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A Collaborative Project to Develop Technology to Capture and Store CO_2 from Large Combustion Sources

Abstract

A major collaborative technology development project has been undertaken by nine international energy companies to develop breakthrough technologies to substantially reduce the cost of CO_2 capture and geologic storage. Prior studies by the companies demonstrated the need to achieve major reductions in the cost of plant and facilities to capture CO_2. Additionally, industry must be in a position to demonstrate to interested stakeholders, that procedures and practices are in place to safely store CO_2, and to measure and verify large quantities of CO_2 injected into geologic formations.

BP, Chevron, ENI, Norsk Hydro, PanCanadian, Shell, Statoil, Suncor, and Texaco have come together to form the CO_2 Capture Project (CCP), recognizing the advantages in pooling resources, experience and innovation, to make delivery of the needed technology more efficient and to provide the best opportunity for success. The project will develop technologies to the 'proof of concept' stage by the end of 2003. While each of these companies is engaged in a portfolio of actions aimed at providing options to reduce GHG emissions, the CCP project represents a substantial part of each companies individual ongoing programs.

This paper discusses the project's importance to BP, the project's progress to date, and a view of what is planned in the coming months.

Introduction

BP has made commitments to reduce emissions of greenhouse gases (GHG's) from its operations. In simple terms, we will reduce our emissions to a level 10% below our 1990 baseline by the year 2010. Managing the impact we make on the environment is an important aspect of being a sustainable business.

In developing strategies to address sustainability, it is helpful to think in terms of at least two planning horizons – short/medium term and long term. Long term solutions may involve changes to fuels (ie. hydrogen), fuel cells, and increased use of renewables. Short/medium term solutions deal with current facilities, fuels, and operating modes.

To reduce our emissions of GHG in the short/medium term, we are pursuing a portfolio of emissions reduction options which include:

1. Implementation of an internal emissions trading program among BP Business Units.
2. Improved energy efficiency in plants and facilities.
3. Improved energy management practices in operations.
4. Capture and geologic storage of CO_2 from large combustion sources.

It is unlikely any single option will result in sufficient reductions to achieve our GHG emission target. We believe all methods could play a role in a cost-optimized program.

Capture of CO_2 from large combustion sources, coupled with geologic storage, is an approach that has the potential to add value to our business. This value can be further enhanced if we can identify constructive and useful ways to utilize CO_2. For example, CO_2 can be an effective solvent, which will improve oil recovery in Enhanced Oil Recovery (EOR) projects and increase the production of methane in Enhanced Coalbed Methane (ECBM) projects. In addition to adding value (income) from the improved oil and gas recovery, a significant fraction of the injected CO_2 remains stored in the hydrocarbon reservoirs. In an environment where CO_2 emissions trading occurs, the stored CO_2 could also be value adding.

Objective

BP is considered an industry leader in designing and operating large EOR projects and is involved in a number of studies to understand the technology and behavior of ECBM projects. As an operator of production, refining, and marketing facilities, we have to manage large combustion sources such as gas turbines, heaters, and boilers. These sources, which generate heat and mechanical and electrical power, typically contain 3 to 12% CO_2 in their exhaust gases. Given suitable proximity and common operatorship of large CO_2 sources and sinks, there is the potential to capture and store CO_2 in a way that enhances the value of the hydrocarbon resource.

However, we have identified gaps in two key technology areas that prevent making capture and geologic storage projects viable.

- The cost of capturing carbon from fuels, or CO_2 from exhaust gas must be lowered dramatically. We believe the cost reduction must be in the 50% to 75% range from today's best available technology.

- Technology, experience, and operating practices must be developed to demonstrate to governments and stakeholders that geologic storage operations can be conducted safely and volumes of stored CO_2 can be measured and verified.

Given the potential importance of capture and geologic storage, as a short/medium term bridging technology, BP set upon a strategy to develop breakthrough technologies to capture CO_2 from large combustion sources and to demonstrate safe and verifiable storage.

Approach

Knowing other companies were interested in these same objectives and that governments were interested in promoting and supporting voluntary actions by industry, BP believed the best way to develop these technologies would be through a collaborative effort where costs and risks could be shared. Pulling together the best resources, ideas, and innovations from the world's most respected energy companies would allow us to take bigger steps than most companies might feel comfortable with on their own, and increases the likelihood of the project successfully meeting its objectives.

Following a relatively short process of defining key project objectives and agreeing on a management framework, the CO_2 Capture Project (the CCP) was formed in March 2000 by BP, Chevron, Norsk Hydro, Shell, Statoil, Suncor, and Texaco. Two additional companies, PanCanadian and ENI S.p.A, joined the project in early 2001. The companies are sharing the cost of the Technology Development program and are making significant contributions of staff and resources.

Each has conducted an internal evaluation of capture and geologic options and each has something unique to contribute to a common effort. Joining together as a single team demonstrates to contractors, consultants, and suppliers (Technology Developers) around the world that major energy companies are interested in and could provide a market for capture and storage technologies.

The project participants are driven to develop solutions, which can be placed into practice in this decade. Scheduling backwards from a target end-point of 2010 and allowing time for demonstration testing and execution of full-scale projects, the CCP Participants agreed the technology research and development program needed to be progressed to the 'proof of concept' stage by 2003. This time constraint requires we quickly identify and focus efforts on most promising technology(ies).

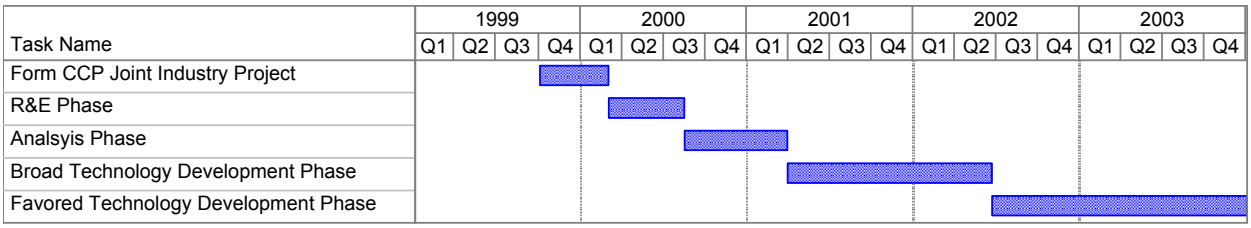

Figure 1

Figure 1 shows the phase approach to developing technology in the CCP. In the Review and Evaluation (R&E) Phase, teams were formed in key technology areas to survey the state-of-the-art in the areas of capture and storage. Prior work was reviewed and options were identified for further R&D. During the Analysis Phase, additional studies were conducted to bring candidate

technologies to a comparable level of understanding and to assess and rank technologies in terms of their potential to deliver results in the 2000–2010 timeframe. Technology development and R&D will be initiated during the Broad Technology Development phase. In mid-2002, we plan to conduct a thorough review of work completed to date and refocus resources on a 'few' most promising technologies in the Favored Technology Development phase.

Figure 2 shows the organizational structure of the CCP. Definition and management of R&D programs will be led by Technical Teams comprised of experts from the CCP Participant companies. The Technical Teams report to a full-time Program Manager who has responsibility and authority for operation of the R&D and delivery of program objectives. The Program Manager reports to an Executive Board consisting of senior technical and management representatives from the Participant companies.

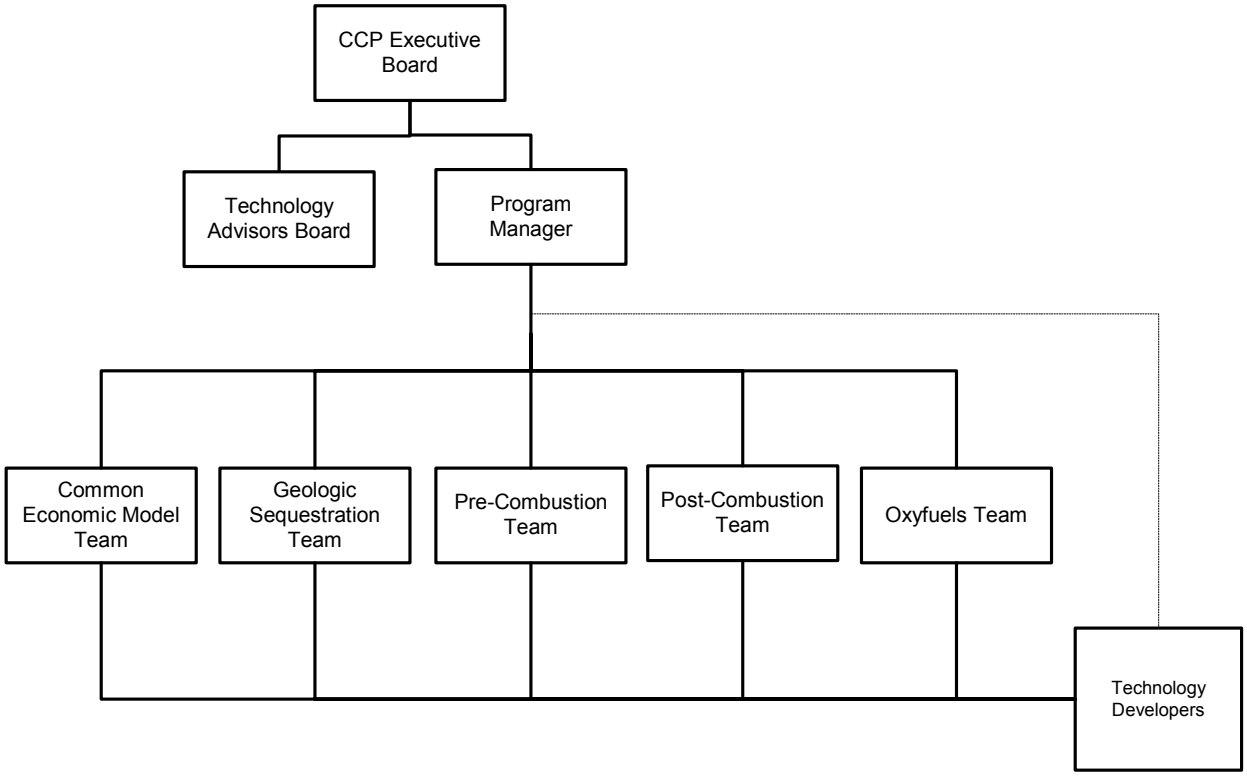

Figure 2: CCP Organization Structure

Technology will be developed by third party Technology Developers under contract to the CCP and under the direction of the Technical Teams and the Program Manager. Engaging and incentivizing best-in-class Technology Developers is critical to the project's success, especially delivery of challenging targets in the relatively short timeframe envisioned.

A structured Technology Assurance Process (TAP) will be utilized to ensure continuous assessment of results and (re)allocation of resources towards the most promising technologies. An important aspect of TAP is an independent Technology Advisors Board (TAB) which has accountability directly to the Executive Board. The TAB is comprised of recognized experts from academia, government, and private industry who do not have a proprietary interest in the

technology being developed. The TAB will review recommendations for work programs and budget allocations and will advise the Executive Board on these and other issues.

Strong support by governments is critical to successful delivery of the project. They share the Participants' desire to move forward with voluntary actions and to develop economic solutions – especially solutions which can be extended to other industry segments. Government involvement comes in two ways:

- First, governments can provide funding to match the Participants' R&D investments. This significantly leverages limited R&D funds and shares the benefits and costs across a broad base. It ensures technology can be accessed by project participants and non-participants alike (although on different commercial terms).

- Second, governments can participate in management of the program through their inclusion on the TAB where they will provide input on technology, work programs, and project assurance. Government agencies have highly-regarded technical expertise and their inclusion will help select and focus the project on promising R&D activities.

Project Description

A strategic review of the CCP Participants' emission sources and the technologies needed to achieve the project's goals, identified key areas where further development would be valuable or could lead to breakthroughs:

- CO_2 capture from combustion sources via:
  - Post combustion capture from exhaust gas
  - Pre-combustion decarbonization of hydrocarbon fuels
  - Oxygen enriched combustion with hydrocarbon fuels (oxyfuel)

- Measurement, verification, and assurance of CO_2 storage in geologic formations.

- A common economic model to steer technology decisions and measure progress against project goals.

- Outreach and engagement of key external stakeholders.

These key areas form the core of CCP's work program.

The principle focus area of the CCP is technology to separate carbon from the fuel or CO_2 from the exhaust gas. We anticipate spending up to 70% of the total program budget in this area. It is not obvious today which of the three capture technologies will offer the greatest likelihood of achieving substantial cost reductions.

Candidate technologies have been scored and ranked in terms of their:

- Potential to achieve a significant reduction in costs.

- Applicability to the CCP Participants' emission sources.
- Environmental benefits (in addition to CO_2 emissions reductions).
- Likelihood of being ready for large scale application before 2010.
- Availability of qualified Technology Developers to carry forward R&D programs.

On the basis of scoring against the above criteria, the CCP has developed an R&D plan with a broad mix of capture technologies. It is quite possible that more than one technology will be required to address the range of conditions given the diversity of equipment types and the need to find solutions for both retrofit and new-build applications.

The Storage, Measurement, and Verification (SMV) Team will stimulate and manage research in the following key areas which are not being thoroughly addressed outside the CCP:

- Tools and methodologies for HSE risk assessment, risk mitigation, and risk remediation.
- Long term (>10 years) monitoring and verification of CO_2 movement in geologic formations.

Additionally, they will develop tools to verify how much CO_2 has been stored such that if and when CO_2 trading systems are in place, our operations and procedures can withstand public scrutiny and audit by third parties.

The Common Economic Model (CEM) will provide a tool to evaluate the key factors which influence economic performance of capture and storage scenarios. At a high level, the model will evaluate full-project economics including the CO_2 capture and compression facilities, distribution pipelines, incremental EOR investments and income streams, and other incentives (i.e. CO_2 trading credits). The model will also be able to focus-in on the power generation/CO_2 capture facilities to evaluate tradeoffs in capital and operating costs and process efficiencies. The CEM will be a key tool in TAP and in prioritizing and making R&D investment decisions.

Outreach in the form of communications, meetings, and presentations is an ongoing process which demonstrates the transparency of the project to others. Engaging key stakeholders at an early stage makes good business sense.

Results

The CCP is still in the early stages of the project and the bulk of R&D lies ahead. However, excellent progress has been made during the first year of operation and the project has reached several major milestones:

- Nine major international energy companies executed a project agreement specifying ownership rights, cost sharing, and decisions making/management processes.
- Project objectives were agreed-to and generic applications (scenarios) were established to set context for technology development.
- Technical teams were formed and fully resourced by the Participant companies.
- State-of-the-art technology studies were completed in the three capture technology areas.

- R&D opportunities were screened, evaluated, and prioritized.
- Following review and endorsement by the TAB, specific R&D budgets and work programs were approved by the Executive Board.
- Co-funding applications were approved by Klimatek and the European Union. Addition co-funding applications were submitted to and are being considered by the U.S. Department of Energy and the European Union.

The CCP participants took a non-traditional approach to forming the project. The joint agreement was signed based on broad goals and aspirations, well before detailed R&D plans were developed. Hence, there was much work to do in 2000 and early 2001 to agree to work plans and put the management framework in place. A strong foundation has been built from which we will initiate and manage the R&D programs this year.

Application

Among the CCP participants, the technology will be deployed to capture CO_2 from a variety of turbines, heaters, and boilers. If applied to a relatively small fraction of the Participants' sources, the groups' GHG emissions could be reduced by up to 10 megatonnes of CO_2 per year. Moreover, the technology could increase recovery of oil and gas through EOR and ECBM projects.

The technology could also have broad applicability in other industries. CO_2 could be captured from large power generation plants, either coal or natural gas fired, and stored in nearby coal beds, oil and gas reservoirs, or deep saline aquifers. The application of technology beyond the CCP Participants is potentially very large.

Irrespective of the application (oil and gas production and refining or large scale power generation), the keys to making these projects viable are new technologies which dramatically reduce the cost of capturing CO_2 or carbon from combustion sources and stakeholder acceptance that geologic storage is safe and verifiable.

Future Activities

Much has been accomplished, but even more remains to be done. As we move forward with the CCP, we expect to discover new issues and new opportunities. We will maintain flexibility and will adjust our strategies accordingly.

We are now in the process of contracting with Technology Developers to carry out the studies. We expect to make a number of contract awards in the very near term in the US, the EU, and Norway. Later in the year, as we begin to get results from these studies we will apply the CEM. If results indicate a particular technology does not have the potential to deliver a major reduction in cost, the study scope will be refocused or the study area will be dropped from further consideration. Resources will continuously be redeployed to the most promising technologies.

The first phase of R&D will continue into 2002 when all activities will be reviewed in the context of their ability to deliver the desired cost reductions in the 2010 time horizon. To enable

a final push to deliver technologies to the 'proof of concept' stage by the end of 2003, the field of candidates will be narrowed. Resources will again be redeployed towards these 'favored' technologies. Any technologies that are dropped from the final phase of development in the CCP will be considered for continued R&D in other venues.

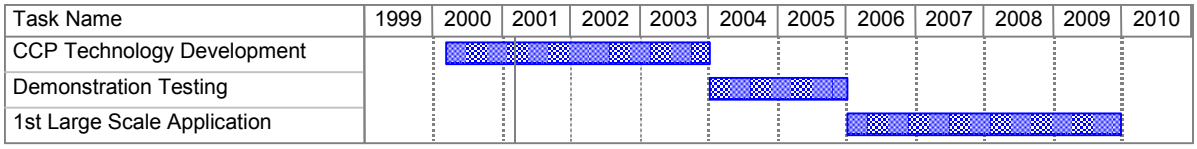

Figure 3.

At completion of the R&D phase at the end of 2003, the Participants will make a decision to proceed to demonstration testing of the most promising technologies (Figure 3). Prior to large-scale implementation, there will be a need to confirm cost and operating performance. Following demonstration testing, large scale implementation of technologies could being as early as 2006.

Conclusions

The CO_2 Capture Project is an important step in developing technologies to reduce emissions of GHG. By using sound fundamental science to underpin research and development of new technology, we believe we will create solutions which can be used widely by industry to remove CO_2 from large combustion sources with a step-change improvement in the cost of CO_2 capture and storage.

It is not often that industry is presented a challenge which offers the opportunity for such a degree of alignment and the chance to work together, to achieve a common goal that has such a potentially huge impact on our business. Reducing CO_2 emissions is important, and the actions taken by the nine international energy companies to form the CCP is an important milestone along the road to success. Industry needs to build on this lead.

Based on what we have seen to date, there is no doubt that something extraordinary will be achieved, something that will make a significant impact on our climate, on our industry and something we as companies and individuals can all be proud of. We look forward to reporting the CCP's progress in future technical papers, conferences, and workshops.