Harvesting energy
FROM THE SUN

Thermal Energy Storage & The Green Transition of Coal

Jes Donneborg
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There is no all-mighty technology
Denmark is known for its wind power

And its Large scale flat panel installations
Chinese CSP projects

China 1st Phase 20 Pilot CSP Projects Distribution

- Qinghai SUPCON Solar Delingha 50MW MS Tower Project
- Northwest Engineering Gonghe 50MW MS Tower Project
t- Huanghe Hydropower Development 135MW DSG Tower Project
- Beijing Shouhang IHW Resources Saving Technology 100MW MS Tower Project
- China Three Gorges New Energy Jinta 100MW MS Tower Project
- YumenXinneng 50MW MS Tower Project
- GuohuaYumen 100MW MS Tower Project
- Northwest Electric Power Design Institute Hami 50MW MS Tower Project
- Dahua Inc. Shangyi 50MW DSG Tower Project
- Royal Tech Yumandongzhen 50MW PT Project
- Shenzhen JinfanAkesai 50MW molten salt PT Project
- Raypower Group Yumen 50MW PT Project
- CECIC Gansu Wuwei Solar Power Gulan 100MW PT Project
- Inner Mongolia China Nuclear Royal TechWuzhongqi 100MW PT Project
- CGN Delingha 50MW PT Project
- Zhongyang Zhangjiakou Chabei 60MW PT Project
- DCTC Dunhuang 50MW MS CLFR Project
- Northern United Power Ulad 50MW CLFR Project
- CITIC Zhangbei DSG 50MW CLFR Project
- ZhangbeiHuaqiang Group Zhangjiakou DSG 50MW CLFR Project
A solution can combine CSP and surplus Wind Electricity with high temperature and low temperature storage.
In Denmark we have wind power, but also coal power

### Electrical grid, in Denmark 2018

<table>
<thead>
<tr>
<th>Source</th>
<th>Production (GWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Power Plants</td>
<td>9.573</td>
</tr>
<tr>
<td>Public Power Plants</td>
<td>2.943</td>
</tr>
<tr>
<td>Wind Turbines</td>
<td>13.899</td>
</tr>
<tr>
<td>Solar Photovoltaic</td>
<td>953</td>
</tr>
<tr>
<td>Import</td>
<td>15.634</td>
</tr>
<tr>
<td>Export</td>
<td>10.409</td>
</tr>
</tbody>
</table>

**CO2- Emission Avg. (2017)**: 200 g/kWh
Spot market – an instrument to balance the Grid through trading and import/export of power
Typically export situation – High wind

Export – 59 kr/MWh
(Money in the bank)
Typically import situation – No wind

Eur/MWh – Nord pool DK1

Import
335 kr
Money out of the box
loss 500,000 Kr/h
1,600,000,000 Kr/y

With 3 x 800 MW
Additional Wind
3,200,000,000 Kr/y
Typical Coal fired power plant unit generating electricity and heat
Coal fired unit replaced with high temperature storage with Molten Salt and Steam generator.
Possible combination with CSP to enhance the business case by additions of Solar energy.
Preliminary prediction of P/L from operation and Investment

Investment in storage incl Boiler and heater
Using existing Turbine and DH infrastructure
150-180 DKK/KWh.
Investment 4.000 MWH = 650 Mio DKK
The future Total Utility Requirements

*To supply the population with reliable green utilities such as Electricity, Heat as well as Fuel in a well balanced network*

More Wind
More Solar PV/CSP
More Geothermal energy
More Heatpumps
More Production of Hydrogen from High Temperature Electrolysis for green transition of the transport sector

Large electrical High Temperature energy storage systems (days/weeks)
Large district heating Low Temperature energy storage systems (weeks/month)
The future Power grid “Questions to be answered”

The future Electricity system
4.700 MW Existing Wind farms
3 x 800 MW New Off-shore wind farms.
(4.700 + 2.400 = 7.100 MW)

Is a new Cabel to UK of 1,300 MW the solution? Are we buying Green Energy?

Is relying on Power Ex/Import the solution?

Are we in position to plan and consume power only when the wind is blowing?

How does EX/IM affect the BNP?

How about our supply security? (Cabel breaks)

Does it have value to be able to store Green Power and be able to return Power to grid?
Conclusion

✓ Reuse existing infrastructure
✓ Use well known technology

AND

➢ Keep the green energy inside the country

Thank You