Summary of Assessments on Carbon Capture and Storage

The approach to carbon capture and storage (CCS) that is being followed in the United States is largely focused on pilot/demonstration projects that propose to capture and store relatively small portions of CO_2 emissions from new advanced coal-fired power plants, and to store those emissions on-site. These are inherently expensive per unit of carbon captured and often lack the potential for scale up that would ensure commercial deployment.

In the summer of 2008, the Commonwealth, led by the Department of Conservation and Natural Resources (DCNR) partnered with the Clinton Climate Initiative (CCI) to assess the technical and economic viability of an integrated "early mover" CCS network of retrofitted coal-fired power plants within Pennsylvania that would be connected to a CO_2 pipeline and a centralized geologic storage facility. The concept is intended to get CCS to scale faster than planned by other state and Federal efforts by capturing both economies of scale through the use of shared infrastructure and the economic development benefits that would accrue to a state in a leadership role in deploying CCS.

In October, 2008, Governor Rendell signed into law Act 129, which required DCNR to assess the following in connection with establishing such a network:

- a study to identify suitable geological formations for storage of CO_2
- assessments of costs, potential risks, existing federal/state regulatory standards, and the types of insurance, bonds, other instruments needed for such a network.

The geologic assessment was submitted to the Governor and the House and Senate Environmental Resource and Energy Committees on May 1, 2009. The risk assessment and CCI reports were submitted on November 1, 2009. These assessments collectively point to three key conclusions:

1. An integrated, at-scale CCS network would be cost competitive compared to both proposed and existing international CCS projects.

2. A CCS network can be developed safely.

3. Pennsylvania possesses significant geologic resources that could be used to store CO_2 emissions and support a CCS network; however CCS cannot be deployed at scale in the Commonwealth now or in the foreseeable future because ownership of adequate pore space cannot be assembled.

Each conclusion is discussed further below.

An integrated, at-scale CCS network would be competitive compared to both proposed and existing international CCS projects.

The per ton cost estimates for capture, compression, transport, and storage associated with the Commonwealth's integrated network approach are among the lowest estimates for CCS anywhere in the world, strongly supporting the concept that capturing economies of scale can drive early deployment of CCS technology that is available today.

The CCI report focuses on the retrofit of six coal-fired power plants in central and southwest Pennsylvania. Later phases of a CCS network would involve the integration of additional power plants, industrial facilities, and new-build generation and the creation of transport and storage facilities.

The initial assessment indicates that the costs of the capture and transport components of a Pennsylvania CCS network would be competitive with both proposed and existing international CCS projects. The estimated capital and operating requirements for a 6-plant network and pipeline system are as follows:

Total Capital Expense for Phase 1 of an Early-User Network (+/- 40% accuracy)

- Capture + compression: **$6,900 m**
- Transport + storage (pipeline to central collection point): **$1,200 m**

Annual operating expense for Phase 1 of an Early-User Network (+/- 40% accuracy)

- Capture + compression: **$260 m**
- Transport + storage: **$9 m**

Even at total network capital costs exceeding $8 billion and annual operating costs of $269 million, preliminary cost and technical analysis leads to a range in total capture and compression costs of $43 - $69/ton, depending on the technology utilized. The costs of transport and storage infrastructure range from $3.3 - $4.2/ton. These per ton costs are at the low-end range of published reports of the estimated cost of CCS.

A CCS network can be developed safely in Pennsylvania.

CCS has well-understood and quantifiable risks that are currently addressed by the insurance market, with the exception of long term liability of a storage site after closure. Favorable geologic conditions exist for CCS network in Pennsylvania. With proper site selection, analysis, and monitoring, risks can be managed.

The capture of CO_2 from power plants and associated risks are fairly well understood. The risk to the public from capture will be minimized as capture will likely be done on the power plant property.

Transport of captured CO_2 will likely occur in a network of pipelines. The 37-year history of CO_2 pipelines in the US has shown that this gas can be transported safely. Pennsylvania currently possesses an extensive pipeline network for natural gas and refined petroleum products, but as of yet, not for CO_2.

Determination of storage risk is highly dependent on the site specific conditions, but protocols for site selection monitoring have been developed by various Federal and international agencies and are being refined.

Liability coverage will likely be available through the design, construction, and injection phases of a CCS project. Long-term liability will probably require a governmental presence for indemnifying and absorbing such risk.

Creation of a sound, coordinated and predictable regulatory mechanism is essential to manage the risks of GS. The report surveys potential policy solutions.

The risk assessment report concludes that a CCS network can be achieved successfully and safely in the Commonwealth. However, additional data and information are needed to further refine this conclusion.

Pennsylvania possesses significant geologic resources that could be used to store CO_2 emissions and support a CCS network; however, CCS cannot be deployed at scale in the Commonwealth now or in the foreseeable future because ownership of adequate pore space cannot be assembled.

Pennsylvania has an estimated geologic capacity to store hundreds of years' worth of carbon emissions at present rates. The geology of Pennsylvania (subject to the adequacy of storage rights and detailed study and analysis to be performed at each prospective sequestration site) can support the development of a geologic sequestration network.

The fundamental barrier to the deployment of CCS on-shore[1] in the United States, apart from a yet-to-be-developed permitting/regulatory structure, is that geologic sequestration requires control of pore space, which may be difficult or impossible to assemble absent Federal carbon caps and Federal or state enabling legislation.

Property rights ownership in the Commonwealth is highly fragmented in much of the state. CCS storage at power plant scale requires some business entity to have extensive control of pore space. Indeed, the rule of thumb used by the US Department of Energy is that one 500 megawatt power plant that captures 90% of its CO_2 emissions over a 40-year operational life and that is injecting captured CO_2 emissions into a 300-foot thick geologic storage formation will require 100 square miles of pore space. Ownership of that pore space must be acquired if it is not already owned by an appropriate business entity. Assembling storage rights on that scale is a fundamental and perhaps insurmountable barrier to the successful deployment of at-scale CCS on-shore in the United States in the absence of Federal carbon caps and enabling legislation.

[1] Much of the CCS work in Europe is directed at storage in depleted gas fields and other formations off-shore, e.g. under the North Sea. There is emerging interest in identifying potential geologic sequestration off the coasts of the United States.

Conclusions

Given the above, the Commonwealth's interest in CCS can be pursued by networks of Pennsylvania power plants finding linkages to offshore CCS projects currently in development, by continuing to look at technologies that find other ways to store or use carbon, such as enhanced oil or gas recovery, and by engaging in an effort to propel development of federal policy/legislation to address the pore space/property rights issue.

In the future, the possibility of storing CO_2 in deep shales (e.g. Marcellus shale once depleted of natural gas) should be pursued, as significant property right are already being assembled by industry.