PAPER SUBMITED TO:

SEPTEMBER 24TH- 26TH 2007

COMMERCIALIZATION OF CARBON CAPTURE AND STORAGE TECHNOLOGY THROUGH PUBLIC-PRIVATE PARTNERSHIPS: A STRATEGIC APPROACH TO ENABLE REGIONAL AND INTERNATIONAL DEPLOYMENT

Will Johnson*
Visage Energy Corp. 6345 Green Valley Circle Suite 216 Culver City, CA 90230,
Office: (310) 216-6887, will@visageenergy.com

Kevin O'Brien
SRI International 333 Ravenswood Ave. Menlo Park, CA. 94025,
Office: (650) 859-3528, kevin.obrien@sri.com

Daryl-Lynn Johnson
Visage Energy Corp. 6345 Green Valley Circle Suite 216 Culver City, CA 90230,
Office: (310) 216-6887, darylynn@visageenergy.com

ABSTRACT

The economic magnitude of developing and deploying Carbon Capture and Sequestration (CCS) technologies requires that the financial burden be shared by many different stakeholders (ratepayers, federal and state funding sources). Typically fast deployment of new technologies tends to be limited by the "learning curves" of the technology's end users. Public-Private partnerships can be constructed to develop the regulatory framework and to share financial burdens among electric consumers and coal producers/electric generators in a region incorporating the *in Libra* concept[1] (i.e. collaboration and cooperation). In addition, a coordinated deployment[2] schedule that is strategically constructed and includes knowledge transfer could accelerate the commercialization of CCS technologies providing real climate change stabilization benefits. A potential route for the Western United States region is discussed, but this approach readily could be expanded nationally and internationally.

INTRODUCTION

The management of Greenhouse Gas (GHG) emissions, in particular CO_2, produced during the course of energy generation from fossil fuels is a critical factor to ensure that sufficient clean energy is available to continue promoting economic growth in the United States. This will require new investments in not only capital equipment, but also in research, development, and deployment of new technologies to manage CO_2 emissions [i.e. Carbon Capture and Storage (CCS) technologies]. Successful deployment of CCS technologies hinges not only on the economics of the

* Air Quality VI Conference Presenter and Corresponding Author: Will Johnson.

process, but also on the ability to create a regulatory environment that encourages investment in these technologies and rewards early adopters. According to a survey published by the National Association of Regulatory Utility Commissioners (NARUC), "whatever the regulatory path States and Federal officials choose for improving the environmental performance of base-load electricity generating facilities, it is clear that future emission limits will be more stringent[3]." This becomes evident as GHG abatement efforts initiated in the future will require more stringent controls at a significantly higher societal burden.

The magnitude[4] of this challenge requires that the public and private sectors collaborate to achieve the objective of a GHG management initiative that is plausible and economically sustainable. Public-Private partnerships enable utilities to leverage ratepayers' funding with existing federal and state funding in order to participate in research, development, and deployment (RD&D). This approach may engage the utility stakeholder in earlier research and development (R&D) maturation stages, such as post proof-of-concept, which could significantly decrease the amount of time anticipated for adoption of emerging CCS technologies. This accelerated knowledge transfer process would not only reduce the learning curve for the technology, but also accelerate the reduction in total operating costs of new technologies. Presented herein, is a detailed analysis of the need for Public-Private partnerships in CCS technology RD&D and the benefits that can be achieved when this approach is leveraged not only on a regional basis, but also on a national and international scale. The CCS technology learning curve could be decreased by the timely and coordinated deployment of utility scale state-of-the-art technologies enabling the sharing of best practices concerning the permitting process, design, construction, startup and operation of power generation facilities with CCS within each of the different technology pathways (pre-combustion, post combustion and oxy-combustion)[2].

Public-Private partnerships also translate into team formation. The team must consider not only technical factors but also business, regulatory and financial factors. The Visage Energy / SRI International team delivers business acumen and coordination into the research and development of new Carbon Capture and Sequestration (CCS) based technologies in order to accelerate the successful development and deployment of these new technologies. This approach, illustrated in Figure 1, would ensure that business needs are considered early in the technology development process by incorporating all members of the "business ecosystem" (i.e. end users, OEMs, and public stakeholders). This is accomplished by developing partnerships that consist of not only the technology developers, but also organizations such as government entities and financial institutions that are critical to ensuring long-term acceptance of the technology by the marketplace. For example, end users and potential manufacturers are included to ensure that the emerging technologies can be manufactured in a cost effective fashion and can be installed at the end user's facility to meet their specific needs. Additionally, state and federal stakeholders are engaged early in the process, providing a regulatory framework that supports the commercialization of CCS technologies due to their greater understanding of CCS technical and economic performance capabilities. It is only through the exchange of information among stakeholders that a plausible approach to GHG management can be realized.

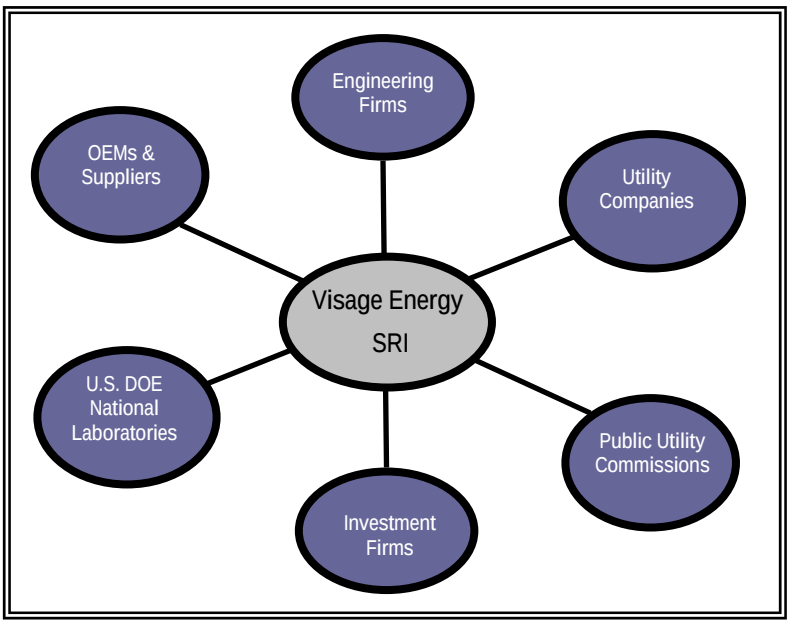

Figure 1: "Business ecosystem" proforma of incorporating members into Public-Private partnerships to rapidly commercialize CCS technologies.

CONSTRUCTING AND COORDINATING PUBLIC-PRIVATE PARTNERSHIPS: THE NEXT STEP

There are **seven key stakeholders** that will need to be brought into alignment to accelerate the demonstration and commercialization of CCS technologies: **I Federal Stakeholders, II Technology Developers, III State Stakeholders, IV End Users, V Environmental Groups, VI Insurance Companies, VII Financial Institutions**. The end goal of successfully financing CCS projects can not occur on a wide scale level if any one of these seven stakeholders is unaligned or excluded.

Frame Setters

I. **Federal Stakeholders** – This group [i.e. DOE (e.g. Office of Fossil Energy), Federal Regulators (e.g. EPA), and Federal Policymakers (Council on Environmental Quality)] will need to provide the overarching federal policy commitments and funding vehicles to promote the acceleration of the wide spread development, deployment and commercialization of CCS projects.

II. **NETL/Other Technology Developers** – This group is clearly important to the development and commercialization of CCS technologies. NETL is the principal CO_2 Capture and Sequestration steward which funds all the other national laboratories to meet NETL's program goals and supports RD&D projects by providing cost share funding on CCS projects with developers, OEM, and utility companies.

III. **State Stakeholders** – This group will develop state policy commitments, the regulatory framework and provide ratepayer funding that will create the incentives and financial resources to accelerate the demonstration and commercialization of CCS projects. Moreover, a high level of cooperation will be required between Regulators in the electric consuming states and those in the coal producing/electric generating states.

IV. **End-users/Utility Companies** – In the future, to ensure rapid commercialization of GHG technologies, utilities need to play a larger role in the demonstration phase and later stage pre-commercial technology development of the RD&D process. Additionally, utility companies need to collaborate with PUCs to determine the appropriate degree of involvement in the RD&D process as these technologies are being developed for utility companies as the end-users. However, unless the state regulators provide adequate policies and funding incentives most utilities will not become actively or appropriately involved in the RD&D process on a cost sharing basis.

V. **Environmental Groups** – The involvement of these groups is critical to gaining public acceptance of Geologic Carbon Sequestration as a safe and viable climate change mitigation tool.

Enablers

VI. **Insurance Companies** – This group needs to be engaged in the process in an effort to begin to model the risk associated with sequestration. The large international insurance companies are unwilling to provide coverage for the unquantifiable risks associated with CCS construction completion, plant performance, and the long term CO_2 sequestration liability. Federal and state policies will be required to bound the sequestration risk and limit exposure to a quantifiable level in order to engage this stakeholder. (i.e. industry could provide reasonable frontstop protection for sequestration risk; whereas the state/federal agencies could provide federal backstop protection for long term sequestration risk)

VII. **Financial Institutions** – With the alignment of groups I through VI, it is reasonable to assume that the capital markets will be willing to provide funding to insurable CCS projects that have Federal and State policies and funding support.

Frame **S**etters + **E**nablers = **A**ccelerated **C**ommercialization

The ultimate goal of financing the deployment of commercialized CCS technologies can only occur when all seven key stakeholders are engaged and collaborating. An analytical and reversed sequential perspective illustrates the necessary collaboration by all key stakeholders.

VII. Financial Institutions will be unwilling to finance CCS projects that have uninsurable and unlimited project risk. Insofar as traditional turn-key financing may not be available for decades for deployment of CCS technologies, new and innovative financing methods will be required for the accelerated development and deployment of these facilities.

VI. Insurance Companies will be unwilling to provide insurance coverage for CCS projects until state and federal regulators bound the liability by providing some form of federal backstop protection to assist in quantifying the risk associated with carbon sequestration.

V. Environmental Groups will be unwilling to seek public support for geologic carbon sequestration until the state and federal government have enacted well defined sequestration policy guidelines and public good safeguards.

IV. End-users/Utility Companies will be unwilling to incur the risk associated with a multi-billion dollar investment in an unproven CCS facility without strong financial support from state and federal agencies. Moreover, many utility companies have not been given the proper financial incentives to actively become involved in the development and deployment of CCS technologies.

III. State Stakeholders are beginning to view CCS as a viable GHG mitigation tool. Some state Commissioners also appear to be willing to consider providing utility companies with ratepayer funds for cost share investments in CCS technologies. However, efforts need to be undertaken to further educate and raise awareness of CCS issues with this group.

II. NETL/Other Technology Developers could receive additional federal funding and cost share participation from utility companies with an increased awareness of the importance of developing and deploying CCS technologies. According to DOE's Principal Deputy Assistant Secretary for Fossil Energy Thomas Shope, if funding were doubled for a multi-region sequestration partnership program and [other pertinent research] managed by NETL, it could accelerate the commercialization time frame[9].

I. Federal Stakeholders' support will be required from numerous different offices of the federal government to accelerate the commercialization of CCS technologies.

REGIONAL PUBLIC-PRIVATE PARTNERSHIPS: A STRATEGIC APPROACH FOR THE WESTERN UNITED STATES

Current Trends

The California Global Warming Solutions Act of 2006 (AB 32) and Green House Gas Emissions Performance Standard for Major Power Plant Investments (SB 1368) both call for California to invest in the development of innovative and pioneering technologies to assist California in achieving 2020 statewide limits on greenhouse gas (GHG) emissions.[5] These bills also call for maximizing environmental and economic benefits for California. The major challenge is meeting energy requirements without sacrificing the environment or the grid reliability of California and other energy "consuming" states in the West (e.g. OR, WA).

In particular, SB 1368 emphasizes that in order to have a meaningful impact on climate change, GHG Performance Standards must address not only California's *energy production* but also its *energy consumption*. In order to manage GHG emissions, California, along with its neighboring western states, will need to create an atmosphere that attracts capital and promotes a coordinated initial deployment and subsequent aggressive cost reduction for a range of new CCS technologies. This concept was best captured by the "three-legged stool[1]" analogy developed by Stu Dalton, Director of EPRI's Generation Sector, and depicted in Diagram 1 of Figure 2. Technology, regulatory environment, and economic incentives must all be well coordinated in order to efficiently deploy technologies that limit GHG emissions. Expanding on this initial concept, collaboration is necessary between net energy consuming states (CA, OR, and WA) and coal producing/generating states (WY, NM, MT, UT, and AZ). An enhancement of the three-legged stool concept would also address the need to accelerate the commercialization of new technologies by coordinating efforts between technology sources (e.g. NETL and Universities) and end users (e.g. utilities). The following sections will provide a more detailed discussion of the enhanced *in Libra* concept.

Engaging Neighboring States (Regulatory and Economic Leg)

During the May 2006 meeting of the Western States Commissions, Bill Keese, co-chair of the Western Governors Clean and Diversified Energy Advisory Committee indicated that the western governors adopted an *in Libra* approach to reducing GHG emissions[1] (defined as operating as one entity). This approach could be expanded with the inclusion of not only energy consuming states in the West, but also coal producing/generating states in the West. This revised approach affects both the Regulatory and Economic "Legs" and is illustrated in Diagram 2 of Figure 2.

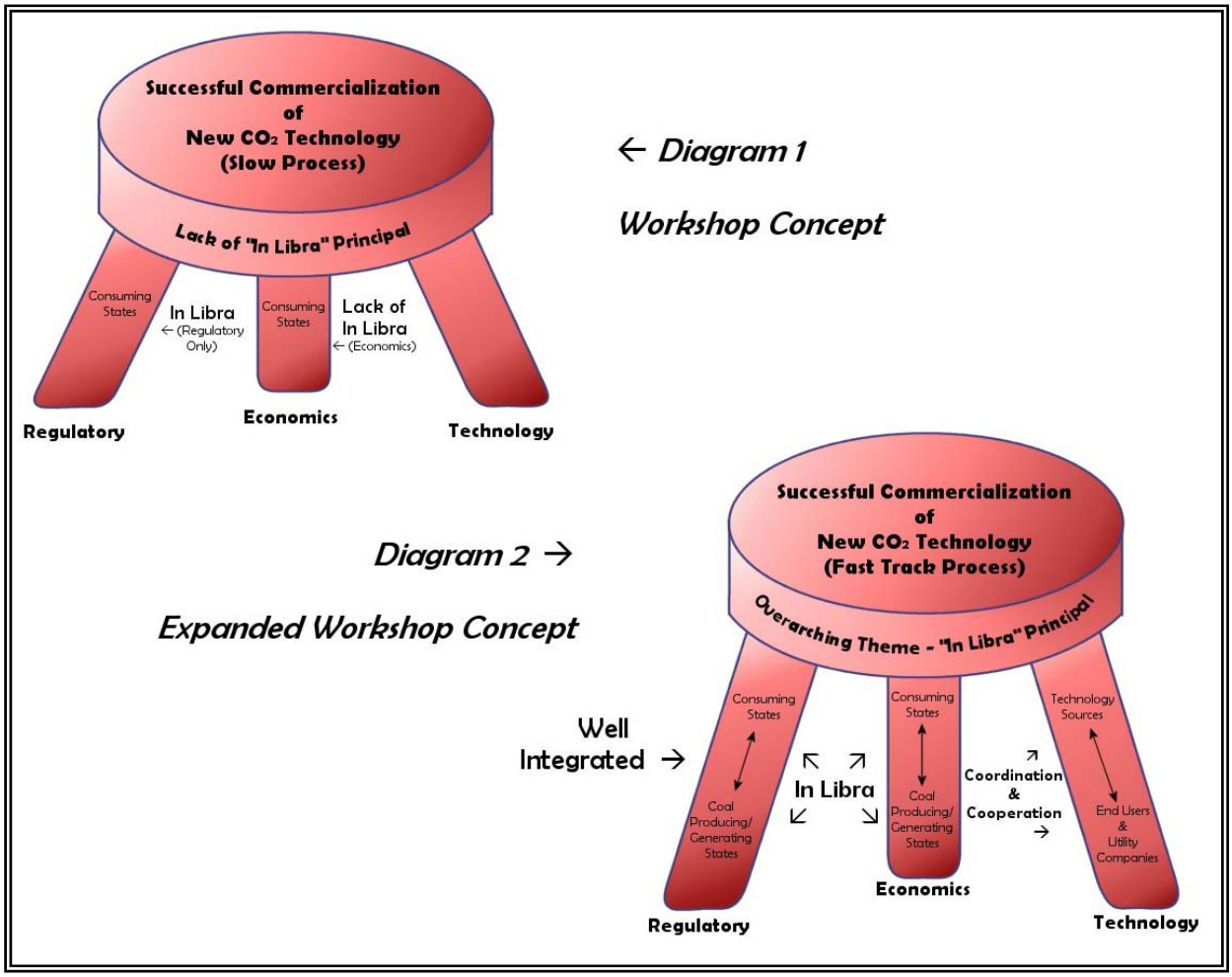

Figure 2: Enhanced *in Libra* concept expanded to include coal producing/generating states

Regulatory Leg

Examples of regulatory activities that could foster interactions between consuming and coal producing/generating states (**Regulatory Leg** of Diagram 2) would include:

- Closer collaboration between all utility commissioners
- Support of construction of new CCS projects including out of state CCS projects with assets dedicated to supplying electricity to California, Washington and Oregon
- Provide state regulatory support for ratepayer funds to be utilized for cost share in CCS technology projects
- Encourage closer cooperation between utilities, financial and insurance entities, and technology sources focused on CCS development

Economic Leg

Examples of economic activities that could foster interactions between consuming and coal producing/generating states (**Economic Leg** of Diagram 2) would include:

- Construction subsidies and suspension of coal severance tax for initial CCS projects
- Joint guarantee from Public-Private partnerships provided by consuming states and coal producing/generating states for indemnification of insurance liability in order to bound risk of CO_2 sequestration for the first few projects as currently there is no such indemnification available for CO_2 sequestration (exception in the case of the indemnification of the FutureGen Alliance if FutureGen is sited in Texas or Illinois)[6,7]
- Collaborate on integrated financing issues associated with CCS technologies
- Provide utilities with rate based reimbursement for all RD&D expenditures associated with their collaboration of new and emerging CCS technologies

Technology Leg (i.e. Connecting Technology Sources and End Users)

Examples of technology related activities that could foster interactions between technology sources and utilities would include:

- Establish a project development committee that involves all CCS stakeholders to ensure that industry issues associated with CCS deployment are resolved proactively
- Coordinate potential capacity additions and retrofits with ongoing research program objectives from technology sources to maximize the technology commercialization potential
- Consideration by utilities of cost/benefit sharing in applied research and commercial CCS deployment

Historically, many utility companies have had a propensity to avoid deploying innovative unproven technologies on baseload generating facilities. Additionally, state Public Utility Commissions (PUCs) have generally provided rate case decisions that encourage reliable electricity production. Consequently, many utility companies have not actively embraced emerging "low serial number" technologies and most have not been involved in the technology RD&D process. As the consensus grows in the scientific community about the effects of anthropogenic GHG emissions on the climate[8], numerous PUCs have begun to take a more active interest in understanding CCS technology and its potential role as a climate change mitigation tool while continuing to provide reliable low cost energy to meet their state's future demand. Subsequently, PUCs should consider providing RD&D funding and incentives which will allow utility companies' ratepayers to participate in the upside of some of the more promising technologies during the earlier stages of development (post proof-of-concept maturation stage). Even with access to adequate RD&D funding, the participation and cooperation of key stakeholders is necessary for the successful commercialization of CCS technologies.

Western Regional Approach: Economic Growth through Knowledge Development and Transfer

Cooperation and coordination is needed between the electric consuming states and the coal producing/electric generating states as well as among the seven key CCS stakeholders in order to provide the proper environment for the acceleration of the development and deployment of commercial CCS technologies. The creation of a Western CCS Technology Depository would enable the Western region to further strengthen the economies of the electric consuming and coal producing/generating states by financially supporting the development and deployment of these projects. (See Figure 3) This would provide the basis for an integrated approach to develop and deploy and more importantly disseminate efficient CCS knowledge that will lower GHG emissions on a global scale. The overarching objective is the development and deployment of efficient CCS facilities and the dissemination of the best practices first regionally, then nationally and subsequently internationally in an attempt to reduce GHG emissions on a global scale. (See Figure 4) Sharing of the knowledge base is the unique aspect of this approach, ensuring that public funds invested in these efforts provide the maximum benefit to the public. Subsequent expansions of this concept will have the potential for global benefits of GHG emission reductions while providing reliable power generation to sustain economic growth.

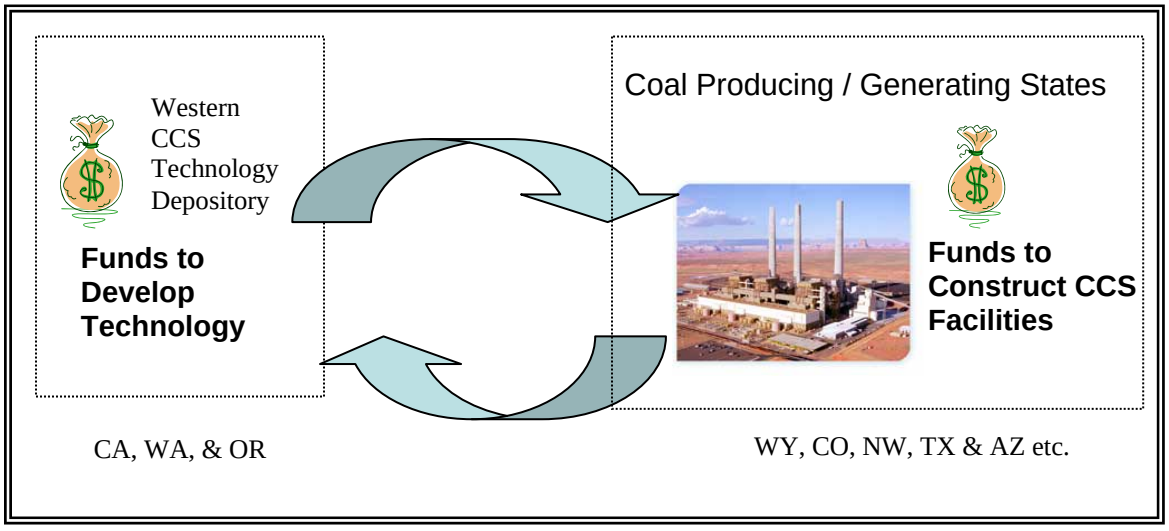

Figure 3: Symbiotic Relationship between Electric Consuming States and Coal Producing/Generating States

Western Regional Approach expanded Nationally/Internationally

The proper environment needs to be developed in order to bridge the gap between the laboratory research and the commercialization maturation stage of CCS technologies. Additionally, it is envisioned that the CCS Technology Depository would interact with the DOE Carbon Sequestration Regional Partnerships and NARUC in order to expand the regional approach nationally and potentially internationally through existing bi-lateral and multi-lateral international agreements.

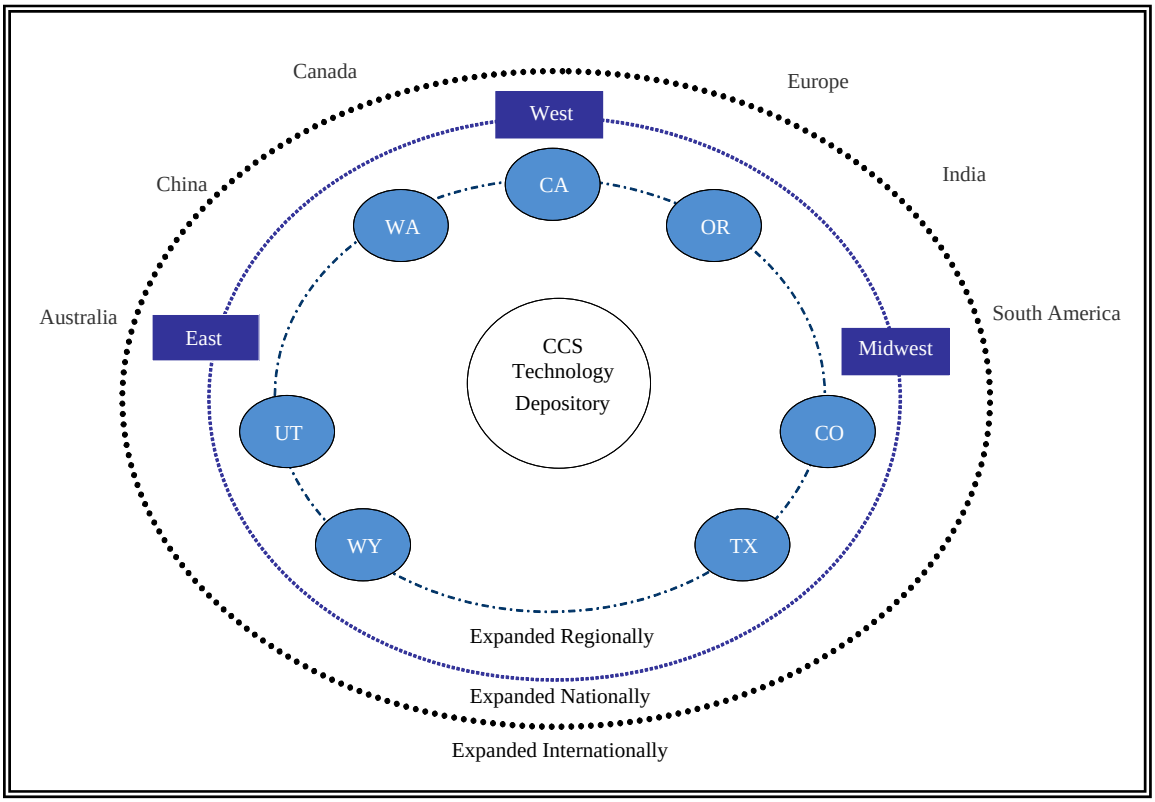

Figure 4: Expanded CCS Technology Depository[10]

Coordinated Deployment and Knowledge Transfer

In parallel to the proposed regional *in Libra* efforts and the alignment of seven key stakeholders, fast deployment of CCS technology in the field and the sharing of knowledge through the establishment of a CCS Technology Depository are vital. It should be noted that fast deployment does not mean wide scale deployment. Assuming it takes 5 years to deploy new technologies at power plants, and technologies are deployed every two years, it is possible that six different CCS projects could be completed in approximately a 20 year time frame. One key issue is that plants constructed later in the cycle (e.g. CCS #N) will obviously have lower operating costs than those constructed early in the cycle (e.g. CCS #1). Subsequently, the earlier stage plants are then at a disadvantage with respect to competing in the market. This disadvantage could be overcome if the consuming states were willing to enter into long-term "Power Purchase Agreements" (PPA) that also contained a "Purchase Power Adjustment Clause" (PPAC). This would ensure that the plants built early in the cycle receive incremental price adjustments for their less competitive electricity as compared to the more efficient later stage plants. This structure would require collaboration between earlier stage and later stage designers / operators as well as the dissemination of technological knowledge internationally. The consuming and generating states could jointly provide indemnification of the unbounded insurance liability risk associated with carbon sequestration projects while the generating states could suspend the coal severance tax for the early CCS facilities.

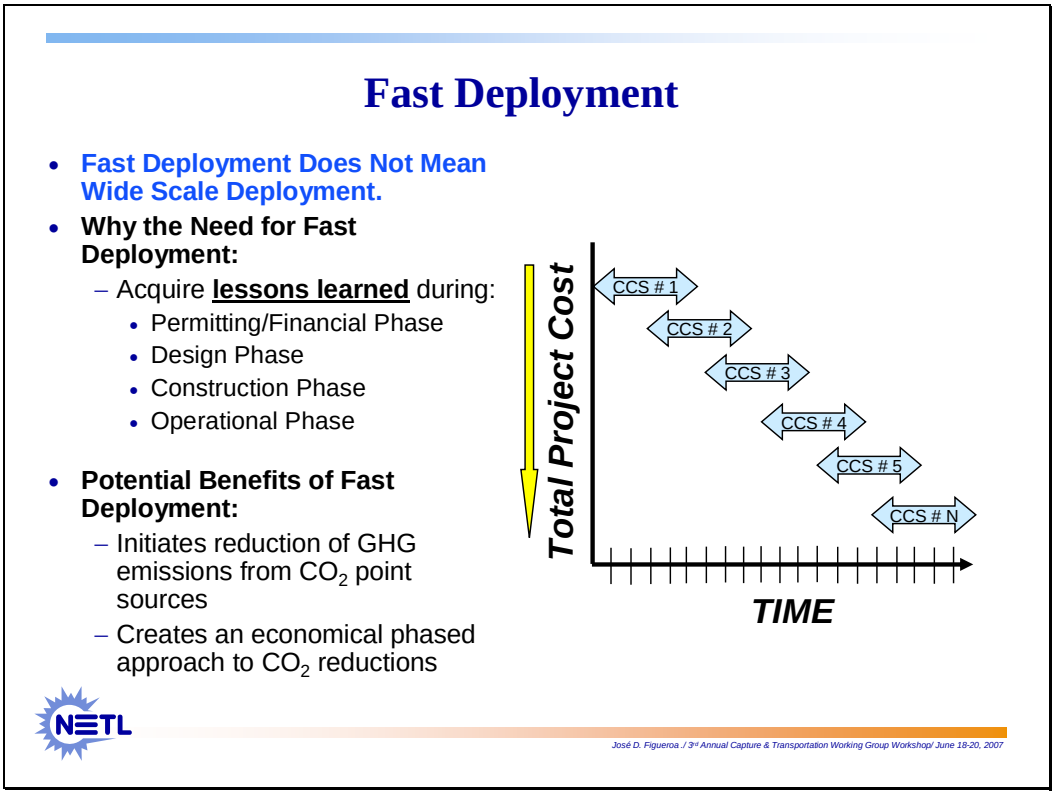

Figure 5: Coordinated timely deployment[2] schedule

Supported Recommendations from NARUC/DOE 2004 Report[11]

Presented below are some suggestions that were developed in a NARUC /DOE Report titled *"An Analysis of the Institutional Challenges to Commercialization and Deployment of IGCC Technology in the U.S. Electric Industry Recommended Policy, Regulatory, Executive and Legislative Initiatives."* Since its development in 2004, little progress has been made in implementing these recommendations. However, some of these recommendations could be adopted regionally among the western states to further the commercialization of CCS technologies and could later be expanded on a federal level.

1. *"The federal and state governments could initiate an expedited process to develop a single set of standards specifically for siting and permitting IGCC power plants including co-production processes."*

2. *"A fund could be established to provide for the sharing of possible IGCC capital cost overruns."* Additionally *"a federally sponsored program similar to the Overseas Private Investment Corporation ("OPIC") could be developed…Special OPIC programs address such matters as: (1) letters of credit; (2) petroleum exploration, development and production; (3)leasing operations; and (4) debt financings, including securities."*

3. *"TSPs, ISOs and RTOs could be required to provide modest credits financed through uplift charges for electricity produced by IGCC power plants in their early stages of operation."*

4. *"A single, dedicated information source and database could be established to assist in the siting and permitting of IGCC power plants, and to assist in the process of equipment and technology procurement."*

5. *"An educational team could be established by DOE to inform and educate the financial community, state regulators, utility management, and the power plant development industry about the proven benefits of the IGCC technology and its commercial viability, and to make a business case for IGCC power plant financing."*

CONCLUSION

Any meaningful effort to solve global warming through the reduction of anthropogenic GHG emissions will require the timely development of CCS technologies with a parasitic energy penalty significantly below those provided by current state-of the-art technologies. In order to expeditiously pursue this ambitious goal, the expansion of the *in Libra* concept (joint collaboration between key stakeholders in CCS industry) along with the creation of a CCS Technology Depository will be necessary. The Frame-Setters will need to develop overarching federal and state policies and provide funding to create the necessary incentives for utility companies to become more actively involved with Technology Sources. Once these groups are fully engaged and aligned, the framework will be set to allow the Enablers to provide adequate insurance and financing for CCS projects. The breath and depth of the CCS commercialization efforts are staggering and could require decades of coordination to achieve the end result of an environment in which the wide-scale deployment of fossil-derived power generation plants with the addition of CCS technologies is accepted as a plausible solution to GHG abatement while achieving economic sustainability.

ACKNOWLEDGMENTS

The authors wish to thank the members of each of the seven stakeholders that shared their insights which lead to the concepts proposed herein. The authors would especially like to express their sincere appreciation and thanks for the support and guidance that initiated this commercialization concept to José D. Figueroa, U.S. DOE National Energy Technology Laboratory.

REFERENCES

1. Transcript from the Advanced Coal Workshop for West Coast Commissions: IGCC Technology, CO_2 Sequestration and Policy Directions, May 2006 http://www.puc.state.or.us/PUC/meetings/pmemos/2006/052406/PUC52406.pdf

2. **Figueroa J.D.,** *Capture-Ready Requirements and Benefits vs. Fast Deployment*, Presented at the 3rd Annual Carbon Capture and Sequestration Working Group Workshop, June 18-20, 2007.

3. **Prepared by NARUC Funded by U.S. Environmental Protection Agency,** *A Survey of State Incentives Encouraging Improved Environmental Performance of Base-Load Electric Generation Facilities: Policy and Regulatory Initiatives*, June 2004 http://www.naruc.org/goto.cfm?returnto=displayindustrynews.cfm&industrytopicnbr=380&page=http://www.naruc.org/associations/1773/files/stateincentivessurvey0804.pdf

4. **Figueroa, J.D**., 2006. Carbon dioxide capture and sequestration potential and issues in the United States. APPA New Generation Meeting, Washington, DC. http://www.netl.doe.gov/publications/carbon_seq/presentations/APPANewGenerationMeetingFinal.zip

5. **Hilton, Seth.,** *The Impact of California's Global Warming Legislation on the Electric Utility Industry*, November 8, 2006

6. **Williams, Michael L., Commissioner** *Legislation improves Texas Chance to Win Futuregen*, May 16, 2006 http://www.rrc.state.tx.us/news-releases/2006/051606.html

7. Signed Senate Bill 1704 on July 30th by Illinois President of the Senate and Speaker, House Representative

8. **International Panel on Climate Control (IPCC)**, *Carbon Dioxide Capture and Storage. Special Report. International Panel on Climate Control (IPCC*), February 5, 2007. Climate Change 2007: The Physical Science Basis – Summary for Policy Makers. http://www.ipcc.ch/SPM2feb07.pdf

9. **Energy Washington Week** *DOE Says Doubling Sequestration Funding Jumpstarts Development*, March 14, 2007

10. **Johnson W.,** *Commercialization of CCS technologies through Public Private Partnerships*, Presented at the 3rd Annual Carbon Capture and Sequestration Working Group Workshop, June 18-20, 2007

11. **DOE/NARUC Partnership for Advanced Clean Coal Technology,** *An Analysis of the Institutional Challenges to Commercialization and Deployment of IGCC Technology in the U.S. Electric in the U.S. Electric Industry: Recommended Policy, Regulatory, Executive and Legislative Initiatives*, March 2004 http://www.naruc.org/goto.cfm?returnto=displayindustrynews.cfm&industrytopicnbr=380&page=http://www.naruc.org/associations/1773/files/igcc_finalreport04.pdf