<table>
<thead>
<tr>
<th>Times:</th>
<th>Speakers:</th>
<th>Content:</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:00 – 09:30</td>
<td></td>
<td>Registration, coffee</td>
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<tr>
<td>09:30 – 09:40</td>
<td>Peter Petrov</td>
<td>Welcome and introduction</td>
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<tr>
<td></td>
<td>Project officer for CO2Europipe</td>
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<td></td>
<td>DG-Research</td>
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<tr>
<td>9:40 – 10:00</td>
<td>Filip Neele</td>
<td>CO₂ transport network scenarios to 2050</td>
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<td></td>
<td>Project coordinator, CO2Europipe</td>
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<tr>
<td></td>
<td>TNO, the Netherlands</td>
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<tr>
<td>10:00 – 10:20</td>
<td>Wim Mallon</td>
<td>Technical challenges</td>
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<td></td>
<td>Senior researcher</td>
<td></td>
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<tr>
<td></td>
<td>Gasunie, the Netherlands</td>
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<tr>
<td>10:20 – 10:50</td>
<td>Tom Mikunda</td>
<td>Policy, regulations, risks</td>
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<tr>
<td></td>
<td>Senior researcher</td>
<td></td>
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<td></td>
<td>Energy research Centre of the Netherlands</td>
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<tr>
<td>10:50 – 11:30</td>
<td>Stijn Santen</td>
<td>Case study results: from detail to high-level analyses</td>
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<td></td>
<td>Director</td>
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<td></td>
<td>CO₂ Net BV</td>
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<tr>
<td>Panel discussion – (Chair: Peter Petrov)</td>
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<td>Panel discussion on the results from the project, their implications and follow-on steps</td>
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<tr>
<td>11:30 – 12:30</td>
<td>Mike Haines (IEA-GHG)</td>
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<td></td>
<td>Barend van Engelenburg (DCMR, NL)</td>
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<td></td>
<td>Russel Cooper (CCSA, UK)</td>
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<td></td>
<td>Wim Guijt (Shell)</td>
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<tr>
<td></td>
<td>Thomas Thielemann (RWE, GE)</td>
<td></td>
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<tr>
<td>12:30 – 13:30</td>
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<td>Lunch</td>
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<td>Close</td>
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Project overview, CO\textsubscript{2} transport scenarios
CO2Europipe

• Aim
  • Define requirements for development of future, large-scale CCS transport network in Europe
    • EU, national initiatives / regulations
    • Timeline for policies / regulatory frameworks to be put in place

• Method
  • Define future large-scale CCS transport requirements
    • CO₂ volumes: what, where, when?
    • Network lay-out ((inter)national, simple or complex)
    • CO₂ management (cross-border issues)
    • Regulations
Future (long-term) CCS infrastructure lay-outs

• Identified future infrastructures from current knowledge of timing of capture and storage

• Study architectures: technical, societal, environmental, etc impacts
  Use current situation as starting point

• Develop business models for different architectures, plus impact of upscaling for large-scale infrastructure

• Derive recommendations
Business cases
Early projects

1. Rotterdam
   • Storage DCS
2. Rhine / Ruhr area, Northern Germany
   • Storage in North Sea, through Emden or Rotterdam
3. Norwegian mainland – North Sea
   • Kårstø offshore CO₂ pipeline
   • EU case
4. Options for CCS in central Europe
   • Poland, Czech Republic
   • National; cross-border
Consortium
CCS transport and storage
Long-term requirements

Aim:
Show requirements for CCS to develop as an emission reduction measure
➢ NW and Central Europe
➢ Time line 2020 – 2030 – 2050

Methods:
• Evaluate CO₂ supply and storage
• Match CO₂ captured streams and storage capacity
• Define indicative transport corridors and volumes
CO₂ capture

- 2020: demo projects
- 2030 and 2050:
  - Economic growth model (PRIMES)
  - Fuel mix changes
- Emission reduction targets:
  - 50% in 2030 (~400 Mt/yr)
  - 80% in 2050 (~1200 Mt/yr)
- CCS: ~1/3 of CO₂ emission reduction
Industrial areas, Emission (now) and capture (future) locations
CO$_2$ storage

- **EU FP6 Geocapacity** database: Clusters of storage locations

- **Storage capacity**
  - Depleted gas fields
  - Oil fields (EOR)
  - Aquifers
  - Gas and oil fields available 50 yrs after discovery
  - Aquifer availability develops between 2025 and 2050
  - Injection rates assumed

<table>
<thead>
<tr>
<th>Storage Type</th>
<th>Capacity (Gt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas fields</td>
<td>20</td>
</tr>
<tr>
<td>Oil fields</td>
<td>5.6</td>
</tr>
<tr>
<td>Aquifers</td>
<td>290</td>
</tr>
</tbody>
</table>
Linking CO$_2$ capture to storage

Three scenarios
1. Reference: Onshore + offshore storage
   - based on national assumptions
2. Offshore only
3. Offshore only + EOR

General assumptions:
- Cross border transport avoided where possible
- Matching at injection rate + storage capacity levels
Reference scenario
2020

~ 40 Mt/yr
Reference scenario 2030

~ 400 Mt/yr
Reference scenario 2050

~ 1200 Mt/yr
Infrastructure development

<table>
<thead>
<tr>
<th>Backbone (km)</th>
<th>Reference scenario</th>
<th>Offshore-only scenario</th>
<th>EOR scenario</th>
</tr>
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<tbody>
<tr>
<td>2020</td>
<td>2,300</td>
<td>4,200</td>
<td>5,300</td>
</tr>
<tr>
<td>2030</td>
<td>14,300</td>
<td>20,900</td>
<td>20,900</td>
</tr>
<tr>
<td>2050</td>
<td>21,800</td>
<td>32,000</td>
<td>33,200</td>
</tr>
</tbody>
</table>

Comparison: EU oil products network ~ 35,000 km

Construction ~ 50-100 km/month, continuously for 30 years
Cost: 50 – 80 billion € until 2050
Storage requirements up to 2050

% of storage type used

% filled
Transport across borders

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference Scenario (Mt/yr)</th>
<th>% of total</th>
<th>Offshore-only scenario (Mt/yr)</th>
<th>% of total</th>
<th>EOR Scenario (Mt/yr)</th>
<th>% of total</th>
<th>Total (Mt/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>7</td>
<td>9</td>
<td>19</td>
<td>40</td>
</tr>
<tr>
<td>2030</td>
<td>89</td>
<td>25</td>
<td>249</td>
<td>70</td>
<td>254</td>
<td>71</td>
<td>400</td>
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<tr>
<td>2050</td>
<td>215</td>
<td>18</td>
<td>861</td>
<td>70</td>
<td>857</td>
<td>70</td>
<td>1200</td>
</tr>
</tbody>
</table>

- Large % transported to other countries
- Requires coordination at EU level
Conclusions from infrastructure maps

- **Uneven distribution** of capture, transport and storage capacity

- **Key players**
  - Capture: Germany, Poland, UK
  - Transport: Germany, Poland, Norway, Baltic region
  - Storage: Germany, Poland, UK, Norway
  - Cross-border transport: North Sea region, Baltic region

- **Infrastructure types**
  - One-on-one ‘networks’ in early phase
  - Complex, multi-user networks throughout most of Europe from about 2030
    - Transition from simple to complex networks: 2020 - 2030
    - Mixing CO₂ flows: common design basis, quality requirements
    - Cross-border issues (liability in transport and storage)
Barriers

• **Uncertainty in storage**: where will pipelines go?
  • Member States to qualify / prove storage capacity
  • > 10 years ahead:
    • Provide certainty on location of certified storage capacity
    • Provide certainty on location infrastructure
    • Provide option to future-proof transport network

• **Transition** from one-on-one to multi-user networks

• **Key players**
  • Uneven distribution of capture, transport, storage
  • Momentum must be maintained

• **Onshore storage**
  • Results in significantly lower transport requirements
Conclusions

- Possibility to **future-proof** infrastructure
  - Optimise development using long-term strategy and goals
  - Minimise cost of construction (coordinated planning)

- **Current demonstration projects**
  - Close gaps in knowledge, regulation

- Transport technology **available today**

- **CO₂-EOR** as driver for CCS
  - Briefly explored in CO₂Europipe