Smart Grids and Demand Side Integration: The battle on redefining roles in electricity distribution

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Ruggero Schleicher-Tappeser
sustainable strategies

ruggero@schleicher-tappeser.eu, 030-86432487

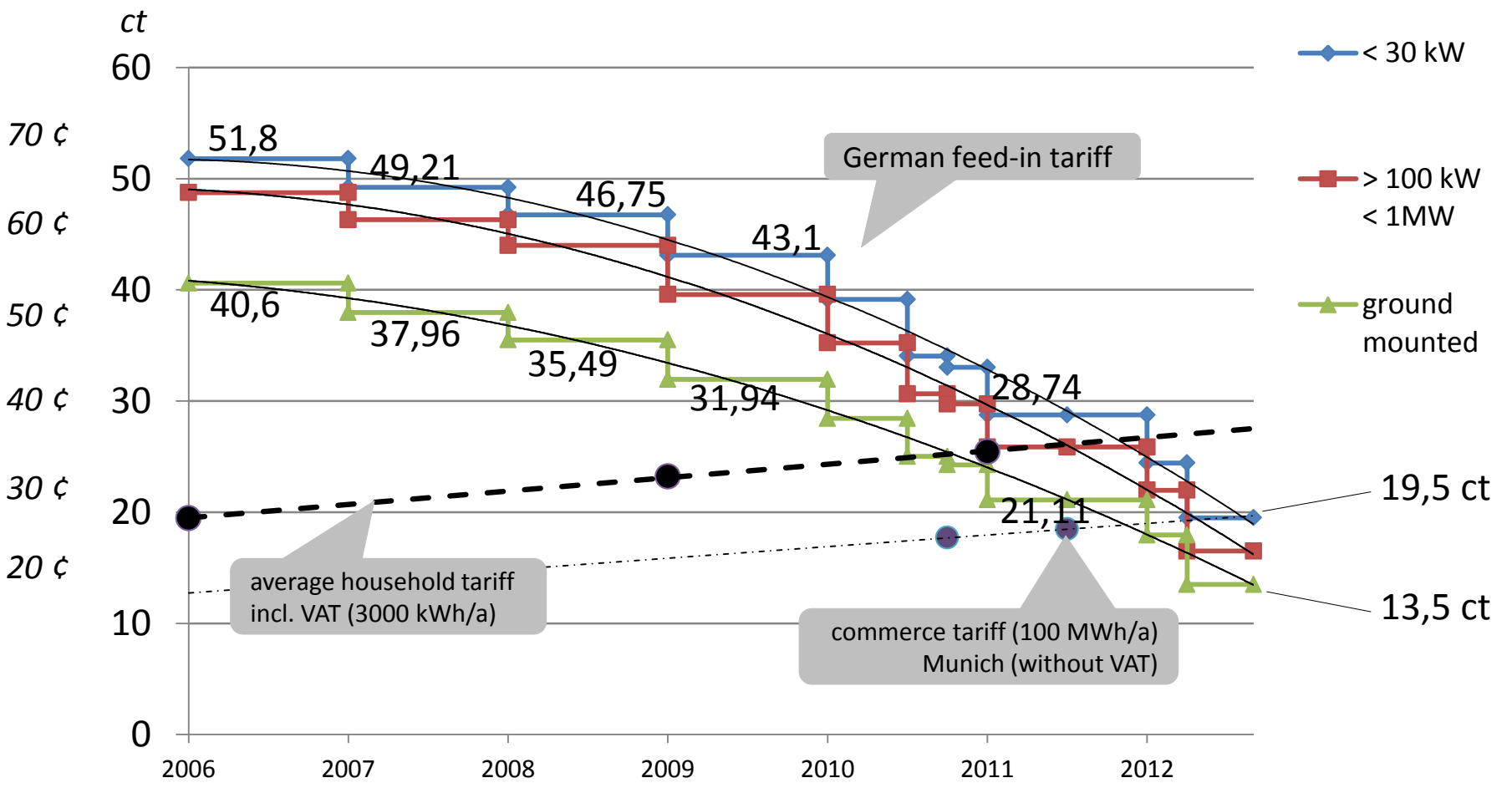
ICT Technologies enabling a fundamental transformation

- ICT are about to transform the electricity sector as they transformed other sectors before
- The term “smart grid” stands for the application of concepts of
  - real-time transparency
  - flexible management of resources
  - control through market mechanisms
  - multiple interaction with a wide range of users

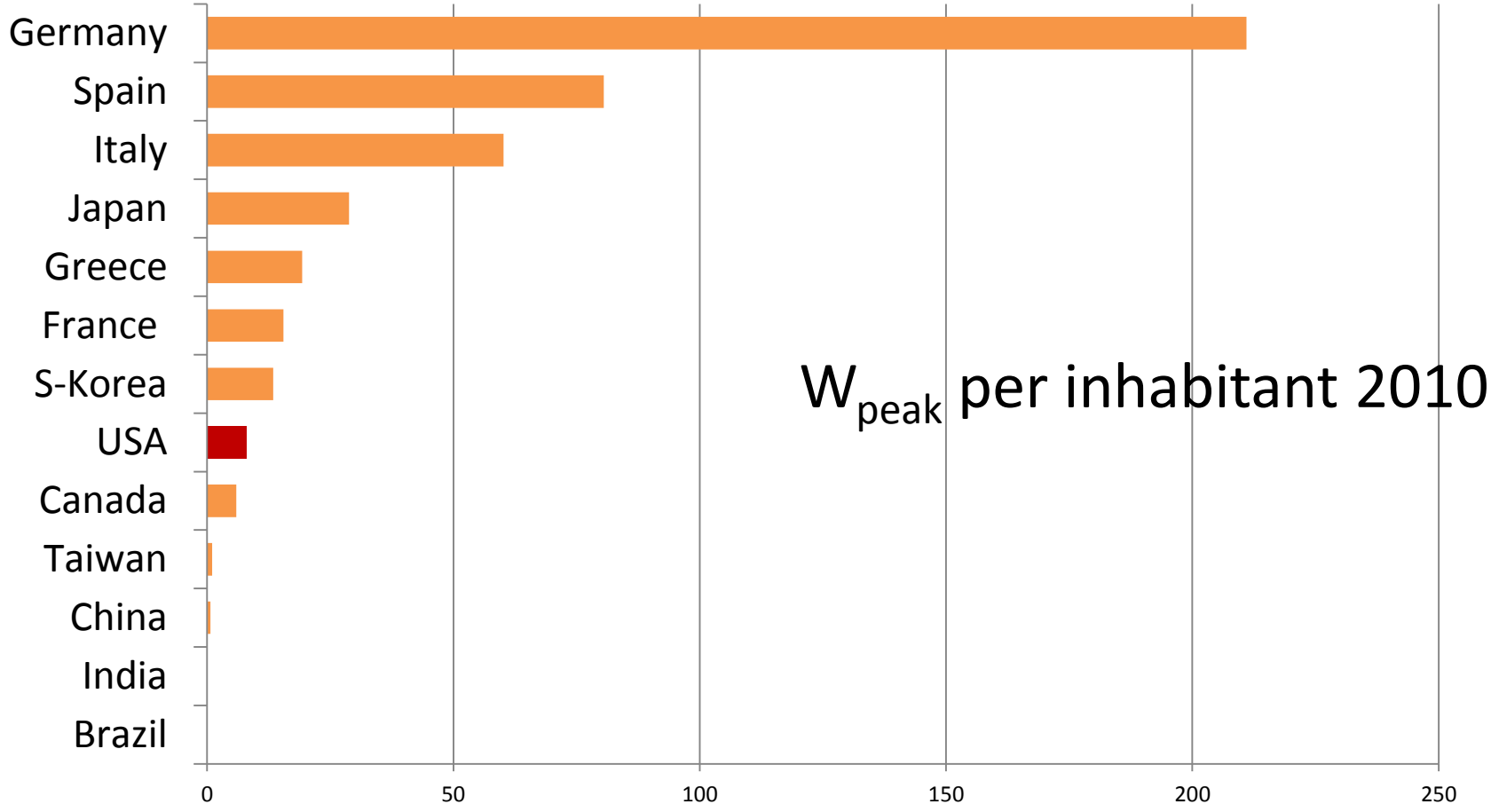
  from the transmission level, across the distribution grid, down to the single photovoltaic roof, washing machine and fridge in the private kitchen
- This raises fundamental questions about management levels, responsibilities, control rights, data access, markets and roles, as well as regulation
- This transition from a centralised top-down control towards a multi-layered governance with distributed responsibility, self-organising sub-structures and a wide range of actors involved is a profound paradigm shift
- It is rather familiar to the IT industry but difficult to understand for the incumbent utilities.

SMART GRIDS: KEY TO THE TRANSITION TOWARDS RENEWABLES

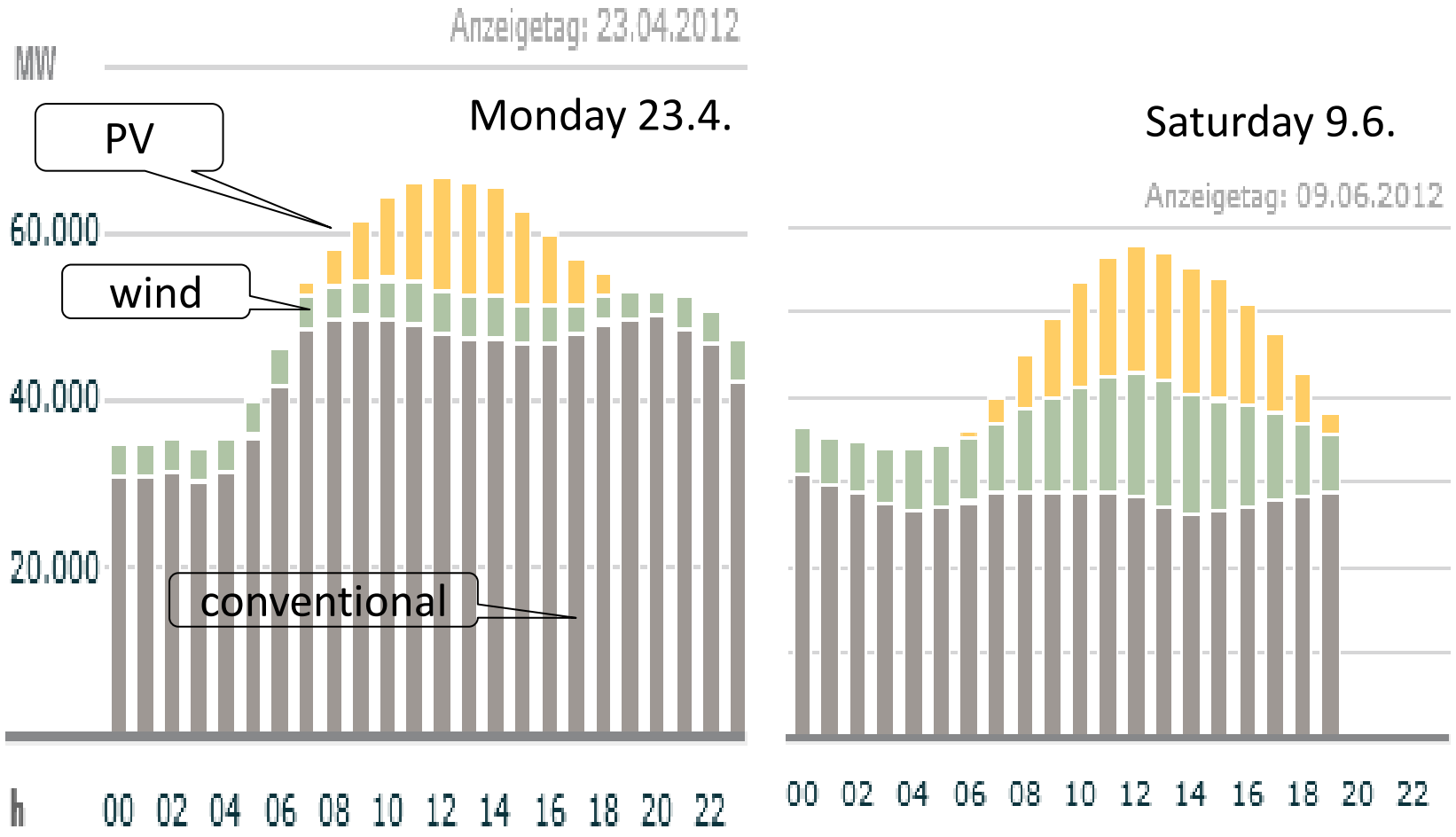
The transition is accelerating: Grid parity in Germany



Germany first country to experience major effects of PV in the grid



PV covers consumption peak
→ declining prices at the power exchange



Sun and wind will dominate – biomass requires too much surface

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electricity

photovoltaics: < 10 m²/MWh/yr

wind : < 10 m²/MWh/yr
surface: (3 x rotor diameter)²

Where applicable, CSP needs about the same surface as PV

Biomass (corn)
> 200 m²/MWh/yr

factor 20 - 100

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transport

electric car with PV

conventional car with biofuel

factor 250

Key characteristics of the new dominant power sources sun and wind

1. Power generation directly depends on changing natural input
   - ➢ Flexible compensation needed

2. Wind and solar power need no fuel
   - ➢ Zero marginal costs → dispatch priority
   - ➢ High interest to exploit full range of fluctuations

3. Sun and wind: essentially distributed
   - ➢ Key role for distribution grid

The challenge of fluctuating renewable power generation

a) Regular variations of solar radiation over the day and the year
   - completely predictable

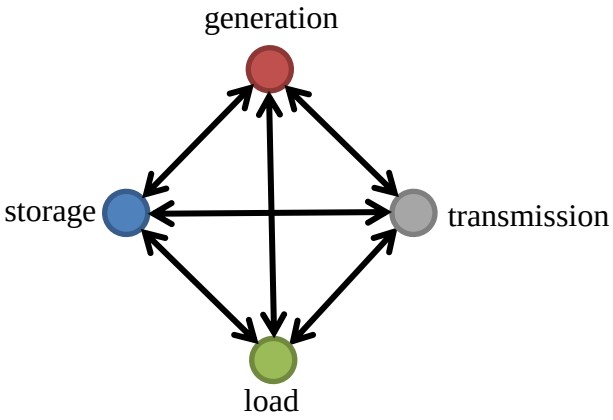
b) Weather-dependent turbulent fluctuations of sun and wind
   - prediction accuracy depends on time horizon, increases strongly some hours before

- Compensation needed by other flexibilities in the system
  → major challenge, reconsider whole balancing
- Time horizon of planning/markets should reflect prediction quality steps
  → reconsider time horizons and mechanisms

Options for providing new flexibility

Generation, load, storage and exchange must be balanced at each point in time – all four can be managed:

1. Flexible backup generation
   - traditional approach, limited when needing fossil fuel
   - old technologies not flexible enough
   - new technologies: gas turbines, distributed CHP, fuel cells
   - today: natural gas, tomorrow: renewable fuel – SNG
2. Increased transmission
   - compensates local fluctuations over distance
   - requires additional transmission capacities
   - cannot compensate daily and seasonal cycles
3. Storage of electricity
   - intuitively the easy solution, but costly
   - different technologies for different time horizons, scales
4. Adapting demand
   - up to large extents cheaper than other solutions
   - nearly untapped: regulatory barriers, new opportunities with ICT



New flexibility requires new control approaches

- Increased transmission and flexible backup generation with large plants are traditional strategies which do not need new control approaches: central structures are already smart
- flexible backup generation with distributed CHP however might profit from smart grids but could be run as an aggregated central system
- storage adds further complexity to the optimisation task, central storage might be managed with present approach – more distributed storage not
- Demand response, finally, has its major potential below the transmission level, for exploiting it, intelligent control across all levels of the grid is needed
- Optimising the use of flexibility resources requires a flexible mix across all levels of the system, permanent optimisation and bidirectional flows – this is not possible without introducing intelligence at all levels, i.e. smart grids
- Only considering the transmission level and neglecting spatial effects might require grid expansion not needed with grid capacity management

The challenge of distributed power generation

- Largest part of new generation feeds directly into distribution grid
  - Germany end of 2011: > 22.000 onshore wind turbines, > 1 million PV plants
  - Germany 2010: 97% of renewable power → distribution grid
    83% of conventional power → transmission grid
- New challenges for distribution grids
  - bidirectional flows
  - peak input loads
  - congestion management necessary
  - insufficient additional income with present rules

- Active distribution grids required:
  Local balancing, local pricing, perhaps local markets
- Similar functions as at the transmission level:
  unthinkable without smart grids
- Inevitable: a redefinition of roles and responsibilities

Intelligence helps to economise energy and hardware

- As in all other technical systems: intelligence with new ITC can optimise use of resources
- Low growth systems where hardware is redundantly deployed for ensuring high reliability (large parts of Europe), are less motivated to question established technical standards and commercial claims by introducing ICT
- High growth systems with permanent hardware bottlenecks (USA, China, India …) have a much higher interest in improving efficient use with the help of ITC

THE EVOLUTION OF THE SMART GRID CONCEPT

Four historical roots of smart grid endeavours

- Smart metering
  - since 1977
  - Italy full roll-out 2000-2005
  - Motives: automated reading / theft prevention / demand response
- Distribution automation / active distribution networks
  - Strong argument in the US where grids are weak and breakdowns frequent
  - Rapid isolation of failures and restoration
  - New emphasis: distributed generation, microgrids
- Energy management in buildings & facilities
  - since decades
  - mainly heating & cooling, energy efficiency
  - increasingly: captive power generation
- E-mobility
  - charging infrastructure that allows for interconnectivity and roaming
  - high unpredicted loads

THE EU SMART GRID POLICY ARENA

Smart Grid Task Force SGTF

- Main body for DG Energy
- Objectives, originally focusing on smart metering
  (1) developing technical standards
  (2) ensuring data protection for consumers
  (3) establishing a regulatory framework to provide incentives for Smart Grid deployment
  (4) guaranteeing an open and competitive retail market in the interest of consumers
  (5) providing continued support to innovation for technology and systems
- Broad steering committee, expert groups, new mandate 2012
- Shift in perspective → Advanced concepts envisaging DSOs with similar competencies as TSOs, prices differentiated in space and time…

Development of Network Codes

- ACER, Agency for Cooperation of Energy Regulators, ACER elaborates Framework Guidelines on request of the Commission
- Then ENTSO-E, the organisation of the Transmission system operators, elaborates Network Codes (usually ready 2 years later)
- Ambitious 3-year work programme:
  - "capacity allocation and congestion management" (ready in 2013)
  - "grid connection" (2013)
  - "system operation" (2013)
  - "balancing" (2014)
  - "Third Party access" (2015)
- Apparently technical discussions have far-reaching consequences for future structures

Nearly concluded: Energy Efficiency Directive

- In Article 12 the new Energy Efficiency Directive (final vote in the EP in September) requires that
  - demand response be allowed to participate alongside supply in electricity markets
  - grid operators treat demand response providers in a non-discriminatory manner when providing balancing and reserve services
- Until now a series of hurdles have prevented demand response measures from competing with the electricity generation
- The directive is a big success for facilitating demand response
- Still open how this will affect direct access for consumers/prosumers to these markets – lobbying will go on

Other important activities

- Cost-benefit analysis and roll-out of intelligent metering systems
  - Requires 80% roll-out by 2020 for positively assessed schemes
- Smart Grids European Technology Platform SG-ETP
- EEGI European Electricity Grid Initiative
  - under the umbrella of the SG-ETP
  - Led by ENTSO-E (TSOs) and EDSO4SG (DSOs)
  - Estimated cost 2 billion
- Wide range of research activities
  - 219 projects in Europe (2011)
  - FP7: 23 projects

Stakeholders present in the EU debates

- Organisations of the electricity sector strongly represented – with exception of weakly represented renewables
- Equipment manufacturers strongly represented – with exception of weakly represented renewables
- IT and Telecom industries increasingly well represented
- Consumer Organisations – present but not very active
- Environmental organisations – no or weak presence
- Cities and Regions – not present in main forums

➢ Organisations representing public interests are heavily under-represented

THE DISCUSSION ELSEWHERE

The discussion in EU member states

- Different conditions concerning the share of renewables, the structure of the electricity sector and problem awareness lead to different priorities
  - more than half of the projects concentrated in Denmark, Germany, Spain & UK
  - different approaches centralised/ decentralised, focus on meters/ on the grid
- Example Denmark
  - Ambitious targets for a deep transformation, most advanced in pulling down responsibilities, heat market as a buffer
  - Estimation: SG investment of DKK 9,8 bn brings benefits of 8,2 bn leading to net costs of 1,6 bn instead of 7,7 bn for traditional grid expansion
  - Danish Energy Association envisages a “dynamic pricing system and a market for ‘using’ the network at DSO-level”, where the “DSO will set the framework, standards and rules for the market”
- Example Italy
  - More centralistic approach: Incumbent ex-monopoly dominates distribution
  - Complete smart-meter roll-out → considerable cost savings


Key elements in the future Smart Grid electricity system
COMMUNICATON
Improved communication and monitoring
PHYSICAL SYSTEM
A robust transmission grid
An active distribution grid
Flexible operation and payment of consumption
An active consumer
The DNO as a market facilitator –
Will become DSO?
Market Facilitator
danishenergyassociation

USA and China

- USA
  - weak grids, long distances, wide range of regulation regimes
  - distribution system automation, peak shaving with demand side management, rapid detection and isolation of grid failures, as well as energy conservation have been key concerns since many years
  - one third of households has smart meters
  - intense centralisation / decentralisation debate
  - market forecasts for 2012 three times as large (9,2 bn) than for Europe
- China
  - smart grids have been declared strategic national priority, double strategy: improving grids and building strong SG industry
  - staggering growth rates of power consumption and grid growth
  - growing importance of fluctuating renewables and e-mobility
  - powerful State Grid Corp. leading the development

KEY ISSUES
OF THE DEBATE AT THE EU LEVEL

Key issue 1:
Role and management of the distribution grid

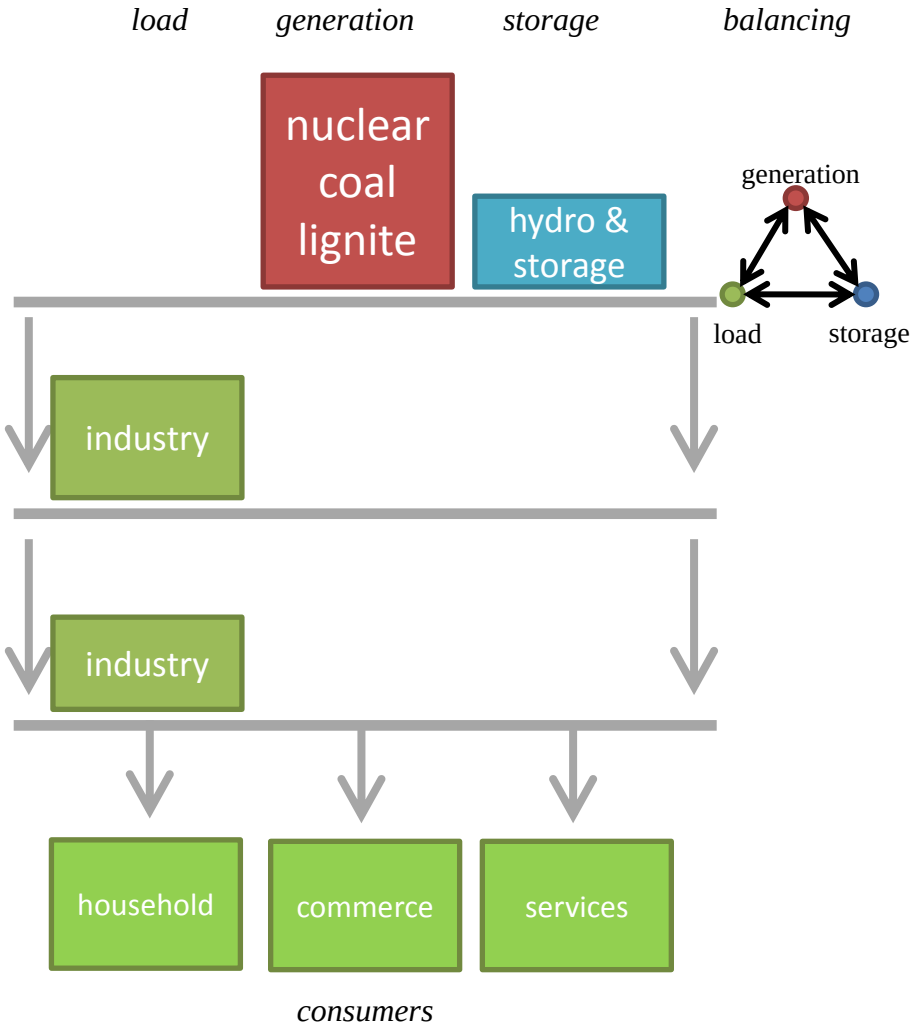
- In the conventional top-down system large power producers and owners of transmission grids controlled the system, liberalisation has only slightly changed the roles with unbundling
- The top level of the system is already being managed with sophisticated ICT
- The smart grid concept: introducing similar control and communication structures at lower levels down to the prosumer & establish intelligent links

➢ Wide range of possible configurations:

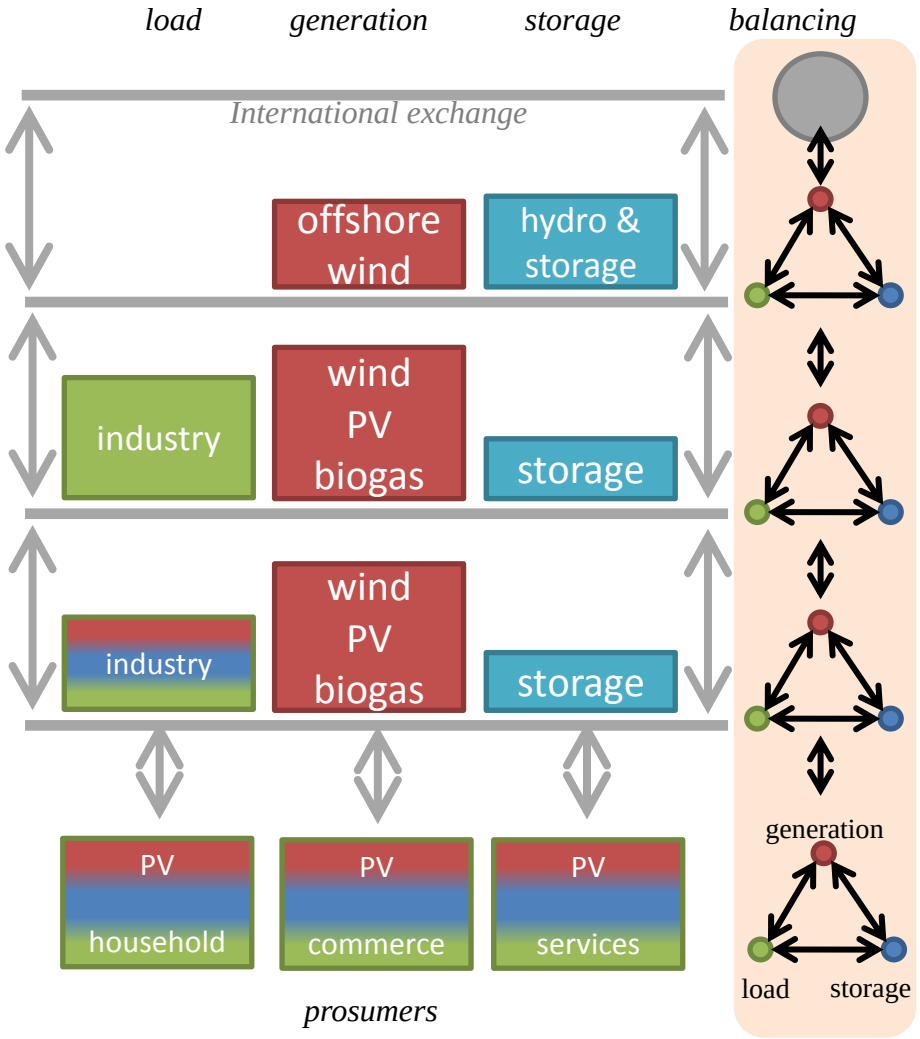
  - How much responsibility and autonomy for grid operators at different levels?
  - Which new roles for service providers establishing commercial links?
  - What belongs to the regulated what to the free market realm?
  - How to manage distribution grid capacity?
  - Where to introduce new market mechanisms? Local electricity markets?

- Incumbents from the old centralistic structures try to maintain their hold
- No shared vision yet among new market entrants

Top-down supply system
(central control)



Multi-level exchange system
(subsidiarity, shared responsibility)



Further progress requires fundamental decisions

- Increasing number of smart grid market participants deceived by slow progress
- Smart grid investments
  - necessary for transition towards renewables
  - huge economic opportunity, new market participants
  - no real business case in present setting
- New definition of roles is necessary for ending stalemate
- All imaginable configurations lead to loss of power and influence for somebody → resistance
- At the same time where renewables reach a threshold, this leads to changing roles of the incumbents: EON, RWE, Vattenfall, Dong…
- Captive PV power generation may drive microgrid development from below: no public framework needed
- Heavy battle behind the curtains, in technical committees

Key issue 2:
The Interface to the consumer/ prosumer

- Smart control of appliances for adapting demand to supply
  - centrally planned demand control or market-based response?
  - different control strategies would allow for more or less autonomy of the consumer
- Transparent consumers – down to brands and use of single appliances?
  - how much should the consumer need to disclose?
  - who should control the interface to the consumer?
  - who should have access to the data?
- How to govern withdrawal from and input to the grid?
  - mainly by time-dependent tariffs?
  - mainly by simple tariffs and exceptional direct cotrol?
  - with a combination of rules and simple tariffs?

Direct control by utility – or autonomy of the consumer ?

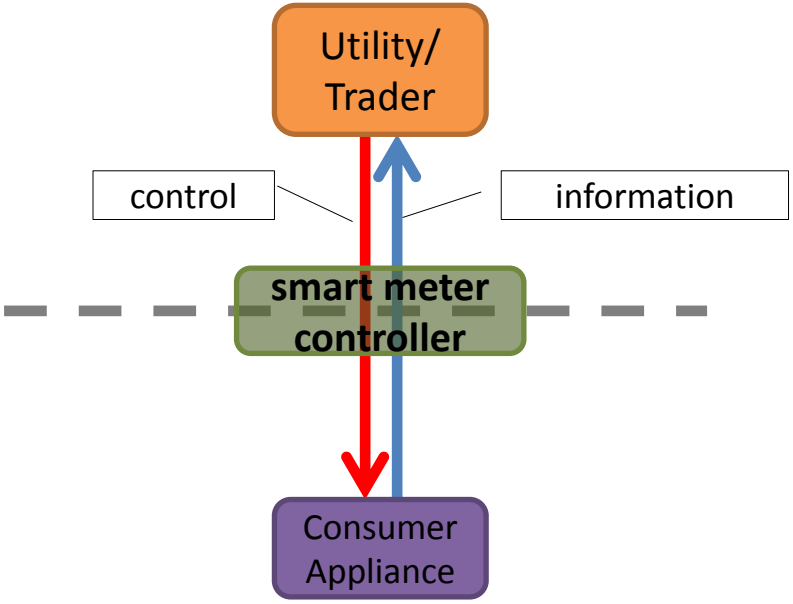
Smart grids would allow for smart control of appliances for adapting demand to supply

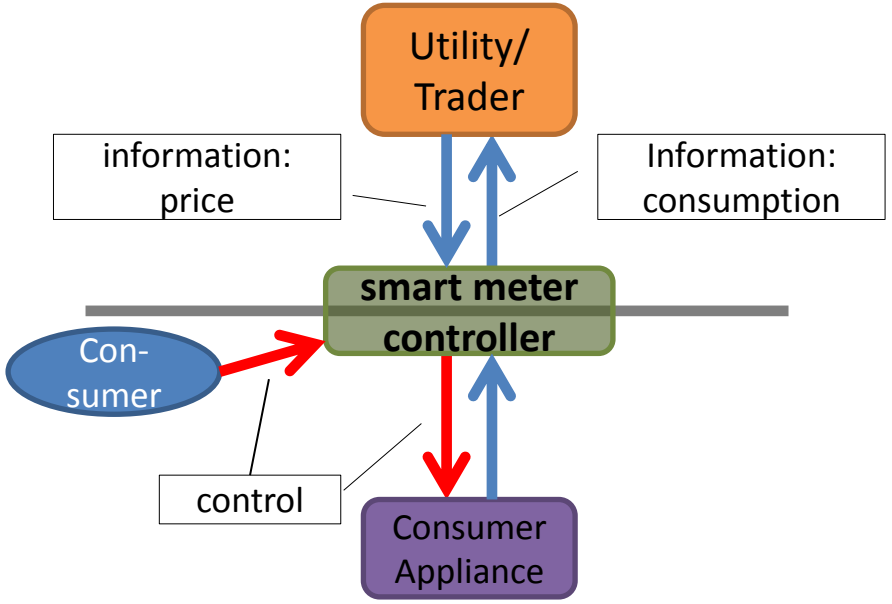
Utilities might directly control major appliances

- calculable impact
- immediate response
- easy short term use

Consumers might become involved in a market-based management of the system

- Price information by the utility
- Manual or programmed response of appliance use





Key issue 3:
Room to manoeuvre for the member states

- How far should the EU go in setting binding rules for member states?
- Good arguments for experimenting with different approaches
  - Novelty of the problem
  - Wide range of different possible solutions
  - Diversity helps innovation
- Good arguments for a set of common elements
  - Fluctuating renewables require more cross-border exchange
  - Larger markets reduce costs for smart grid technologies
  - Common approach facilitates emergence of strong European industries facing international competition
  - Strong European approach allows for more independent European decisions
- Joint approaches require intense discussions and enough time
- We need a vision for a differentiated and coherent multi-level governance approach!

Key issue 4:
Speed and transparency of the process

- The discussion is at the same time an open learning process concerning new issues, and a result-oriented negotiation process setting rules for many years to come:
  - difficulty of fully understanding the issues at stake for the own interest group or for society – by the broad public and also for many stakeholders involved
  - cultural gaps between: policy and market specialists/ technicians; top-down approach of the energy industry/ more systemic thinking of the IT industry
  - efforts, but also difficulties to ensure communication and coordination between different discussion forums and policy processes
  - lack of transparency concerning the different initiatives and discussions, of the stakeholders involved and, most important, their positions
  - difficulty to understand importance and implications of standards and codes being developed – many stakeholders are culturally reluctant and lack resources to be more involved in these detailed issues
- Not all stakeholders are unhappy with this lack of transparency
- Environmental problems are urging – slowing down the process is no option
- Speeding up the learning process is the only solution

The EU Smart Grid discussion will shape the energy transition in Europe

- Distributed fluctuating renewable power generation requires
  - dynamic balancing of generation, storage, transmission and consumption
  - bi-directional power flows in the distribution grid
  - active grid capacity management also in the distribution grid
  - a different control logic of the electricity system
  - a new architecture for electricity markets
- The present system will become unsustainable in less than five years because of a boom in captive power generation with photovoltaics
- Conventional dumb distribution grids cannot cope with these challenges, active distribution with *smart grids* is getting essential for the transition
- Different system architectures are conceivable – interest groups struggle for a new distribution of roles
- The transition discussion has neglected the distribution grid – the big transformation is going on below the transmission level
- The EU level is essential: a new wave of regulation setting the frame
- Important decisions concerning the future system architecture are being taken in the next 12 months at EU level with little public control – more transparency and an accelerated learning process are urgently needed

Acknowledgements

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THANK YOU FOR YOUR ATTENTION

You will find this presentation and more on my website

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Ruggero Schleicher-Tappeser