Federal Research Management for Carbon Mitigation for Existing Coal Plants

Discussion Paper

Prepared for

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from Existing Coal Plants
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There are currently 645 conventional coal plants in operation in the US, which collectively comprise the single largest source of CO_2 emissions (32%). The current conventional coal plant fleet supplies around 50% of U.S. electricity and represents over one trillion dollars in infrastructure investment.

Also, while there appears to be a de facto moratorium on the construction of new coal fired generation in the U.S. the deployment of coal-fired generation is growing rapidly on a global basis. The significant growth of the economies of China and India, coupled with their large coal reserves and reliance on conventional coal fired-power generation, [1] substantially increases CO_2 emissions into the atmosphere.

The imperatives of climate change and coal consumption in the US, China and other countries suggest a strong public interest in mitigating CO_2 emissions from existing coal plants. The development, demonstration and rapid deployment of cost effective CCS retrofit technologies would return significant benefits under a future cap and trade program. The benefits have been estimated in several different ways, but in all cases they are substantial. For example:

- The National Academy of Sciences conservatively estimated the net present value of economic benefits of $4-7 billion for federal investment in carbon capture technology, and $2-4 billion for investments in carbon sequestration technology.[2]

- A recent study for Pew Center stated that "…with the experience gained from 30 demonstrations of CCS, the capital costs of wide-scale implementation of CCS in coal-fueled plants could be $80 to $100 billion lower than otherwise." [3]

- Achieving the 14% reduction in greenhouse gas emissions in 2020, as proposed in President Obama's FY 2010 budget, could be accomplished at an annual savings of $5-7 billion, beginning in 2020, for every $1 per ton reduction in the marginal price of carbon dioxide allowances resulting from more cost effective control technologies.

While the potential benefits are significant, current RD&D programs are inadequate for exploiting these opportunities. As recently noted by the General Accountability Office, "DOE's research strategy has, until recently, devoted relatively few resources to lowering the cost of CO_2 capture from existing coal-fired power plants, focusing instead on innovative technologies applicable to new plants." [4] At the current program pace, the technologies and infrastructure for

1 According to the World Coal Institute, "Coal Facts 2008," coal currently accounts for 78% of power generation in China and 69% in India.

2 "Energy Research and Development and America's Energy Future," Statement of Robert M. Fri, Visiting Scholar, Resources for the Future, before the Committee on Energy and Natural Resources, United States Senate, March 5, 2009.

3 "A Program to Accelerate the Deployment of CO_2 Capture and Storage (CCS): Rationale, Objectives, and Costs" Vello A. Kuuskraa, Pew Center on Global Climate Change, October 2007.

4 "Climate Change: Federal Actions Will Greatly Affect the Viability of Carbon Capture and Storage As a Key Mitigation Option", United States Government Accountability Office, September 2008

CO2 emissions capture and sequestration at scale or for low or no-carbon alternative fuels will not likely be deployed widely for at least twenty years, well beyond the decision-making timeframe assumed in virtually all cap and trade proposals.

This profile places significant pressure on the federal government to devise specific policies and programs to capture and sequester CO_2 from existing plants, to dramatically increase plant efficiency, or to employ other technologies and configurations to reduce carbon emissions from existing plants. This paper discusses possible program models to further define and accelerate such support.

Assumptions for Discussion Purposes

For purposes of discussion, we stipulate that:

- a program specifically for retro-fitting [5] conventional coal-fired power plants to capture and sequester carbon, refurbishing existing plants to increase efficiency, re-powering existing plants with advanced CCS technologies such as oxy-firing, or co-firing with low carbon fuels (RRRC) is in the public interest and urgently needed to reduce the cost of compliance with a cap and trade program;

- the program will have a significant and specific focus on development of capture technologies which may or may not be coupled to sequestration activities;

- such a program must span the research continuum from basic research to large-scale demonstration of the commercial viability of key technologies, refurbishments or other improvements, with a significant focus on the latter;

- the program should, at a minimum, be designed to achieve CO_2 emissions levels at a cost per ton that is competitive with estimates of projected market-clearing prices for carbon dioxide allowances;

- to ensure success, the program should have the characteristics of:

    - adequate, sustained funding over time;
    - a program structure that fosters close collaboration among industry, universities and National laboratories to enable rapid research, development and deployment effective program management with significant technical domain expertise including an understanding of the investment/commercial considerations of the industry; and
    - significant inter-agency coordination and committed, capable federal leadership at the highest levels of the agency and within the White House

5 In this paper, retro-fitting is used as shorthand for the suite of technologies that can be applied to existing pulverized coal steam generation power plants, either through add-ons to existing plants, rebuilding and upgrading existing boilers with carbon capture, repowering of existing boilers with gasification or other technologies, modifying the combustion characteristics of boilers through oxy-combustion, increasing the thermal efficiency of existing boilers to reduce greenhouse gas emissions per unit of power output, and co-firing with low-carbon fuels. This suite of technology options is referred to in this paper as Retrofits, Rebuilds, Repowering and Co-firing with low carbon fuels, or RRRC.

Key Questions for Discussion

Designing a robust, high impact and sustained program that is broad in scope and structured and managed to maximize climate mitigation goals, maintain commercial viability and provide affordable power raises both design and process questions for participants to consider as they review this paper:

- Is there an optimal program model to enable rapid development and deployment of technologies necessary to meet program objectives?
- Can such outcomes be accommodated by existing programs at DOE? If so, which one(s)?
- What existing authorities might DOE employ to meet the objectives of such an effort? Are these authorities adequate or being utilized to the maximum extent practicable?
- Is an entirely new program necessary? If so, are new authorities required or are existing organic statutes adequate for addressing the requisite tasks of such a program?
- Are there structural, personnel and/or standard operating procedures at DOE that might impede timely achievement of program objectives?

Review of Current DOE Clean Coal and CCS RD&D Program Activities

To design an RRRC technology program for existing coal plants, it is important to first review current programs at DOE, where the Office of Fossil Energy has several RD&D programs aimed at mitigating the impacts of CO_2 emissions from coal combustion. These include the Clean Coal Power Initiative, the Regional Carbon Sequestration Partnerships Program, several IGCC related programs, and the Innovation for Existing Plants Program (FY 09 budget request is in Figure 1).

Advanced Integrated Gasification Combined Cycle program (IGCC): The IGCC program has been focused on a broad set of technology improvements to current gasification technology to enhance performance, reduce cost and reduce emissions of all pollutants, including CO_2. This program also includes R&D on technology enhancements, such as membrane air separation, to facilitate pre-combustion capture of CO_2. DOE/FE appears to have assigned a high priority to gasification technology as the preferred solution to carbon capture, because the incremental cost for carbon capture from gasification is estimated to be significantly less than the incremental cost for carbon capture from pulverized coal combustion.[6]

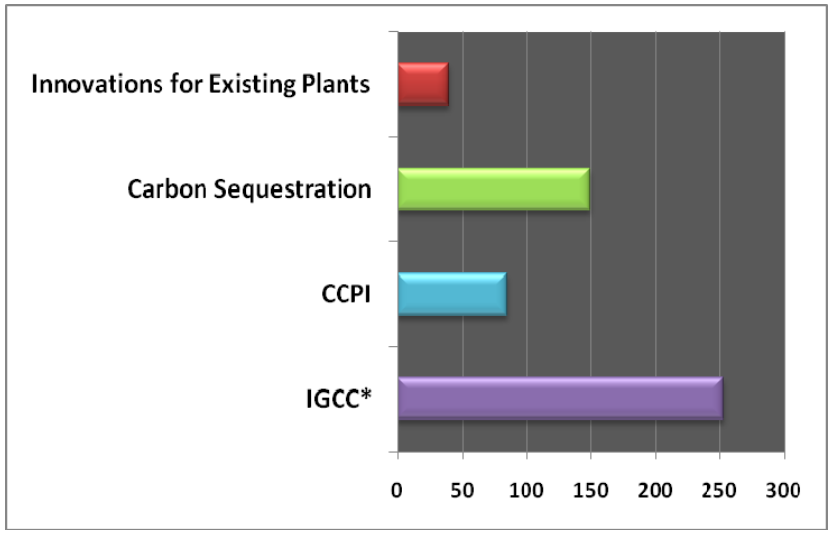
The recent GAO report noted that DOE's R&D program has focused on IGCC as the preferred technological option, noting that DOE has invested $2.3 billion in gasification technology.[7] However, the emphasis on this technological solution assumes that many new IGCC plants can be deployed, either as new plants that would replace existing PC plants, or as repowering opportunities at existing PC plants. The DOE analysis is based on a comparison among options for new builds. The DOE analysis did not address the economic trade-offs between constructing new IGCC generation plants with carbon capture and retrofitting or modifying existing PC plants with carbon capture.

6 The DOE Report "Cost and Performance Baseline for Fossil Energy Power Plants—Volume I: Bituminous Coal and Natural Gas to Electricity," Final Report, 2007 showed that carbon capture would increase the cost of a newly constructed IGCC plant by 35%, while carbon capture would increase the cost of a newly constructed PC power plant by 77%.

7 U.S. GAO, p.34.

Innovations for Existing Plants (IEP): This program historically focused on R&D on technologies for environmental controls at existing pulverized (PC)plants. Since FY 2004, the program has emphasized R&D on the control of mercury emissions. Beginning in FY 2008 2009, DOE shifted the focus to "the development of technology to reduce CO_2 from PC power plants." [8] In February of 2008, DOE released a solicitation for R&D projects "specifically focused on developing technologies for CO_2 capture and separation that can be retrofitted to existing pulverized coal (PC) power plants." [9] In response to this solicitation, DOE awarded a total of $36 million for 15 projects. However, this program is designed to support R&D at the laboratory and pilot-scale, but apparently not demonstration-scale projects.

Figure 1. FY 2009 Budget Request



***includes FutureGen, Advanced Turbines, Advanced IGCC**

FutureGen: The FutureGen program was originally planned for support a single, large scale, green-field demonstration of IGCC coupled with other advanced technologies for carbon capture and geologic sequestration, with the objective of achieving near zero emissions. In 2008, the Bush Administration reorganized the program to broaden its focus from a single plant to several large–scale demonstration facilities. The revised FutureGen solicitation proposed to fund the incremental cost of CCS for an IGCC plant, with the project sponsor funding the full cost of the IGCC portion of the project. DOE issued a draft Funding Opportunity Announcement[10] that specified the following criteria for a demonstration project under the restructured FutureGen:

- Performance levels of 81% carbon capture at a scale of 300 MWe, plus sequestration of at least one million metric tons of CO_2 per year in a saline formation;

8 FY 2009 Congressional Budget Justification, Fossil Energy Research and Development, U.S. Department of Energy, February 2008, p.31.
9 Ibid, p.36.
10 "Restructured FutureGen," Draft Financial Assistance Funding Opportunity Announcement, U.S. Department of Energy, National Energy Technology Laboratory, May 7, 2008.

- DOE cost share of the lesser of the incremental cost of CCS (for a new plant) or 50% of the cost (of a retrofit or repowering project);
- A demonstration period of 2-5 years, after which the project would receive no DOE assistance; and
- A hard cap of $600 million on the federal share, with no allowance for any cost escalation after the time of the award.

DOE received comments on the draft solicitation, but the Bush Administration took no further action. Secretary Chu recently stated that the Obama Administration would review the FutureGen plan. The Secretary stated that "We are taking, certainly, a fresh look at FutureGen, how it would fit into this expanded portfolio."[11]

Sequestration R&D: This program supports a variety of carbon capture and sequestration activities. About 80% of the sequestration program is allocated to the Regional Carbon Sequestration Partnerships.[12] The Regional Carbon Sequestration Partnerships Program is focused on developing technologies, regulatory policies and infrastructures to enable large scale sequestration of CO_2 from coal-fired power plants for a range of coals and geologies. The Program supports seven regional partnerships. In addition to the regional partnerships, the program supports R&D on several carbon capture technologies, including membrane separation for gasification technology and two oxy-combustion R&D for two pilot scale projects (Babcock and Wilcox and BOC Group).

Clean Coal Power Initiative: The Clean Coal Power Initiative (CCPI) was initiated in FY 2003 to demonstrate a wide range of emerging technologies in coal-based power generation. The program was originally proposed as a 10-year $2 billion program. CCPI Round I and CCPI Round 2 solicitations focused on advanced environmental control and gasification technologies. In August 2008, DOE released a solicitation for demonstration projects as part of the CCPI program (CCPI Round III). Table 1 highlights key features and requirements articulated in the Round III solicitation.

While the CCPI Round III solicitation officially closed on January 20, 2009, it is expected that DOE will re-open the solicitation, make some modifications to the specifications in the solicitation, and extend the deadline for submission of proposals. This will enable DOE to deploy the additional $800 million included in the recent American Recovery and Reinvestment Act, signed into law on February 17, 2009. There also may be a CCPI Round 4 solicitation that would be funded in the upcoming FY 2010 appropriations bill.

11 "DOE taking 'fresh look' at FutureGen, energy chief says," Greenwire, March 5, 2009.
12 U.S. GAO, p.35.

Table1. Key Features of CCPI's Round III Solicitation

Priorities	Funding	Contract Type	Match Requirements	Eligibility	Schedule	Technical Selection Criteria
Deployment of: **--advanced coal based CCS or reuse technologies** **-- 300,000 tons/yr from demonstration plants must be captured & sequestered or put to beneficial use** **--carbon capture process must operate at 90% efficiency**	**--$440M with additional $800M in Stimulus** **--multiple projects will be funded**	**--Cooperative Agreement with flow thru provisions for major subcontractors** **--FAR provisions apply**	**--50% federal cost share,** **--no federal cost share on overruns**	**--Make progress toward 10% COE increase for gasification systems or 35% for combustion and oxy-combustion systems** **--Make progress toward 50 CCS of plant CO2 emissions**	**RFP : 8/11/08** **Submissions: 1/20/09** **Selections: 7/09** **Awards: 6/10**	**Criterion #1 (50%): technology merit, technical plan, site suitability** **Criterion #2 (30%): project organization, project management plan** **Criterion #3 (20%): commercialization potential**

Summary Observations: The GAO Report noted that DOE officials indicated spending about $50 million on carbon capture technology between FY 2002-2007. Beginning in FY 2008, DOE increased the focus of its R&D programs on carbon capture technology. Based on a review of the current recent DOE program plans, budgets and funding solicitations, we can draw several general observations:

1. The DOE R&D programs have had a heavy emphasis on carbon capture technologies related to coal gasification;

2. The R&D programs generally have been more focused on new plant applications rather than retrofits;

3. Carbon capture technology R&D has not been a specific program focus area. In fact, work on carbon capture technology can be found in four different budget line items within the Fossil Energy R&D budget; and

4. All of the carbon capture technology R&D work to date has been at small scale – laboratory experiments and pilot plant testing.

Is CCPI Adequate for Existing Retrofits, Refurbishment, Repowering and Efficiency?

Of all coal technology programs in the DOE Office of Fossil Energy, the CCPI program, as reflected in the Round III solicitation, offers the best starting point for developing a broader RRRC technology initiative. There are however several key issues with the current CCPI program

structure that limit its value as a programmatic vehicle for existing coal plant retrofit, refurbishment, re-powering and efficiency RD&D.

Key issues with the current CCPI solicitation can be divided into:

- the structure and focus of the solicitation itself, and;
- generic DOE/federal process issues which manifest in impediments to the timely stand-up and implementation of applied research programs of this type.

➢ **Structure and Focus**

CCPI Round III Solicitation Not Sufficiently Flexible to Meet RRRC Needs: The major features of the CCPI Round III solicitation are highlighted in Table 1. This solicitation, while focused on retrofits, places high priority on sequestering CO_2, stating that "300,000 tons per year from demonstration plants must be captured and sequestered or put to beneficial use."

A specific RRRC program necessarily includes a major focus on the development of capture as opposed to sequestration technologies and may or may not require explicit linkage to sequestration. Indeed, requiring a link at such an early stage of an RRRC program may impede progress in this area of research at a time when a focus on RRRC research is urgently needed.

On the plus side, linking capture and sequestration provides a source of CO_2 for a demonstration program and avoids "catch and release" concerns. Also, this link may reflect the real world system required to manage a CCS business in the future and provide opportunities to develop a business model.

On the other hand, a focus on sequestration implicitly excludes plant efficiency and co-firing research and demonstration. In addition, the specific skills sets on the part of researchers and industry partners for developing capture technologies are very different from those associated with sequestration. Further, broad partnerships sufficient to span the CCS value chain from power plants to reservoir management may be extremely difficult to assemble and retain over the lengthy solicitation period for CCPI Round III. As seen in Table 3, the time period from program authorization and funding to project start-up can take 2-3 years.

Also, as noted DOE programs to date have had much greater focus on sequestration and new plant research issues as opposed to the development of capture technologies for retrofit applications. As a matter of DOE practice and policy, different stages of research development are treated differently in both contract structure and industry match requirements. The one-size-fits all match requirement in the solicitation for CCPI Round III may not be appropriate for the range of research required for a program focused on specific RRRC needs.

Finally, such a structure may or may not reflect the ultimate equities of the parties engaged in the research or the regulatory structures under which the various entities are operating. Liability issues and regulatory requirements will undoubtedly be different across the CCS business chain and should be accommodated in the solicitation.

➢ **Process Issues and Concerns**

CCPI Solicitation Process Is Extremely Slow, Discourages Participation. Simply stated, from a process perspective, the CCPI program (and its immediate predecessor, the Power Plant Improvement Initiative, PPII) has had a poor performance record. A review of the combined record of the PPII and CCPI Rounds I and II shows that:

- For the combined total of PPII, CCPI Round I and CCPI Round II, summarized in Table 2, DOE received a total of 73 applications, and selected 20 projects for negotiation of awards. However, half of the projects withdrew from the program. As a result, in over nine years only 10 projects were actually implemented.

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Table 2. PPII/CCPI Solicitation Summary Data

	Power Plant Improvement Initiative	CCPI Round I	CCPI Round II	CCPI Round III
Applications Received (Proposed DOE Share)	24 ($251 M)	36 ($316 M)	13 ($1 B)	TBD
Selections for Negotiation	8	8	4	TBD
--In Negotiations	0	1	0	TBD
--Applications Withdrawn	3	3	1	TBD
Cooperative Agreements Achieved	5	4	3	TBD
--Withdrawn After Reaching a Cooperative Agreement	1	1	0	TBD
Cooperative Agreements in Implementation or Completed (DOE Contribution)	4 ($29 M)	3 ($33.5 M)	3 ($277 M)	TBD

- The process for soliciting applications, conducting reviews and selections and negotiating awards was extremely time-consuming. On average it took 24 months from the time that funds were appropriated until the time of the initial award for the first project. Project schedules are summarized in Table 3.

Table 3. Solicitation Schedules/ DOE Cost-Shared Clean Coal Technology Demonstrations

	PPII	CCPI Round I	CCPI Round II	CCPI Round III
Funds Appropriated	October 27, 2000 ($95M)	November 5, 2001 ($150M)	November 10, 2003	December 26, 2007
Solicitation Issued	+3 Months	+4 Months	+3 Months	8 Months
Applications Received	+2 ½ Months (24 applications)	+5 Months (36 applications)	+4 Months (13 applications)	5 Months
Selections for Negotiations	+5 Months (8 projects)	+5 Months (8 projects)	+4 Months (4 projects)	+6 Months (projected)
Initial Award	+9 Months	+13 ½ Months	+15 Months	+12 Months (projected)
Total Time from Appropriations to Initial Award	20 Months	27 ½ Months	26 Months	31 Months (projected)

There is no evidence to suggest this lengthy process will be shortened to accommodate the urgent requirements for climate mitigation and the need to address past programmatic biases towards new plants through an aggressive CCS program for existing plants.

Based on DOE's announced plans for the CCPI Round III solicitation, it will take 31 months from the time that funds were originally appropriated for FY 2008 until financial assistance awards are expected to be finalized. The likelihood that DOE will re-open the solicitation in response to the enactment of the stimulus funds will extend this timeline even further. This lengthy process is especially problematic as CCPI funds are included in the stimulus package which has a goal of rapid implementation.

CCPI Financial Incentive Structure is Inadequate. The federal financial incentive structure of CCPI is based on 50% direct federal cost sharing of eligible project costs, limited to capital costs plus a short term period of demonstration operations (typically start-up, shakedown and perhaps 12 months of operations). In addition, DOE establishes a hard cost cap, no schedule flexibility and no liability protection for the sponsor related to sequestration operations. The 50% cost sharing was incorporated into the 2005 authorization for CCPI; however, the legislation provided administrative flexibility which has not been exercised.[13]

The level of financial incentive afforded by 50-50 cost sharing appears to be a critical issue. To better understand this issue, it is worth reviewing the genesis of the requirement. The concept of 50-50 cost sharing for coal technology demonstration projects was first established in the Clean Coal Technology Program in the 1985. This program was created to demonstrate technologies for reducing the emissions of acid rain precursors. The program was initiated five

13 Section 988 (c)(2) of the Energy Policy Act of 2005 states that "The Secretary may reduce the non-Federal share required under paragraph (1) if the Secretary determines the reduction to be necessary and appropriate, taking into consideration any technological risk related to the activity."

years prior to the passage of legislation that established a national cap and trade program for reducing acid rain.

At that time, the 50% "buy-down" of project costs by DOE was viewed as a sufficient incentive to encourage demonstration project proposals from the private sector. As further incentive, the federal funds for the future year costs of these multi-year demonstration projects was appropriated in advance, giving private participants a degree of certainty as to the reliability of a sustained and expensive partnership with DOE. [14]

This model has been largely carried over in the CCPI demonstration program, and is embodied in the current CCPI Round III solicitation for CCS retrofit technologies. However, the electricity market into which the Clean Coal Technology Program demonstration projects were deployed has changed greatly over the past two decades. In the 1980s and most of the 1990s, the electricity market was characterized by integrated utilities, with franchise service territories, and cost-based rates subject to state regulation. Host utilities were able to pass through to customers their 50% cost share of a demonstration project. In fact, some state commissions created special cost pass through structures specifically for R&D projects.

The current electricity market is no longer vertically integrated, and the generation segment of the industry consists of both regulated utilities and merchant generators selling into a competitive market. Thus the ability of a power generation company to participate in an RRRC technology demonstration program is dependent upon whether the federal financial incentives are adequate to enable the project to sell its power *competitively*. The experience with the delays and cancellations of recent CCPI demonstration projects may reflect structural issues related to electricity market considerations as much or more than DOE administrative impediments. [15]

In recognition of the market-driven rather than cost-driven nature of the electricity market, it is essential that structuring of the federal financial incentive provide a market-based structure. It is also important that the program solicitation and structure do all it can to encourage industry participation in the face of uncertain funding.

DOE has made some movement to address the rigidities of its cost share practices in its 2008 FutureGen solicitation. The solicitation recognizes that a CCS demonstration project will have incremental costs relative to non-CCS project. Subject to a hard cost cap of $600 million per project, DOE has proposed to fund the lesser of the incremental cost of the CCS component or 50% of project costs. This approach, while more creative and flexible, is still inadequate because it assumes a priori: (1) that an IGCC project (without the CCS features) could be deployed into

14 Even by the end of the Clean Coal Technology Program (CCTP), it was becoming evident that the business model was not working effectively. The CCTP program awarded funding to a total of 57 projects, of which only 33 or 58% were completed. Of significant note, all 5 projects receiving awards in the fifth and final round of CCTP subsequently withdrew from the program.

15 The DOE FY 2007 Congressional Budget Request proposed a 90% reduction in CCPI funding, from $49.5 million to $4.957 million, justified due to the need to resolve administrative delays identified in the Program Assessment Rating Tool (PART) due to "…legal issues with contract filing, the private sector's difficulty securing adequate financing for their cost-share, extended negotiations over contract terms, and other issues. Furthermore, the PART review identified potential project management concerns." Despite these findings, the only significant change made in the Round III solicitation was dropping the requirement for a repayment plan.

electricity markets on a competitive basis, and; (2) that project sponsors could demonstrate the CCS features within the cost cap established by DOE.

The House Appropriations Committee Report accompanying the FY 2009 Energy and Water Development Appropriations bill proposes a similar approach. The Report recommends that DOE consolidate the existing CCPI Round 3 solicitation and the FutureGen funding into a single new initiative, the proposed "Carbon Capture Demonstration Initiative (CCDI)." The CCDI would be modeled after CCPI Round III, except that the federal share of eligible costs shall "…not exceed the lower of: (1) the incremental cost of implementing a facility with CCS as compared to a state of the art facility without such technology, or (2) 50% of the total allowable costs for each project." [16]

While this language is helpful, it has two limitations: (1) the "lower of" test may limit the federal share to only the 50% level, especially for retrofit projects, and; (2) it is not clear that eligible new build projects would be able to market power at competitive prices even if the level of federal assistance was set on the basis of incremental cost.

Finally the issue of incremental operating costs needs to be addressed. DOE practice is to offer cost sharing only though a specified demonstration period that encompasses start-up, shake down and testing. Typically, the demonstration period covers a period of about two years from the completion of construction, although in a few past cases, the demonstration period has been extended up to about five years. CCS projects will have high incremental operating costs due to the combination of increased plant O&M associated with capture operations, cost for compression, transport and injection of carbon dioxide, and reduced power plant output. These reductions are both significant and continuing. A short demonstration period likely will be inadequate.

***The Performance Objectives in CCPI are not Sufficiently Flexible*.** The CCPI Round III solicitation represents a major advance toward the needs of demonstrating CCS retrofit technologies. However, the performance specifications established in the solicitation are at the same time narrow as well as far reaching. For example:

- The CCPI Round III solicitation incorporates technical performance requirements for reductions in emissions of criteria pollutants and improvements in thermal efficiency guided by 2020 goals set in the Energy Policy Act of 2005.[17] However, the establishment of the carbon capture goal was set administratively at a "gold" standard level of 90**%** carbon capture. Setting an ambitious performance level is appropriate for an R&D program, but a demonstration program that is intended to accelerate commercial deployment should be governed by cost effectiveness considerations. In a future cap and trade regime, there may be a market for technologies with a wider range of performance levels. One of the principal objectives of the proposed cap and trade program is to establish a price for carbon.

16 "Energy and Water Development Appropriations Bill, 2009," H.R. 7324, Committee on Appropriations, U.S. House of Representatives, Report No. 110-921, December 10, 2008.
17 See Section 402(a)(1)(B) and 402(a)(2) (B), and Table 1 in the CCPI Round III solicitation.

The carbon price level may allow for the cost effective deployment of technologies in some applications that do not have to meet the 90% capture level.[18]

- The solicitation is limited to only CCS retrofit technologies at coal-fired power plants. There may be opportunities to demonstrate technologies for CCS from natural gas fired generation more easily and cheaply than for coal.

- The solicitation specifies that all eligible demonstration projects must capture carbon. Alternatives that reduce carbon emissions through increased thermal efficiency or co-firing are not eligible.

CCPI's Selection Criteria Do Not Favor Commercialization Potential. The CCPI Round III solicitation sets out three sets of evaluation criteria: technical, project management and financial. The criteria are as follows:

Technical
50% - Technology Merit, Technical Plan, and Site Suitability
30% - Project Organization and Project Management Plan
20% - Commercialization Potential

Financial
20% - Adequacy of Funding Plan (i.e. non-federal share)
40% - Adequacy of Financial Business Plan (i.e. project economics)

The solicitation further specifies that the technical criteria will be weighted more heavily in the final selection decisions than the financial criteria. Commercialization potential appears to be undervalued, where such potential is weighted at only 20%. In light of the urgent need to address emissions from existing plants, and the imperatives of the stimulus, commercialization potential would seem to be a more important project differentiator than is currently envisioned in the CCPI solicitation under way.[19]

CCPI Does Not Take Advantage of Flexible Contracting Authorities. The CCPI program model contains a number of rigid contracting procedures that, in effect, make cost control an important end in itself.

The CCPI program uses a Cooperative Agreement as the legal instrument for providing federal assistance. A Cooperative Agreement is a financial instrument that is widely used by DOE to fund R&D projects with non-governmental entities (private industry, not-for-profit entities, and in some cases universities). Cooperative agreements are well-suited for laboratory or small-scale experimental research; they are however an extremely cumbersome contract vehicle for funding large projects that are intended to demonstrate the commercial viability of technologies that, while designed to meet public goods, will be used by industry in the private marketplace.

18 For example the Section 48a and 48b investment tax credits for coal based CCS investments, recently authorized in the Energy Improvement and Extension Act of 2008, require a minimum of 65% carbon capture.
19 The 2005 CCPI authorization legislation would appear to support the adoption of more market-oriented selection criteria. Section 402(d) of the Energy Policy Act of 2005 directs the Secretary to make selections that, in addition to technical performance, "…achieve overall cost reductions…improve the competitiveness of coal…and demonstrate methods and equipment that are applicable to 25 percent of the electricity generating facilities."

Examples of the types of restrictions applicable to cooperative agreements include:

- ***Eligible costs***: The cooperative agreements incorporate the use of cost principles from the Federal Acquisition Regulation (FAR). These principles were established largely to govern federal government acquisition of goods and services and not commercial projects ultimately owned and operated by private entities. Companies that perform government contracting services as their main line of business have developed the necessary capabilities for FAR compliance; FAR requirements however can impose high transaction costs on private firms that only have a single federal financial assistance award.

- ***Cost sharing***: In addition to the problems with cost sharing as a conceptual framework for federal financial assistance, as a matter of practice, DOE's cost sharing requirements are implemented in a very stringent manner. For example, DOE establishes a hard cap on the federal cost share at the time of the financial assistance award when project development costs are partially or largely unknown; there is no way to estimate costs with any degree of precision.

  Also, federal and non-federal cost shares must be maintained throughout each stage of the project, providing no flexibility for the private sector partner to utilize different financing vehicles for planning, design, construction and operation. Finally, although authorized to cost share up to 25% of cost escalation, DOE policy makes cost share on escalation unallowable; this places 100% of the cost risk on the private sector party, creating an unreasonable allocation of risk for first-of-a-kind demonstrations of a new technology.

- ***Reimbursement and Audit Procedures***: DOE funds are provided only on the basis of cost reimbursement and in many cases only after audits by DOE. The solicitation does not permit more business-like practices such as draw schedules or use of third party audits to avoid delays in scheduling government audits.

- ***Schedule Flexibility***: the solicitation allows for no changes in project implementation schedules from those established at the time of the award of the financial assistance. DOE reserves the right to make unilateral changes in schedule, but the project sponsors are prohibited from even requesting modifications to the schedule. This requirement is much more onerous than commercial contracting practices, which allow for mutual renegotiation of project schedules, with appropriate changes in compensation, including liquidated damages, as necessary.

CCPI Has No Sequestration Liability Framework. A significant omission in the CCPI Round III solicitation is the lack of any framework for addressing liability issues associated with geologic sequestration.

The solicitation requires that the project sponsor provide full indemnification of DOE, leaving 100% of sequestration liability risk with the project sponsors**.** Projects that propose to place captured carbon into CO_2 pipelines for use in enhanced oil recovery (EOR) operations may be able to accept full liability risk, since EOR is well established and there is an existing network of

pipeline and other facilities to handle the CO_2. However, the CCPI restriction is a serious impediment to CCS projects that may wish to demonstrate storage or sequestration of CO_2 in other geologic media.

The federal government has yet to establish regulations for geologic sequestration, and only a few small scale experiments are currently underway. This is problematic for existing programs; the DOE Regional Carbon Sequestration Program is currently encountering serious impediments due to the lack of a viable strategy for addressing the liability associated with geologic carbon sequestration. A recent survey of 19 of the 25 Phase II geologic sequestration pilot projects for which data was available found that:

- 11 of the 19 projects (60%) reported significant legal issues. Legal issues related to liability have caused one project to be cancelled, and have delayed others;

- The time devoted to non-research functions (legal, permitting, administrative) ranged from 5% to as high as 90% of overall personnel time where significant legal issues were encountered; and

- The prevalence of legal barriers for RD&D projects were encountered for projects with relatively small injection volumes, "…even where risks associated with health and safety, property damage, and CO_2 leakage were widely acknowledged by stakeholders to be negligible." [20]

This study recommended legislation to provide a liability shield for research organizations, along with government indemnification to protect property rights holders, parties granting consent to projects and third parties who may be affected by CCS research.[21] The liability shield and indemnification provision could be limited to non-EOR sequestration, and in particular, geologic sequestration in saline formations which lack the economic incentives associated with EOR applications.

Absent such protection, opportunities to conduct sequestration RD&D activities in geologic formations may be severely restricted. The explicit refusal of DOE to provide any liability protection in the CCPI Round III solicitation may prove to be penny-wise, pound-foolish, since sequestration in geologic formations represents the largest potential source for carbon storage.

The potential for sequestration issues to impede RRRC technology demonstrations cannot be ignored, especially when the CCPI Round III solicitation explicitly ties capture to sequestration. Currently, CCPI Round III and the Regional Carbon Sequestration Partnerships Program are separate endeavors; linkages are clearly needed. The Round III solicitation states that "DOE is interested in allowing demonstration projects under CCPI to integrate with the sequestration field tests…" but the integration is left to the project participants; there is neither any process under the solicitation, nor any special incentives, to facilitate such integration.

20 "Advancing Carbon Sequestration Research in an Uncertain Legal and Regulatory Environment: A Study of Phase II of the DOE Regional Carbon Sequestration Partnerships Program, "Craig A. Hart, Harvard Kennedy School, Discussion Paper 2009-01, January 2009.
21 Ibid, p21.

Program Drivers for an Expanded and Accelerated RRRC

To date, DOE has focused largely on the development of technologies for new power generation applications and funding has been allocated primarily to coal gasification based technologies. While important for meeting long-term climate mitigation goals, IGGC plants will not likely be developed or widely deployed for some time; DOE's flagship research program in this area has been delayed and restructured and the investment community continues to express skepticism about the viability of IGCC.

This strategy needs to be revised in view of the national priority that has been assigned to achieving national and international reductions of greenhouse gas emissions; there is an urgent need for development and demonstration of technologies that can reduce or sequester carbon emissions from the current fleet of pulverized coal plants.

New, lower cost technology solutions are needed to help reduce the cost of compliance with likely future greenhouse gas emissions targets. The President's FY 2010 budget proposes a national cap and trade program that would reduce emissions by 14% by 2020. The budget assumes that the program would be implemented through auctions that would create a carbon price of about $20 per ton through FY 2019. There is no information currently available as to the possible carbon price path beyond FY 2019.

Current estimates show that retrofitting CCS technologies to existing coal plants have an avoided cost of $67-111 per ton.[22] Absent new technology solutions, two adverse and related outcomes could occur:

- Without sufficient lower cost CCS options, compliance with the caps will not be achieved through retrofit of existing fleets; a large fraction of the current 314 GWe coal fleet will become uneconomic and non-compliant and may have to shut down.

- If there are insufficient compliance options available to meet the reduction targets at the President's budget estimated auction price level, the market clearing price for carbon allowances could driven up to levels of 3-4 times the levels projected in the President's FY 2010 budget.[23]

Time is of the essence. The President's budget projects that the carbon cap, and associated auctions, could begin as early as FY 2012. Capital investments in base load power generation

22 "Near-Term Technologies for Retrofit CO_2 Capture and Storage of Existing Coal-fired Power Plants in the United States", Dale Simbeck and Ms. Waranya Roekpooritat, Discussion Paper prepared for MIT Symposium on Coal Retrofit Technology, March 2009. A 2007 Report by the Congressional Budget Office, "The Potential for Carbon Sequestration in the United States," estimated the cost of CCS for both new and existing plants in the range of $20-90 per ton, for sequestration in geologic media. A 2008 McKinsey study, "Carbon Capture & Storage: Assessing the Economics", estimated between $38-57 per ton of CO_2 abated for its reference plants, though it put the cost for early demonstration projects at $77-115 per ton.

23 The FY2010 Budget conservatively assumes option prices of about $20 per ton. This results in net revenues, after the proposed set aside for clean energy technologies, of $525.7 billion over the ten year budget horizon through FY2019. This number appears to have been carefully matched to the revenue loss estimate $536.7 billion for the proposed extension of the Making Work Pay Tax Credit, which is the proposed mechanism for recycling climate revenues. The budget appears to anticipate that auction prices could be higher and states "all additional net proceeds will be used to further compensate the public."

have long lead times; 3-4 years for new natural gas combined cycle, five years or more for new coal-fired generation and 8-10 years for new nuclear generation. Further, companies need to start the process of adopting expansion plans; this should be based on the best available information. It is worth recalling that the Clean Coal Technology Program was started five years prior to the passage of related provisions in the Clean Air Act, providing technology options for meeting the requirements of the law.

The current DOE carbon capture R&D program is planned to complete testing at pilot plant scale by 2012 and begin providing performance and cost data at commercial scale by 2020. The schedule for achieving commercial scale projects needs to be substantially accelerated, and the "bandwidth" of data from demonstration facilities needs to be significantly expanded.

The sequestration R&D program should proceed in parallel with the RRRC Demonstration Program to validate the technical feasibility of large scale geologic sequestration. To date, DOE has devoted significantly more resources to sequestration research, and the seven existing regional partnerships are close to initiation of Phase III larger scale field tests. Current estimates suggest that the cost of carbon capture comprise 50% or more of the total cost of CCS, and unlike the regional partnership activity, geology is a secondary driver for a retrofit program; plant type and age, current emissions controls, capacity factors, age, etc., are much more relevant considerations, although proximity to sequestration sites should also drive project selection and development.

In short, cost, time, urgency, the nascent state of the research, historical performance of related DOE programs, and the pending legislative agenda necessitate serious consideration of an alternative management model.

New and Improved Management Models for an RCCC Program

For discussion purposes, we examine two possible enhanced research management models – a DOE model that seeks to take maximum advantage of the current statutory framework and administrative flexibility available to DOE, and a new government corporation as an entity that would assume program responsibility for RRRC technology demonstration and commercialization activities.

Enhanced DOE Management Model: The enhanced DOE management model would build upon the CCPI program model and specifically address the problems discussed in this paper. The principal elements of the model include:

- *Program Objective*: to develop the technology base to enable business decisions on RRRC technology deployment in 2015. Having RRRC technology options ready for deployment decision by mid-2015 will enable existing plants to make material contributions to achieving 2020 interim reduction targets in the proposed cap and trade program.

- *Program Scope and Implementation strategy*: An RRRC program should support multiple commercial scale (or scalable to commercial scale) demonstration projects, in parallel, on an accelerated basis. The scope of the program would include pre-combustion, oxy combustion and post combustion carbon capture technologies, carbon

efficiency improvement and renewable co-firing technologies. The technologies would be either for retrofit applications to existing boilers or repowering applications that would include boiler replacement. The technologies could be demonstrated on a variety of coals, or on natural gas. A representative suite of technology options is illustrated in Table 4.

- *Technical Performance Objectives*: Technologies that achieve significant reductions in or avoidance of carbon dioxide emissions would be eligible. No specific numerical targets would be set. Instead, decisions on the technical performance levels of proposed technologies would be based on an assessment of the size of the technology's market potential under a cap and trade program, weighted against the availability or expected availability of affordable, higher performing options.

- *Program cost*: It is estimated that the total cost of the proposed demonstration program for the identified suite of technologies would be up to $15 billion depending upon the number of demonstrations and the level of federal financial incentives.

- *Greater project collaboration and less competition at the demonstration stage*: RRRC technologies for retro-fit, refurbishment, re-powering and co-firing would be demonstrated in parallel. Theoretically, this would lower the competitive pressures as a larger set of winners would be supported in efforts to meet the specific needs of individual plants, and utility fleets. It would also bring a broader range of research participants into the process. DOE should actively promote greater collaboration in project proposals. Robust participation across industry, universities and national laboratories will supply a form of peer review and will help ensure rapid dissemination of results. The competitive stage will occur when successfully demonstrated technologies compete for commercial deployment. More demonstration projects, each with a broader mix of collaborators, will lead to greater market competition and lower compliance costs in the future.

- *Structure of Federal Financial Incentives*: Federal financial assistance would be awarded as a combination of direct assistance, loan guarantees and tax credits. A single application process would be established to allow for consideration of the whole federal financial assistance package. The overall level of federal financial assistance would be established on the basis of the need to "buy-down" the project costs in order to sell electricity on a competitive basis.

- *Project Evaluation Criteria*: New evaluation criteria would be established that would provide greater weight to commercialization potential.

- *Expedited Application Evaluation Process*: The current DOE evaluation process can be expedited by separating the technical and financial reviews into two separate processes, and bringing outside experts into the both evaluations:

    - The technical review would be led by DOE personnel, with the advice and assistance of an outside technical review panel, modeled after NSF and NIH peer review panels, to advise DOE on the relative technical merits of proposals.

- The financial review would be conducted by DOE with the advice and assistance of commercial project finance experts.

- *Corporate Decision-making Model:* The broader objectives of the proposed RRRC demonstration program are more amenable to a Board of Directors decision-making model, rather than the Source Selection Authority model used for R&D solicitations. A DOE Selection Board, modeled after the DOE Credit Review Board, would ensure that the final selections reflected the perspectives of senior Departmental officials with expertise in science, technology, policy, environmental and financial matters.

- *Form of federal financial assistance instrument*: For spending assistance (direct awards and loan guarantees), a single federal financial assistance instrument would be developed, using authorities currently available to DOE for Other Transactions Authority and the Title XVII loan guarantee authority.

- *Conditional and Final Awards*: In order to expedite contract negotiations, reduce risk and diminish the potential for unrealistic conditions, DOE would enter into "conditional awards" to include provisions to protect the government's interests while outstanding terms and conditions are being finalized. Conditional awards could allow for a "draw" of up to 10% of the federal assistance during the period of conditionality, so that project planning and design activities could proceed while remaining issues are resolved. Each award would contain a hard cap on federal assistance, but the cap would be established at the time that detailed design is at least 50% complete.

- *More Flexible Demonstration Period*: The length of the demonstration period should reflect market conditions as well as technical considerations. In particular, the length of assistance should allow for a transition where the enactment of a mandatory greenhouse gas reduction program begins to establish a price signal for carbon. Terminating federal assistance for a CCS demonstration project while the market price of carbon is zero virtually guarantees that the project will not be able to sell electricity under competitive terms.

- *Cost accounting, controls and accountability*: Strict cost accountability would be maintained, using commercial practices rather than standard government procurement practices.[24] The project sponsors could utilize established commercial cost accounting, control and audit procedures, subject to DOE review. DOE payments to the project would be based upon a negotiated draw schedule.

- *Central Reserve Fund*: Project awards would allow for contingencies, consistent with normal business practices. In addition, DOE would establish a central reserve fund, not to exceed 20% of the cost of the program, to manage any cost and schedule related issues outside of normal contingencies. DOE's exercise of the central contingency fund would be subject to special reporting to OMB and Congress.

24 The standard FAR restrictions on unallowable costs specified in 48 CFR 31.205, such as advertising, entertainment, fines and penalties, lobbying, etc. would still apply.

- *Carbon Sequestration Liability*: In order to expedite the demonstration of carbon capture technologies, DOE should consider options that provide greater flexibility to project sponsors.

    - One option is to allow project sponsors to demonstrate initially carbon capture only, deferring a decision on carbon sequestration until such time as the carbon capture technology is successfully demonstrated and a federal regulatory and liability scheme for carbon capture is in place.

    - Another option is for DOE to indemnify demonstration program participants from any liability for geologic carbon sequestration liability so long as the participants can demonstrate compliance with applicable federal and state sequestration regulations and permitting requirements in effect at the time of the project award. DOE indemnification would be transferable to any future national carbon sequestration liability protection regime.

Table 4. Technical Specifications for the RRRC Demonstration Program

PRE-COMBUSTION CCS

Candidate Units	**Older, smaller coal units** **Existing gas turbine units**
Demonstration Size	**About 200 Mw_e**
Coal Type	**Varies (depending on gasification technology)**
Demonstration	**Repower existing generator with IGCC**
Candidate Technologies	**GE** **E-Gas** **Siemens** **Shell**
Number of Demonstrations	**3**
Alternative Configuration	**Industrial polygeneration demonstration**

OXY-COMBUSTION

Candidate Units	**Moderately old sub-critical PC without SO_2 and NO_x controls**
Demonstration Size	**300-500 Mw**
Coal Type	**Low-sulfur**
Demonstration	**Repowering of unit to supercritical PC with Oxy-combustion**
Candidate Technologies	**Alstom** **B&W**
Number of Demonstrations	**2**

POST-COMBUSTION DEMONSTRATION PROGRAM

Candidate Units	**Newer supercritical PC units equipped with FGD and SCR**
Demonstration Size	**200-500 Mw_e**
Coal Type	**Various**
Demonstration	**Retrofit CCS to existing facilities**
Candidate Technologies	**MHI hindered amine** **Fluor MEA** **ABB Lummis MEA** **ConSolve improved amine** **Alstom chilled ammonia** **PowerSpan ammonia**
Number of Demonstrations	**3-6**

New Government Corporation Model: The management model described above also could be implemented through the establishment of a new Government Corporation whose mission included the demonstration and commercialization of RRRC technologies.

There have been a number of proposals to establish a new government corporation to accelerate the pace of energy technology commercialization. These proposals are based on a belief that the current Department of Energy is not capable of successfully executing a major technology demonstration and commercialization program.

The MIT Coal Study proposed the establishment of a Clean Coal Demonstration Corporation. Referring to the proposed CCS technology demonstration program, the MIT Report noted that "…DOE has limited capability to carry out such a task: its staff has little experience with commercial practice, it is hampered by federal procurement regulations, and it is constrained by an annual budget cycle." [25]

A 2008 Report by the Center for American Progress recommended an Energy Technology Corporation to manage demonstration projects across all technologies, including carbon sequestration. The Report stated that; "It is particularly important to foster effective government/industry collaboration on demonstration projects because the purpose of such projects is to establish commercial feasibility. Too often, the commercial potential of demonstration projects is obscured by the involvement of federal agencies and their restrictive federal procurement requirements, government-loan repayment procedures, and concerns about intellectual property rights. As a result, the market is not convinced of an effective demonstration of technology and private industry does not get the information it needs from the demonstration to make investment decisions." [26]

These concepts have been embodied in legislation proposed by Senator Bingaman, former Senator Domenici, and Representative Inslee. Table 5 contains a summary of several of these proposals. These proposals have two principal motivations: (1) that the current DOE is not capable of instituting the types of structural and process reforms needed to rapidly respond to the climate challenge, and; (2) a government corporation provides a more flexible structure to manage quasi-business activities.

25 "The Future of Coal: Options for a Carbon-Constrained World," Dr. James Katzer, Executive Director, MIT, 2007, pp 101-102,

26 "A New Strategy to Spur Energy Innovation," Peter Ogden, John Podesta, and John Deutch, Center for American Progress, January 2008.

TABLE 5. SUMMARY OF GOVERNMENT CORPORATION PROPOSALS

MIT

THE FUTURE OF COAL: OPTIONS FOR A CARBON-CONSTRAINED WORLD, MARCH 2007

Scope	3-5 carbon capture demonstration plants (250-500 Mw_e scale) and 3-5 sequestration demonstration projects (1 million MT/year scale)
Method of Support	Purchase of CO_2 through reverse auction under multi-year take or pay contracts
Management	Quasi-public corporation ("Clean Coal Demonstration Corporation")
Budget	$5 billion over 10 years
Financing	Direct Federal appropriation or small charge (less than $0.5 million per kWh) on coal-fired generation

PEW CENTER

A PROGRAM TO ACCELERATE THE DEPLOYMENT OF CO_2 CAPTURE AND STORAGE: RATIONALE, OBJECTIVES AND COSTS, OCTOBER 2007; AND,

A TRUST FUND APPROACH TO ACCELERATING DEPLOYMENT OF CCS: OBJECTIVES AND CONSIDERATIONS, JANUARY 2008

Scope	10-30 commercial-scale demonstrations of CCS over 10- to 15-year period; staggered deployment schedules to gain from "learning by doing" and 5-10 large-scale demonstrations of storage (primarily in saline formations)
Method of Support	Cost reimbursement for CCS capital and operating costs, including reimbursement for reduction in generation output due to CCS operation
Management	CCS Trust Fund, not subject to annual appropriations, managed by a quasi-public or private entity
Budget	$8-30 billion total; $0.8-1 billion per year (2006 $)
Financing	$0.4-0.5 mills per kWh fee on coal-based generation

EPA, CLEAN AIR ACT ADVISORY COMMITTEE (CAAC)

ADVANCED COAL TECHNOLOGY WORK GROUP, JANUARY 2008

Scope	5-10 early commercial CCS facilities over 5- to 10-year period
Method of Support	Payment of incremental costs of CCS through reverse auction
Management	Quasi-Governmental entity managing a quasi-Governmental fund
Budget	$5 billion minimum ($1 billion annually for 5 years), extendable to 10 years
Financing	Three options: 1. Charge on fossil fuel generation 2. Use of proceeds from the auction of allowances 3. Industry contributions

H.R. 6258 –BOUCHER BILL

CARBON CAPTURE AND STORAGE EARLY DEPLOYMENT ACT, JUNE 2008

Scope	Large-scale demonstrations of CCS over 10-year period
Method of Support	Competitive grants and contracts and purchase of CO_2 through reverse auction and recovery of compliance costs
Management	Carbon Storage Research Corporation; private, off-budget entity, established as division or affiliate of Electric Power Research Institute via industry association referendum among fossil fuel-based electricity distribution utilities (those representing 2/3 total fossil fuel-based electricity delivery); corporation dissolves after 15 years
Budget	$1-1.1 billion per year
Financing	Assessment on fossil fuel-based generation: Coal: $0.43 mills per kWh Natural gas: $0.22 mills per kWh Oil: $0.32 mills per kWh

Federal policy on the use of quasi-government corporations is somewhat vague. President Truman was the first President to attempt to establish a federal policy on the formation of government corporations, stating that "Experience indicates that the corporate form of organization is peculiarly adapted to the administration of government programs which are predominantly of a commercial character…" [27] The most recent statement of federal policy was a Clinton Administration OMB Memorandum, "Specifications for Creating Government Corporations" that created a process for OMB review of government corporation proposals. [28] The guidance defined a three part analysis:

- First – is this a businesslike enterprise?
- Second – Why not privatize?
- Third – Should the entity become a government corporation? This requires three findings: (1) the entity is sufficiently businesslike, (2) it cannot privatize immediately, and (3) it would function better as a corporation than under other alternatives.

In view of DOE past performance in managing large capital projects, and in particular, in the implementation of the CCPI program, there is a strong case to be made for vesting the RRRC technology demonstration program activities in a new organization. With respect to the program design specified above, a new government corporation likely would be superior to the current DOE organization in three areas:

- *Management personnel:* the increased flexibility to attract and retain high quality program managers (and out-place poor performing managers) makes the government corporation more attractive that the current DOE.

- *Financial Flexibility*: the program model described above requires a more sophisticated and flexible approach in fashioning a package of federal financial incentives tailored to each project. A government corporation would more likely have a more complete financial "tool box" and the capability to use it to support individual demonstration projects.

- *Carbon sequestration liability management:* An RRRC demonstration program will be a path breaking effort, and will require agility and creativity in addressing liability issues. In fact, it is likely that the experience gained from an accelerated RRRC demonstration program will inform the development of future regulatory and liability management schemes. The types of challenges that could be encountered likely could be better managed through a new government corporation than the existing DOE.

Programmatic features of three alternative research program models – CCPI Round III, an "Enhanced DOE Model" and a "New Management Model" – are seen in Table 6.

27 U.S. Congress, House Document No. 19, 80th Congress, 1st Session, 1948, pp. M57-61.
28 "Memorandum for Heads of Executive Departments and Agencies on Government Corporations," U.S. Office of Management and Budget, M-96-05, December 8, 1995.

Table 6. Comparison of CCS Technology Program Management Models

	Current CCPI Business Model	Enhanced DOE Business Model (Existing Authority)	New Management Entity (New Legislation)
Decision-making Programmatic Project-Specific	Secretary/Assistant Secretary Source Selection Official	 Secretary/Assistant Secretary Credit Review Board Model	 Board of Directors/CEO Board of Directors/CEO
Application review process	Reviews by DOE personnel with Limited use of consultants; Sequential review by NETL and DOE/FE/HQ	External peer review panels modeled after NSF and NIH (and subject to appropriate non-disclosure and conflict of interest). If necessary, DOE can utilize parallel review teams to ensure consistency.	External peer review panels modeled after NSF and NIH (and subject to appropriate non-disclosure and conflict of interest). If necessary, DOE can utilize parallel review teams to ensure consistency.
Federal Personnel	All program personnel subject to federal personnel requirements	All program personnel subject to federal personnel requirements	Program management staff can be hired without federal personnel restrictions, and can be limited term appointments (similar to NSF and Sematech)
Funding Mechanism	Cooperative Agreements	Other Transactions Authority (OTA)	Cost-sharing, equity investments, loans, loan guarantees, securitization, insurance
Coordination of financial incentives	Three separate application and decision-making process for cost sharing, loan guarantees and tax credits	Single application and review process within DOE for cost-sharing and loan guarantees; DOE coordination with Treasury to provide seamless interface with the applicant on tax credit	Single application and review process, with seamless interface with Treasury on tax credit issues
Eligible and ineligible costs	FAR cost principles	Generally accepted business practices; FAR ineligible costs would still apply	Generally accepted business practices; FAR ineligible costs would still apply
Cost Controls	Cost cap established at time of award; no cost sharing of cost overruns	Cost cap established when project achieves at least 50% detailed driven, but prior to construction; sharing of limited cost increases	Cost cap established when project achieves at least 50% detailed driven, but prior to construction; sharing of limited cost increases
Cost Sharing	At least 50% non-federal cost sharing and within budget period	Waivers permitted based upon technology risk; size of sponsoring company and potential benefit of the technology	Waivers permitted based upon technology risk; size of sponsoring company and potential national benefit of the technology
Schedule Controls	Project sponsor is not permitted to request a schedule extension. DOE may in its sole discretion extend the schedule by up to four years	Project sponsor is not permitted to request a schedule extension. DOE may in its sole discretion, extend the schedule by up to 4 years.	New entity can establish appropriate incentives or disincentives to encourage timely completion of projects
Audits	DOE Audits (Through DCAA)	3rd Party audits	Audits conducted by new entity or by 3rd parties
Intellectual Property Rights			New entity can negotiate rights commensurate with level of investment
Liability	Applicant indemnifies the government for any project-related liability	DOE provides liability protection From geologic sequestration activities conducted in conformance with EPA VIC permits; DOE establishes reserve fund to cover liability	DOE provides liability protection from geologic sequestration activities conducted in conformance with EPA VIC permits; DOE establishes reserve fund to cover liability

Funding Mechanisms

As stipulated, adequate and sustained funding is essential for the success of the proposed RRRC demonstration program.

The current CCPI program receives annual appropriations, and each of the three CCPI solicitations to date have been fully funded—i.e. DOE had funds on hand from current or past appropriations at the time the cooperative agreements were finalized. Thus recipients did not need to be concerned about the risk if future appropriations were not provided.

The downside of this approach was that the total size of project awards was limited by the level of appropriations that could be provided on a lump sum basis in a single appropriations bill. Both CCPI Round I and CCPI Round II were funded in this manner. CCPI Round III promises to be the largest solicitation to date, with a total federal funding pool of up to $1.5 billion, cobbled together from unspent funds from prior solicitations, FY 2008 appropriations, stimulus funds, and the FY 2009 Omnibus Appropriations Act. However, this result was obtainable only through a unique combination of events that likely will not be replicated. Moreover, the Obama Administration goal to reduce the federal deficit by 50% over the next four years means that there will be increasing pressures on future appropriations levels -- another funding mechanism is needed.

Such a mechanism is found in the clean energy technology funding mechanism proposed in President Obama's FY 2010 budget which would set aside $15 billion per year ($150 billion over ten years) from receipts from the proposed cap and trade program. There is however, a timing problem.

Because the first auctions are not proposed until FY 2012, the new $15 billion funding mechanism would not begin until then. This funding-phase problem could be resolved if DOE were authorized to borrow up to $15 billion from the Treasury, effective the beginning of FY 2010, with revenues from the proposed cap and trade program pledged for repayment as they are received. This amount represents only 10% of the proposed set aside for clean energy technology, but would provide a large and secure funding source to quickly initiate the CCS retrofit demonstration program and enable it to attract a robust set of research partners. Although there are many details to be resolved over the cap and trade legislation, it seems highly likely that some form of mandatory program for carbon dioxide emission reductions will become law in the relatively near future.

A final alternative to provide adequate and sustained funding for the CCS retrofit technology demonstration program is to establish a new dedicated funding source for the program. The most obvious source of funding would be a new fee imposed on coal production with proceeds dedicated to the funding of the RRRC technology program.

The issues surrounding the establishment of a fee were addressed in detail in a two-part study by the Pew Center in 2007.[29] The study recommendation contained three key components:

29 "A Trust Fund Approach to Accelerating Deployment of CCS: Objectives and Considerations," Naomi Pena and Edward S. Rubin, Pew Center on Global Climate Change, January 2008.

- establishment of a Trust Fund, managed by a quasi-public or private entity;
- a dedicated funding source from a new fee of 0.4-0.5 mills per kwh on coal-based generation; and
- independence from annual appropriations.

These concepts were embodied into legislation (H.R. 6258) introduced in by Rep. Rick Boucher in 2008. The details of the Pew recommendations and the Boucher bill are shown in Table 5.

While the fee concept has a sound policy rationale—internalizing the cost of developing CCS controls within the price of coal—the concept has significant political controversy. The utility industry supported the legislation, provided that the fee could be passed through in rates charged to customers. However, this in turn generated opposition from members of Congress concerned about the appearance of imposing a new albeit small tax on consumers, especially in view of the severe economic downturn.

Management Model for the "Over the Horizon" RRRC Program

Separate from the near term demonstration program, there will be a need for continuing basic and applied research to support and accelerate RRRC technology development as well as to conduct analytical work to support the program.

The R&D requirements likely will fall into two areas: further evolutionary process improvements to existing RRRC technologies and R&D on novel and potentially breakthrough opportunities. These structure, participants and requirements of these two R&D activities are very different, both from each other as well as from those for RRRC demonstration projects. As such, they should be managed separately.

The evolutionary R&D activity can be managed through the current DOE Office of Fossil Energy coal technology R&D programs. The Office of Fossil Energy has long experience in managing this type of R&D activity. Moreover, the evolutionary R&D program can be more easily controlled, in terms of scope of work and program schedules, to fit within alternative annual budget profiles.

The potentially breakthrough research requires a different, and separate, management structure. This type of research would be an ideal candidate for inclusion with the DOE Advanced Research Projects Agency—Energy (ARPA-E). ARPA-E, designed to replicate where possible, the successful DARPA program at DOD, is currently being stood up at DOE. Features of the new program focus in large part on process -- relative freedom from the restrictions and requirements under which most federal research programs operate including burdensome contracting, reporting, and oversight orders and regulations, low pay grades, the rigidities of the civil service system, and multi-leveled management hierarchies. Other features will likely include:

- A small, relatively non-hierarchical organization
- Flexible hiring and contracting practices that are atypical of the federal government
- The ability to hire quickly from the academic world and industry at wages substantially higher than those of the federal workforce
- Short tenures, turnover of personnel enabling fresh leadership and ideas on a continuous basis
- A lean, effective, agile – and largely independent – organization that can stop and start targeted programs based on performance and …relevance

- A focus on creative, out of the box transformational research that could lead to new ways of fueling the nation . . . as opposed to incremental research on ideas that have already been developed
- Longer-term research funding in a highly flexible program – risk taking

ARPA-E received an appropriation of $400 million in the stimulus legislation, and likely will receive additional annual appropriations in future years. It is proposed that $40 million, or 10%, of the ARPA-E funds be allocated to R&D focused on breakthrough opportunities in RRRC. This program would be directed by a senior program manager, assisted by a small staff of individual project managers.

In keeping with the general philosophy of the ARPA-E approach, the senior program manager or the individual project managers of both could be scientists or research managers on term appointments or loans to DOE. ARPA-E could develop individual R&D projects drawing from the concepts and ideas presented in the accompanying paper on over-the-horizon research opportunities. In addition, the ARPA-E program, with its greater agility, would be empowered to seek scientific breakthroughs through, for example, the intersection of conventional carbon chemistry with new developments in nanotechnology-based separations, or biochemistry and other cutting-edge technologies. The objective would be to seek out the "home run" opportunities, and cut losses early.

The initial $40 million endowment for a program of breakthrough research in RRRC technology could provide the momentum for the first 1-2 years of research projects. Additional funding likely would be needed beginning in the FY 2011 federal budget cycle.

The drawback to this approach for which there would be three different programs dedicated to meeting the same of similar objectives is governance. DOE has a long history of stove-piped programs and a poor track record for managing cross-cutting issues and programs. There would need to be a coordinating mechanism for RRRC programs; to be effective, it should report to one of the top leaders of the Department, not lower than the appropriate Undersecretary with broad jurisdiction over energy research.

Conclusion

We posed several questions at the beginning of this discussion and would like to re-visit them to summarize this analysis.

- Is there an optimal program model to enable rapid development and deployment of technologies necessary to meet program objectives?
- Can such outcomes be accommodated by existing programs at DOE? If so, which one(s)?
- What existing authorities might DOE employ to meet the objectives of such an effort? Are these authorities adequate or being utilized to the maximum extent practicable?
- Is an entirely new program necessary? If so, are new authorities required or are existing organic statutes adequate for addressing the requisite tasks of such a program?
- Are there structural, personnel and/or standard operating procedures at DOE that might impede timely achievement of program objectives?

Climate imperatives, coupled with the need for affordable electricity supplies and historical program bias, make an RRRC program an urgent necessity. The focus of the current CCPI Round III solicitation would address some but not all of the needs for RRRC technology development. Further, the inflexibility of the requirements of the Round III solicitation, coupled with historical DOE practice, severely inhibit a rapid, comprehensive and robust response to RRRC technology development.

This paper recommends a fundamentally different approach to RRRC demonstration program, as compared to the current CCPI Round III solicitation:

- A commercial, rather than a technical demonstration program
- A program with a broad scope to demonstrate multiple technologies in parallel, and allow the competition at the deployment stage.
- A program that presumes enactment of a mandatory greenhouse gas emissions reduction program, with targets and timetables similar to those proposed in the President's FY 2010 budget, and a planned transition from demonstration into compliance mode of operation.
- A demonstration program based on cost effectiveness considerations rather than technology-forcing requirements
- Federal assistance packages that take into account competitive market pressures rather than stringent but arbitrary cost caps
- Financial assistance agreements based on commercial terms and conditions rather than government procurement restrictions.

The recommended strategy can be implemented using the current CCPI demonstration program as the starting point. However, significant changes in CCPI III would be essential for accommodating the time drivers, the need for enhanced flexibility, and the expanded as well as more focused scope of an RRRC Program. Changes that could be made absent any additional authorities should include:

- an expanded scope which allows for efficiency and co-firing technology demonstrations, as well as demonstration of technologies to mitigate CO_2 emissions from gas-fired power generation;
- change selection criteria to add weight to commercialization possibilities;
- utilization of existing authorities, most specifically "others transaction authority" that could ease contracting impediments associated with cooperative agreements and rigid compliance with the FAR;
- the creation of single financial assistance package for proposal winners;
- additional contract term flexibility including conditional awards, a central reserve fund for unanticipated costs, allowance for use of industry accounting practices and systems, etc.;
- de-coupling of the capture and sequestration requirements of the solicitation, or interim provision of liability protection for geologic sequestration; and
- funding of novel RRRC concepts from the ARPA-E program, recognizing that this would create a need for a high-level coordinating body within DOE to ensure that different RRRC efforts are complementary and not duplicative

Such changes could begin with the anticipated re-opening of the current CCPI Round III solicitation, and could be expanded into a future solicitation in 2010. More fundamental change requires new legislation, most importantly:

- establishing a separate government corporation. While this could ultimately be the best option for successful commercialization of demonstrations, it has a severe timing drawback; it requires new statutory authority and would involve significant startup delays. Consideration of this option in parallel with CCPI Round III is recommended.

Congressional consideration of legislation to authorize the establishment of a new "clean energy" financing authority appears likely in 2009. However, even if such legislation is enacted in 2009, it is likely that the activation of a new quasi-government entity for financing new clean energy technologies may take at least 12, and more likely 18 months. Thus, a new entity may not be operational until sometime in 2011. Timing considerations suggest the need for a parallel strategy of optimizing current DOE processes in tandem with the consideration of a new structure and process outside of DOE.