THE FEASIBILITY OF CARBON DIOXIDE CAPTURE AND STORAGE IN THE UK

PROJECT DEFINITION AND SCOPING PAPER

by the Sustainable Energy Policy Unit, DTI

1 Introduction

The paper has been produced as a precursor to the work identified in the Review of the Case for Government Support for Cleaner Coal Demonstration Plant[1] (the Review) to investigate the feasibility of CO2 capture and storage as a means of reducing emissions from coal-fired power generation.

The Review recognised that:

"*there is a strong case for assessing in a systematic way the legal, scientific, engineering and economic aspects both of EOR and of geological CO_2 capture and storage. Such an assessment needs to precede any further analysis of the policy case for government support for steps to use CO_2 in this way.* "

The PIU Review's of Energy Policy reached a similar conclusion[2] stating that:

"*CO_2 C&S can reduce emissions by 80-90%. Early indications are that CO_2 C&S would be able to provide power at 3-4.5 p/kWh, without allowing for any associated benefit for enhanced oil recovery. The technology has been demonstrated on a small scale, but substantial uncertainties surround both costs and feasibility. If the CO_2 could be used for enhanced oil recovery, there would be added costs – for example at the wellhead – and benefits, from oil sales."*

The purpose of this study is to follow through on these conclusions and to define the scope and objectives of the work.

2 Background

The review recognised that technologies for controlling many of the pollutants from coal-fired power generation, such as SO_2 and NOx, were already well developed and widely deployed. The emphasis was now on technologies which would substantially reduce or even eliminate CO2 emissions from power generation.

A meeting in the DTI on 1st February 2002 identified a number of issues which needed to be resolved before any government policy could be developed for supporting CO_2 capture and storage. These included:

[1] Review of the Case for Government Support for Cleaner Coal Technology Demonstration Plant, published by the DT January 2002.
[2] Para 6.58

- legal issues linked to the provisions of the London and OSPAR conventions, if storage below the sea bed storage is contemplated
- geological issues to be considered for storing CO_2 underground including reservoir security
- engineering challenges and risks associated with capture, transport and storage
- infrastructure issues
- potential for Enhanced Oil Recovery (EOR)
- possible environmental impacts
- economic and commercial issues.
- social and political issues.

The study's mission is to:

- To inform decisions regarding CO_2 C&S as a low carbon option.
- Assess the circumstances that would make this a nationally and internationally acceptable solution for UK sustainable energy needs.
- To establish the timeframe of relevance for implementing CO2 C&S technologies.

It objectives are:

1) Establish the feasibility of the Mission
    - Is this a viable low carbon option in technical terms?
2) Assess the likelihood of this being an acceptable option
    - Define the potential barriers:
        - –Technical
        - –Markets and Economic
        - –Public acceptability
        - –Legal (national & international)

        What is the likelihood that these are soluble?
    - Establish the circumstances that could make this a competitive technology against it's rivals.
    - What contribution will it make to achieving the Government targets of reducing greenhouse gas emissions.
    - What UK export opportunities would this technology give?
3) To define the role for Government in all of this?
4) To allow judgements to be made about the work to be completed done.
5) To write an interim paper by early October. For the White Paper.

The Benefits arising from the Study are perceived to be:

- Acquiring a better understanding of the environmental and economic issues around CO2 capture and storage.
- Understanding the legal issues around CO2 storage.
- Assessing the available information on the safety and cost effectiveness of CO2 storage
- Assessing the potential for increasing amount of oil extracted and delaying the closure of North Sea oil operations.

- Understanding the potential for the storage of CO2 from other European countries the North Sea.
- Evaluating the contribution to the UK's security of energy supply and providing more energy options for power generation.
- Assessing the potential to develop competency in this technology with consequential opportunities for world leadership and the export of UK expertise.
- Enabling better informed decisions on energy policy.

Approach

CO2 C&S requires the investigation of three areas each with different technologies and issues which need to be assess and resolved:

- CO2 Capture
- CO2 transport
- CO2 Storage

3 CO_2 Capture

As much of the technology for capturing CO2 is well understood, the key issue here is the economics of the operation and its competitiveness compared with other forms of generation such as renewables and natural gas-fired generation. This stage of the process is considered to be by far the most expensive accounting for about 75% of the costs. We therefore need to determine:

- The full economic cost of capturing the CO_2 at the power station site and the effect this has on the cost of power generation.
- Comparisons of the full economic costs between IGCC and pf technologies.
- Comparisons between different separation technologies e.g. amine scrubbing and membrane.
- Comparisons between their relative effectiveness in capturing the CO_2.

Much of this work has already been covered as part of the CCT Review but further work on these figures is required to improve reliability.

A second consideration is the technologies which can be used to capture the CO2. IGCC plant would have some additional advantages because the CO_2 is more easily and efficiently captured from the so-called syngas gasification produces. Additionally hydrogen is a valuable side product from the process. However, at the moment IGCC plant cannot produce power at a competitive rate. Retrofitting CO_2 capture to an existing pf boiler plant would have a significant impact on the overall efficiency of the plant, but would avoid the capital costs associated with construction from scratch. Retrofitting CO2 capture equipment to an existing CCGT plant would also have possibilities. Other factors to consider are should:

- Whether to immediately transport the gas to storage or to be temporary store it at the power station site for later transport and,

- The processing it requires before it is shipped, e.g. drying, compressing etc.

Experts to assist in clarifying these issues would come from:

- universities and engineering research bodies,
- consulting engineers (e.g. Flor and Mott-MacDonald),
- boiler plant manufacturers,
- power generators,
- gasification experts, and
- turbine manufacturers.

4 CO_2 Transport

Transportation of CO_2 can either be by pipeline/tanker or both.

The key issues here revolve around:

- The costs of the various means of transportation to the storage site.
- The planning issues associated with pipelines.
- The technical issues concerning the integrity of the CO_2 in transit (the level of any background leakage and the risks and environmental consequences of sudden release CO2 due to component failure).

Information gathered as part of the Clean Coal Review will contribute towards the work required to estimate the costs for transport.

Clarifying the planning issues will be the key issue here and the perceptions of the risk associated with compressed CO2. It will be vital therefore to establish the safety of pipelines or tankers carrying compressed CO2. Such work will require reviewing available data on component failure and assessing the probabilities of CO2 escaping and the safety and environmental consequences which could arise from such an event. It is possible that existing knowledge of the gas pipeline infrastructure and transportation will provide reliable guidance here.

Expert advice on these issues will come from:

- gas pipeline engineers (e.g. Transco),
- Health and Safety Executive,
- IEA GHG and,
- the DTI's Oil and Gas Directorate.

5 CO_2 Storage

This is currently the most controversial area involving the storage of the CO_2 underground. Storage in geological formations below the North Sea is the option most discussed at present, possibly accompanied by enhanced oil recovery (EOR), which would extend the life time of oil and gas fields. There is however some experience of storage in the Sleipner field off Norway and the Weyburn project in

Canada. Other areas could be considered for storage such as in the Irish Sea (of use to power generators in Wales and Western UK), the depleted gas fields of the Southern North sea, possibilities also exist for storage inland and for enhanced CBM production.

The key issues here are:

- The legality of CO_2 storage in the North Sea. The OSPAR and London Conventions, which cover waste disposal at sea or under the seabed, may prevent this as they stand. Whilst the use of CO_2 for EOR appears to be legal under the Conventions, simply disposing of it into geological formations such as saline aquifers is probably not. There is, however, no international consensus on the interpretation of these conventions at present. These conventions do not appear to cover disposal in geological formations under land and the legal status of storage in geological formations not under the sea would need to be determined.

- International relations. There could also be a potential business opportunity for the UK to receive CO2 from neighbouring countries, such as Norway and Denmark both of whom are also considering capture and storage.

- Geological aspects. Will the CO_2 stay down in the ground? BGS research based on seismic data from the Sleipner project suggest that aquifers exist which will contain the gas, but present the data presently available might not detect slow leakage. There could be leakage from sealed bore holes (eg due to the CO_2 having a chemical interaction with the concrete plug) or via other possible geological routes, and the possibility of sudden leakage is likely to be of concern unless the probability can be shown convincingly to be very remote. It will therefore be necessary to show a) that methods exist by which slow leakage (say order 1% per year) from a storage reservoir could be monitored, and b) that a convincing case can be made, based on review of existing data and probabilistic risk analyis, that the probability of catastrophic failure is very low.

- The storage capacity and cost implications for storage below the sea or the land in each of the principal candidate types of geological formation

- Social issues. Public concern over storing underground and the possibility of the disastrous consequences of leakage and of storing up a problem for the future. It will be necessary to provide a convincing case, based on the analysis outlined in the paragraphs above. Hence it will be necessary to contact key stakeholders with an interest in this at an early stage.

- Engineering and technical issues. Surrounding the technology to inject the CO_2 into the wells, either for storing or for EOR. Corrosion issues and other metallurgical issues and the overall risk of component failure need to be identified and assessed to contribute to the risk analysis already discussed.

In addition to discussion of legal issues under the London and OSPAR conventions, the 19th plenary meeting of the Intergovernmental Panel on Climate Change (IPCC), Geneva (April 2002) discussed producing a Special Report on geological carbon sequestration technologies, which is likely to happen over the next three years. A

Special Report by the IPCC would be significant in determining how these technologies are viewed internationally, and the way they could be counted in the greenhouse gas inventories of Parties.

Expert advice can be drawn from the:

- DTI's Oil and Gas Directorate,
- Lawyers,
- DEFRA,
- oil companies,
- British Geological Survey and,
- IEA Greenhouse Gas

6 Infrastructure Issues

Despite different issues for the three components there are overarching infrastructure issues which need to be assessed. These are:

- The market in CO_2 covering the inter-working of CO_2 producers (power generators, oil companies and other industries which produce large quantities of CO_2), transporters (pipe line companies or gas transporters) and consumers/storage. A price for CO_2 would need to be established which would encourage such trade, taking into account for example values under the Emissions Trading Scheme and values associated with EOR.

- In the case of EOR the adequacy of the quantities of CO2 collected with that required for EOR at any given time. Also the quality of the CO2 for oil recovery.

- Overall economics of fossil fuel power generation with CO_2 C&S versus other energy technologies needs to be compared and the competitiveness of the former determined.

- Will the various technologies for capture, transport and storage work together?

Costed options for a CO2 capture and storage demonstration plant will be prepared. This will look at feasible locations, technologies and issues associated with risk.

7 Key Outputs

End Product

The key output would be a paper for ministers' approval and eventual publication making recommendations on what the policy the government's might adopt for CO_2 capture and storage. This will be based on the options available and make recommendations for the further work necessary .

Overall Management

The overall work will be managed by Brian Morris with assistance from other DTI Energy group officials, DEFRA and Future Energy Solutions. The expert knowledge of industry and academia will also be drawn on. The tasks for the studies are defined below with the relative roles played by each party.

A working Group will be established with membership from the following:

ENP2 (Sustainable Policy Energy Unit)
Oil and Gas Directorate
Trade Partners UK
International Trade Partners
DEFRA
Carbon Trust
IEA Greenhouse Gases
FES
British Geological Survey
Foresight
DTI Coal Policy Directorate

The work of the Working Group would oversee and comment on the work and to agree the tasks for the next stage. The Group would meet about once a month.

8 Stages and products

Task 1 - Undertaking a number studies to adress the issues described above.

Description: Investigation and research into the issues outlined above. Reports would be produced on each issue with evaluated options for solutions and any further work necessary. Because of the future policy implications Ministers will need to be consulted at this stage for their approval to continue to the consultation stage.

Studies to be undertaken:

a. Legal issues

Outline definition

To determine the current position on legal constraints to CO2 storage both on land and under the seabed around the UK.

Responsibility

Under the Seabed

The work will be defined by DTI/DEFRA with approval of the Working Group

The work will be undertaken by DEFRA on the London/OSPAR issues..

Timescales July 2002.

Onshore

DTI will ask Ken Fergusson (retired head of the Coal Authority) to provide advice on onshore storage.

b. Technology

Outline Definition

CO2 Capture

This will cover:

- Viable power generation solutions for CO2 capture (covering for newer technologies such as IGCC to retrofitting pf plant).
- Capture technologies
- How much CO2 can each technology capture as against illustrative estimates of how much we might need to capture to meet UK targets.
- The quality of the CO2 and the processing required to make it usable.
- The issues around storage on site or immediate transport.

The costs of the various viable solutions will need to be determined from the technology to capture the CO2 to the point where it is out of the gate for onward transportation. If there is any further R&D required on technology holes. If hydrogen is a viable side product from IGCC generation.

Responsibility

The study will be defined by DTI with approval of the Working Group

The study will be undertaken by a selected consultancy on the basis of their providing the appropriate experience, expertise and value for money.

The contact will be managed by FES.

Timescales July to October 2002.

CO2 Transport

Outline Definition

This study will investigate the issues around transportation of the gas outlined above.

Responsibility

The study will be defined by DTI with approval of the Working Group

The study will be undertaken by a selected consultancy on the basis of their providing the appropriate experience, expertise and value for money.

The contact will be managed by FES.

Timescales July to October 2002.

CO2 Storage

Outline definition

To consider:

- the use of Co2 for Enhanced Oil Recovery. To assess the benefits and issues of using CO2 from fossil fuel generation for this.

- the geological issues around CO2 storage, especially concerning the reliability of the CO2 staying underground with no leakage back to the atmosphere. Identify reserves suitable for CO2 stoarge.

- the options for storage, not only in the North Sea but also under the sea bed elsewhere around the UK as well as underground storage inland, including the possibilities for enhanced CBM production.

- the engineering issues around the transport of the CO2 from the shore to the storage site and injection under ground (either at sea or on land).

Responsibility

The study will be defined by DTI/DEFRA with approval of the Working Group

The study will be undertaken by a selected consultancy on the basis of their providing the appropriate experience, expertise and value for money.

The contact will be managed by FES.

Timescales July to October 2002.

c. Political/social issues

Outline definition

To determine the social, political and international relations issues around CO2 storage in the North Sea as to assess storage in the Irish Sea as well as on land.

Responsibility

The study will be defined by DTI/DEFRA with approval of the Working Group

The study will be undertaken by DTI and DEFRA

Timescales July to October 2002.

d. International Issues

Outline definition

To assess the possibilities for:

- collaboration with other countries such as Norway and Denmark on CO2 storage issues in the North sea. To also assess the benefits of such collaboration particularly in terms of the costs of a North sea pipe work and storage infrastructures. To also identify existing projects to determine if there are advantages of the UK joining these.
- the concerns of other countries whose coast line runs along any sea which is considered for storage.
- the export opportunities for the UK for storing other countries CO2.
- considering the need for inventory methods which would be acceptable under the UN-FCCC and Kyoto protocols.

International Trade Partners is also organising a mission to the USA and Canada in the autumn of 2002. This will provide an opportunity to assess the possibilities of collaboration with these countries on the research, development and deployment.

Responsibility

The research will be undertaken by DTI in consultation with DEFRA on inventory related questions.

Timescales: July to October.

e. Infrastructure Issues

Outline definition

This should address the overall economics of CO2 capture and Storage within the context of competitive power generation in the UK, answering the question about the commercial viability of the process. The costs incurred should be collected from the previous studies. It should consider:

- the price for CO2 which need to attained if its capture and storage is to be viable.
- the impact of EOR on the attractiveness of CO2 in the first instance. Will it be enough to establish an infrastructure so that later, when the CO2 is for storage only, the costs will be economic.
- the impact of an Emissions Trading Scheme which gives a value to CO2. Would it provide a sufficient incentive for investment.
- the impact this will have on the costs of generation and the price of electricity which will need to be reached to make the CO2 capture attractive. How will this compare with other sustainable forms of power generation (conventional as well as renewable)?

As these figures cannot be based on past evidence then a range of options will need to be considered and assumption clearly stated and justified.

This study will draw from the work of the other studies.

Responsibility

The study will be defined by DTI with approval of the Working Group

The study will be undertaken by a selected consultancy on the basis of their providing the appropriate experience, expertise and value for money.

The contact will be managed by FES.

Timescales October 2002.

Task 2 – A High level study will be undertaken to provide input to the Energy White Paper by early October 2002.

Outline definition

A top level paper covering the legal, economic as well as storage issues around CO2 capture and storage will be produced to inform the White Paper.

Responsibility

DTI

Timescales early October 2002.

Task 3 - Public Consultation

A seminar will be arranged with industry and other interested bodies being invited to discuss the issues.

Timing: October 2002

Task 4 - Development of final conclusions and policy recommendations

The outputs from tasks 1 and 2 would be used to develop a paper with recommendations to ministers, identifying further work needed, and the way the UK could feed in to international discussions on these technologies including technical and scientific input under the London and OSPAR conventions, and the work by IPCC.

Timing:

As project plan is attached as Annex A to this paper.

Brian Morris
ENP2

11 June 2002