



## Minutes of the Technical Group Meeting

Tokyo, Japan

Tuesday, 04 October 2016

### LIST OF ATTENDEES

#### Chair

Åse Slagtern (Norway)

#### Delegates

Australia: Andrew Barrett (*Vice Chair*), Max Watson  
Canada: Eddy Chui (*Vice Chair*), Mike Monea  
Czech Republic: Pavel Kavina, Richard Nouza  
France: Didier Bonijoly, Dominique Copin  
Germany: Jürgen-Fr. Hake  
Japan: Ryoza Tanaka, Takashi Kawabata  
Korea: Chang-Keun Yi, Chong Kul Ryu  
Norway: Stig Ø.U. Svenningsen, Lars Ingolf Eide  
Saudi Arabia: Fahad Almuhaish, Amar Alshehri  
United Kingdom: Brian Allison  
United States: John Litynski, Stephanie Duran

#### Representatives of Allied Organizations

Global CCS Institute: Alex Zapantis, Hiroshi Nambo  
IEAGHG: Tim Dixon

#### CSLF Secretariat

Richard Lynch, Adam Wong

#### Invited Speakers

Japan: Takayuki Higashii, Research Institute of Innovative Technology  
for the Earth (RITE)  
Yoichi Kaya, RITE  
Shin-ichi Nakao, RITE  
Jiro Tanaka, Japan CCS Company  
United States: Issam Dairanieh, CO<sub>2</sub> Sciences  
Tom Erickson, University of North Dakota Energy and  
Environmental Technology Center  
Sean McCoy, Lawrence Livermore National Laboratory  
Hideo Nomoto, 8 Rivers Capital [and] NET Power

**Observers**

Australia:	Josh Cosgrave*
Canada:	Dave Malloy
Japan:	Junko Hirai, Takashi Honjo, Kimiko Nakanishi, Takuro Okajima*, Yoshinobu Sato, Yutaka Tanaka
Netherlands:	Maurice Hanegraaf
United States:	Roger Aines, Sallie Greenberg

\* CSLF Policy Group delegate

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

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

Ms. Slagtern also mentioned that the current meeting would be, as usual, very content-rich, with many items of interest to attendees. This includes presentations from two projects that have been nominated for CSLF recognition, an update on carbon capture and storage (CCS) activities in Japan, a presentation on reducing lifecycle biofuel emissions with CCS, two presentations on utilization – one on utilization of CO<sub>2</sub> and one on low-carbon utilization of lignite, a report on results from the CSLF-recognized CO<sub>2</sub> Separation from Pressurized Gas Stream Project, an update on recent activity of the ISO's TC265 working group on CO<sub>2</sub> capture, and presentations by both the IEA Greenhouse Gas R&D Programme and the Global Carbon Capture and Storage Institute.

**2. Meeting Host's Welcome**

Yoichi Kaya, President of Japan's Research Institute of Innovative Technology for the Earth (RITE), welcomed the meeting attendees to Tokyo. Prof. Kaya stressed the importance of CCS toward meeting COP21 greenhouse gas reduction targets. To that end, Japan has undertaken a vigorous R&D program on CCS, as exemplified by the Tomakomai CCS Demonstration Project that has been nominated for CSLF recognition and will be visited by meeting attendees later in the week. Prof. Kaya stated that Tomakomai Project shows that Japan is very enthusiastic about CCS and its potential for CO<sub>2</sub> emissions reduction, and he congratulated the CSLF for its continuing strong leadership in this area.

**3. Introduction of Delegates**

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

**4. Adoption of Agenda**

The Agenda was adopted with no changes.

**5. Approval of Minutes from London Meeting**

The Minutes from the June 2016 Technical Group Meeting in London, United Kingdom were approved with no changes.

## 6. Report from CSLF Secretariat

Richard Lynch provided a report from the CSLF Secretariat which reviewed highlights from the June 2016 Mid-Year Meeting in London. This was a four-day event, including a workshop themed on “CCS Post-Paris: Realising Global Ambitions” (co-sponsored with the United Kingdom’s Carbon Capture & Storage Association). Presentations and a summary document from the Workshop are online at the CSLF website.

Mr. Lynch stated that there were three main outcomes from the London Technical Group meeting. There was agreement that the Advanced Pore Space Utilisation Task Force will incorporate geo-steering into its activities as a new focal area and decisions on formation of new task forces was deferred until this current meeting. Also, there was agreement that the presentation by the Chairman of the Task Force on CO<sub>2</sub> Storage Efficiency in Deep Saline Aquifers, at the June 2015 Technical Group meeting, would be considered as that task force’s final report.

Mr. Lynch stated that there were two Action Items from the June 2016 meeting. France was asked to determine if it can lead a new task force in Industrial CCS, and will be informing the Technical Group of its decision at this current meeting. Also, the Secretariat was asked to make the summary and presentations from the April 2016 CSLF Offshore Workshop available at the CSLF website. Mr. Lynch stated that these are all available at a University of Texas website and that a link to them has been created at the CSLF website.

## 7. Overview of CCS-related Activities in Japan

Takashi Kawabata, representing Japan’s Ministry of Economy, Industry and Trade (METI), briefed the Technical Group on policy developments in the Japan related to CCS, and also provided a summary of CCS project activities and future challenges that may affect Japan’s road toward CCS deployment.

Mr. Kawabata stated that Japan’s CCS policy has been to achieve practical use of CCS technology by about the year 2020. This is being accomplished by the Tomakomai CCS Demonstration Project, which will confirm the safety of CCS utilization in Japan and also provide important information about large-scale CCS which will set the stage for future commercial-scale projects. Other contributors to achieving this goal are a continuing R&D program and also the Geological Survey of Japan which is identifying and characterizing potential CO<sub>2</sub> storage sites.

Concerning Japan’s CCS projects, Mr. Kawabata stated that the Tomakomai Project will be capturing and injecting approx. 100,000 tonnes of CO<sub>2</sub> annually over a three year period which started in April 2016. Prior to start-up, a site survey had been completed in the year 2011 followed by a four year preparation period which included design and construction of the capture facility, drilling injection wells, and test operation. Additional site surveys in other parts of the country have so far identified geologic CO<sub>2</sub> storage reservoirs with a cumulative capacity of approx. 150 billion tonnes. Two other areas of activity mentioned by Mr. Kawabata were research on CO<sub>2</sub> capture, including work with solid sorbents and membranes, and the Osaki CoolGen Project, currently under construction near the city of Hiroshima, which is a coal gasification combined cycle project that in its proposed second and third stages will incorporate CO<sub>2</sub> capture and fuel cell power production, respectively.

Mr. Kawabata concluded his presentation by mentioning some future challenges which must be overcome if CCS is to succeed in Japan. These include finding ways to reduce

the cost of all aspects of CCS, establishing an effective risk management system, developing an overall business case for CCS which will drive project projects, developing the regulatory framework from a legislative point of view, and enhancing public acceptance of CCS.

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

Tim Dixon gave a concise presentation about the IEAGHG and its continuing collaboration with the CSLF's Technical Group. The IEAGHG was founded in 1991 with the mission to provide information about the role of technology in reducing greenhouse gas emissions from use of fossil fuels. The focus is on CCS, and the goal of the organization is to produce information that is objective, trustworthy, and independent, while also being policy relevant but not policy prescriptive. The "flagship" activities of the IEAGHG are the technical studies and reports it publishes on all aspects of CCS, the eight international research networks about various topics related to CCS, and the biennial GHGT conferences, the next one in November 2016 in Lausanne, Switzerland. Other IEAGHG activities include its annual International CCS Summer School, peer reviews with other organizations, activity in international regulatory organizations such as the ISO and the London Convention, and collaboration with other organizations, including the CSLF.

Mr. 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 five IEAGHG studies that originated from the CSLF Technical Group.

## **9. Update from the Global Carbon Capture and Storage Institute (GCCSI)**

Alex Zapantis gave a short presentation about the GCCSI and its priority outcomes for 2016/17. These fall into two categories: fact-based influential advice / advocacy and authoritative knowledge sharing. For the former, it is important that CCS be increasingly portrayed as an emissions reduction technology that must be deployed to achieve a low-carbon future. Further, CCS must be positioned as a necessary technology for closing the gap between global climate ambitions (i.e., the 1.5 degrees C scenario) and current mitigation plans. To that end, key national and regional governments will need to confirm the important role of CCS in their carbon mitigation planning by implementing policy drivers that will encourage use of CCS. Concerning knowledge sharing, Mr. Zapantis stated that developing and sharing information that encourages the deployment of CCS will need to be an ongoing and necessary collaborative effort. This would include development of information products such as fact sheets and Op-Eds, effectively using digital platforms to disseminate these products, convening knowledge sharing workshops and other events, and ensuring all outputs are based on high quality peer reviewed studies.

Mr. Zapantis concluded his presentation by reporting that the GCCSI has allocated slightly more than half its total resource toward advocacy of CCS. To that end, the GCCSI will be implementing a comprehensive engagement plan at the upcoming COP22 meeting. This will include an unofficial UNFCCC side event, "Taking the Clean Energy Transformation from Nationally Determined Contributions (NDCs) to Action", which is

being done in partnership with the International Council for Sustainable Energy and the European Business Council for Sustainable Energy. There will also be an additional COP22 side event specifically on CCS.

#### **10. 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 four main activities: reviewing projects nominated for CSLF recognition, updating the CSLF Technology Roadmap, organizing technical workshops for CSLF meetings, and finding ways to better engage sponsors of CSLF-recognized projects. Mr. Barrett reported that much of the PIRT meeting had been taken up by review of two projects that have been nominated for CSLF recognition and by discussions related to project engagement, and that there were four main outcomes from the meeting:

- The PIRT has recommended approval by the Technical Group for both the Tomakomai CCS Demonstration Project and the NET Power 50 MW<sub>th</sub> Allam Cycle Demonstration Project.
- The PIRT has implemented a project engagement strategy where CSLF-recognized projects will be contacted for updates on their progress and accomplishments during years when there are CSLF Ministerial Meetings (i.e., every two years). The CSLF Secretariat will oversee this activity. Information received from projects will be utilized for future TRM updates and to prepare a summary document as an input to the 2017 CSLF Ministerial Meeting.
- The PIRT has approved a small revision to the CSLF Project Submission Form and will use the completed Form from the Tomakomai CCS Demonstration Project as a model for future project sponsors to use as an example of the kinds of project information being requested.
- The CSLF Technology Roadmap update is on schedule for roll-out at the 2017 CSLF Ministerial Meeting (as reported in the next item).

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

The Chair of the TRM working group, Andrew Barrett, gave a short progress report presentation about the 2017 TRM. The TRM working group had been formed at the 2015 Technical Group meeting in Riyadh with the mandate to produce a new TRM in time for the next CSLF Ministerial Meeting. The process chosen for the rewrite was to use the 2013 TRM as a basis and refresh its content as needed. Mr. Barrett stated that there have been four teleconferences of the working group and that the current focus has been on Section 4, "Technical Needs".

At the previous day's PIRT meeting, there had been consensus that the structure of the 2017 TRM will be changed to eliminate Section 3 ("Assessment of Present Situation") with any pertinent information from that section rolled into other sections of the TRM. The 2017 TRM will include information about recent developments in CCS, including relevant COP21/COP22 outcomes and technologies such as CCS with industrial sources and bio-energy with CCS. Mr. Barrett concluded his brief report by stating that the TRM Working Group is on track to complete a draft final version of the 2017 TRM in time for the 2017 CSLF Mid-Year Meeting and the final product will be ready for roll-out at the 2017 CSLF Ministerial Meeting.

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

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

Mr. Eide stated that the task force has held one preliminary meeting, in April in the United States, and a teleconference about a week prior to the current Technical Group meeting. The task force timeline calls for completion of the first draft of the final report in time for the 2017 CSLF Mid-Year Meeting and a finalized report, as well as findings and conclusions, at the 2017 CSLF Ministerial Meeting. The contents of the report will include sections on the current status and future potential for offshore CO<sub>2</sub>-EOR, a summary of emerging technical solutions for offshore CO<sub>2</sub> storage and EOR, descriptions of potential CO<sub>2</sub> supply chain issues and infrastructure needs, a description of regulatory requirements for offshore CO<sub>2</sub> utilization and storage, a summary of monitoring, verification and assessment tools for offshore CO<sub>2</sub>-EOR, and recommendations for overcoming any barriers to accomplishing offshore projects. Drafts of many of these sections are already in progress and all sections have assigned leads within the task force who are shepherding the process.

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

Task Force Chair John Litynski gave a brief update on the task force, which was established at the November 2015 meeting in Riyadh. The focus of the task force is to identify and summarize global efforts, successes, and challenges to deployment for BECCS. Current task force members include the United States (as chair), Italy, Norway, and the IEAGHG. Others who have expressed interest in either joining the task force or providing input for the task force's final report included the Netherlands, the European Commission, and the United Kingdom. Mr. Litynski stated that a technical focus of the task force is to look at the unique challenges for CO<sub>2</sub> capture technologies to be deployed at bio-power, biofuels, and other bio-industry facilities. This includes both current projects and also business cases for possible future projects – the task force will summarize current finding and identify any technology gaps. The list of projects being examined by the task force includes the ADM ethanol facility in the United States and the Klemetsrud waste-to-energy facility in Norway.

Mr. Litynski stated that a first draft of the final report will be completed prior to the 2017 CSLF Mid-Year Meeting. A finalized version of the report will be ready for the 2017 CSLF Ministerial Meeting. The overall structure of the report includes chapters on the commercial status of BECCS, an overview of BECCS technology options and pathways, a summary of BECCS resource assessments and emissions profiles, a summary of economic analyses for BECCS concepts, and a concluding chapter of findings and recommendations. Next steps for the task force will be to assign leads for each chapter of the report and to work with the International Energy Agency's Bioenergy team on its BECCS efforts so as to understand its overall approach and to leverage its knowledge as an input into the task force's report.

#### **14. Report from 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. Mr. Allison stated that the purpose of the task force is to investigate the existing capabilities in improved pore space utilisation for CO<sub>2</sub> storage. This includes summarizing the effectiveness and readiness of various techniques and developing ideas for necessary R&D to develop capability in the most opportune technologies. Current task force members include Australia and the United Kingdom (as co-chairs), Canada, France, Japan, the United Arab Emirates, the United States, and the IEAGHG. Mr. Allison also stated that the current name for the task force should be considered a working title, and could change before its final report is issued.

Dr. Watson briefly described the expected task force report contents. Included will be sections on well design (including flow control), injection operations (including pressure management, plume steering, and brine extraction), reservoir simulation (including geochemically enhanced injectivity), modified injection (including technologies such as micro-bubble injection), and utilization of heterogeneous reservoir storage. The latter category was recently added to the task force's scope and includes, as sub-categories, methods for manipulation of the CO<sub>2</sub> injection rate and CO<sub>2</sub> physical characteristics such as density and temperature, which would encourage CO<sub>2</sub> to take other paths within the storage reservoir, not just the path of least resistance.

Dr. Watson stated that the task force will not be addressing risk management issues, which would need to be the focus of a separate task force. The task force timeline will result in a draft of its final report in time for the 2017 CSLF Mid-Year Meeting and a finalized report, including a set of recommendations, by the 2017 CSLF Ministerial Meeting.

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

Technical Group Chair Åse Slagtern provided a brief update on the Technical Group Action Plan, in follow up to a preliminary discussion on the topic that had occurred at the previous day's PIRT meeting. Over the past three years, seven Technical Group task forces have completed final reports. Last year, at the CSLF Ministerial Meeting in Riyadh, three new task forces were formed. At the June 2016 Technical Group meeting in London, Didier Bonijoly had stated that France was interested in leading a new task force on Industrial CCS, but had needed to consult with in-country stakeholders before he could give a definite answer.

Following Ms. Slagtern's presentation, Dr. Bonijoly confirmed that France would chair a new Industrial CCS Task Force and that the "Club CO<sub>2</sub>" organization in France, which includes industrial partners Solvay, Air Liquide, Total, Lafarge, Sofregaz, and ArcelorMittal, will be involved in the task force's activities. Dr. Bonijoly stated that the task force will work on carbon capture, utilization and storage (CCUS) aspects more than CCS, expects to have a scope of work by about the end of 2016 and an initial draft task force report in time for the 2017 CSLF Mid-Year Meeting. There was an invitation for other CSLF Members to join the task force and interested was expressed by Canada, Germany, the Netherlands, Norway, Saudi Arabia, and the United States, but in each case there was need to check with the home office before a definite commitment could be given.

Takashi Kawabata also proposed a new task force on CCS Regulation, to be chaired by Japan, which would examine what are reasonable regulations for CCS. Because of its topic, this would most likely be a joint Policy Group-Technical Group task force and Mr. Kawabata stated that Japan would prepare a detailed proposal in time for the next CSLF meeting. There was interest from Australia, Norway, and the United States, as well as the GCCSI and IEAGHG, though the three CSLF Members stated that they would have to check in with their home office before a definite commitment could be given. Since this would be a joint Policy-Technical task force, Mr. Kawabata stated that he would also propose this at the Policy Group meeting later in the week.

**16. Review and Approval of Project Proposed for CSLF-Recognition:  
Tomakomai CCS Demonstration Project**

*(nominated by Japan, Australia, Canada, France, Norway, Saudi Arabia, the United Kingdom, and the United States)*

Jiro Tanaka, representing project sponsor Japan CCS Company, gave an overview presentation about the Tomakomai project. This is an integrated large-scale pilot project, located at a refinery complex in Tomakomai city on the island of Hokkaido in Japan, which is capturing CO<sub>2</sub> from the refinery's hydrogen production unit with a steam methane reformer and a pressure swing adsorption process, and injecting the CO<sub>2</sub> by two directional wells to the nearby offshore sub-seabed injection site. The overall objective is to demonstrate the technical viability of a full CCS system, from capture to injection and storage in saline aquifers. This will contribute to the establishment of CCS technology for practical use in Japan and set the stage for future deployments of commercial-scale CCS projects. The project includes capture and injection of up to about 100,000 tonnes per year of CO<sub>2</sub> for three years and a comprehensive measurement, monitoring and verification (MMV) regime for the injected CO<sub>2</sub>. The project also includes a detailed public outreach effort which has engaged local stakeholders and increased community awareness about CCS and its benefits.

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

**17. Review and Approval of Project Proposed for CSLF-Recognition:  
NET Power 50 MW<sub>th</sub> Allam Cycle Demonstration Project**

*(nominated by the United States, Japan, Saudi Arabia, and the United Kingdom)*

Hideo Nomoto, representing project sponsors 8 Rivers Capital and NET Power, gave an overview presentation about the NET Power project. This is a capture-only large-scale pilot project, located in La Porte, Texas in the United States, whose overall objective is to demonstrate the performance of the Allam power cycle. The Allam Cycle is a next-generation gas turbine-derived power cycle that uses high-pressure CO<sub>2</sub> instead of steam to produce power at low cost and with no atmospheric emissions. The project includes construction and operation of a 50 MW<sub>th</sub> natural gas-fueled pilot plant and also design of a much larger proposed commercial-scale project. The anticipated outcome of the project is verification of the performance of the Allam Cycle, its control system and components, and purity of the produced CO<sub>2</sub> with learnings being used in the design of a future commercial-scale project using this technology. The pilot plant is currently under construction with commissioning commencing by the end of 2016 and operation anticipated in the first half of 2017.

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

## 18. Reducing Lifecycle Biofuels Emissions with CCS

Sean McCoy, representing the Lawrence Livermore National Laboratory in the United States, gave a presentation which described a case study, based on relative energy intensity, for retrofitting CCS to a corn ethanol production facility. Dr. McCoy prefaced his presentation by providing three cogent reasons for why CCS in biofuels applications makes sense: on a lifecycle basis, CO<sub>2</sub> emissions from biofuels can be lower than from petroleum-based fuels, but they are still not zero; emissions-based trading systems are driving reductions in fuel emissions intensity and create a value proposition for CCS; use of CCS in biofuels can contribute to learnings which translate to cost reductions for CO<sub>2</sub> capture, and spur development of transport / storage infrastructure for all potential CCS applications.

For biofuels production via fermentation, CO<sub>2</sub> can be captured from the fermentation process and also from fuel combustion that produces utility steam and hot air for grain drying, evaporation, and other plant processes. Dr. McCoy stated that the case study examined three different scenarios: a baseline case with no CO<sub>2</sub> capture, a case where CO<sub>2</sub> was captured only from the fermentation process, and a case where there was full CO<sub>2</sub> capture from both fermentation and steam production. Results showed that fermentation capture alone did not produce a CO<sub>2</sub> reduction per unit of energy consumed by the plant. Full capture, on the other hand, resulted in a reduction in overall CO<sub>2</sub> emissions by nearly 50% on that same basis.

Dr. McCoy closed his presentation by stating that a possible next step would be to do a process-based lifecycle assessment to compare the potential impact of CCS on both alternative fuel and petroleum-based fuel with different technology options. Also, sustainability of current CO<sub>2</sub> capture processes should be examined to determine what innovations would be valuable.

## 19. Transforming CO<sub>2</sub> into Commercial Products

Issam Dairanieh, CEO of CO<sub>2</sub> Sciences, Inc. in the United States, gave a presentation about the Global CO<sub>2</sub> Initiative (GCI) and how it is attempting to build a new pathway for reducing carbon emissions by converting CO<sub>2</sub> into useful products. The GCI is comprised of two platforms: a not-for-profit to fund R&D (CO<sub>2</sub> Sciences) and a planned future for-profit to fund commercial investments. Dr. Dairanieh stated that a large number of products can be created using CO<sub>2</sub>: chemicals, construction materials, fuels, plastics, and food from agriculture. The GCI has conducted both economic and environmental assessments for production of CO<sub>2</sub>-based products using three criteria:

- Does the process lead to CO<sub>2</sub> reduction?
- Can the process be scaled and are markets material?
- Is the process competitive and commercially viable?

Dr. Dairanieh stated that a major conclusion from the assessment was that the market for CO<sub>2</sub> utilization is massive, with an opportunity of approx. US\$1 trillion in annual revenue. This could remove up to 4 gigatonnes per year (approx. 25% of which would be stored permanently) of the approx. 35 gigatonnes global annual CO<sub>2</sub> emissions. However, many processes for utilizing CO<sub>2</sub> are not mature or yet commercially viable. Some companies are already moving ahead with commercial ventures that utilize CO<sub>2</sub>, but in general there is a need for more philanthropic investments to fund R&D and greater profit investments to bring technologies to market scale. There is also a need for support for early stage technologies through policy and regulatory incentives as well as “impact” investing.

Dr. Dairanieh concluded his presentation by stating that the time is right for investments in CO<sub>2</sub>-based products and that a number of factors are converging to accelerate the development of relevant technologies. These include the greater sense of urgency resulting from the COP21 outcomes, continuing improvements in the costs for capturing CO<sub>2</sub>, initial market traction from these initial CO<sub>2</sub> utilization commercial ventures, and the creation of major governmental initiatives such as Mission Innovation which have pointed toward CO<sub>2</sub> utilization as a possible pathway toward reducing carbon emissions.

## **20. Pathway to Low-Carbon Lignite Utilization**

Tom Erickson, CEO of the University of the North Dakota's Energy and Environmental Research Center (EERC) in the United States, gave a presentation that described ongoing activities and how new technologies will help to keep low rank coal a relevant resource. Mr. Erickson stated that EERC is focused on energy and environmental solutions for more than 1,300 clients in 52 countries, and is the lead organization for the United States Department of Energy's Plains CO<sub>2</sub> Reduction Partnership which includes more than 120 partner organizations across nine U.S. states and four Canadian provinces.

Concerning the availability and local usage of low rank coal, Mr. Erickson stated that in North Dakota there is an 800 year supply at current usage rates, and a suite of technologies are in various stages of development and demonstration which will allow this low-cost resource to be consumed with low carbon intensity. These include use of advanced technologies such as lignite-based Allam Cycle power production and CCS including enhanced oil recovery (EOR). Mr. Erickson stated that North Dakota has ample opportunity for EOR, as it ranks as sixth largest energy producer and second greatest petroleum producer in the United States. Another opportunity for low-carbon lignite utilization in North Dakota is retrofit of existing utility power plants for carbon capture. To that end, a new initiative, Project Tundra, is underway with a goal of developing next-generation, advanced CO<sub>2</sub> capture technologies for utility use, and also creation of an energy corridor that includes CO<sub>2</sub> transport pipeline infrastructure to EOR and storage locations.

Mr. Erickson closed his presentation by stating that to lowering the carbon intensity for energy production would strengthen North Dakota's local economy, as there is a mandated carbon emissions target. Renewables and bioenergy are part of the mix for achieving this goal, but development and deployment of advanced technologies are absolutely needed for continued use of North Dakota's vast fossil energy resources.

## **21. Results from CSLF-recognized Project: CO<sub>2</sub> Separation from Pressurized Gas Stream**

Shin-ichi Nakao of RITE provided an update on the progress and activities for the CSLF-recognized CO<sub>2</sub> Separation from Pressurized Gas Stream Project. This is a bench-scale project, recognized in 2004 at the 2<sup>nd</sup> CSLF Ministerial Meeting, which is evaluating promising new gas separation membranes for potential use in CO<sub>2</sub> capture processes. Prof. Nakao stated RITE has been investigating the use of modular gate membranes for selective CO<sub>2</sub> removal from pressurized gas streams. Current work is centered on pre-combustion applications for use with coal gasification-based technologies, and results have shown that there is a large potential energy savings compared to conventional physical absorption processes. This could translate into a CO<sub>2</sub> capture cost of approximately half that for conventional liquid sorbent processes.

Prof. Nakao ended his presentation by stating that work is still underway to solve technical issues and to optimize membrane modules for use with real-world synthesis gas produced by coal gasification, and that the capital cost of these membrane systems needs to be reduced. A long-term field test is desirable as an eventual next step.

## **22. Recent Activity of the ISO Technical Committee 265 (TC265) Working Group on CO<sub>2</sub> Capture**

Takayuki Higashii of RITE gave a presentation about the ISO and its TC265 Working Group on CO<sub>2</sub> Capture. Mr. Higashii is the Convener of the CO<sub>2</sub> Capture Working Group, which was formed in 2013 and has held eight meetings. Its next meeting is scheduled for December 2016 in Sapporo, Japan. The Working Group membership currently consists of 56 experts from 14 member countries, with Japan as lead. The mission of the Working Group is to develop ISO standards for CO<sub>2</sub> capture that will help to provide a common basis for commercial business transactions and encourage the safe and effective utilization of CO<sub>2</sub>. The focus of the Working Group is on CO<sub>2</sub> capture at large stationary point sources such as power plants. Mr. Higashii stated that, overall, a broad range of sectors will be covered, including the power industry, the cement industry, the iron and steel industry, and gas production and the chemical industry. Technologies of interest include post-combustion CO<sub>2</sub> capture, oxyfuel combustion, and pre-combustion CO<sub>2</sub> capture.

Mr. Higashii provided information the overall methodology for developing ISO standards. The ISO itself does not write standards; that activity is the responsibility of its technical committees. Once these proposed standards are written, ISO member countries then approve the standards which are then adopted by other nations. The ISO TC265 has a scope of standardization of design, construction, operation, environmental planning, risk management, monitoring / verification of storage, and other activities related to CO<sub>2</sub> capture, transport, and geologic storage.

Mr. Higashii closed his presentation by briefly describing current activity of the CO<sub>2</sub> Capture Working Group. A recently published technical report describes CO<sub>2</sub> capture systems based on published papers and other documents and then summarizes the different issues deemed most important by the TC265. This report is intended to provide guidance for the eventual development of ISO standards for CO<sub>2</sub> capture. Also, a proposed new standard on “Performance Evaluation Methods for Post-Combustion CO<sub>2</sub> Capture Integrated with a Power Plant” has reached the ‘Committee Draft’ stage, where Working Group experts must reach a  $\frac{2}{3}$  consensus for it to progress to its next ‘Draft International Standard’ stage. The CSLF, as a liaison organization, can bring its expertise to these and other activities of the TC265 which in the end will help endure wider acceptance of any international standards that eventually result.

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

Ryozo Tanaka provided a short preview of the next day’s Technical Workshop. Stephanie Duran stated that planning was underway for 2017 CSLF meetings, but there was not yet confirmation on the host for the 2017 Mid-Year meeting. An announcement would be forthcoming within the next 1-2 months.

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

Andrew Barrett provided a brief update about an item from the June 2016 Technical Group meeting. It had been reported that the United Nations Framework Classification

(UNFC), which is a universally accepted and internationally applicable scheme for classification and reporting of fossil energy and mineral reserves and resources, had developed a set of specifications for applying UNFC methodology to CO<sub>2</sub> storage. Mr. Barrett stated that this classification methodology had been submitted to and passed by the Committee on Sustainable Energy of the United Nations Economic Commission for Europe (UNECE), and is now active. Mr. Barrett also stated that the Society of Petroleum Engineers has established a working group for developing a CO<sub>2</sub> storage resource management system, which would be an analog to its current petroleum resource management system. News about the new working group would probably be forthcoming soon.

Dominique Copin proposed that the Technical Group consider taking on a new activity for documenting that the overall value of CCS is greater than its overall cost. There was not consensus to proceed, however, as there are communications aspects to such an activity that would more properly be the responsibility of the Policy Group's Communications Task Force. Mr. Copin was asked to make this suggestion instead at the Policy Group meeting later in the week, as this could result in a joint Policy-Technical task force.

Stephanie Duran stated that a preview of the new CSLF website would take place during the CSLF Policy Group meeting later in the week.

## **25. Closing Remarks / Adjourn**

Åse Slagtern thanked the meeting host and sponsors, the Secretariat for its support, and the delegates for their active participation. She then adjourned the meeting.

## **Summary of Meeting Outcomes**

- The Tomakomai CCS Demonstration Project is recommended by the Technical Group to the Policy Group for CSLF recognition.
- The NET Power 50 MW<sub>th</sub> Allam Cycle Demonstration Project is recommended by the Technical Group to the Policy Group for CSLF recognition.
- France will form and lead a new Technical Group task force on Industrial CCS.
- The TRM Working Group will complete a final draft of the 2017 CSLF TRM in time for the 2017 CSLF Mid-Year Meeting.
- The three existing Technical Group task forces will complete drafts of their final reports in time for the 2017 CSLF Mid-Year Meeting.