CO_2 Capture Project Phase 2 – CCP2
Progress Through Partnership

Summary of CCP2:

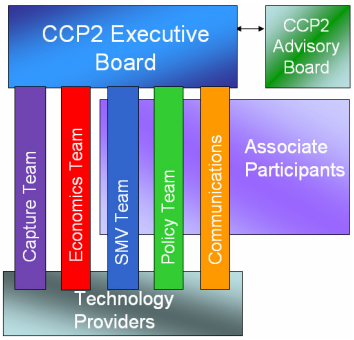
- Is an international industry/government partnership, including 8 of the world's leading energy companies and 3 governments.
- Is currently in Phase 2 (2005 - 2008) of a 3 phase program. Building on the success of Phase 1 developing technology performance with $30mm in funding
- Technical teams comprised of representatives of 8 partner companies integrated with a broad selection of technical providers working to reduce the cost of CO_2 capture and storage, demonstrate that CO_2 storage is safe, measurable and verifiable and to advance the capture and storage of CO_2.
- Involving other interested parties in the NGO community.
- Government Agencies are providing co-funding for select portions of the program (i.e. European Commission – CACHET, European Commission – CLC Gas Power, Norwegian Research Council-Climit and the US DOE).

CCP2 Project Objectives

- Undertake research, development and pilot testing to further reduce cost of CO_2 capture from large fixed sources, building on the cost reduction success of Phase 1.
- Reduce technical and cost uncertainties and deliver CO_2 capture technologies to demonstration stage by 2009.
- Demonstrate that the geological storage of CO_2 is secure and can represent a viable Greenhouse Gas mitigation technique. Further develop technology, best practice and industry standards for storage site evaluation, risk assessment, well integrity, monitoring & verification.
- Establish an extended network for CO_2 storage demonstrations to share learning and best practice.

Structure of CCP2

The diagram below is an illustration of the separate teams and groups within CCP2. The project has five multi-disciplinary technical teams (shown as the vertical pillars) working together to deliver the program results.



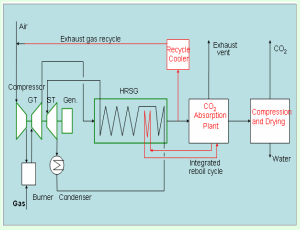
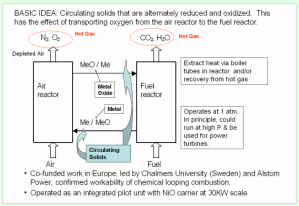
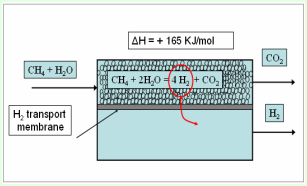
Executive Board – directs the overall program of work and prioritizes specific projects to be undertaken.

- **Advisory Board** – comprised of a panel of international technology experts providing independent advice and review of the CCP2 technology program.
- Technical teams – represented by the 5 pillars above (**Capture**/**Economics**/**SMV**/**Policy**/**Communications**) – formed for the purpose of progressing development in each area. Each team is led by a designated team leader. Team objectives are discussed in more detail to the right.
- **Technology Providers** – including academic institutions, private research companies, CCP participants, national laboratories and consulting firms. Engaged by CCP2 and directed by the technical teams for the development of new concepts and improving existing technologies.
- **Associate Participants** – a new level of membership offered for CCP2 to engage with the Communications, Policy and SMV teams.

Capture:

Project objectives for Phase 2:

- Build upon Phase 1 results by further developing known technologies as well as exploring novel ideas.
- Bring forward at least one selected technology to be ready for pilot testing in a large scale facility by 2009.
- Reduce the cost of CO_2 capture and the associated technical and economic uncertainties.

Near term priorities (by 2010)	Mid term priorities (2010 - 2015)	Long term priorities (beyond 2015)
1) Best Integrated Technology (BIT) Based on the integration of typical post-combustion amine washing (enhanced by the use of novel solvents, flue-gas recycle and heat integration) in a new built power generation facility. ***Climit***	**4) Chemical Looping Combustion** • A novel approach to oxy-firing • Based on a solid carrier particle able to chemically adsorb oxygen from the air and release it in the presence of a gaseous fuel with immediate complete combustion. ***CLC Gas Power***	**7) Hydrogen Membrane Reformer** • Combination of reforming reactor and separation • Extract product gas (H_2) from reactor, no traditional CO_2 removal system required • Drive equilibrium limited reactions towards completion • Expand allowed range of temperature and pressures. ***Climit***
		
Other near term technologies include: **2) Advanced Steam Reforming (HyGenSys)** – a heat exchanger reactor with high energy integration leading to co-generation of hydrogen and electrical power through direct heat recovery from flue gas in a gas turbine without steam. ***CACHET*** **3) Sorption Enhanced Water Gas Shift** – uses high temperature CO_2 adsorbent in presence of WGS catalyst. Allows complete conversion of CO/H_2O to CO_2/H2, recovering a pure CO_2 stream. ***CACHET***	***Other mid term technologies include:*** **5) Chemical Looping Reforming or H_2 Production** - extends the chemical looping concept to production of syngas or hydrogen. ***CACHET*** **6) Membrane Water Gas Shift** – based on metal membranes permeable to hydrogen, allowing complete conversion of CO/H_2O to CO_2/H_2, recovering a pure CO_2 stream. ***Climit***	***Other long term technologies include:*** **8) One-Step Hydrogen** – based on the circulating chemical looping and chemical reforming principal, a "redox" iron-based solid material is oxidized by water reacting and producing hydrogen. The circulating material is subsequently reduced by a carbon-containing stream producing CO_2. ***CACHET***

Economics Team:

- Assess the financial impacts of new technical developments.
- Provide an integrated cost picture for CCS in terms of cost of CO_2 avoided as well as the impact to the cost of electricity when the new CCS technology is incorporated.

SMV:

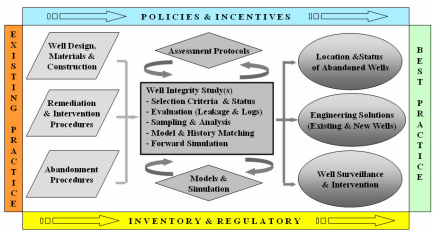
The CCP2 SMV team aims to:

- Ready potential cost effective technologies for deployment.
- Develop a system of site assessment protocols.
- Address emerging issues in CO_2 storage.

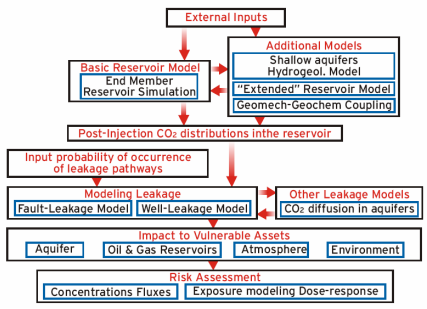
The CCP2 SMV team is addressing:

- CO_2 containment issues for wells and reservoir seals.
- Development of a simplified tool for lifecycle monitoring and decommissioning schemes.
- Key operational and monitoring strategies specific to coal beds.

Well integrity
Well integrity has become the premier containment issue in geographical storage of CO_2. A comprehensive well field study is proposed to evaluate well condition, predict survivability and identify engineering solutions.



Certification framework
At present, site selection criteria, reservoir simulation approaches and risk assessment methodologies are fragmented and vary in complexity. The "Certification Framework" is a streamlined, life-cycle approach to project certification aimed at meeting regulatory expectations.



Other SMV programs include:

Coupled geochemical-geomechanical simulation
Injection of CO_2 in reservoirs results in pressure increases which can fracture reservoir rock or breach cap rocks. The coupled geochemical-geomechanical simulation tests the extent to which the aperture opening effect (permeability increase) of pressure can be counteracted by geomechanical reactions that act to reduce pressure increase.

Well-based in-situ detection of CO_2
A pressurized vessel containing water saturated sand will be injected with supercritical and vapor phase CO_2.

Operational Parameters – operability of Enhanced Coal Bed Methane
Coal bed recovery might be enhanced by CO_2 via desorption of methane and adsorption of CO_2 (~2X). The low permeability and reactivity of coal, however, introduce injectivity and conformance complications. Simulation of CO_2 flooding using field data is applied to optimize injection-production rate while avoiding formation damage and cap rock breaching. ***DOE***

Monitoring – remote (satellite and aerial) detection of CO2 and methane
Monitoring CO_2 leakage to the surface over field-scale areas will introduce considerable operating and post-closure expenses to CO_2 storage projects. Remote sensing of CO_2 and methane will be a potential solution if sensors capable of directly detecting both gases are developed. This project will test such a modified sensor using aerial field surveys over controlled leaks. ***DOE***

Monitoring – novel geophysical monitoring of ECBM performance and leakage
Seismic monitoring might add significant expense to low margin operations such as CO_2 ECBM and may not be applicable in some settings. The resolution of low cost novel non-seismic geophysical techniques (EM and SP) will be simulated using field data. ***DOE***

Policy Development and Understanding:

- Provide information and advice to the CO_2 Capture Project on national and global policies, regulations, legislation, incentives and any other developments that may impact or benefit the technology program being undertaken.

Communications:

- Coordinate international forums for outreach and engagement with industry, NGO's and opinion leaders.
- Publish and produce project information in multimedia formats.

Future Plans: CCP Phase 3 2009 – 2012 demonstration of successful capture and storage technologies

Private/p ublic project partners and co-funders:

European Union · Norges forskningsråd · U.S. Department Of Energy

For more information, visit
www.co2captureproject.org
or, contact Linda M. Curran, CCP2 Program Manager
curranlm@bp.com – Tel +1-630-420-4338