WP2
Power-to-gas plants in a future Nordic District Heating System

7h researchers’ seminar
Jussi Ikäheimo (VTT)
Introduction

• Revisit the topic "Power-to-gas usage in the North European market with high shares of wind and PV"

• Power-to-gas plants in a future Nordic District Heating System
Simulation cases

**PV**
- 300, 450, 600 €/kW

**Battery**
- 150, 300 €/kWh

**Power to gas**
- 500, 1500 €/kW

**EV**
- 40 %
Annual power & heat generation

**power**

<table>
<thead>
<tr>
<th>Power generation TWh/a</th>
<th>P2G 1500 €/kW</th>
<th>P2G 500 €/kW</th>
<th>PV 300 €/kW</th>
<th>PV 600 €/kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elec. storages</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydro</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuclear</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**district heat**

<table>
<thead>
<tr>
<th>District heat generation TWh/a</th>
<th>P2G 1500 €/kW</th>
<th>P2G 500 €/kW</th>
<th>PV 300 €/kW</th>
<th>PV 600 €/kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat storages</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mun. waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Annual wind & solar power generation

wind

solar PV

Wind power generation TWh/a

Solar PV generation TWh/a

PV 300 €/kW  PV 450 €/kW  PV 600 €/kW

plan - P2G 500 €/kW
plan - P2G 1500 €/kW
oper. - P2G 500 €/kW
oper. - P2G 1500 €/kW

NEO CARBON ENERGY
P2G investments and operation
Optimizing power-to-gas within a district heating network
Glance at VTT’s models

Spatial scale

VTT-TIMES

Balmorel

Wilmar

DHUC

Temporal scale
DHUC structure

- Electricity
- Solar
- Wind
- Heat pump
- Bio-CHP plant
- CO₂ storage
- Heat boiler
- Solar thermal
- Heat storage
- Heat
- Electrolysis
- Storage
- Methanation
- Compression
- Distribution
- SNG
- Export
Simplified plant model

Steam cycle

Boiler

FGC

G

CO₂ storage

shipping

CO₂ storage

H₂

CH₄
Some economic assumptions

<table>
<thead>
<tr>
<th>plant</th>
<th>category</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>P2G</td>
<td>investment cost</td>
<td>750 – 1250 €/kW&lt;sub&gt;e&lt;/sub&gt;</td>
</tr>
<tr>
<td>P2G</td>
<td>O&amp;M fixed cost</td>
<td>10 €/kW-year</td>
</tr>
<tr>
<td>P2G</td>
<td>O&amp;M variable cost</td>
<td>3 €/MWh</td>
</tr>
<tr>
<td>P2G</td>
<td>efficiency (LHV)</td>
<td>54 %</td>
</tr>
<tr>
<td>PCC</td>
<td>Investment cost</td>
<td>1000,000 €/(t/h)</td>
</tr>
<tr>
<td>PCC</td>
<td>O&amp;M fixed cost</td>
<td>40000 €/a/(t/h)</td>
</tr>
<tr>
<td>PCC</td>
<td>O&amp;M variable cost</td>
<td>8 €/t</td>
</tr>
<tr>
<td>CO&lt;sub&gt;2&lt;/sub&gt; storage</td>
<td>inv. cost</td>
<td>1800 €/t</td>
</tr>
<tr>
<td>heat pumps</td>
<td>inv. cost</td>
<td>575 €/kW&lt;sub&gt;th&lt;/sub&gt;</td>
</tr>
<tr>
<td>bio boiler</td>
<td>inv. cost</td>
<td>400 €/kW</td>
</tr>
</tbody>
</table>

![Graph](image)
Power-to-gas investments in the system

Price region resulting from Balmorel
Heat generation profiles

- Power to gas utilizes heat storage for excess heat in summer
- Accounting for 50\% of bio-based emissions leads to lower CHP utilization
- Power-to-gas capacity is also reduced from 780 to 610 MW
- Both bio and gas boilers are used only at peak demand
Local scheduling compared to the multinational model

- Possible to see the effects of multinational RES production on local level
CO₂ value in storage

CO₂ storage tons

SNG value €/MWh

750 €/kWh
1000 €/kW
1250 €/kW

value of CO₂

€/t

NEO CARBON ENERGY
Case for PCC?

- Optimizing the post-combustion capture plant capacity leads to a much smaller plant.
- This affects also power-to-gas but it remains profitable in the 1000 €/kW and 80 €/MWh_{SNG} case.
Conclusion

- Power-to-gas at the SNG cost level defined by multinational models looks very profitable in a district heat network setting
  - Break-even SNG price 65-80 €/MWh_{LHV}
- CO_{2} storage is an important element in decoupling power-to-gas and CHP
- Heat storages further decouple demand and heat generation
- Plants were assumed price takers
  - We must take into account the possible effects in power price
Thank you