TRANSITION OF THE DANISH POWER SYSTEM
-from fossil fuels to large scale wind power

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ENERGINET
THE DANISH TRANSMISSION SYSTEM OPERATOR

We own and operate the overall electricity and natural gas transmission system in Denmark.

- Independent public enterprise owned by the Danish Ministry of Energy, Utilities and Climate
- The consumers contribute to our activities through tariffs
- Our finances are based on a break-even principle (regulation to be revised!)

Mission: Reliable energy for society
Vision: Balanced and sustainable energy supply
THE ENERGY SYSTEM IN DENMARK IS CHANGING

• By 2020, wind power will constitute 50% of the electricity consumption
• By 2030, renewable energy will constitute 50% of the energy consumption
• By 2050, Denmark will be independent of fossil fuels

Strategic commitments of Energinet:
- Security of supply
- Efficient green transition
- Healthy investment climate
THE DANISH POWER SYSTEM – OVERVIEW

- Characteristics of the system
FLEXIBILITY AND MARKETS ENSURE FULL UTILIZATION AND BALANCE

- One week in September 2015 illustrating the highly flexible Danish power system

- High variation in residual demand compared to “classic” demand
- On Wednesday (2nd September), no central units in operation
- The market handled the dispatch of the system
OPERATING THE DANISH POWER SYSTEM WITHOUT CENTRAL STATIONS

Characteristics:

• Market does not schedule any central power station in DK-W to operate (2nd September 2015 and later occasions)

• System stability by operating:
  • SK4 VSC (700 MW DK-NO)
  • Synchronous compensators:
    • 4 in DK-W
    • 2 in DK-E
TOOLBOX FOR EFFICIENT LARGE SCALE RES INTEGRATION

- Strong transmission grids and interconnectors
- International electricity markets
- Flexible generation system
- High quality forecasts and market based operation
TRANSMISSION – EUROPEAN COOPERATION

**TYNDP in numbers**

**TYNDP 2018**

2030

- 48 to 58% of the demand covered by renewables in TYNDP 2030 scenarios
- 65 to 75% CO2 emissions reduction in TYNDP 2030 scenarios compared to the 1990 levels
- €114bn proposed investments by 2030
- €2bn to 5bn annual savings in generation costs due to TYNDP projects

166 Transmission Projects proposed:
- Consisting of 357 investments
- 261 Overhead Lines
- 77 Subs
- 23 Underground Cables

15 Storage Projects proposed:
- 12 Hydro Pumped Storage
- 3 Compressed air

**New RES**
- Bioenergy
- Wind energy
- Solar energy
- Electricity Highways 2050

ENTSO-E: European Network of TSOs - Electricity
THE ELECTRICITY MARKETS
The Electricity market is not just one market, but a suite of markets
DAY AHEAD MARKET COUPLING

The European market is coupled in the day ahead market. This means that power produced in Italy can be consumed in Finland.

The price, generation, exchange for each area are calculated with the restrictions of capacities on the interconnectors.

All calculations are done in the same algorithm (Euphemia).
HIGH FLEXIBILITY OF POWER PLANTS

Operational range: 10–100%

Ramping rate: 3-4% per minute

Heat accumulators and electric boilers

Source: Dong Energy
Energinet.dk forecasts
- Wind power
- Solar PV
- Load

BRP power schedules
- Planned production
- Technical min/max.

Energinet.dk online measurements
- Production
- Exchange
- Load

Interconnector schedules
- Germany
- Sweden
- Norway
- DK1-DK2

- All wind in DK has balance responsibility
- ~100% wind traded on NordPool
- Economic support schemes for wind (e.g. market price plus 3-4 cent/kWh)
- Offshore parks: lowest price from tender
WIND POWER FORECASTING

NCC takes over balancing task

Mean Absolute Error

+ on-line measurements!
OUTAGE MINUTES (ELECTRICITY) IN EUROPE
- VERY HIGH SECURITY OF SUPPLY IN DENMARK IN PERIOD WITH INCREASING SHARE OF RENEWABLES
CONCLUSION

Measures of large scale renewables

50% wind by 2020 => 100% fossil free by 2050

Measures and solutions

Strong transmission grids
International electricity markets
Flexible generation system
Harmonized Grid Codes
High quality forecasting
Market based operation

Sector coupling: power system with the heat and transport sector

Long term: P2G integration with the gas sector (power to gas)
Thank You for your attention.

For more information visit www.energinet.dk