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ROYAL INSTITUTE
OF TECHNOLOGY

# On the Value of SmartGrids for Power Systems

Keynote,Tuesday October 18

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# Metering in my house (5500 kWh/year)

**Everyone has a type of this in Sweden**

# Metering in my house (5500 kWh/year)



**Grid invoice (monopoly)**



**Energy invoice (competition: ≈140 suppliers)**

- Measures absolute value
- Sends data one time per day
- Sends the state on the screen
- Uses GSM (GPRS)
- Hourly measures under discussion

**Meter:**

# Aim of a power system:

1. Supply consumers with electricity when they want
= keeping the continuous balance between production and consumption
**(deregulated → competition)**

2. Keep the voltage for the consumers
**(regulated monopolies)**

**un**bundling

## Power = current · voltage

# **Structure:**

- What is "Smartgrids"?
- Driving forces for Smartgrids
- On the structure of the Value of SmartGrids for Power Systems.
- Examples of existing and new SmartGrid solution and requirements for implementation
- **EIT-InnoEnergy-SmartGrids!**

**Experience**

**A smart person**

**Decision**

**Action**
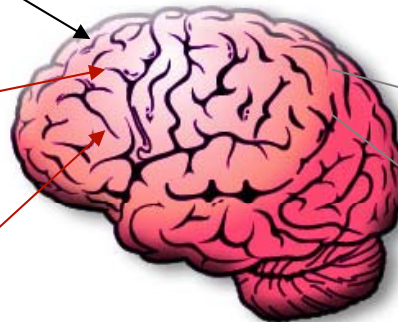
**Information**

- A person considers information from the senses, takes decisions and take actions and/or spreads the conclusions to others
- A "smart" person, can select interesting information, take "smart" decisions and take the "right" actions
- To be "smart" also implies that one understand the consequences of the actions.

**Experience**

**A smart person**
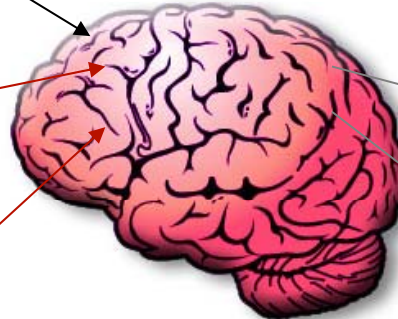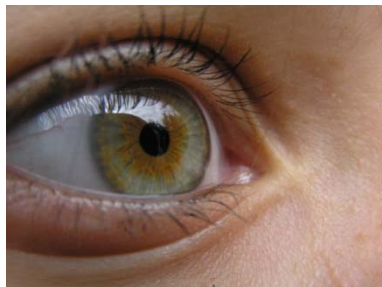
**Decision**

**Action**

**Information**

To be able to be "smart" the following is needed:
- Good information
- "Smart" decisions
- Possibility to be considered
- Knowledge of consequences of actions
- Take notice of of consequences of actions = experience

**Experience**

**A smart person**

**Decision**

**Action**

**Information**

**Feedback**
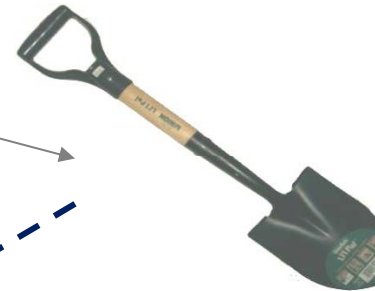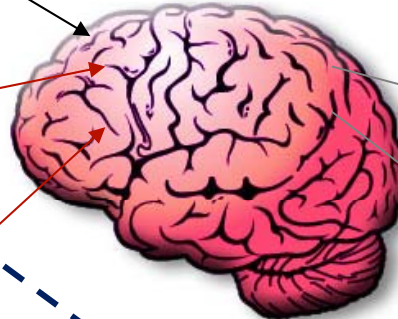
To be able to be "smart" the following is needed:
- Good information
- "Smart" decisions
- Possibility to be considered
- Knowledge of consequences of actions
- Take notice of of consequences of actions = experience

**Model**

**A smart grid
measure ➜ think ➜ control**

**Infor-
mation**
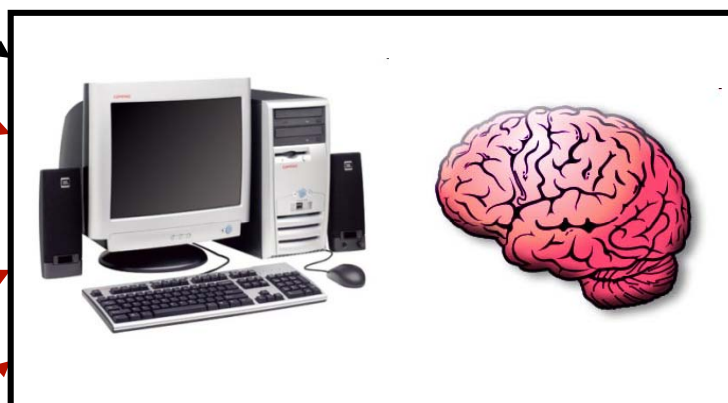
**Action**

**Decision**

- A smart grid uses available information, takes decisions and actions and/or spreads the conclusions to other grids.
- A "good action" means that one can estimate the consequences of the actions, i.e. a good model!

# Comments on SmartGrids

- **Information** is important, i.e. IT to transmit data, e.g. AMR
- The "**smart**" part are the decisions, not the information!
- **Controllability is** central. If there are not components to control, then the value of more information is lower.
- **Consequence analysis**, is important, i.e. an analysis of what happens after a control action ➜ a good model is needed
- "**Smart-Grids**" includes all from applications with existing technology up to advanced research.

# A smart grid
## measure ➔ think ➔ control

- **Measure** More measurements are **(will be)** available today/**tomorrow**, e.g. AMR, PMU
- **Think**: Computers are **(will be)** much faster and trainer simulators can make the decision takers more efficient
- **Control**: More controllable devices are **(will be)** available, e.g., HVDC, SVC, EV, DSM in households etc.
- **IT:** is **(will be)** needed and can include sending of price signals, direct control signals, decision support etc.

# Some personal comments:

**"Smartgrids are <u>needed</u> for …."**

- **LS**: One can, e.g., integrate large amounts of wind power and/or electric vehicles without new Smartgrids technology, but it may be less efficient

**"With Smartgrids the losses are reduced"**

- **LS**: Often this is not the case since Smartgrids means a higher use of existing equipment instead of investment in more copper!

**"How much will Smartgrids cost?"**

- **LS**: One should only invest in Smartgrids if it creates a net benefit, otherwise not.

# Driving forces for Smartgrids

# Driving forces for Smartgrids



Value of more intelligence in power system

Value > Cost

Cost = Value

Cost for more intelligence in power system

Amount of intelligence in power system
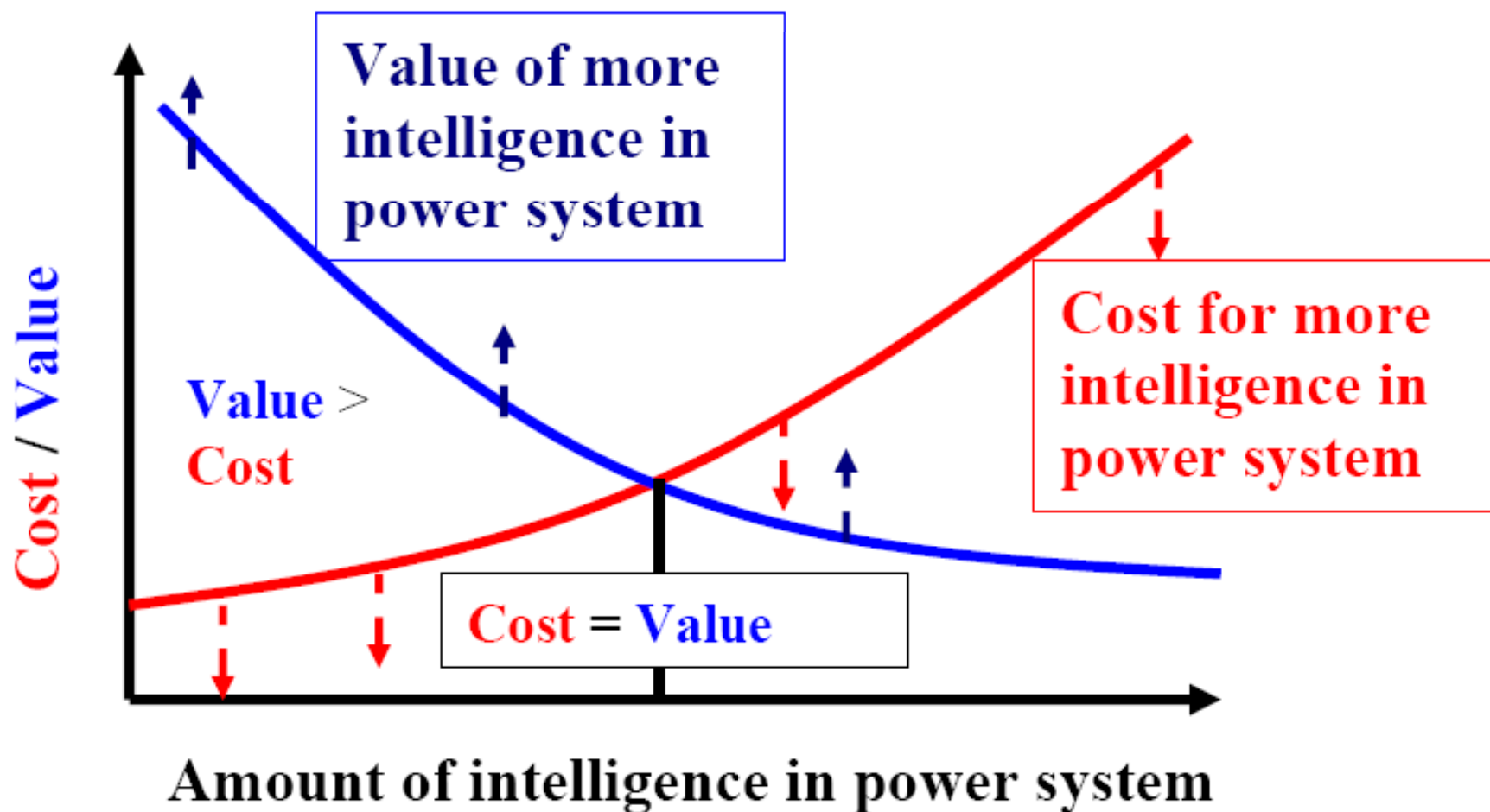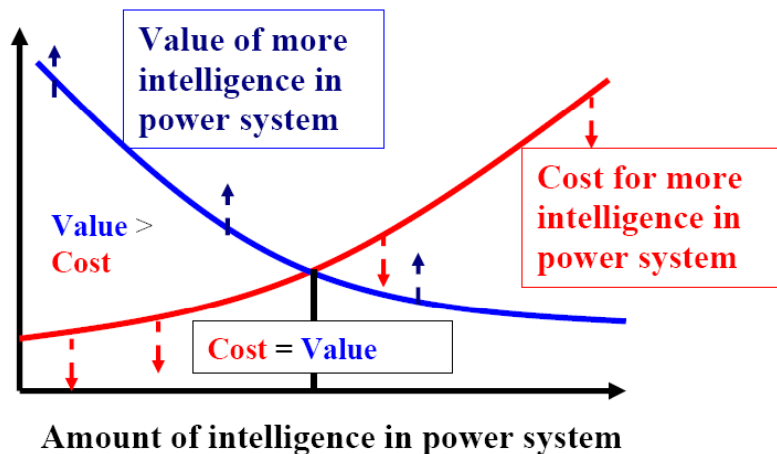
**Increasing value:**
- More variable power sources
- Higher pressure on cost efficient operation
- Higher requirements on reliability

**Decreased cost:**
- For measuring
- For control
- For information transfer
- For information processing

# 20-20-20 goals:
# Wind power and transmission capacity

**Spain wind: 19 635 MW**

**Portugal wind: 3 937 MW**

**Irland wind: 1539 MW**

*Source: REE*

kW/km²
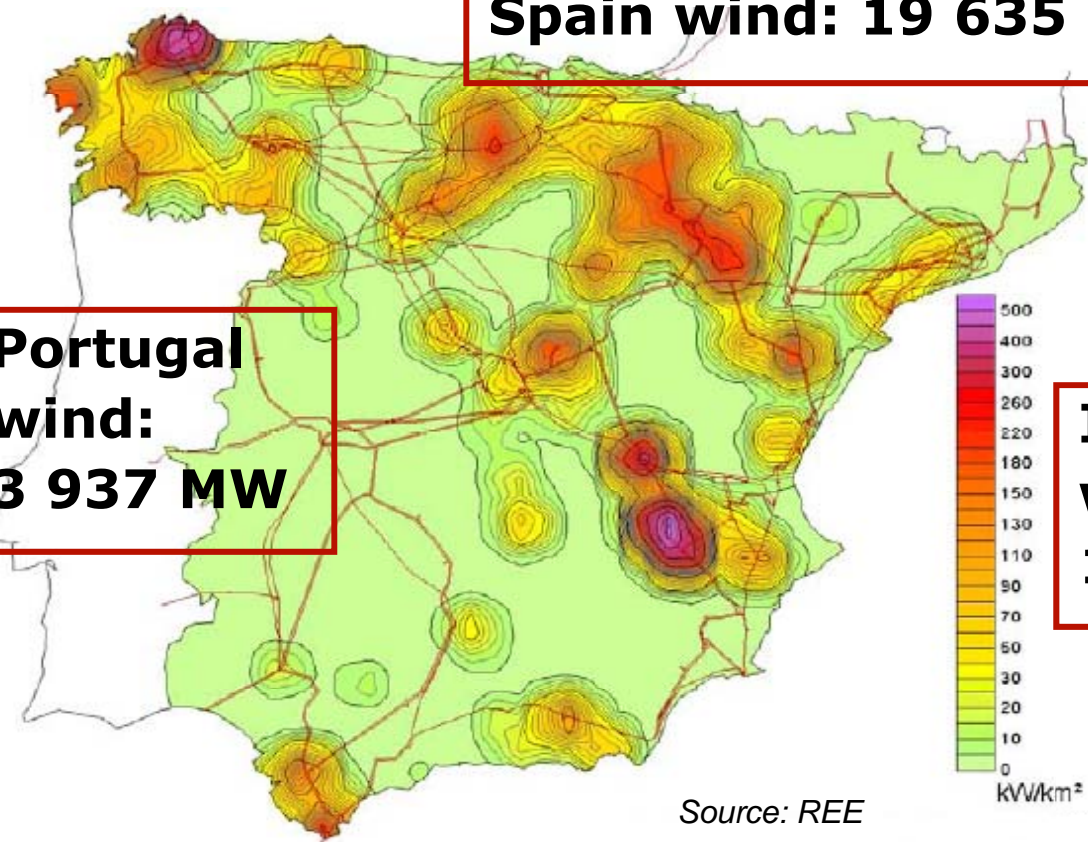
| | wind energy 2010 |
|---|---|
| Sp | 16 % |
| Po | 17 % |
| Ir | 13 % |

| | wind max share |
|---|---|
| Sp | 54 % |
| Po | 81 % |
| Ir | 52 % |

- Portugal –Spain: 1200 MW
- Spain – France: 1200 MW
- Spain – Marocco: 650 MW

- Irland - Scottland: 450 MW
- Planned: +850 MW

# Pricing in power markets - 1

**2**: Bids

**1**: Sources with capacities

**5**: Production

**3**: Prices

**4**:Control actions

# Pricing in power systems - 2

**Now**
**11-12**

**Yesterday**
**Bid: 12.00**

Day-ahead market MWh/h

**Bid: Some hours ago**

Intraday market

**2: Bids**

**1: Sources with capacities**

**5: Production**

**3: Prices**

**4: Control actions**

**Bid: 10 min before hour**

Regulating market
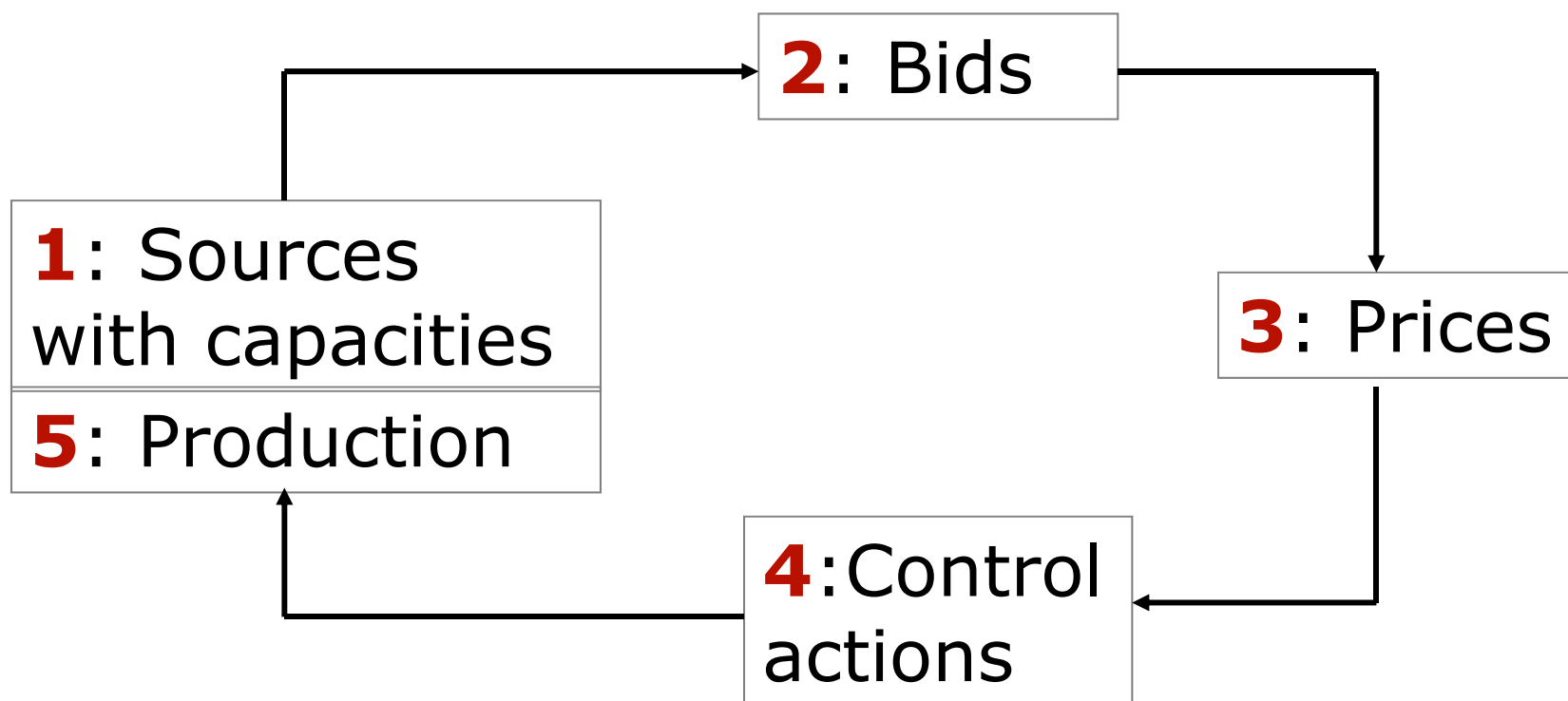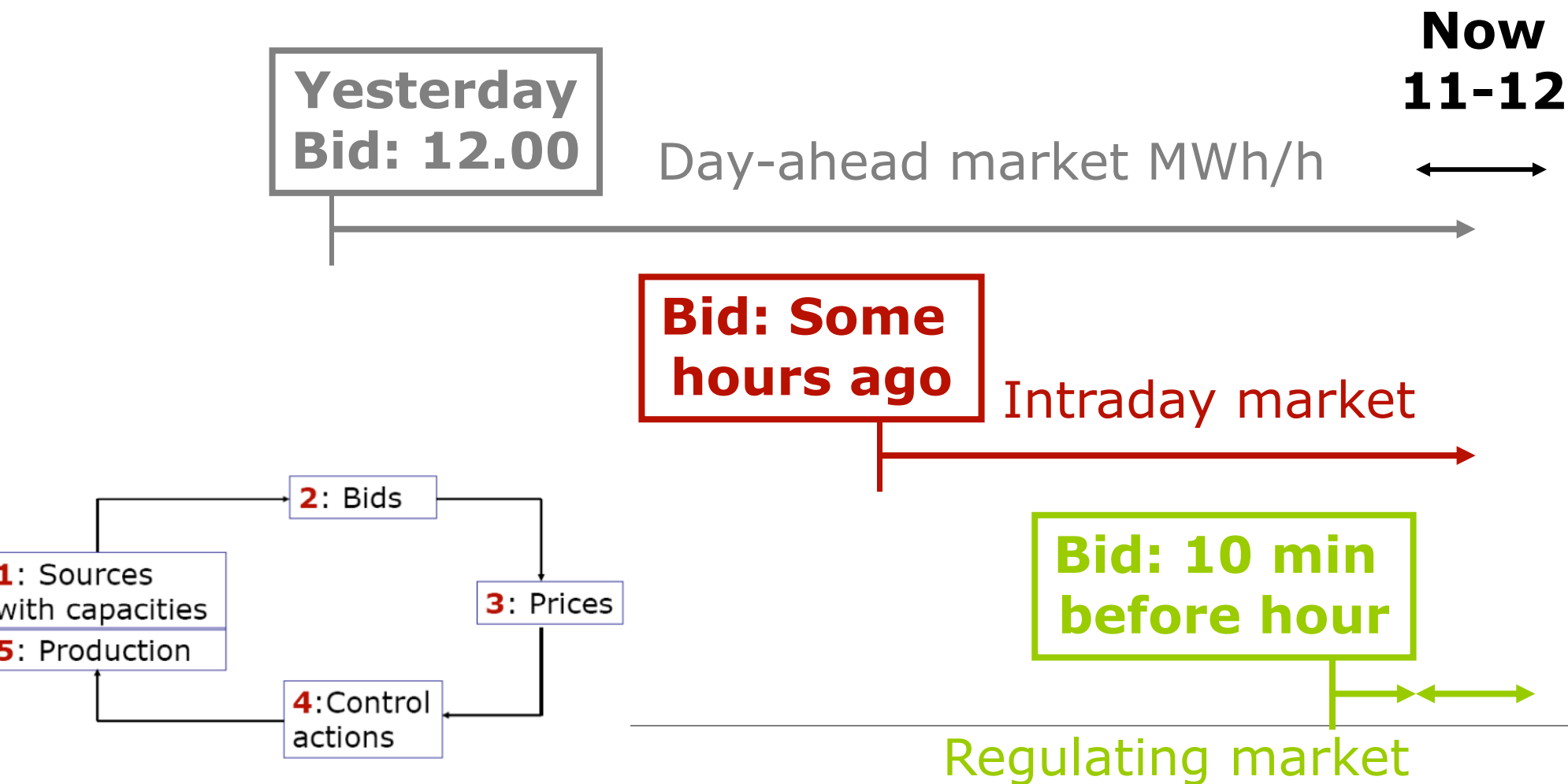
# On up-dated forecasts



WMPP average quarter-hour power output as at December 11 2000

Forecast calculated on December 10 at 11:00
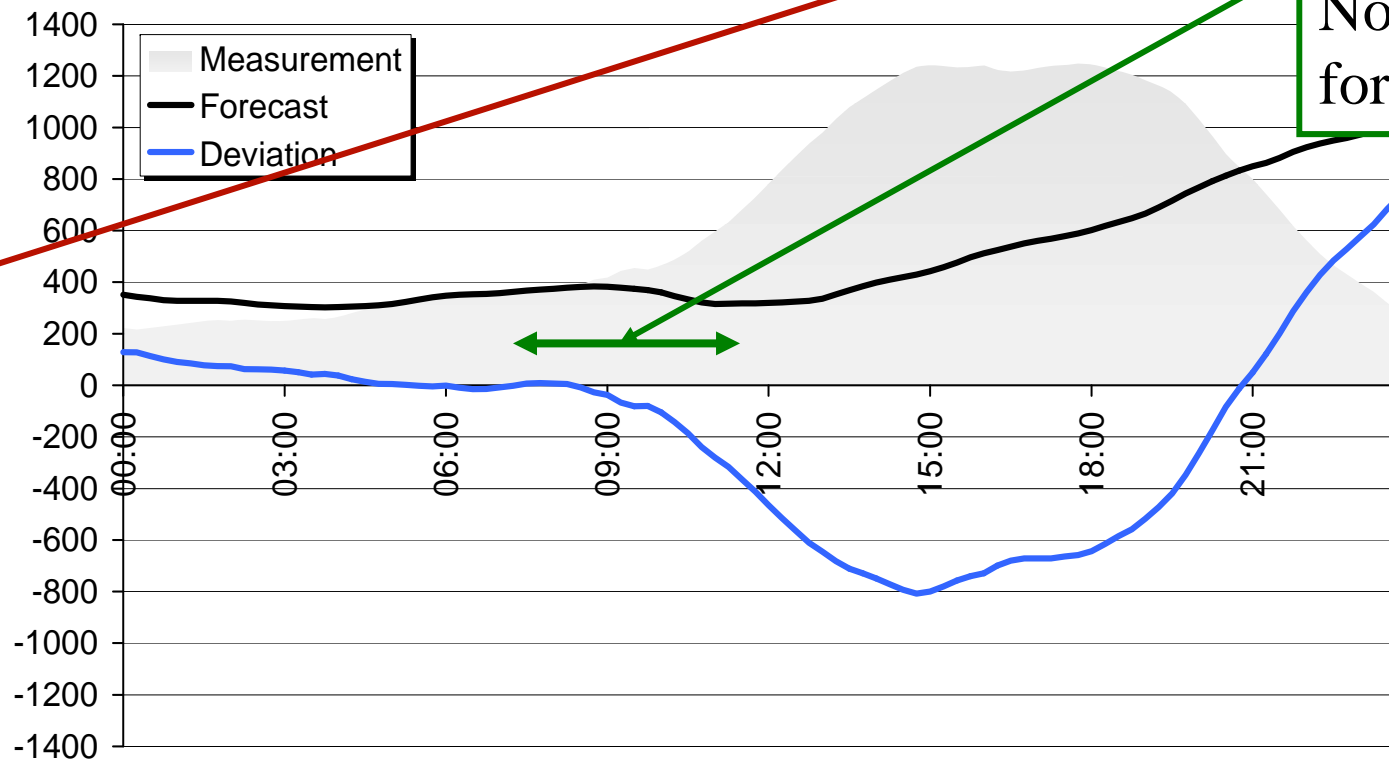
Decision for balancing: Now improved forecast!

Legend:
- Measurement
- Forecast
- Deviation

# Pricing in power systems - 4

**With an assump-tion of perfect competition:**

- Prices are based on production marginal costs
- Low costs units are used first
- Higher load ➔ higher prices:

## Weekly demand
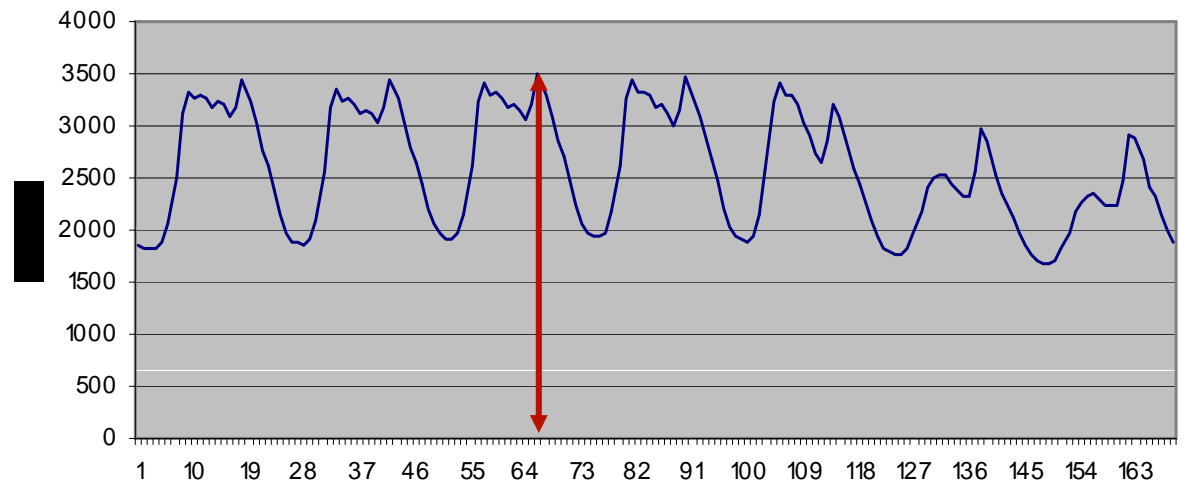
## pricing
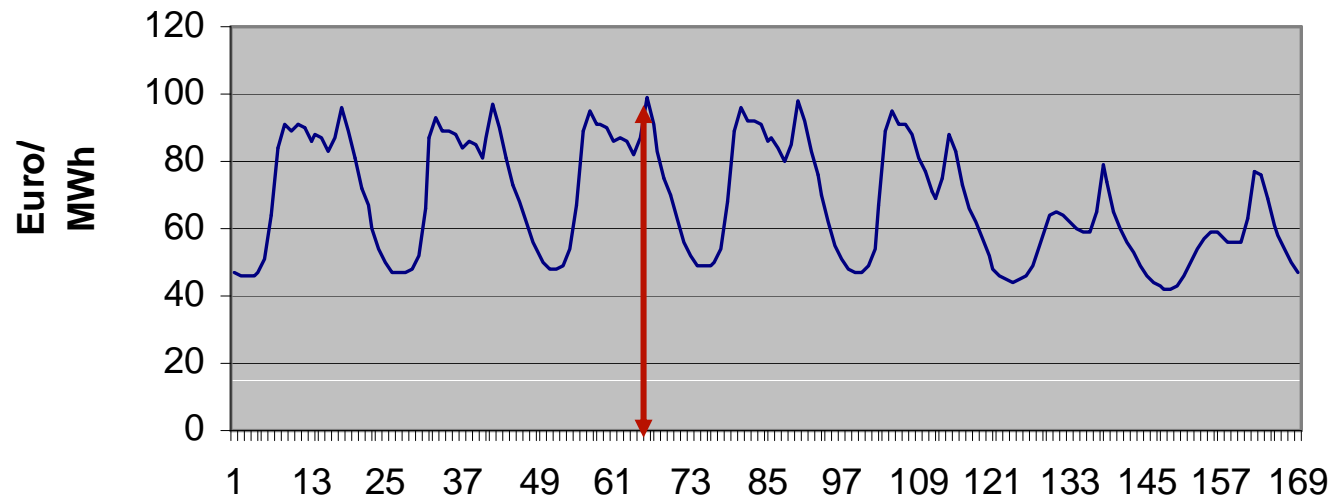
# Pricing in presence of variable sources (e.g. wind)

Wind power has a marginal cost ≈ zero

The production level is depending on wind speed

It is not easy to make good long term (hours) forecasts

Other units have to cover the net load = demand - wind

**W Denmark 10/1-17/1 2005**
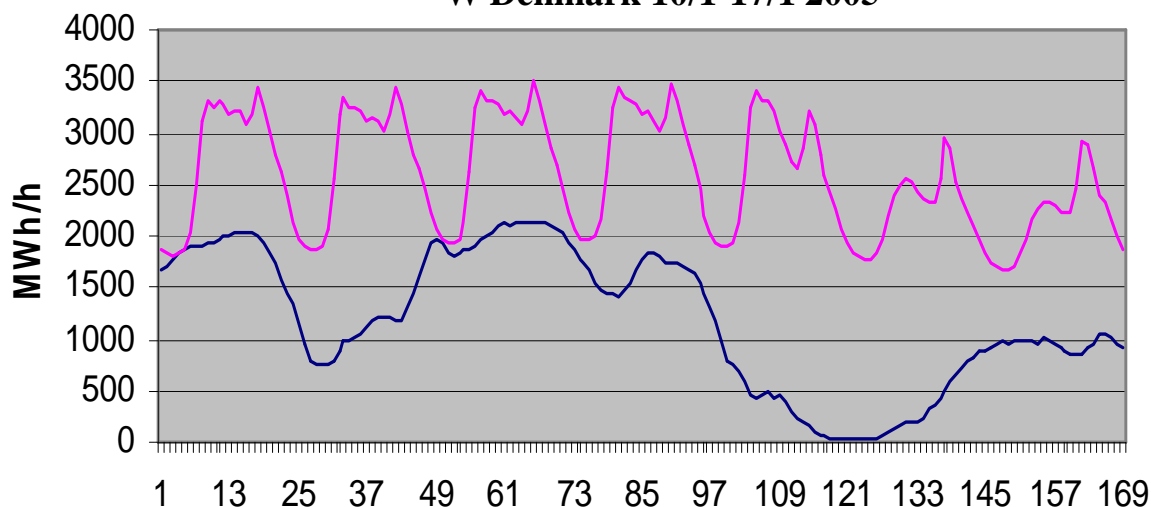


**Weekly demand + wind**
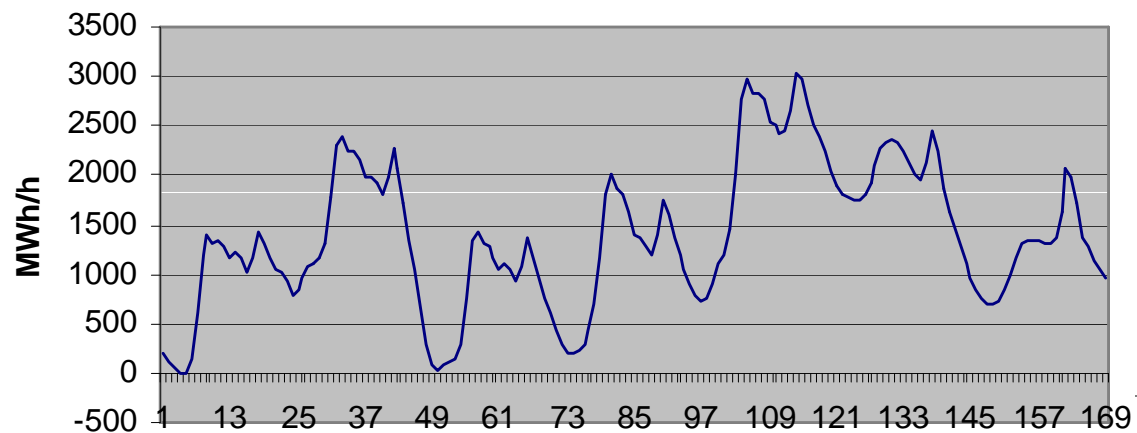


**Weekly net demand**

# Pricing in presence of variable sources

- Other units have to cover the net load = demand – wind
- The other units production is controlled by price!
- ➔ more volatile price
- **Note: This is independent of "fixed price" etc**

**Weekly net demand**

**"Thermal pricing"**
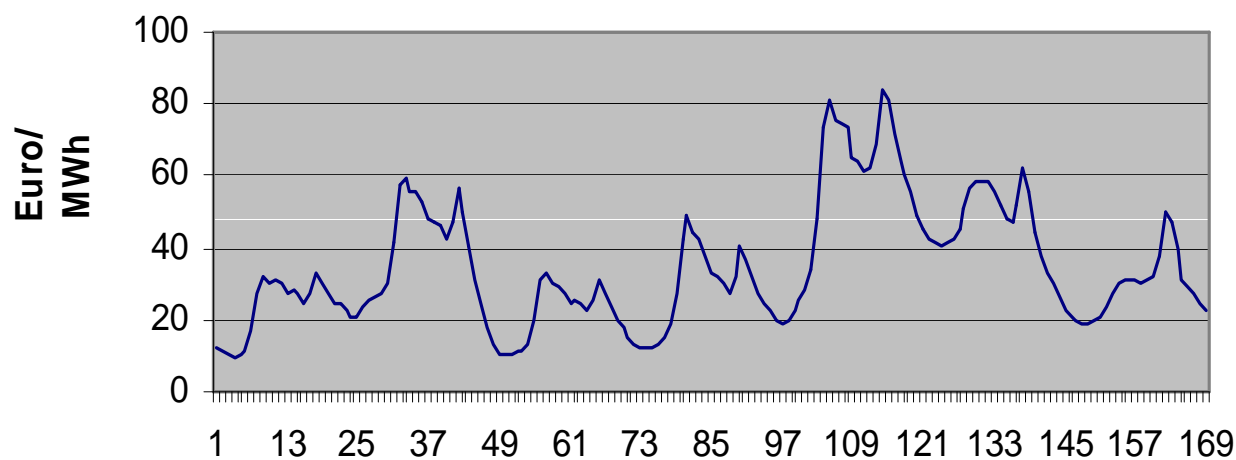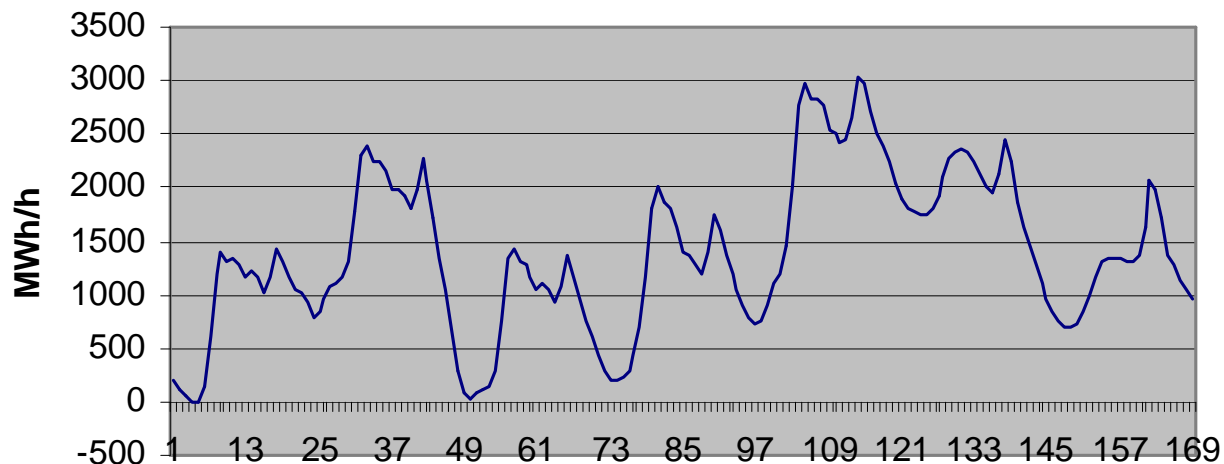
# Solutions and competition

Assume a system with large price variation:

- ➔ Three types of "business opportunities"
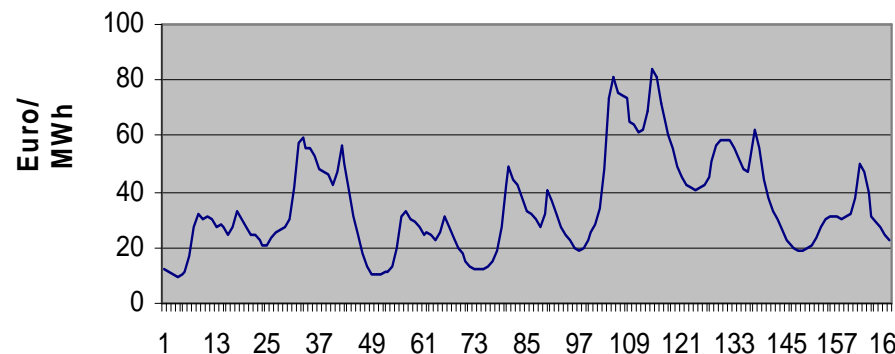


| More trading with neighbors | Demand side management | Flexible plants |
|---|---|---|

- There is a competition between these methods.
- Much transmission reduces price changes ➔ less interest in DSM

# On the structure of the Value of SmartGrids for Power Systems.



- More variable power ➔ higher need for flexible consumers

**However:**

- Wind power forecasts are more uncertain ➔ larger volumes on shorter markets (not so easy to plan)

- Wind power does **NOT** have **a typical daily pattern** ➔ No "typical" pattern of prices either.

- ➔ One can not, e.g., count on "load your electric car during the night".

- There can be days with low prices or high prices ➔ **relatively large energy volumes**

- **Flexibility competition** from power plants and lines
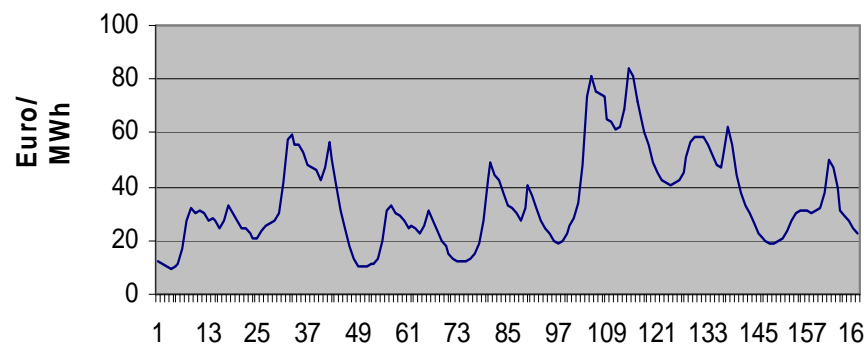
# On the structure of the Value of SmartGrids for Power Systems.

- More variable power ➔ higher need for flexible consumers

Euro/MWh

| y-axis: 0, 20, 40, 60, 80, 100 | x-axis: 1, 13, 25, 37, 49, 61, 73, 85, 97, 109, 121, 133, 145, 157, 16 |
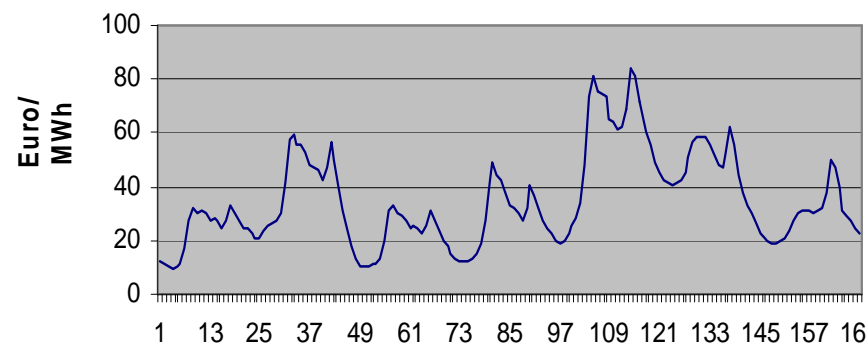
**Structure:**

- Consume **less** at **high** prices (= low wind, high consumption)

- Consume **more** at **low** prices (= high wind, low consumption)

# Possible "SmartGrid" in (not only) my house



**Wood pellets boiler**
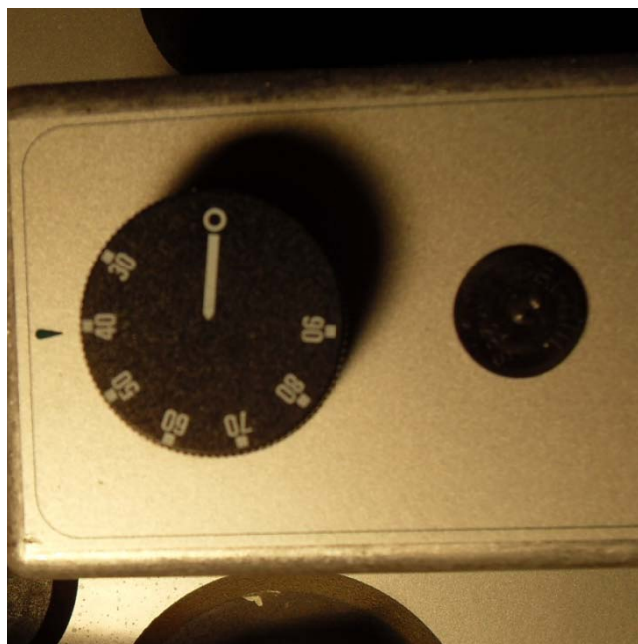


**Today: Reserve electric heating when heat < 40°**
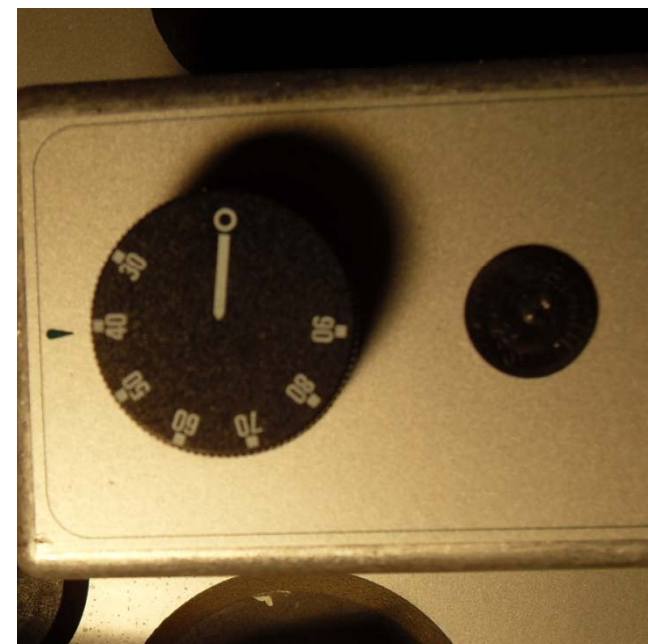


**Tomorrow (SMART): Start electric heating when price < 4 Euro-cent/kWh**

# Possible "SmartGrid" in (not only) my house

**Requirements for SMART solution:**

- **Hourly meetering (= pay changing price) + information sent to burner with, e.g., SMS, etc**

- **OR: (more complicated): Contract with supplier (which still means hourly measurements)**



**Tomorrow (SMART): Start electric heating when price < 4 Euro-cent/kWh**

# AMR in Sweden today
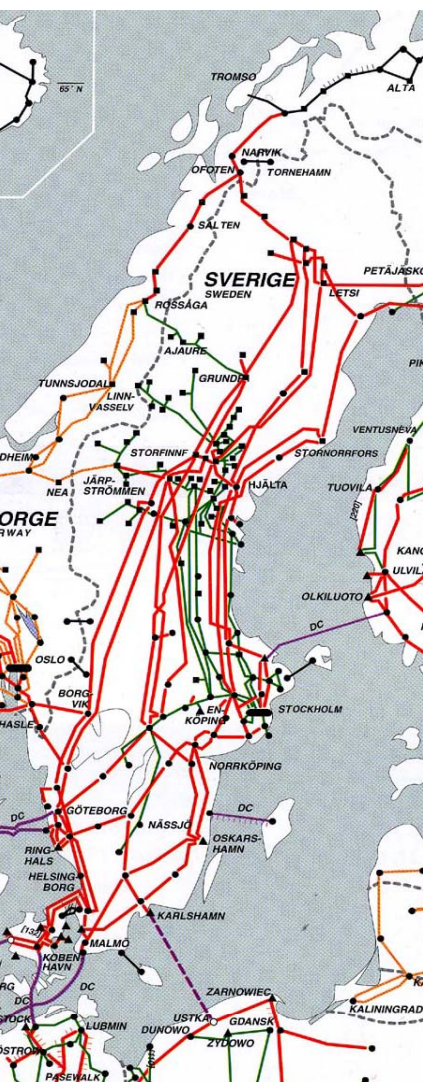
- Full unbundling for all consumers, also households ➔ often a **grid-bill + energy-bill**
- Measurements performedby grid owner.
- In Sweden all consumers (also households) pay for true consumption which is measured per month and sent in using IT technology.
- Most meters measure per hour.
- Some grid companies offer the service for costumers to study their hourly consumption on internet.
- It is technically possible to, e.g., charge consumers based on hourly prices and hourly consumption.

# AMR/DSM test in Sweden

- Customers were offered lower prices for the whole year except for 40 hours with very high prices, 0.3-1 Euro/kWh
- Customers to be alerted 1 day ahead via SMS or e-mail
- Only hourly metering, SMS and e-mail needed
- 80 households, participated the winter 2004-05
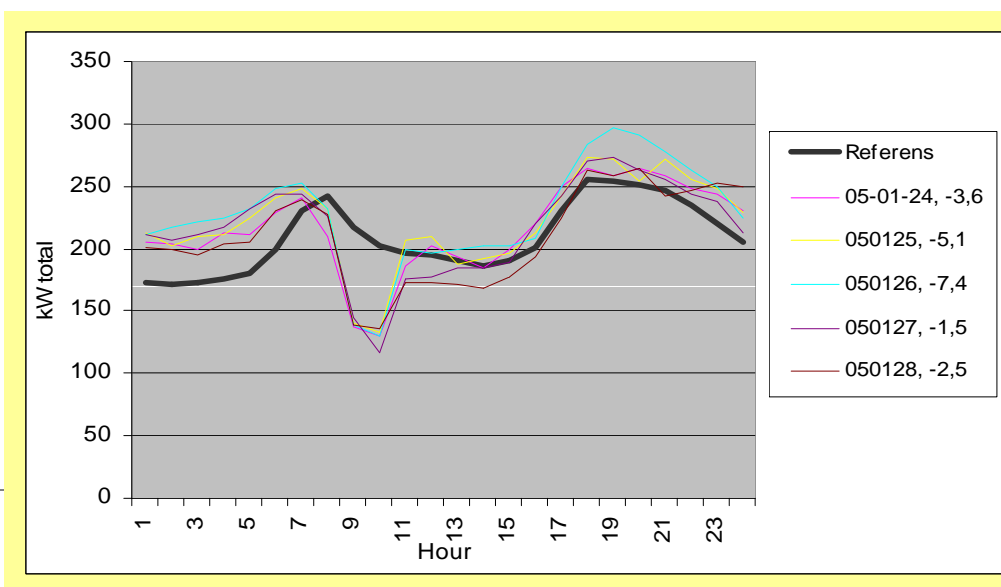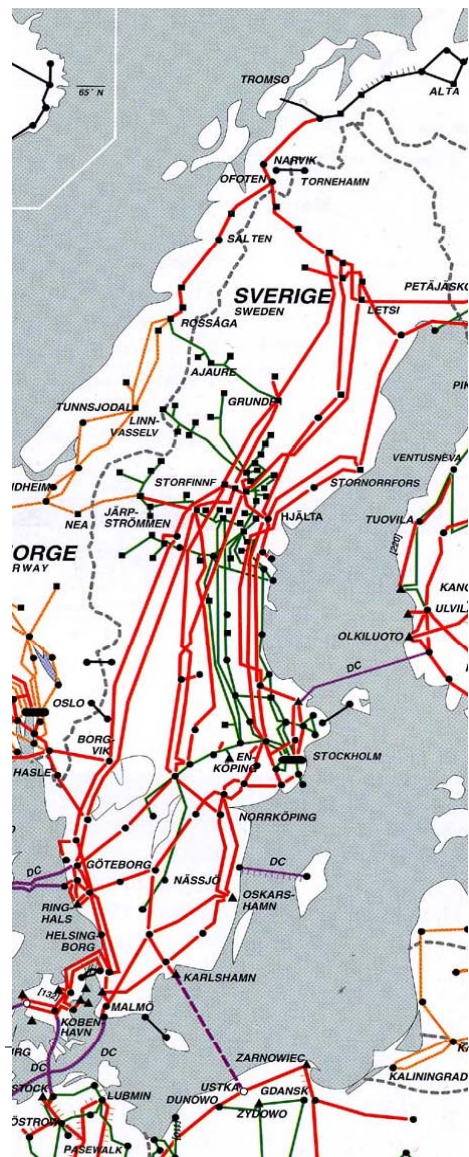
= a possible Smartgrid future everywhere

# AMR current use in some parts of Sweden/Finland
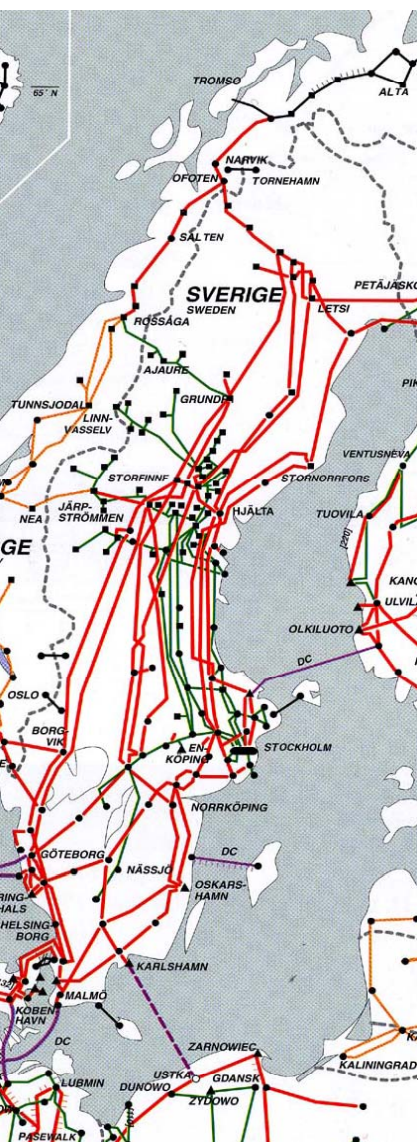
- Customers can get hourly consumption information with approx one day delay
- Interface through the a web page, free of charge service

- Hourly data as well as alarms and queries are interfaced into the DMS system
- Outage management
  - Number of customer trouble calls reduced,
  - Faster fault repairing and shorter interruptions
  - Reduced amount of trouble shooting and unnecessary customer visits
  - Security: real-time information of zero conductor faults and voltage level
  - Accurate and extended reporting and statistics

# Smart EV Consumtion-Production balance
## measure ➜ think ➜ control

Model, coupling price-time-volume

**Decision**

Price signal
Control signal

Measure frequency

**Information**

**Analyze Estimate benefit**

**Action**

Stop loading

Position Plans

Measure actual loading

Feed in
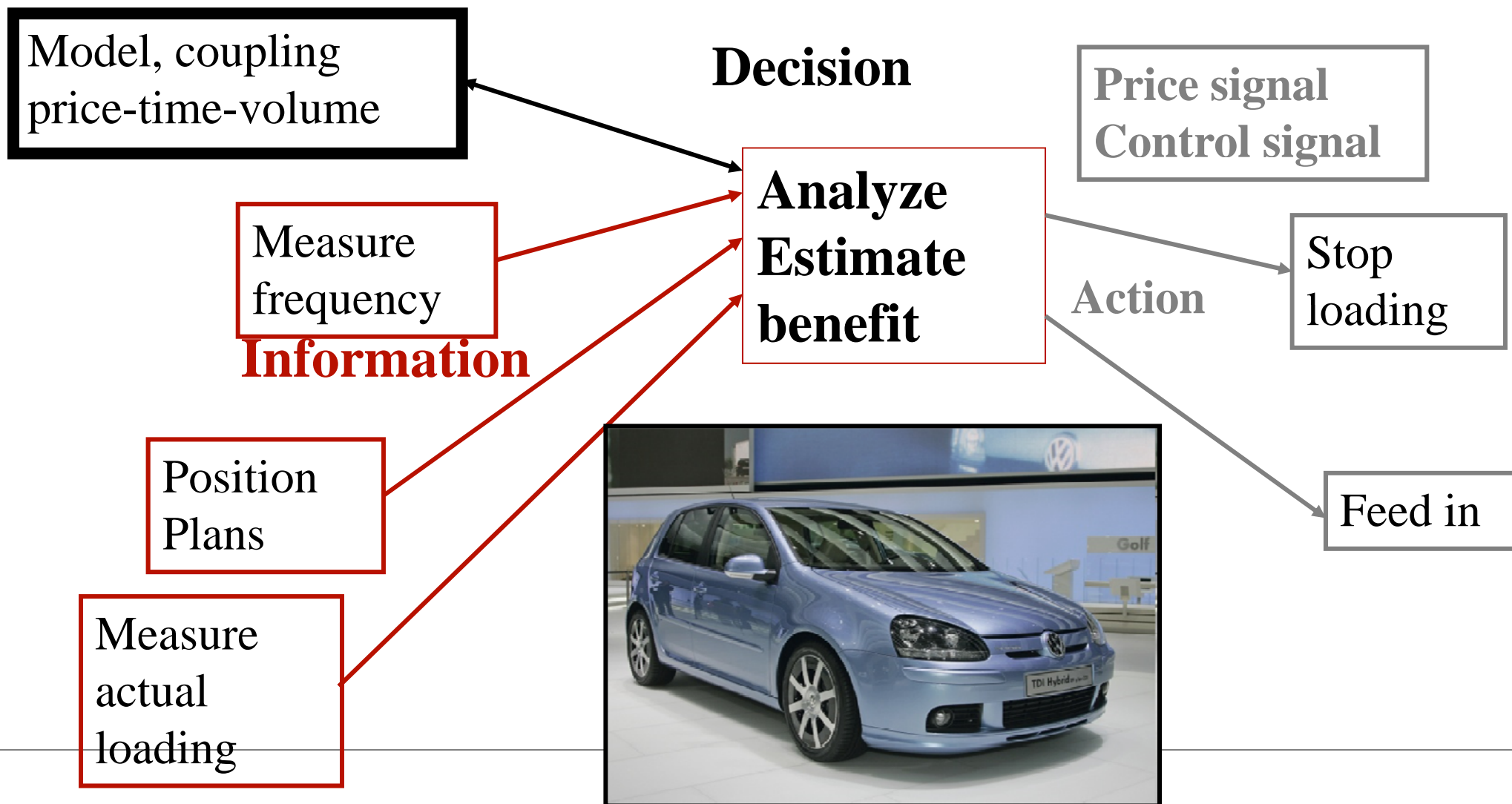
# Smart Balancing services -1

**Nordic regulating market**:

- No AGC (except Dk-W)!
- Assume that wind power decreases in Denmark with 100 MW
- The bids to the regulating market (tertiary control – up-regulation in 15 minutes) are coordinated in the Nordic system
- If an up-regulating bid from northern Finland is the cheapest and transmission limits are not violated, then this one is used!
- Distance: ~1400 km
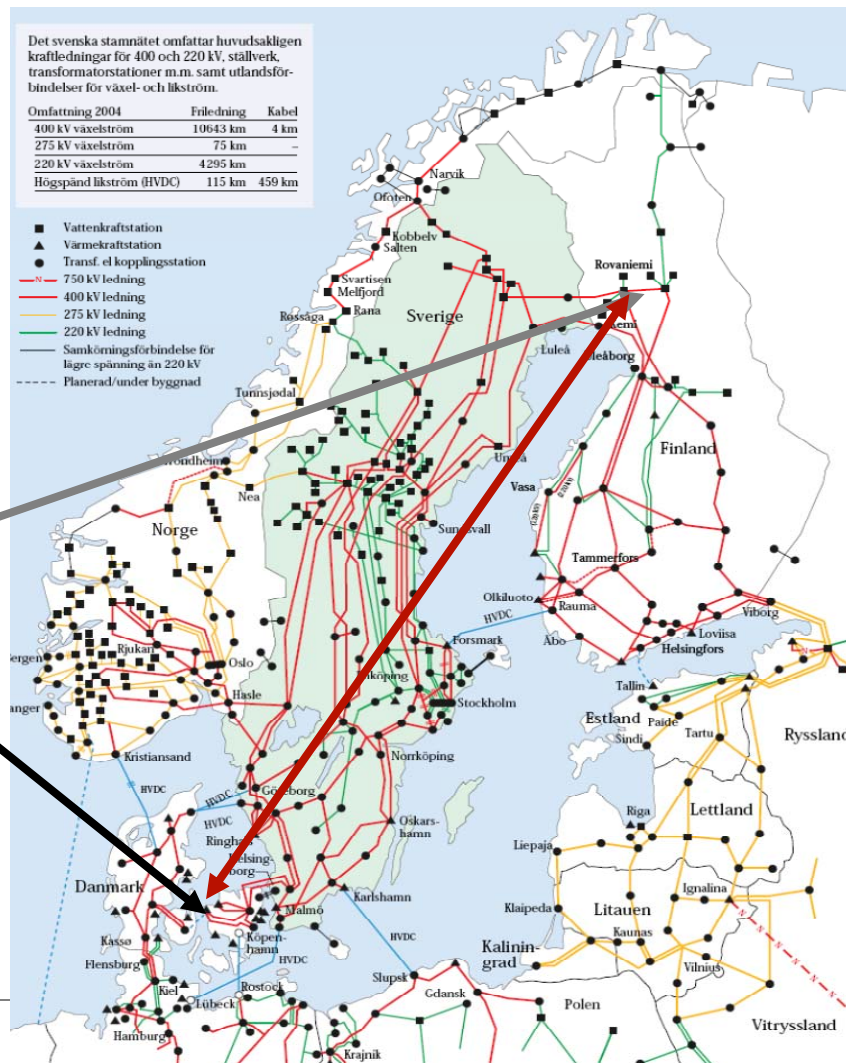
# Smart Balancing services -2

**Central Europe**:

- In largely meshed systems as central Europe it is a challenge to compensate wind power decrease in Netherlands with power production increase in eastern Hungary within 15 minutes?

- Distance: ~1400 km

# KIC InnoEnergy – A world class alliance of top European players with a proven track record



- 13 companies,
  10 research institutes,
  13 universities
- ~50% industry partners (incl. associated partners)
- >50% of key research players in Europe
- Covering the whole energy mix
- Knowledge triangle balanced along all dimensions
- Strong connection with VCs and local governments

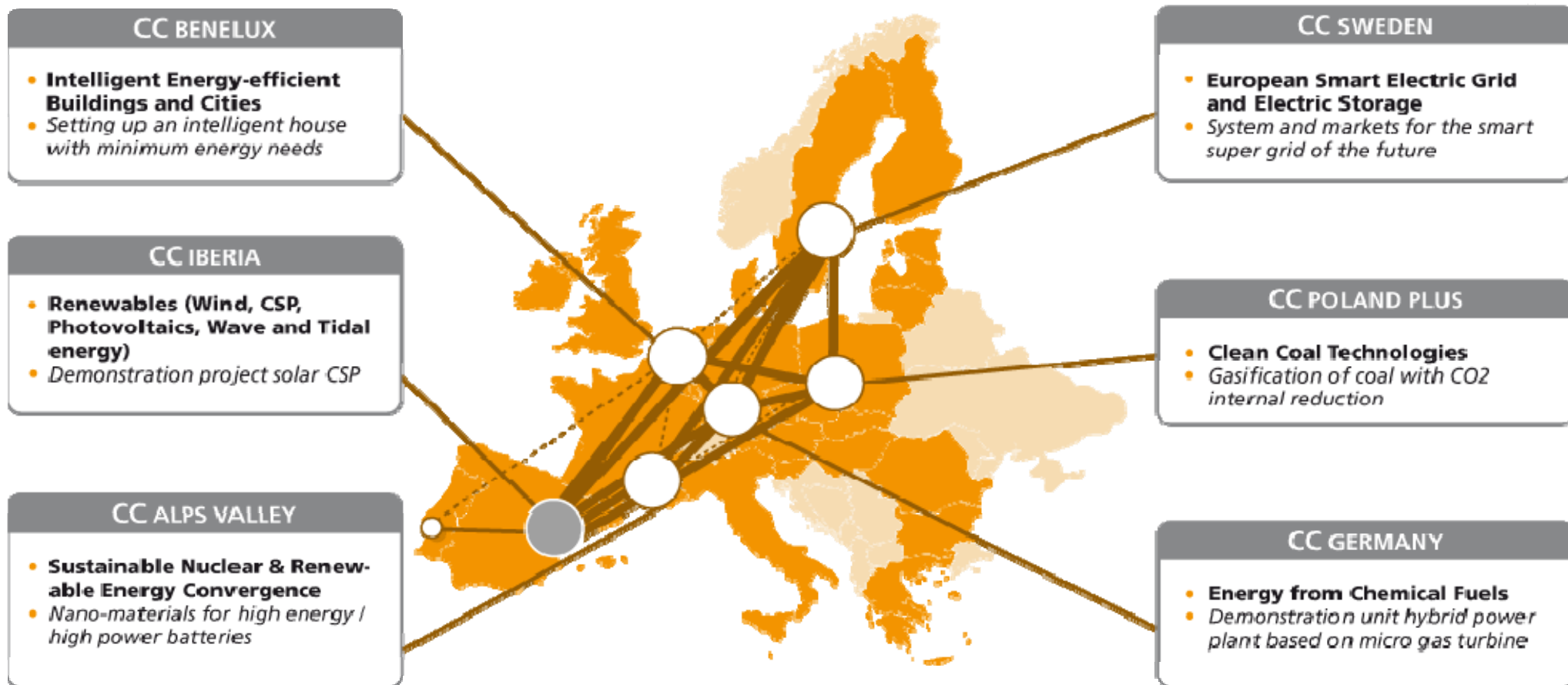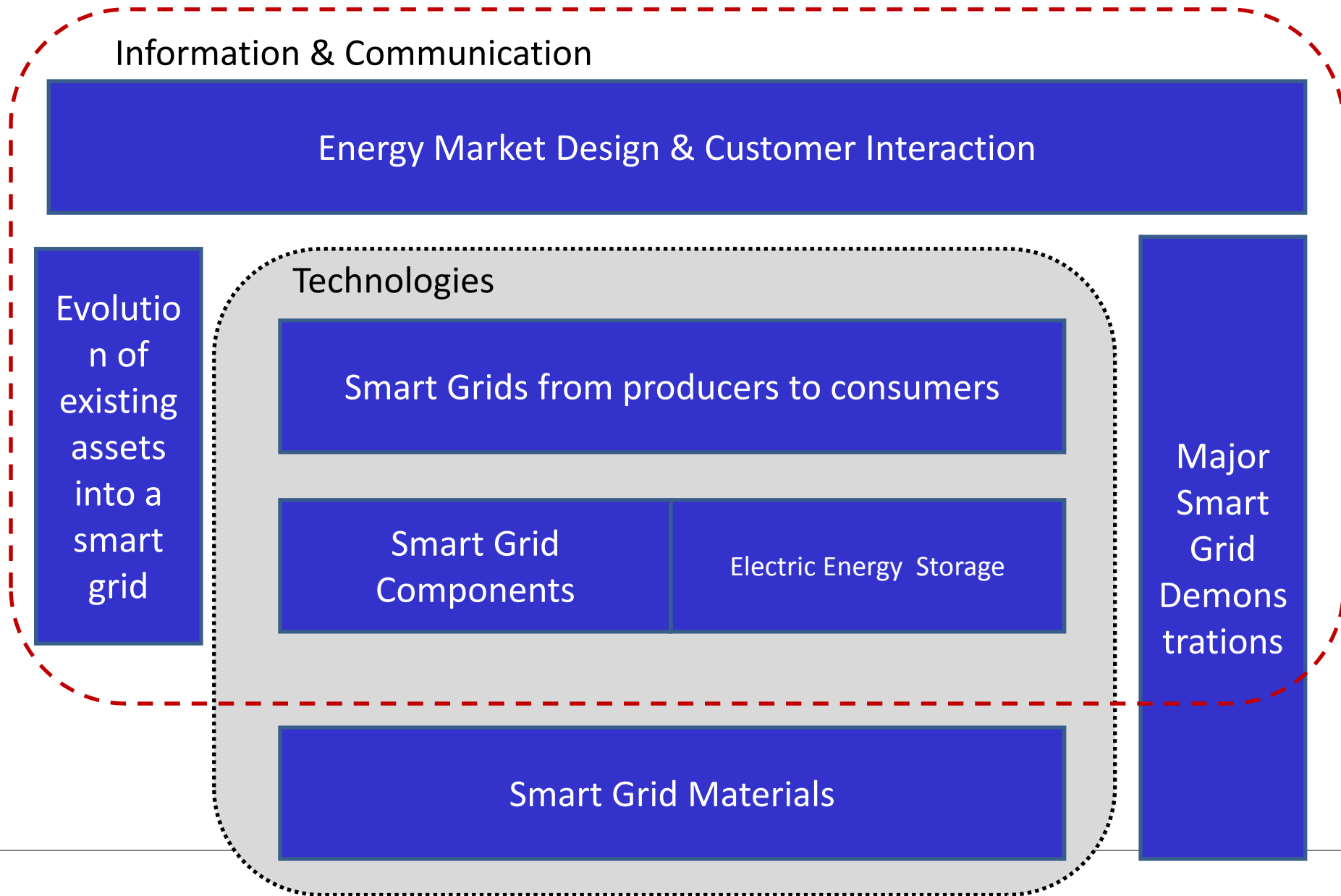# KIC InnoEnergy will bring innovation to the whole energy-mix coherent with the SET Plan

## CC BENELUX

- **Intelligent Energy-efficient Buildings and Cities**
- *Setting up an intelligent house with minimum energy needs*

## CC IBERIA

- **Renewables (Wind, CSP, Photovoltaics, Wave and Tidal energy)**
- *Demonstration project solar CSP*

## CC ALPS VALLEY

- **Sustainable Nuclear & Renewable Energy Convergence**
- *Nano-materials for high energy / high power batteries*

## CC SWEDEN

- **European Smart Electric Grid and Electric Storage**
- *System and markets for the smart super grid of the future*

## CC POLAND PLUS

- **Clean Coal Technologies**
- *Gasification of coal with CO2 internal reduction*

## CC GERMANY

- **Energy from Chemical Fuels**
- *Demonstration unit hybrid power plant based on micro gas turbine*

Information & Communication

Energy Market Design & Customer Interaction

Evolution of existing assets into a smart grid

Technologies

Smart Grids from producers to consumers

Smart Grid Components

Electric Energy Storage

Major Smart Grid Demonstrations

Smart Grid Materials

# Conclusions

**Smartgrids = business as usual**

or

**Smartgrids = vision for tomorrow**?

# Conclusions

**Smartgrids = business as usual**
**YES (**take the best of new technology)
**NO** (new driving forces)

**Smartgrids = vision for tomorrow**?
**YES** (large possibilities)