Market and network regulatory ROADMAPS for increasing electricity generation variable by Wind, PV and CHP in Europe Up till 2020 and beyond

Measures and regulation to increase the generation, market and demand flexibility & controllability for systems for systems: based on Denmark Roadmap

Grohnheit, Poul Erik

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Measures and regulation to increase the **generation, market** and **demand flexibility & controllability for systems** for systems: based on Denmark Roadmap

Poul Erik Grohnheit, Risø DTU, Technical University of Denmark

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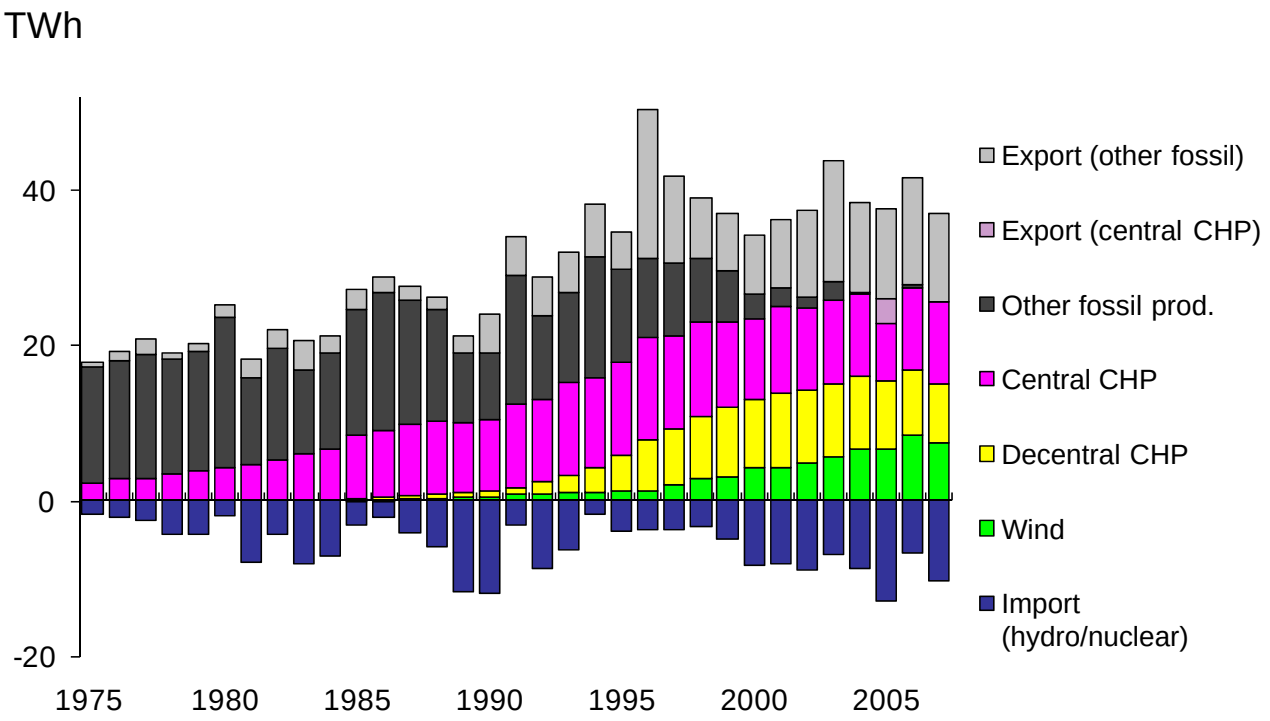
Overview

- Starting point: Result of the old Danish ‘Roadmap’
- Is more than 25 % wind power feasible in a regional electricity market?
- Price areas for electricity spot markets
- Aggregation of DG/RES units
- Micro CHP
- Demand response
- Denmark: Final RESPOND roadmap
- Summary of recommendation for generation and demand

Denmark: Starting point for RESPOND roadmap

- Two small electricity market
- Strong connections to neighbours
- Trade depending of variations in hydro power
- 20 % wind in electricity market
- Nearly 50 % district heating in heat market
- CHP with heat storages
- Limited market for industrial CHP
- Some potential for micro CHP

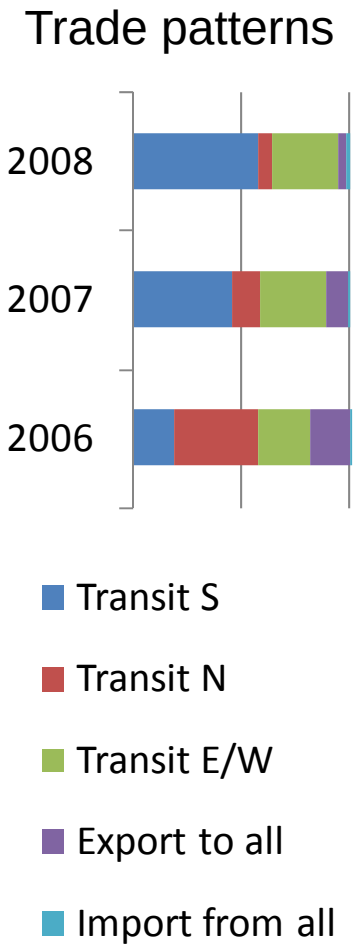


The figure summarises the result of the official Danish 'Roadmap' developed 1976-1981 as a result of the oil shocks in 1973 and 1979.

Electricity production and import, Denmark 1975-2007.
Source: Dansk Energi and own calculations.

Electricity flows and capacities in the Nord Pool price area Western Denmark

	2006	2007	2008
Consumption, TWh	21.4	21.6	21.6
Wind production, TWh	4.6	5.6	5.2
Net Import, North, TWh	-2.4	3.5	5.6
Net Import, South, TWh	-2.1	-5.2	-6.6
Share of wind	22 %	26 %	24 %
Central thermal capacity, GW	3.40	3.40	
Decentral thermal capacity, GW	1.74	1.74	
Wind power capacity	2.39	2.39	
Max. Load, GW	3.75	3.77	3.75
Min. Load, GW	1.41	1.38	1.30
Max. Wind, GW	2.20	2.21	2.18



Wind power extremes in the Nord Pool price area Western Denmark

	2006	2007	2008
Wind production above 100 % of consumption, hours	27	50	43
Wind production below 10 % of consumption, hours	381	371	352
Above 100 €/MWh and wind production below 10 % of consumption, hours	7	8	12
12 or more consecutive hours with wind production below 10 % of consumption, events	13	9	7
Highest number of consecutive hours with wind production below 10 % of consumption	40	76	25
Above 100 €/MWh and up-regulation more than 20 % higher. hours	1	5	22
Down-regulation negative prices, hours	201	137	46
Up-regulation above 100 €/MWh, hours	68	204	585
Up-regulation above 200 €/MWh, hours	1	65	120
Elbas (intraday market): Price quotations, Elbas, hours (from April 2007)	0	1070	1834
Elbas: Difference more than 10 € to area price, hours	0	132	622

Market development – Nord Pool price area Western Denmark

- Nord Pool (Norway from 1993 expanded to other Nordic countries)
- Western Denmark day-ahead market since July 1999
- With auctions for reserves and regulation market
- Balancing responsible parties (production and consumption)
- Co-operation between TSO and market players on IT-development
- Decentral CHP above 10 MW must take part in the market from 2005 (above 5 MW from 2007)
- Block bids (minimum reduced from 4 to 3 consecutive hours from 2006)
- Daily auctions for reserves from 2007
- Elbas introduced from 2007
- DSO development of 'smart grids'

Market development driven by
- Import, export and transit
- Wind power
- Large and small-scale CHP

Support schemes for DG/RES

- Feed-In-Tariffs have been the most widely used type of support of DG/RES
- However lack of incentives to meet system needs
- Premium on the spot market price is preferred, when the share of intermittent generation becomes significant
- The market premium for wind may be as low as € 13 per MWh – compared to the typical wholesale price 50 €/MWh
- A negative price floor at -200 €/MWh has been introduced in some day-ahead markets – as an incentive for down-regulation even for wind power

Price areas for electricity spot markets

- Western Denmark: Spot prices are highly influenced by wind
- The intraday market started late (April 2007) – with very limited liquidity
- Price areas are necessary for proper price signals for both generators and consumers
- The same prices are used for congestion management in the transmission network (market splitting and implicit auctions)
- The Netherlands is similar to Western Denmark in area, climate, international connections, wind power and CHP, but the electricity system is six times larger
- Other regions may be similar, although not identified as price areas
- Recommendation: Market splitting by geographical price areas should be introduced in Germany, UK and Spain, when spot prices become dependent of wind

Aggregation of DG/RES units

- Small and medium scale CHP in Denmark facing the electricity market from 2005 led to a significant increase in flexibility.
- Balance Responsible Parties, brokers and other entities can operate ‘virtual power plants’, covering a range of technologies and markets.
- Once established, aggregators may dynamically develop their portfolio of units and support the necessary infrastructure.
- Recommendation: Encourage aggregation of DG/RES units by brokers/Balance Responsible, etc. operating Virtual Power Plants on day-ahead, intraday and balancing markets.

Micro CHP – and larger systems

- Micro CHP is not yet a mature technology
  – several technologies are being developed
- Usually limited flexibility of industrial CHP
- Large-scale implementation of micro CHP in households should consider 3 kW units with heat storage rather than 1 kW units
  – for flexible response to intermittent generation
- Economies of scale for CHP technologies
- Heat distribution systems are necessary for flexible operation and competition between fuels and technologies
- Heat storages, heat pumps and electric boilers for down-regulation may be added to heat distribution
- Recommendation: Support schemes for CHP should balance conversion technology and heat distribution infrastructure

Demand response – Background

Demand response is to get **customers to react to variations in supply**.

Increased intermittent production e.g. wind implies an **increased and stochastic variation in production.**

When production from intermittent producers is high, the price becomes low and demand should increase and vice versa. That is, market prices may be used as an incentive for demand response.

Requires interval metering and that customers actually are charged for their consumption on an e.g. hourly basis. **Time-of-Use prices do not reflect the stochastic nature of intermittent productio**n and prices should be hourly market prices.

At present price incentives in the market are very small and most customers do not react to hourly prices when charged these.

Demand response – Recommendations

Recommendations related to demand response:

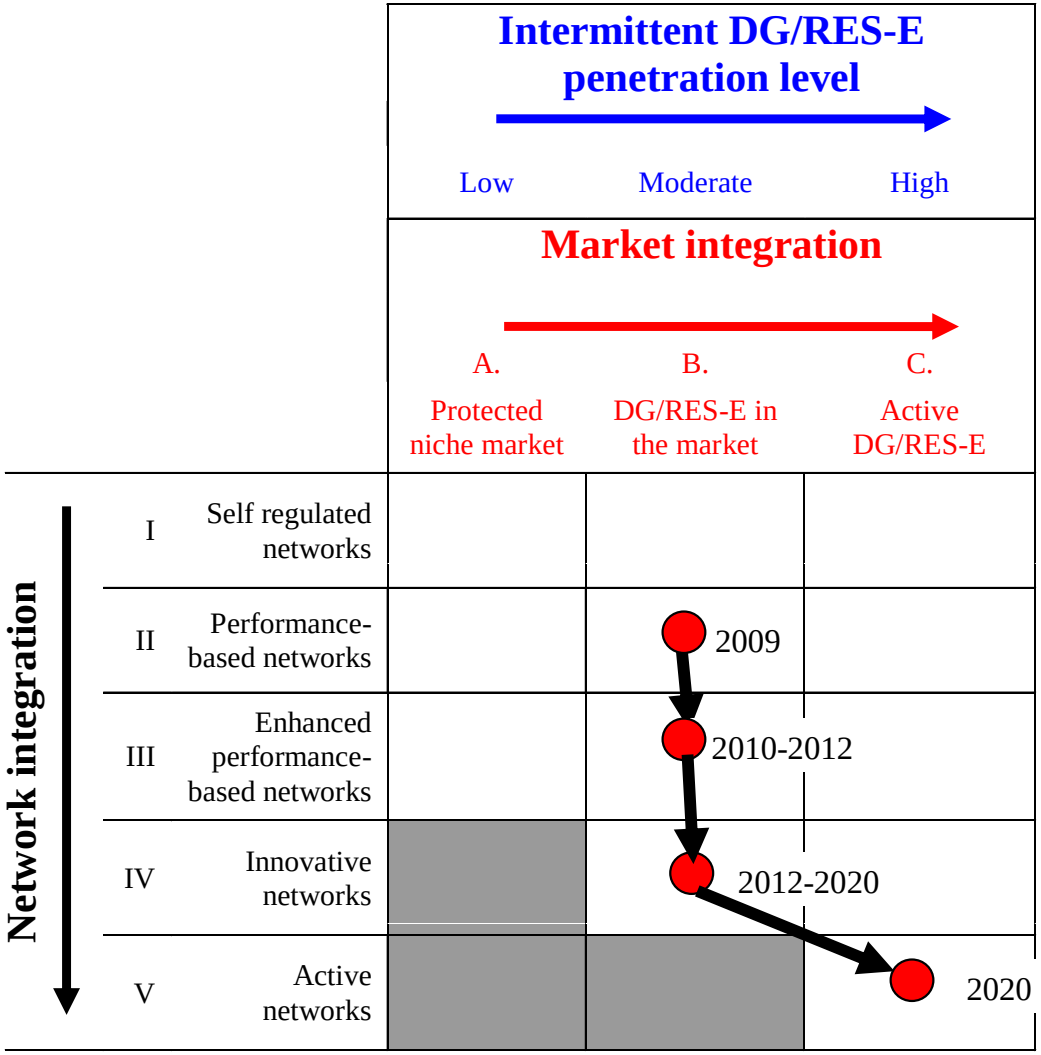
- Hourly metering of consumption
  - general roll-out of meters cheapest per meter, but not necessarily the optimal solution
  - **communication standards** and functionality of meters need clarification

- Prices
  - should by default be **hourly market prices** (with increased intermittent production variation in hourly prices will increase)
  - **Fixed price-additives** e.g. taxes should be **reduced**, or changed to % on market prices (has implications for security of revenues and variations in bills)

- Technologies
  - information on market prices (costs of obtaining information should be reduced)
  - **automatic response to prices** or other signals in the net or from TSO´s, e.g. frequency controlled cut-off of demand
  - **electrical vehicles should be charged according to system needs**
  - storage technologies at present expensive, may become cheaper in the future

Denmark: Final RESPOND roadmap

- Energinet.dk is operating electricity and gas networks since 2005
- District heating networks are operated by local companies
- The Energy.dk 20-20-20 Roadmap considers all three networks for the target of 50% wind energy



Summary of recommendation for generation and demand

- Increasing the flexibility of conventional generation, i.e. Hydro power with reservoirs and gas fuelled plants
- Enhance response capabilities by peak load units and heat distribution systems supplied by CHP
- Establish commercial aggregators to develop ‘virtual power plants’
- Establish geographical price areas for spot and balancing markets
  - to provide proper price signals for generation, demand response, and network congestion management