The transformation of distribution grids in the context of the European Energy Transformation

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Agora Energiewende: Stakeholder-Dialog Verteilnetze

IMPRESSUM

SCHLUSSBERICHT
Empfehlungen des Stakeholder-Dialogs
Verteilnetze für die Bundespolitik

ERSTELLT IM AUFTRAG VON
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KONZEPT UND TEXT
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Disclaimer
Dieser Bericht ist das Resultat eines moderierten Diskussionsprozesses mit den vom genannten Teilnehmern.
Er stellt nicht notwendigerweise die Meinung von Agora Energiewende dar.
Driver 1: 
Politics wants renewable energies

- Binding EU target for 2020: 20% of all energy from renewable sources → renewable share in power production must be higher
- Targets for 2030: 45% Renewables ??
- Denmark: - 2020: 50% wind power
  - 2035: power and heat completely renewable
- Germany: - Reduce CO2 emissions by 80-95% until 2050

Lead scenario 2011: structure of gross power production
Driver 2: Breakthrough of ICT and semiconductor technologies

- PV: electricity production from solar radiation with semiconductors
  - No moving parts
  - No fuel, no operational costs
  - Mass production of standardised elements
  - High scalability, distributed application possible

- Semiconductor power electronics
  - Highly efficient converters, transformers
  - Remote control of electrical parameters
  - New options for DC applications and systems

- ICT
  - Complex control options with cheap distributed intelligence
  - Multi-level systems
  - Flexible configuration, involvement of a variety of actors

- Breakthrough of storage technologies ??
Cost of Ownership over 20 years in Germany

### Cost Breakdown

<table>
<thead>
<tr>
<th>Year</th>
<th>Investment</th>
<th>Interests</th>
<th>O&amp;M</th>
<th>Inverter Service</th>
<th>Land Lease</th>
<th>Insurance</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>€3,64</td>
<td>€0,99</td>
<td>€0,07</td>
<td>€1,82</td>
<td></td>
<td>€1,82</td>
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<tr>
<td>2010</td>
<td>€2,10</td>
<td>€0,10</td>
<td>€0,08</td>
<td>€1,05</td>
<td>€0,25</td>
<td>€1,00</td>
</tr>
<tr>
<td>2012</td>
<td>€0,99</td>
<td>€0,07</td>
<td>€0,08</td>
<td>€0,25</td>
<td>€0,10</td>
<td>€0,00</td>
</tr>
</tbody>
</table>

Data: Bächler (2013), PV-magazine
Unfamiliar to business and government: 5 to 10 times shorter innovation cycles

→ More rapid build-up of capacities (e.g. Dec. 2011 in Germany: 3,5 GW PV)
→ More rapid decrease of costs
→ More rapid transformation of the electricity sector

Dramatic acceleration compared to traditional energy technologies
Driver 3: New actors in the game

- Classical utilities have only a small share in renewable electricity generation
- Over 1 million solar power installations in Germany
- Local and regional initiatives and cooperatives
- **New actors** have other decision criteria and profit expectations
- Revival of municipal utilities with new business models
- IT and communication industries

Ownership of renewable power generation in Germany 2012

- Private persons: 34.90%
- Farmers: 11.20%
- Banks / funds: 11.20%
- Project companies: 12.50%
- Contracting comp.: 0.20%
- Commerce: 14.40%
- International utilities: 14.40%
- Regional utilities: 1.30%
- Other utilities: 3.50%
- "Large 4" utilities: 4.90%
- Others: 1.00%

Total: 72.9 GW
Politics calls for renewables
Generation change in technology
New actors use distributed RES

Fluctuating RES require flexibility
Distributed feed-in
Fix costs dominating
Increasing self-supply

Drivers for change
Challenges in the electricity system
Germany: 28.5% renewable electricity in Q1-2, 2014
Challenge 1: Fluctuating generation
Four basic options for more flexibility

1. **Flexible generation**
   - flexible fuel-based plants
   - curtailment of wind and solar

2. **Increased exchange**
   - grid expansion
   - on all levels

3. **Power storage**
   - requires cheaper storage
   - in proximity of generation or consumption

4. **Demand side management**
   - requires incentives and learning
   - Lowest system level
Challenge 2 – distributed generation
From centralised to distributed generation: the old system

Central generation, central balancing

Low grid costs

High grid costs
From centralised to distributed generation: new generation pattern – old logic?

Distributed generation, centralised balancing

- Partially reversed flows
- Reduced net flows
- Balancing requires strong exchange between levels
From centralised to distributed generation: active distribution grids

Distributed generation, balancing on all levels

- Active balancing on lower levels can significantly reduce the need for exchange
- This, however, requires new frame conditions
Liberalisation & Unbundling: Problematic disregard for spatial patterns

- Newly created markets entirely based on characteristics of traditional technologies
  - Large scale, highly centralised power generation
  - Considerable variable costs (fuel)
  - System governance on the top level, dumb distribution
- Intrinsic consideration of spatial aspects by the old monopolies was abolished
  - Growing role of non-spatial markets
  - More and more non-spatial balancing groups
  - Separate decision making for grid development and generation investments
  - Increasing divergence of grid pattern & generation pattern → more grids needed
- New technologies exacerbate this tendency → COPPER-PLATE APPROACH GETS INCREASINGLY UNSUSTAINABLE

- Technicians call for cellular structures and tendentially to go back to integrated area monopolies
- Economists insist on competition, but tendentially are stuck with old centralistic market structure

→ New Approaches are necessary
Challenge 3: Renewables have nearly no variable costs

- Present energy only markets have been designed for electricity generation with fuels and high variable costs.
- Growing share of renewables drives spot market prices down → generation cannot cover costs through these markets.
- Electricity supply becomes all infrastructure: long-term investments in grids & generation.
  - Public infrastructure (similar to water supply?)
  - Private long-term consumer goods (similar to houses?)
Challenge 4 – Self-Supply
Power from the roof cheaper than from the grid

Feed-in-tariff in Germany

Average household tariff (3000 kWh/a) (incl. VAT)

Tariff for commerce (100 MWh/a) Munich (without VAT)

-40%
Self supply boosts interest in energy management

Private household cloudless summer day, 4 persons, PV system 5 kWp
Without additional measures self-supply only ca. 30%

Commerce: Consumption mainly during sunshine hours

Shifting loads into sunshine hours

- Storing electricity
- Shifting loads
- Coupling with heat and mobility markets
- Flexibility of user system increases massively

Should be used for increasing flexibility of the whole system
Boom of self-supply to be expected: industry, small business, residential

- Inquiry on captive power generation in German industry:
  - 13% of have it, mostly conventional
  - additional 16% are planning, mostly RES
- Cost advantage interesting in growing number of countries
- Also self-supply with CHP increases
- Uncertainty about future regulatory framework

Belgium: Audi factory:
3,5 MW rooftop PV plant for self-supply

Germany: ALDI Süd:
> 100 food retail stores with PV:
own consumption 90%, self-supply 50%
Integrated heat and power supply: cheap heat storage increases flexibility

- Particularly interesting for large office and residential buildings
- Regulatory obstacles can be overcome
- District heating
High potential for self-supply threatens financiability of the system

Estimating the self-supply potential in Germany:

- Roof areas „well suited” for PV: 20% of electricity consumption
- PV on nearby surfaces: 10% of electricity consumption
- CHP: 10% of electricity consumption

50% of electricity consumption is directly used by industry and does not flow through distribution grids.

→ Electricity sales flowing through distribution grids could drop considerably
→ New tariff structures are needed
Politics calls for renewables
Generation change in technology
New actors use distributed RES
Fluctuating RES require flexibility
Distributed feed-in
Fix costs dominating
Increasing self-supply
Enhance grid capacity
Enable local balancing
Define client interface
Secure supply
Distribute costs equitably

Drivers ➔ Challenges ➔ Tasks
Task 1: Intelligent grid capacity management in distribution grids

- In a series of regions in Germany reverse flows are already frequent
- Reverse flow in distribution grids can cause capacity problems
- Adding conventional hardware to remove bottlenecks can be costly
- Over 80% of these costs can be saved by intelligent grid capacity management
- Most capacity problems are caused by voltage problems as voltage patterns change. Two strategies can be combined to avoid them:
  - Controlling reactive power in the distribution grid
  - Installing controllable local network substations where this is not sufficient
- Peak shaving can be the next step, grid pricing
- Approaches differ strongly concerning the required information exchange
Task 2:
Enable local balancing

- Delimitation ancillary services / volume market
- Local selling models
- Structuring of the balancing groups
- Grid fees
- Local markets
Task 3: Interface public system / client: external control or autonomy of the consumer?

Direct control by utility/DSO
- Calculable reaction
- Immediate response
- Short-term control concept

Control over price signal
- Price signal from supplier
- Manual or programmed reaction
- Contracts / learning of bulk effects

- High data volume exchange
- High requirements for technical interface (smart meters)
- Data security issues
- Local optimisation more difficult

- Low requirements for data exchange: only price signals and cumulated consumption / supply
- Market design needs to deliver time and location dependent price signals, stronger dependency on kW
- Combines with decentralised grid stabilisation concepts
Task 4: Multi-level responsibility

Top-down supply system
(central control)

Multi-level exchange system
(subsidiarity, shared responsibility)

Distribution Grid
Politics calls for renewables -> Generation change in technology -> New actors use distributed RES

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Increasing self-supply

Enhance grid capacity
Enable local balancing
Define client interface
multi-level responsibility
Secure supply
Distribute costs equitably

Grid costs: acceptance, distribution
Energy information system
Market design
Strong interests in a complex system: Lack of Transparency, Conflicts, Resistance to change
Outlook

• Turbulent change of the electricity system
• Increasing costs of the public system
• Increasingly interesting private solutions
• Strong efforts needed for adapting the system to new challenges, maintaining a reliable, affordable, public system
• Who pays the bill for the transformation?
• Public debate more and more confused
• Transparency!
Thank you

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