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Good morning and thank you for inviting me to testify today. I am Sarah Forbes and I lead the CO_2 Capture and Storage (CCS) work at the World Resources Institute. The World Resources Institute is a non-profit, non-partisan environmental think tank that goes beyond research to provide practical solutions to the world's most urgent environment and development challenges. We work in partnership with scientists, businesses, governments, and non-governmental organizations in more than seventy countries to provide information, tools and analysis to address problems like climate change, and the degradation of ecosystems and their capacity to provide for human well-being.

The World Resources Institute (WRI) has taken a lead in exploring the challenges, opportunities and state of technical knowledge in the field of carbon capture and storage. We convened a two year stakeholder process which resulted in the *Guidelines for Carbon Dioxide Capture, Transport, and Storage* (http://www.wri.org/publication/ccs-guidelines) published in November 2008 which can serve as a benchmark for decision-makers to use in evaluating potential projects. In developing the *Guidelines*, WRI brought together a diverse group of more than 80 technical experts including government officials, NGOs, academics and businesses.

Coal use is responsible for over 40 percent of global carbon dioxide emissions.[1] Without significant, deliberate action to reduce these emissions we cannot address climate change. Carbon capture and storage is one of a number of critical technologies coal-burning nations will need to consider and deploy in the coming decades. International collaboration will be essential to moving CCS technology to scale – reducing costs and securing a global response to the climate challenge. In the next five years, we must move from demonstration to deployment.

In this testimony, I will provide an update on some of the key international collaborations on CCS already underway, and offer some ideas for future direction. I would like to make three key points, each of which I will expand on below.

[1] Energy Information Administration. International Energy Outlook, 2008. Figure 76. http://www.eia.doe.gov/oiaf/ieo/emissions.html

First, I will describe the urgent need for a global network of CCS demonstrations that includes joint technology development along with collaboration on resolving investment, regulatory, legal and social barriers to CCS deployment.

Second, I will talk specifically about collaboration on CCS with one country—China. I will describe the efforts many countries and businesses are taking to ensure that at least one of the global CCS demonstrations is in China.

Third, I will describe a few of the major international CCS collaborations that are underway and offer suggestions for how these efforts may best complement each other as the technology is demonstrated worldwide.

I will conclude by providing some concrete suggestions for near-term actions that can be taken to enhance collaborations with China and facilitate global deployment of CCS technology.

1. Develop a Global Network of CCS Demonstrations

In technology development there is a period known as the "valley of death" where a technology has been proven in the laboratory and at a small scale but has yet to move from a research effort to commercialization. CCS technology has progressed quickly from an idea to a key part in proposed climate change mitigation plans. This progression is partly thanks to the early successes seen in the pilot capture demonstrations and research and commercial projects where CO_2 has been injected at rates up to a million tons per year. Moving the technology forward into commercialization will require integrated capture and storage demonstration at power-plant scale. A key finding of the *Guidelines for Carbon Dioxide Capture, Transport, and Storage* (http://www.wri.org/publication/ccs-guidelines) was that even though additional research is needed in some areas, there is adequate technical understanding to safely conduct large-scale demonstrations. In fact, many of the remaining questions about CCS technology can only be answered by additional experience with the technology or policy interventions.

Most experts agree that we need between 15 and 20 demonstrations of differing capture and storage configurations globally. Last July, the G8 set a goal of 20 demonstrations announced by 2010.[2] The U.S Climate Action Partnership, of which WRI is a member, (USCAP)[3] further recommends building at least five projects of CCS enabled coal fueled facilities in the United States by 2015 (see www.US-CAP.org).

Achieving these goals in the right time frame is critical to deal with the looming climate challenge but at the same time will require significant investment. There is a need for establishing a clear and robust international financing mechanism to fund these projects globally. It will also require substantial (but not insurmountable) progress on addressing lingering regulatory, investment, legal, and social issues. The global development of

[2] http://www.enecho.meti.go.jp/topics/g8/g8sta_eng.pdf
[3] http://www.us-cap.org/blueprint/index.asp

environmental regulatory frameworks for CCS, is testament to our readiness to demonstrate the technology. In 2008, regulatory frameworks for CCS were released at the state and federal level in the U.S. [4,5] and Australia[6] and a Directive for CCS, which included environmental regulations, was passed at the European Union[7] level. Global progression towards a common understanding of how to safely implement the technology seems within reach.

This effort of building a global network of CCS demonstrations will require a significant investment and commitment of resources, along with coordination and support from senior government representatives. However, through strong international collaboration each country need not demonstrate the full suite of capture and storage options. For example, when the UK first announced their plans to move forward with a post-combustion CCS demonstration, it was described as being complimentary to the U.S. FutureGen project which was at that time planning to demonstrate at-scale capture with an Integrated Gasification Combined Cycle (IGCC) plant.[8] The collective group of global demonstrations should include the full suite of different capture configurations and test storage in a variety of geologic settings.

To address this need, Congress can commit funding for public-private partnership demonstration projects in the U.S. and formally participate in international demonstration efforts. CCS demonstrations will require billions in research funding with estimates at about $1-1.5 billion per project. Funding allocated in the American Recovery and Reinvestment Act of 2009 is important, but still falls short of what will be needed to commercialize CCS technology. A robust funding mechanism and clear plan for collaboration among demonstration projects is critical. One example of such a plan was recently approved by the European Union with funding for demonstrations coming from the proceeds the European Trading Scheme (ETS) and coordination among projects required.[9] The global CCS demonstration network should include collaborative work on not only technology development, but also information-sharing on legal, social and regulatory issues.

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[4] Washington State finalized their regulations in June 2008. http://www.ecy.wa.gov/news/2008news/2008-180.html

[5] U.S. EPA's proposed rule was released in July 2008 http://www.epa.gov/safewater/uic/pdfs/prefr_uic_co2rule.pdf

[6] http://www.environment.gov.au/settlements/industry/ccs/publications/environmental-guidelines.html and http://www.environment.gov.au/settlements/industry/ccs/publications/ccs-propertyrights.html

[7] http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P6-TA-2008-0612+0+DOC+XML+V0//EN&language=EN and http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/08/798&format=HTML&aged=0&language=EN&guiLanguage=en

[8] Presentation given at the 2007 Regional Carbon Sequestration Partnerships Annual Review Meeting http://www.netl.doe.gov/publications/proceedings/07/rcsp/pdfs/Graves%20UK%20CCS%20Activity%20December%202007%20-%20IRG.pdf

[9] The EU recently adopted a legal framework for CCS and also provided funding mechanisms through auction allowances and the EU stimulus recovery package http://www.scotland.gov.uk/Resource/Doc/917/0077923.ppt#303,8,EU Emission Trading System

2. Enhance Capacity for CCS Demonstration in China

According to the Energy Information Administration, China's coal-related carbon dioxide emissions may grow to 51 percent of the world's total by 2030.[10] With 20 percent of the world's population, China has 14 percent of the world's coal reserves, but less than one percent of the world's oil and gas reserves. While China is actively developing its non-carbon power sources—hydropower, nuclear, and newer alternative energies—rapid growth will still not be enough to replace coal as a core part of its expanding electricity infrastructure. Deployment of CCS in China may be the only way to globally make the needed reductions in carbon dioxide emissions.

China is conducting research and quickly moving towards developing and demonstrating CCS technologies. In fact, the Chinese government was among the foreign governments who had pledged to commit funding for the original FutureGen project.[11] Chinese companies and government institutions are undertaking a CCS research themselves and with a number of international partners. For example:

- The Chinese power industry has several projects focusing on coal gasification. The largest, GreenGen, sponsored by China's five largest power companies, will build a 200 MW integrated gasification combined cycle power plant in the city of Tianjin. Phases two and three of this project plan for CCS in nearby depleted oil fields, with injection planned before 2020. U.S. Peabody Energy is the one international equity partner in this effort.
- China has two major efforts with European collaborators, the UK-China Near Zero Emissions Coal Project[12] (NZEC) and the **CO**operation **A**ction within CCS **CH**ina-EU[13] (COACH) Project. Both have done a great deal of preparatory and conceptual work on CCS.
- China's Huaneng group built a small carbon capture demonstration plant at Gaobeidian in Beijing with assistance from Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO.) Discussions about a second phase are in process.
- Both PetroChina, China's largest oil company, and Shenhua, its largest coal company, have pilot CCS programs.

There is also a realization in China that robust policies and regulations will be needed to ensure that CCS projects are done responsibly. Tsinghua University has partnered with WRI to draft a set of *Guidelines for Safe and Effective CCS in China*. The effort is modeled after the stakeholder process led by WRI in the U.S. where a diverse set of stakeholders together developed a comprehensive set of guidelines for CCS projects (http://www.wri.org/publication/ccs-guidelines). Development of a *Guidelines* document

[10] Energy Information Administration. International Energy Outlook 2008. http://www.eia.doe.gov/oiaf/ieo/emissions.html

[11] China, India, Australia, Japan and South Korea pledged funding for FutureGen http://www.futuregenalliance.org/costs.stm

[12] http://www.nzec.info/en/

[13] http://www.co2-coach.com/

that is available in Chinese for potential project operators, financers, insurers, and legal experts to as a tool in understanding how to conduct CCS projects responsibly will facilitate demonstration of the technology in China. To enable this effort, Tsinghua University and WRI have assembled a steering committee that includes leading CCS experts from China and the United States. The Chinese members of the steering committee recently traveled to the United States and toured some of the leading CCS research institutions (including the injection well being drilled in Illinois). This effort is being funded with support from the U.S. Department of State under the Asia Pacific Partnership.[14]

It would be to the benefit of both the U.S. and China if there were more direct collaboration on CCS demonstrations. Not only would working together solve technical problems faster, but given the rate at which Chinese companies are moving, the learning would hardly be one way. Jointly-funded and operated demonstrations, that include Government funding combined with private-sector investment is an essential next step. This will require a serious funding commitment as well as programs that facilitate information sharing on regulatory and policy issues and support for U.S. businesses working internationally.

Examples of programs that would help build increased capacity for CCS in China or other emerging economies include research exchange programs to bring students and faculty from China to see projects operating in the U.S. and study with leading researchers. An effective near-term approach would be to establish a research exchange program for visits to ongoing demonstrations in the U.S. including the Department of Energy's Regional Sequestration Partnership Phase III projects. Exchange programs for environmental regulators and policy experts may also prove useful in resolving the legal, regulatory, and social challenges of deploying CCS technology. The Department of State in collaboration with the Department of Energy has implemented successful exchange programs in the past which could be replicated with a focus on CCS technology and policy.

3. Key International CCS Collaborations Underway

There are several high-level international CCS efforts underway, along with numerous individual projects like the WRI-Tsinghua University effort I just described. Each of these efforts can play an important role in the development of the technology. Key to successful integration of these efforts will be clarifying the niche each effort is designed to fill, eliminating redundancies, and designing a path for collaboration.

I would like to highlight three key CCS-specific initiatives already underway:

1. The Carbon Sequestration Leadership Forum[15] (CSLF) is a Ministerial-level effort initiated by the U.S. Department of Energy. It has been in place since 2003 and has been influential in collaborations among governments.

[14] http://www.asiapacificpartnership.org/
[15] http://www.cslforum.org/

2. Australia has recently initiated a Global CCS Institute,[16] for which the Prime Minister has allocated $100M per year for the next 10 years. This institute is designed to focus specifically on collaboration surrounding demonstration projects.
3. The International Energy Agency[17] (IEA) coordinates international research through the IEA GHG Program. IEA Secretariat is also developing an international roadmap for CCS at the request of the G-8. This roadmap is designed to answer the question of whether and how we can achieve the goal of 20 CCS demonstrations announced globally by 2010 and will provide recommendations for better coordination among international collaborations.

As the technology progresses from R&D towards demonstration, these international efforts can provide an avenue for information-sharing at various levels: the CSLF at the ministerial-level, the IEA among government energy departments, and the Global Institute among those running demonstration projects. It is time to evaluate the existing programs in the context of an emerging suite of global demonstration projects and to form formal partnerships with others perusing demonstrations (UK, EU, China, Canada, Australia). Congress might consider commissioning a formal report on international CCS efforts and use the results of it along with the IEA's International CCS Roadmap (expected publication date October 2009)[18] to clarify and formalize the role of the various international CCS organizations that have emerged. Additionally, although the U.S. Department of Energy's Regional Partnership Program has been acknowledged as the "world's most ambitious program"[19] the work is largely unknown in the international community, in part because it is difficult for researchers to receive approval to travel internationally on their government grants. A scholarship program for U.S. researchers working on government-funded projects to attend international CCS meetings and present the results of their research may be useful in better communicating the results of leading U.S. research in this area. Such a merit-based program could be managed through the Department of Energy. Formal arrangements to partner with other countries on demonstrations must be established soon.

Conclusions

Unless we act now to aggressively begin to implement a global CCS demonstration program, we will lock in untold additional quantities of CO_2 emissions from non-CCS, coal-fired power plants around the world. Globally, CCS R&D has progressed to the point of demonstration-readiness and there is a race underway to see who will build the world's first large-scale integrated demonstration of capture, transport, and storage along with power production. The global nature of climate change and the urgent need to act now to avoid locking in a high emissions trajectory for the future necessitates increased and coordinated international collaborations. We need to specifically partner with emerging economies on demonstrating CCS technology, through joint public-private

[16] http://www.pm.gov.au/media/Release/2008/media_release_0484.cfm
[17] http://www.iea.org/Textbase/subjectqueries/cdcs.asp
[18] http://www.iea.org/textbase/subjectqueries/ccs/ccs_roadmap.asp
[19] http://www.netl.doe.gov/publications/press/2008/08019-IEA_Finds_US_CCS_Plans_Ambitious.html

partnerships. In these international collaborations we must seek ways to build capacity and support efforts to develop global policies and environmental regulations that protect human health and ecosystems. This will include coordination and collaboration on demonstrations that begins in the planning stages along with projects that build capacity on regulatory and policy issues (like the WRI-Tsinghua APP project).

In my testimony, I have mentioned five specific actions to consider that will help facilitate international collaboration on CCS, which are summarized here:

1. Commit funding for demonstration projects in the U.S. and in China that are geared towards joint technology development; such projects should be public-private partnerships. The global network of demonstrations should include the full suite of capture technology approaches and test storage in a variety of geologic settings.
2. Develop a framework and funding for research exchange programs to bring researchers from other countries to see projects operating in the U.S. and study with leading researchers. The Department of State in collaboration with the Department of Energy has implemented successful exchange programs in the past which could be replicated with a focus on CCS technology and policy.
3. Increase bi-lateral efforts to facilitate capacity building and information sharing on regulatory and policy issues.
4. Establish formal partnerships with other countries developing CCS demonstration projects (UK, EU, China, and Australia) to facilitate information-sharing and avoid duplication among demonstration efforts. Also, commission a formal report on international CCS efforts and use the results of it and the IEA CCS Roadmap to clarify and formalize the role of the various international CCS organizations that have emerged.
5. Develop a scholarship program for U.S. researchers working on government-funded projects to attend international CCS meetings and present the results of their research. Such a merit-based program could be managed through the Department of Energy.