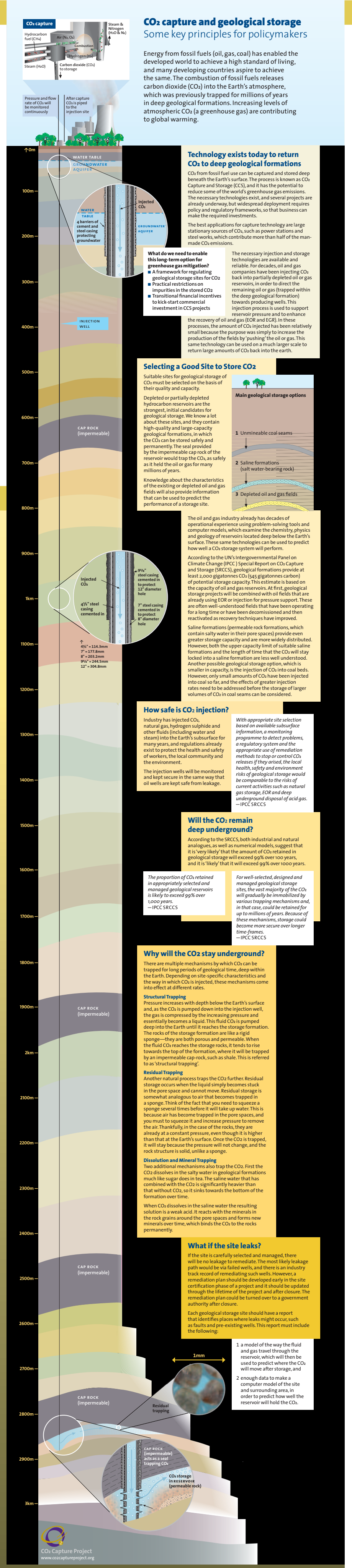
“There are some very important advantages to be gained if we could press for a CCS component in any energy mix.”

Sir Jonathan Porritt
Chairman of the Sustainable Development Commission

CCP has just published an overview of our three policies together with a striking 1 metre long poster illustrating CO_2 injection and underground storage. To obtain copies please contact XXX

CO_2 capture and geological storage in depth



Storing CO_2 underground: the future

Although the mechanics of carbon capture and storage (CCS) have been in place since the 1970s, only in the last few years, as the realities of climate change have been borne home to all but a few sceptics, have we seen an increasingly focused attempt to use the technology. By 2005, three industrial projects to store CO_2 underground were already underway: in Algeria, Norway and Canada. But in the two years following, the major industrialized nations have begun to put in place projects that would store liquidized carbon dioxide more than 800 metres down in the Earth's crust. In 2007, the University of Texas received a grant to study the feasibility of storing CO_2 into deep brine reservoirs, beginning, in 2007/8, with an annual injection of 1 million tonnes per year of the fluid into reservoirs near a depleted oilfield in Mississippi. Gaz de France has recently signed an agreement to undertake a pilot project in Germany involving injection of CO_2 into the almost depleted Altmark Gas Field, the second largest onshore field in Europe. BP is pursuing similar schemes in California and Abu Dhabi, and there is huge potential to utilize the UK's disused oil and gas fields in the North Sea as receptacles for CO_2, following the lead of Statoil in the Sleipner Gas Field in the Norwegian sector: the world's first example of CCS, active since 1996, and home to 8 million tonnes of CO_2 that otherwise would reside in the atmosphere.

“Clearly, in the future we must do things differently, perhaps using energy sources such as renewables, or sources we have not yet found ways of harnessing. In the meantime we have little alternative but to continue burning fossil fuels. And while we do so it is essential we cause as little environmental damage as possible. Achieving this demands the capture of greenhouse gases where they are generated and not discharging them to the atmosphere. Once captured, they must then be stored securely for many thousands of years. This process is known as CCS.”

Lord Ronald Oxburgh former Chairman, Shell Transport and Trading

» CCP Phase 2

CCP Phase 2 is improving selected technologies and solving the critical issues identified in Phase 1. At least one technology shall be ready for field demonstration by the year 2008. The CCP portfolio includes technologies that will reach the market at different times, with a sequenced approach from short-term (ready for demo by 2009–2010) to long-term (after 2015) implementation. While a generalized reduction in capture costs is expected through the years, even short-term technologies demonstrate the potential to achieve CCP cost targets for specific applications. The main focus of CCP Phase 2 is on pre-combustion technologies, but the development of promising technologies in the fields of post-combustion and oxy-firing is also continuing.

Pre-Combustion Projects

The CACHET Project, co-funded by the European Union, is developing a set of technologies for pre-combustion CO_2 capture, used with power generation in Network Group for Composites in Construction (NGCC) schemes. The Project is focused on both shorter-term CO_2-separation technologies, which may find application in several pre-combustion scenarios (e.g. Membrane Water Gas Shift or Sorption Enhanced Water Gas Shift) and longer-term hydrogen production technologies, with the potential to replace current Auto-Thermal or Steam-Reforming Units in the widespread application of CCS from 2020 onwards. In the long term, Hydrogen Membrane Reforming (HMR) is another promising technology; StatoilHydro is developing HMR, with co-funding by the Norwegian Government in the frame of the CLIMIT Project.

Post-Combustion Projects

On the post-combustion side, the CCP is supporting a program (based on experimental testing and simulations) to assess the technical and economical feasibility, as well as limits, of Exhaust Gas Recycle (EGR) in power-generation schemes and the integration of the washing system with the power island. Oxy-firing shows particular potential, and is used in two projects focused on applications of specific interest to oil companies:

- Chemical Looping Combustion (CLC) continues the development of this flameless combustion technology for application to refinery boilers, increasing the scale of operation from 10 to 100kW, in an EU-funded Project (CLCGASPOWER). A demo unit in the mega watts range may be considered for further development.
- Fluid Catalytic Cracking (FCC) units are the single largest source of CO_2 emissions in refineries, through the effluent from the regenerator. Oxy-firing seems to be the most promising and cheapest option to mitigate this type of emission.

Future Steps

Most technical programs in CCP2 will conclude by mid-2008, while only CACHET will continue until the 1st quarter of 2009. In the meantime, planning for a continuation of the program has already started and selection of technologies will be chosen as the final technical/economical assessments become available.

CO_2 Capture Project » PHASE 2

Interim News

Overall Goals

The CO_2 Capture Project is now in its second phase (CCP2) and plans to accomplish the following goals:

1. Reduce technical and cost uncertainties associated with CO_2 capture technologies and demonstrate that geological storage of CO_2 is a secure and viable means of reducing greenhouse gas emissions.
2. Reduce CO_2 Capture costs by 20–30% through choosing the right technologies.
3. Identify and address the critical issues surrounding the geological storage of CO_2, and encourage public awareness and acceptance.
4. Develop consistent technological standards for the evaluation of the risk, security and well integrity of storage sites. Compose a set of proposed standards for storage, monitoring, verification, and abandonment that will allow credit from emissions-trading schemes.
5. Develop a way of sharing information between organizations about both capture and storage demonstrations.

» Storage technology goals

Geological Integrity and Optimization

CCP2 is establishing a universal methodology to standardize the minimum integrity and optimization requirements for all sites, even though each site will be analyzed separately.
Both the characteristics of each reservoir and the reservoir's potential performance will be simulated.

Risk Assessment

Every geological storage site must demonstrate the potential for increasing security with time, to reduce future monitoring costs and liabilities. The risk assessment will vary from site to site. The assessment will be quantitative, and it will analyze site selection, operation, and abandonment.

Well Integrity

The integrated well-integrity project oversees both well-design specifications and long-term performance simulation. In addition, the project considers remediation and intervention strategies.

Monitoring and Verification

CCP2 is developing a new system that will optimize the resolution and cost effectiveness of novel approaches to performance monitoring, leakage detection and verification.

Integration

CCP2 is developing a detailed strategy, to integrate information about risk, geological integrity and optimization, as well as monitoring and verification, to produce a comprehensive strategy for site selection, operation and abandonment.

> “CCS will play a significant and growing role as one of the major building blocks of a solution to the climate crisis.”
>
> **Al Gore** New York University Law School, September, 2006

Additional CCP2 Storage Projects

- Coupled Geochemical-Geomechanical Simulation (University of Bergen) – Coupled numerical simulation software capable of accounting for differential geochemical and geomechanical effects of CO_2 injection is complete and currently under testing.
- CO_2 ECBM Operability and Monitoring (Sproule Associates and Lawrence Berkeley National Laboratory) – Tests of practical guidelines for safe and effective CO_2 injection into coals, using a site specific geological models and simulation, are in progress.
- Direct, Remote Detection of CO_2 and Methane (University of California, Santa Cruz) – Application of a novel sensor for detection of major greenhouse gases. A field survey showed that the sensor was insufficiently sensitive for CO_2 detection but operating and data analysis protocols for subsequent surveys will become available.
- Detection of CO_2 by logging (Schlumberger) – A specially constructed vessel was used to assess the threshold of CO_2 detection, using the RST tool in two modes.

The IPCC and Al Gore receive the Nobel Peace Prize

In December 2007 the Intergovernmental Panel on Climate Change (IPCC) and Al Gore received the Nobel Peace Prize “for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change.”

Over the past two decades, the scientists and officials from over one hundred different countries, who make up the IPCC, have documented anthropogenic global warming. When Professor R. K. Pachauri, Chairman of the IPCC accepted the award on the organization’s behalf, he acknowledged the thousands of scientists and experts who contributed to the work of the panel. Al Gore has probably done more than any other single individual to bring the issue of climate change to international public attention through his political activities, books, lectures, and film.

The future is knocking at our door right now. Make no mistake, the next generation will ask us one of two questions. Either they will ask: “What were you thinking; why didn’t you act?” Or they will ask instead: “How did you find the moral courage to rise and successfully resolve a crisis that so many said was impossible to solve?

Al Gore from his Nobel Lecture, December 10, 2007

> “Stabilisation levels assessed can be achieved by deployment of a portfolio of technologies that are either currently available or expected to be commercialised in coming decades.”
>
> **Dr. R K Patchouli** Chairman IPCC, November 17, 2007

bp Eni Shell Chevron BR PETROBRAS StatoilHydro ConocoPhillips SUNCOR ENERGY The Research Council of Norway

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> “It is now clear that — as well as renewable sources of energy — cleaner fossil fuel technologies, including the capture of CO_2 and its long-term storage underground, are likely to become crucial elements of carbon reduction strategies over the next few decades, particularly for emerging economies. These technologies have the potential to provide a step change in reducing emissions.”
>
> **The Right Honourable Gordon Brown** Prime Minister of Great Britain, Climate Change Speech, November 19, 2007

» News in brief

Certification Framework for Geological Storage of CO_2

The CCP2 Storage Program, through Lawrence Berkeley National Laboratory and the University of Texas, is developing an integrated protocol for geological site assessment that incorporates geological data entry, a reservoir simulation routine and risk (=probability x impact). The objective is to streamline the initial assessment process in a simple and transparent manner without the need to resort to multiple, complex numerical simulation packages. To date, a rapid prototype application has been delivered and one case study has been completed. By the conclusion of the CCP2 program, the application will be equipped with more rigorous modelling capability, tested on additional sites and rolled out to stakeholder groups.

Wellbore Integrity Project

Wellbore integrity is considered a critical containment issue in CO_2 storage. The CCP2 Wellbore Integrity Project aims to provide much needed direct field data on the condition of well materials exposed to CO_2-charged fluids. Modelling and simulation, based in the acquired data will enable projection of the future long-term stability of well materials under these conditions and development of engineering solutions to well design, construction and intervention. To date, one comprehensive well study (logging, sampling and permeability testing by Schlumberger) has been completed in a 30-year-old CO_2 production well. Preliminary data assessment (Los Alamos National Laboratory) indicates that the well materials, although altered to varying extent, are physically intact and continue to provide a barrier to CO_2 movement. In 2008, access to two additional wells will be accessed, providing essential data for regulatory decisions on regulatory standards for well engineering.

CCP2 Executive board recommends specific objectives

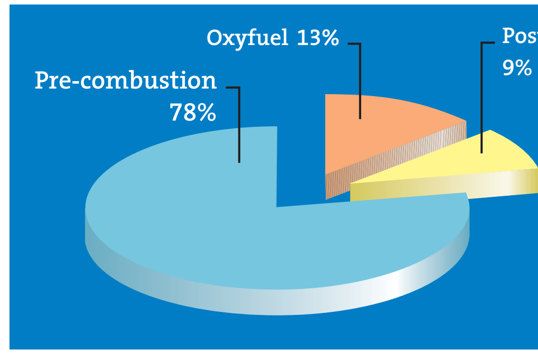
The CCP2 Executive Board has recommended that capture technologies should aim to reduce cost and technical uncertainties prior to demonstration, by running the research and development of several projects in tandem, but organizing pilots sequentially. Technology development should be halted when success is achieved. Success is defined as a 50% cost reduction from the baseline established in 2000. (January 17, 2008)

In addition, the industry must develop both guidelines for secure, cost-effective CO2 geological storage and a network that includes resources for geological storage demonstrations.

> “CCS is absolutely essential if the world is serious about limiting greenhouse gas emissions”
>
> **Lord Ronald Oxburgh** former chairman, Shell Transport and Trading

» Capturing CO_2

The capture of CO_2 is the most expensive stage of the capture–transport–storage cycle, and it accounts for roughly 80% of the total cost. Careful choice of the most efficient capturing technologies will be crucial to make CO_2 capture economically viable. In 2007 CCP2 capture team have concentrated on evaluating the relative strengths and costs of various capture methods, and the results should be available toward the end of this calendar year.



▲ Structure of capture program

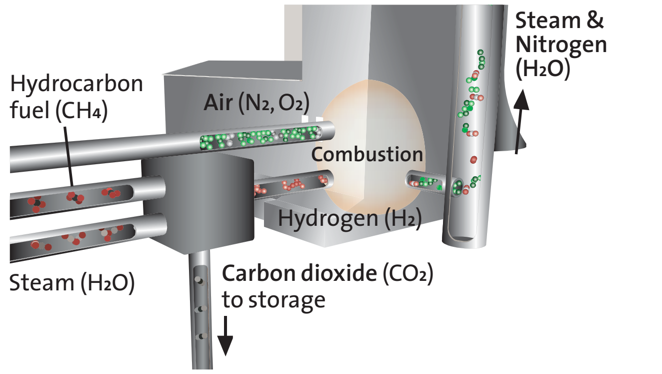
The three main techniques for capturing CO_2 in a gas-fired plant are pre-combustion capture, oxyfuel capture and post-combustion capture.

Pre-combustion capture converts a fossil fuel into a mixture of hydrogen and CO_2 (“syngas”) and then separates the CO_2, leaving the hydrogen to be used as a “clean” fuel. When burned, hydrogen produces no CO_2 emissions. It simply gives off water vapour.

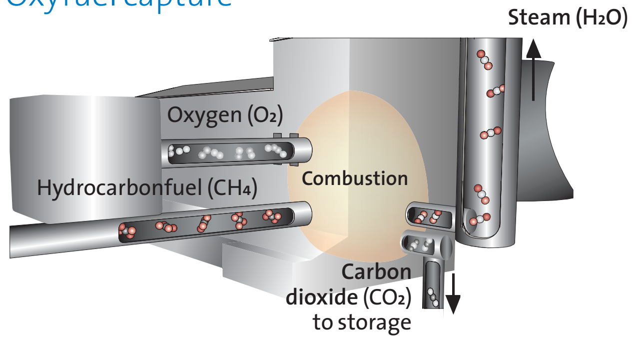
In **Oxyfuel capture**, fossil fuels are burned in pure oxygen rather than air, in order to increase the combustion temperature. CO_2 and steam comprise the resulting exhaust stream. The CO_2 can be “captured” simply by condensing the steam.

In **Post-combustion** capture, CO_2 is separated from the exhaust gas, using solvents, such as amines. Each amine absorbs CO_2 at a particular temperature and pressure; therefore, the CO_2 can be removed by varying the temperature and pressure.

Pre-combustion capture



Oxyfuel capture



Post-combustion capture