

# 2<sup>nd</sup> International Workshop on Offshore Geologic CO<sub>2</sub> Storage

## International updates from Norway, UK, Japan, Netherlands, Australia, South Africa, and USA

Hosted by Bureau of Economic Geology University of Texas Austin at Lamar University, Beaumont, Texas, 19–20 June 2017

Tim Dixon IEAGHG, Susan Hovorka BEG, Tip Meckel BEG, Katherine Romanak BEG, Owain Tucker Shell, Nick Hoffman CarbonNet, Kim Swords Sonardyne, Lars Ingolf Eide Research Council Norway, Niels Peter Christensen Gassnova, Keisuke Uchimoto RITE, Noel Kamrajh SANEDI

**TEXAS** WHAT STARTS HERE CHANGES THE WORLD

### CSLF Report on Offshore Geologic CO<sub>2</sub> Storage



*"There is a growing wealth of research, development and practical experiences that are relevant to CO<sub>2</sub> storage offshore, but this expertise is familiar only to a few specific countries around the world. However there is also significant global potential for offshore CO<sub>2</sub> storage, and countries who are not yet active but may become interested in offshore storage, would benefit from knowledge sharing from these existing experiences and expertise. Such international knowledge sharing would be facilitated by international workshops and by international collaborative projects."*

(CSLF Ministerial Nov 2015: CSLF-T-2015-06)

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### 2<sup>nd</sup> Workshop

**Aim:** To address and build on the recommendations and topics raised at the first workshop to take offshore storage forward. Continuing theme of 'how to do'.

**Objectives:** Technical 'deeper-dive' into key topics:

- How to find storage offshore;
- Technical aspects and experiences of offshore monitoring;
- CO<sub>2</sub>-EOR offshore;
- Infrastructure developments and decisions
- U.S. developments in offshore storage assessment
- Conclusions and recommendations
- Field Trip

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### Conclusions 1

- Site selection methods are becoming mature;
- Examples from different regions show some similarities as well as methods for adapting to regional geologic conditions, source distribution, and national goals and policies.
- Case studies at South Africa and Australia show methods of systematic refinement and down selection.
- Lowering risk for project include favoring denser data about the subsurface, known injectivity, proximity sink to source.
- Conservative approach favors assessing multiple sinks and multiple sources, so that one no-go does not derail whole
- Using current best geologic practices – i.e. chronostratigraphic instead of lithostratigraphic.
- Not just based on geological characteristic – needs to be large enough to be a business case.

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### Conclusions 2

- Deep dive into Monitoring plans shows that they are now successfully passing through negotiation with regulators.
- Pragmatism in balancing risk reduction with cost management is illustrated in cases from Peterhead, ROADS, and Norway, although different monitoring approaches are still seen.
- AUV environmental monitoring reduces cost and reduces human safety issues.
- Multiple approaches to overburden and water column monitoring are demonstrated.
- Overburden - ability to characterize and monitor in time-lapse.
- Sensitivity of data and density of data to demonstrate no leakage are beginning to be considered.

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### Conclusions 3

- CO<sub>2</sub> EOR continues to be considered as a prospective part of information in Norwegian and UK north Sea, GOM, and basins globally. Information and analysis continues to increase (see major summary by CSLF task force).
- However the business case that would allow EOR to be profitable remains elusive – competition for capital – onshore first in USA, or other potential energy projects or alternative ways of recovery, delay in payback
- Timing/cost issues with re-use of infrastructure offshore – eg Norway
- Access to CO<sub>2</sub> will stimulate EOR projects

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### Conclusions 4

- Policy approach to shift from individual projects to infrastructure, eg Alberta Carbon Trunk Line
- Infrastructure economies of scale – cost reductions
- Subsea solutions are coming for adding CO<sub>2</sub>-EOR to existing platforms. Components exist, need to qualify for CO<sub>2</sub>
- Salt and shale ductility, and bentonite plugs, sealing to P&A wells
- A lot of options for infrastructure new and reuse – very site specific

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### Recommendations

- Design for research purposes wells made to leak CO<sub>2</sub>
- We can learn from USA re-use of wells for CO<sub>2</sub>-EOR
- Tools for assessing infrastructure
- Communication with offshore infrastructure owners
- More communication on infrastructure with institutions eg governments
- Communicating developing country importance, eg to Green Climate Fund – learn from good example in South Africa
- Address data gaps
- Qualify subsea systems for CO<sub>2</sub>

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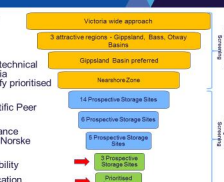
### International Steering Committee

Tim Dixon, IEAGHG (Chair)  
Katherine Romanak, BEG (Co-Chair, Host)  
Susan Hovorka, BEG (Host)  
Tip Meckel, BEG (Host)  
Anthony Sumridge / Noel Kamrajh, SANEDI (host)  
John Litynski / Traci Rodosta, US DOE  
Lars Ingolf Eide, Research Council of Norway

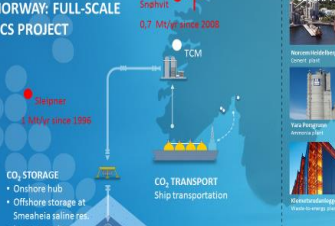
Di Zhou, China Academy of Sciences  
Flig Neele, TNO  
Paulo Negrais Seabra-Independent Consultant (formerly Petrobras)  
Ryozo Tanaka, RITE  
Owain Tucker, Shell  
Philip Ringrose, Statoil  
Michael Carpenter, Gassnova  
Paul Latalas, Lamar University

**STORAGE CERTAINTY - A MAJOR FOCUS**

- Two-stage process
  - regional
  - site specific
- Technical and non-technical assessment - criteria developed to identify prioritised storage sites
- Independent Scientific Peer Reviews
- Independent assurance certification by Det Norske Veritas
- Statement of Feasibility
- Certificate of Verification



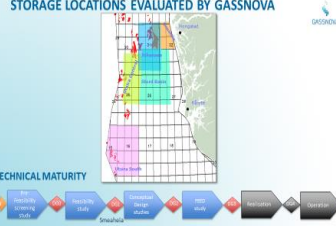
**NORWAY: FULL-SCALE CCS PROJECT**




CO<sub>2</sub> STORAGE

- Onshore hub
- Offshore storage at Smeaheia saline res.
- Large capacity

**STORAGE LOCATIONS EVALUATED BY GASSNOVA**



**TECHNICAL MATURITY**



**Goldeneye monitoring**

Balancing the requirements for an EU permit and the need to contain costs



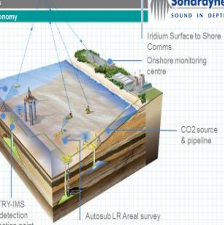
Dr Owain Tucker  
Global Applications CCS/CO<sub>2</sub>

**CONOP - Concept of Operations**

Risk based small coverage - Autonomy

**Sonardyne** SOUND IN DEPTH

A system of systems configurable to meet the needs of different stores



ASV: Buoy, Subsea surface Comms gateway

Land: Point chemical, Aerial location Comms to surface

SENTRY-IMS: Leak detection @ injection point

Autobus LR Areal survey

Hydium Surface to Shore Comms

Onshore monitoring centre

CO<sub>2</sub> source & pipeline

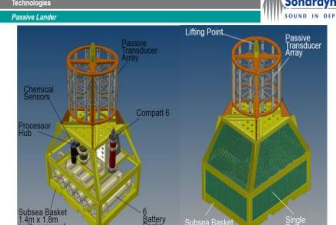
**Technologies**

Vehicle Load



**Technologies**

Passive Lander



Chemical Sensors

Processor Hub

Subsea Basket 1.5m x 1.5m (20% reserved for capacity)

Compact 6

Battery Packs

Lifting Point

Passive Transducer Array

Subsea Basket 1.4m x 1.8m

Single Buoy Hook for

**Leak Detection. Keisuke Uchimoto (RITE)**

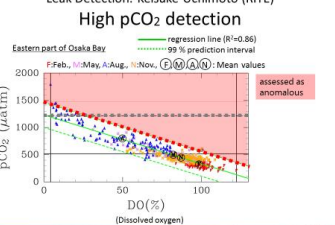
### High pCO<sub>2</sub> detection

Eastern part of Osaka Bay

regression line (R<sup>2</sup>=0.86)

95% prediction interval

assessed as anomalous



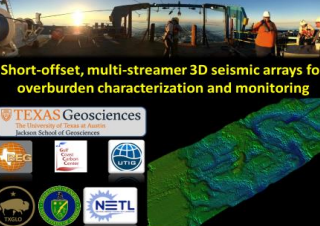
pCO<sub>2</sub> (µatm)

DO (%)

(Dissolved oxygen)

RITE: Research Institute of Innovative Technology for the Earth

**Short-offset, multi-streamer 3D seismic arrays for overburden characterization and monitoring**



TEXAS Geosciences  
Jackson School of Geosciences  
Bureau of Economic Geology  
The University of Texas at Austin

NETL

**Carbon Sequestration leadership forum**

Available Subsea Processing Building Blocks



Subsea process system building blocks

Injection CT

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Status

### CSLF TASK FORCE ON OFFSHORE CO<sub>2</sub>-EOR

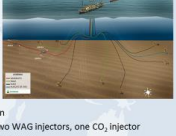
Enabling Large-scale CCS using Offshore CO<sub>2</sub> Utilization and Storage Infrastructure Developments

Lars Ingolf Eide  
2<sup>nd</sup> International Workshop on Offshore CO<sub>2</sub> Geologic Storage  
Beaumont, Texas, USA  
19-20 June, 2017

**Carbon Sequestration leadership forum**

### Lula Project

- Reservoir well suited for miscible CO<sub>2</sub>-EOR
- CO<sub>2</sub> content in gas = 11 %
- Extensive reservoir characterization
- Robust and flexible development strategy
- Careful choice of topside solution and materials
- Membranes used for CO<sub>2</sub> separation
- WAG solution with six producers, two WAG injectors, one CO<sub>2</sub> injector
- No major operational or reservoir problems
- Monitoring with downhole pressure gauges and tracers



**Carbon Sequestration leadership forum**

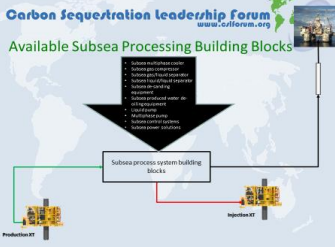
### Approaches for enabling offshore CO<sub>2</sub>-EOR

- Using late-life oilfield infrastructure
- Using oilfield satellite projects
- Focusing CO<sub>2</sub>-EOR on the residual oil zone (ROZ)
- Reservoir modelling: Issues particular to CO<sub>2</sub>-EOR
  - Phase behaviour
  - Reactions with rocks
  - Multiphase flow in porous media
  - Oil instability



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### Available Subsea Processing Building Blocks

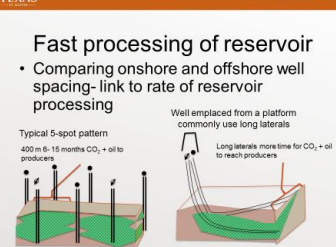


Subsea process system building blocks

Injection CT

**Fast processing of reservoir**

- Comparing onshore and offshore well spacing-link to rate of reservoir processing



Typical 5-spot pattern

400m 6–15 months CO<sub>2</sub> + oil to producers

Well emplaced from a platform commonly use long laterals

Long laterals: more time for CO<sub>2</sub> + oil to reach producers

