2013 Ministerial Briefing Documents

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Briefing Documents

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Seven key actions for next seven years

Despite strong advances in clean energy technologies and serious intentions to address climate change, fossil fuels continue to dominate the world fuel mix. As a result, over the past twenty years, the CO_2 emission intensity of the global energy supply has remained stable and the total energy-related emissions have grown significantly[1]. Given the long life span of the energy sector infrastructure, coal and other fossil fuels will inevitably continue to play a very significant role. The IEA estimates that even under an ambitious climate scenario[2], fossil fuels represent 45% of primary energy use in 2050.

CCS offers a solution for dealing with the challenge of reducing emissions while preserving economic value of fossil fuels and related infrastructure. If CCS is to play its full role, by 2050 some 8Gt of CO_2 (equalling almost the current US and EU annual CO_2 emissions combined) will need to be captured and stored per year globally, if we are to stay on a 2 degrees Celsius trajectory[3]. Over the next four decades, this requires the creation of a new industry, comparable in size to today's oil and gas industries – not a small challenge.

It is clear that there is no time to lose if this challenge is to be met. Beginning a successful commercial deployment of CCS right after 2020 and continuing its fast expansion after 2030 directly depend on our actions *today*. Given a substantial time span between project identification and implementation, CCS-related action, or inaction, today will determine the scale of CCS deployment in 2020. It is very likely that the CCS projects that will start operating by 2020 are already at advanced stages of planning today.

Meeting the Challenge

However, today many buildings blocks essential for CCS are missing, or are available only in a small number of countries. Therefore prompt, focused and coordinated action by government, industry, the research community and financiers is required right now to set us up on the right pathway. The IEA 2013 CCS Roadmap[4] identifies seven key actions needed in the next seven years, to create a solid foundation for CCS deployment to start in early 2020s. These near-term actions are directly relevant for decision-makers in both government and industry today.

The seven key actions below are necessary up to 2020 to lay the foundation for scaled-up CCS deployment:

- **Introduce financial support mechanisms for demonstration and early deployment of CCS to drive private financing of projects.** This requires policies that provide for adequate financial payments to operators to cover the costs associated with building and operating capture, transport and storage equipment.

- **Implement policies that encourage storage exploration, characterisation and development for CCS projects.** There is a need for regional or national pre-competitive storage exploration and evaluation programmes. Governments should encourage and undertake national high-

[1] Tracking Clean Energy Progress report, International Energy Agency.
[2] 2DS scenario, International Energy Agency
[3] 2DS scenario, International Energy Agency.
[4] IEA 2013 CCS Roadmap

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level storage investigation and ensure that policies and incentives boost the timely exploration of storage sites on project level.

- **Develop national laws and regulations as well as provisions for multilateral finance that effectively require new-build, base-load, fossil-fuel power generation capacity to be CCS-ready**. To avoid potential lock-in of future emissions, laws and regulations should be put in place to ensure that new base-load plant be constructed in a way that allows the addition of CO_2 capture equipment at a later date. The CCS readiness status must also be maintained.

- **Prove capture systems at pilot scale in industrial applications where CO_2 capture has not yet been demonstrated.** Pilot-scale tests, and subsequently demonstration installations, are urgently needed at cement kilns, steel blast furnaces and in the refining sector, where there is currently a clear lack of CCS projects.

- **Significantly increase efforts to improve understanding among the public and stakeholders of CCS technology and the importance of its deployment.** Governments need to take the responsibility for explaining the role of CCS in national energy and climate strategies. Working actively to gain public acceptance is an integral part of any single CCS project and subsequently of wider deployment.

- **Reduce the cost of electricity from power plants equipped with capture through continued technology development and use of highest possible efficiency power generation cycles.** Many technical improvements are possible on capture technologies, such as reduced regeneration energy requirements and improved heat integration. It is also necessary to build the base power plant with highest possible efficiency parameters.

- **Encourage efficient development of CO_2 transport infrastructure by anticipating locations of future demand centres and future volumes of CO_2.** Various future demands and conditions must be considered when developing transport infrastructure. Governments will also need to decide what role they will play in at least the first steps of CO_2 infrastructure development.

Towards the success of CCS

If the world government and industry leaders do not act now, CCS deployment will be delayed. Analysis by the IEA analysis suggests that in the power sector only, delaying introduction of CCS from 2020 to 2030 would increase the investment required to keep the world on track for the 2°C target by more than $1 trillion[5]. Thus, it should be understood that while high costs of CCS may seem like a burden for societies today and is often cited as a reason for inaction, delay in its deployment may result in an even higher financial burden in the future.

CCS represents a significant opportunity, and we need to put it on track for successful deployment. Implementing the actions outlined above, and others specific to national or regional circumstances, we can start to build ground for positive responses by investors.

[5] "Redrawing the energy-climate map", World Energy Outlook Special report, IEA 2013

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Key Messages and Recommendations from the 2013 CSLF Technology Roadmap

Prepared by the CSLF Technical Group Executive Committee

Key messages from the Technology Roadmap

- First generation CO_2 capture technology for power generation applications is available today (albeit expensive).
- CO_2 transport is an established technology.
- CO_2 storage is safe provided that proper planning; operating, closure and post-closure procedures are developed and followed. However, sites display a wide variety of geology and other *in situ* conditions.
- Data collection for site characterization, qualification and permitting currently requires a long lead-time (3-10 years) mostly before an investment decision on detailed design work and then construction for a large new capture facility.
- There are no technical challenges per se in converting CO_2-EOR operations to CCS, although issues like availability of high quality CO_2 at an economic cost, infrastructure for transporting CO_2 to oil fields; and legal, regulatory and long-term liability must be addressed for this to happen.
- There is a broad array of non-EOR CO_2 utilization options that, when taken cumulatively, could provide a mechanism to utilize CO_2 in an economic manner. These options are at various levels of technological and market maturity
- Need for plain language communication to allay any public fears and concerns that may arise from transport and geological storage of CO_2.

Key Recommendations from the 2013 Technology Roadmap

Towards 2020 nations should work together to ensure that CCS remains a viable GHG mitigation option, building upon the global progress to date through:

International Collaboration

- Establish international networks of laboratories (like the European Carbon Dioxide Capture and Storage Laboratory Infrastructure, ECCSEL) and test centres and comprehensive RD&D programmes.
- Establish international collaborative R&D programmes that facilitate the demonstration of safe long term CO_2 storage.
- Address the different priorities, technical developments and needs of developed and developing countries.

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Demonstration Projects

- Implement large-scale demonstration projects in power generation in a sufficient number to gain experience with 1st generation CO_2 capture technologies and their integration into the power plant;
- Encourage and support the first demonstration plants for CO_2 capture in other industries than the power sector and gas processing and reforming, particularly in the cement and iron and steel industries.
- Develop sizeable pilot-scale projects for CO_2 storage that can provide greater understanding of the storage medium, establish networks of such projects to share the knowledge and experience for various geological and environmental settings, jurisdictions and regions of the world, including monitoring programmes.

Common Standards, Specifications and Best Practices

- Agree on common standards or best practices for establishing CO_2 storage capacity in geological formations.
- Develop common specifications for impurities in the CO_2 stream for the transport and storage of CO_2.
- Develop internationally agreed common standards or best practices for the screening, and selection of CO_2 storage sites in order to reduce lead-time and have the sites ready for permitting between 2020 and 2025, including CO_2-enhanced oil recovery (CO_2-EOR) sites.

Regional networks and opportunities for CCS

- Design large-scale, regional CO_2 transport networks and infrastructure that integrate CO_2 capture from power generation as well as other industries, CO_2 transport and storage
- Conduct regional (nationally as well as internationally) impact assessments of large-scale CCS implementation as part of an energy mix with renewables and fossil fuels.
- Map regional opportunities for CO_2 utilization and start implementing projects.

CO2 Utilization Options

- Continue R&D and small-scale testing of promising non-EOR CO_2 utilization options.

Towards 2030 nations should work together to:

- Move 2nd generation CO_2 capture technologies for power generation and industrial applications through demonstration to commercialisation, with possible targets of 30% reduction of energy penalty, normalized capital cost, and normalized operational and maintenance (O&M) costs compared to 2013 costs for 1st generation technologies
- Implement large-scale regional CO_2 transport networks and infrastructure, nationally as well as internationally.
- Demonstrate safe, large-scale CO_2 storage and monitoring
- Qualify regional, and potentially cross-border, clusters of CO_2 storage reservoirs with sufficient capacity.
- Ensure sufficient resource capacity for a large-scale CCS industry, by starting widespread exploration as soon as possible, because of the long lead times.
- Scale-up and demonstrate non-EOR CO_2 utilization options.

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Financial incentives for CCS: towards stable policy

To secure future CCS deployment at scale, the number of CCS projects needs to increase substantially over the next decade. Such an increase requires support policies that will help establish CCS as a mature technology, able to compete commercially with other CO_2 abatement options. Specific financial incentives are required for CCS in the short to mid-term.

Early mover firms are reluctant to invest in early CCS projects as they are unable to recover their costs. There is no business case and very little, if any, first-mover advantage. Furthermore, capital providers may not be able to differentiate between "good" and ''bad'' projects, which will discourage the flow of capital to early CCS projects. Also, interdependency between capture plants, CO_2 transport and storage sites requires strong coordination in planning. The risk of failing coordination, or differing interests by different parties involved, increases uncertainty for private investors.

Different policy objectives – different incentive measures

When designing policy to support CCS, governments must start by defining the *objective(s)* of policy support. Generic objectives of CCS policy may typically be:

- Ensuring technology learning and reducing cost,
- Achieving emission reductions, and
- Improving access to capital by projects.

To serve these objectives, governments have a toolbox of economic instruments at their disposal. It must be stressed that different policy objectives are best served by different incentive mechanisms:

- Ensuring technology learning is typically best achieved by instruments that ensure an increasing level of early deployment. Feed-in tariffs (FIT) and quantity-based instruments (portfolio standards, etc) are examples of such mechanisms. These instruments have played a major role in the successful promotion of renewable energy, providing a stable revenue base for operators.
- Emission reductions can be achieved through many mechanisms. An economy-wide carbon pricing mechanism, either through taxation or cap-and-trade, is often regarded as the most cost-effective instrument. Sector-specific instruments are also available, such as an emission performance standard that limits the amount of CO_2 that can be emitted from certain type of facilities. Other mechanisms include for example feebates: a carbon tax applied to emissions above a certain baseline, combined with tax credits or cash payments if the emissions are below the baseline.
- Improving access to capital could be achieved through direct government contribution of capital (via grants, equity co-investment, the provision of debt) or financial risk mitigation instruments such as credit guarantees and insurance products. As the technology matures over time, a shift from capital contribution to risk mitigation measures may be warranted.

Evolving policy in a stable *policy architecture*

The relative importance of policy objectives, and hence the choice of policy instruments, will evolve over time. Initially, incentive policy will focus on trials of CCS, seeking to ensure technical learning and reduce cost. In the beginning the main policy goal is not to make emission reductions for their own sake, but rather to advance CCS technology and establish commercial arrangements between capture, networks and storage operators. Therefore, only relying on policy that aims purely at emission reductions, for example by putting a price on CO_2 emissions, will not suffice to secure first

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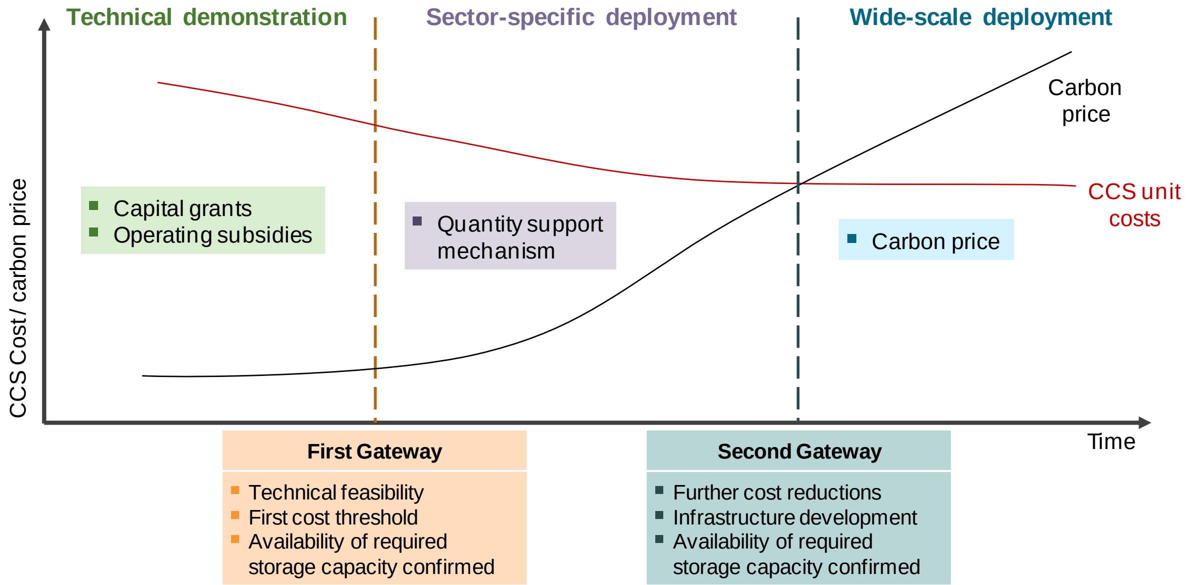
deployment of CCS in the short to mid-term. Pricing instruments need to be complemented by instruments that ensure technical learning. As CCS technology will mature over time and investor become more familiar with the technology, emission reduction policies will afterwards take a stronger role in driving CCS.

This calls for a long-term policy strategy that creates a framework under which different instruments are introduced, depending on the maturity of the technology. A long-term CCS development path could for example be divided into the following three phases:

1. Technical demonstration. The policy objective of the first phase is to ensure that a sufficient number of CCS projects are implemented to allow for technical demonstration and basic learning. This can be achieved, for example, by public capital grants and operating subsidies, and by setting up structures ensuring collaboration and knowledge sharing between parties to maximize learning.
2. Sector-specific deployment. A second phase is a period of larger scale deployment, even though CCS cost may not be covered by a carbon price alone. Widespread deployment, even in one sector, is unlikely to be feasible through public grants, so the emphasis would switch to quantity support mechanisms, such as feed-in tariffs, portfolio standards, and for example loan guarantees. Policy might also extend to infrastructure, setting out arrangements for network development and storage.
3. Wide-scale deployment. In a third phase, as CCS technology becomes fully proven at commercial scale, CCS is stimulated by an economy-wide pricing of CO_2 emissions. Narrower, sectoral approaches can also be used.



In conclusion, it is important to recognize that CCS will require different types of incentive policies, and these policies must evolve over time. In most of its applications CCS is today entering a technical demonstration phase. It is therefore important for today's CCS financing debate to actively seek incentive mechanisms that provide revenue certainty and directly promote technical learning and cost reductions. It is now widely accepted that a carbon price alone will not be enough in the short term to provide enough incentives for CCS deployment. In the short term, due to more and more stringent public finances, it is also more important than ever for governments and industries to collaborate very closely to maximize learning from first large CCS projects.

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Key Next Steps to Support the Large Scale Development of Power and Industrial Carbon Capture and Storage (CCS): the findings of the UK CCS Cost Reduction Taskforce

In recognition of the importance of cost reduction for the development and widespread deployment of CCS, the UK Government established an industry-led CCS Cost Reduction Task Force (CRTF). The Task Force was created in March 2012 with the objective of publishing a report to advise Government and industry on reducing the cost of CCS so that projects are financeable and competitive with other low carbon technologies in the early 2020s.

While initiated in the UK, membership was drawn from a broad spectrum of UK and international organisations, such that key findings may be applicable elsewhere.

Key conclusion

The Cost Reduction Task Force presented their Final Report in May 2013. The primary conclusion of the Task Force was that UK gas and coal power stations equipped with carbon capture, transport and storage have **clear potential to be cost competitive with other forms of low-carbon power generation**, **delivering electricity at a levelised cost approaching £100/MWh ($160/MWh) by the early 2020s**, and at a cost significantly below that soon thereafter.

This conclusion was based on a comprehensive analysis of potential savings across the full chain of CCS, as well as wider cost savings such as from reducing the cost of capital or incorporating new revenue streams such as from CO_2-based Enhanced Oil Recovery (EOR).

Opportunities for cost reduction

Their analysis highlighted five areas where significant cost reductions could be achieved:

1. investment in large CO2 storage clusters, supplying multiple CO2 sites;
2. investment in large, shared pipelines, with high use;
3. investment in large power stations with progressive improvements in CO2 capture capability that should be available in the early 2020s;
4. a reduction in the cost of project capital through a set of measures to reduce risk and improve investor confidence in UK CCS projects; and
5. exploiting potential synergies with CO_2-based EOR.

An indication of the relative significance of each of these factors (for the UK) is given in the graph below. The analysis assumes that early CCS projects will have higher costs because of their smaller size; relatively short lifetime if retrofitted onto existing power plants; single point-to-point full chain configuration; engineering prudence and risk averse commercial and financing arrangements. These early projects are represented by the first column, with costs in the range of £150-200/MWh ($240-320/MWh). The subsequent columns illustrate potential costs of follow-on projects, taking into account the cost reductions achievable.

The greatest savings have been identified in the areas of transport and storage, improved financeability and improved design and performance. In addition, the Task Force estimated a

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potential additional EOR benefit in the range of £5-12/MWh ($8-20/MWh) for gas CCS, and £10-26/MWh ($16-24/MWh) for coal CCS, which would be in addition to the reductions identified on the graph.

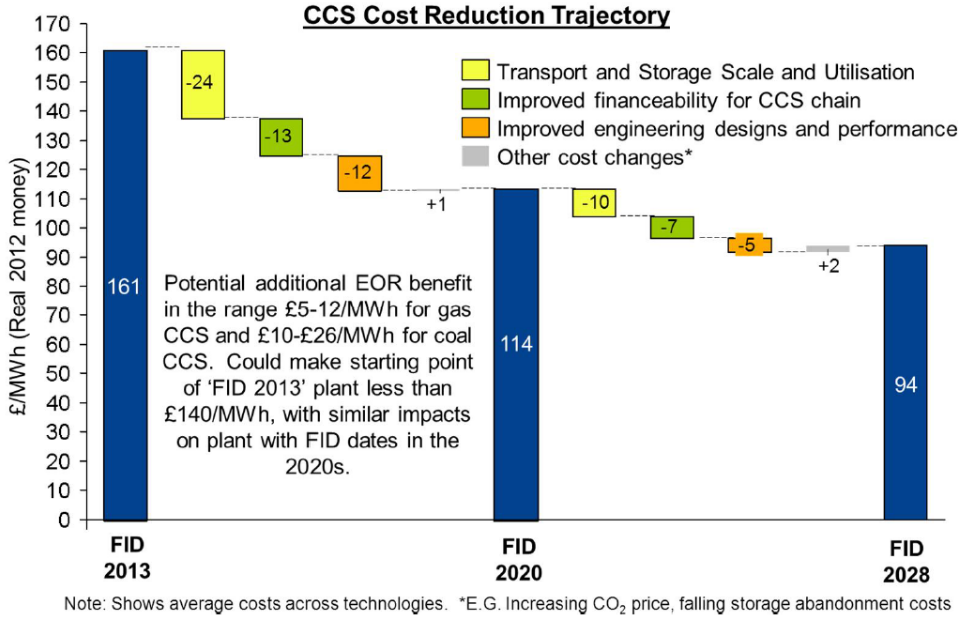

Figure 1: Waterfall Graph - key components of potential cost reduction across the CCS chain

To note, cost savings for a range of different technology configurations were analysed by the Task Force but average cost levels across technologies are used here to simplify messages. Full details of the analysis undertaken are available in the Task Force's report.

In addition to identifying the opportunities for cost reduction, the Task Force also looked at how these cost savings could be achieved.

CCS landscape

The Task Force highlighted the importance of a wider 'landscape' that is favourable to the development of CCS projects. They propose that cost reductions can only take place if a conducive landscape engenders the transition from the early projects to one where CCS is viewed as conventional. The key characteristics of such a landscape include:

1. Credible long term Government policy commitment to CCS - including a suitable regulatory structure and financial and policy framework to foster development of CCS.
2. Successful demonstration of full chain CCS projects at scale - including a commitment to knowledge sharing from projects in the UK and globally.
3. Continued engagement with the financial community - so that they understand the technology and can appropriately assess risk, as well as to ensure their needs are factored into policy development.

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The landscape alone will not, by itself, guarantee that costs of CCS projects can be reduced. However, the Task Force believe it will enable a wide range of cost reducing actions to be pursued. Their analysis then examined what are the most important of these actions for encouraging deployment and securing cost reductions.

Key next steps to support large scale development of CCS

While the UK Government is taking forward a comprehensive Commercialisation Programme to build the first full-chain CCS plants in the UK, the Task Force examined the key next steps needed to support *subsequent* large scale development of CCS. As with the cost savings identified, these are UK specific but are likely to be applicable elsewhere too.

Seven key steps were identified to allow the follow-on and future CCS projects to be developed in a way that delivers the identified cost reductions. These were:

1. Ensure optimal CCS transport and storage network configuration – identifying options for transport and storage system configurations that take into account likely future developments and minimise long run costs.
2. Incentivise CO2 EOR to limit emissions and maximise hydrocarbon production
3. Ensure funding mechanisms are fit-for-purpose – funding instruments should be suitable for widespread use in coal and gas CCS projects.
4. Create bankable contracts - focus on how to construct contracts that will be needed to make follow-on projects bankable.
5. Create a vision for development of CCS Projects from follow-on projects through to widespread adoption with the aim of encouraging prospective developers of CCS projects.
6. Promote characterisation of CO_2 storage locations to maximise benefit from storage resource - the aim is to reduce the 'exploration risk' premium, thereby making storage sites bankable both commercially and technically.
7. Create policy and financing regimes for CCS from industrial CO_2 sources.

In addition to these Key Next Steps, the Task Force identified a further 26 supporting steps which should be taken in order to mitigate investor and operational risks and underpin successful development of future CCS projects. Details of these, and the full analysis undertaken by the Task Force, is set out in the **CCS Cost Reduction Task Force Final Report** available from the UK Government Website:

https://www.gov.uk/government/policy-advisory-groups/ccs-cost-reduction-task-force

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REGIONAL CHALLENGES AND OPPORTUNITIES FOR CCS

BACKGROUND PAPER FOR THE 5TH CSLF MINISTERIAL

NOVEMBER, 2013

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On a global basis, the CCS industry is still in its very early stages, although progress is being made. On average, in the past few years one or two large scale projects have entered construction each year, and the number of operational projects is slowly increasing. But on a regional basis, the picture is far from uniform, and global trends mask significant local differences in the progress of and outlook for the industry.

North America

Seventy per cent of the world's active (those in operation or under construction) large-scale CCS projects are in North America. This includes the first two large-scale projects in the power generation sector, which are currently under construction, as well as long-running projects which have successfully demonstrated safe storage of many millions of tonnes of CO_2.

All of the operating projects, and all but one of the projects under construction, in North America are using or intend to use the captured CO_2 for enhanced oil recovery (CO_2–EOR). The opportunities to utilise CO_2 as a commodity with value have been very important in enabling a business case for large-scale projects in North America, where EOR is a long-established practice.

North America also has a significant share (29 per cent) of the large-scale projects in planning stages. A large majority of these projects are also examining EOR options. However the number of projects in the planning stages in North America has fallen noticeably in the past four years. Many projects have been cancelled or deferred, and while there is a range of reasons for this, developers primarily cited difficulty in making the business case for a first-of-a-kind demonstration project under the current economic, market, and policy or regulatory environment. In particular, it is evident that EOR opportunities in themselves are not always sufficient for projects to proceed, as quite a few of the projects cancelled or put on hold have involved plans to sell CO_2 for EOR, but this potential revenue source was not enough to overcome the gaps in making the case for the project.

Europe

In Europe, despite numerous policy initiatives, no new large–scale CCS project has entered operation since 2008. The two operating projects in this region, both in Norway, have successfully demonstrated dedicated CO_2 storage, in one case since 1996. But they have not been followed by other projects entering either construction or operation.

Until recently, the number of large-scale projects being planned in Europe was relatively stable, and several were hopeful of being able to make a final investment decision (FID). In 2013, however, six European projects were cancelled or put on hold and no new projects were announced. This reflects the ongoing difficulty for project proponents to assemble a viable business case or make a positive FID to move into construction.

The decreased number of European projects since 2012 can be linked to several causes, but a major issue has been funding. In December 2012, no CCS project was awarded funding under the much anticipated first round of the European Commission's (EC) NER300 funding program. Only the Ultra-Low CO_2 Steelmaking (ULCOS) Blast Furnace project passed the selection and secured the mandated co-funding agreement from its member state (France), but it was subsequently withdrawn by the project developer. This was a significant setback to the original plan announced by European governments in 2008 to fund up to 12 CCS projects over the two phases of the NER300 program. The EC expressed its regrets at the absence of CCS projects under the first call. It commented that member states had not confirmed their projects due to reported funding gaps or lack of CCS project maturity. It has to be noted that the amount of funding available under NER300 is much less than was originally anticipated, due to large declines in the value of European Union (EU) Emissions Trading System (ETS) allowances which fund the program. Compared with North America, there are also fewer opportunities to earn revenue from use or sale of CO_2 in Europe, where EOR opportunities are limited.

It should also be noted that in Europe projects are more likely to be put on hold than cancelled. Project proponents in these cases may be hopeful that more incentives will emerge in the future to enable their projects to be reinstated.

Despite these difficulties, there is some progress in Europe. The UK's energy market reforms and CCS Commercialisation Programme are progressing, and several projects in continental Europe are pursuing additional financing that may enable them to make an FID in the near future.

China

After North America and Europe, China has the next largest number of large-scale CCS projects in planning. China has already demonstrated significant progress in CCS through numerous pilot and small scale projects operating at up to 120,000 tonnes of CO_2 a year. The apparent next step, consistent with the objectives of the country's 12th Five Year Plan, is to build at least one large-scale CCS demonstration project in the next few years. Large-scale projects in planning are in a variety of industry sectors and capture technologies, and are considering both EOR and dedicated storage options. Importantly, the developers of several large-scale projects have pilot projects that are already in operation. This approach is typical in China, where pilot projects are considered important for companies to build confidence before scaling up.

China's 12 large-scale projects are steadily progressing through the project lifecycle. The more advanced projects are dominated by China's large state–owned petroleum companies. These petroleum companies tend to own the full CCS chain, from CO_2 source to sink, which reduces the complications associated with third party involvement and allows them to move much more swiftly. These companies also have direct opportunities to use the CO_2 for EOR, helping to improve the finances of the overall CCS project.

Rest of world

In addition to the regions mentioned above, there is one operating large-scale project in each of South America (Brazil) and Africa (Algeria); and one under construction in each of Australia and the Middle East (Saudi Arabia). These projects all utilise CO_2 separated as part of natural gas processing, so there is little or no additional capture cost involved. The Brazilian and Saudi projects use the CO_2 for EOR, while the Algerian and Australian projects involve injection for dedicated storage.

Several more projects are in the planning stages in Australia, the United Arab Emirates (UAE) and Korea. Of these, the most advanced are in the UAE. Here again, initial plans are to obtain a very pure stream of CO_2 from an industrial process for EOR, thus minimising capture costs and obtaining a revenue stream from use of the CO_2.

Final observations

The pace of CCS development varies considerably around the world. In North America, EOR (sometimes in combination with other revenue sources) offers opportunities for project developers in a range of industries to offset the costs of capture facilities. The size and maturity of the EOR market in North America is a major factor behind the leadership of this region in developing large-scale CCS projects. However, even there EOR in itself may not be sufficient to allow projects to proceed. There are numerous examples of projects which have been forced to shelve or abandon plans for CCS projects, due to factors such as a lack of policy or regulatory support, or other economic and market circumstances.

In Europe, opportunities for EOR are much less, and there projects tend to rely on government policy settings, including regulation and financial support, in order to proceed. A combination of factors,

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including recent low prices in EU carbon markets, has meant that projects have struggled to make a positive FID in recent years.

Projects in operation or under construction outside of North America and Europe obtain CO_2 from natural gas processing, where there are little or no additional capture costs. Utilising such low cost sources of CO_2 may point a way forward for many countries to obtain experience in CCS, particularly where there are EOR or other opportunities to offset compression, transport and storage costs. China is a notable example of a country where such opportunities may exist, and there are several such large-scale projects in advanced stages of planning.

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CSLF Capacity Building Program Progress Report

Report by the CSLF Capacity Building Governing Council

CSLF Capacity Building Program

The CSLF Capacity Building Program was approved by the CSLF Policy Group and endorsed by Ministers in 2009. The Program strives to assist all CSLF Members to develop the information, tools, skills, expertise, and institutions required to implement carbon capture and storage (CCS) demonstrations and then move rapidly into commercial operation.

The Program Plan further defines four program initiatives:

- Disseminate practical information
- Build capacity in emerging economies
- Assist government and regulatory agencies
- Build academic and research institutions for CCS

Each of the capacity building projects undertaken by the CSLF, as described below, addresses one or more of these program initiatives.

Governance of the CSLF Capacity Building Fund

The CSLF Capacity Building Fund Governing Council is composed of representatives of significant donors. The Governing Council oversees financial aspects of the Capacity Building Program. The Governing Council began its operation by developing a Terms of Reference for its operation and for governance of the CSLF Capacity Building Fund.

The Governing Council also developed a procedure for soliciting and evaluating requests for capacity building projects using criteria established by the Capacity Building Task Force. This procedure was implemented from 2010 to 2013 in coordination with the Capacity Building Task Force by soliciting and evaluating requests from emerging economy CSLF Members.

Collaborations

The CSLF is collaborating with the Global Carbon Capture and Storage Institute in the management of its Capacity Building Program and is coordinating its activities with CCS capacity building activities of the World Bank. Various other industrial and academic institutions in Member countries are taking part in CSLF capacity building projects.

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Capacity Building Projects

To date, a total of 13 capacity building projects in four countries have been approved and either have been, or will be, conducted by the CSLF. While projects may be held in a specific country, workshops and other events are open to participants from all CSLF Members.

Approved projects include:

Brazil

- Training Program in carbon capture applied to mineral coal combustion and gasification process - This program is building and developing a knowledge base in the process of carbon capture in Brazil through a training program applied to mineral coal combustion and gasification process. The program brings foreign skilled personnel to instruct local human resources and allows Brazilian researchers to participate in practical trainings at the United States Department of Energy (US-DOE) – National Energy Technology Laboratory (NETL) or institutions with recognized expertise. This project has three courses divided over two and a half years.
- Develop a training program in the process of CCS in the offshore environment - This program was for professionals from the oil industry, research institutions, universities and stakeholders in general and was critical to the sustainable development of Brazil's petroleum industry.
- Develop a knowledge base on environmental impact assessment and CO_2 monitoring technologies - This knowledge base will be used for the development of CCS projects in South America by bringing skilled personal to instruct local human resources and advise on the appropriate technology and instrumentation necessary for a specific project. The first course, a basic one, was held in July 2012 and was titled "Understanding Carbon Capture and Storage."
- CO_2 Storage in the Clean Development Mechanism – Opportunities in Portuguese Language Countries – From September 19-20, 2013, a workshop was held in Lisbon, Portugal that helped to disseminate knowledge about CCS technology among the Community of Portuguese Language Countries (CPLP) members. The workshop allowed participants to discuss business and investment opportunities, and promoted cooperation between companies and institutions capable of intervening in the activities necessary to implement energy and industrial projects integrated with CCS in CPLP countries.

China

- Develop website on Carbon Capture Utilization and Storage Technologies - This project established the first website focusing on CCS technologies and its development in China. The aims were to serve as a platform to share information and knowledge on technology advancements and good practices, and to educate the public. The website was also translated into English.
- Workshop on experience sharing among CCS demonstration and pilot projects - This workshop was held in July 2012 in Beijing, China. It focused on CCS experience sharing in China and served as a platform of exchange and discussion within China and internationally. Participants were representatives of government departments, academia, industrial stakeholders, and NGOs.

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- Workshop on legal and regulatory issues for CCS technology development – This workshop was held in October 2012 in Beijing, China, and introduced the role of regulatory and enabling environments for CCS development, experiences of developed countries, and how China may move forward. Participants were representatives of government departments, academia, industrial stakeholders, and NGOs.
- Exploring CCUS Legal and Regulatory Framework in China - This project aims to explore the CCUS legal and regulatory issues in China through an empirical perspective. The project also plans to raise awareness among relevant stakeholder groups, with an aim to promote the establishment of such a regulatory framework and to facilitate the implementation of future CCUS demonstration projects in China.
- Roadmap: CCUS Financing in China - This project aims to address CCUS challenges by formulating the financial roadmap for CCUS development and demonstration in China and spreading information to key stakeholders.

Mexico

- Introduce CCS into academic programs - This project was held in March 2012 and educated professors and graduate students on carbon capture, utilization and storage through two workshops. The first workshop focused on "CO_2 Geological Storage and Enhanced Oil Recovery," while the second workshop was on "CO_2 Capture." The project also sent two individuals from Mexico to attend the Greenhouse Gas Control Technologies (GHGT)-11 Conference in November 2012 in Kyoto, Japan.
- Internships on CCS - This proposal will link qualified Mexican personnel to international projects with similar background, objectives, and operations to demonstration projects around the world. Mexico is interested in CO_2 monitoring strategies and techniques and one form of obtaining such experience is via this proposed internship. The first intern will undertake the internship in Australia at the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) in Australia.

South Africa

- Conduct workshops and conferences during South Africa's CCS week - Two workshops were held in October 2011 to disseminate information on CCS to relevant stakeholders.
- Impacts of CCS on South African national priorities beyond climate change - The aim of this study was to improve the understanding of how CCS impacts South Africa's national priority issues beyond CO_2 mitigation and climate change, such as sustainable development, improved local infrastructure, job creation and protection, poverty alleviation, and social upliftment.

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CCS Technology Gaps, Opportunities and Research Fronts

Report by the CSLF Task Force on Technology Opportunities and Gaps

Executive Summary

This paper sets out the key findings from the taskforce report on CCS technology and associated issues and research fronts.

At a high level there are no major technology gaps or impediments to CCS; the technology is available and can be effectively deployed. The focus of development is now on driving down costs and securing more efficient operational, monitoring and regulatory outcomes.

Current commercially available capture technologies will evolve to lower costs by building more projects. More attention is needed on the next generation of capture technologies that promise much lower costs. In the absence of market forces, these technologies need to be supported, particularly by assisting the transition from the laboratory to larger scale pilots and demonstrations. This will ensure that much lower cost capture is available by 2030 and beyond. More attention is required on technologies for capturing CO_2 from natural gas combustion, as the emergence of plentiful low cost shale gas leads to more gas combustion.

Pipeline transportation of CO_2 is a mature technology, but more experience is need in the planning and design of large-scale transport hubs and also in demonstrating large-scale transport of CO_2 by ship.

A significant body of knowledge from the oil and gas industry, combined with over 15 years of R&D on the behaviour of CO_2 in deep rock formations, underpins a strong consensus that safe CO_2 storage is possible today. The lead times from initiating exploration through to approvals and construction will often be 10 -15 years. The rate at which exploration is incentivised will have a profound impact on the degree to which CCS can contribute to reaching 2050 global reduction targets. Early action will increase the deployment of CCS and in turn affect the rate of technology improvement.

Monitoring, measurement and verification (MMV) for stored CO_2 continues to progress well. An important new front is the development of MMV technologies and strategies for storage in offshore environments.

It is recommended that Governments continue to support and incentivize international technology collaboration and researcher exchange to spark faster development and diffusion of CCS technology.

Introduction

CCS is one of the key technologies in the fight against climate change, because it is the only technology that can deal with a significant global inventory of power stations and industrial

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processes that emit large volumes of CO_2 from fossil fuel use. The CSLF continues to take a keen interest in the status of the technology, its effectiveness and likely trajectory of improvement and cost reduction. The key observations on each major area of technology are as follows:

Carbon Capture and Integrated Combustion

A number of capture technologies are available today (mostly solvent-based) and are deployed on large scale demonstrations or industrial processes; capture costs can be expected to fall substantially by 2025-2030, particularly if promising technologies are moved though the development pathway.

There is a need to continue to support 2nd and 3rd generation technology development, from pilot to large-scale demonstration, to secure the lowest cost technologies for the future. Adsorbents and membranes are likely to play a big role in the next generation of technologies.

For all capture technologies, improvements must focus on all dimensions: (1) materials, (2) equipment, (3) impurity handling/tolerance, (4) process design and heat integration, and (5) environmental impact.

Retrofit of more modern coal-fired power stations can result in much lower costs of electricity than closing viable stations and building new low emission coal-fired stations.

More work is required on the flexible operation of power plants using CCS, where day-to-day CCS operations can be optimized with respect to electricity market prices and renewable energy production.

For oxyfuel technologies on coal combustion the technology is mature, but for natural gas combustion an important new technology field is opening up, where new turbine design is an important R&D front. Improvements that lower the cost of oxygen will benefit all oxyfuel technologies.

Chemical looping is an important emerging technology for some industrial processes such as cement manufacture and also for fluidised bed combustion of coal; moving the technology to larger scale is a priority.

CO_2 Transport

The technology for transport of CO_2 is well established, with over 6,500 km of CO_2 pipelines in the US, transporting 48-58 Mtpa. Although transport pipeline technology is mature and available, some technology improvements are needed to get costs down and further increase safety, including managing and designing for variations in CO_2 composition in multiple source hubs (includes understanding equations of state and operational implications), fracture propagation control, corrosion control and CO_2 dispersion modeling for safety case and risk assessment purposes.

Experience is needed in planning, designing and implementing, large-scale CO_2 transport networks, including hubs and multiple points of capture. Large-scale transport of CO_2 by ship offers promise and needs to be demonstrated at scale.

Storage

A significant established body of technology from the oil and gas industry has combined with the research and demonstration on CCS over the last 10-15 years to underpin a strong consensus that safe CO_2 storage is possible today. New knowledge will be gained from the numerous larger scale deployments underway. This will fine-tune the technology for large-scale deployment. Key research and improvement areas are:

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1) Modeling CO_2 behaviour in the sub surface.
2) Improvements to optimise operational effectiveness and storage efficiency.
3) Development (based on oil and gas industry practice) of internationally consistent standards for: a) storage site characterisation methodologies; b) storage efficiency factors; and c) capacity estimation and reporting.
4) Technology and risk management strategies to mitigate or manage unintended CO_2 migration.

Monitoring, Measurement and Verification (MMV)

MMV continues to be a vital part of CCS technology development, as it underpins operational decisions as well as the relationship with regulators and the community. Some key observations and recommendations are:

1) Establish technologies and methodologies for offshore (sub marine) MMV, as a significant portion of global storage capacity is offshore.
2) Continue work on controlled release calibration and natural analogues; these experiments are important for CO_2 detection and accounting;
3) Develop an agreed methodology and language for dealing with what will be the principal result of most monitoring – a null result;
4) Continue the rapidly evolving trend to continuous, high resolution, low cost, low impact subsurface monitoring;
5) Continue to develop new seismic interpretation and inversion techniques for enhanced CO_2 detection.

Building Technical Knowledge Capability and People

The broad deployment of CCS will require a significant pool of technically skilled people as well as continuing growth and dispersion of the CCS technology knowledge base. Governments are encouraged to continue R&D and technology development to both develop the knowledge base and to train engineers and scientists in CCS technologies. Stimulating international collaboration amongst researchers is also important to get more rapid development and dispersion of the technology.

Industry dynamics associated with exploration and technology development

One of the most pressing problems for global CCS deployment at scale is getting the requisite amount of exploration started when there is a weak price on carbon. The lead times from initiating exploration through approvals and construction will often be as long as 10-15 years. This has implications for the degree to which CCS can contribute to 2050 targets and the rate of technology development[1].

Governments are encouraged to start the identification and pre-competitive data generation of prospective storage basins, as well as making assessments of the likely realistic storage capacity. It is also necessary to either start exploration or incentivise the private sector to start exploration.

[1] If exploration is slow, large-scale deployment will be slow, which will in turn slow learning-by-doing for current technologies and market pull for the next generation of technologies. Conversely, if governments incentivise the market to act, with carbon prices, taxes or mandates, the result will be synergistic for both exploration and discovery of storage capacity and also for technology development. The result will be lower costs, which will in turn drive the market dynamics more strongly.

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Conclusion

Governments around the world now have a technology at their fingertips that can be deployed to manage carbon emissions, but the rate of take-up and the associated improvements in technology needs to be incentivised. There are profound role-of-government lessons from the development of the nuclear industry and SO_2 scrubbing in the US and also from the global LNG industry. Governments played a decisive role in both the development and the diffusion of these technologies. Governments must continue to be involved in the same way in CCS development; where the diffusion and take-up of the technologies is strongly driven by the credibility of incentives for industry to invest in commercial scale projects and technology development.

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Technical Challenges in the Conversion of CO_2-EOR Projects to CO_2 Storage Projects

Summary of the Report by the CSLF Task Force on Technical Challenges in the Transition from CO_2-EOR to CCS

Forty years of experience and more than 120 CO_2-EOR operations currently active in the world indicate that there is sufficient operational and regulatory experience for this technology to be considered as being mature, with an associated storage rate of 90-95 % of the purchased CO_2. Application of CO_2-EOR for CO_2 storage has a number of advantages:

1) It enables CCS technology improvement and cost reduction;
2) It improves the business case for CCS demonstration and early movers;
3) It supports the development of CO_2 transportation networks;
4) It may provide significant CO_2 storage capacity in the short-to-medium-term, particularly if residual oil zones (ROZ) are produced;
5) It enables knowledge transfer, bridging the experience gap and building and sustaining a skilled CCS workforce; and
6) It helps gaining public and policy-makers acceptance.

The current number of CO_2-EOR operations in the world is negligible compared with the number of oil pools in the world, and **the main reason CO_2-EOR is not applied on larger scale is the unavailability of high-purity CO_2 in the amounts and at the cost needed for this technology to be deployed on a large scale**. The potential for CO_2 storage and incremental oil recovery through CO_2-EOR is significant, particularly if residual oil zones (ROZ) and hybrid CO_2-EOR/CCS operations are considered. Besides the main impediment in the adoption and deployment of this technology mentioned above, **the absence of infrastructure to both capture the CO_2 and transport it from CO_2 sources to oil fields suitable for CO_2-EOR is also a key reason for the lack of large scale deployment of CO_2-EOR**.

There are a number of commonalities between CO_2-EOR and pure CO_2 storage operations, both at the operational and regulatory levels, which create a good basis for transitioning from CO_2-EOR to CO_2 storage in oil fields. However, currently there are a significant number of differences between the two types of operations that can be grouped in seven broad categories:

1) Operational, including CO_2 purity and quality;
2) Objectives and economics;
3) Supply and demand;
4) Legal and regulatory;
5) Assurance of well integrity;
6) Long term CO_2 monitoring requirements; and
7) Industry's experience.

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There are no specific technological barriers or challenges *per se* in transitioning and converting a pure CO_2-EOR operation into a CO_2 storage operation. The main differences between the two types of operations stem from legal, regulatory and economic differences between the two. While the legal and regulatory framework for CO_2-EOR, where it is practiced, it is well established, the legal and regulatory framework for CO_2 storage is being refined and is still evolving. Nevertheless, it is clear that CO_2 storage operations will likely require more monitoring and reporting 1) of a wider range of parameters, 2) outside the oil reservoir itself, and 3) on a wider area, and for a longer period of time than oil production. Because of this, pure CO_2 storage will impose additional costs on the operator. A challenge for CO_2-EOR operations which may, in the future, convert to CO_2 storage operations is the lack of baseline data for monitoring, besides wellhead and production monitoring, for which there is a wealth of data.

In order to facilitate the transition of a pure CO_2-EOR operation to CO_2 storage, operators and policy makers have to address a series of legal, regulatory and economic issues in the absence of which this transition can not take place. These should include:

1. Clarification of the policy and regulatory framework for CO_2 storage in oil reservoirs, including incidental and transitioned storage CO_2-EOR operations. This framework should take into account the significant differences between CO_2 storage in deep saline aquifers, which has been the focus of regulatory efforts to date, and CO_2 storage in oil and gas reservoirs, with particular attention to the special case of CO_2-EOR operations.
2. Clarification if CO_2-EOR operations transitioning to CO_2 storage operations should be tenured and permitted under mineral/oil & gas legislation or under CO_2 storage legislation.
3. Clarification of any long-term liability for CO_2 storage in CO_2-EOR operations that have transitioned to CO_2 storage, notwithstanding the CO_2 stored during the previous phase of pure CO_2-EOR.
4. Clarification of the monitoring and well status requirements for oil and gas reservoirs, particularly for CO_2-EOR, including baseline conditions for CO_2 storage.
5. Addressing the issue of jurisdictional responsibility for pure CO_2 storage in oil and gas reservoirs, both in regard to national-subnational jurisdiction in federal countries, and to organizational jurisdiction (environment versus development ministries/departments).
6. Examination of the need to assist with the economics, particularly the cost of CO_2 and the infrastructure to bring anthropogenic CO_2 to oil fields.

The Policy Group should take note of these issues and establish ways to address them within CSLF, and make appropriate recommendations to the governments of its members.

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Utilization Options of CO_2

Summary of the Phase 2 Report by the CSLF Task Force on Utilization Options of CO_2

The Phase 2 Report on CO_2 Utilization Options provides a more thorough discussion of the most attractive CO_2 utilization options based upon economic promise and CO_2 reduction potential. This report looks at the current and future economic viability, potential for co-production, and Research, Development and Demonstration (RD&D) needs of these options. The CO_2 Utilization Task Force members selected the following options for further investigation: enhanced gas recovery (CO_2-EGR), shale gas recovery, shale oil recovery, urea production, algal routes to fuels, utilization in greenhouses, aggregate and secondary construction material production, and CO_2-assisted geothermal systems. This work did not include Enhanced Oil Recovery, which is addressed by a separate CSLF Task Force.

As identified in the Phase 1 report, market potential for many of the utilization options is limited (i.e., small, and/or 'niche'), with some exceptions (e.g., enhanced oil recovery – not a subject of this report – or the conversion of CO_2 to fuels or chemicals). However, when taken cumulatively, the sum of these options can provide a number of technological mechanisms to utilize CO_2 in a manner that has potential to provide economic benefits for fossil fuel fired power plants or industrial processes. As such, they may well be a means of supporting the early deployment of carbon capture and storage (CCS) in certain circumstances and accelerating deployment.

One of the key observations from this report is that the potential uses of CO_2 are broad. CO_2 has the potential to be used in the extraction of other energy resources, as a working fluid, and as a chemical feedstock. These applications have some market potential, although the technology maturity varies widely. Some applications, such as urea production, already have an existing global market, while other less mature options, such as algae to fuels have the potential for significant markets and require additional RD&D to address technical challenges and to validate the utilization of CO_2 as an option, reduce the cost and improve the efficiency.

There are a wide range of CO_2 utilization options available, which can serve as an additional mechanism for deployment and commercialization of CCS by providing an economic return for the capture and utilization of CO_2. The results offer several recommendations that can assist with the continued development and deployment of non-EOR CO_2 utilization options in this context.

1. For commercially and technologically mature options such as urea production and utilization in greenhouses, efforts should be on demonstration projects. For urea production, the focus should be on the use of non-traditional feedstocks (such as coal) or 'polygeneration' concepts (such as those based on integrated gasification combined cycle (IGCC) concepts) which can help facilitate CCS deployment by diversifying the product mix and providing a mechanism for return on investment. For utilization in

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greenhouses, new and integrated concepts that can couple surplus and demand for CO_2 as well as energy, thus optimizing the whole energy and economic system, would be valuable.

2. Efforts that are focused on hydrocarbon recovery, such as CO_2 for enhanced gas recovery (via methane displacement), or CO_2 utilization as a fracturing fluid, should focus on field tests to validate existing technologies and capabilities, and to understand the dynamics of CO_2 interactions in the reservoir. R&D efforts on CO_2 as a fracturing fluid should focus on the development of viscosity enhancers that can improve efficiency and optimize the process. Issues such as wellbore construction, monitoring and simulations should leverage those tools and technologies that currently exist in industry or are under development through existing CCS R&D efforts.

3. For algal routes to fuels and aggregate/secondary construction materials (SCM) production, the primary focus should be on R&D activities that address the key techno-economic challenges previously identified for these particular utilization options. Independent tests to verify the performance (less energy requirements with CO_2 utilization to produce SCM and building materials) of these products compared to technical requirements and standards should be conducted. Support of small, pilot-scale tests of first generation technologies and designs could help provide initial data on engineering and process challenges of these options.

4. For CO_2-assisted geothermal systems, more R&D and studies are necessary to address the subsurface impacts of utilizing CO_2 in this application. Additionally, small pilot-scale tests could provide some initial data on actual operational impacts and key engineering challenges that need to be addressed.

5. Finally, more detailed technical, economic, and environmental analyses should be conducted to better quantify the potential impacts and economic potential of these technologies and to clarify how R&D could potentially expand the market for these utilization options (e.g., in enhanced gas recovery) and improve the economic and environmental performance of the system. A holistic approach, not only taking a one-dimensional technocratic perspective, is important.

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GLOBAL CCS INSTITUTE

STATUS AND BENEFITS OF INTERNATIONAL CCS NETWORKS

BACKGROUND PAPER FOR THE 5TH CSLF MINISTERIAL

NOVEMBER, 2013

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It is widely acknowledged that knowledge sharing on a global basis will be critical in facilitating the widespread deployment of carbon capture and storage (CCS) as a climate change mitigation technology. The need for international knowledge sharing is even more crucial in the current economic environment, which has resulted in fewer large scale CCS projects in operation than originally anticipated.

Current Status of CCS Knowledge Sharing

Knowledge sharing in CCS is taking place globally through topic-specific workshops, seminars/webinars, conferences and in particular, via networks. A number of knowledge sharing networks exist around the world, covering both project and non-project contexts (such as policy, regulatory, storage, etc.). The Global CCS Institute assists many of these networks; examples include:

- European CCS Demonstration Project Network - a network of European CCS demonstration projects, all of which are aiming to be operational by 2015. The goal is to create a prominent community of projects united in the goal of achieving commercially viable CCS by 2020. The Institute, together with consortium partners TNO, IFP and SINTEF, provides secretariat and knowledge dissemination services for the network.
- Japanese Knowledge Network – an Institute-funded network that involves over 20 organisations sharing knowledge on topics such as how to communicate technical details of CCS to non-technical audiences and the correlation between CCS and seismicity.
- Bastor2 – the Bastor2 (Baltic Storage of CO2) project is intended to run over two years and will collect information from prior geological surveys and develop models in order to assess the conditions and capacities for storage.
- CCS Costs Network – develops methodologies and tools for CCS cost studies across the CCS supply chain. The Institute participates in the sharing of lessons learned and analysis with the network.
- International Carbon Capture and Storage Test Centre Network - Sharing of knowledge from CCS test facilities around the world to accelerate commercialisation.
- International CCS Regulatory Network – organised by the International Energy Agency to provide a neutral forum for CCS regulators, policy makers and stakeholders to discuss and share updates and views on CCS regulatory developments

Many other knowledge networks exist around the world covering the lifecycle of research to commercial deployment. Some are highly formalised such as the European CCS Demonstration Project Network while others tend to better classified as communities of practice.

International Knowledge Sharing is Happening

As is shown above, many CCS knowledge networks have a country or regional focus. Designing knowledge networks – groups of experts that often engage in a private way – is a challenging process. If not designed or managed properly, little tends to be achieved. Done at an international level this is even more complex because the barriers to sharing are more significant and the incentives fewer.

That said, there is a significant amount of international knowledge sharing happening in CCS, primarily oriented around public content. The Global CCS Institute, for example, shares detailed knowledge from many projects and policy initiatives around the globe, undertakes a sophisticated annual survey of over 100 projects and has a mature knowledge sharing framework of systems, policies and procedures. Project presentations have had thousands of visitors to online webinars to complement private events.

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This open model allows participants to use non-confidential, public information in order to stimulate more private detailed discussion amongst CCS practitioners. Participants get together for face-to-face working groups (and webinars and video-conferences) based on their expertise. In these private settings which are more conducive to establishing relationships and trust, participants become more comfortable with sharing private knowledge.

Recommendations to Improve International Knowledge Sharing

There are several opportunities to improve the effectiveness and efficiency of existing international knowledge sharing practices in the CCS space. This includes improved knowledge sharing through events, more targeted dissemination of information, reuse of digital capabilities and better engagement with experts outside the CCS community. Below are features of successful international knowledge sharing and the principles that should be followed to enhance the prospects of success for existing and new knowledge networks.

Clear outcomes

- Focus the network on solving problems in a collaborative way. Analysis and problem solving should be the focus of the network, not data collection.
- Clearly identify knowledge gaps and low-level areas of focus. Upfront planning should take a greater focus so that the correct people are brought into the knowledge sharing process and existing information is more properly re-used.

Practical approaches to information sharing

- Remove the focus on sharing confidential information (CI). Documenting and sharing of CI inherently goes against how most organisations will want to operate, especially in an international context. Without financial carrots or regulatory sticks, there are few incentives to share information at this level and MOU-style agreements won't be strong enough. Many of the key problems being faced by projects can be addressed without the detailed documenting of confidential information.
- Better leverage the large amounts of public information already available. There is a significant amount of publicly available information provided by organisations like the Global CCS Institute. High quality, public information can provide the foundation for getting participants together to collaborate on more sensitive issues in private.

Digital technology for better connectivity

- Use advanced digital technologies for international knowledge sharing. This is absolutely critical as meeting face-to-face is often neither practical nor cost-effective. This should include public knowledge sharing as well as webinars, video-conferencing and private collaboration. The goal should be, as best as possible, to simulate a face-to-face experience through information technology as a "place between" events.
- Leverage existing digital platforms and systems. Utilising established knowledge sharing technologies such as those provided by the Global CCS Institute can support individual initiatives in a global knowledge network to the point where they would not need any additional IT capabilities for knowledge sharing. In addition, knowledge networks can still maintain their own distinct online "brand". This is already being done for a number of networks and the Institute will be taking this approach in assisting the CSLF.

Financial sustainability

- The network should be funded through a financially sustainable model. Through common digital technologies and a decreased focus on confidential information the costs for running international knowledge sharing can be minimized, which is important for long-term sustainability.

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Engagement outside the CCS community

- Some content from the network should be written for an external audience. Better advocacy for CCS is a critical aspect of taking it forward. Network reports are often written for an "internal" audience even if they are made available to the public. Creating versions of network papers that have an advocacy goal in mind should be a key feature of any network.
- Promoting key content to non-CCS practitioners should be a key priority. Publishing high-quality materials online and engaging with the right audience groups can have significant advocacy benefits in better positioning CCS as a key solution for decarbonisation.

Finally, there is a need to take a greater focus of knowledge sharing on "promising CCS markets" by improving engagement with countries that are less mature in their CCS implementation programmes. Japan, for example, does not have any large-scale CCS projects but has very considerable expertise, many leading companies and an effective existing knowledge sharing network that is already sharing valuable materials internationally. Accelerating the inclusion of Chinese expertise into international networks could also be greatly beneficial, given the importance of that country for the future deployment of CCS. Following the principles above could facilitate the ability to advanced knowledge sharing with these countries and with others around the world.

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Carbon Sequestration Leadership Forum

www.cslforum.org

CHARTER FOR THE CARBON SEQUESTRATION LEADERSHIP FORUM (CSLF)
A CARBON CAPTURE AND STORAGE TECHNOLOGY INITIATIVE

The undersigned national governmental entities (collectively the "Members") set forth the following revised Terms of Reference for the Carbon Sequestration Leadership Forum (CSLF), a framework for international cooperation in research, development demonstration and commercialization for the separation, capture, transportation, utilization and storage of carbon dioxide. The CSLF seeks to realize the promise of carbon capture utilization and storage (CCUS) over the coming decades, ensuring it to be commercially competitive and environmentally safe.

1. Purpose of the CSLF

To accelerate the research, development, demonstration, and commercial deployment of improved cost-effective technologies for the separation and capture of carbon dioxide for its transport and long-term safe storage or utilization; to make these technologies broadly available internationally; and to identify and address wider issues relating to CCUS. This could include promoting the appropriate technical, political, economic and regulatory environments for the research, development, demonstration, and commercial deployment of such technology.

2. Function of the CSLF

The CSLF seeks to:

2.1 Identify key obstacles to achieving improved technological capacity;

2.2 Identify potential areas of multilateral collaborations on carbon separation, capture, utilization, transport and storage technologies;

2.3 Foster collaborative research, development, and demonstration (RD&D) projects reflecting Members' priorities;

2.4 Identify potential issues relating to the treatment of intellectual property;

2.5 Establish guidelines for the collaborations and reporting of their results;

2.6 Assess regularly the progress of collaborative RD&D projects and make recommendations on the direction of such projects;

2.7 Establish and regularly assess an inventory of the potential RD&D needs and gaps;

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2.8 Organize collaboration with the international stakeholder community, including industry, academia, financial institutions, government and non-government organizations; the CSLF is also intended to complement ongoing international cooperation;

2.9 Disseminate information and foster knowledge-sharing, in particular among members' demonstration projects;

2.10 Build the capacity of Members;

2.11 Conduct such other activities to advance achievement of the CSLF's purpose as the Members may determine;

2.12 Consult with and consider the views and needs of stakeholders in the activities of the CSLF;

2.13 Initiate and support international efforts to explain the value of CCUS, and address issues of public acceptance, legal and market frameworks and promote broad-based adoption of CCUS; and

2.14 Support international efforts to promote RD&D and capacity building projects in developing countries.

3. Organization of the CSLF

3.1 A Policy Group and a Technical Group oversee the management of the CSLF. Unless otherwise determined by consensus of the Members, each Member will make up to two appointments to the Policy Group and up to two appointments to the Technical Group.

3.2 The CSLF operates in a transparent manner. CSLF meetings are open to stakeholders who register for the meeting.

3.3 The Policy Group governs the overall framework and policies of the CSLF, periodically reviews the program of collaborative projects, and provides direction to the Secretariat. The Group should meet at least once a year, at times and places to be determined by its appointed representatives. All decisions of the Group will be made by consensus of the Members.

3.4 The Technical Group reports to the Policy Group. The Technical Group meets as often as necessary to review the progress of collaborative projects, identify promising directions for the research, and make recommendations to the Policy Group on needed actions.

3.5 The CSLF meets at such times and places as determined by the Policy Group. The Technical Group and Task Forces will meet at times that they decide in coordination with the Secretariat.

3.6 The principal coordinator of the CSLF's communications and activities is the CSLF Secretariat. The Secretariat: (1) organizes the meetings of the CSLF and its sub-groups, (2) arranges special activities such as teleconferences and workshops, (3) receives and forwards new membership requests to the Policy Group, (4)

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coordinates communications with regard to CSLF activities and their status, (5) acts as a clearing house of information for the CSLF, (6) maintains procedures for key functions that are approved by the Policy Group, and (7) performs such other tasks as the Policy Group directs. The focus of the Secretariat is administrative. The Secretariat does not act on matters of substance except as specifically instructed by the Policy Group.

3.7 The Secretariat may, as required, use the services of personnel employed by the Members and made available to the Secretariat. Unless otherwise provided in writing, such personnel are remunerated by their respective employers and will remain subject to their employers' conditions of employment.

3.8 The U.S. Department of Energy acts as the CSLF Secretariat unless otherwise decided by consensus of the Members.

3.9 Each Member individually determines the nature of its participation in the CSLF activities.

4 Membership

4.1 This Charter, which is administrative in nature, does not create any legally binding obligations between or among its Members. Each Member should conduct the activities contemplated by this Charter in accordance with the laws under which it operates and the international instruments to which its government is a party.

4.2 The CSLF is open to other national governmental entities and its membership will be decided by the Policy Group.

4.3 Technical and other experts from within and without CSLF Member organizations may participate in RD&D projects conducted under the auspices of the CSLF. These projects may be initiated either by the Policy Group or the Technical Group.

5 Funding

Unless otherwise determined by the Members, any costs arising from the activities contemplated by this Charter are to be borne by the Member that incurs them. Each Member's participation in CSLF activities is subject to the availability of funds, personnel and other resources.

6 Open Research and Intellectual Property

6.1 To the extent practicable, the RD&D fostered by the CSLF should be open and nonproprietary.

6.2 The protection and allocation of intellectual property, and the treatment of proprietary information, generated in RD&D collaborations under CSLF auspices should be defined by written implementing arrangements between the participants therein.

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7. Commencement, Modification, Withdrawal, and Discontinuation

7.1 Commencement and Modification

7.1.1 Activities under this Charter may commence on June 25, 2003. The Members may, by unanimous consent, discontinue activities under this Charter by written arrangement at any time.

7.1.2 This Charter may be modified in writing at any time by unanimous consent of all Members.

7.2 Withdrawal and Discontinuation

A Member may withdraw from membership in the CSLF by giving 90 days advance written notice to the Secretariat.

8. Counterparts

This Charter may be signed in counterpart.