Peterhead Power Station Case Study

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Introduction and overview

The proposed hydrogen power plant with carbon capture and storage project at Peterhead, Scotland, would have been the world's first industrial-scale hydrogen power project capturing carbon dioxide from natural gas and safely storing it permanently in a depleted oil well.

A number of technologies intended for use in this proposed project are already operating on a large scale around the world but this project would have integrated their operation.

The plant would have split natural gas from North Sea fields into hydrogen and carbon dioxide. Methane (natural) gas from a North Sea well would have been cleaned to remove the sulphur. A planned catalytic reformer would have split the methane, using steam and air into hydrogen and carbon monoxide, a shift reformer would have added steam and water to produce hydrogen and carbon dioxide. The hydrogen would have fuelled a 475MW combined cycle gas turbine (CCGT) power station while 1.8 million tonnes of carbon dioxide per year would have been dehydrated and stored in oil reservoirs simultaneously enhancing oil production (see Figure 1). 60 million more barrels of oil could have been extracted from the Miller field, thus extending its life.

The plant would have been the first large purely hydrogen-fired gas turbine power station in the world, producing 475MW of low carbon electricity with the capture of about 90% of the carbon dioxide emitted by an equivalent conventional plant.

An animation of the process is available at:

http://www.bridgecomms.co.uk/bp/df1.swf

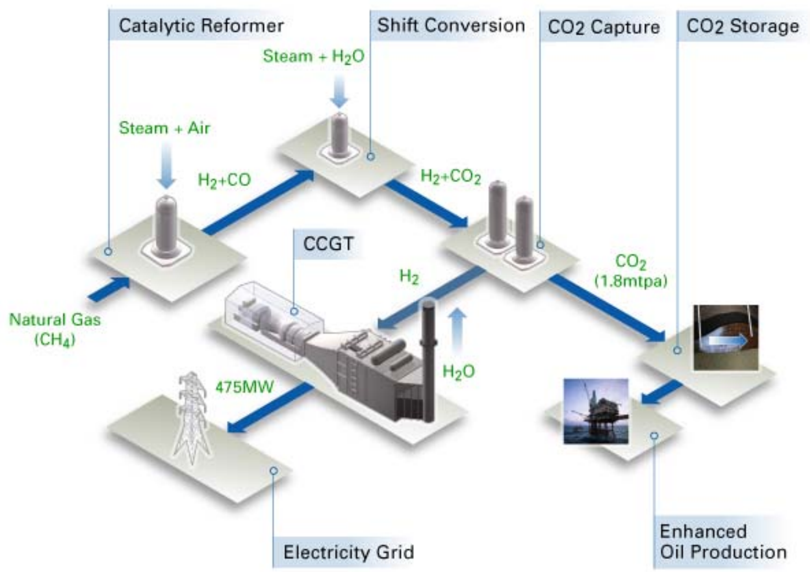

Figure 1 Diagram of the proposed hydrogen power plant at Peterhead ©BP

Project Goals

The objective was to demonstrate that the existing technology elements for a hydrogen-fueled power plant with carbon capture and storage were available in today's market at the scale required and that all the components could be integrated.

Funding sources and participants

BP and Scottish & Southern Energy provided a large amount of the initial finance to design the project. However, the project could not proceed as envisaged because the Miller platform feeding the proposed oil field could not be kept available to meet the timelines of the Department of Trade and Industry Carbon Capture and Storage funding competition. An estimate of the project's cost is £500 million.

Description of components and selection criteria

All the components selected are proven technology as the project philosophy was to minimise risk. It was planned that a combined cycle gas turbine would be used to generate electricity. Running a gas turbine solely on hydrogen as opposed to hydrogen and carbon monoxide (syngas) was an innovative step forward. Procurement of the gas turbine was via a contract that defined the performance criteria required and the financial penalties that would be incurred if the performance criteria were not met. To mitigate risk further, the project undertook burner testing using hydrogen.

The greatest challenge was integrating the components of the hydrogen plant and scheduling transportation, while at the same time developing a ‘brownfield’ site offshore.

The project was intended to be a viable demonstration project on the same scale as conventional gas power plants. The depleted oil well needed to be large enough to store 20 years worth of carbon dioxide, as this is the typical design life of a gas power plant. The geology and size of the Miller field that was selected to store the carbon dioxide was well understood.

The use of hydrogen as a fuel for transport was not a primary focus of the Peterhead project but was not discounted as a future option if local demand was present.

Environmental Aspects and Safety Issues

The health and safety issues were dealt with under existing legislation. The absence of on-site hydrogen storage reduced the potential hazards. There was more concern over the handling of carbon dioxide at high pressure than handling hydrogen, but these concerns were resolved satisfactorily. The Health and Safety Executive and the Scottish Environmental Protection Agency worked as the joint Competent Authority and were involved from an early stage, particularly to ensure compliance with the requirements of the Control of Major Accident Hazard Regulations 1999. Planning approval was achieved without objection from the Scottish Executive.

The use of CO_2 within the project and EOR (Enhanced Oil Recovery) scheme meant that the capture element of the project could be conducted under existing Petroleum Regulations and did not contravene the OSPAR (Convention for the Protection of the Marine Environment of the North-East Atlantic) and London Convention anti-dumping treaties.

Public Acceptance

There was good engagement with the local public from the start of the project that resulted in widespread acceptance. A conscious decision was taken not to have any on-site hydrogen storage in order to mitigate the potential scale of any incident. This contributed to increased regulatory body and public confidence.

Economic considerations

The predicted cost of the electricity generated was comparable with other low carbon power generation in the UK and would require the equivalent incentives. Additional support for renewable or carbon neutral generation in the UK is provided by renewable obligation certificates on a per MWh generated basis and can be traded separately to power. The renewable obligation certificate in the UK fluctuates in price but is currently around £42/MWh. The primary need is for robust policy incentives over a time horizon against which companies can make substantial investments decisions.

Whether the carbon capture and storage was an additional cost or the additional output from the field offset the cost was highly dependent on the oil price that was assumed. However the EOR scheme alone would not be sufficient to pay for the project on credible forward oil price scenarios

The project failed due to the Department of Trade and Industry's competition process extending the timeframe and uncertainty to an extent that the Miller field could not be kept available. The Miller field, that was identified for carbon capture, was ready for decommissioning at the end of 2006. This was extended until spring 2007 when the funding was initially delayed. However when funding was further delayed, maintaining the field became unviable.

Lessons learned

Positive lessons: Future potential

Although the installation of the plant at Peterhead is now unlikely as the Miller field will be decommissioned, the knowledge gained from the process has been valuable. Hydrogen Energy have already identified other potential projects. A coal carbon capture and storage project is proposed in Australia and a carbon capture and storage project is being considered in California.

Negative lessons:

Attempts should be made to ensure that all parties (partners, suppliers and governments) move together with the appropriate level of commitment and risk.

Conclusions

The components for carbon capture and storage are available and proven. However their integration has yet to be demonstrated at Peterhead, as the project has not proceeded. If the carbon store is to be a depleted oil well then the design and installation of the plant must be co-ordinated with its decommissioning and transition to other use. The Peterhead project ultimately failed due to a delay in funding that rendered the project unviable. In order to encourage such projects, long-term robust incentives are required for low carbon energy.

Without hydrogen storage the existing health and safety and planning regulations are sufficient in the UK for this type of project. Openness and engagement with the public resulted in widespread acceptance and support of the project.

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