



## Minutes of the Technical Group Meeting Melbourne, Victoria, Australia Wednesday, 17 October 2018

### LIST OF ATTENDEES

**Chair** Åse Slagtern (Norway)

### **Delegates**

Australia: Andrew Barrett (*Vice Chair*), Max Watson  
Brazil: Ana Musse  
Canada: Eddy Chui (*Vice Chair*), Mike Monea  
China: Ping Zhong  
European Commission: Jeroen Schuppers  
France: Didier Bonijoly  
Italy: Paolo Deiana, Sergio Persoglia  
Japan: Ryoza Tanaka, Yukihiro Kawaguchi, Takuro Okajima  
Korea: JaeGoo Shim, YiKyun Kwon  
Norway: Lars Ingolf Eide, Espen Bernhard Kjærgård  
Saudi Arabia: Amar Alshehri, Pieter Smeets  
United Kingdom: Brian Allison  
United States: Mark Ackiewicz, Sallie Greenberg

### **Representatives of Allied Organizations**

CO<sub>2</sub>GeoNet Association: Sergio Persoglia  
Global CCS Institute: Alex Zapantis  
IEAGHG: Tim Dixon, Jasmin Kemper

**CSLF Secretariat** Richard Lynch

### **Invited Speakers**

Australia: Jason Russo (*Department of Industry, Innovation and Science*)  
David Byers (*CO2CRC*)  
John Torkington (*Chevron Australia*)  
Kevin Dodds (*ANLEC R&D*)  
Ian Filby (*Victorian Department of Economic Development, Jobs, Transport and Resources*)  
Dominique Van Gent (*Western Australian Department of Mines, Industry Regulation and Safety*)  
United Kingdom: M. Pourkashanian (*University of Sheffield*)  
United States: Frank Morton (*National Carbon Capture Center*)

## **Observers**

Australia:	Sarah Chapman ( <i>Department of Industry, Innovation and Science</i> ) * Chamaka DeSilva ( <i>Department of Industry, Innovation and Science</i> ) Kingsley Omosigho ( <i>Department of Industry, Innovation and Science</i> ) Tim Sill ( <i>Department of Industry, Innovation and Science</i> ) *
Canada:	Kathryn Gagnon ( <i>Natural Resources Canada</i> ) * Beth Hardy ( <i>International CCS Knowledge Centre</i> )
Japan:	Jiro Tanaka ( <i>Japan CCS Company</i> )
Korea:	Mi Hwa Kim ( <i>KETEP</i> )
Saudi Arabia:	Hamoud Alotaibi ( <i>Ministry of Energy</i> ) * Abdullah AlSarhan ( <i>Ministry of Energy</i> ) *
United States	Jarad Daniels ( <i>Department of Energy</i> ) * Katherine Romanak ( <i>University of Texas</i> )

\* 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 CSLF delegates and stakeholders to Melbourne. Ms. Slagtern mentioned that this would be a busy meeting, with presentations on many topics of interest related to carbon capture and storage (CCS) including presentations by the International Test Center Network, meeting host CO2CRC, and three CSLF-recognized projects. Additionally, there would be updates from all of the Technical Group's task forces as well as the Technical Group's three allied organizations: the CO<sub>2</sub>GeoNet Association, the Global CCS Institute (GCCSI), and the IEA Greenhouse Gas R&D Programme (IEAGHG). 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**

Jason Russo, General Manager of Onshore Minerals at the Australian Government's Department of Industry, Innovation and Science, welcomed meeting attendees to Melbourne while acknowledging the traditional custodians of the land and paying respects to their elders – past, present and future. Mr. Russo then set the stage for the meeting by affirming Australia's overall commitment to CCS and by briefly describing some of its activities, from R&D being conducted by CO2CRC to large-scale projects such as the Gorgon Project. Mr. Russo closed his welcoming speech by also acknowledging the contributions over the past three years of the Technical Group Vice Chair and PIRT Chair Andrew Barrett, who was participating in his final CSLF meeting.

### **3. Introduction of Delegates**

Technical Group delegates and stakeholders present for the meeting introduced themselves. Thirteen of the twenty-six CSLF Members were represented. Stakeholder observers from six countries were also present, as were representatives from the three allied organizations.

#### **4. Adoption of Agenda**

The Agenda was adopted with no changes. (*Note: Subsequently, due to scheduling considerations for the presenter, the update from the CSLF-recognized Gorgon CO<sub>2</sub> Injection Project was moved forward in the agenda by one place.*)

#### **5. Approval of Minutes from April 2018 Meeting**

The Minutes from the April 2018 Technical Group Meeting were approved with no changes.

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

Richard Lynch provided a report from the CSLF Secretariat which reviewed highlights from the April 2018 CSLF Technical Group Meeting in Venice, Italy. This was a two-day event, consisting of PIRT and Technical Group meetings, that was held just prior to the CO<sub>2</sub>GeoNet Association's 2018 Open Forum. Presentations from both meetings are online at the CSLF website.

Mr. Lynch reported that there were several notable highlights and outcomes from the meeting:

- The Norcem Carbon Capture Project, sited in Norway, received a CSLF Global Achievement Award. (*Note: The project sponsor representative was not able to attend the meeting, so presentation of the award took place in Norway in May.*)
- The Enabling Onshore CO<sub>2</sub> Storage in Europe (ENOS) Project received PIRT and Technical Group approvals. (*Note: ENOS became a CSLF-recognized project following Policy Group approval at its October 2018 meeting in Melbourne.*)
- The Technical Group formed a new Task Force to examine non-Enhanced Oil Recovery (EOR) CO<sub>2</sub> utilization options, with a plan and timeline to be presented at the next Technical Group meeting. Task force members include the United States (Chair), Australia, Canada, France, the Netherlands, and Saudi Arabia.
- The Technical Group formed an ad hoc committee to follow up on recommendations from the CSLF Technology Roadmap (TRM). This committee will also attempt to gauge the use of Technical Group task force reports, and will align itself with the Policy Group's Academic Task Force and Communications Task Force. The United States is the Chair of this committee.
- The Bioenergy with CCS (BECCS) Task Force, chaired by the United States, issued its final report and has completed its activities.
- The Task Force on Hydrogen Production and CCS, chaired by Norway, has completed its preliminary "Phase 0" activities and will not continue further. Instead, a workshop on Hydrogen with CCS will be organized for a future CSLF meeting.
- The CCS for Energy Intensive Industries Task Force, chaired by France, and the Improved Pore Space Utilisation Task Force, co-chaired by Australia and the United Kingdom, will both present final reports at the next Technical Group meeting.
- The Technical Group will not form a new task force on CO<sub>2</sub> Capture by Mineralization, as it was deemed premature to do so.

## **7. Update from the CO<sub>2</sub>GeoNet Association**

Sergio Persoglia, Secretary General of the CO<sub>2</sub>GeoNet Association, gave a short presentation about the organization and its activities. CO<sub>2</sub>GeoNet is a pan-European research association for advancing geological storage of CO<sub>2</sub>. It was created as a European Union FP6 Network of Excellence in 2004 and transformed into an Association under French law in 2008. Dr. Persoglia stated that the overall mission of the CO<sub>2</sub>GeoNet Association is to be the independent scientific voice of Europe on CO<sub>2</sub> geologic storage in order to build trust in the technologies involved and to support wide-scale CCS implementation. Membership comprises 29 research institutes from 21 countries, and CO<sub>2</sub>GeoNet uses the multidisciplinary expertise of its members to advance the science supporting CCS. There are currently four categories of activities: joint research, scientific advice, training, and information / communication.

Dr. Persoglia then provided an update on recent activities of the organization. Since the April 2018 Technical Group meeting in Venice, the CO<sub>2</sub>GeoNet Association has been involved in several diverse areas of activity. It has advised and monitored the actions on CCS and also carbon capture and utilization (CCU) in the European SET Plan; it has consulted on the Innovation Fund; it has been involved in developing standards for CCS/CCU via the ISO; it has developed position papers for use by policy-makers; and it is playing an active role (including organizing a side event on “Demystifying Negative Emission Technologies”) in the roll-up to COP24. The CO<sub>2</sub>GeoNet Association is also overseeing the ENOS project.

Dr. Persoglia concluded his presentation with a short update on its 13<sup>th</sup> Open Forum, which was held immediately following the CSLF Technical Group meeting in Venice. There were 116 registered attendees representing 27 countries; presentations, videos, and key messages are now online at the CO<sub>2</sub>GeoNet website. The Open Forum included a knowledge-exchange workshop and two other workshops organized by the ENOS Project. There was also a meeting with journalists. Dr. Persoglia stated that the next Open Forum will be held next year in Venice on May 7-8, and that he hoped that many CSLF delegates will be able to attend.

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

Tim Dixon, Programme Manager for the IEAGHG, gave a presentation about the organization 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. Currently there are 33 Members from 15 countries plus OPEC, the European Union, and the IEA’s Coal Industry Advisory Board (CIAB). These Members set the strategic direction and technical programme for the organization. The IEAGHG’s 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 (320 reports published as of October 2018), the six international research networks about various topics related to CCS, and the biennial GHGT conferences (the next one in Melbourne during the week after the CSLF meeting). 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 seven IEAGHG studies that originated from the CSLF Technical Group or related activities, including reports on three International Workshops on Offshore Geologic CO<sub>2</sub> Storage.

Mr. Dixon concluded his presentation with showing lists of reports recently published, reports in progress to be published, studies underway, studies awaiting start, and webinar series. Mr. Dixon also briefly described IEAGHG's research networks and other upcoming events.

## **9. Update from the Global CCS Institute**

Alex Zapantis, General Manager – Commercial for the Global Carbon Capture and Storage Institute (GCCSI), gave a presentation about the organization. The GCCSI has recently reorganized on how it operates, having moved away from a regional structure toward more of a global outlook on CCS. The overall mission is still to accelerate the deployment and commercial viability of CCS globally, but the new functional structure starts with advocacy, which will lead to new policy towards CCS, which will lead to investment, which will result in deployment. The overall focus is on valued and impactful work which will expand and leverage the GCCSI's resources in the CCS community. Mr. Zapantis mentioned that services of the GCCSI include research on key aspects of CCS deployment (including publication of an annual "Global Status of CCS" document), advice and capacity building (through tailored workshops, conferences, and presentations to groups such as the CSLF), and communications / advocacy (to build awareness of CCS and its role in achieving climate targets and reducing emissions).

Mr. Zapantis stated that the GCCSI has been working extensively with its members. This has included drafting and launching the United Kingdom Carbon Capture, Utilization and Storage (CCUS) Cost Challenge Task Force report titled "Delivering Clean Growth", organizing GCCSI-led CCS forums in eight different cities around the world, organizing two CCS 'safaris' in Norway, and organizing a CCS side event with China at COP23. In closing, Mr. Zapantis briefly described the GCCSI's involvement in the upcoming global CCUS summit titled "Accelerating CCUS" which will be held in Edinburgh, Scotland, UK in late November.

## **10. Activities of CO2CRC Ltd.**

David Byers, CEO of CO2CRC Ltd., gave a presentation about the organization and its activities. For more than a decade, CO2CRC has been at the forefront of demonstrating the scientific viability of CCS in Australia. It is the first company in Australia to have undertaken CCS end-to-end, from capture to storage, and its research is demonstrating CCS at pilot scale using novel technologies. To date, more than 80,000 tonnes of CO<sub>2</sub> have been injected, monitored, and safely stored in CO2CRC test programs. Mr. Byers stated that CO2CRC's strategic focus areas optimizing storage, reducing capture costs, enhancing CO<sub>2</sub> utilization, and collaboration & leadership. The first two are being

investigated for validation at the Otway Research Facility, where low-cost and low-impact monitoring technologies, well integrity and leakage mitigation methodology, and durable membrane/adsorbent materials for CO<sub>2</sub> separation from mixed gas streams will be tested. CO<sub>2</sub>CRC is also providing expert advice on CCUS for government and industry, leveraging its technical proficiency and research track record. Its expertise is also being used to support Australian industry efforts to increase hydrocarbon recovery through CO<sub>2</sub>-EOR and to investigate bio-refinery viability in an Australian context.

Concerning the CO<sub>2</sub>CRC Otway Research Facility, Mr. Byers stated that it is one of the most comprehensive CO<sub>2</sub> storage demonstration laboratories in the world, and is verifying the fundamental science of CO<sub>2</sub> storage in Australia while further validating injection, storage and monitoring technologies globally. The facility features a state-of-the-art seismic monitoring array for observing and benchmarking subsurface technologies and processes, and has produced and made available high quality, comprehensive datasets from its previous operations. The Otway Project, to date, consists of three stages. An initial stage, from 2004 to 2009, demonstrated safe transport, injection and storage of CO<sub>2</sub> into a depleted gas reservoir. The second stage, which started in 2009 and will conclude in 2019, has demonstrated safe injection of CO<sub>2</sub> into a saline formation. The third stage, which began in 2015 and will conclude in 2022, will develop and validate safe, reliable and cost-effective technologies for subsurface monitoring of stored CO<sub>2</sub>. Additional stages of the project are anticipated, one of which will develop cost-effective, compact CO<sub>2</sub> separation technologies from mixed CO<sub>2</sub>-natural gas streams, while another will improve the capability to predict the role of geologic faults in controlling CO<sub>2</sub> fluid flow in the near surface while improving near surface monitoring capabilities.

Mr. Byers closed his presentation by mentioning CO<sub>2</sub>CRC's role in an initiative to more closely examine what CO<sub>2</sub>-EOR opportunities exist across Australia. This will include both research activities and reservoir characterizations to gauge EOR potential.

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

The PIRT Chair, Andrew Barrett, gave a short presentation that summarized the previous day's meeting, which was held in Warrnambool just prior to the site visit to the nearby CO<sub>2</sub>CRC Otway Research Facility. Mr. Barrett reported that the meeting featured a presentation by Max Watson about the Otway Facility, but the main topic on the agenda was a presentation by Sallie Greenberg about the Technical Group's ad hoc committee on task force maximization and knowledge sharing. An outcome from this agenda item was that it was deemed essential for the committee to continue its activities with no firm end date, as this will be one of the things that defines the overall worth of CSLF activities. An action resulting from the meeting was that whenever a task force completes a report, the PIRT should have an active role in dissemination of this news, via the CSLF Secretariat, in the form of an informational email of some sort to the overall CSLF mailing list. The CSLF's allied organizations will also be requested to pass this news on via their own mailing lists.

At the conclusion of Mr. Barrett's presentation it was noted that this is his final CSLF meeting due to impending retirement. In appreciation of his three years of service as PIRT Chair, he was presented (by the Technical Group Chair) a recognition award for his leadership of the PIRT.

## **12. Report from the CCS for Energy Intensive Industries Task Force**

Task Force Co-Chair Didier Bonijoly gave a brief update on the task force, which had been established at the October 2016 meeting in Tokyo with a mandate to investigate the opportunities and issues for CCS in the industrial sector and show what the role of CCS could be as a lower-carbon strategy for CO<sub>2</sub>-emitting industries. The focus of the task force is to show how CCS in energy intensive industries will contribute to the double target of economic growth and climate change mitigation, with an objective to provide recommendations for technology developments that are needed to accelerate the deployment of CCS for these industries. Dr. Bonijoly reported that the task force consists of members from France's Club CO<sub>2</sub>, with additional contribution from Canada, Germany, the Netherlands, Norway, Saudi Arabia, the United Arab Emirates, and the United States. The task force also has commitment from a wide range of professional and technical expertise in the industrial sector including oil and gas (both upstream and downstream), cement, steel, hydrogen, chemicals, fertilizer, and waste-to-energy.

Dr. Bonijoly then called on task force member Lars Ingolf Eide to summarize relevant issues being addressed. These include: why CCS 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<sub>2</sub> emissions for different industries, and the status of CCUS developments from laboratory scale to industrial demonstration. The task force's final report will include short chapters on nine industrial sectors: steel, cement, waste-to-energy, fertilizers, hydrogen production, natural gas production, heavy oil production, chemicals, and refining. There will also be an annex with detailed papers for each of these sectors. Important conclusions from the task force's work are that:

- Some process CO<sub>2</sub> emissions by energy intensive industries may be difficult if not impossible to reduce without CCUS.
- The value of CCUS can be much higher than the costs.
- CCUS is costly and may present operational challenges: it needs incentives and creative business models to stimulate widespread large-scale implementation.
- CO<sub>2</sub> utilization options can provide many energy intensive industries a revenue stream to offset the high costs of carbon capture. However, the climate mitigation potential for some utilization approaches can be limited.
- RD&D must be accelerated to drive down CCUS costs.

Mr. Eide concluded the presentation by stating that the task force has completed most of its work and that draft versions of all chapters in its final report have been prepared, though they are at different levels of maturity. The task force was unfortunately not able to have the report completed in time for the current meeting, but does expect it to be finalized and launched in time for the next meeting.

## **13. Report from the Improved Pore Space Utilisation Task Force**

Task Force Co-Chairs Brian Allison and Max Watson 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. Mr. Allison stated that the purpose of the task force is to investigate the concept of improved utilisation of geological storage space resource to increase CO<sub>2</sub> 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<sub>2</sub> storage projects.

Dr. Watson then provided a summary of the task force's focus and activities. With straightforward CO<sub>2</sub> injection, in particular when storing in saline formations, a large portion of available pore space in a geological storage site is bypassed. Utilized storage capacity is typically about two orders of magnitude lower than the pore space resource, and the resulting large lateral spread of CO<sub>2</sub> requires costly monitoring relative to the volume stored. Being able to improve pore space utilisation may be very beneficial in terms of increased storage capacity, reduced monitoring costs, and increased ability for 'hub' style storage operations. There are five main improved pore space utilisation techniques: improved sweep efficiency techniques from the oil and gas sector; pressure management via active and passive relief wells and/or increased injection pressure; microbubble CO<sub>2</sub> injection; CO<sub>2</sub> saturated water injection and geothermal energy; and compositional, temperature and pressure swing injection. All of these have reasonably high potential, but their technology readiness levels have not yet risen to the point where large-scale tests are imminent.

Dr. Watson concluded the presentation by providing a timeline for the task force final report. Coordination and alignment with key contributors will occur in early November, and task force members will circulate the draft report within their countries and organizations by about the end of November. Following this review cycle, the finalized version of the report should be ready for launch during the first part of 2019, prior to the next Technical Group meeting.

#### **14. Report from the Non-Enhanced Hydrocarbon Recovery (EHR) Utilization Options Task Force**

Task Force Chair Mark Ackiewicz gave a brief update on the task force, which had been established at the April 2018 meeting in Venice. A previous task force related to this topic (which had then included EOR) had existed between 2011 and 2013 and had issued two reports before disbanding. Key messages from these two reports were that:

- There are many CO<sub>2</sub> utilization options.
- EOR is the most near-term utilization option.
- Non-EOR CO<sub>2</sub> utilization options are at varying degrees of commercial readiness and technical maturity.
- Early R&D or pilot-scale activities should focus on addressing techno-economic challenges, verifying performance, and supporting smaller-scale tests of first generation technologies and designs.
- More detailed technical, economic, and environmental analyses should be conducted.

Mr. Ackiewicz reported that following the disbanding of that task force there have been other kinds of activities on this topic, including incentives and policy changes of various kinds, and also reports by academia, government, and independent organizations. There have also been, and continue to be, conferences entirely focused on CO<sub>2</sub> utilization or having that topic for one or more sessions. And, to date, there has been one CSLF-recognized project on CO<sub>2</sub> utilization: the Carbon Capture and Utilization / CO<sub>2</sub> Network Project located in Jubail, Saudi Arabia and sponsored by SABIC. Mr. Ackiewicz stated that this new task force would not be a continuation of the previous one – its main goal is to add value and not re-invent. Initially, the new task force will check on the status of

non-EHR CO<sub>2</sub> utilization by reviewing the reports, projects, conferences, activities, and projects of various kinds, and government initiatives that have occurred since the closure of the previous task force. The task force will then develop a set of recommendations which will be presented at the next Technical Group meeting. Mr. Ackiewicz closed his presentation by listing the members of the task force: the United States (Chair), Australia, Canada, France, the Netherlands, and Saudi Arabia. Following Mr. Ackiewicz's presentation, Brazil, China, and the IEAGHG also joined the task force.

#### **15. Update on CSLF-recognized Project: Gorgon CO<sub>2</sub> Injection Project**

John Torkington, Climate Change Team Manager Chevron Australia, gave a presentation about the CO<sub>2</sub> capture and storage aspects of the Gorgon Liquefied Natural Gas (LNG) Project, located off Australia's western coast approximately 1,300 kilometers north of Perth. The Gorgon Project is Australia's largest single resource development, with more than 50 trillion cubic feet of discovered natural gas resources – enough to supply a city the size of New York for 100 years. There are six equity partners for the project, with Chevron Australia holding the largest stake and also being the project operator. Natural gas is being extracted at the rate of approximately 15 million tons per year, with production of an additional 20,000 barrels of condensate per day. Much of the gas is being liquefied for export to markets in eastern Asia, while some of the gas is supplying a natural gas pipeline that provides Western Australia an equivalent of up to 300 terajoules per day for its energy needs.

Mr. Torkington stated that the natural gas being extracted contains significant amounts of CO<sub>2</sub> which will be separated, compressed, and transported by pipeline to one of three sites on Barrow Island, where it is injected more than two kilometers down into the Dupuy Formation. This geologic formation has sufficient storage capacity to contain all the CO<sub>2</sub> separated during the expected 40-year lifetime of the project. The overall CO<sub>2</sub> injection rate is 3.4 to 4 million tonnes per year, which makes the Gorgon CO<sub>2</sub> Injection Project the largest of its kind in the world. Mr. Torkington stated that Barrow Island is a world-class nature reserve and a large amount of project resources has been allocated, and more than 300 environmental procedures of various kinds have been developed, to retain that status. This includes a strict quarantine management system to prevent non-indigenous plant and animal species from entering the island's ecosystem. Mr. Torkington closed his presentation by describing some of the CCS aspects of the project, which are equally rigorous. These include an extensive integrated monitoring plan (which includes seismic monitoring and reservoir surveillance wells) to track movement of the underground CO<sub>2</sub> plume. These are essential for the CCS part of the project to achieve its overall objective, to demonstrate the safe commercial-scale application of CO<sub>2</sub> storage technologies at a scale not previously attempted.

#### **16. Report on International Overview of CCU Symposium**

Didier Bonijoly gave a short presentation about the International Overview of CCU Symposium, which was held in early July in Paris and sponsored by France's "Club CO<sub>2</sub>", a working group which currently has 24 members representing research organizations, governmental entities, and industry. The one-day Symposium drew 150 attendees and had a program which included a plenary plus a workshop. The plenary included reviews of policies, key projects, and other initiatives of interest from eleven countries; the workshop was set up with four teams working on life cycle assessment (LCA) barriers for CO<sub>2</sub>-to-fuels, chemicals, mineralization, and bioconversion, and one other team working on standardization. There were several lessons learned from the

workshop, two of the most important being: Use LCA at the beginning of the development of technologies to screen opportunities and provide solutions. And: Assess two different references – the current, most available process/technology and an environmentally competitive solution even if it's not economically viable. Dr. Bonijoly closed his presentation by reporting several conclusions from the Symposium:

- CCUS plays a key role in global climate goals – 15% toward achieving the 2-degrees-C target and 32% toward achieving the less-than-2-degrees-C target.
- CO<sub>2</sub> utilization addresses political and public acceptance drawbacks of CCS.
- Many countries plan to support research and demonstration projects for CO<sub>2</sub> utilization in order to encourage new technologies.
- No CO<sub>2</sub> utilization options are currently available which meet the three criteria proposed by the International Energy Agency (IEA): emission reduction, economic viability, and market.
- CO<sub>2</sub> utilization and storage technologies must be developed and deployed in parallel, and not be perceived as competing with each other.
- Market insights for CO<sub>2</sub> utilization are promising, with the potential for converting more than 6 billion tonnes of CO<sub>2</sub> per year into useful products such as building materials, chemical intermediates, fuels, and polymers. However, significant progress toward scalable technologies is needed,

#### **17. Activities of the Australia National Low Emissions Coal Research and Development (ANLEC R&D) Initiative**

Kevin Dodds, General Manager for Research at ANLEC R&D, gave a presentation about the organization and its activities. ANLEC R&D is a partnership between the Australian Government and the Australian coal industry and has the goal of accelerating deployment of lower emission technology for coal-fired power stations in Australia. It was founded in 2010 and has deployed a research effort of more than A\$200 million in more than 25 institutions throughout Australia. The current focus is to accelerate commercial deployment of CO<sub>2</sub> storage across three Australian geological basins.

Mr. Dodds provided several examples of large ANLEC R&D research and technology initiatives being pursued by Australian commercial-scale projects: For the Callide Oxyfuel Project in southwestern Australia, a study determined that low-cost desulfurization is viable and that separate NO<sub>x</sub> removal and mercury capture are not required. A Gippsland Basin marine monitoring activity performed an assessment of shallow-focused marine monitoring technologies for sub-seabed CO<sub>2</sub> storage in southeastern Australia, while also developing and verifying an atmospheric assurance system for the Gippsland near-shore environment. For the Surat Basin in eastern Australia, a project co-funded by ANLEC R&D has been established to demonstrate the viability of CCS which will result in a both a feasibility study and a front end engineering design (FEED) study.

#### **18. Update on the China Australia Geological Storage of CO<sub>2</sub> (CAGS) Project**

Andrew Barrett, General Manager of Energy Systems at Geoscience Australia, gave a short presentation about the CAGS project, a bilateral activity between China and Australia that is jointly managed by Geoscience Australia and the Administrative Centre for China's Agenda 21. The overall focus is on capacity building in China and Australia for geological storage of CO<sub>2</sub>. Mr. Barrett stated that project activities have included

capacity building for Chinese researchers and central government officials at a national level and scientific exchanges involving mostly junior Chinese academics. The Australian government has also funded research projects in China.

Mr. Barrett highlighted one of the recent CAGS capacity building activities, a workshop and CCS school in China's Xinjiang Province in 2017. It was the first bilingual conference on CCS in that part of China and brought Australian and international expertise to the region. The outcome was the launch of the Xinjiang CCUS Research Centre at the workshop. Other activities in the current phase of the CAGS Project include integrated monitoring research of a CO<sub>2</sub>-EOR demonstration project at Yanchang oilfield, an assessment of potential CO<sub>2</sub> geological storage in China's Junggar Basin, and a feasibility study of the Xinjiang Guanghui CCUS Pilot Project. Mr. Barrett closed his presentation by providing examples on how the CAGS Project is leveraging further investment, and how the project has increased collaboration through its exchange program. These will all be of benefit to several large pilot projects that are already underway in China and to seven large-scale CCUS projects (two of which are in Xinjiang) that are in the planning stage. Mr. Barrett also stated that because of the CAGS Project, CCUS is also gaining new momentum in Australia.

#### **19. Update from CSLF-recognized Project: CarbonNet Project**

Ian Filby, the CarbonNet Project Director for the Victorian Department of Economic Development, Jobs, Transport and Resources, gave a short presentation about the CarbonNet Project, located in southeastern Australia. This project is investigating the feasibility for a large-scale multi-user CO<sub>2</sub> capture, transport and storage network in the Latrobe Valley and nearby areas including the offshore Gippsland Basin. It has been jointly funded by the Australian and Victorian governments and has had a significant research investment from organizations such as ANLEC R&D. The lead research organization for CarbonNet is CO<sub>2</sub>CRC, while the GCCSI is handling knowledge sharing aspects of the project.

Mr. Filby stated that the Victorian State Government, in 2017, issued a policy statement on the future use of brown coal which supports CCS – it acknowledges strong interest in new industries for low emission, high value products from coal (e.g., hydrogen and fertilizers) and identifies opportunities for new coal-based projects that could utilize CCS. And it also commits to completing the CarbonNet Project. Mr. Filby reported several outcomes from a feasibility and commercial definition study which was recently completed: Geological storage site selection has certified a portfolio of three sites including a prioritized site. Feasibility studies across the full CCS chain have been done, as well as environmental risk assessment for air and groundwater potential impacts. A risk-adjusted whole of life costings for CO<sub>2</sub> transport and storage has been determined, and there have been market soundings with industry which have resulted in understanding of the preconditions for potential investors. Finally, a regulatory framework review has been done and a resulting regulatory fix plan is being implemented. Next steps include storage site appraisal activities and creation of a monitoring network, as well as stakeholder and community engagement. Mr. Filby closed his presentation by briefly describing the project's commercialization pathway, which includes implementation of supportive policies by government, completion of storage site appraisal, and obtaining investment by industrial customers and CCS service providers.

## **20. Update from CSLF-recognized Project: South West Hub Project**

Dominique Van Gent, Carbon Strategy Coordinator for the Western Australian Department of Mines, Industry Regulation and Safety, gave a short presentation about the South West Hub Project, located in southwestern Australia. This project has an eventual goal of implementing a large-scale CO<sub>2</sub> hub for multi-user capture, transport, and storage, where several industrial and utility point sources of CO<sub>2</sub> would be connected via pipeline to a geologic storage site. Mr. Van Gent stated that the area of Western Australia along the Indian Ocean coast south of Perth and north of the city of Collie is the heart of industry in the region and has CO<sub>2</sub> emissions of approximately 25 million tonnes per year. Screening studies conducted between 1998 and 2007 have identified a potential storage site near Collie and since then there has been extensive modeling and reservoir characterization activities. These have provided the information that the site can accept injection rates of at least 800,000 tonnes of CO<sub>2</sub> per year for more than 30 years, and the underground CO<sub>2</sub> plume will remain contained for at least 1,000 years. All this can be achieved through a well count of nine or less. Mr. Van Gent provided that it may even be possible to store much higher volumes, as injection rates of 3 million tonnes per year for 30 years have been modeled. If this proves feasible, then the South West Hub could be a sequestration site for CO<sub>2</sub> produced throughout the eastern Asia region.

Mr. Van Gent concluded his presentation by stating that the project has several needs if it is to progress further: There is a need for continued Government support as there is currently no business imperative. There is a need for industry to voice its support for CCS technologies as they pursue decarbonization. And there is a need to develop a narrative for the community about the overall worth and safety of CCS. For that last need, Mr. Van Gent stated that the only way to build confidence with the public is through a well-planned demonstration.

## **21. Update from the Mission Innovation Carbon Capture Innovation Challenge**

Brian Allison, Assistant Head CCUS R&D and Innovation at the United Kingdom's Department for Business, Energy and Industrial Strategy and Co-Lead for Mission Innovation's Carbon Capture Innovation Challenge (CCIC), gave a short presentation about Mission Innovation and its CCIC. Mission Innovation is a multilateral Ministerial-level initiative that was launched in November 2015 with the overall goal of accelerating the pace of clean energy innovation, to achieve performance breakthroughs and cost reductions in order to provide widely affordable and reliable clean energy solutions. Mission Innovation seeks to double cumulative Mission Innovation countries' investment in clean energy (from \$15 billion to \$30 billion) over five years (from 2016 to 2021), to increase private sector engagement in clean energy innovation, and to improve information sharing among Mission Innovation countries.

Mr. Allison stated that currently there are twenty Mission Innovation countries that are participating in the CCIC. The overall objective is to enable 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 overall work plan includes organizing CCUS Experts Workshops, engaging stakeholders (both industry and NGOs), and building multilateral collaboration mechanisms. To that end, a CCUS Experts Workshop, co-chaired by the United States and Saudi Arabia, was held in 2017 and 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. Mr. Allison 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<sub>2</sub> capture, CO<sub>2</sub> utilization, and CO<sub>2</sub> storage. In addition to these, a separate group was focusing on crosscutting issues. Each of these focal areas developed a set of international agreed priority research directions (PRDs), which were summarized in the report “Accelerating Breakthrough Innovation in Carbon Capture, Utilization, and Storage” dated September 2017. Mr. Allison stated that the PRDs are not meant to be prescriptive and all-inclusive. Instead, they were designed to inspire the CCUS research community to elucidate and illuminate the science that underpins CCUS. Mr. Allison concluded his presentation by providing the next steps for the CCIC. These include creating an action plan, developing collaboration mechanisms, and fostering engagement with industry and other multilateral CCUS initiatives, including the CSLF.

## **22. Report on 3<sup>rd</sup> International Workshop on Offshore Geologic CO<sub>2</sub> Storage**

Tim Dixon gave a short presentation about the continuing series of workshops, co-sponsored by the IEAGHG, about offshore geologic storage of CO<sub>2</sub>. This third in the series, hosted by the Research Council of Norway in early May, addressed and built on recommendations and topics raised by the first two workshops (which were held in 2016 and 2017, respectively), and continued the theme of “how to do”. Mr. Dixon stated the series of workshops originated following the 6<sup>th</sup> CSLF Ministerial (in 2015), where one of the messages to Ministers was that even though there is a growing wealth of research, development and practical experiences concerning offshore CO<sub>2</sub> geologic storage, this expertise is familiar to only a few specific countries. There are other countries with offshore storage potential which are not yet pursuing these technologies and could benefit from knowledge sharing.

Mr. Dixon reported that the scope of this 3<sup>rd</sup> workshop was very broad and included sub-themes such as value chains for offshore storage, re-use of existing infrastructure, monitoring offshore CO<sub>2</sub> storage and EOR, offshore CO<sub>2</sub> resource assessment, standards and regulatory frameworks, updates from current projects, and brainstorming toward an international collaborative project. Mr. Dixon described each of these in detail, and then closed his presentation with a list of recommendations resulting from the workshop. These included:

- Explore models for a proposed international collaboration project.
- Consider how to build knowledge sharing from hands-on operational projects (including a proposed international collaboration project).
- Provide a roadmap to existing information sources about offshore storage.
- Determine which developing countries would be attracted to offshore storage.
- Identify key people in those developing countries and find mechanisms for bringing them to workshops and other conferences themed on offshore storage. Advocacy toward funders of CCS is needed.

## **23. Update on International Test Center Network (ITCN)**

Frank Morton, Director of Technology at the National Carbon Capture Center (NCCC) in the United States, and Prof. M. Pourkashanian of the University of Sheffield in the United Kingdom, gave a short presentation about the ITCN and its collaborative activities. Mr. Morton stated that 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<sub>2</sub> 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<sub>2</sub> 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. Among the benefits of ITCN membership are online access to the ITCN Handbook, online access to ITCN Facilities database, and online access to the ITCN community via the Members' Exchange facility. There are currently thirteen ITCN members which global represent four continents.

Mr. Morton welcomed the ongoing ITCN partnership with the CSLF Technical Group, stating that it was willing to be part of future Technical Group activities concerning CO<sub>2</sub> capture. Prof. Pourkashanian closed the presentation by describing several possible kinds of future collaboration between the ITCN and the Technical Group. These include evaluation of CO<sub>2</sub>-containing flue gas from natural gas combustion and trying to find ways to support model development and advanced simulations with a focus on reducing capital costs / operating expenses.

Following the presentation, ensuing discussion reinforced the overall worth of collaboration between the ITCN and the Technical Group. Lars Ingolf Eide stated that such cooperation will be very useful to Technical Group task forces and toward future updates of the TRM. Mike Monea complimented the ITCN on its willingness to share information. Mark Ackiewicz stated that one thing that would really be of help to the Technical Group would be the ITCN providing information on any recurring specific challenges that need to be addressed for specific CO<sub>2</sub> capture technologies. In response, Mr. Morton stated that the ITCN would provide the Technical Group a list of such recurring issues.

#### **24. Preview of CSLF Presentation at GHGT14**

Lars Ingolf Eide provided a preview of the "Recent Activities of the Technical Group of the Carbon Sequestration Leadership Forum" presentation that was scheduled for the following week at the GHGT14 conference. The presentation provided brief overviews of the CSLF's overall objectives, organization structure, and current activities. The presentation also described the benefits for projects seeking CSLF recognition (to both the project sponsors and the CSLF) and the TRM and its recommendations. At the close of the presentation there were several slides which provided information about the current Ad Hoc Committee for Task Force Maximization and Knowledge Sharing Assessment including future plans and the way forward for this activity.

#### **25. Report from the Ad Hoc Committee for Task Force Maximization and Knowledge Sharing**

Committee Chair Sallie Greenberg made a presentation which in part recapped her previous day's presentation on this topic at the PIRT meeting. During the April 2018 Technical Group meeting in Venice, there was consensus of a need to measure progress on technical recommendations from the 2017 TRM and also to assess the impact and usage of task force reports. Dr. Greenberg reported that, following the Venice meeting, a small ad hoc group came together for this purpose and during the middle of 2018 conducted a survey to gather details on how TRM and task force reports were being used. In the months following that meeting, this group was formalized as the Ad Hoc

Committee for Task Force Maximization and Knowledge Sharing. During that time the Ad Hoc Committee drafted a white paper which briefly described its four main areas of examination:

- Task Force utilization analysis;
- TRM recommendation analysis and creation of baseline for future tracking;
- Knowledge sharing recommendations for dissemination; and
- Potential alignment of Task Forces with Technical and Policy Group activities within the CSLF (Academic, Communication, other), and also with outside organizations (IEAGHG, CCS Knowledge Center, CO<sub>2</sub>GeoNet) and platforms (Mission Innovation, Clean Energy Ministerial, ACT).

Dr. Greenberg stated that the Ad Hoc Committee conducted a survey of Technical Group delegates prior to the current meeting to gather details on how the TRM and task force reports are being used and by whom as a first step in establishing a baseline for understanding TRM monitoring. Although more work is needed, responses received indicated that the majority of respondents have read and used the TRM. Further, web statistics indicate that the TRM is the second-most downloaded document (after the CSLF Charter) if documents supporting CSLF meetings are excluded. Responses to the survey also indicated that there were three main types of TRM usage: to help define important topics relevant to CCUS, for developing national CCUS strategies and reports of various kinds, and as background information for developing specific RD&D strategies and proposals.

There was also useful information from the survey about usage of task force reports. The most widely-used reports are those which focus on CO<sub>2</sub> capture technologies, hydrogen with CCS, offshore CO<sub>2</sub> storage, and CO<sub>2</sub> utilization through enhanced oil recovery (EOR). These reports have been most often used for knowledge and technical gain, RD&D program planning, and (by the ISO TC265 committee) in developing standards. Additional usages have been for technology assessment, strategic planning, and proposal development. Dr. Greenberg stated that more than 50% of the survey respondents reported that task force reports have been used in decision making, policy making, or in knowledge sharing forums.

In concluding, Dr. Greenberg provided some suggestions for future Technical Group activities, based in part on information gleaned from the survey. It identified that there was an obvious need to track TRM technology recommendations, which will be an ongoing priority of the ad hoc committee, but beyond that the survey indicated there appear to be several areas where activities are warranted. These include:

- Hub/infrastructure;
- Support of developing countries (*note: this was approved by the CSLF's Capacity Building Task Force in its meeting which immediately followed the Technical Group meeting*);
- Cost-effective capture technologies;
- More clarity on economic benefits of low-carbon policy; and
- Providing technical inputs into any business model and socio-economic benefits discussions.

Dr. Greenberg stated that a future workshop on hub/infrastructure would be an especially worthwhile activity, especially if it resulted in a report as a deliverable. Also, better knowledge sharing of all Technical Group results is imperative, and the

Technical Group should find better methods for wider distribution of its reports, especially the TRM.

In the ensuing discussion, Lars Ingolf Eide complimented the Ad Hoc Committee's work by stating that responses concerning the need for improved infrastructure provided insight for possible future Technical Group activities such as a Hub and Infrastructure task force. Mark Ackiewicz agreed and stated that the Technical Group's allied organizations can play a role in various ways, for instance in co-sponsoring technical workshops. Sergio Persoglia, speaking for the CO<sub>2</sub>GeoNet Association, expressed an interest in helping to organize targeted workshops that could relate directly back to technical recommendations from the TRM or from task forces. Tim Dixon, speaking for the IEAGHG, agreed but stated that any such cooperative activities needs to be beneficial to the allied organization as well as the Technical Group. Åse Slagtern suggested that a good working mode going forward for collaborating with allied organizations would be to jointly produce overview reports, hold workshops, and engage in other similar activities, and that the Ad Hoc Committee could work out specific details. There was consensus for adopting that approach and also that the Ad Hoc Committee should continue its activities for the foreseeable future, as this is a very important Technical Group function.

## **26. Possible New Technical Group Activities**

Technical Group Chair Åse Slagtern made a short presentation that summarized existing Technical Group activities and possible new ones. There are now four active task forces (or equivalent) besides the PIRT: Improved Pore Space Utilization (co-chaired by Australia and the United Kingdom, active since 2015), CCS for Energy Intensive Industries (chaired by France, active since 2016). Non-EHR Utilization Options (chaired by the United States, formed at the Venice Technical Group meeting), and the Ad Hoc Committee (chaired by the United States, formed following the Venice Technical Group meeting). Ms. Slagtern stated that there are many other potential new topics that had been identified by a previous Technical Group working group. Two that were ranked with a high priority are "Hydrogen with CCS" and "CO<sub>2</sub> Hubs and Infrastructure". Concerning Hydrogen with CCS, Ms. Slagtern noted that a Task Force had formed for a preliminary "Phase 0" but had concluded that it would be better to have a workshop on this topic than to continue the task force. The IEAGHG and the CSLF's Norway delegation have been asked to take the lead in planning the workshop. Ms. Slagtern concluded her presentation by stating that there was not yet any Technical Group activities concerning CO<sub>2</sub> Hubs and Infrastructure.

Ensuing discussion resulted in formation of a new Hub and Infrastructure Task Force. However, this task force will conduct only preliminary "Phase 0" activities to review what has previously been done (e.g., reports and conference presentations) on the topic. The task force will present a recommendation on whether or not to continue past this preliminary phase at the next Technical Group meeting. Task force members for the preliminary phase are Norway (lead), Australia, Brazil, Canada, and the United Kingdom

## **27. Update on Future CSLF Meetings**

Richard Lynch reported that the 2019 Mid-Year Technical Group meeting would be held in Champaign, Illinois, USA, and called on Sallie Greenberg to provide additional information. Dr. Greenberg stated that the date would be in April the week following Easter, and would be held in conjunction with the Annual Meeting of the Midwest

Geological Sequestration Consortium (MGSC) which will be open to CSLF meeting attendees. More details will be forthcoming soon.

## **28. Open Discussion and New Business**

There was no new business and no other announcements.

## **29. Election of Technical Group Officers**

Richard Lynch presided over this item of the agenda. Mr. Lynch stated that according to the CSLF Terms of Reference and Procedures, CSLF Chairs and Vice Chairs are elected every three years. The previous election for the Technical Group was in 2015 at the CSLF Ministerial Meeting in Riyadh, Saudi Arabia.

By consensus, Norway was re-elected as Chair. Australia and Canada were re-elected as Vice Chairs. Japan was elected as Vice Chair, replacing South Africa.

## **30. Closing Remarks / Adjourn**

Technical Group Chair Åse Slagtern thanked the delegation from Australia for hosting the meeting, CO2CRC Ltd. for arranging the field trip to the Otway Research Facility, the Secretariat for its pre- and post-meeting support, and the delegates and invited speakers for their active participation. She then adjourned the meeting.

## **Summary of Meeting Outcomes**

- Norway was re-elected as Technical Group Chair. Australia and Canada were re-elected as Technical Group Vice Chairs. Japan was elected as Technical Group Vice Chair, replacing South Africa.
- The CCS for Energy Intensive Industries Task Force and the Improved Pore Space Utilisation Task Force will present their final reports at the next Technical Group meeting.
- The Non-EHR Utilization Options Task Force will present a set of recommendations at the next Technical Group meeting. New task force members are Brazil, China, and the IEAGHG.
- A new Hub and Infrastructure Task Force was formed to conduct initial “Phase 0” activities to review what has previously been done (e.g., reports and conference presentations) on the topic. The task force will present a recommendation on whether or not to continue past this preliminary phase at the next Technical Group meeting. Task force members for the preliminary phase are Norway (lead), Australia, Brazil, Canada, and the United Kingdom.
- The Ad Hoc Committee for Task Force Maximization and Knowledge Sharing will continue its activities for the foreseeable future, as this is a very important Technical Group function. A priority item will be to develop a methodology on how to measure any global progress in implementing TRM technical recommendations.
- A general working mode going forward for collaborating with allied organizations will be to jointly produce overview reports, hold workshops, and engage in other similar activities. Practical implementation will be worked out by the Ad Hoc Committee.
- The ITCN will provide the Technical Group a list of recurring specific challenges that need to be addressed for specific CO<sub>2</sub> capture technologies.

- The IEAGHG and Norway's Technical Group delegation have been given the lead to plan a joint CSLF-IEAGHG workshop themed on Hydrogen with CCS.
- The next Technical Group meeting will be held in Champaign, Illinois, USA in April 2019, and would be held in conjunction with the Annual Meeting of the Midwest Geological Sequestration Consortium (MGSC) which will be open to CSLF meeting attendees.

