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### Minutes of the Technical Group Meeting

Abu Dhabi, United Arab Emirates

Monday, 01 May 2017

#### LIST OF ATTENDEES

##### Chair

Åse Slagtern (Norway)

##### Delegates

Australia: Andrew Barrett (*Vice Chair*), Max Watson  
Canada: Eddy Chui (*Vice Chair*), Mike Monea  
China: Ping Zhong, Yi-Ming Wei  
Czech Republic: Lubomir Mazouch  
European Commission: Jeroen Schuppers  
France: Didier Bonijoly, David Savary  
Italy: Paolo Deiana, Sergio Persoglia  
Japan: Ryoza Tanaka, Takashi Kawabata  
Korea: Chang-Keun Yi, Chong Kul Ryu  
Netherlands: Harry Schreurs  
Norway: Jostein Dahl Karlsen, Lars Ingolf Eide  
Saudi Arabia: Ammar AlShehri  
South Africa: Tony Surridge (*Vice Chair*), Landi Themba  
United Arab Emirates: Meshayel Omran AlAli, Fatma AlFalasi  
United Kingdom: Brian Allison  
United States: John Litynski, Stephanie Duran

##### Representatives of Allied Organizations

Global CCS Institute: Jeff Erikson, John Scowcroft  
IEAGHG: John Gale

##### CSLF Secretariat

Richard Lynch

##### Invited Speakers

Saudi Arabia: Tidjani Niass, Saudi Aramco  
United Arab Emirates: Fatima Al Foor Al Shamsi, Ministry of Energy  
Arafat Al Yafei, Abu Dhabi Carbon Capture Company  
Dipak Sakaria, Abu Dhabi Carbon Capture Company  
United States: Grant Bromhal, National Energy Technology Laboratory  
John Hamling, University of North Dakota Energy and  
Environmental Technology Center  
Sallie Greenberg, University of Illinois

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## Observers

Algeria:	Radia Sedaoui
Australia:	Sarah Chapman*
Canada:	Kathryn Gagnon*, Simon O'Brien
India:	Shishir Tamotia
Japan:	Jiro Tanaka
Kuwait:	Harish Reddy
Norway:	Bjørn-Erik Haugan, Roy Vardheim
Saudi Arabia:	Pieter Smeets
United Arab Emirates:	Ahmed AlHajaj, Kasia Waker
United Kingdom:	Jon Gibbins, Tom Howard-Vyse
United States:	John Harju, Frank Morton

\* CSLF Policy Group delegate

## **1. Chairman's Welcome and Opening Remarks**

The Chair of the Technical Group, Åse Slagtern, called the meeting to order and welcomed the delegates and observers to Abu Dhabi. Ms. Slagtern mentioning that this would be a busy meeting, with updates from several task forces as well as the working group that is updating the CSLF Technology Roadmap. In addition there would be discussion on possible future Technical Group activities.

Ms. Slagtern also mentioned that the current meeting would be, as usual, very content-rich, with many items of interest to attendees. This includes presentations from three projects that have been nominated for CSLF recognition, an update on carbon capture and storage (CCS) activities in the United Arab Emirates, a presentation on the newly-formed carbon storage data consortium, two presentations on carbon dioxide (CO<sub>2</sub>) utilization – one on use of CO<sub>2</sub> in industry and one on brine extraction as it relates to enhanced water recovery, a report on results from the CSLF-recognized Uthmaniyah Enhanced Oil Recovery (EOR) Project, a report on recent activity of the ISO's TC265 working group on CO<sub>2</sub> capture, and updates from both the IEA Greenhouse Gas R&D Programme (IEAGHG) and the Global Carbon Capture and Storage Institute (GCCSI).

## **2. Meeting Host's Welcome**

Her Excellency Fatima Al Foora Al Shamsi, Assistant Undersecretary for Electricity and Future Energy Affairs at the United Arab Emirates' Ministry of Energy, welcomed the meeting attendees to Abu Dhabi. Dr. Al Shamsi stated that carbon capture, utilization and storage (CCUS) technology is rapidly evolving thanks to the efforts of governments around the world increasing their efforts to address climate change, and that the use of CCUS technologies has great potential in the United Arab Emirates. CCUS provides a viable route to competitive, low-carbon power and remains one of the few viable options for significant reductions in the emissions of heavy industries. However, it requires a spirit of innovation, research, and development, as well as human and financial resources.

Dr. Al Shamsi stated that the United Arab Emirates was the first country in the Middle East to set up a separate company for developing commercial-scale CCUS projects, the first being the Al Reyadah project which will be hosting a site visit as part of the overall CSLF meeting. The Al Reyadah project also shows that the United Arab Emirates is committed to climate action and responsible energy production through private and public sector partnerships. Dr. Al Shamsi closed her welcoming speech by urging meeting attendees to have many productive discussions during this important meeting.

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## **3. Introduction of Delegates**

Technical Group delegates present for the meeting introduced themselves. Sixteen of the twenty-six CSLF Members were represented. Observers from eleven countries were also present.

## **4. Adoption of Agenda**

The Agenda was adopted with no changes.

## **5. Approval of Minutes from Tokyo Meeting**

The Minutes from the October 2016 Technical Group Meeting in Tokyo, Japan were approved with no changes.

## **6. Report from CSLF Secretariat**

Richard Lynch provided a report from the CSLF Secretariat which reviewed highlights from the October 2016 CSLF Annual Meeting in Tokyo. This was a five-day event, including a technical workshop and a site visit to the Tomakomai CCS Demonstration Project. Presentations from all meetings and the workshop are online at the CSLF website.

Mr. Lynch stated that there were several key outcomes from the Tokyo Technical Group meeting. First and foremost, the Tomakomai CCS Demonstration Project and the NET Power Allam Cycle Demonstration Project were both recommended by the Technical Group to the Policy Group for CSLF recognition. Additionally, France agreed to form and lead a new task force on Industrial CCS and the other three existing task forces were given a goal to complete drafts of their final reports in time for the current meeting. Finally, the CSLF Technology Roadmap (TRM) working group was given a goal to complete a final draft of the 2017 TRM in time for the current meeting. As a follow-up, Mr. Lynch reported that a mostly-final version of the 2017 TRM has been completed and is included in the meeting documents book, but that the three task force chairs have all decided that, in light of their final report drafts being still under review, these documents would not yet be available to the full Technical Group.

## **7. CCUS in the United Arab Emirates**

Dipak Sakaria played a short video about the Abu Dhabi CCUS Project (in advance of a longer presentation later in the meeting) which gave a time-lapse depiction of construction of the project. Mr. Sakaria stated that the project, with its associated pipeline infrastructure, would be a working platform which would leverage future CCUS projects in the United Arab Emirates.

## **8. Update from the IEA Greenhouse Gas R&D Programme**

John Gale gave a concise presentation about the IEAGHG and its continuing collaboration with the CSLF's Technical Group. The IEAGHG was founded in 1991 with the mission to provide information about the role of technology in reducing greenhouse gas emissions from use of fossil fuels. The focus is on CCS, and the goal of the organization is to produce information that is objective, trustworthy, and independent, while also being policy relevant but not policy prescriptive. The "flagship" activities of the IEAGHG are the technical studies and reports it publishes on all aspects of CCS, the seven international research networks about various topics related to CCS, and the

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biennial GHGT conferences (the next one in October 2018 in Melbourne, Australia). Other IEAGHG activities include its biennial post combustion capture conferences (the next one in September 2017 in the United States), its annual International CCS Summer School, peer reviews with other organizations, activity in international regulatory organizations such as the ISO and the London Convention, and collaboration with other organizations, including the CSLF.

Mr. Gale mentioned that since 2008 the IEAGHG and CSLF Technical Group have enjoyed a mutually beneficial relationship which allows each organization to cooperatively participate in the other's activities. This has included mutual representation of each at CSLF Technical Group and IEAGHG Executive Committee (ExCo) meetings, and also the opportunity for the Technical Group to propose studies to be undertaken by the IEAGHG. These, along with proposals from IEAGHG ExCo members, go through a selection process at semiannual ExCo meetings. So far there have been four IEAGHG studies that originated from the CSLF Technical Group, plus an additional proposed study which became an International Workshop on Offshore Geologic CO<sub>2</sub> Storage.

Mr. Gale concluded his presentation with a list of reports recently published, reports in progress to be published, studies underway, and studies awaiting start. Mr. Gale also briefly described IEAGHG events, including its webinar series and next year's GHGT conference.

## 9. Update from the Global Carbon Capture and Storage Institute

John Scowcroft gave a short presentation about the GCCSI and its vision for CCS. The Institute is an international membership organization with offices in Melbourne, Washington D.C., Brussels, Beijing, and Tokyo. It has a diverse international membership including governments, global corporations, small companies, research institutes, and NGOs. The strength of the Institute is that it has specialist expertise which covers the entire CCS/CCUS chain.

Mr. Scowcroft provided a summary of how the GCCSI perceives the global status of CCS. As of April 2017 there are 40 large-scale CCS projects throughout the world which are in operation, construction, or in the planning stages. The 22 projects operation or in construction can capture and store approximately 40 million tons of CO<sub>2</sub> per year. However, this is only a small fraction of the estimated 4,000 million tons of CO<sub>2</sub> per year which would need to be stored (by the year 2040) as part of the IEA's 2 °C scenario. Eighteen of these 40 large-scale projects are located in North America, with another eight in China. Of the 17 projects currently in operation worldwide, twelve of them are in North America. Large-scale CCS projects have been implemented in many different industries: power generation, coal-to-liquids, chemicals production, iron and steel production, synthetic natural gas production, fertilizer production, oil refining, natural gas processing, and hydrogen production.

Mr. Scowcroft closed his presentation by stating that the GCCSI is evolving in reaction to the ever-changing CCS landscape of the world – its new approach is more bold and provocative, while its support of research is less prolific and more deliberative and impactful. Overall, the GCCSI is moving from knowledge sharing towards advocacy.

## 10. Preview of Mission Innovation Experts Group Workshop

Tidjani Niass gave a short presentation about Mission Innovation and its CCUS Innovation Challenge. The overall goal of the Mission Innovation initiative for the

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participating countries to double their clean energy R&D investment over five years, while encouraging greater levels of private sector investment in transformative clean energy technologies. To that end, planning is underway for an invitational “Experts Workshop” to discuss basic research needs for CCUS. The venue will be in the United States, and the projected dates for the event are September 25-29, 2017.

Dr. Niass stated that the overall objective for the CCUS Innovative Challenge is to develop a route to near-zero CO<sub>2</sub> emissions from power plants and carbon intensive industries. This would involve identifying and prioritizing breakthrough CCUS technologies, developing pathways to close RD&D gaps, recommending multilateral collaboration mechanisms, and driving down the cost of CCUS through innovation. The United States and Saudi Arabia are the Workshop leads, with 18 other countries also participating. The Experts Workshop will focus on CO<sub>2</sub> capture, utilization and storage science and will result in a report that will guide innovation on CCUS. Other parts of the work plan include establishing strategic partnerships with like-minded organizations and engaging industry via a subgroup focused on that aspect.

## 11. Report from the CSLF Projects Interaction and Review Team (PIRT)

The PIRT Chair, Andrew Barrett, gave a short presentation which summarized PIRT activities and the previous day’s meeting. The PIRT is currently involved in three main activities: reviewing projects nominated for CSLF recognition, updating the CSLF Technology Roadmap, and finding ways to better engage sponsors of CSLF-recognized projects. Mr. Barrett reported that much of the PIRT meeting had been taken up by review of three projects that have been nominated for CSLF recognition and by discussions related to project engagement, and that there were three main outcomes from the meeting:

- The PIRT has recommended approval by the Technical Group for the Al Reyadah CCUS Project, the Carbon Capture Simulation Initiative / Carbon Capture Simulation for Industry Impact, and the National Risk Assessment Partnership.
- The mostly-final draft of the 2017 TRM has been sent to all CSLF delegations, with a firm deadline of July 1<sup>st</sup> for receiving comments. A finalized version will be completed and sent to the CSLF Secretariat by September 15<sup>th</sup> and a publication-ready version will then be prepared for publication and inclusion in Ministerial Meeting briefing documents.
- The PIRT’s projects engagement initiative has produced useful information, but the CSLF still needs to ramp up its efforts in this area.

Mr. Barrett stated that there had been extensive discussion on project recognition criteria, about whether the existing criteria are still appropriate and if these criteria unintentionally exclude appropriate projects. From this, two actions emerged:

- The PIRT Chair and the CSLF Secretariat will review the CSLF and PIRT Terms of Reference documents to clarify project qualifications for CSLF recognition and to present recommendations at the next PIRT meeting. (*Note: this has since expanded to include the Technical Group Executive Committee and the Chair of the Policy Group’s Communications Task Force.*)
- The CSLF Secretariat will revise the Project Engagement survey form to include questions asking why the project sought CSLF recognition, or what benefits that project sponsors expect from CSLF recognition.

## 12. Progress Report on 2017 CSLF Technology Roadmap (TRM)

The Chair of the TRM working group, Andrew Barrett, gave a short progress report presentation about the 2017 TRM. The TRM working group had been formed at the 2015 Technical Group meeting in Riyadh with the mandate to produce a new TRM in time for the next CSLF Ministerial Meeting. The process chosen for the rewrite was to use the 2013 TRM as a basis and refresh its content as needed. Editorial responsibility for updating the document was shared among the working group, with Lars Ingolf Eide of Norway being the editor-in-chief. The Working Group has been chaired by Australia with representation from Norway, Canada, South Africa, the United Kingdom, the United States, the IEAGHG, and the CSLF Secretariat. In addition, there have been contributions from several international experts on CCS.

Mr. Barrett briefly described the main changes from the 2013 TRM:

- New time horizons were being used for medium- and long-term recommendations and targets (2025 and 2035 respectively, instead of the previous TRM's target dates of 2030 and 2050).
- The “Background” chapter was revised to reflect COP21 targets, and quantitative targets which meet the IEA 2 °C scenario were used for CO<sub>2</sub> sequestration.
- A new section was included on non-technical measures such as regulations, and there is expanded discussion on CCS, CCU, and CCUS.
- The chapter on “Assessment of Present Situation” was shortened and merged into the “Technology Needs” chapter.
- There is less detail concerning specific technology types and fundamentals, and more emphasis on industrial and biomass CCS.
- There is a new separate section on sectors other than power, industry and biomass (though hydrogen production with CCS is the only topic so far).
- There is more emphasis on development of a “clusters and hubs” approach toward CCS, and also on ship transport of CO<sub>2</sub>.
- Recent CO<sub>2</sub> storage projects and activities have been referenced, and description has been updated and expanded about various aspects of CO<sub>2</sub> utilization.
- There are identified actions to meet technology needs throughout the CCS chain.

Mr. Barrett stated the main findings of the 2017 TRM are that CCUS works in power and industrial settings, but implementation of CCUS is well behind the trajectory of reaching the stated COP21 “less than 2 °C temperature rise” goal. Additionally, CCUS is not possible without the right policy settings and the appropriate financial framework. There are several important recommendations made by the TRM:

- Based on the IEA 2 °C scenario, governments and industry should work together to contribute to the COP21 targets by implementing sufficient large-scale projects in the power and industry sectors to:
  - Permanently store 0.5 gigatonnes (Gt) of CO<sub>2</sub> per year by 2025 (or have permanently captured and stored 2 GtCO<sub>2</sub>); and
  - Permanently store 2.7 GtCO<sub>2</sub> per year by 2035 (or have permanently captured and stored 20 GtCO<sub>2</sub>).
- Governments and industry should work together to:
  - Develop supportive policy incentives and support for CCS on similar terms as other low-carbon technologies;
  - Develop markets and business models for CCUS support;

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- Accelerate legal and regulatory frameworks for CCS; and
- Develop strategic transportation and storage infrastructures using a cluster-and-hub approach, in particular for industrial CCUS, including early identification and characterization of potential CO<sub>2</sub> storage sites.
- Improve CCUS public outreach and education, supporting educators as well as community proponents of CCUS projects.
- Facilitate exchange of data from operating large-scale CCUS projects.
- Support RD&D for novel and emerging technologies along the entire CCUS chain, in order to drive down costs.
- Map opportunities, conduct technology readiness assessments, and resolve main barriers for the implementation of CCUS.

Mr. Barrett concluded his presentations by briefly describing next steps. The mostly-final draft of the 2017 TRM has been sent to all CSLF delegations, with a firm deadline of July 1<sup>st</sup> for receiving comments, but there is understanding that information contained in the forthcoming *IEA Energy Technology Perspectives 2017* report could possibly lead to additional edits to the TRM. Mr. Barrett stated that after all edits are finished, a finalized version will be completed and sent to the CSLF Secretariat by September 15<sup>th</sup> and a publication-ready version will then be prepared for publication and inclusion in Ministerial Meeting briefing documents.

### 13. Report from the Offshore CO<sub>2</sub>-EOR Task Force

Task Force Chair Lars Ingolf Eide gave a brief update on the task force, which was established at the November 2015 meeting in Riyadh. The purpose of the task force is to highlight differences and issues between onshore and offshore CO<sub>2</sub>-EOR as well as offshore CO<sub>2</sub>-EOR and pure offshore CO<sub>2</sub> storage. The task force will also highlight any technical solutions which benefit both pure offshore CO<sub>2</sub> storage and offshore CO<sub>2</sub>-EOR. Task force members include Norway (as chair), Brazil, Canada, Mexico, the United States, and the IEAGHG.

Mr. Eide stated that the task force has held two teleconferences since the October 2017 CSLF meeting in Tokyo. A preliminary first draft of the task force's final report has been completed, but it was still undergoing review at the time of the 2017 CSLF Mid-Year Meeting. The contents of the report will include chapters on the basics of offshore CO<sub>2</sub>-EOR, insights from the Brazilian "Lula" off-shore CO<sub>2</sub>-EOR project, approaches and emerging technical solutions toward enabling offshore CO<sub>2</sub>-EOR, description of potential CO<sub>2</sub> supply chain issues, issues involved with monitoring and verification of storage, description of regulatory requirements for offshore CO<sub>2</sub> utilization and storage, and recommendations for overcoming any barriers to accomplishing offshore projects. Mr. Eide stated that revisions and a final review by the task force members would be completed by mid-October and that the task force report will be ready in time for the 2017 CSLF Ministerial Meeting.

### 14. Report from the Bioenergy with CCS (BECCS) Task Force

Task Force Chair John Litynski gave a brief update on the task force, which was established at the November 2015 meeting in Riyadh. The focus of the task force is to identify and summarize global efforts, successes, and challenges to deployment for BECCS. This includes surveying and identifying existing projects, government programs, market drivers, barriers to large-scale deployment, and opportunities for

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BECCS technologies. The task force mandate includes developing a concise information resource, in its final report, which will help to point the way forward for the CSLF and its member countries in this area.

Mr. Litynski stated that a first draft of the task force report was completed in mid-March. Comments received by task force members went into a second draft, which had been distributed to task force members just prior to the 2017 CSLF Mid-Year Meeting. A finalized version of the report will be ready for the 2017 CSLF Ministerial Meeting. The overall structure of the report includes an introductory chapter which describes BECCS challenges and benefits, a summary of BECCS resource assessments and emissions profiles, a summary of the commercial status of BECCS technology deployment, an overview of BECCS technology options and pathways, and a concluding chapter of findings and recommendations. Next steps for the task force will be to address all task force comments and complete unfinished sections (including the executive summary), finalize the report and obtain comments from Technical Group delegates, and prepare the final report for publication.

### 15. Report from the Improved Pore Space Utilisation Task Force

Task Force Co-Chair Brian Allison gave a brief update on the task force, which was established at the November 2015 meeting in Riyadh. The purpose of the task force is to investigate the existing capabilities in improved pore space utilisation for CO<sub>2</sub> storage. This includes summarizing the effectiveness and readiness of various techniques and developing ideas for necessary R&D to develop capability in the most opportune technologies. Current task force members include Australia and the United Kingdom (as co-chairs), Canada, France, Japan, the United Arab Emirates, the United States, and the IEAGHG. Mr. Allison stated that the task force is still in the information collection stage, and called on other task force members for updates on their focal areas.

John Gale reported that the IEAGHG was still preparing the chapter about non-technical issues and that a draft would be ready a few weeks after the 2017 Mid-Year Meeting. Ryozo Tanaka stated that another chapter of the report would include information about microbubble injection, which he described in his presentation at the 2016 CSLF Mid-Year Meeting in London. Didier Bonijoly mentioned that the report will include information on application of pore space optimization for new technologies such as the combination of CCS with hydrothermal geothermal energy. Mr. Allison stated that the British Geological Survey and other organizations were adding their input to a section on non-technical aspects such as regulatory issues.

Task Force Co-Chair Max Watson stated that improved pore space utilisation related to EOR was not being considered by the task force and neither was reservoir stimulation, as these would greatly increase the level of effort and require expertise beyond what exists with task force participants. Dr. Watson mentioned that the chapters on technical aspects were progressing well, but that there were many different technologies being looked at. Recommendations from the task force will be two-fold: a “low cost” option and a “high efficiency” option. Dr. Watson also stated that it was likely that new injection technologies to be tested at the CSLF-recognized Otway Project and possibly elsewhere would be influenced by outcomes from this task force.

Mr. Allison concluded the group presentation by stating that the task force timeline may not result in its final report being ready in time for the 2017 Ministerial Meeting, though a draft of it would be done by then and recommendations for the CSLF Ministers would

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also be ready. The task force will most likely continue into 2018, as the some of the recommendations will set the stage for future work by the task force.

During ensuing discussion, Jeroen Schuppers mentioned that a European Commission-funded project in Iceland had utilized microbubble techniques for injecting CO<sub>2</sub> from a geothermal plant into a basalt geologic storage formation. Mr. Schuppers stated that the CO<sub>2</sub> had mineralized within one year, and that this might be a new technology area that could be referenced in the task force report.

## 16. Report from the CCS and Industry Task Force

Task Force Chair Didier Bonijoly gave a brief update on the task force, which was established at the October 2016 meeting in Tokyo. The task force mandate is to investigate the opportunities and issues for CCUS in the industrial sector. The task force is currently comprised of members of France's Club CO<sub>2</sub>, and that delegates and stakeholders from Germany, the Netherlands, Norway, Saudi Arabia, and the United States had also expressed interest in joining.

Dr. Bonijoly stated that the industry currently accounts for about 21% of CO<sub>2</sub> emissions (Process CO<sub>2</sub>), which is nearly as much as the amount of CO<sub>2</sub> being emitted from electricity and thermal power plants (Combustion CO<sub>2</sub>). In particular, large industries are major contributors and for these there is little recourse – a power generating facility can be switched to utilize lower emitting technologies, but those options do not always exist for heavy industry.

Dr. Bonijoly stated that the task force will not have a final report ready for the upcoming 2017 Ministerial Meeting, and its activities would carry over into 2018. Areas of interest for the task force include investigating aspects of various technologies that could be used to capture CO<sub>2</sub> in an industrial setting, and also determining what are the principle obstacles for development of CCS in industry. There would be a focus on the most critical industries and the task force would also investigate possible alternatives to CCS, such as CO<sub>2</sub> utilization, to see if these are workable at any relevant scale.

## 17. CO<sub>2</sub> Utilization in Industry: Overview, Prospects and Recommendations

David Savary gave a presentation which provided a useful overview of CO<sub>2</sub> utilization prospects for industry. As a background, annual worldwide CO<sub>2</sub> emissions from fossil fuel use in industry and for power generation reached approximately 36 gigatonnes (Gt) in 2015, which constituted a 60% increase from 1990 levels. As a comparison, annual current utilization of CO<sub>2</sub> for production of chemicals and for EOR is approximately 250 megatonnes (Mt), or about 0.7% of the amount of CO<sub>2</sub> annually generated. However, given appropriate business models and regulatory environment, annual worldwide CO<sub>2</sub> utilization has the potential for being as high as about 4% of the amount of CO<sub>2</sub> annually generated. Mr. Savary stated that France's Club CO<sub>2</sub>, representing CCS stakeholders throughout the country, has been actively investigating opportunities for CO<sub>2</sub> utilization and in October 2016 sponsored the 2<sup>nd</sup> CO<sub>2</sub> Utilization Workshop, in the city of Lyon.

Mr. Savary stated that there were many conclusions and recommendations that resulted from the workshop. Concerning research, development and innovation, there was consensus that public-private collaborations are essential to make any significant inroads toward increased CO<sub>2</sub> utilization and that demonstration-scale projects are needed. These projects should involve all stakeholders, including economic development agencies, civil society organizations, and other NGOs. This would help to increase awareness and

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reassure the public as well as convincing civil society about the worth of such projects. Valorization of CO<sub>2</sub> is also needed, as a means of partially offsetting the cost of capturing the CO<sub>2</sub>. A greater value of CO<sub>2</sub> would be a driver for increased utilization. Such valorization could happen not only from consideration of CO<sub>2</sub> as a valuable chemical intermediate but also from environmental benefit considerations.

Mr. Savary ended his presentation by summarizing France's proposals for the Mission Innovation CCUS Challenge. These include development of a simple and widely-acceptable life cycle analysis methodology in order to assess environmental impacts of manufactured products involving CO<sub>2</sub> utilization, finding means for direct use of CO<sub>2</sub> from flue gases for purposes such as algae and carbonate mineral production, and reducing energy consumption required in CO<sub>2</sub> utilization processes via new methodologies involving catalysis and mineralization.

## 18. Brine Extraction and Storage Test Program in the United States

John Hamling gave a presentation which provided a background and description of field projects for using brine extraction as a means for pressure management of CO<sub>2</sub> storage in deep saline aquifers. In general, brine extraction for pressure management purposes can enable dedicated CO<sub>2</sub> storage and improve the geologic CO<sub>2</sub> storage potential of a deep saline aquifer. Brine extraction can also be used for active reservoir management (ARM), which allows geosteering the CO<sub>2</sub> plume in the aquifer reservoir, diverting pressure from leakage pathways, and reducing stress on the cap rock layer above the reservoir. Additionally, brine extraction and its subsequent treatment, in arid areas of the world, can provide a valuable source of water. However, use of brine extraction adds incremental infrastructure, operating and energy costs, brings in the requirement for treatment and discharge/ reinjection of the extracted brine, adds complexity and possible efficiency loss to the project, and can lead to added health, safety and environmental considerations.

Mr. Hamling described two field projects in the United States which will be evaluating ARM strategies and economics, validating models, and testing monitoring techniques. The Energy & Environmental Research Center (EERC) project in western North Dakota is making use of a commercial saltwater disposal facility and included an enclosed water treatment test bed. The Electric Power Research Institute (EPRI) project in northwestern Florida is sited at a coal-fueled power plant with active wastewater disposal and an open-air water treatment test bed. These projects will include field testing of pressure management strategies and scenarios, active reservoir surveillance, and evaluation of various brine treatment technologies. The overall program is focused on dedicated geologic CO<sub>2</sub> storage applications, but outcomes could benefit a broad range of industries.

## 19. Review of Technical Group Action Plan and Possible New Technical Group Activities

Åse Slagtern provided a brief update on the Technical Group Action Plan, in follow up to a preliminary discussion on the topic that had occurred at the previous day's PIRT meeting. Over the past four years, seven Technical Group task forces have completed final reports. There are four currently active task forces, all of which are on track to complete their activities in 2017 or 2018. Ms. Slagtern stated that there are at least ten possible future actions, identified by a Technical Group working group back in 2015, but there had not yet been any consensus to form task forces around any of these.

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Ensuing discussion led to consensus on a proposal from Ms. Slagtern to create a small working group, to be led by Norway, which would evaluate the existing list as well as any other ideas for possible future Technical Group actions. This includes a new action on CO<sub>2</sub> capture from hydrogen production which has been proposed by Norway and supported by the United Kingdom, Australia, and Japan. Delegates from Australia, Saudi Arabia, the United Kingdom, and the United States volunteered to participate in the new working group, while delegates from Canada, Japan, and the Netherlands offered to provide input as needed.

## **20. Review and Approval of Project Proposed for CSLF-Recognition:**

### **Al Reyadah CCUS Project**

*(nominated by the United Arab Emirates [lead], Australia, Canada, China, the Netherlands, Norway, Saudi Arabia, South Africa, the United Kingdom, and the United States)*

Arafat Al Yafei, representing project sponsor Abu Dhabi Carbon Capture Company, gave a technically detailed presentation about the Al Reyadah project. This is an integrated commercial-scale project, located in Mussafah, Abu Dhabi, United Arab Emirates, which is capturing CO<sub>2</sub> from the flue gas of an Emirates Steel production facility, and injecting the CO<sub>2</sub> for EOR in the Abu Dhabi National Oil Company's nearby oil fields. The main objectives are to reduce the carbon footprint of the United Arab Emirates, implement EOR in subsurface oil reservoirs, and free up natural gas which would have been used for oil field pressure maintenance. The Al Reyadah Project includes capture, transport and injection of up to 800,000 tonnes per year of CO<sub>2</sub> (processed at the required specifications and pressure) and is part of an overall master plan which could also create a CO<sub>2</sub> network and hub for managing future CO<sub>2</sub> supply and injection requirements in the United Arab Emirates.

After a brief discussion, there was consensus to recommend to the Policy Group that the project receive CSLF recognition.

## **21. Review and Approval of Project Proposed for CSLF-Recognition:**

### **Carbon Capture Simulation Initiative / Carbon Capture Simulation for Industry Impact (CCSI/CCSI<sup>2</sup>)**

*(nominated by the United States [lead], China, France, and Norway)*

Grant Bromhal, representing project sponsor the U.S. National Energy Technology Laboratory (NETL), gave a technically detailed presentation about CCSI/CCSI<sup>2</sup>. This is a computational research initiative, with activities ongoing at NETL, four other National Laboratories, and five universities across the United States, with collaboration from other organizations outside the United States including industry partners. The overall objective is to develop and utilize an integrated suite of computational tools (the CCSI Toolset) in order to support and accelerate the development, scale-up and commercialization of CO<sub>2</sub> capture technologies. The anticipated outcome is a significant reduction in the time that it takes to develop and scale-up new technologies in the energy sector. CCSI<sup>2</sup> will apply the CCSI toolset, in partnership with industry, in the scale-up of new and innovative CO<sub>2</sub> capture technologies. A major focus of CCSI<sup>2</sup> will be on model validation using the large-scale pilot test information from projects around the world to help predict design and operational performance at all scales including commercial demonstrations. These activities will help maximize the learning that occurs at each scale during technology development.

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After a brief discussion, there was consensus to recommend to the Policy Group that the project receive CSLF recognition.

## **22. Review and Approval of Project Proposed for CSLF-Recognition: National Risk Assessment Partnership (NRAP)**

*(nominated by the United States [lead], Australia, China, and France)*

Grant Bromhal, representing project sponsor NETL, gave a technically detailed presentation about NRAP. This is a risk assessment initiative, with activities ongoing at NETL and four other National Laboratories across the United States, including collaboration with industry, regulatory organizations, and other types of stakeholders. The overall objective is development of defensible, science-based methodologies and tools for quantifying leakage and seismic risks for long-term CO<sub>2</sub> geologic storage. The anticipated outcome is removal of key barriers to the business case for CO<sub>2</sub> storage by providing the technical basis for quantifying long-term liability. To that end, NRAP has developed and released a series of computational tools (the NRAP toolset) that are being used by a diverse set of stakeholders around the world. The toolset is expected to help storage site operators design and apply monitoring and mitigation strategies, help regulators and their agents quantify risks and perform cost-benefit analyses for specific CCS projects, and provide a basis for financiers and regulators to invest in and approve CCS projects with greater confidence because costs of long-term liability can be estimated more easily and with greater certainty.

After a brief discussion, there was consensus to recommend to the Policy Group that the project receive CSLF recognition.

## **23. Results from CSLF-recognized Project: Uthmaniyah CO<sub>2</sub>-EOR Demonstration Project**

Ammar AlShehri provided a brief update on the progress and activities for the CSLF-recognized Uthmaniyah CO<sub>2</sub>-EOR Demonstration Project. This is a commercial-scale demonstration, recognized in 2013 at the 5<sup>th</sup> CSLF Ministerial Meeting, which is capturing and utilizing approximately 800,000 tonnes of CO<sub>2</sub> per year for enhanced oil recovery. Dr. AlShehri stated that the Uthmaniyah project is part of Saudi Aramco's overall carbon management activities and that Saudi Aramco has developed a technology roadmap that includes capturing CO<sub>2</sub> from fixed and mobile sources, CO<sub>2</sub> conversion into industrial applications, and CO<sub>2</sub> sequestration as focal areas in addition to CO<sub>2</sub>-EOR.

Dr. AlShehri stated that the Uthmaniyah project captures CO<sub>2</sub> from natural gas processing operations and includes an 85-kilometer pipeline to transport the CO<sub>2</sub> to the injection site. A key feature of the project is its monitoring regime, which includes seismic monitoring, electromagnetic surveys, plume tracking, and inter-well tracer tests to accurately determine the CO<sub>2</sub> flow path. Monitoring parameters include the volume of the sequestered CO<sub>2</sub>, plume evolution, CO<sub>2</sub> migration and containment, and incremental oil recovered. This monitoring is being carried out continuously with data routed through a field center. Dr. AlShehri concluded his presentation by mentioning that this project is only a test to determine the feasibility of CO<sub>2</sub>-EOR in Saudi Arabia, as there will not be a need for widespread use of this technology for probably several decades. However, advances that will result from this project will add to the overall knowledge base for EOR and as a result, improve the economics for its deployment.

## 24. Results from CSLF-recognized Project: Illinois Industrial CCS Project

Sallie Greenberg provided a brief update on the progress and activities for the CSLF-recognized Illinois Industrial CCS Project. This is a commercial-scale demonstration, recognized at the 2012 CSLF Annual Meeting, which is sequestering approximately 3,000 tonnes of CO<sub>2</sub> per day. Dr. Greenberg stated that this project is a collaboration between the Archer Daniels Midland Company and the Midwest Geological Sequestration Consortium, plus other corporations and organizations, and is so far the only large-scale project in the United States that is storing CO<sub>2</sub> into a deep saline aquifer geologic storage formation. A companion project, the Illinois Basin Decatur Project, has already stored nearly one million tonnes of CO<sub>2</sub> into the same geologic formation as part of a comprehensive research program whose monitoring component has led to gains in knowledge about reservoir modeling, plume forecasting, and risk assessment.

Dr. Greenberg stated that the Illinois Industrial CCS Project began large-scale CO<sub>2</sub> injection just prior to the current CSLF Mid-Year Meeting. A rate-limiting step in the overall schedule had been completion of the permitting process. An Underground Injection Control (UIC) “Class VI” Permit was required from the U.S. Environmental Protection Agency (EPA) before injection could start, and this was the first such UIC Class VI permit that has been issued. The project includes development and validation of software tools as part of an “Intelligent Monitoring System” approach which will enable access, integration and analysis of real-time surface/subsurface data for decision-making and automation of sequestration activities.

Dr. Greenberg concluded her presentation by mentioning that the Illinois Industrial CCS Project will, in the end, store up to about 5.5 million tonnes of CO<sub>2</sub>. The saline aquifer that will sequester the CO<sub>2</sub> has a much larger capacity than that, and a follow-on U.S. Department of Energy program, the Carbon Storage Assurance and Facility Enterprise (CarbonSAFE), could result in greater than 50 million tonnes of CO<sub>2</sub> being sequestered there. The overall goal of CarbonSAFE will be to improve the overall knowledge base for large-scale CO<sub>2</sub> storage, validate models and various technologies related to geologic CO<sub>2</sub> storage, and contribute to best practice manuals which will be of use to future commercial CO<sub>2</sub> storage projects.

## 25. Overview and Status of the Carbon Storage Data Consortium

Sallie Greenberg provided a brief update on the Carbon Storage Data Consortium (CSDC), which had been created in 2016 following discussions in 2015 between United States and Norway researchers. The CSDC underpins another CSLF initiative, the Large-Scale Saline Storage Project Network, whose formation had been announced in November 2015 at the 6<sup>th</sup> CSLF Ministerial Meeting. Current membership of the CSDC include two organizations in the United States, four in Norway, and the IEAGHG.

Dr. Greenberg described how the CSDC data sharing network could work. Sponsoring organizations involved with geologic CO<sub>2</sub> storage would provide information to a CSDC project team, which would process/screen the data and make it available to a broader user community via a data-hub provider. The CSDC is currently exploring alternative technical solutions for data sharing, ranging from the simple, low-cost-but-low-flexibility to the complex, higher cost-and-full-flexibility approaches. The initial goal of the CSDC is to secure international co-funding to ensure long-term operations, and to expand its membership by inviting organizations in other countries besides the United States and Norway to join. A near term objective is to formally launch the consortium and make the first CO<sub>2</sub> storage datasets available before the end of 2017.

## 26. Update on Activities of the ISO/TC265

Ryozo Tanaka provided a brief update about the International Organization for Standardization (ISO) TC265 technical committee. The objective of TC265 is to prepare standards for the design, construction, operation and related activities in the field of CO<sub>2</sub> capture, transportation and geologic storage. The TC265 is comprised of six working groups focused on different aspects of CCS, each with proposed standards working their way through review and approval procedures. The most recent meeting of TC265 was in late November 2016, in Sapporo, Japan. At that meeting, Mr. Tanaka gave a short presentation about the CSLF that included information on its objectives, organization, previous meetings, and activities of CSLF Technical Group task forces. The next meeting of TC265 will in November 2017 in Sydney, Australia. There was consensus that Sallie Greenberg would represent the CSLF at that meeting.

## 27. Update on Future CSLF Meetings

Richard Lynch provided a brief logistical update about the site visit to the Al Reyadah CCUS Project, and stated that information about the 7<sup>th</sup> CSLF Ministerial Meeting, to be held in Abu Dhabi near the end of 2017, would be forthcoming at the Policy Group's meeting later in the week. There was nothing to report about the 2018 Mid-Year Meeting, but Max Watson stated that Australia has offered to host the 2018 Annual Meeting, at a date in October 2018. Additional details would also be forthcoming at the Policy Group's meeting.

## 28. Open Discussion and New Business

Sergio Persoglia provided a preview of the following week's meeting of the CO<sub>2</sub> GeoNet Association in Venice, Italy and Paolo Deiana gave a brief illustration of the Sulcis International CCS Summer School scheduled in the week from 19 to 23 June in Carbonia, SW Sardinia, Italy.

Mike Monea stated that there would be a CCS workshop in Regina, Saskatchewan, Canada in early October, which would focus on SaskPower's Boundary Dam Project and the related Aquastore Project.

Lars Ingolf Eide reported that he would be making a presentation about the CSLF at an upcoming conference in Trondheim, Norway, and would be vetting his presentation through the Technical Group's Executive Committee for comments and any suggested changes.

Stephanie Duran mentioned that the newly-designed CSLF website includes a list of such meetings and conferences and requested that information on upcoming events be sent to the CSLF Secretariat so that they can be given additional visibility through the website.

## 29. Closing Remarks / Adjourn

Åse Slagtern noted that this was the final CSLF meeting for Takashi Kawabata, who is moving on to other duties at Japan's Ministry of Economy, Trade and Industry. Mr. Kawabata was given a round of applause for his many years of involvement with the CSLF. Ms. Slagtern then thanked the meeting host United Arab Emirates Ministry of Energy, the Secretariat for its support, and the delegates for their active participation. She then adjourned the meeting.

## Summary of Meeting Outcomes

- The Al Reyadah CCUS Project is recommended by the Technical Group to the Policy Group for CSLF recognition.
- The Carbon Capture Simulation Initiative / Carbon Capture Simulation for Industry Impact initiative is recommended by the Technical Group to the Policy Group for CSLF recognition.
- The National Risk Assessment Partnership initiative is recommended by the Technical Group to the Policy Group for CSLF recognition.
- The Technical Group will form a new working group, to be chaired by Norway, which will evaluate existing and new ideas for possible future Technical Group actions.
- Sallie Greenberg will represent the CSLF at the next meeting of the ISO/TC265, in November 2017 in Sydney, Australia.

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