Prior to RCSP

• In the beginning was Sleipner
  • 1 Mt/y Injection started in 1996 – continued to date for 17 years
  • First to demonstrate you could observe injected CO$_2$ with seismic monitoring
  • Demonstrated you can track fate of the CO$_2$ in the reservoir
  • First to calibrate reservoir models against seismic monitoring
Prior to RCSP

• Next in line was Weyburn
  • 1Mt/y CO2 injection into a depleting oil field
  • First project to demonstrate seismic monitoring was suitable for deep shallow reservoirs
  • First to prove the benefits of doing a surface monitoring baseline
    o Kerr Incident
Commercial Application of CCS in Oil and Gas Sector

Sleipner 1 Mt/y CO₂

Weyburn 2.5 Mt/y CO₂

In-Salah 1.2 Mt/y CO₂

Snohvit 0.7 Mt/y CO₂

Gorgon 3 Mt/y CO₂

160km sub sea pipeline

350km overland pipeline


RCSP Time Window
<table>
<thead>
<tr>
<th>Number</th>
<th>Project Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BSCSP Basalt</td>
</tr>
<tr>
<td>2</td>
<td>Carbfix</td>
</tr>
<tr>
<td>3</td>
<td>CarbonNet</td>
</tr>
<tr>
<td>4</td>
<td>CIDA China</td>
</tr>
<tr>
<td>5</td>
<td>CS Energy Calido Oxyfuel Project</td>
</tr>
<tr>
<td>6</td>
<td>CSEMP</td>
</tr>
<tr>
<td>7</td>
<td>Fenn/Big Valley</td>
</tr>
<tr>
<td>8</td>
<td>Frio, Texas</td>
</tr>
<tr>
<td>9</td>
<td>JCP Yubari/Ishikani ECBM Project</td>
</tr>
<tr>
<td>10</td>
<td>K12B</td>
</tr>
<tr>
<td>11</td>
<td>Keltzin</td>
</tr>
<tr>
<td>12</td>
<td>Marshall County</td>
</tr>
<tr>
<td>13</td>
<td>Masdar/ADCO Pilot project</td>
</tr>
<tr>
<td>14</td>
<td>MGSC Loudon Field EOR Phase II</td>
</tr>
<tr>
<td>15</td>
<td>MGSC Mumford Hills EOR Phase II</td>
</tr>
<tr>
<td>16</td>
<td>MGSC Sugar Creek EOR Phase II</td>
</tr>
<tr>
<td>17</td>
<td>MGSC Tanquary ECBM Phase II</td>
</tr>
<tr>
<td>18</td>
<td>Mountaineer</td>
</tr>
<tr>
<td>19</td>
<td>MRCSP Appalachian Basin (Burger) Phase II</td>
</tr>
<tr>
<td>20</td>
<td>MRCSP Cincinnati Arch (East Bend) Phase II</td>
</tr>
<tr>
<td>21</td>
<td>MRCSP Michigan Basin Phase II</td>
</tr>
<tr>
<td>22</td>
<td>Nagaoka Pilot CO2 Storage Project</td>
</tr>
<tr>
<td>23</td>
<td>Otway (Stage I)</td>
</tr>
<tr>
<td>24</td>
<td>Otway II Project (Stage 2AB)</td>
</tr>
<tr>
<td>25</td>
<td>PCOR Lignite</td>
</tr>
<tr>
<td>26</td>
<td>PCOR Williston Basin -Phase II (NE Mcgregor Field)</td>
</tr>
<tr>
<td>27</td>
<td>SECARB - Black Warrior Basin Coal Seam Project</td>
</tr>
<tr>
<td>28</td>
<td>Recopol</td>
</tr>
<tr>
<td>29</td>
<td>SECARB - Central Appalachian Coal Seam Project</td>
</tr>
<tr>
<td>30</td>
<td>SECARB - Mississippi Saline Reservoir Test Phase II</td>
</tr>
<tr>
<td>31</td>
<td>SECARB - Stacked Storage Project Cranfield Phase II</td>
</tr>
<tr>
<td>32</td>
<td>SECARB - South West Hub (Cole South West Hub)</td>
</tr>
<tr>
<td>33</td>
<td>Surat Basin CCS Project (Previously Wandoan)</td>
</tr>
<tr>
<td>34</td>
<td>SWP San Juan Basin Phase II</td>
</tr>
<tr>
<td>35</td>
<td>Tschop Dome, Wyoming</td>
</tr>
<tr>
<td>36</td>
<td>Total Lacq</td>
</tr>
<tr>
<td>37</td>
<td>West Pearl Queen</td>
</tr>
<tr>
<td>38</td>
<td>WESTCARB Arizona Pilot (Cholla)</td>
</tr>
<tr>
<td>39</td>
<td>WESTCARB Northern California CO₂ Reduction Project</td>
</tr>
<tr>
<td>40</td>
<td>WESTCARB Rosetta-Calpine test 1</td>
</tr>
<tr>
<td>41</td>
<td>WESTCARB Rosetta-Calpine test 2</td>
</tr>
<tr>
<td>42</td>
<td>Western Kentucky</td>
</tr>
<tr>
<td>43</td>
<td>Zerogen Project</td>
</tr>
</tbody>
</table>
Project Lead Times
Small scale injections outside USA

- Coal seams – direct injection
  - RECOPOL/MOVECBM, Poland
  - JCOP ECBM Project, Japan
  - CIDA, China

- Coal seams – after drainage
  - Nothing outside USA

- Direct injections not successful – EU/Japan lost interest

- Basalt formations
  - CarbFix, Iceland
    - CO₂ dissolved in water prior to injection
Small scale injections outside USA

• **Deep saline formations**
  - Nagoka, Japan
    - Post closure monitoring underway
  - Lacq, France
  - Mustang, Israel

• **Depleted gas fields**
  - Ketzin, Germany
    - Post closure monitoring underway
  - Otway, Australia
  - K-12B Netherlands
Project Highlights

• K12-B
  • The reservoir model was calibrated to an approximately 17 year production history and could accurately predict the pressure response for 2 short-term CO2 injection tests.
Otway

- Was the first to specifically determine the CO$_2$ residual saturation in a saline aquifer
- Using observed downhole pressures resulted in an average value of the CO$_2$ residual saturation between 15-19 %.
Ketzin

![Diagram of Ketzin](image-url)

- **Soil Gas Measurements**
- **SD-ERT 3D ERT x-hole**
- **CO₂-Capture**
- **Pressure Sensors at all well heads**
- **Seismic VSP**
- **MSP**
- **Star Experiment 2D x-hole**
- **CO₂-Monitoring**
- **Reservoir**
- **Smart Casing Electrodes (A-DTS)**
- **Cap Rock**
- **Fluid Sampling GMS-Sensor**
- **Optical P/T Sensor**
Examples of pilot successes

- **K-12 B, The Netherlands**
  - Monitoring and operational experience used to develop permit application for ROAD project to EC.
  - First Injection/Monitoring permit approved by EC.

- **Nagoka, Japan**
  - Monitoring during earthquake demonstrated that seismic activity does not impact storage security
  - Post closure monitoring demonstrated CO$_2$ dissolution in reservoir brine
Examples of pilot outcomes

• Weyburn, Canada
  • Demonstrated importance of baseline monitoring
  • Supposed leak from site was disproved based on baseline monitoring
  • New technique by University of Texas based on C isotope analysis showed baseline data not critical

• ZeroGen, Australia.
  • Need historical geological data before you commit to start drilling.
Public Awareness

- Pilots play a key role
  - Visitor centres at sites
  - Direct local dialogue
  - First hand experience of CO2 storage site
  - Meet the scientists
  - Disseminate information a local level
  - Build public confidence
    - Lacq, France
    - Ketzin, Germany
A picture tells a 1000 words
Concluding Remarks

- CO₂ injection pilots are the key to global implementation of CCS.
  - Build science/knowledge base
  - Key to developing public confidence
  - Develop expertise for future larger scale implementation
- The number of CO₂ pilot projects outside the USA roughly number those in the RCSP
- The data we have to date comes to a large degree from non USA pilots
  - Weyburn, Sleipner, Ketzin, K12-B & Cranfield published in IJGGC
- Urge you when you have time to publish your work.
- RCSP results are the next step in building the knowledge base on CO₂ storage.
The next 10 years?

- New storage pilots in Taiwan, Israel, South Africa, UK and Switzerland
- New integrated demos in: UK (2), Norway, Netherlands?
- China, to take the lead on CCS development?
- South East Asia becomes a big CCS player?
- Middle East next centre for CO2-EOR roll out
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October 5 - 9
TWO THOUSAND AND FOURTEEN
AUSTIN, TX – USA

• Call for papers 27th September 2013
• Deadline for abstracts 10th January 2014
• Registration opens 7th March 2014
• Authors notified 2nd May 2014
• Early bird closes 13th June 2014
Thank you, any Questions?

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