Demand response:
Needs and possible realisation

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Demand response
Presentation outline

- **Introduction video Web2Energy; demand side integration**
- **Context**
- **Demand response in energy grids**
- **kW- and kWh-applications**
- **Demand side integration mechanisms with ICT**
- **Projects**

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IPCC Forecasts and Renewable energy

2100	Economic focus	Environmental focus
Globalisation	1.4 - 6.4 °C	1.1 - 2.9 °C
Regionalisation	2.0 - 5.4 °C	1.4 - 3.8 °C

A changing electricity supply

- Europe: Decreasing base load (coal, gas, nuclear)
- Netherlands 2030: 50 % of supply from new gas fields
- EU-targets according to ‘trias energetica’

Trias energetica (2020)

1. Increase efficiency of energy usage	20%
2. Use renewables	
3. Clean usage of fossil fuels	

37 percent of renewable electricity

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Drivers for demand response on the system level

- Matching load and generation on:
  - The European level
  - The national level
  - The regional level
- Role in several phases of operation:
  - Normal operation
  - Capacity management/critical operation
  - Gracefull degradation; load shedding
  - Power Outage/Black start
- Reduce grid and backup investments
- Less reserve power and curtailment of renewables
- Consumer participation

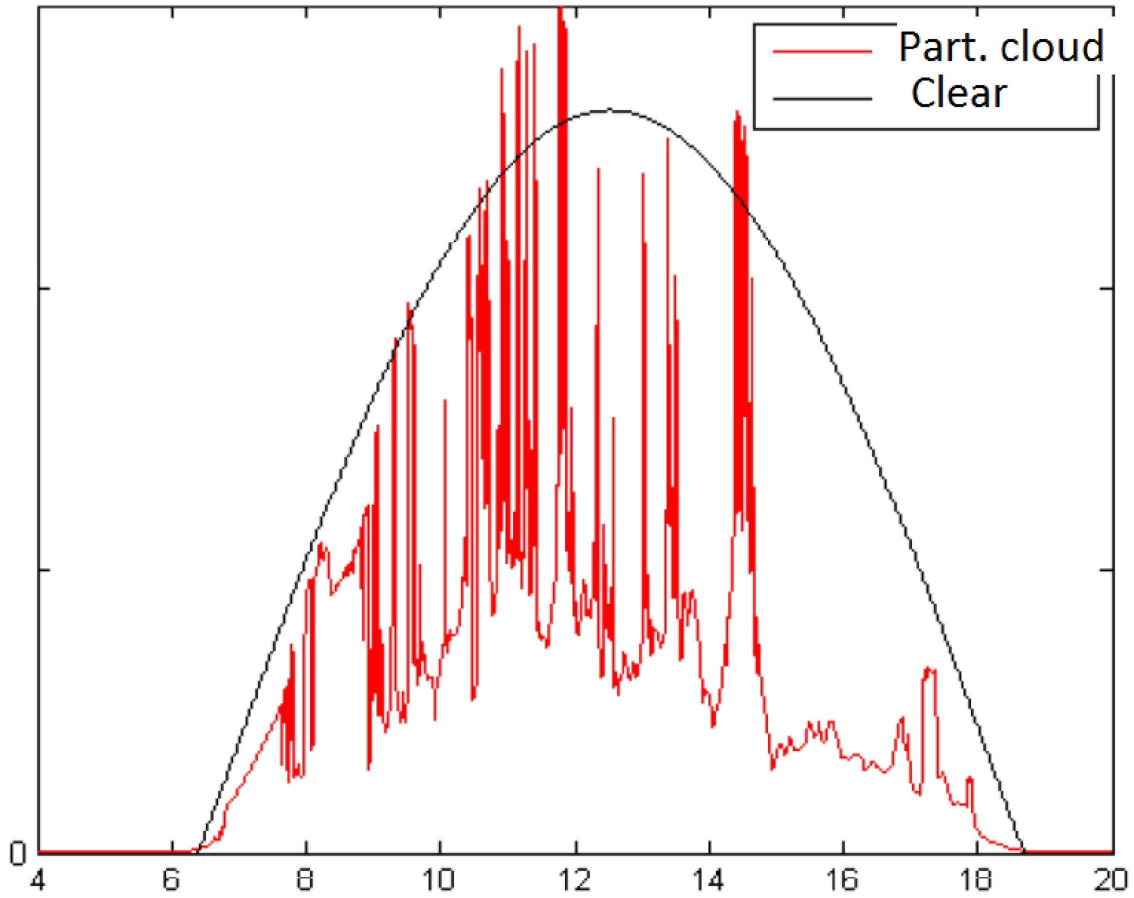
Demand response from new energy carriers with impact on electricity grids

Electrification
Mobility: Electric vehicles (> 9 kW)

- Currently: 20 km/hr (220 V ~)
- Top-of-the-line: 100 km/hr (220 V ~)
- Possible: 550 km/hr (DC; level3)

Heating, ventilation and air conditioning:
- Heat pumps (2-6 kW)
- Small-scale **cogeneration** of electricity and heat
  - Stirling μ-CHP (1.1 kW)
  - Fuel cells (1-5 kW)
  - Micro turbines (3 kW)

PV in distribution grids



Demand response in future energy grids

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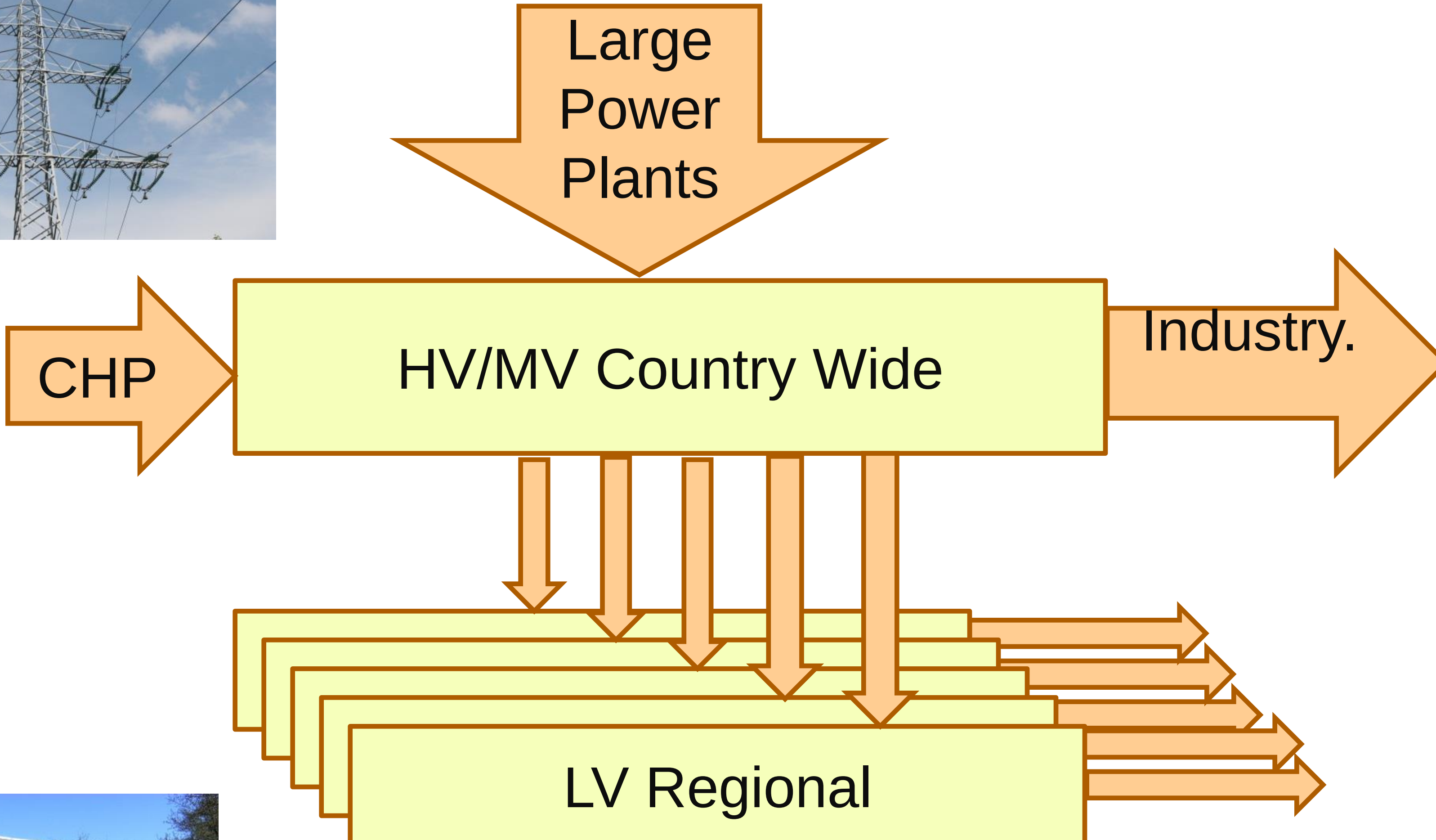
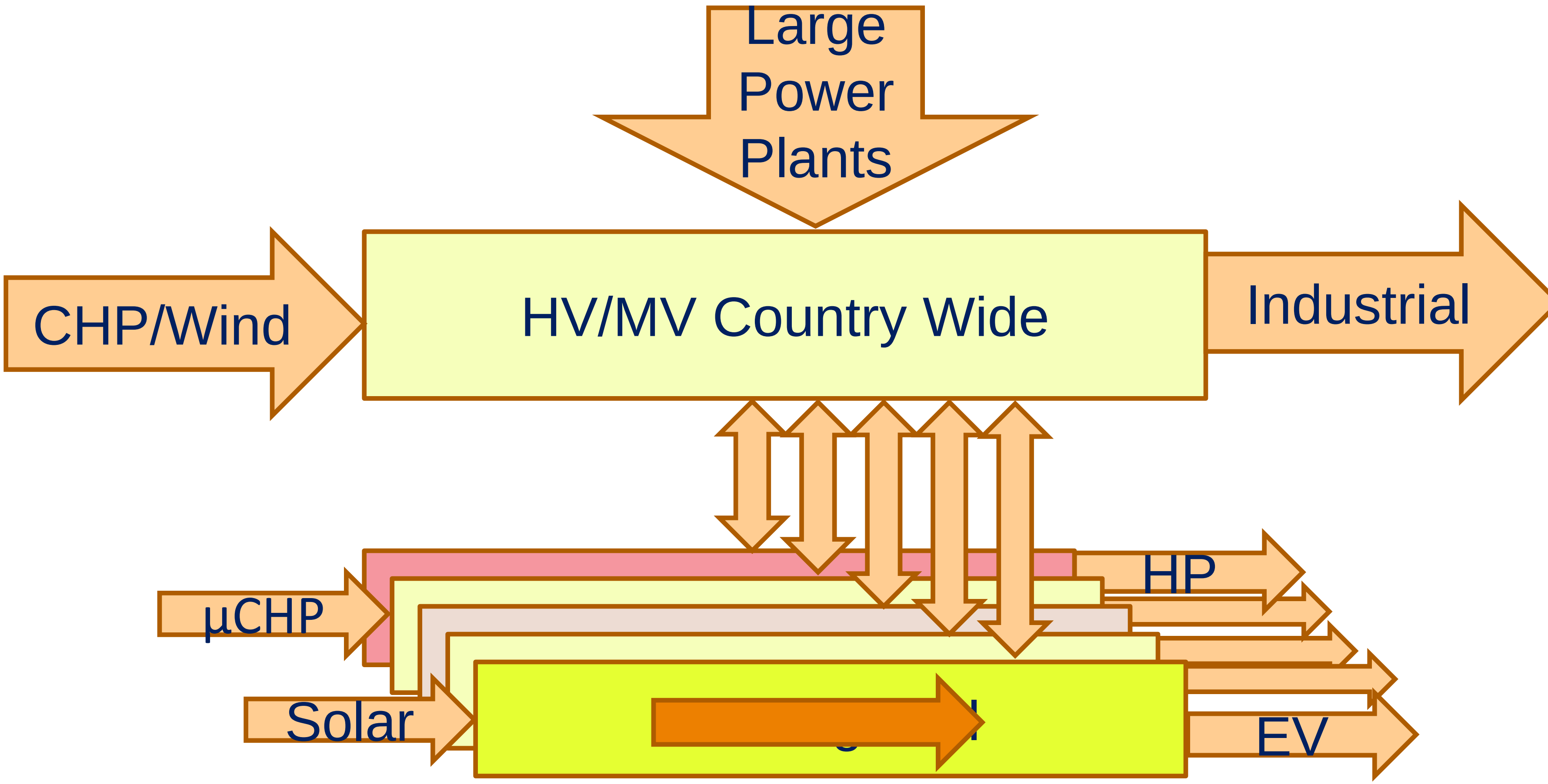
Current electricity streams



Additional streams due to new supply and demand

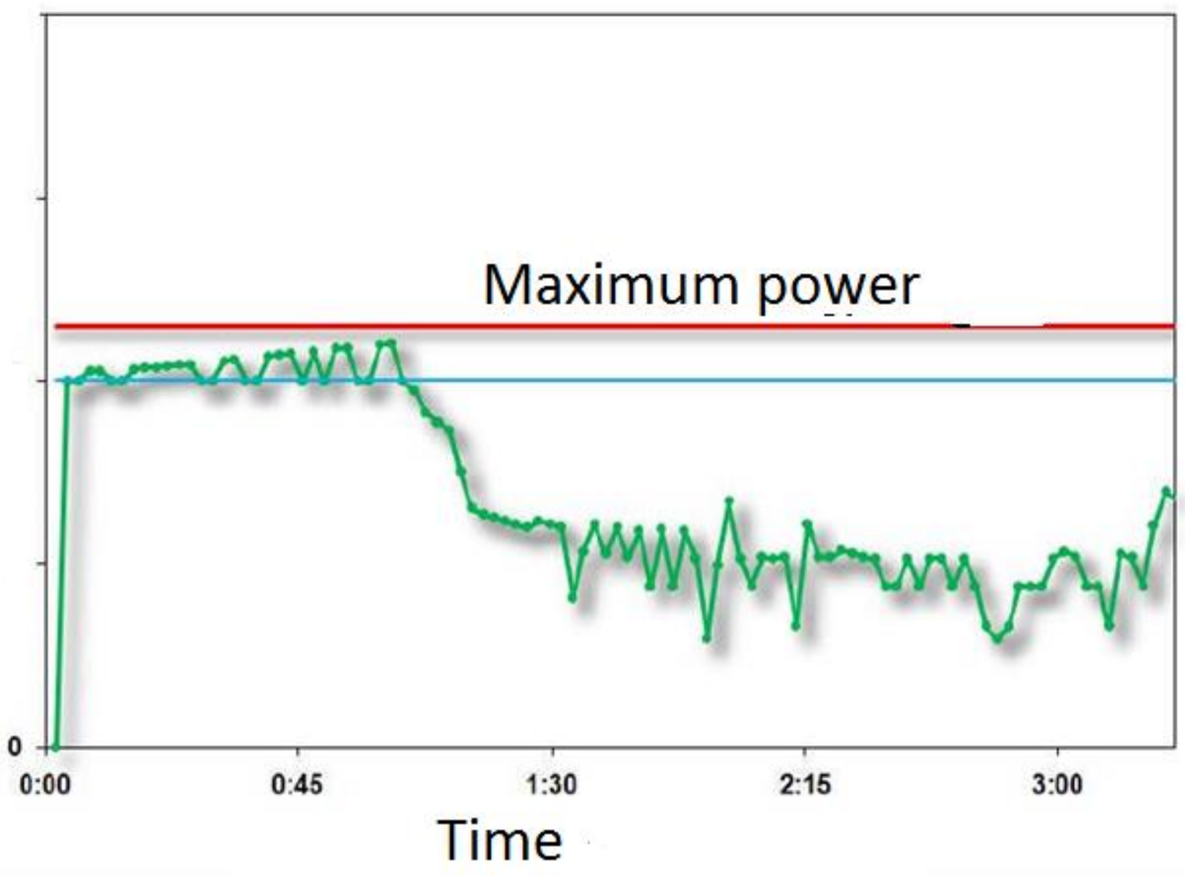


Demand response and electricity distribution (kW)

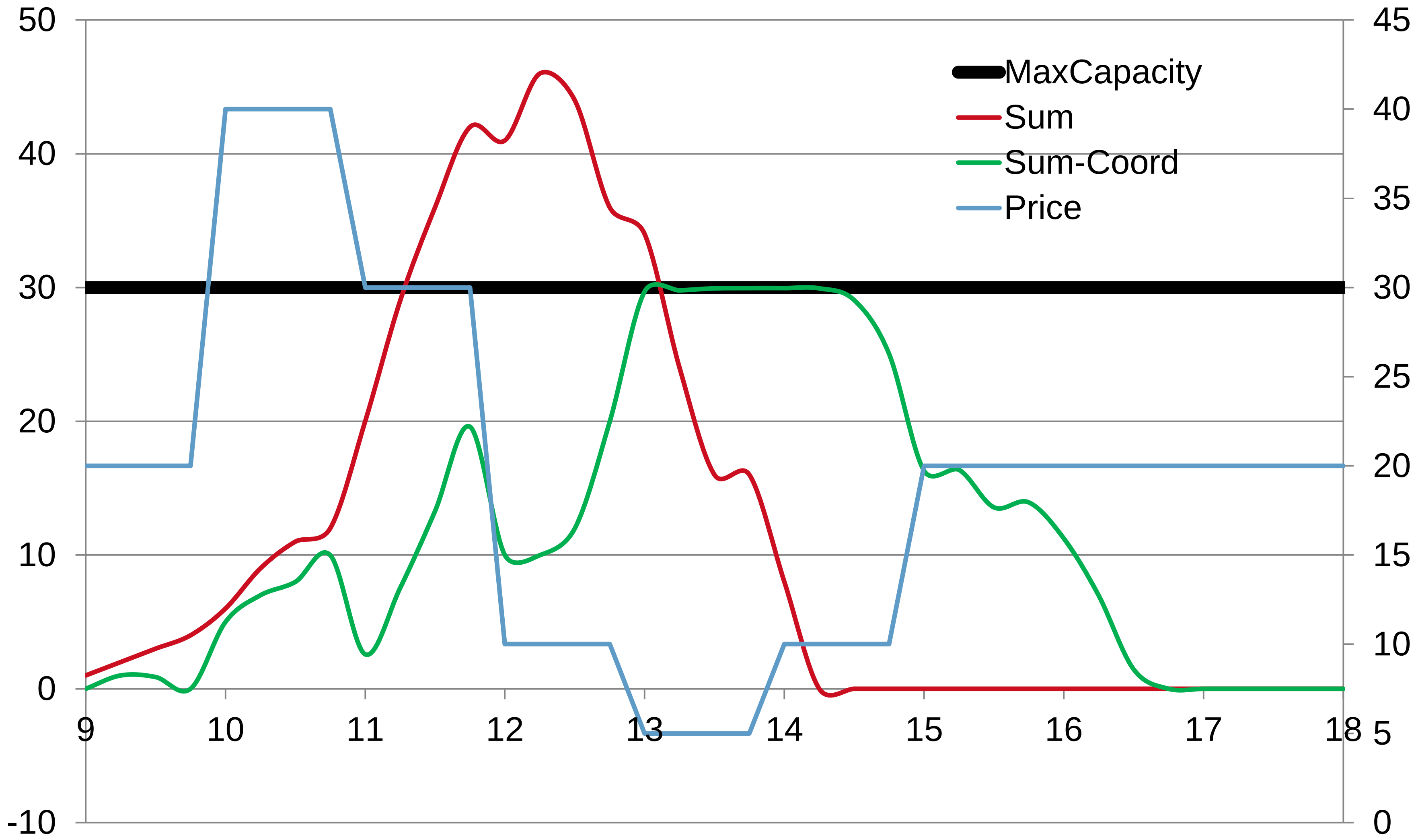
- Optimization of assets within shorter timeframes
  - Now life cycle >30 years
- Increased uncertainty of planning
  - EV, dispersed energy resources
- Dynamically react on monitoring of lower Voltage levels
  - Fault detection
  - Black start
  - Load shedding
  - Self healing
  - Condition monitoring

- Active and malleable distribution grids with more flexibility

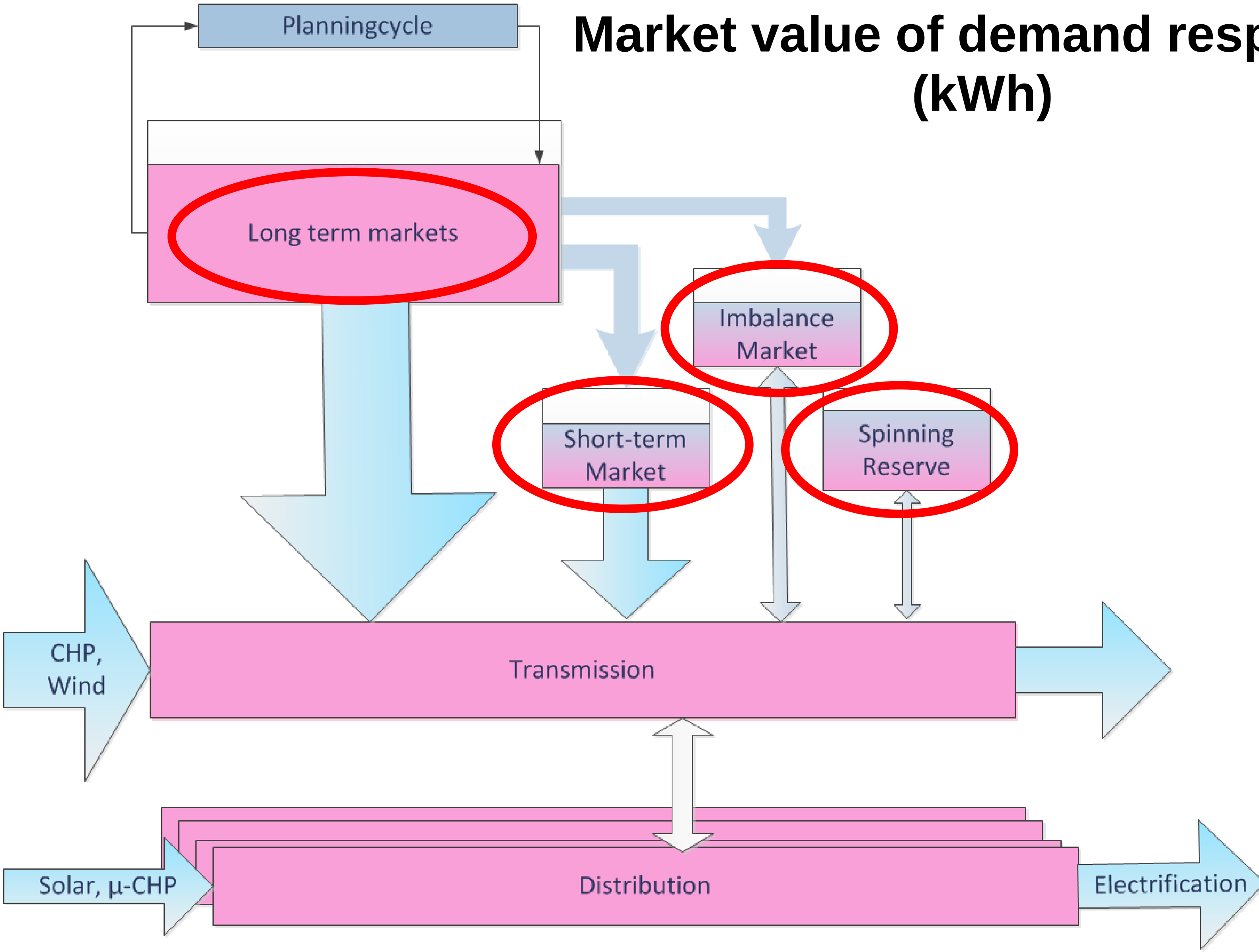
Blackstart of a HP-cluster in an active distribution grid



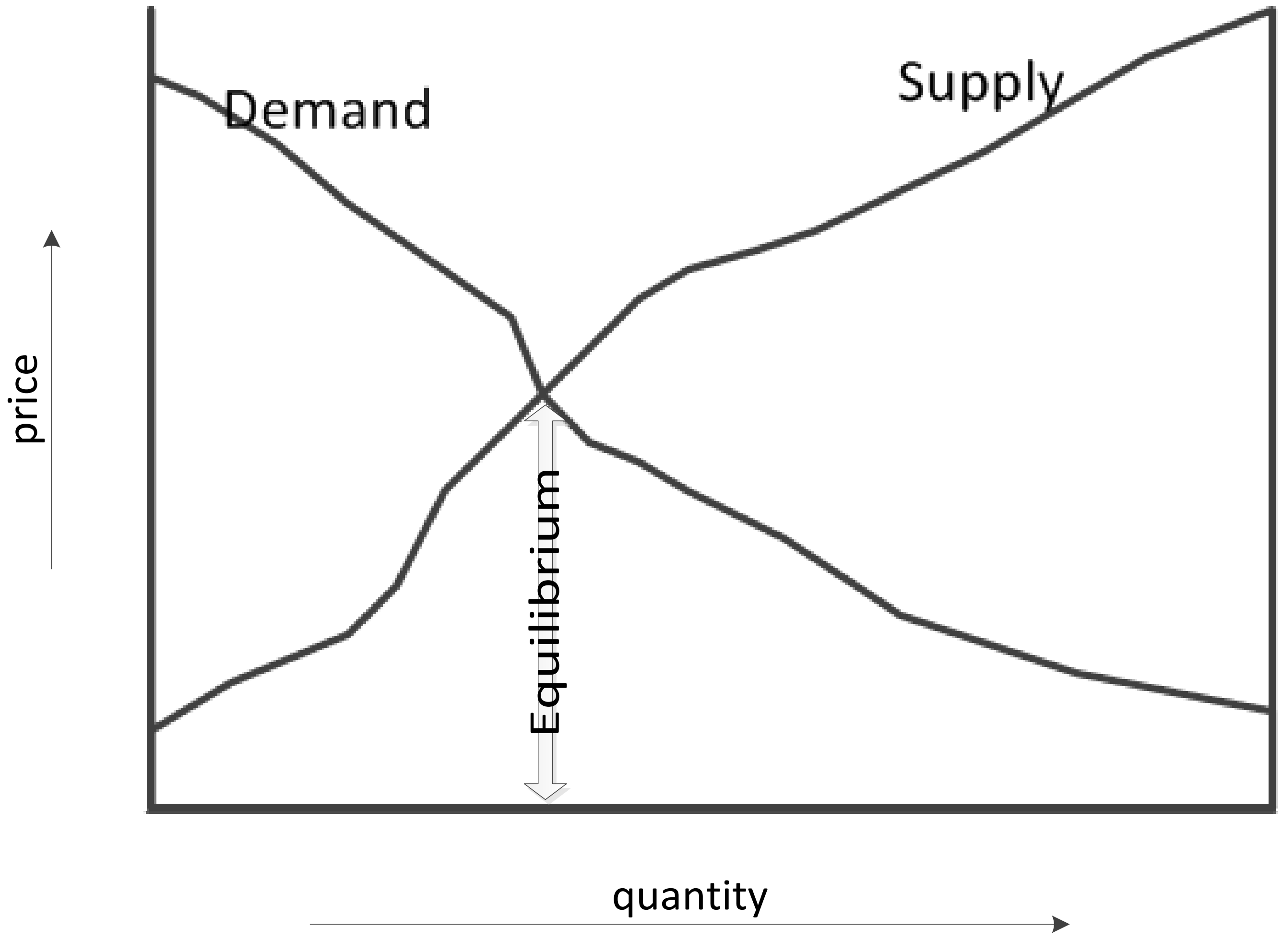
Charging EVs in a building

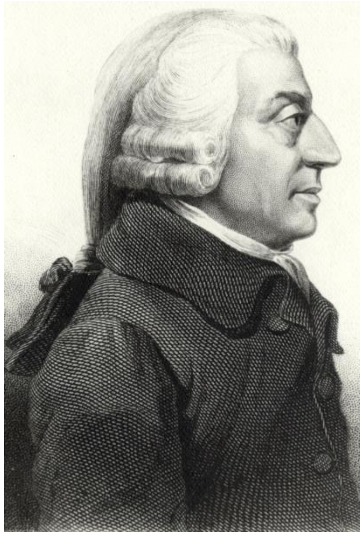


Market value of demand response (kWh)



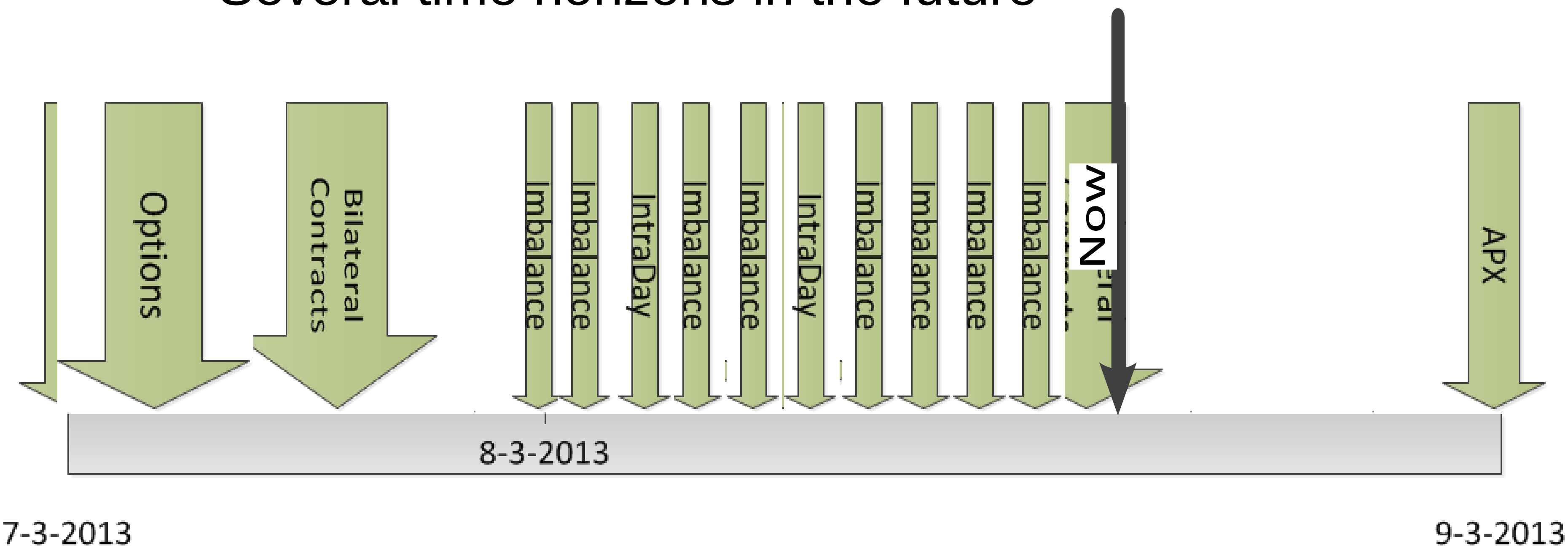
Amsterdam Power Exchange market mechanism

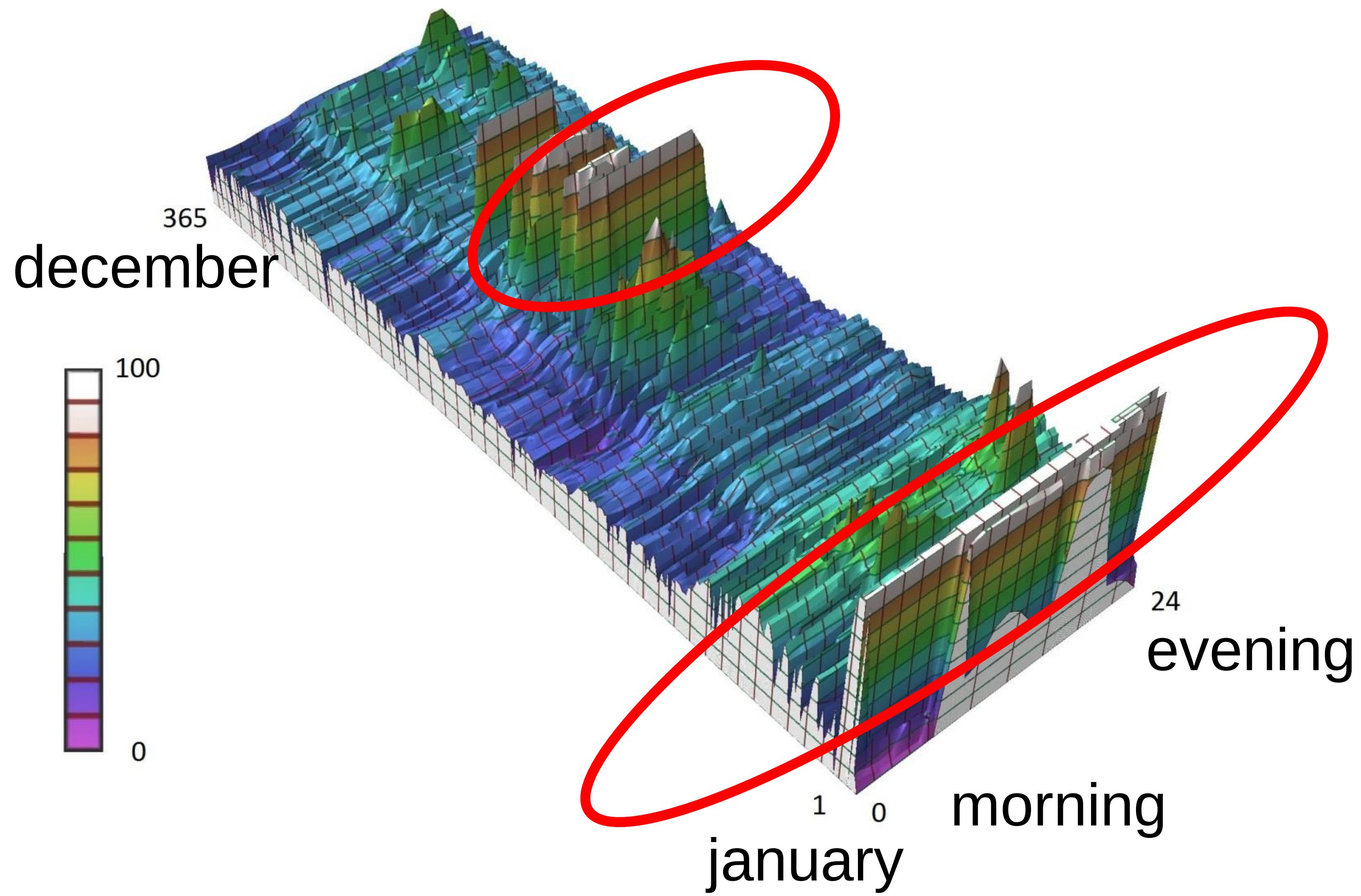


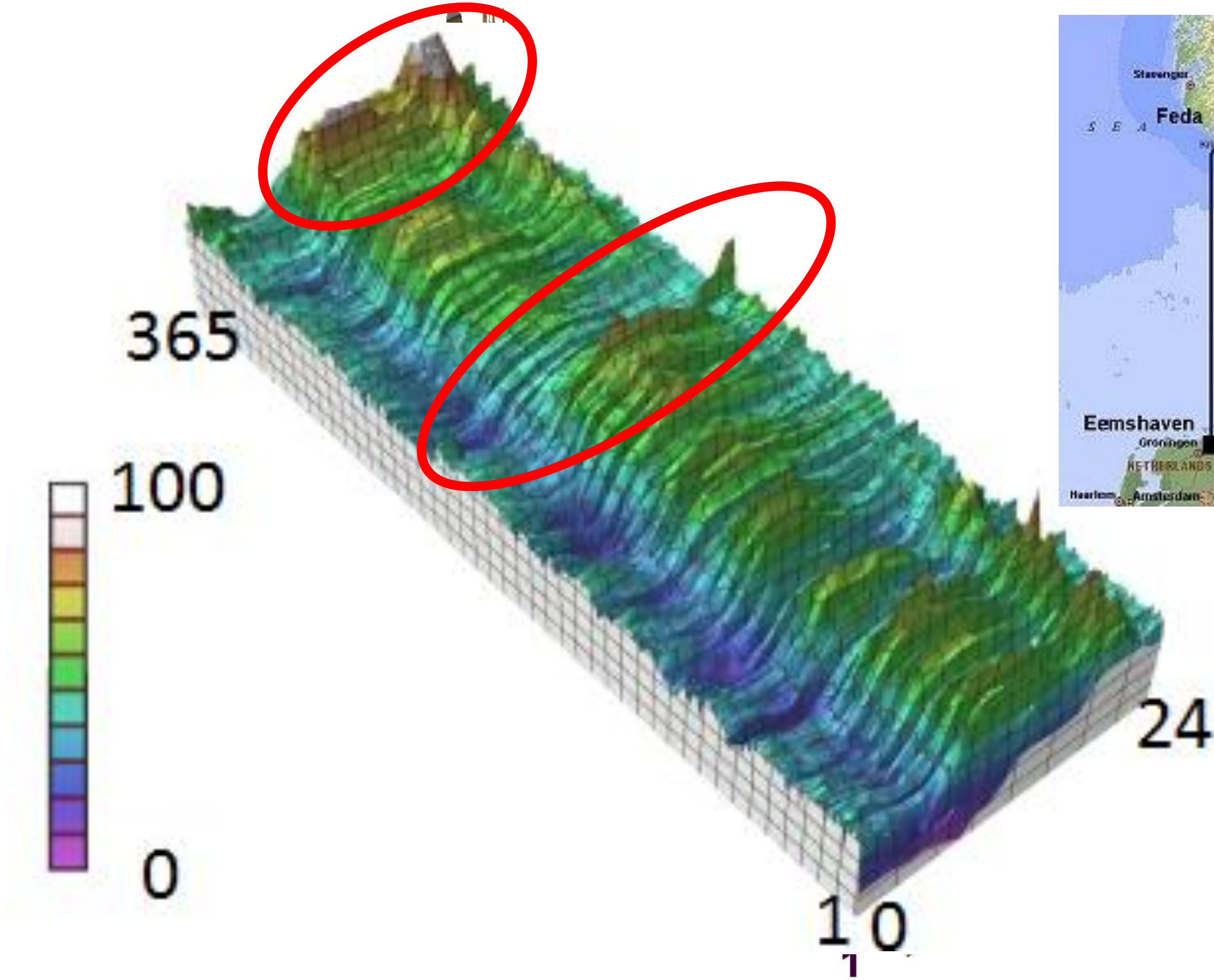


Achieve supply/demand equilibrium

- kWh vs kW
- Momentaneous balance at all levels
- Operation based on competitive markets
    - Several time horizons in the future

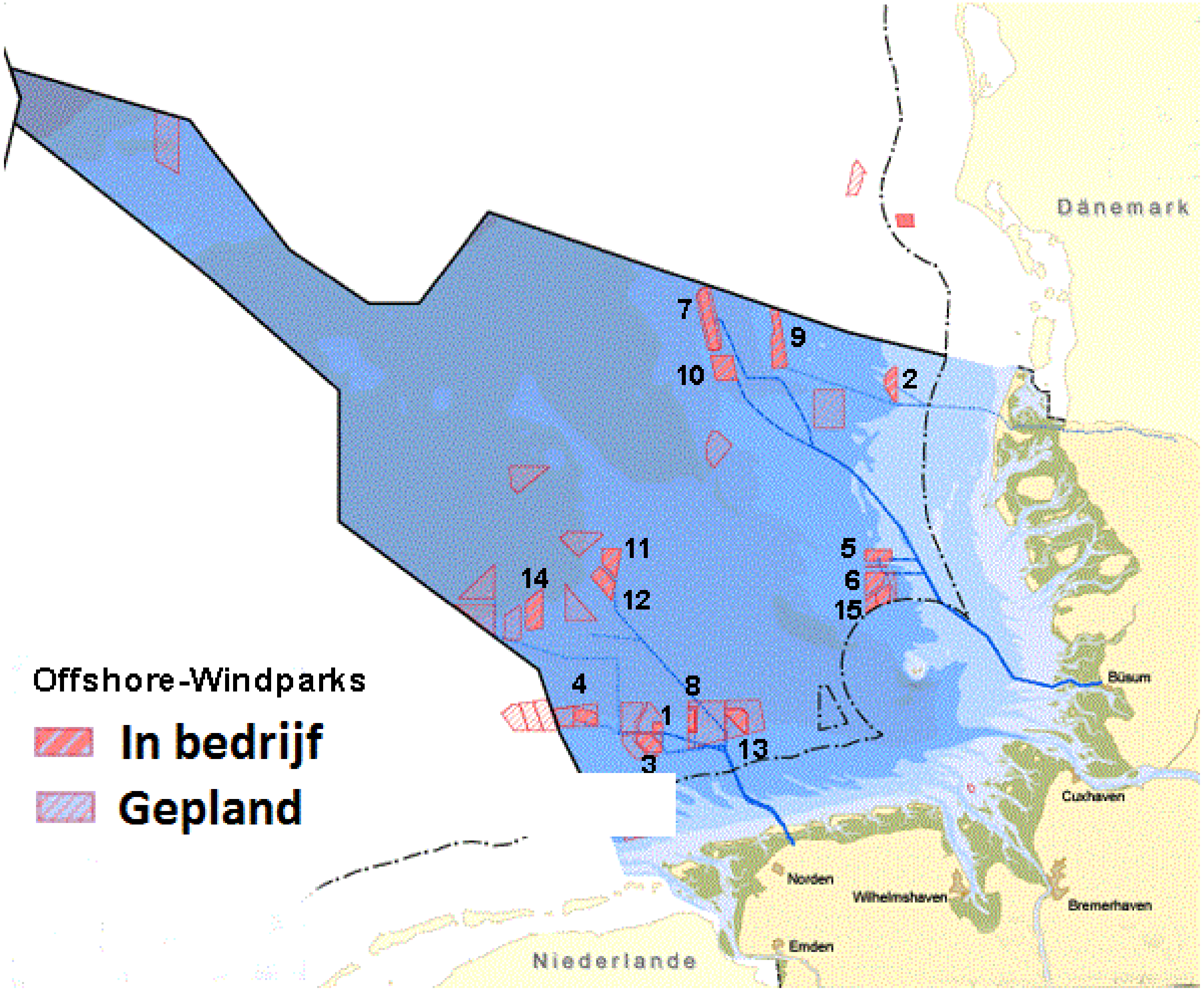



365
december
100
0
24
evening
1
0
morning
january


365
100
0
24
1
0

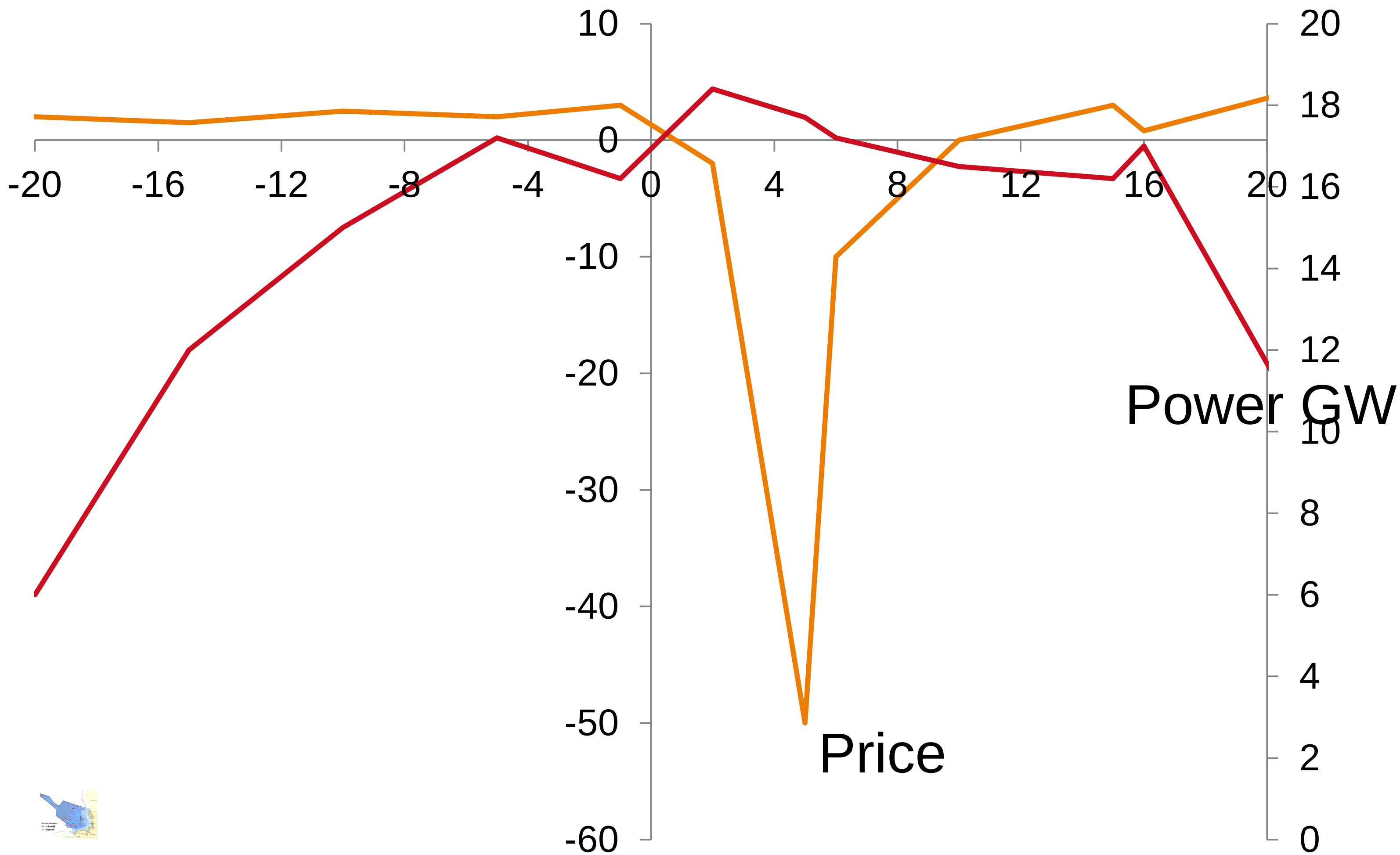

Feda
Eemshaven
Stavanger
Gothenburg
Hamburg
Groningen
Amsterdam

Surplus of wind energy in autumn 2009: German spot price



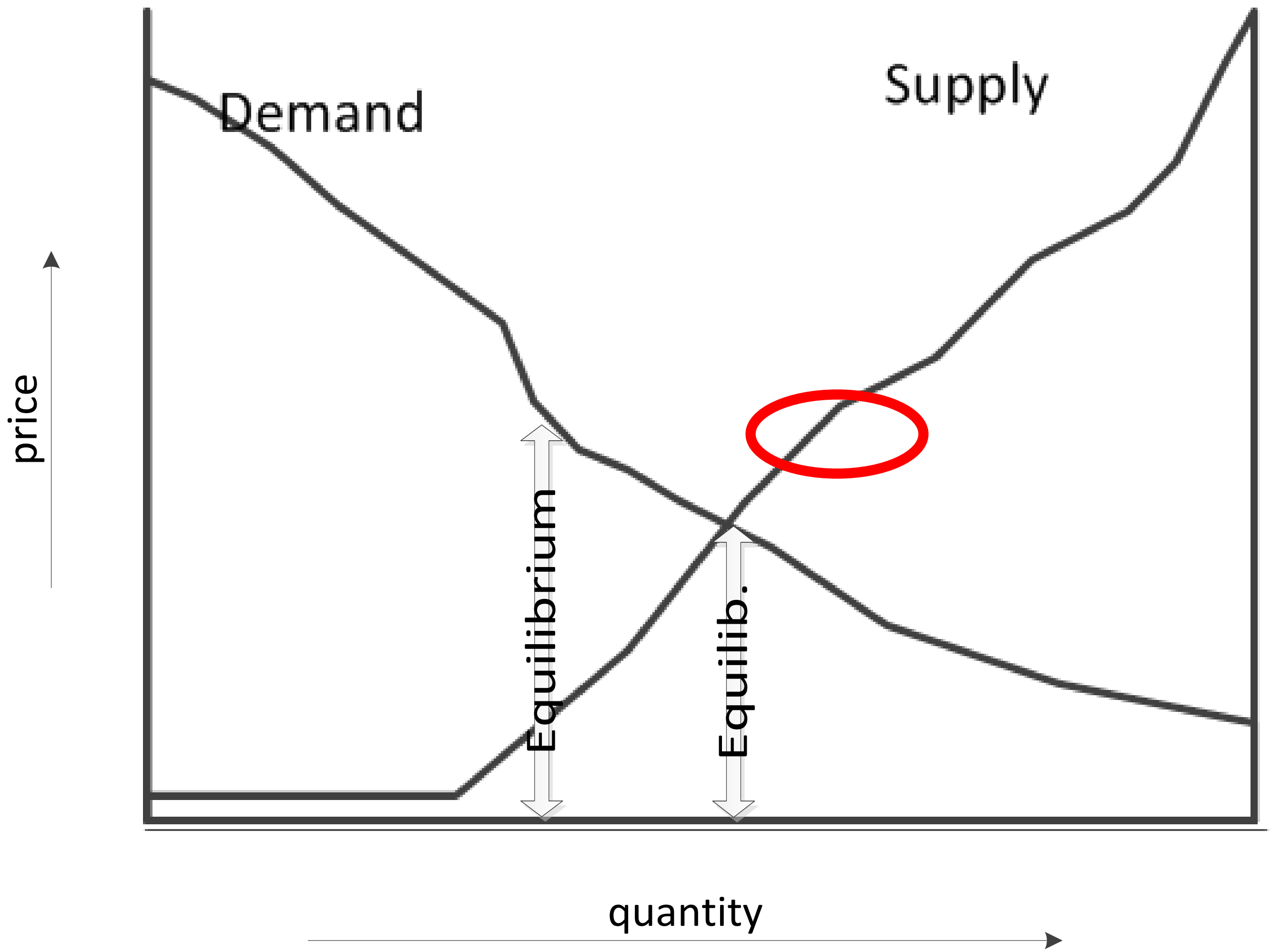
EEX-2009

Surplus of wind energy in autumn 2009: German spot price



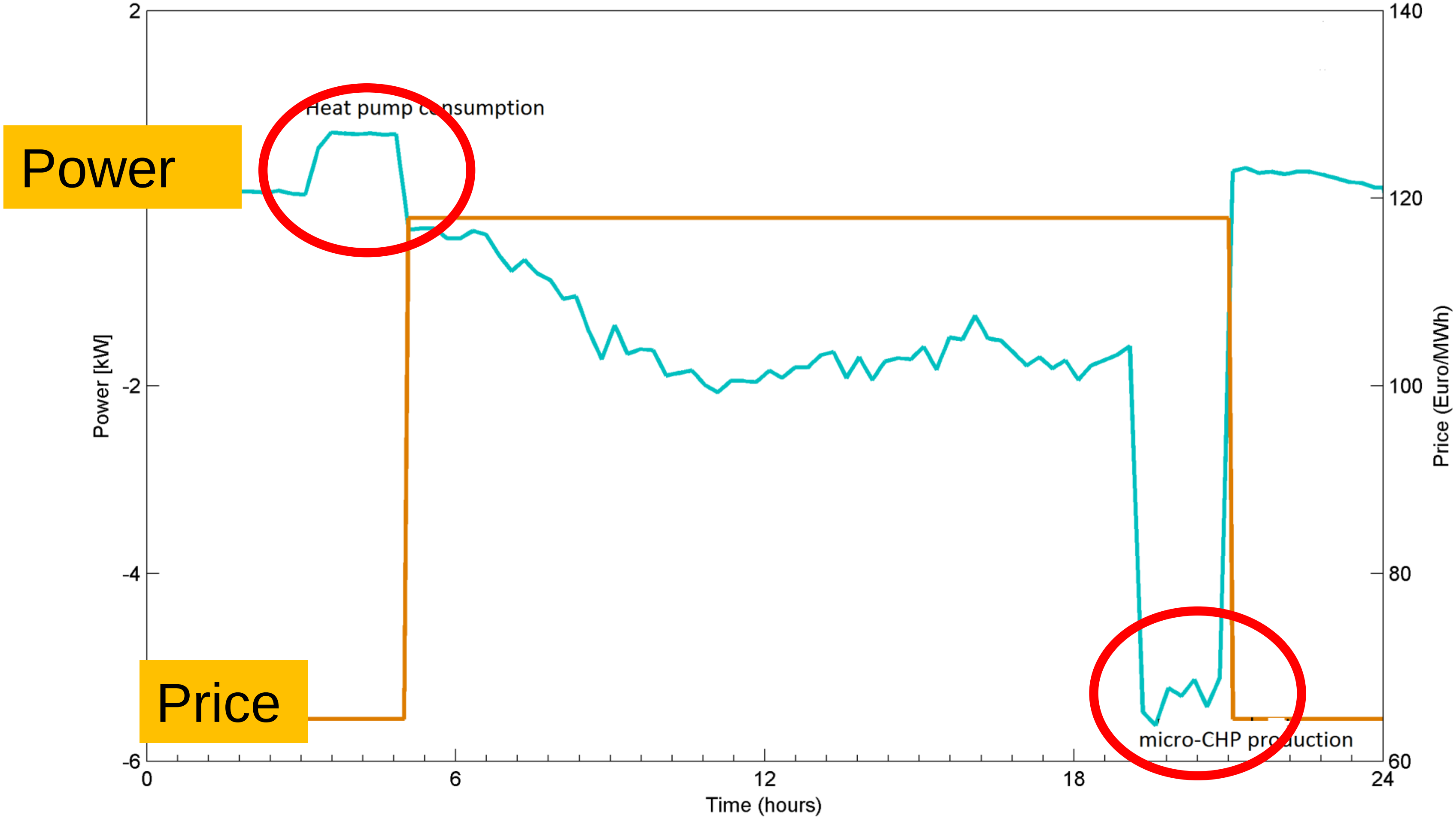
EEX-2009

Market equilibrium and wind in-feed




Hoogkerk
PowerMatching City

tion


Power
Price
Heat pump consumption
micro-CHP production
Power [kW]
Price (Euro/MWh)
Time (hours)
2
-2
-4
-6
140
120
100
80
60
0
6
12
18
24

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Demand response already is around with larger customers

- NL: maximum system load 16000 MW, average 10000 MW
- Large industrial users:
  - Contingency management reserve capacity
  - Real-time potential (Deloitte, 2004)
    - 1730 MW available; 70 % used (1000 MW)
    - 35 % switched on price signals; 65 % door Programme Responsable
- Small customers (SenterNovem, 2005)
  - 710 MW in use; 1220 MW potentially available

US: Integration in virtual power plants, that are operated as a service

- Used in congested systems

Differentiating and rewarding smaller customers

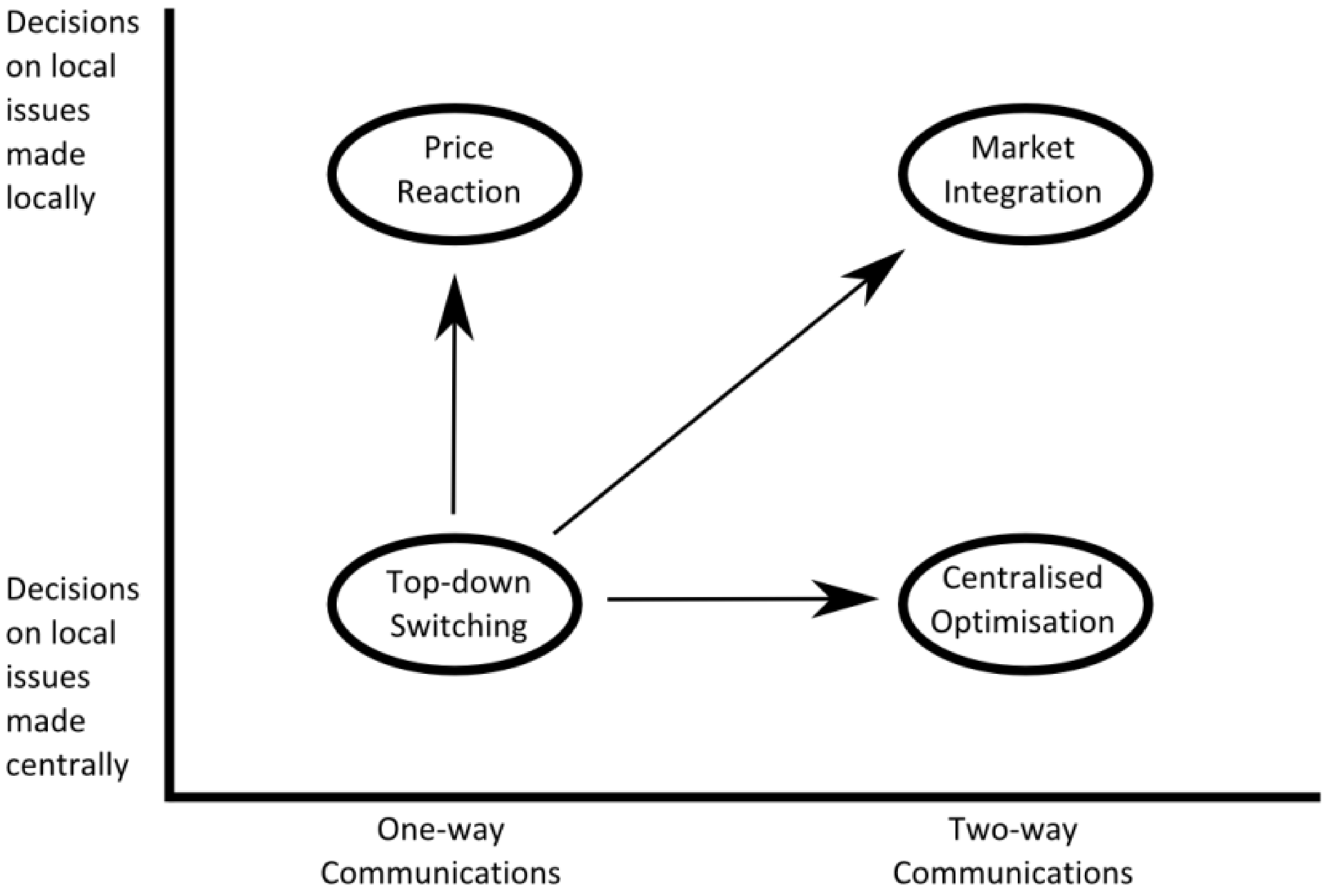
EU-directive:

- Shorter feedback cycle
- Users (5-15 % increased energy efficiency)

Reward for:

- Energy flexibility
  - Market friendliness (Energy)
- Capacity flexibility
  - Grid friendliness (Power)

Smart Energy Management Matrix



Smart Energy Management Matrix

Decisions on local issues made locally

Decisions on local issues made centrally

Top-down Switching

- Partial Use of Response Potential
- Uncertain System Reaction
- Autonomy Issues

One-way Communications

Two-way Communications

Smart Energy Management Matrix

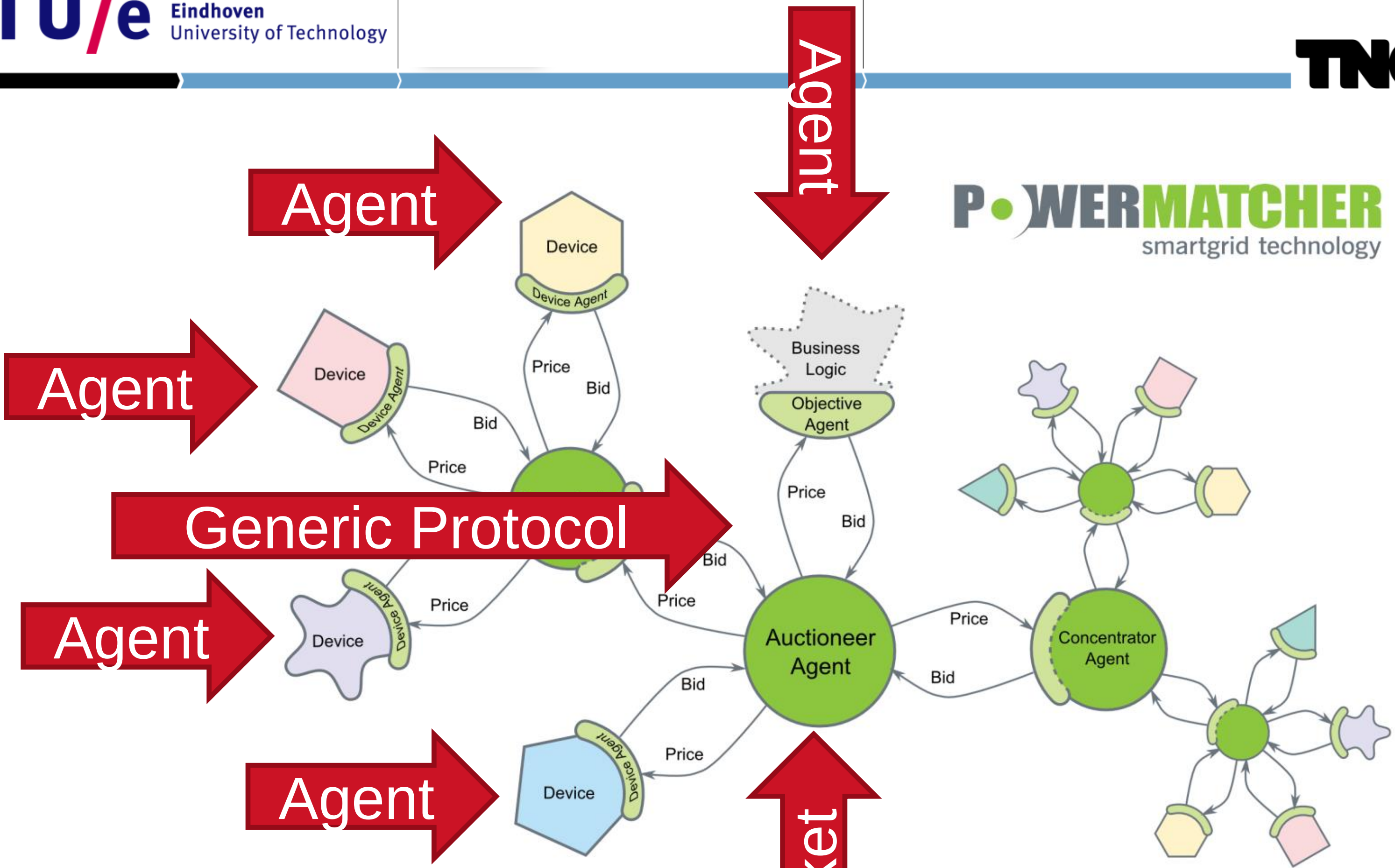
	One-way Communications	Two-way Communications
Decisions on local issues made locally		
Decisions on local issues made centrally	**Top-down Switching** - Partial Use of Response Potential - Uncertain System Reaction - Autonomy Issues	**Centralised Optimisation** + Full Use of Response Potential + Certain System Reaction - Privacy and Autonomy Issues - Low Scalability

Smart Energy Management Matrix

	One-way Communications	Two-way Communications
Decisions on local issues made locally	**Price Reaction** + Full Use of Response Potential - Uncertain System Reaction - Market Inefficiency + No Privacy Issues	
Decisions on local issues made centrally	**Top-down Switching** - Partial Use of Response Potential - Uncertain System Reaction - Autonomy Issues	**Centralised Optimisation** + Full Use of Response Potential + Certain System Reaction - Privacy and Autonomy Issues - Low Scalability

Smart Energy Management Matrix

	One-way Communications	Two-way Communications
Decisions on local issues made locally	**Price Reaction** + Full Use of Response Potential - Uncertain System Reaction - Market Inefficiency + No Privacy Issues	**Market Integration** + Full Use of Response Potential + Certain System Reaction + Efficient Market + No Privacy Issues
Decisions on local issues made centrally	**Top-down Switching** - Partial Use of Response Potential - Uncertain System Reaction - Autonomy Issues	**Centralised Optimisation** + Full Use of Response Potential + Certain System Reaction - Privacy and Autonomy Issues - Low Scalability



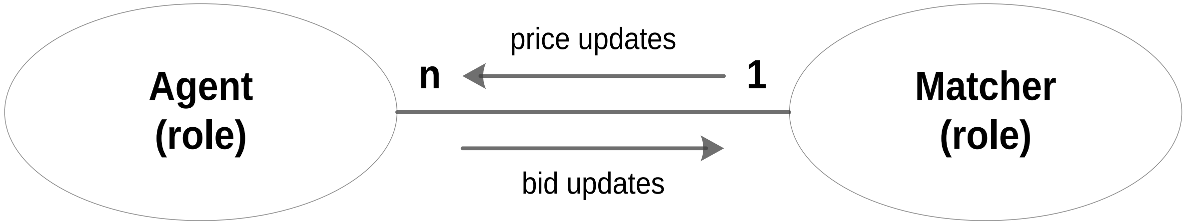
PowerMatcher is an approach **supply / demand management**
which defines a **ulti-agent system**
in which **agents** interact as in a **real-time market**

Bids and prices

PowerMatcher agents operate in a **real-time market:**

- Bids express the *instant* **willingness** (flexibility) to **consume** and/or **produce**
- A price is the **price for demand / supply**

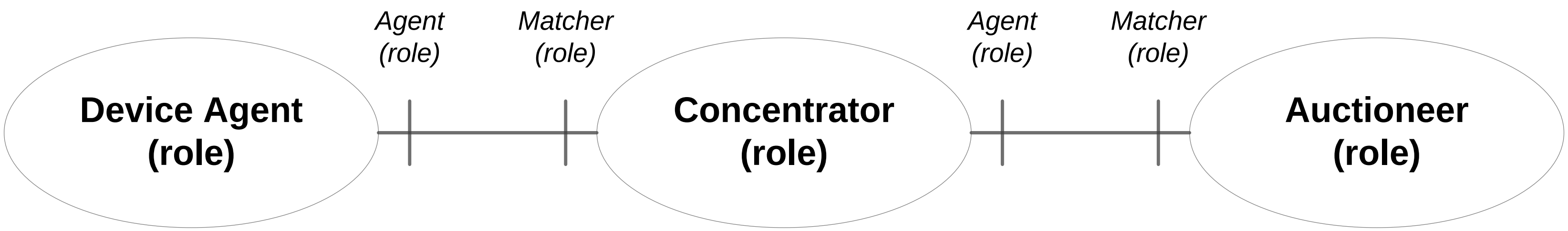
PowerMatcher roles



- **Agent:** Expresses bids to its matcher based on flexibility in supply / demand it represents
- **Matcher:** determines price for its agents based on the supply and demand bids.

- Any agent is associated to exactly one matcher (normally)
- Any number of agents may be associated with one matcher

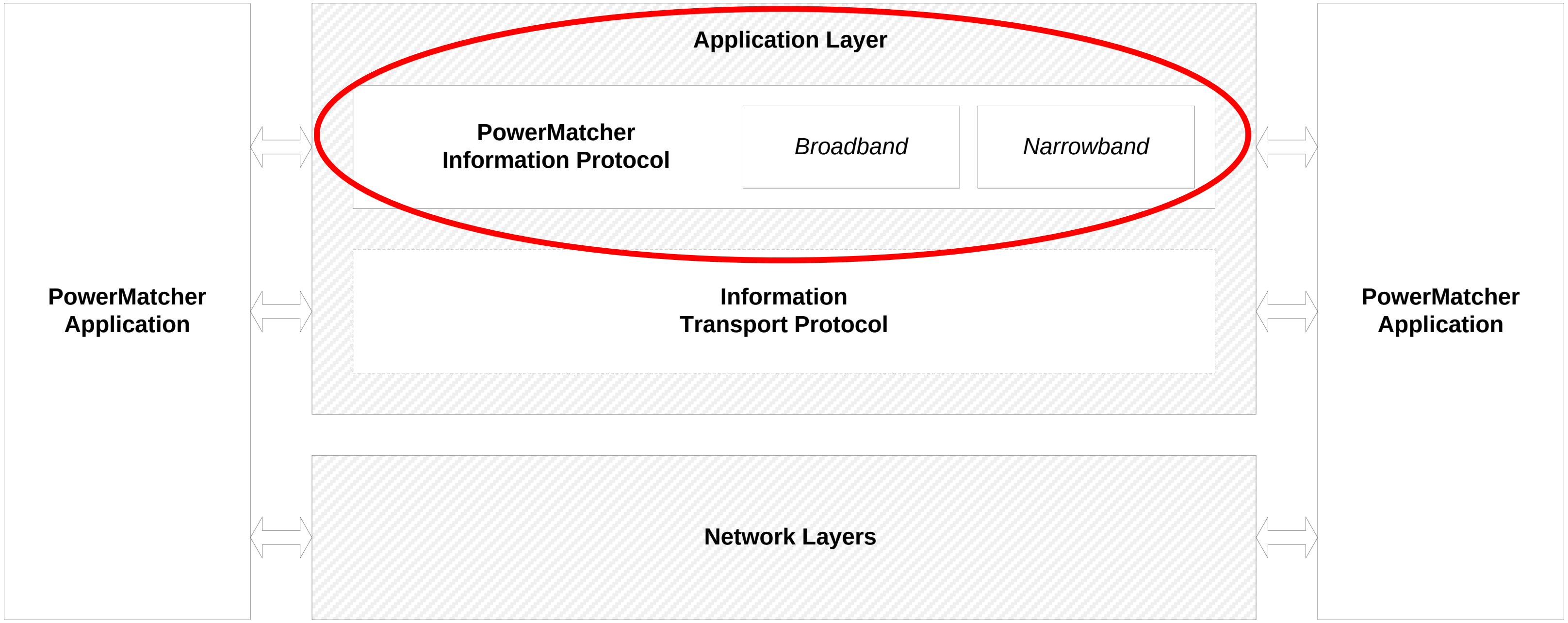
PowerMatcher roles



- **Device agent:** leaf node in a PM hierarchy
  - which represent the specific needs and possibilities of supply / demand (a device) and its users.
- **Auctioneer:** the root matcher in a PowerMatcher hierarchy
  - responsible for setting the market price for the hierarchy.
- **Concentrator:** an ‘interior’ node in a PM hierarchy
  - concentrates bids from agents further down the hierarchy (in the role of matcher), and represents all lower agents towards a node higher in the hierarchy;
  - price updates received by concentrators are propagated down to the associated agents lower in the hierarchy.

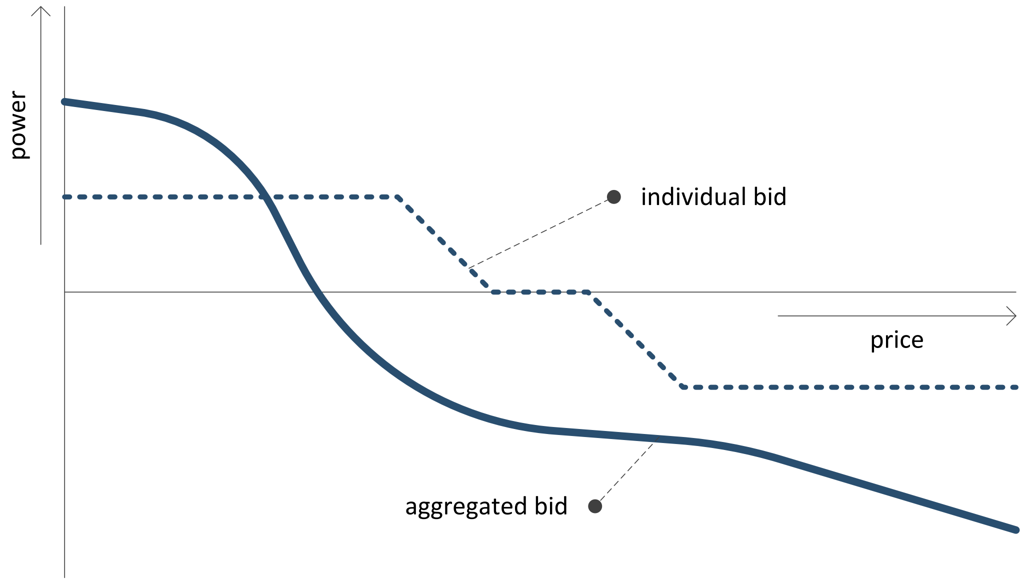
PowerMatcher communicates with appliances and the grid through open standards

Communications protocol stack



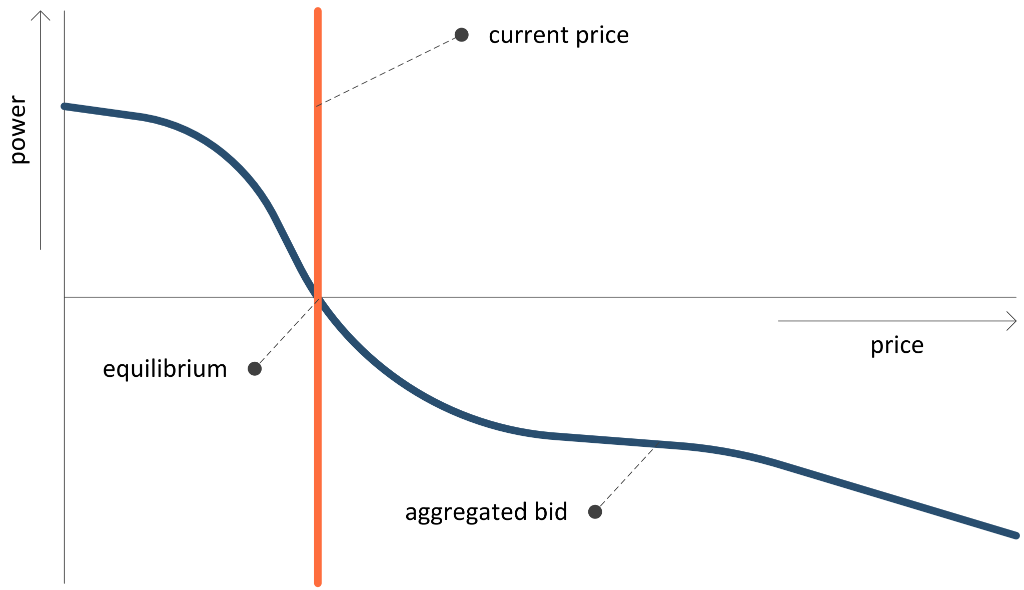
Bids are concentrated and aggregated

- **Bids** can be **summed** to represent the **total supply / demand** as **function** of **price -> Scalable**



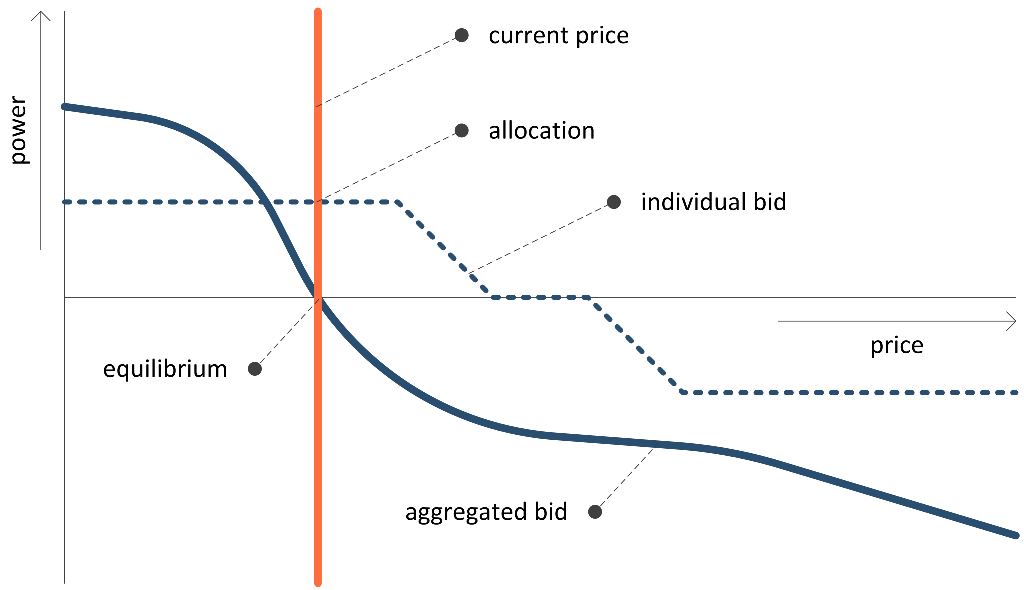
Equilibrium pricing

- The **basic pricing mechanism** is to determine the **balance supply and demand**



Allocation

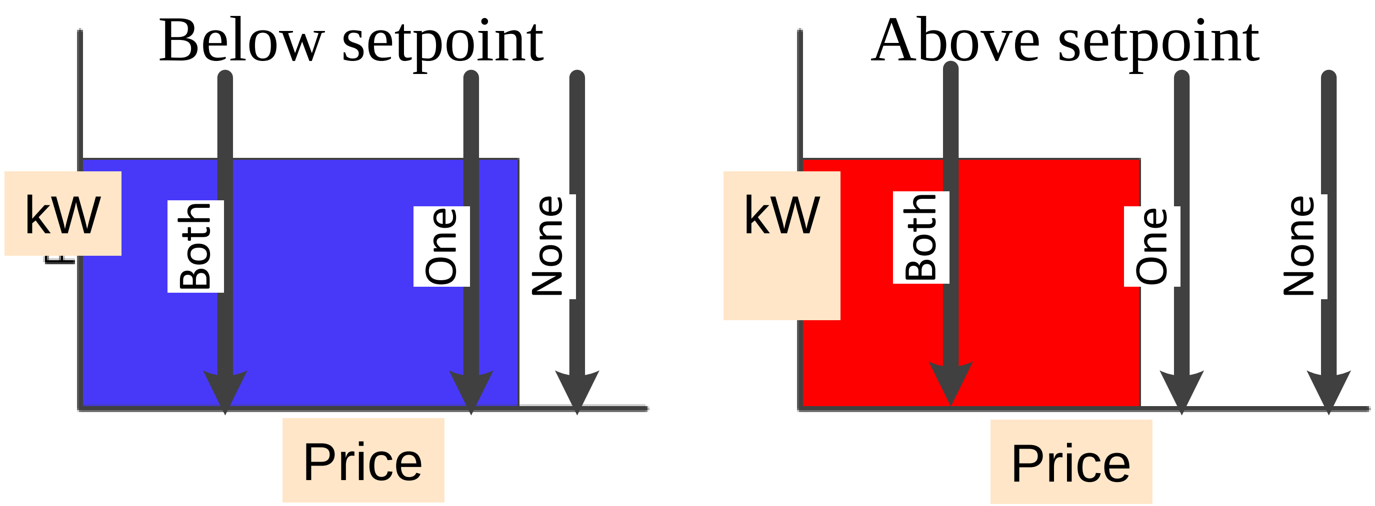
- The **price** – together with their **bids** – **determines** the **allocation** for agents.



Example of PowerMatcher bidding game

- Software agent based
- Information exchanged between agents

Bids and Prices for a heat pump



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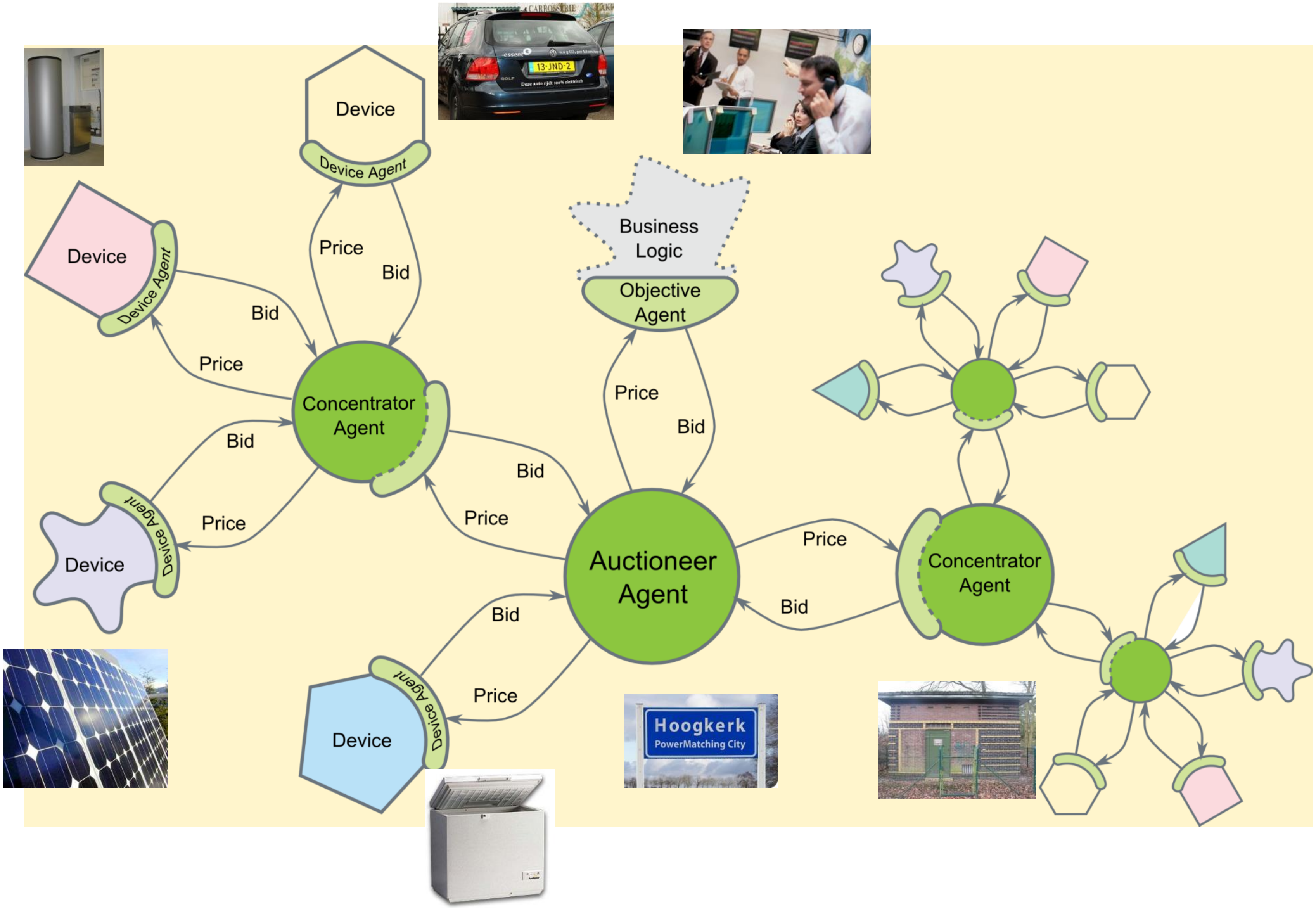
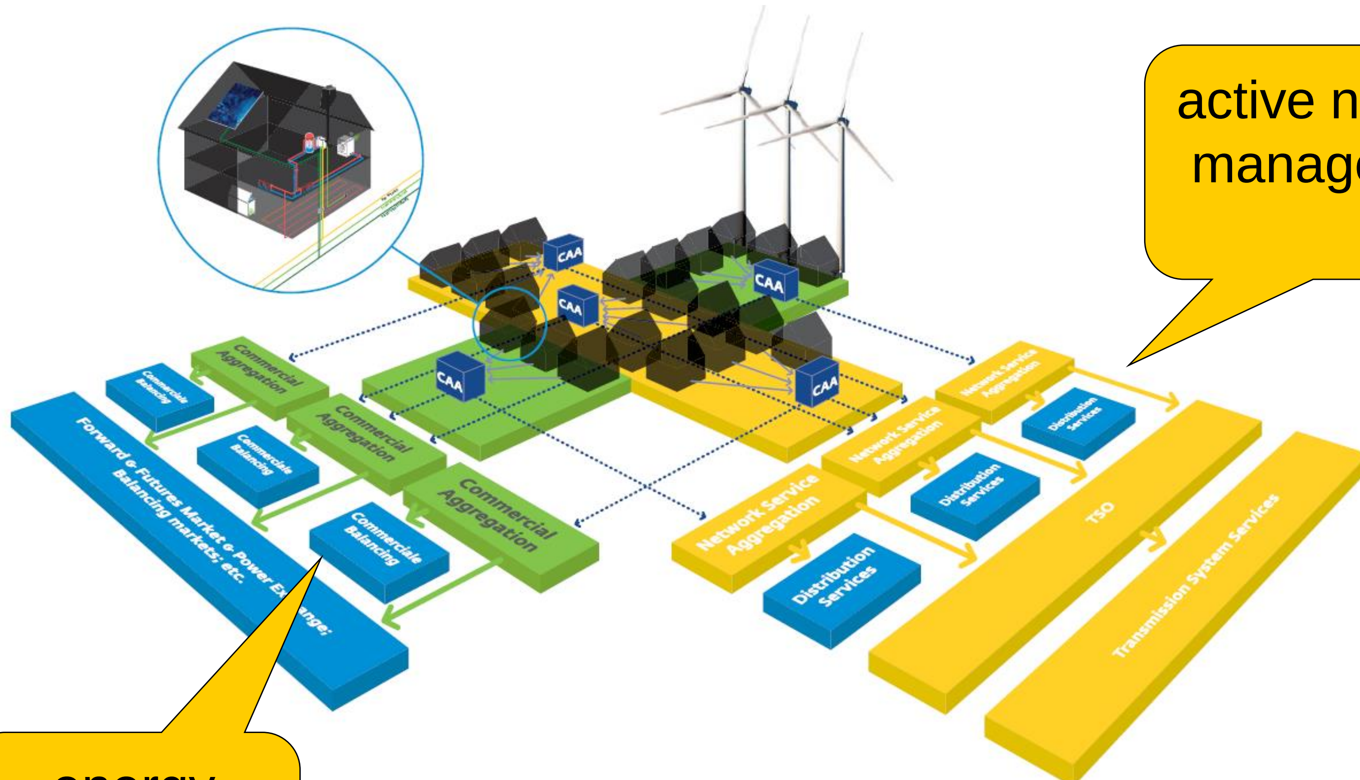
Joining nodes in virtual power plants (PowerMatchingCity)



PowerMatcher enables optimization between energy supplier and distribution system objectives



active network management

energy market trade

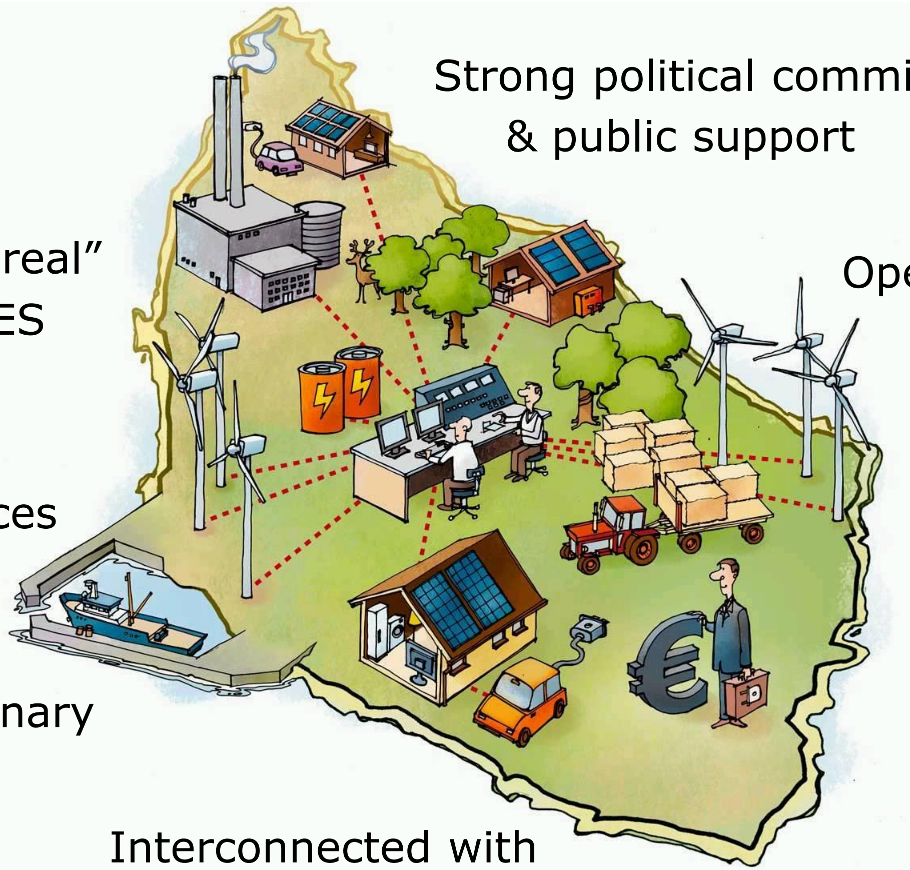
EcoGrid

Strong political commitment
& public support

Demonstration in a “real”
system with 50 % RES

High variety of low
carbon energy sources

Several active
demand & stationary
storage options



Operated by the local
municipal owned
DSO, Østkraft

Eligible RD&D
infrastructure & full
scale test laboratory

Interconnected with
the Nordic power Market

EcoGrid

Demonstrat
system with

High variet
carbon ene

Several
demand
storage

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Conclusions

- Demand response provides a valuable tool for designing more malleable electricity grids
  - From an asset management perspective
    - Broader design margins
  - For capacity management applications (kW)
    - Better component utilisation
  - For energy management applications (kWh)
    - Less varying prices on the market
  - Provides a mechanism for better integration of consumers in the electricity system

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