

Pew Center/NCEP 10-50 Workshop

Contributing Paper: Gasification and Carbon Capture and Storage: The Path Forward

*Jon Davis, Head
Rio Tinto Energy Technology Group*

I. Introduction

The ultimate objective of the United Nations Framework Convention on Climate Change is to stabilize atmospheric concentrations of greenhouse gases (GHG) at a level that prevents dangerous anthropogenic interference with the earth’s climate system. To achieve this objective, it will be necessary for net anthropogenic emissions of GHG to ultimately fall to near zero. Technologies that permanently dispose of fossil fuel emissions will be critical to our ability to address the challenges of climate change.

Coal accounts for approximately 38% of fossil fuel CO₂ emissions. Internationally, it is the most abundant energy resource, and is widely dispersed and available at low cost. Coal plays an important role in the energy portfolio of both developed and developing economies. Two technologies are central to carbon capture and sequestration (CCS) of CO₂ emissions from fossil fuels. Gasification extracts energy from coal in a gaseous form (syngas), from which a high purity stream of CO₂ can be captured and permanently stored in deep underground formations. This is known as geological sequestration.

Both gasification and CO₂ injection into the subsurface are widely used technologies. Gasification has a thirty-year history in the chemical and petroleum industries, where it has an installed base of over 60 GW of syngas. Many of these applications involve the conversion of the syngas into hydrogen. In fact, a key advantage of gasification and geological sequestration is that the production of hydrogen is implicit in the process, and the technologies are therefore key links in not only establishing the security of future energy supplies, but also to the emergent hydrogen energy future. A number of researchers believe that coal gasification with geological sequestration will be one of the lowest cost sources of emissions-free hydrogen.

Underground storage of CO₂ is technically feasible and applicable at scale to the disposal of CO₂ from power stations – all the component technologies are commercially available and widely used. Naturally occurring underground reservoirs demonstrate that CO₂ is retained in favourable geology for millions of years. Currently, 20 Mt of CO₂ are used annually for enhanced oil recovery in the United States (via injection in depleted oil and gas fields), being pumped to injection points through more than 2,000 km of pipelines.

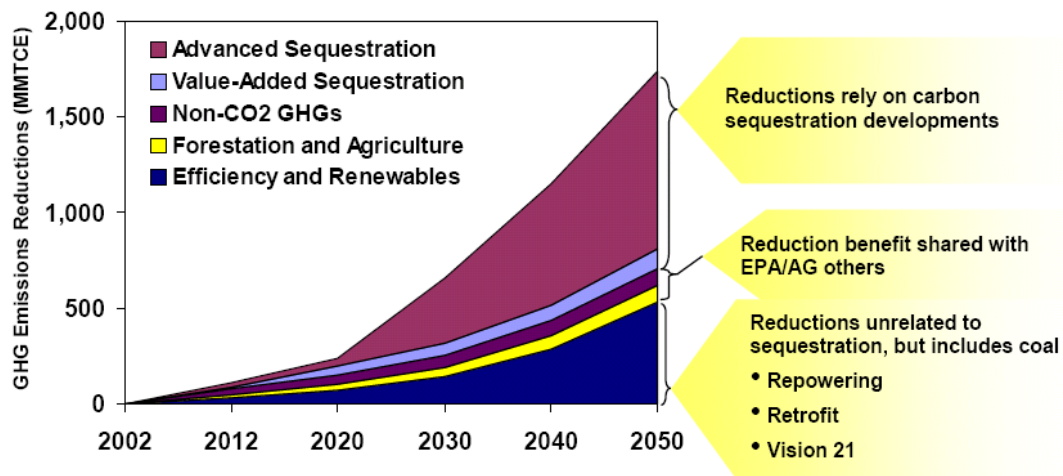
The gasification of coal and capture, transport and underground injection of CO₂ are therefore available and mature technologies. While gasification technologies are currently more expensive than conventional power generation technologies, experience has shown that additional installations will substantially reduce the capital costs. Thus, we need to better understand the costs associated with implementing these technologies at commercial scale.

In addition, geologic sequestration needs to be demonstrated at utility scale, utilizing a variety of geologic formations, to demonstrate its viability as a policy option.

II. Technology Roadmaps

The most complete currently available technology roadmaps for gasification and CCS have been developed in the US and Japan. These roadmaps align well against each other and a range of more recent studies by bodies such the WCI and the Canadian Clean Power Coalition.

The figure below (DoE, 2003) is typical of the projected implementations for advanced sequestration technologies. Up to ~ 2020 the emphasis is on demonstration projects, with commercial implementation occurring after this time.



From "Carbon Sequestration: Technology Roadmap and Program Plan" US DoE NETL Report, 3-2003^{1,2,3}

The DoE roadmap indicates the following timetable:

To 2012

- Conduct R&D to enable geosequestration at <US\$10/ton carbon
- Commence demonstration of geosequestration at > 1 million tonnes per annum (Mtpa) CO₂,⁴ including 4-6 large-scale international demonstration projects
- Develop instruments and protocols for the measurement, monitoring and verification (MMV) of carbon storage

To 2020

- Commercial deployment of carbon capture and storage at no net increase in costs

¹ "Value-added" sequestration refers to enhanced oil recovery (EOR) and enhanced coal bed methane (ECBM)

² "Shared reduction benefit" means that the reduction does not come exclusively from utility sector emissions.

³ Vision 21 is the U.S. Department of Energy initiative to develop pilot IGCC and CCS projects

⁴ This is the minimum scale of injection generally considered necessary to adequately stress the host geology in a way that demonstrates the viability of geosequestration at utility scale.

Post 2020

- Increasing commercial deployment

The Japanese development route is essentially similar in the definition of the key technologies and the timetable for their development. By 2020 the Japanese government projects that:

- Gasification will be in commercial use
- Hydrogen production with CO₂ recovery will have been demonstrated
- Fuel cells will have been demonstrated to run on coal-derived hydrogen
- Liquid fuels and chemicals will be routinely produced from coal

As a result, coal gasification becomes a core technology from 2020, with widespread carbon capture and storage and production of hydrogen for fuel cell use.

III. Non-Technical Issues

The issues to be addressed if the technology is to be widely implemented are, however, wider than the technical considerations (such as reducing the costs of CO₂ capture and demonstrating the permanence of storage), and include:

- **Social** – ensuring that CCS is publicly acceptable
- **Legal** – creating appropriate legal frameworks for the storage rights to geological structures below the surface; and
- **Administrative** – ensuring that an international series of demonstrations at scale, drawing on both government and industry support, enables commercialization of CCS technology in an appropriate timeframe.

Much of the debate to date has centered on the technical issues; however it is likely that the social, legal and administrative issues will be at least as complex, and unless properly addressed, have the potential to significantly delay commercial implementation of the technologies.

IV. Demonstrations and International Co-operation

Satisfactorily resolving these issues will only be possible by conducting a series of demonstrations, to address all realistic combinations of capture technologies and storage options.

These activities will be complicated by the required scale: realistic stressing of the host rock geology only occurs at injection rates at or above 1 Mtpa of CO₂, and confirmation of the retention properties of the reservoir requires injection for approximately three to five years, with monitoring continuing for some years after this.

Demonstrations at this scale are however already underway – the Sleipner project in the North Sea has been operating since 1996, injecting one million tonnes of CO₂ annually; and the U.S.-

Canadian Weyburn project has been recovering CO₂ from the North Dakota gasification operation and pipelining it for EOR use in Canada.

However a further four to six such demonstrations will be required, focusing on the technical issues outlined above and testing the concept in numerous operating locations. Because of the long project lead times, and the costs associated with these activities, it is imperative that these activities are co-ordinated internationally, with appropriate sharing of the findings to address public concerns about the technology.

Overall, considerable administrative and political effort will be required to ensure that an international series of demonstrations at scale, drawing on both government and industry support, enables commercialization of CCS technology in an appropriate timeframe.

The necessary R&D and demonstration projects will be most efficiently and cost-effectively handled as an international series of carefully constructed and integrated parallel programs. Obvious questions arise as to how the necessary coordination will occur, how public and private interests will share the project intellectual property, how the coordination agent(s) will be appointed and empowered, and how the necessary long-term RD&D funding commitments can be secured.

International co-operation and a suitable portfolio of demonstration projects is however developing. The significant sequestration demonstrations (Sleipner, Weyburn, Snohivist) report globally through such organizations as the IEA Greenhouse Program. When other projects under development are considered – Al Salah, Gorgon and FutureGen – the emergence of a critical mass of these demonstrations starts to become clear.

At the other end of the scale, small trials to develop MMV techniques are underway in Japan and Texas, and are proposed for Australia.

V. Conclusions

Underground storage of CO₂ is technically feasible and applicable at scale to the disposal of CO₂ from power stations – all the component technologies are commercially available and widely used. Naturally occurring underground reservoirs demonstrate that CO₂ is retained in favorable geology for millions of years.

The issues for the coal and utility sectors are to ensure that the costs of gasification are acceptably low; that geologic sequestration has been demonstrated to be a viable policy option; and that the public, legal and administrative issues around CCS have been addressed.