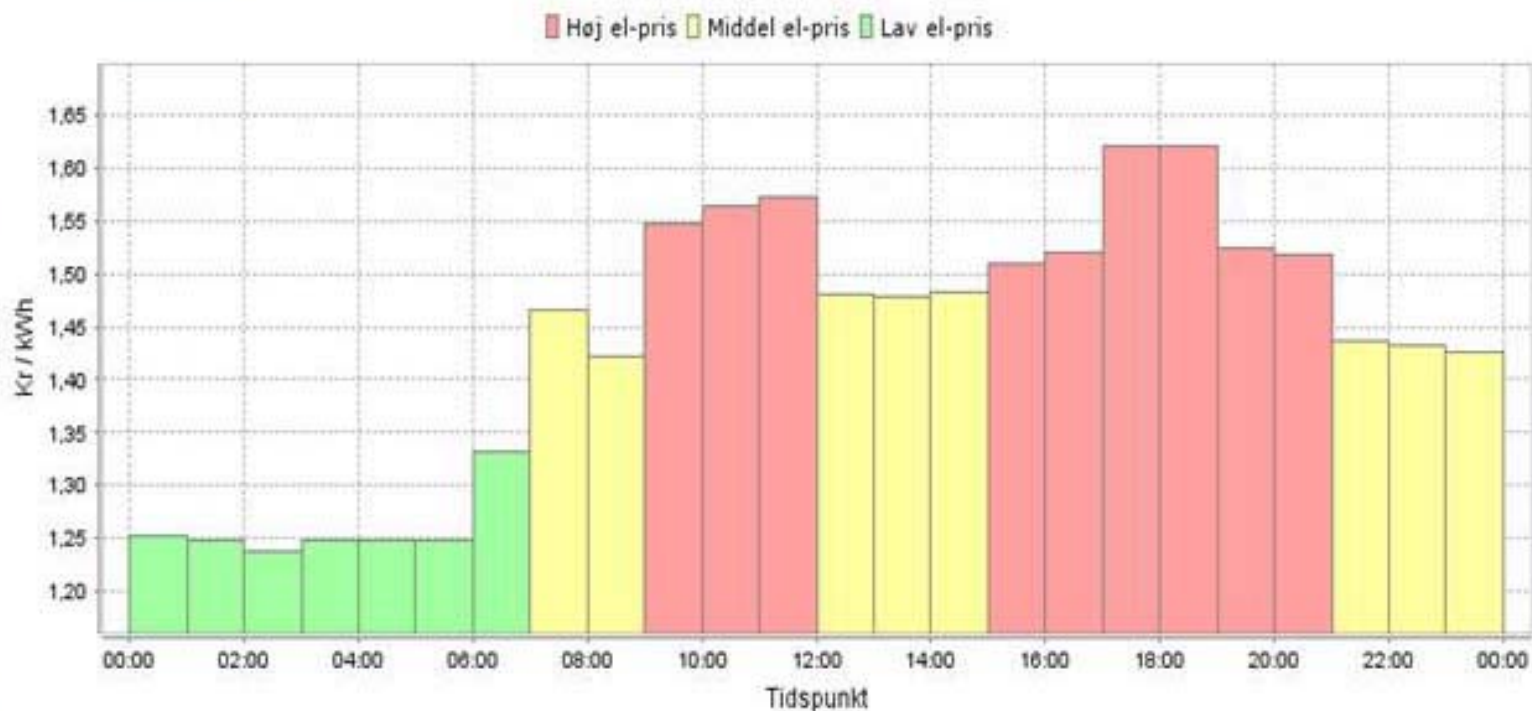
LOG OUT



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El-priser 

Dato:  



Sidst opdateret: 10-nov-06 09:13

[OPDATER](#)

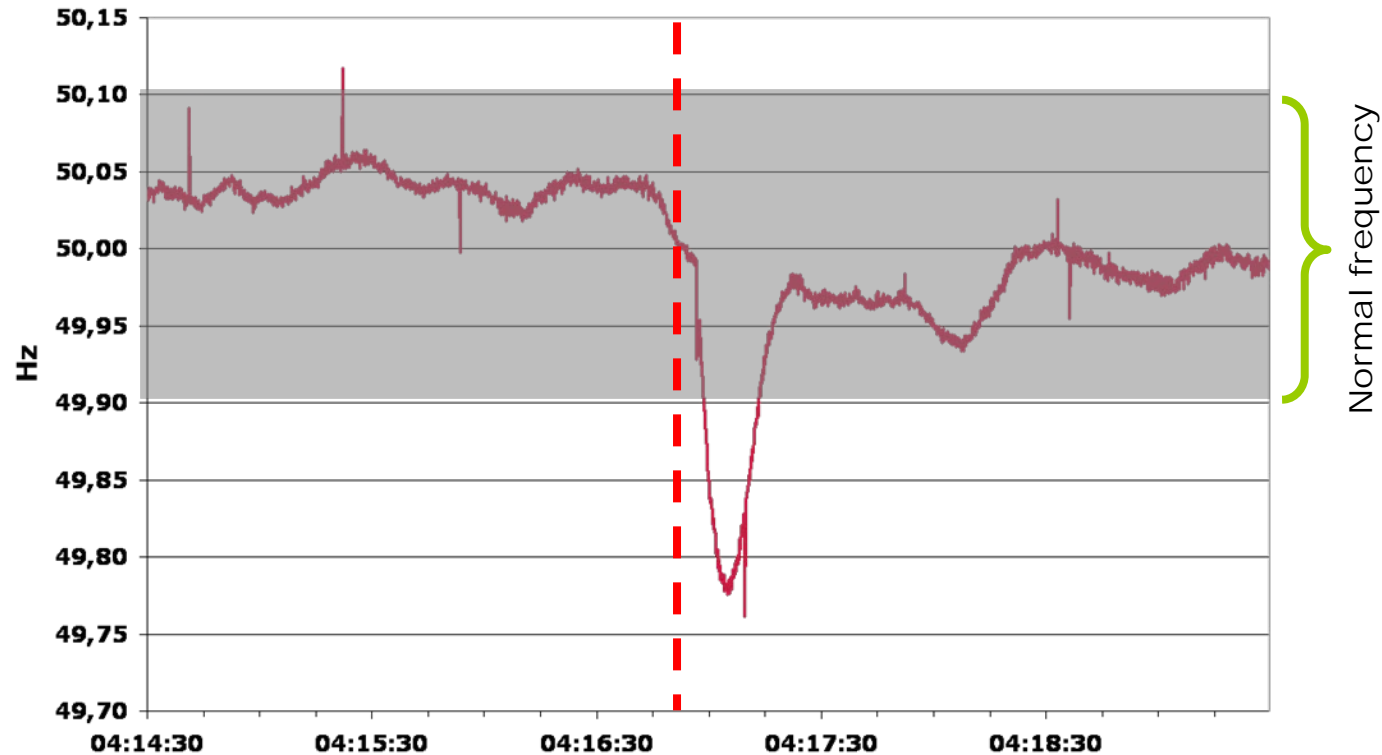
[LOG UD](#)

# 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

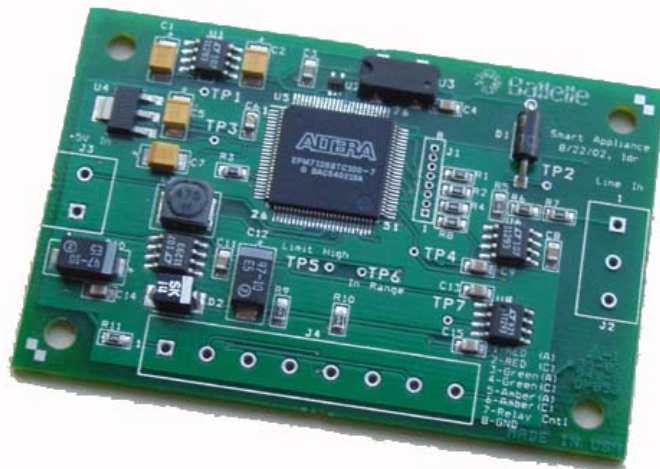
Frequency



Normal frequency

# 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?

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