

## Carbon capture and storage in central Appalachia - feasibility, costs and regulatory impact

### ABSTRACT

In an ever increasing “carbon” society; our awareness, management and growth will be measured by our carbon footprint (or output of Greenhouse Gas (GHG) emissions). As power producers fight the battle between electrical demand vs. carbon reduction, one of the essential tools will be capture and storage (e.g. sequestration) of carbon dioxide.

Standardization of the regulatory framework for Carbon Capture & Storage (CCS) will be key to any success in the “Sequestration” realm. Present progress and an overview of the US Department of Energy’s (DOE) Southeastern Carbon Sequestration Partnership’s (SECARB) Virginia Coal Carbon Sequestration project will be shared. Implementation, economic, risk & liability issues will be discussed.

### 1. INTRODUCTION

Apart from the technical feasibility of Carbon Dioxide Capture (or Sequestration) and Storage (CCS), there remain complex regulatory and public perception issues to overcome before CCS will be accepted and therefore used by industries and markets. This paper reviews the current standards, codes and regulation framework in the U.S. and Canada as well as the potential NIMBY (e.g. Not In My Back Yard) issues and newly defined NUMBY issues (e.g. Not UNDER My Back Yard) raised by CCS as well as the potential risks associated with CCS.

### 2. CARBON CAPTURE & STORAGE

#### 2.1 Overview

Carbon Capture and Storage (or Sequestration) “CCS” is the term now commonly applied to describe the processes whereby carbon dioxide (CO<sub>2</sub>) is captured during the combustion of coal, compressed and converted to a supercritical fluid, and stored in deep geologic formations via injection wells. Regional geology may allow for multiple horizons to be used in a “stacked” array to increase storage capacity in a given region. Increasing the storage capacity in a given area will allow for the reduction of transportation issues typically addressed via pipeline infrastructure (Fig. 1).

CCS is not new, at least not geologically speaking. The Intergovernmental Panel on Climate Change has noted that CO<sub>2</sub> has been naturally trapped in geologic formations for hundreds of millions of years, including CO<sub>2</sub> that has been held under the Pisgah Anticline in Louisiana and Mississippi for more than 65 million years. The DOE and International Energy Agency estimates that the U.S. has over 3,000 gigatons of CO<sub>2</sub> sequestration potential; which is equal to the emissions of approximately 1,000 coal-fired power plants for 1,000 years.

Similarly, oil producers in Texas and other oil producing states have been injecting CO<sub>2</sub> for purposes of Enhanced Oil Recovery (EOR) for decades. This process has been and is regulated and permitted by the EPA and delegated state agencies under the Safe Drinking Water Act’s Underground Injection Control (UIC) program. The U.S. regulatory framework is generally speaking a two-piece puzzle: GHG Reporting via EPA Mandatory Reporting Rule (MRR) and

## CCS: Source to Sink

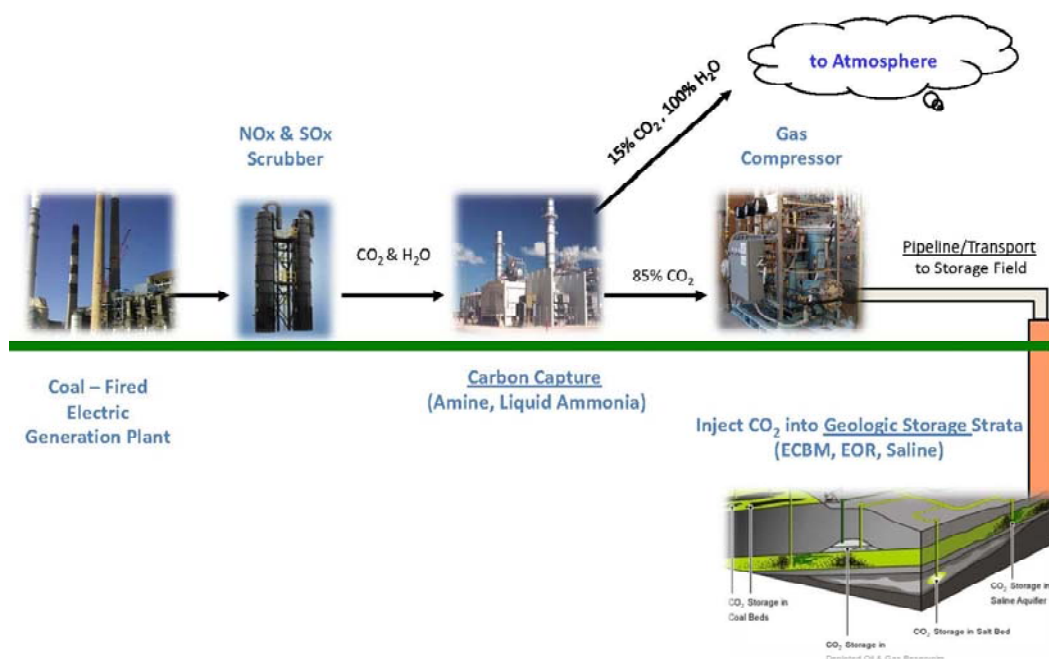


Figure 1: Typical Carbon Capture and Storage.

some anticipated form of Carbon Cap & Trade via Waxman-Markey Bill “American Clean Energy & Security Act of 2009”.

The real confusion within the U.S. framework falls in the Voluntary vs. Regulated debate. Presently, there are no mandatory requirements for carbon sequestration. With that being said however, most electric regulating bodies in the U.S. are requiring all new applications to “address” the carbon question of what to do with carbon emissions, while not specifying how - e.g. lack of regulation.

The fear or reluctance in the marketplace for industrial investment is the lack of clear direction. “Does my carbon project fall under...”

- CAR – CMM Protocol development.
- CDM’s within IPCC or UNFCCC.
- REC’s – RGGI vs. States (27 presently have some form of Renewable Energy Credit program).
- Carbon Credits: CCX vs. Over.
- ANSI vs. CSA -America for ISO 14064-14066.

The myriad of choices, and more importantly a lack of “enforcement” by virtue of the present voluntary status, makes it very difficult to encourage private, commercial investment from

the affected industrial markets.

Contrary to U.S. policy, the international community in general is a one piece puzzle; relying on the Kyoto Protocol and the International Organization for Standardization (ISO) for guidance. Additionally, as most countries are signatory to the Kyoto Protocol, a singular approach is at least an option.

### 2.2 The Need for Standardization

Standardization is critical for success. It allows all parties equal access. It encourages interaction and is required for Key Nations to become/remain engaged. This is specifically true relative to the Kyoto Protocol, where the U.S. is not presently an option for participation, and therefore absent from most international trading schemes.

Regardless of Market (GHG, CCSS, Clean Energy) standardization must address four key factors: Cost, Validation, Standards & Regulations, and Risk & Liability.

Whether voluntarily adopted or required by law, standards touch us all every day. For example, standards exist for indoor air quality, for sustainable tree harvests and now we are seeing the development of standards that define the elemental efforts needed to protect the climate –

carbon reductions (also known as carbon offsets).

Standards work to everyone's benefit:

- by defining many safety requirements, they help reduce the risk of personal injury;
- by setting out performance and design criteria, they bring order and know-how to the problems, like making plugs fit sockets;
- by setting recognized benchmarks, they help open doors to new markets and facilitate trade around the world;
- by providing a framework for best management practices, they help advance business excellence;

Recent assessments (Blum, 2006) have confirmed that standards provide economic benefits by influencing institutional change and the structure of the economy; creating a competitive advantage in sectors or technologies with high uncertainty; expanding markets and supply chains.

Standards influence institutional change and the structure of economies by changing the knowledge content of companies so that they can become more decentralized (i.e. globalized) in their operations, supply chains and market opportunities. Standards allow companies to access suppliers who can manufacture components, vendors who can sell their products and labor and knowledge anywhere in the world.

Firms that initially develop and implement standards that become industry accepted have a competitive advantage in the marketplace. This advantage can be leveraged to fund the evolution of that industry standard or to finance development of new industry standards, thereby using standardization and new product development to generate profits.

Finally, standards can speed product development and reduce risk during the first critical phases of entering a new marketplace. This is primarily the benefit that is driving the development of voluntary carbon standards. New markets, like that associated with carbon trading are characterized by high development and deployment risk and significant financial leveraging. These risks can be reduced by using standards that reduce the potential uncertainty for both buyers and sellers and provide for smoother and less costly transactions.

All of these benefits facilitate trade between

buyers and sellers both domestically and internationally, which is why it is understandable that standards have begun to enter the arena of climate change, both to help improve environmental management but also to support emerging emissions trading markets.

### 3. SECARB - VIRGINIA COAL PROJECT

The Southeast Regional Carbon Sequestration Partnership's (SECARB) Central Appalachian Coal Seam Project is one of the seven DOE's Partnerships researching CCS. Design and implementation of the test are underway. The selection of the well was based on geologic considerations for the site, preliminary reservoir modeling, surface access and landowner and mineral owner negotiations.

The regional study area is located within the Central Appalachian Basin, a northeast-to-southwest-trending basin encompassing approximately 10,000 square miles in southwestern Virginia and southern West Virginia. The principal area of investigation for most of the detailed geologic mapping consists of portions of five counties located within southwestern Virginia including Buchanan, Dickenson, Russell, Tazewell and Wise Counties and four counties in West Virginia, including Fayette, McDowell, Raleigh and Wyoming.

Phase I - Initial Characterization and Preliminary Feasibility Study was completed in 2005. Phase II began with an expanded Study Area, Reserve Modeling and Pilot Scale CO<sub>2</sub> Injection. Presently, Phase II is completing Task 10 which focuses on the characterization of the region to identify several sites for a potential large-volume CO<sub>2</sub> injection test to validate the carbon sequestration and enhanced coalbed methane recovery potential in the Central Appalachian Basin with additional characterization of secondary storage reservoirs. A large-volume (>100,000 ton CO<sub>2</sub>) test is necessary to create the high level of confidence in this technology that is necessary prior to planning for commercial deployment.

The objectives of the project include:

- Characterize potential large-volume test sites in Central Appalachia for coal seam sequestration and enhanced coalbed methane recovery.

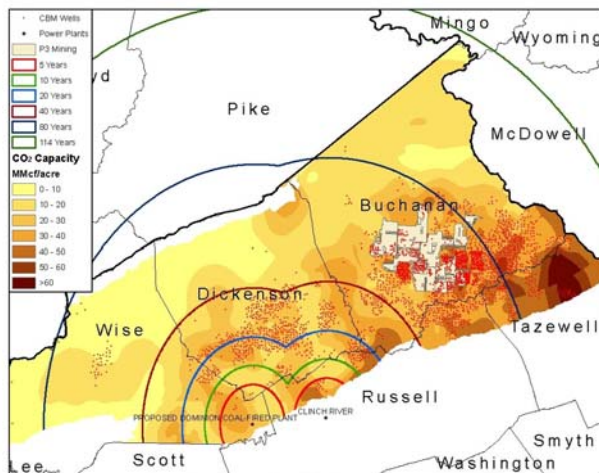


Figure 2: CCS Storage Capacity.

- Delineate and characterize saline aquifers in the region that could provide secondary carbon sequestration options.
- Review and identify depleted or partially-depleted oil and gas fields that could support large-volume CO<sub>2</sub> injection tests.
- Identify options for stacked storage reservoirs in Central Appalachia.
- Design test site operations, measurement, monitoring and verification program and site closure.
- Select several test sites in Central Appalachia for a large-volume carbon sequestration coal seam project which could lead to commercial deployment.
- Implement public outreach and education.

The Phase II Task 10 work is designed to serve as the initial geologic and engineering characterization phase for a future large-volume sequestration project. The aim of the future project is to store a large volume of CO<sub>2</sub> which can stress formations sufficiently to evaluate the structural integrity and long-term storage capacity of coal-bearing strata in Appalachia. Rigorous measurement, monitoring, and verification tools will be used to ensure the storage and integrity of the CO<sub>2</sub> plume in a future large-volume test. The research goals of this project are to verify the ability of coal seams to store large volumes of CO<sub>2</sub> and to quantify the ECBM recovery potential.

Recent accomplished field testing and completion of reserve modelling indicate that the basin has great potential. Based in limited field data, it is estimated that the limited study area could accommodate 100% storage of two

proximal coal fired electric power plants for 100 years. Figure 2 details the isometric storage intervals based on the present data.

#### 4. ISSUES & CONCLUSIONS

New technology and new regulations almost always encounter resistance. In the case of CCS, the resistance is less about change and more about the lack of clear direction, lack of regulation and lack of international standardization. This “lack of” effect slows progress and raises more questions than it answers.

The basic regulatory framework is already under development or exists in different forms. The adaptation of these programs to CCS ought to proceed as quickly as possible, including scientifically-justified, risk-based performance standards and monitoring rules. Even if that occurs, however, there will still be a number of key legal issues to be addressed if CCS is to be widely deployed, most of which are related to post-injection storage issues.

There are some major issues/questions that are presently being discussed; that once resolved, should allow the technology and the international community to implement a more coherent strategy which has the potential to address the required program elements.

The U.S. Supreme Court ruling in *Massachusetts v. EPA* allowing the regulation of carbon dioxide as a pollutant under the Clean Air Act has had several significant impacts. The first is that carbon dioxide can be regulated only as it pertains to air issues (above ground). This does not co-exist well with the underground portion of the sequestration requirements. Secondly, the potential regulation of carbon dioxide as a waste could have its largest impact on the oil & gas transportation model of “Forced Pooling & Unitization”. This is an evolution of an eminent domain concept that allows the Federal Energy Regulatory Commission (FERC) to mandate and regulate the storage and transportation of natural gas in geological formations even if the property owner declines. The concept works because natural gas is an asset (a commodity) and as such, FERC requires the compensation of property owners for the use of the geology. Under *Mass. V. EPA*, if carbon dioxide is in fact a waste, the Forced Pooling and Unitization rules won’t apply due to the liability of carbon versus

the asset value of natural gas.

This nuance opens the discussion of liability discussions for carbon dioxide storage fields. As an example, in WV a typical carbon dioxide storage field may be as large as 50 square miles. Assuming an average of 1,250 parcels/square mile and one surface right holder and two subsurface right owners requires 187,500 liability and indemnification agreements for one storage field. Since this is a non-asset (liability) issue, the landowner has the right to demand a monetary value to "assume" the liability for the carbon dioxide being stored on their property. It doesn't take long for 187,500 land owners requiring any sizable fee (\$100,000) applied to the multitude of storage fields required for the amount of money required to complete the task to reach Monopoly© Money status. This same logic will most likely be applied to the infrastructure issues of Right of Way (ROW) for the required pipeline and transportation of the CO<sub>2</sub> to the storage field.

The cost to implement this emerging technology is not cheap. Present Energy Information Agency (EIA) estimates to implement full scale (85 %) CCS at the power plant level would have following impact:

- Increase in current average consumer power cost of 10.6¢ per kWh.
- New power plant construction costs with integrated CCS systems would increase 15-25% increase over current average \$2B cost.
- Retrofit existing facilities would have a construction cost of 20-45% of original construction costs.
- The parasitic load on the U.S. fleet to operate the CCS technology is 40 GW of parasitic demand - which is 50-800 MW plants.

With the plethora of NIMBY & NUMBY issues, domestic and international standards, managed by and regulated in both a voluntary and mandatory framework, one thing is clear...there is no single answer to the CCS problem. Therefore, one should not consider the possibility of a "silver bullet" solution. The only option is for "silver buckshot" - all options must be considered and evaluated to reach an international standard which will allow this emerging technology to be widely used, accepted and successful.

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