GRID INTEGRATION & PLANNING
- EXPERIENCES FROM DENMARK

Windergy India 2017

Peter Jørgensen, Vice President, Energinet
ENERGINET – STATE-OWNED TRANSMISSION SYSTEM OPERATOR

- Ensure short- and long-term security of supply for electricity and gas
- Ensure well-functioning markets for electricity and gas
- Own, operate and develop the gas and electricity transmission grids
THE ENERGY SYSTEM IN DENMARK IS CHANGING

- By 2020, wind power will constitute 50% of the electricity consumption
- By 2050, Denmark must be completely independent of fossil fuels

Strategic commitments of Energinet:
- Security of supply
- Efficient green transition
- Healthy investment climate
DEVELOPMENT OF THE POWER SYSTEM IN DENMARK

Drivers:
• Attractive feed-in tariffs/premiums
• Favorable grid connection conditions
• “One-stop shop” permit processes based on a stable political commitment!

Grid Integration and Planning

Energy balance 2015

- Wind Power: 42%
- Central Power Plants: 27%
- Local Power Plants: 11%
- Imports: 46%
- Exports: 28%
A WEEK IN DENMARK WITH 51% WIND POWER
MARKET DRIVEN DYNAMICS
EXAMPLE: HIGH WINDS – LOW PRICES – NO LARGE POWER PLANTS in DK West
DENMARK - PART OF A LARGER MARKET AREA

http://www.ifitweremyhome.com/compare/DK/IN
TOOLBOX FOR EFFICIENT WIND POWER INTEGRATION IN DENMARK

- Strong transmission grids and interconnectors
- International electricity markets
- Flexible generation system
- Specialized forecasting and operational planning tools
HIGH FLEXIBILITY OF POWER PLANTS

Operational range: 10–100%

Regulating rate: 3-4% per minute

Heat accumulators and electric boilers

<table>
<thead>
<tr>
<th>Technical key data of Esbjergværket CHP Plant</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Commissioned</td>
<td>1992</td>
</tr>
<tr>
<td>Max power production (net)</td>
<td>378 MW</td>
</tr>
<tr>
<td>Max district heat production</td>
<td>460 MJ/h</td>
</tr>
<tr>
<td>Coal consumption at full load</td>
<td>120 t/h</td>
</tr>
<tr>
<td>Oil consumption at full load</td>
<td>73 t/h</td>
</tr>
<tr>
<td>Steam pressure</td>
<td>251 bar</td>
</tr>
<tr>
<td>Steam temperature</td>
<td>560 °C</td>
</tr>
</tbody>
</table>

Source: Dong Energy
EVEN WIND FARMS REACT ON MARKET PRICES
- AND PROVIDE ANCILLARY SERVICES
NETWORK CODES TO ENSURE GRID SUPPORT FROM ALL ASSETS

Connection Codes

Market Codes

Operation Codes

Grid Integration and Planning
WIND POWER FORECASTS TO REDUCE IMBALANCES

Mean Absolute Error (MAE) as a function of horizon [hours].

+ on-line measurements!
OPERATIONAL PLANNING SYSTEMS TO REDUCE RISKS AND COSTS
- PREDICTED IMBALANCE – ON-LINE UP-DATED

Closing the gap before the operating hour

Predicted Imbalance
IT IS ALL ABOUT MAXIMIZING THE VALUE OF WIND POWER GENERATION - AND MAINTAINING SECURITY OF SUPPLY

+ value of ancillary services provided by wind turbines

1. Profile costs
   - Relative market value of wind power (DK West)

2. Balancing costs < 10% in DK with 40% WP

3. Grid investments often constitute positive business cases for society

Source: Lion Hirth, from presentation "The Optimal Share of Variable Renewables", 8 July 2015
ENERGY BECOMES SUSTAINABLE
In 2050, all energy in Denmark must come from renewable energy sources

WWW.ENERGINET.DK

THANK YOU FOR THE ATTENTION