RREB 1: Synergies in the integration of energy networks for electricity, gas, heating and cooling

EC Policy officer: Javier Castillejos-Alsina
Lead author: Lukasz Brodecki (USTUTT)
Authoring team: Ulrich Fahl, Jan Tomaschek (USTUTT), Javier Alonso (KIC IE)
Reviewer: Aurélie Faure (IFRI)

Hot Energy Topic (HET)

Time: 4 weeks
Pages: 1 - 5
Issues: 18 - 21 in 3 years

Rapid Response Energy Brief (RREB)

Time: 6 weeks
Pages: 4 - 10
Issues: 12 in 3 years

Policy Report (PR)

Time: 6 months
Pages: 60 - 100
Issues: 12 in 3 years

Focus

Discussions with EC policy officer

- **Objective:** to spur discussions on future options and timeline for developing synergies between different networks
- **Case studies:** to showcase the different types of network interactions in a multi-energy grid
- **Evolution:** impact of increased shares of renewables and transition from uni-directional to multi-directional energy flows
- **Beyond kWh:** A more inclusive/comprehensive definition of efficiency increase and renewable integration
- **Modelling approaches & databases:** minor focus
- **International cases:** putting the EU energy market in context

Agenda

- Introduction
- Background
- Integrated Energy Network
- Technologies
- Conclusion and way forward
- References

Introduction

European Commission Emission Targets

- 40% greenhouse gas emission reduction by 2030 compared to 1990 level
- 27% share of gross final energy consumption based on renewable energy sources by 2030
- No mandatory division among individual member states

➔ Focus on efficiency, energy mix and spatial distribution

Approach

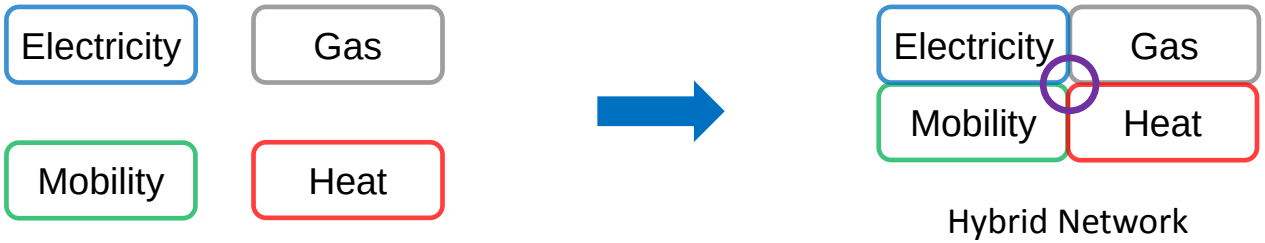
- Integration of intermittent renewable energy source (solar, wind)
- Establishment of flexibility mechanisms for energy supply security

➔ Utilization of interdependencies between different energy carriers

➔ Establishment of an interconnected hybrid grid including secure electricity, gas, heating and cooling supply

Background: Hybrid Networks

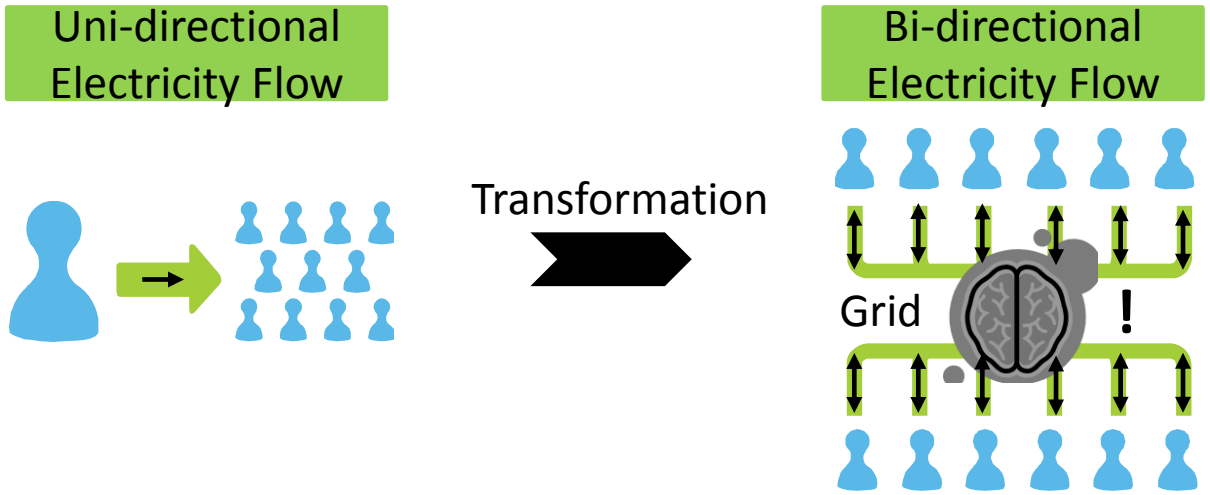
- Fundamental changes due to increased (fluctuating) renewable share
- Necessary extension of transmission network
- Integration of seperate energy networks into connected hybrid networks



- Goal: Utilization of synergies between different technologies
- Establishment of an efficient and flexible (multi-functional) energy system in compliance with system security
- Coordination of energy transport, distribution and storage → " ◯ "
- „System intelligence" in cross-domain network necessary

Background: Energy Market

- Growing share of de-centralized electricity generation
- Multidirectional flows of energy in grid
- Increasing number of „Prosumers"

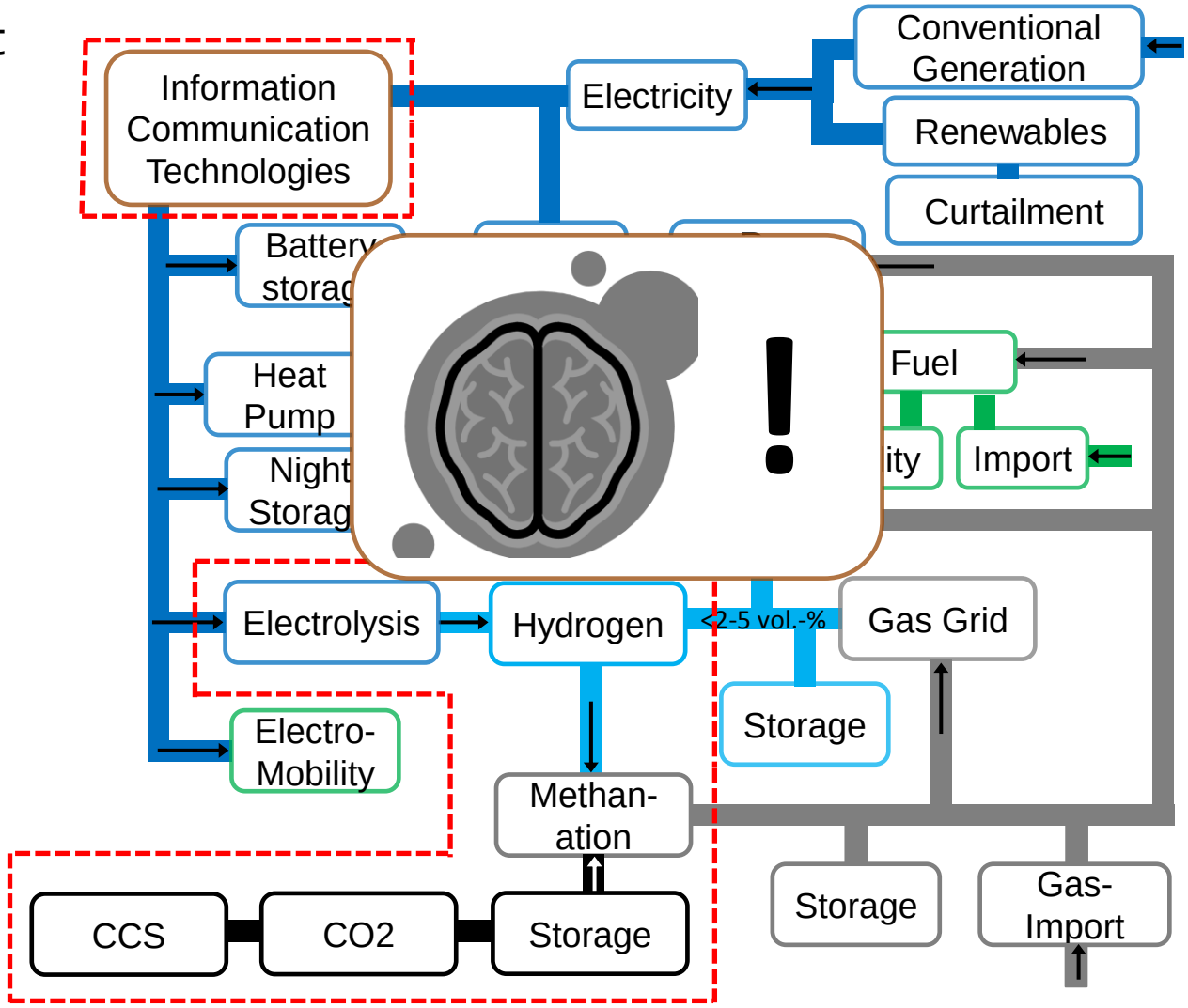


- System intelligence for integration of large numbers of small-scale distributed generators
- Goal: Power transmission with minimal loss and energy supply based on demand for heating, cooling, fuel

➔ Hybrid Networks optimize energy conversion processes

Integrated Energy Network

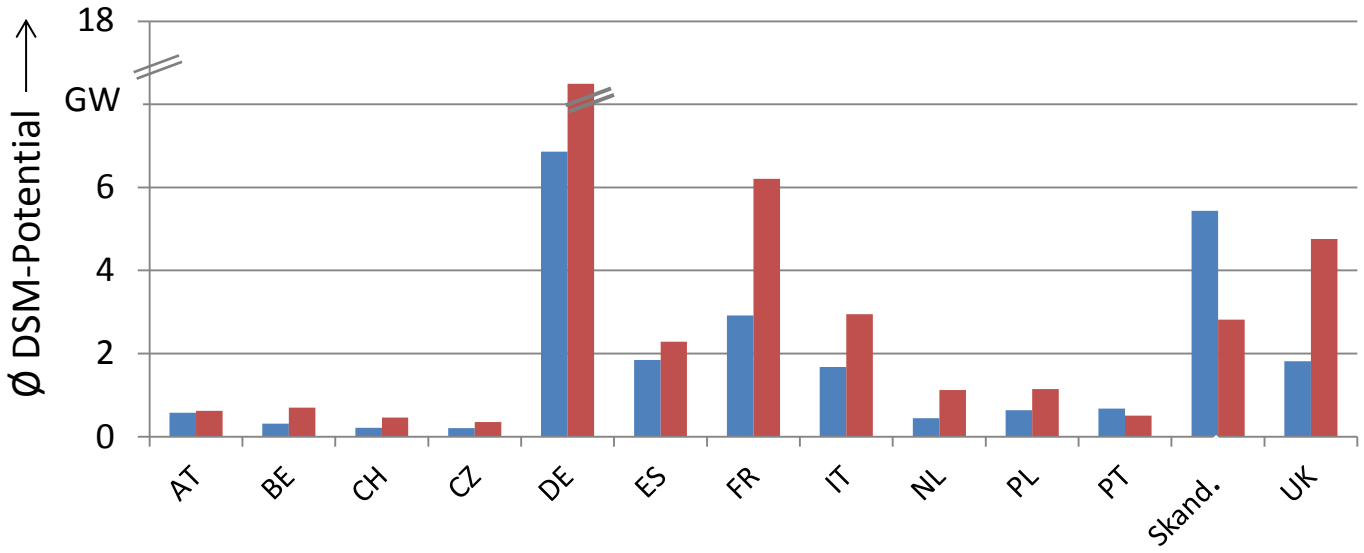
- Combines different "Energy Markets"
  - Electricity
  - Gas
  - Heat
  - Mobility
- Exemplary Power-to-Gas path as flexibility option
- Necessity of "Intelligence" in the energy system



Information and Communication Technologies

- Implementation of Sensoring and Metering infrastructure as foundation of an intelligent energy system
- Passive and active meters
  - → Up to 10% reduction in electricity consumption feasible
- Smart meters basis for Demand-Side-Management (DSM)

Forecasted DSM Potential in Europe by 2020[1]



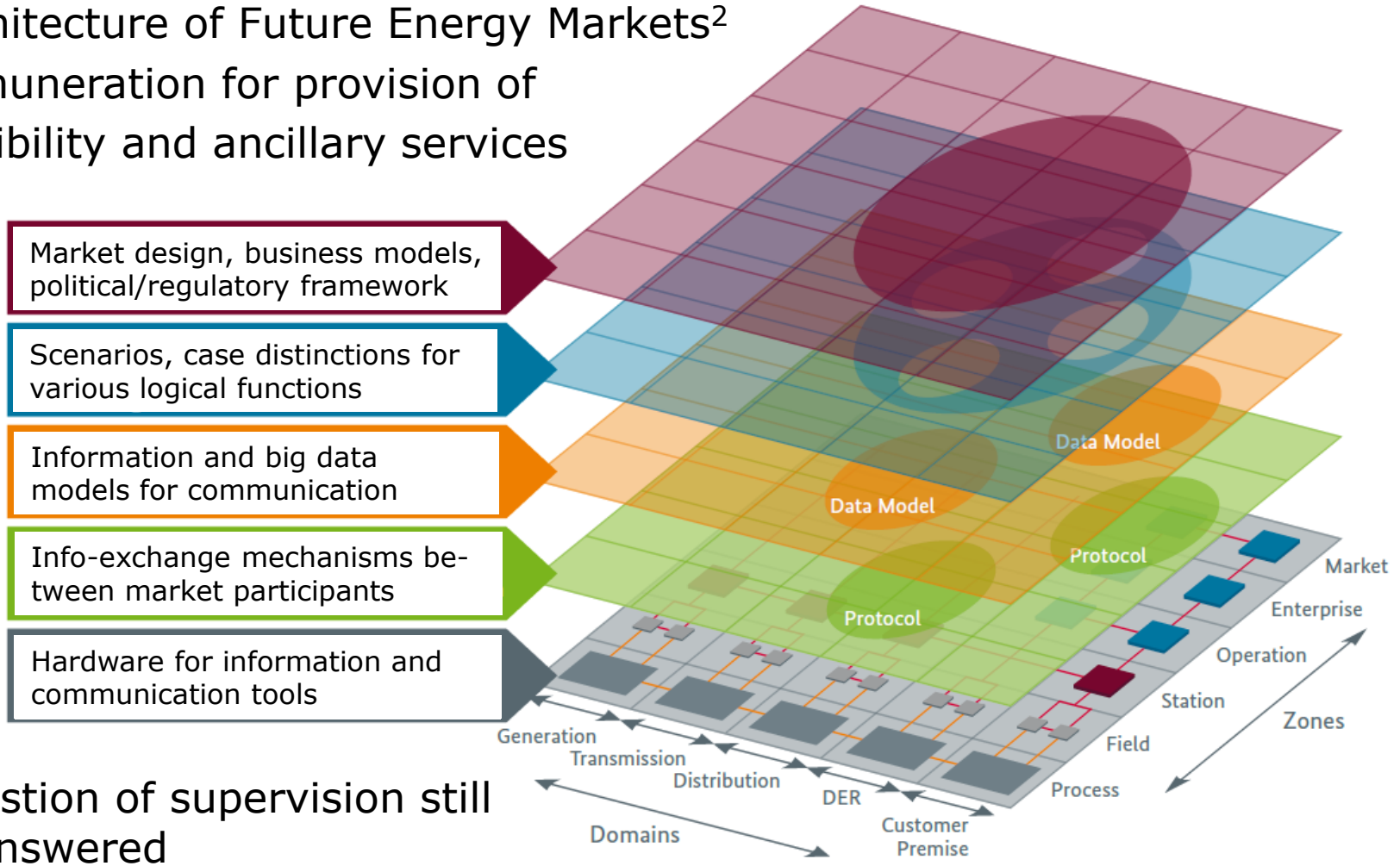
Load Reduction

Load Increase

Source:
[1] WE, Grote, Drees, Budke, Moser

Intelligent Grid Architecture

- Architecture of Future Energy Markets[2]
- Remuneration for provision of flexibility and ancillary services



- Question of supervision still unanswered

Source: [2] Siemens Smart Grid Architecture Model (SGAM)

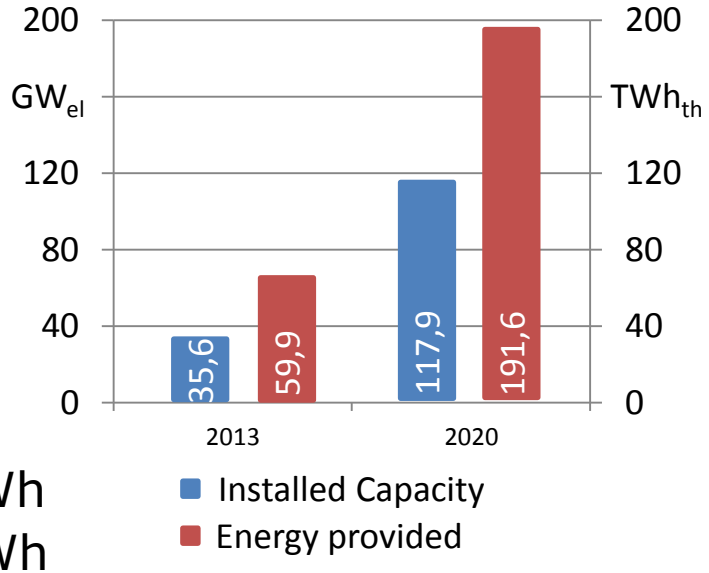
Heat Pump Potential

- Currently consumption of 160 TWh/a for resistive electric heating in Europe[3]
- Gradual replacement by efficient heat pumps (COP ~ 3)

➔ Possible reduction of primary energy consumption by 75%

Heat Pump Statistics in EU21[4]

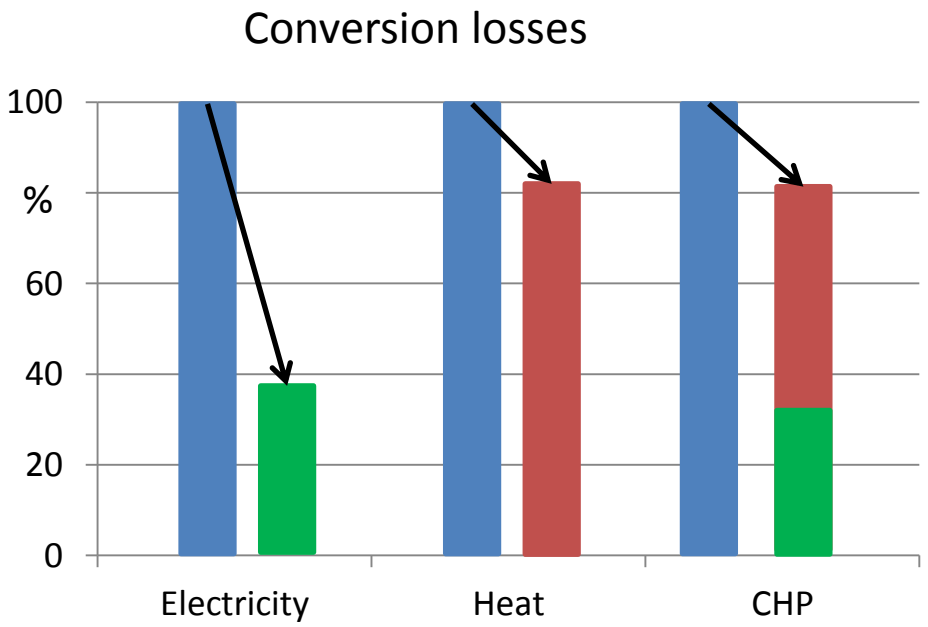
- Not included Romania, Slovenia, Greece, Malta, Lithuania, Luxemburg, Cyprus
- High market penetration in private household sector, especially in Scandinavian countries
- Primary energy savings 2013: 29.54 TWh
  Primary energy savings 2020: 80.20 TWh



Sources:
[3] Roadmap 2050
[4] EHPA

Combined Heat and Power – Co-generation

- Overall Efficiency ~60-85%
- CO_2 emission reduction of 65% per kWh (of useful energy output) compared to separate generation[5]
- Possible extension to combined cooling, heat and power
  → Trigeneration

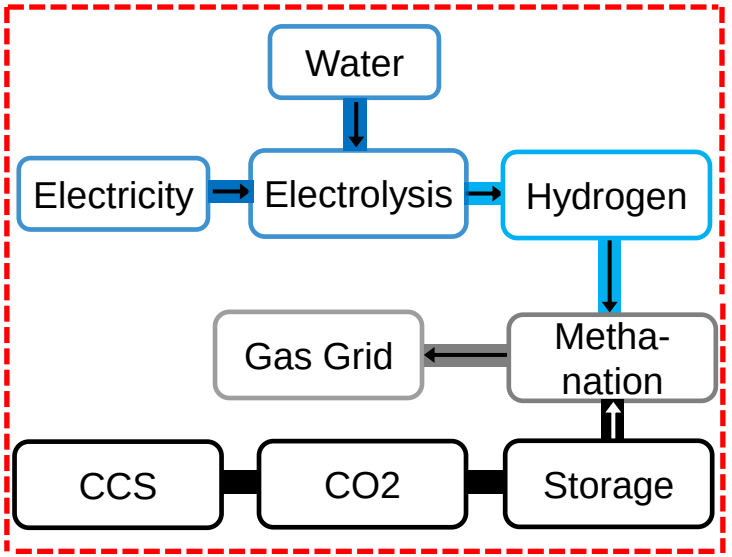


- High market competitiveness and large market penetration of CHP plants[6]

➔ Promotes concept of energy producing consumers – "prosumers"

Sources:
[5] Green Building Practices
[6] IEA 2014

Power-to-X



Power-to-Gas[7]

- Flexibility mechanism
- Technology Readiness Level (TRL) ~6-8
- Electrolysis efficiency 60-80%
- Modulation 1 kW_{el} - 5 MW_{el}
- Methanation efficiency ~70%
- Compatibility with Carbon Capture and Storage technology (CCS)
- Further utilization of hydrogen/methane can be handled according to consumer needs (fuel → mobility, gas → heat)

Sources:
[7] NEP 2013, Sterner 2009
[8] DNV KEMA 2013

Power-to-Heat[8]

- Night storage heaters (in EU27 37 GW_{el} capacity)
- Electric heating 149 GW_{el} in EU27 by 2050

➔ High potential for DSM measures in an integrated hybrid network

Conclusion and way forward

- Interactions of different technologies and utilization of synergy effects are part of an efficient energy system (Hybrid Network)
- Design based on local conditions and under consideration of technology and energy carrier characteristics

➔ High complexity and promotion of scientific research

- Political incentives and stability for planning security
- Set of precise signals for market framework

➔ Liberalization, harmonization and coordination of European Energy market

- Holistic perspective for energy market
- Establishment of ICT infrastructure for system intelligence

➔ Increasing transparency and balanced data protection

References

[1] Grote, Drees, Budke, Moser, „Einfluss des Demand Side Managements auf den Kraftwerkseinsatz in Europa“, ET, 12/2013

[2] Siemens Infrastructure & Cities Sector / Smart Grid Division, Press Release, 2012 May 11th

[3] „Roadmap 2050 – A practical guide to a prosperous, low-carbon Europe, Technical Analysis“, April 2010

[4] „European Heat Pump Market and Statistics Report 2013“, EHPA

[5] Elsarrag, Alhorr, „Optimisation of CCHP and biomass heating for maximum CO_2 reduction in a mixed-use development“, Green Building Practices, 2013

[6] „Energy Technology Perspective 2014“, „Energy Outlook 2013“, IEA

[7] „Netzentwicklungsplan Strom 2012“

[8] Raadschelders, Sikkema, Groen, „Potential of Smart Electric Thermal Storage Contributing to a low carbon energy system“, DNV KEMA Energy & Sustainability, 2013

Thank you for your attention!

Questions?