Proton Ventures
Decentralised Ammonia Production
In the Netherlands;
the solution for storing sustainable energy

Presentation dd 21-9-2016
Our vision is to develop and implement sustainable, decentralized and small-scale ammonia production plants and/or energy storage systems, stored as anhydrous ammonia for various applications such as fuel storage applications, chemicals and/or, fertilizers.
Just a case study
GEEN KOLEN MAAR WINDMOLEN
Nuon-4-ammonia

- [https://www.youtube.com/watch?v=VRUzakQkvwM](https://www.youtube.com/watch?v=VRUzakQkvwM)

- [Superbatterij-Eemshaven.mp4](https://www.youtube.com/watch?v=VRUzakQkvwM)
The Dutch Grid

NH3_Storage 1

NH3_Storage 2
“The case study”

sponsored by RVO and partners

- Extended Literature Search
- Out of box thinking
- Market studies on Power and chemicals under study
- Recent problems and CO2 emission targets
- Stake holder discussions
- Actual project ideas
Growth of wind power in the European Union

Yearly Capacity Installations (GW) and Cumulative Capacity (GW) from 2000 to 2015.
EU member state market shares for total installed capacity (GW). Total 141.6 GW.
Source: (EWEA 2016)
European cross-border flows. (Source: (TENNET 2016))

Figure 28: Annual total of physical cross-border flows in CWE region and at the German borders in TWh. Source: TenneT, ENTSO-E, Swissgrid
Discrepancy (Actual – Forecast wind power) per hour in Germany

Discrepancy (MW)

Time - Hourly for one year
Hourly discrepancy (Actual – Forecast wind power) in Germany
Table 4.1: Energy storage technologies

<table>
<thead>
<tr>
<th>Storage type</th>
<th>Power rating</th>
<th>Suitable storage duration</th>
<th>Response time</th>
<th>Technical lifetime</th>
<th>Technological maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pumped Hydro</td>
<td>100 MW to GW’s</td>
<td>hours to years</td>
<td>sec-min</td>
<td>25+ years</td>
<td>Commercial</td>
</tr>
<tr>
<td>Compressed Air</td>
<td>10-100 MW’s</td>
<td>hours</td>
<td>sec-min</td>
<td>25+ years</td>
<td>Commercial</td>
</tr>
<tr>
<td>Flywheel</td>
<td>1 MW</td>
<td>hours</td>
<td>sec-min</td>
<td>20 years</td>
<td>Commercial</td>
</tr>
<tr>
<td>Electrical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacitors</td>
<td>&lt;100 kW</td>
<td>&lt;1 hour</td>
<td>sec</td>
<td>25+ years</td>
<td>Partially commercial</td>
</tr>
<tr>
<td>Superconductor magnet</td>
<td>10 kW-1 MW</td>
<td>&lt;1 hour</td>
<td>sec</td>
<td>25+ years</td>
<td>Partially commercial</td>
</tr>
<tr>
<td>Electro-chem</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Battery (various types)</td>
<td>&lt;50 MW</td>
<td>min-hours</td>
<td>sec</td>
<td>5-10 years</td>
<td>Commercial</td>
</tr>
<tr>
<td>Chemical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrogen</td>
<td>kW-GW</td>
<td>hours to years</td>
<td>sec-min</td>
<td>20 years</td>
<td>Development</td>
</tr>
<tr>
<td>Ammonia</td>
<td>kW-GW</td>
<td>hours to years</td>
<td>sec-min</td>
<td>20 years</td>
<td>Development</td>
</tr>
<tr>
<td>Thermal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensible/latent heat</td>
<td>10-100 kW’s</td>
<td>hours</td>
<td>sec-min</td>
<td>5-10 years</td>
<td>Partially commercial</td>
</tr>
</tbody>
</table>
Overview of energy storage technologies
Production, transport and storage costs for ammonia and hydrogen

<table>
<thead>
<tr>
<th></th>
<th>Hydrogen (€/kg $H_2$)</th>
<th>Ammonia (€/kg $H_2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production</strong></td>
<td>2.70</td>
<td>3.40</td>
</tr>
<tr>
<td><strong>Pipeline transport</strong></td>
<td>1.69</td>
<td>0.17</td>
</tr>
<tr>
<td><strong>Storage</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 day</td>
<td>0.71</td>
<td>0.03</td>
</tr>
<tr>
<td>15 day</td>
<td>1.78</td>
<td>0.05</td>
</tr>
<tr>
<td>182 day</td>
<td>13.48</td>
<td>0.49</td>
</tr>
</tbody>
</table>
Roadmap CO₂ Reduction NL – Nuon View

First step until 2030: *Current technologies*

Power CO₂ emissions reduction towards ~21 Mton in 2030.
Total demand: ~120 TWh
Average CO₂ emission: ~175 kg/MWh

- Primarily wind/solar new built, 50% of demand
- Phasing out coal or decrease emissions to level of gas
- Gas: ~18 Mton emissions for ~45 TWh of power
- Other emissions waste/industry related
- Demonstration of (storage) technologies needed >2030

Second step after 2030: *Tech to be developed*

Power CO₂ emissions reduction towards ~7 Mton in 2050
Total demand 150..200 TWh due to electrification.
Average CO₂ emissions: <50 kg/MWh

- Remaining gas CCGT (20 TWh / 7 Mton emissions)
- Wind / solar up to 60% of demand
- New built power production and storage that needs to be (a) flexible and (b) zero emission (~50 TWh)
- Large scale electrification of transport, industry, heating
Actual Plan in phases

- Production of ammonia in decentralised places
  - North Netherlands, in combi with H2 byproduct/ Electrolysers/Solar/wind
- NH3 storage 1
- Development of 400 ktpa ammonia convertor based on sustainable energy
  - Pricing realistic compared to peak power ( @sustainable cheap NH3)
  - Economic at price levels of Peak power (max 5 times bottom price power)
  - Proven technology (Haber Bosch initial, later Battolyser/SSAS etc)
  - To avoiding grid problems ( exactly at main grid)
  - Logistical problems solved ( at shore)
  - Power production solved (guarantees by Power plant builders)
  - Accepted by stakeholders
Actual Ideas

• NH3 storage 2
• **Tidal Energy** based at no grid/low voltage grid
  – New infrastructure cheaper than cables (CAPEX discussion)
  – Logistics solved (short distances /conversion to urea)
  – Acceptable by Dutch laws (especially storage at tourist attraction)
  – Acceptable by Permitting conditions
  – Pricing of such ammonia/Power
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Ongoing projects

• Power/to/ammonia: Rethinking the role of ammonia/from a value added product to a flexible energy carrier
• Decentralized production of ammonia
• Power2Ammonia
  Value Chains and business cases in industrial and rural circumstances
• Gas2ammonia
  • Biogas, flared gas, waste gases
Decentralized production of Ammonia for usage as a fuel, fertilizer or de-nox
Conclusions

• Small scale production of NH3 to solve CO2-emissions is “best solution”
• Can be economical at levels of app 300 Euro/t NH3
• Is proven technology for
  – Gas2ammonia/biogas2ammonia/Power2/ammonia
• NH3 conversion to Power expected to be “proven” for mix of 25% NH3 in Nat gas, to increase to 40% target
• If 40% it seems solving the problems till 2030.
• Further improvements on technology always interesting/but mainly on H2 costs.

Thus:

• **Decentralised Power2ammonia is the only solution in NL and maybe many other countries/areas.**
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Thank you

Questions?