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Prepared by CSLF Secretariat

Minutes of the Technical Group Meeting

Abu Dhabi, United Arab Emirates
Monday, 04 December 2017

LIST OF ATTENDEES

Chair	Åse Slagtern (Norway)
Delegates	
Australia:	Andrew Barrett (*Vice Chair*), Max Watson
Canada:	Eddy Chui (*Vice Chair*), Mike Monea
China:	Jinfeng Ma
European Commission:	Jeroen Schuppers
France:	Didier Bonijoly, Dominique Copin
Italy:	Sergio Persoglia
Japan:	Ryozo Tanaka, Jiro Tanaka
Korea:	Chang-Keun Yi, Chong Kul Ryu
Mexico:	Jazmin Mota
Netherlands:	Harry Schreurs
Norway:	Lars Ingolf Eide, Espen Bernhard Kjærgård
Romania:	Constantin Sava, Anghel Sorin
Saudi Arabia:	Ammar Alsheikh, Tidjani Niass
South Africa:	Noel Kamajh (*Vice Chair*), Landi Themba
United Arab Emirates:	Ararat AlYafei, Fatma AlFalasi, Reshma Francy
United Kingdom:	Brian Allison
United States:	Mark Ackiewicz, Sallie Greenberg
Representatives of Allied Organizations	
Global CCS Institute:	Jeff Erikson
IEA:	Tristan Stanley
IEAGHG:	Tim Dixon
CSLF Secretariat	Richard Lynch, Adam Wong
Invited Speakers	
Australia:	Max Watson, CO2CRC
United Arab Emirates:	Fatima AlFoora AlShamsi, Ministry of Energy and Industry
United Kingdom:	Ceri Vincent, British Geological Survey (and) CO_2GeoNet
United States:	John Harju, University of North Dakota Energy and Environmental Technology Center
	Frank Morton, National Carbon Capture Center
	Chris Romans, MHI America

Observers

Australia:	Timothy Sill*
Canada:	Goran Vlajnic
Japan:	Leandro Figueiredo
Korea:	Mi Hwa Kim*, Yi Kyun Kwon
Norway:	Arne Graue, Stig Svenningsen*
Saudi Arabia:	Feruih Alenuzey, Robert Dibble, Wolf Heidug, Pieter Smeets
United Arab Emirates:	Mohammad Abu Zahra, Sherry Adel Asaad, Ahmed AlHajaj, Hind Nuaman AlAli, Martin Jagger, Kasia Wakar
United Kingdom:	Brendan Beck, Gardiner Hill
United States:	Damian Beauchamp, Bill Brown, Jarad Daniels*, Ed Steadman

* CSLF Policy Group delegate

1. Chairman's Welcome and Opening Remarks

The Chair of the Technical Group, Ase Slagtern, called the meeting to order and welcomed the delegates and observers to Abu Dhabi. Ms. Slagtern mentioned that this would be a busy meeting, with presentations on many topics of interest including presentations of results from three CSLF-recognized projects plus review of one new project which has been nominated for CSLF recognition. Ms. Slagtern also called attention to the downloadable documents book that had been prepared by the Secretariat for this meeting, which contains documents relevant to items on the agenda.

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 and Industry, welcomed the meeting attendees to Abu Dhabi. Dr. Al Shamsi stated that the 2017 CSLF Mid-Year meeting, also in Abu Dhabi, was an excellent example of how the collective knowledge of world class experts in the field of carbon capture and storage (CCS) can lead to progress. Three projects were recognized by the CSLF at that meeting, including the Al Reyadah Carbon Capture, Utilization and Storage (CCUS) Project which captures industrially-produced carbon dioxide (CO_2) from the Emirates Steel facility and delivers it to an ADNOC oil field where it is utilized for enhanced oil recovery. For the energy sector of the United Arab Emirates, the Al Reyadah project shows how partnerships and a

bold vision can deliver success in the field of carbon capture, utilization and storage. Dr. Al Shamsi closed her welcoming speech by thanking all organizations such as the IEAGHG and Global CCS Institute as well as the task forces under the CSLF for their continuing efforts on advancing various aspects of CCS and looked forward to productive discussions and positive outcomes from this meeting.

3. Introduction of Delegates

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

4. Adoption of Agenda

The Agenda was adopted with no changes. Presentations by delegates from Romania and China were included in the "General Discussion" agenda item.

5. Approval of Minutes from 2017 Mid-Year Meeting

The Minutes from the May 2017 Technical Group Meeting in Abu Dhabi were approved with no changes.

6. Report from CSLF Secretariat

Richard Lynch provided a report from the CSLF Secretariat which reviewed highlights from the May 2017 CSLF Mid-Year Meeting. This was a five-day event, including a site visit to the Al Reyadah CCUS Project and a technical workshop themed on "Carbon Utilization Challenges and Opportunities" and "Spotlight on Carbon Capture". Presentations from all meetings and the workshop are online at the CSLF website.

Mr. Lynch stated that there were several key outcomes from the May 2017 Technical Group meeting. First and foremost, the Al Reyadah CCUS Project, the National Risk Assessment Partnership, and the Carbon Capture Simulation Initiative / Carbon Capture Simulation for Industry Impact were all recommended by the Technical Group to the Policy Group for CSLF recognition. Additionally, there were reports from four existing Technical Group task forces and formation of a new working group, led by Norway, to evaluate existing and new ideas for possible future Technical Group actions. Finally, the CSLF Technology Roadmap (TRM) working group reported that a mostly-final version of the 2017 TRM had been completed and was undergoing final review.

7. Update from the IEA Greenhouse Gas R&D Programme (IEAGHG)

Tim Dixon, the Technical Programme Manager for the IEAGHG, gave a concise presentation about the IEAGHG and its continuing collaboration with the CSLF's Technical Group. The IEAGHG was founded in 1991 as an independent technical organization 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 biennial GHGT conferences (the next one in October 2018 in Melbourne, Australia). Other IEAGHG activities include its biennial post combustion capture

conferences, its annual International CCS Summer School, peer reviews with other organizations, activity in international regulatory organizations such as the UNFCCC, the ISO TC265, and the London Convention, and collaboration with other organizations, including the CSLF.

Mr. Dixon 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 the 2nd International Workshop on Offshore Geologic CO_2 Storage.

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

8. Update on the Global Status of CCS

Jeff Erikson, General Manager for the Americas at the Global Carbon Capture and Storage Institute (GCCSI), gave a short presentation about the global status of CCS. Since the early 1970s, more than 200 million tonnes of CO_2 have been captured and stored in deep underground geologic formations. Overall, capture technologies are now widely utilized at large-scale globally, with costs declining as new facilities come online and technologies further mature. As of 2017 there are 17 large-scale CCS projects throughout the world which are in operation, capturing more than 30 million tonnes CO_2 per year annually. An additional four large-scale projects are scheduled to come online in 2018, and will capture an additional 16 million tonnes CO_2 per year. Between December 2016 and December 2017 there were start-ups of two large-scale facilities in the United States (the Petra Nova Project and the Archer Daniels Midland Project). In Norway, the offshore Sleipner and Snøhvit facilities have surpassed 20 million tonnes of CO_2 captured and stored. In Canada the Quest Project has achieved more than 2 million tonnes of CO_2 captured and stored since its 2015 start-up and the SaskPower Boundary Dam Project will soon reach that same milestone. Additionally, two other western hemisphere large-scale projects (the Industrial Air Products Project in the United States and the offshore natural gas processing Santos Basin Project in Brazil) have each captured more than 4 million tonnes of CO_2 since their start-ups.

Mr. Erikson stated that three other large-scale projects, in China, Australia and Canada, are scheduled to come online in 2018, with the Gorgon Project in Australia having a capacity of up to 4 million tonnes of CO_2 captured and stored annually. And besides all these very large-scale activities, there are many somewhat smaller facilities throughout the world, including the Tomakomai CCS Project in Japan, which are conducting important technology verification activities on various aspects of CO_2 capture, monitoring, and verification of storage. In closing his presentation, Mr. Erikson stated that the GCCSI has published an extensive report on the global status of CCS and it is available for viewing at its website.

9. Update from CO_2GeoNet

The Chair of the CO_2GeoNet Executive Committee, Ceri Vincent, gave a short presentation about the CO_2 GeoNet Association and its activities. CO_2GeoNet is a pan-European research association for advancing geological storage of CO_2. It was created as a European Union FP6 Network of Excellence in 2004 and transformed into an Association under French law in 2008. There are now 28 members from 21 countries, including industry, academia, and research institutes. As an independent and multidisciplinary scientific body, CO_2 GeoNet has an important role in building trust in CO_2 geological storage and supporting large-scale implementation of CCS.

Ms. Vincent stated that CO_2GeoNet has four categories of activities: joint research, scientific advice, training, and information / communication. An example of a joint research activity is the Enabling Onshore Storage (ENOS) Project, which began in 2016 and will run through 2020. ENOS currently has 29 partners from 17 countries, with five field laboratories / pilot sites. The overall goal of the project is to prepare a favorable environment for onshore CO_2 storage in Europe.

Ms. Vincent also stated that CO_2GeoNet is very active in outreach activities, exemplified by its being selected (along with the U.K. CCS Association) as the CSLF's regional stakeholder 'champion' for Europe and has contributed to the CSLF's overall stakeholder engagement strategy. It is also involved in training activities via educational programs and is building a framework for a Masters-level graduate school course for CCS. Ms. Vincent concluded her presentation by mentioning that CO_2GeoNet holds an annual Open Forum; the theme of the 2017 Forum was "Driving CCS towards implementation" and included the knowledge-sharing workshop "Bringing CCS into new regions".

10. Report on Mission Innovation Experts Group Workshop

The Co-Chair of Mission Innovation's Carbon Capture Innovation Challenge, Tidjani Niass, gave a short presentation about Mission Innovation and the Innovation Challenge. Mission Innovation is a Ministerial-level initiative that was launched in November 2015 at the Paris climate meeting and currently includes 22 countries plus the European Commission. Collectively, these countries represent 60% of the world's population, 70% of the global GDP, 80% of worldwide government investment in clean energy RD&D, and 67% of the total world greenhouse gas emissions. The overall goal of the Mission Innovation initiative is for the 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, an invitation-only "Experts Workshop", as part of the Carbon Capture Innovation Challenge (CCIC), was held in the United States in September 2017.

Dr. Niass stated that the overall objective for the CCIC is to develop a route to near-zero CO_2 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 Experts Workshop, which was co-chaired by the United States and Saudi Arabia, focused on establishing the current state of technology in CCUS, identifying and prioritizing R&D gaps and opportunities, and establishing high priority research directions to address opportunities. Dr. Niass stated that the Workshop was a success, with 22 countries participating and a total of 257 participants representing government, academia, and industry. There were three main focus areas: CO_2 capture, CO_2 utilization, and CO_2 storage. In addition to these, a

separate group was focusing on crosscutting issues. Outcomes included creation of an international consensus on the most critical scientific challenges in these areas as well as crosscutting topics and establishing internationally agreed priority research directions such as tailoring material properties to enable CCUS. Next steps will be publication of the Workshop report (scheduled for early 2018), developing and implementing collaboration mechanisms, fostering engagement with industry, and preparing for the upcoming 3rd Mission Innovation Ministerial.

Ensuing discussion brought forth several ideas for Mission Innovation and the CCIC to consider. Jeroen Schuppers stated that the European Union's "Horizon 2020" research and innovation programme contains a number of topics which are open to participation from Mission Innovation member countries. Ryozo Tanaka inquired how the next steps described in the presentation would be addressed. Dr. Niass replied that there are not yet any definitive plans for doing so, but the CCIC Steering Committee would be discussing this in its teleconferences and in a meeting to be held in early 2018 in Ottawa, Canada. Brian Allison stated that the European Research Area Network's Accelerating CCS Technologies (ACT) initiative, which has so far selected eight transnational projects representing a combined funding of €38 million, is very interested in having projects and activities identified under the Carbon Capture Innovative Challenge respond to future ACT calls for project proposals. Mr. Allison also stated that while the Experts Group Workshop is a good start, he hoped that the Carbon Capture Innovative Challenge would soon take the next step beyond that. Dr. Niass agreed, and stated that the ACT platform might be a good place to start but does went more collaboration opportunities than just that.

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 (TRM), and finding ways to better engage sponsors of CSLF-recognized projects. Mr. Barrett reported that there were three main outcomes from the meeting:

- The PIRT has recommended approval by the Technical Group for the CO2CRC Otway Project Stage 3 to become a CSLF-recognized project.
- The 2017 TRM has been completed and launched. It should be noted that this is a beginning and not an end in itself, and there should be actions taken by the CSLF to ensure that the TRM remains a living and useful document. To that end, a PIRT working group was organized to explore and suggest approaches for tracking follow-up and progress of the TRM recommendations. The group will also explore the feasibility of utilizing expertise and learnings from CSLF-recognized projects as input to future editions of the TRM.
- The PIRT's Terms of Reference document was reviewed and updated. Significant changes included updating the methodology for how the PIRT approves projects proposed for CSLF recognition.

Mr. Barrett stated that the PIRT meeting had also featured a preview of an item on the Technical Group's current meeting agenda on evaluating new ideas for Technical Group future actions. The discussion in the PIRT meeting had helped clarify thinking about how to proceed in this area, and would be summarized during the agenda item on that topic later in the current Technical Group meeting.

12. Preview of 2017 CSLF Technology Roadmap (TRM)

The Chair of the TRM working group, Andrew Barrett, and the Editor of the TRM, Lars Ingolf Eide, gave a short 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 2017 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 Mr. Eide the editor-in-chief. The Working Group was 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:

- For the purposes of the 2017 TRM, CCUS has been defined as a subset of CCS.
- New time horizons were 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 that meet the IEA 2 ºC scenario were used for CO_2 sequestration.
- There is a new section on non-technical measures such as regulations.
- There is now less detail concerning specific CO_2 capture technology types and fundamentals, and more emphasis on industrial and biomass CCS.
- There is a new section on CO_2 capture or hydrogen as a mechanism to decarbonize industry.
- There is more emphasis on development of a "clusters and hubs" approach toward CCS, and also on ship transport of CO_2.
- Recent CO_2 storage projects and activities have been referenced, and description has been updated and expanded about various aspects of CO_2 utilization.
- There is expanded and updated text, particularly on offshore CO_2-Enhanced Oil Recovery (EOR) and other CO_2 utilization options. A description of barriers to CO_2 utilization was also added.
- There are identified actions to meet technology needs throughout the CCS chain.

Mr. Barrett then yielded to Mr. Eide who stated the main findings of the 2017 TRM are that CCUS works in power and industrial settings. However, the coming years is a critical period for CCS and therefore a sense of urgency must emerge which will drive actions. Substantial and perhaps unprecedented investment in CCS and other low carbon technologies is needed to achieve the targets of the Paris Agreement, and the main barriers to implementation are inadequate government investment and policy support initiatives, challenging project economics, and uncertainties / risks that stifle private sector investment. Other significant findings are that rapid development of CCS is critical in the industry and power sectors, especially in those industries for which CCS is the most realistic path to decarbonization. Negative CO_2 emissions can be achieved by using a combination of biomass and CCS, while costs and implementation risks for CCS can be reduced by developing industrial clusters and CO_2 transport / storage hubs. Finally, members of the CSLF consider it critical that public-private partnerships form to facilitate cost-reductions and accelerated implementation of CCS.

Mr. Eide then described the priority recommendations made by the 2017 TRM. Governments and industry must collaborate to ensure that CCS contributes its share to the Paris Agreement's targets by implementing sufficient large-scale projects in order to achieve the following:

- Long term isolation from the atmosphere of at least 400 megatonnes (Mt) of CO_2 per year by 2025 (or permanent capture and storage of a total of 4,800 Mt of CO_2).
- Long term isolation from the atmosphere of at least 2,400 Mt of CO_2 per year by 2035 (or permanent capture and storage of a total of 16,000 Mt of CO_2).

To that end, CSLF members recommend the following actions to the CSLF Ministers:

- Promote the value of CCS in achieving domestic energy goals and global climate goals.
- Incentivize investments in CCS by developing and implementing policy frameworks.
- Facilitate innovative business models for CCS projects.
- Implement legal and regulatory frameworks for CCS.
- Facilitate CCS infrastructure development.
- Build trust and engage stakeholders through CCS public outreach and education.
- Leverage existing large-scale projects to promote knowledge-exchange opportunities.
- Drive down costs along the whole CCS chain through RD&D.
- Accelerate CCS in developing countries by funding storage appraisals and technology readiness assessments.
- Facilitate implementation of CO_2 utilization.

Mr. Eide concluded the presentation by stating the takeaway message that is being provided to the Ministers: **Governments have a critical role in accelerating the deployment of CCS**.

13. Report from the Offshore CO_2-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 was to highlight differences and issues between onshore and offshore CO_2-EOR as well as offshore CO_2-EOR and pure offshore CO_2 storage. The task force also highlighted any technical solutions that benefit both pure offshore CO_2 storage and offshore CO_2-EOR. Task force members included Norway (as chair), Brazil, Canada, Mexico, the United States, and the IEAGHG. The methodology of the task force was to examine existing, although not necessarily published, information.

Mr. Eide stated that a draft of the task force's final report had been completed and previewed at the 2017 CSLF Mid-Year Meeting. The contents of the report includes chapters on the basics of offshore CO_2-EOR, insights from the Brazilian "Lula" off-shore CO_2-EOR project, approaches and emerging technical solutions toward enabling offshore CO_2-EOR, description of emerging technical solutions for offshore CO_2-EOR and offshore CO_2 storage, description of potential CO_2 supply chain issues, issues involved with monitoring and verification of storage, description of regulatory requirements for offshore CO_2 utilization and storage, a summary of barriers that exist for implementing offshore CO_2-EOR projects, and recommendations for overcoming those barriers.

Following Mr. Eide's presentation there was consensus by the Technical Group to accept the final report. Mr. Eide then stated that the task force was hereby disbanded.

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

Task Force Chair Mark Ackiewicz 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 the overall commercial status for BECCS, technology options and pathways, biomass resource assessments, emissions profiles, and economic analyses. The draft report identifies various commercial projects in operation, market drivers, and barriers to large-scale BECCS demonstration and deployment. Mr. Ackiewicz also presented a set of findings and recommendations from the task force on the topics of biomass feedstocks, technology, analyses, outreach / communications, and financing. The task force's final report was drafted by the United States Department of Energy, the IEAGHG, the Center for Carbon Removal, and the International Research Institute of Stavanger, and included review and contributions from CO_2GeoNet, the Research Council of Norway, SINTEF, and Shell. Mr. Ackiewicz stated that a draft of the task force's final report has been completed and is in final review.

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. Task force members include Australia and the United Kingdom (as co-chairs), France, Japan, Norway, the United Arab Emirates, and the IEAGHG. The purpose of the task force is to investigate the concept of improved utilisation of geological storage space resource to increase CO_2 storage capacity, review the current state of processes and technologies that enhance utilisation of the storage space, highlight key techniques that have recently emerged internationally, and provide a set of options for stakeholders to develop into their CO_2 storage projects. Pore space utilisation related to EOR and reservoir stimulation were not considered by the task force as these would greatly increase the level of effort and require expertise beyond what exists with task force participants.

Mr. Allison stated that the task force's final report would include six topics related to pore space utilisation: regulatory considerations, technology & process review, microbubble injection, saturated water & geothermal energy production, compositional & temperature swing injection, and ranked technique effectiveness. Work is complete on all topics except for the technology & progress review and ranked technique effectiveness sections, which are still under review. Mr. Allison concluded his presentation by stating that the task force timeline now shows the final report review cycle to be complete by mid-March 2018, after which it will be sent to task force members for a final check and then to the entirety of the Technical Group. The final report will be presented to the Technical Group at its next meeting.

16. Report from the CCS for Industries Task Force

Task Force Chair Didier Bonijoly asked Dominique Copin to present the task force report. This task force was established at the October 2016 meeting in Tokyo with a mandate to investigate the opportunities and issues for CCUS in the industrial sector and show what the role of CCUS could be as a lower-carbon strategy for CO_2-emitting industries. The task force consists of members from France's Club CO_2, with additional commitment from Canada, Norway, Saudi Arabia, the United Arab Emirates, and the

GCCSI. Mr. Copin mentioned that almost all industrial sectors are engaged in this activity either via a company in one of those sectors or a professional organization. Relevant issues being examined include: why CCUS for industry is an important issue, which industries and their emissions to focus on, what potential alternatives to CCS exist (if any) to achieve zero CO_2 emissions for different industries, and the status of CCUS developments from laboratory scale to industrial demonstration.

Mr. Copin stated that the task force's time line calls for it to receive and review contributions to its final report through the end of January 2018. The first draft of the report will be done in March 2018 and will be presented to the Technical Group at its next meeting. A review cycle for the draft report will produce a finalized report by about mid-2018. During ensuing discussion, Tristan Stanley mentioned that the IEA is just starting on a new roadmap for decarbonizing the iron and steel industry, and would be willing to share results with the task force.

17. Update from Working Group on Evaluating Existing and New Ideas for Possible Future Technical Group Actions

At the 2017 CSLF Mid-Year Meeting, a working group (led by Norway) had been created by the Technical Group to appraise all unaddressed items in the Action Plan from 2015, propose new topics for appraisal, and review past task force reports to see if any updates are warranted.

The working group's chairman, Lars Ingolf Eide, made a short presentation that summarized existing Technical Group activities and possible new ones in advance of a more detailed discussion during the next day's full Technical Group Meeting. There are currently four active task forces besides the PIRT: Improved Pore Space Utilization (co-chaired by Australia and the United Kingdom), Bioenergy with CCS (chaired by the United States), Industrial CCS (chaired by France), and Offshore CO_2-EOR (chaired by Norway which completed its activities in 2017). Mr. Eide stated that there are eleven other possible future actions identified by the 2015 working group, but there had not yet been any consensus to form task forces around these possible actions. Additionally, there have been eleven other actions, which were completed between 2006 and 2015 and have resulted in task force final reports.

Mr. Eide then described the process for developing and prioritizing a long list of future potential actions. In all, 24 potential new topics were included – eleven unaddressed items from 2015, eleven past task force topics (for possible updates), and two new proposals. The members of the working group then participated in a preference poll, which resulted in a "final four" of highest ranked topics:

1. Hydrogen as a Tool to Decarbonize Industries (which was the clear winner)
2. Reviewing Best Practices and Standards for Geologic Monitoring and Storage of CO_2
3. CO_2 Capture by Mineralization
4. Global Scaling of CCS

Mr. Eide stated that for the proposed action on Hydrogen as a Tool to Decarbonize Industries, the working group had come up with several sub-topics that could be addressed: hydrogen production and use; hydrogen with CCS, synergies with renewables, life cycle costs and carbon footprint; and hydrogen value chain. Additionally, there are several existing activities and programs – in Europe, Japan, and the United States as well as with multinational energy companies such as Statoil, Gasunie, and Vattenfall Nuon – which could be mapped in a "Phase 0" of a new Technical Group task force.

Ensuing discussion led to the formation of the new Task Force on Hydrogen with CCS which would conduct "Phase 0" activities in time for the next Technical Group meeting, where a decision would be made on whether or not to continue the task force. For this zeroth phase, the task force will be led by Norway (Lars Ingolf Eide), with participation / contributions by Australia (Max Watson), Canada (Eddy Chui), France (Didier Bonijoly), Japan (Ryozo Tanaka), the Netherlands (Harry Schreurs), Saudi Arabia (Ammar Alshehri), the United Arab Emirates (Arafat AlYafei), the United Kingdom (Brian Allison), the IEAGHG (Tim Dixon), and the CSLF Secretariat (Richard Lynch).

Additionally, Harry Schreurs gave some information on the CO_2 Capture by Mineralization proposed activity, after which several other delegates expressed interest. Mr. Schreurs stated that he would investigate the possibility for the Netherlands to lead a task force on this topic and that he would present a detailed proposal at the next Technical Group meeting.

18. Report on Global CCS Symposium

Mike Monea, President and CEO of the International CCS Knowledge Centre (ICCSKC), provided a short presentation on the October 2017 Global CCS Symposium which was held in Regina, Saskatchewan, Canada and hosted by the ICCSKC. Mr. Monea stated that the ICCSKC was established as a non-profit organization in 2016 with a mandate to advance the understanding and use of CCS as a means of managing CO_2 emissions. Its focus is on facilitating the sharing of data, information, and lessons learned from SaskPower's Boundary Dam CCS Project and other large-scale CCS projects in other parts of the world.

Mr. Monea stated that the theme of the three-day October 2017 Symposium was "Advancing a Path Forward" with an emphasis on positive and noteworthy stories of CCS projects that are in operation as provided by representatives of those projects. There were 150 representatives from 16 countries in attendance, with sessions themed on "Large-Scale CCS Development: It Can be Done", "Key Economic Considerations – Building on Experience for the Future", and "Optimization – An Insider's Look" as well as other sessions about advancements in CO_2 storage, CCS in a Paris world, exploring enabling policies for CCUS development, and CCUS on industrial sources. Mr. Monea closed his presentation by providing some of the key takeaways from the symposium: the costs of CCS are coming down; CCS allows us to transition out of fossil fuels in a clean way; EOR is a tool to spur development but policies must go further; CO_2 conversion sounds good but may take more energy; and small scale CCUS is not enough – more large-scale demonstrations are needed.

19. Update on International Test Center Network (ITCN)

Frank Morton, Director of Technology at the National Carbon Capture Center (NCCC) in the United States, gave a short presentation about the ITCN and its collaborative activities. The ITCN was launched in 2013 to accelerate CCS technology development. Its main function is to facilitate knowledge sharing of operational experience and non-confidential information for CO_2 capture technologies, in terms of facility operations, facility funding, safety, and analytical techniques. Among the objectives of the ITCN are increasing insight and awareness of different technologies that may reduce risks and increase investments in CO_2 capture technologies and enhancing public awareness and acceptance of the technologies involved. The ITCN will also work with technology developers as appropriate on scale-up testing of their technologies.

Mr. Morton stated that criteria for a test facility's membership in the network is that the facility must be operating on real flue gas (i.e., be connected to a power plant or industrial plant), it must have the intent of being neutral in any technology decisions, and it must be willing to share information and receive visitors. The ITCN currently has 18 members (including the NCCC) representing large and smaller-scale CO_2 capture facilities on four continents, and in the four years it has been in existence there have been numerous collaborations between its members. Mr. Morton concluded his presentation by briefly describing future activities of the ITCN. These include sharing information with China, which will be operating two test CO_2 capture facilities, and with India, which is interested in CO_2-EOR.

20. Results from CSLF-recognized Project: Rotterdam Opslag en Afvang Demonstratieproject (ROAD)

Harry Schreurs provided a retrospective overview of the recently-cancelled ROAD project. ROAD had been recognized by the CSLF at its 2009 Ministerial Meeting in London, but its ten-year life was ended by insurmountable funding issues. However, there were many valuable lessons learned, which were described by Mr. Schreurs. Concerning CO_2 capture, there were sufficient proven technologies available where there was confidence that any engineering problems could be solved – in other words, the technology is available and will work. For CO_2 transport there were some technical uncertainties such as managing two-phase flow behavior but CO_2 pipelines are by now conventional technology which will work. CO_2 storage technologies are also available and have been proven to work, but storage regulations (especially issues concerning liability) are not yet to the point where a large-scale project is easily do-able.

Mr. Schreurs stated that while the lack of a regulatory regime was a potential show-stopper, the actual reason that ROAD failed (which also applies to other failed large-scale CCS projects in Europe) was because nobody was prepared to pay for it – ROAD was a project without a customer or a constituency. Industrial partners did not have a business case and public funders did not have sufficient public and political support. For the latter, CCS had been perceived in the Netherlands as being in competition with investments in renewables and as an optional measure of last resort in an attempt to keep coal-fueled power generation relevant. Mr. Schreurs closed his presentation by stating the key lesson learnt from ROAD: Government has to fund CCS, at least for the initial round of demonstrations, because there is not yet any other customer. To succeed, projects must be designed and operated to maximize long-term Government support.

21. Review and Approval of Project Proposed for CSLF-Recognition: CO2CRC Otway Project Stage 3
(nominated by the Australia [lead], Canada, France, Mexico, Norway, Saudi Arabia, and the United Kingdom)

Max Watson, representing project sponsor CO2CRC, gave an overview presentation about the Otway Stage 3 project. This is the third stage of a multistage CO_2 storage program, located in southwestern Victoria, Australia. The goal is to validate cost and operationally effective subsurface monitoring technologies to accelerate the implementation of commercial CCS projects. Specific objectives include developing and validating the concept of risk-based CO_2 monitoring and validation (M&V), assessing the application of innovative M&V techniques through trials against a small-scale CO_2 storage operation at the Otway research facility, and expanding the existing Otway facility such that field trials of various storage R&D are possible, including low invasive,

cost-effective monitoring and migration management. An anticipated outcome is that this project will result in improved and less expensive M&V techniques which will be applicable to other onshore sites as well as sub-seabed CO_2 storage projects.

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

22. Results from CSLF-recognized Project: Plant Barry Integrated CCS Project

Chris Romans, representing technology provider MHI Americas, provided a brief summary of the CO_2 capture aspects for the now-completed Plant Barry Integrated CCS Project. The project utilized MHI's proprietary KM CDR Process for capture of CO_2. Mr. Romans stated that the Plant Barry Project, located near Mobile, Alabama in the United States and operated jointly by The Southern Company and MHI, was an important large pilot project which helped prove commercial viability of MHI's carbon capture technology with coal-fueled flue gas. A slipstream provided flue gas equivalent to 25 megawatts of power production and some of the captured CO_2 was transported by a 19-kilometer pipeline to the injection site, where it was stored in deep saline formation approximately 3 kilometers below ground. In all, more than 200,000 tonnes of CO_2 was captured in the duration of the project, with 115,000 tonnes transported and stored. Mr. Romans closed his presentation by stating that this experience gained during this project resulted in scale-up of the CO_2 capture technology for use in the W.A. Parish "Petra Nova" demonstration project in Texas, which is capturing 4,776 tonnes of CO_2 per day.

23. Results from CSLF-recognized Project: Lacq Integrated CCS Project

Dominique Copin, representing project sponsor Total, provided a brief summary of the now-completed Lacq Integrated CCS Project. This was an intermediate-scale project based on natural gas-fueled oxyfuel combustion which tested and demonstrated an entire integrated CCS process throughout the complete industrial chain, from emissions source to underground storage in a depleted gas field. The project captured and stored a total of 51,000 tonnes of CO_2 from an oxyfuel gas-fired industrial boiler in the Lacq industrial complex in southwestern France. The goal was to demonstrate the technical feasibility and reliability of the integrated process, including the oxyfuel boiler, and also included geological storage quantification methodologies, as well as monitoring and verification techniques, to prepare for future larger-scale long term CO_2 storage projects. Mr. Copin stated that the outcome from the CO_2 capture component of the project was that a sufficient amount of data was obtained to design a full-scale 200-megawatt oxyfuel boiler. Results from the CO_2 storage component included characterization of a depleted gas reservoir as a CO_2 storage site as well as a demonstration of the ability to monitor the integrity and environmental impact of such a CO_2 storage site. Mr. Copin also stated that the Lacq Project's public outreach campaign was very successful in engaging the populace in the vicinity of the project. In that regard, the project published a brochure in 2014 that summarized its stakeholder outreach activities and has also created a "lessons learned" document that is available at the GCCSI website.

24. Results from CSLF-recognized Project: Uthmaniyah CO_2-EOR Demonstration Project

Ammar Alshehri, representing project sponsor Saudi Aramco, provided a brief update on the progress and activities for the Uthmaniyah CO_2-EOR Demonstration Project. This is a large-scale demonstration which is capturing and utilizing approximately 800,000

tonnes of CO_2 per year. It was highlighted that Saudi Aramco does not need EOR to meet the global energy demand; the project is a long-term resource planning strategy and an approach to protect the environment. 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_2 from fixed and mobile sources, CO_2 conversion into industrial applications, and CO_2 sequestration as focus areas in addition to CO_2-EOR. The Uthmaniyah project captures CO_2 from natural gas processing operations and includes an 85-kilometer pipeline to transport the CO_2 to the injection site. Overall, approximately 2,000 tonnes of CO_2 per day are being injected with about 80% of the CO_2 being retained in the reservoir.

A key feature of the project is its monitoring program, which includes seismic monitoring (via an array of 1,000 sensors), cross-well electromagnetic surveillance for plume tracking, borehole / surface gravity methods for plume tracking and leak detection, and inter-well tracer tests to accurately determine the CO_2 flow paths. Monitoring parameters include the volume of the sequestered CO_2, plume evolution, and CO_2 migration and containment. 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 CCS-EOR in Saudi Arabia, as there will not be a need for widespread use of this technology for probably several decades.

25. Regional Evaluation of the Complete CCS Value Chain

John Harju, Vice President for Strategic Partnerships at the University of North Dakota's Energy and Environmental Research Center (EERC), gave a short presentation, which provided an overview of the synergies that exist between regional coal and petroleum producers via use of CCUS. A project team headed by EERC is conducting a quantitative evaluation of the technical and economic impacts of the carbon value chain in North Dakota, which is the 6th greatest coal producer and the 2nd greatest petroleum producer in the United States. CCUS in North Dakota is therefore key for assuring that energy can be provided in a clean, affordable and reliable manner. Mr. Harju stated that EERC's quantitative evaluation has been comprehensive, including upstream activities (lignite mining and power generation), CO_2 transportation aspects, and downstream activities (CO_2-EOR and associated CO_2 storage). The high-level economic impact of CCUS in North Dakota is a positive effect on the regional economy and tax revenues. CCUS would result in a continuous and affordable supply of CO_2 which would greatly increase the amount of petroleum that can be produced. Mr. Harju stated that the EERC evaluation is examining ways to capitalize on the regional synergies, and this would include development of potential business models which factor in process and demand for coal, oil and electricity, and also examining the effect of current and possible future incentives at both he state and federal level. The effect of the increasing amount of energy being obtained from renewables is also being considered. Mr. Harju closed his presentation by pictorially indicating that only a small fraction of shale oil in North Dakota is currently economically recoverable, and that better understanding the techno-economic impacts of linking North Dakota lignite with CO_2-EOR will lead to a more robust energy industry in the state.

26. 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 6th CSLF Ministerial Meeting. Current membership of the CSDC includes two organizations from the United States, five from Norway, and the IEAGHG. The overall objectives of the CSDC are to accelerate improved understanding and minimize uncertainties associated with storage of CO_2, to establish and operate a platform for sharing reference datasets from pioneering CO_2 storage projects, to provide to data owners a simple, standard and low cost solution for making data available to research organizations worldwide, and to open an international network for data and knowledge exchange. The goal is to make initial CSDC datasets available in the 2018/2019 timeframe.

Dr. Greenberg described how the CSDC data sharing network could work. Sponsoring organizations involved with geologic CO_2 storage would provide information to the CSDC project team and steering committee, which would process/screen the data and make it available to a broader user community via a data hub provider. Survey results from 50 stakeholder respondents have clarified how the CSDC should move forward: ranking of datasets is very important as most stakeholders are users and not providers of datasets, but few respondents appeared open to paying a fee in order to participate. As a result, 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. Dr. Greenberg concluded her presentation by stating that the CSDC has been awarded funding from both the United States Department of Energy's National Energy Technology Laboratory and Norway's CLIMIT program. However, it is important to secure additional international commitments to ensure its long-term operations. To that end, the CSDC is seeking to expand its membership by inviting organizations in other countries besides the United States and Norway to join.

27. Outcomes and Messages from 2nd International Workshop on Offshore CO_2 Storage

Tim Dixon provided a brief update on results and outcomes from the 2nd International Workshop on Offshore Geologic CO_2 Storage, which was held in June 2017 and hosted by Lamar University, in Beaumont, Texas in the United States. Mr. Dixon stated that the workshop had been organized by the University of Texas's Bureau of Economic Geology in collaboration with the IEAGHG and the South Africa National Energy Development Institute (SANEDI). One of the purposes of the workshop was to facilitate sharing of knowledge and experiences among those who are doing offshore CO_2 storage and those who have an interest in doing so at some point in the future. Mr. Dixon stated that the workshop was a good capacity building event and overall there were 50 attendees representing nine countries.

Mr. Dixon stated that the aim of the workshop was to build on recommendations and topics raised during the 1st Workshop in order to take offshore storage forward. In particular, there were technical "deep dives" into several key topics: how to find storage offshore; technical aspects and experiences of offshore monitoring; offshore CO_2-EOR; infrastructure developments and decisions; and developments in offshore storage assessments in the Gulf of Mexico. Outcomes from the workshop were a set of conclusions and recommendations, relevant to areas such as environmental monitoring, risk mitigation, cost management, and infrastructure, as well as their policy implications. Mr. Dixon closed his presentation by mentioning that a report on the workshop has been completed and has been posted to the IEAGHG website.

28. Update on Activities of the ISO/TC265

Sallie Greenberg provided a brief update about the International Organization for Standardization (ISO) TC265 technical committee. The overall objective of TC265 is to prepare standards for the design, construction, operation and related activities in the field of CO_2 capture, transportation and geologic storage. The TC265 consists of six working groups focused on different aspects of CCS, each with proposed standards working their way through review and approval procedures. Concerning the TC265 and the CSLF, there has been significant interest by the TC265 in the CSLF's TRM and its recently published Regulatory Task Force Case Study Report. Dr. Greenberg reported that at the most recent meeting of TC265 was in late November 2017, in Sydney, Australia, there was discussion about a possible greater liaison by the TC265 with the CSLF which might include topics such as a stakeholder engagement standard. At that meeting, Dr. Greenberg gave a short presentation about the CSLF that included information on its objectives, organization, previous meetings, and activities of CSLF Technical Group task forces. During ensuing discussion, the Technical Group reached consensus that Dr. Greenberg would be the Technical Group's liaison to the TC265.

29. Preview of Technical Group Presentation at Ministerial Conference

Technical Group Chair Åse Slagtern previewed her "Messages and Recommendations from the CSLF Technical Group" presentation to the upcoming Conference of CSLF Ministers. The presentation mostly summarized recommendations from the TRM (listed above in Item 12), but also noted that barriers are in place that are preventing the widespread utilization of CCS. Ms. Slagtern concluded her presentation by emphasizing the Technical Group's "takeaway message" to the Ministers: **Governments have a critical role in accelerating the deployment of CCS**.

30. Update on Future CSLF Meetings

Richard Lynch stated that there was nothing yet to report about the 2018 Mid-Year Meeting. Policy Group Chair Jarad Daniels stated that he would be interested in hearing from any CSLF Member who would like to host the 2018 Mid-Year Meeting or one of the 2019 meetings. Mat Watson re-affirmed that Australia will be hosting the 2018 Annual Meeting in October 2018 on a week adjacent to the week of the IEAGHG's GHGT conference. Additional details would also be forthcoming soon.

31. Open Discussion and New Business

Two previously unscheduled presentations were made during this item. Constantin Sava, Senior Scientist at Romania's National Institute of Marine Geology and Geoecology (GeoEcoMar), provided information about the Accelerating Low carbon Industrial Growth through CCS (ALIGN) project, which is addressing specific issues across the CCUS chain using results from projects in the United Kingdom, the Netherlands, Germany, and Norway. There are currently 31 partner organizations and the project has so far secured approximately €15 million in funding. The project will run through 2020 and consists of six work packages: CO_2 capture, CO_2 Transport, CO_2 storage, CO_2 Re-Use, Industrial Clusters, and Societal Issues. Dr. Sava also made a brief presentation about the Enhanced Oil Recovery with Storage (ECO-BASE) Project, which is being managed by the International Research Institute of Stavanger, Norway and in which GeoEcoMar is a project partner. ECO-BASE is attempting to establish a business case for CO_2-EOR in southeastern Europe, with a first step of developing detailed and

integrated roadmaps for CCUS in that part of Europe. Expected milestones include accomplishing the mapping of existing CO_2 sources and possible CO_2 sinks while determining what the most promising opportunities for CO2-EOR are in terms of developing a business case. There would also be capacity building opportunities for the region with outreach and CCUS-related instructional courses.

Jinfeng Ma, representing the National & Local Joint Engineering Research Center of Carbon Capture and Storage Technology of Northwest University in Xi'an, China, gave a short presentation that described China's CCUS progress and deployment. Prof. Ma stated that the Chinese government has adopted several incentive policies to promote the demonstration of CCS projects, but the most important government plans are an energy technology innovation action plan by the National Development and Reform Commission (NDRC) and the National Energy Administration (NEA) in 2016, and the 13th Five-Year Plan for National Scientific and Technological Innovation by the Ministry of Science and Technology (MOST) in 2016. NDRC and the Asian Development Bank (ADB) have also created a roadmap for CCS demonstration and deployment in China. ADB has also provided support to Northwest University for a team of experts to design a comprehensive strategy for China to promote CCS. Prof. Ma also provided information about planned and operational CCS projects in China, of which there are many. One of these is the Jingbian CCS Project, which was recognized by the CSLF in 2015. Prof. Ma stated that the measuring, monitoring and verification component of this pilot-scale project includes research and study of parameters such as efficiency of geochemistry and reservoir simulation, CO_2 injection strategy, confirmation of wellbore integrity and CO_2 plume migration, confirmation of caprock integrity, and advanced online monitoring techniques.

32. Closing Remarks / Adjourn

Ms. Slagtern thanked the meeting host United Arab Emirates Ministry of Energy and Industry, the Secretariat for its support, and the delegates for their active participation. She then adjourned the meeting.

Summary of Meeting Outcomes

- The CO2CRC Otway Project Stage 3 is recommended by the Technical Group to the Policy Group for CSLF recognition.
- The 2017 TRM has been completed and launched.
- With the issuance of its final report, the Offshore CO_2-EOR Task Force has now completed its activities and has disbanded.
- The BECCS Task Force and the Improved Pore Space Utilisation Task Force will present their final reports to the Technical Group at its next meeting.
- The CCS for Industries Task Force will present a draft report at the next Technical Group meeting.
- A new Task Force on Hydrogen with CCS has been formed, with initial "Phase 0" activities reviewing existing activities and programs in Europe, Japan, and the United States as well as those by multinational energy companies. Participants in this initial phase include Norway (lead), Australia, Canada, France, Japan, the Netherlands, Saudi Arabia, the United Arab Emirates, the United Kingdom, the IEAGHG, and the CSLF Secretariat.

- A detailed proposal on forming a new task force on CO_2 Capture by Mineralization will be presented by the Netherlands at the next Technical Group meeting.
- United States delegate Sallie Greenberg will be the Technical Group's liaison with the ISO TC265 technical committee on CO_2 capture, transportation and geologic storage.