

Carbon Dioxide Capture and Storage: UK Experts Mission to Japan

Highlights

A mission of UK experts on CO₂ capture and storage (CCS) was undertaken to Japan from 29 September to 3 October 2008, with the support from Science and Innovation Section of the British Embassy Tokyo. A wide range of discussions were held with officials from government departments, and public and private sector organisations. A number of highlights were selected by the mission team as worthy of particular mention.

Policy

1. The Japanese Government appears to apply a more interventionist role in helping CCS to develop in Japan than the UK government does in the UK. Whereas Japan applies a *dirigiste* model, the UK has tended to adopt a *laissez-faire* or free-market approach. The Japanese Government, through the Ministry of Economy, Trade and Industry (METI), has undertaken a consensual planning approach with the key companies and research institutes. There is, consequently, a strong ownership of, and identification with, the national CCS programme. There also appeared to be a reasonable level of clarity in the roles ascribed to each organisation and over a reasonable length of time. This *dirigiste* approach has advantages in reducing inefficient competition and in encouraging long-term commitment to investment.
2. The Mission was very impressed by the work, staff, facilities and working environment at the Research Institute of Innovative Technology for the Earth (RITE), based in Kyoto. RITE has impressive, up-to-date facilities and custom-built equipment. As part of its extensive programme of activities, it covers the CCS value-chain from capture to storage, and includes engineering, geology, economics, systems analysis and public perceptions. The research ranges from basic 'blue skies' research to more applied RD&D. The Institute also has a strong relationship with industry. The existence of RITE clearly depends upon a strategic, focused and secure funding stream from METI.

Regulation

3. Domestic regulations regarding CO₂ storage in Japan (onshore and offshore) are currently being formulated by the Japanese Government.
4. As described in the London Convention, the purity of CO₂ for geological storage must be 'overwhelmingly CO₂'. For capture with amine-based solvents, the Ministry of Environment (MoE) has interpreted the term 'overwhelmingly CO₂' as $\geq 99\%$ CO₂. For other capture processes, the MoE has not yet come to a decision. For oxyfuel, for example, the requisite purity

level could conceivably be lower. It appears that the licensee will be required to make a case to the MoE if the purity of CO₂ in the captured stream is to be less than 99%.

5. The Japanese Government has not, as yet, adopted the notion of handover of the CO₂ storage site to the state in the post-closure period. It was felt that the approach taken by the UK Government (led by the Department of Energy and Climate Change), including its consultation on regulation and its associated approach to implementation of the requirements of the EU Directive, would be of value to the Japanese Government.

Finance

6. Japan does not have an emissions trading scheme, though there has apparently been some initial discussion on establishing one. Without an ETS, or an equivalent carbon tax, it is not clear how the financial incentives for developing and deploying CCS will be present in the Japanese context. The immediate priority appears to be the development of one or more pilot plants. In December 2008, the European Union agreed a package of climate and energy measures, including a directive on CCS and inclusion of CCS within the EU ETS. As a consequence, the EU ETS remains the principal policy instrument internationally for facilitating CCS deployment. Japanese companies will be looking eagerly to the European market for opportunities to export their CO₂ capture technologies.

Public awareness

7. Kansai Electric Power Plant Company (KEPCO) has an excellent programme of public engagement and dissemination. A key focus of KEPCO concerns its relationship to its local and wider community. It maintains a culture of openness, via its visitor centre, developing woodlands and organising community events. It was felt that the UK power utilities could draw constructive lessons from this positive attitude of engagement and the commitment to being a real part of, and contributing to, the community.

Storage

8. Estimates of geological storage capacity in Japan have been updated since they were previously reported in the early-1990s. The new estimates provide higher values than the earlier study indicated. The new estimates were summarised by RITE as follows:

Type of Formation	Anticline capacity, Gt CO ₂	Sedimentary basin capacity, Gt CO ₂
Depleted oil and gas	3.5	27.5
Identified aquifer	5.2	
Identified closure	21.4	88.5
Total capacity:	30.1	116.0
Grand total	146.1	

9. Though this is encouraging, a note of caution is required. The updated estimates are probably over-optimistic; they are based upon generic assessments of suitable geological formations, rather than on the detailed assessment of potential storage reservoirs that will take substantially longer to establish. There is an absence of the basic geological data that would permit a more detailed evaluation of the storage capacity. With the exception of Hokkaido Island and one or two other locations in Japan, which have been explored for oil and gas, there are very few bore holes at a sufficient depth in Japan. This makes it difficult to evaluate the geology and, consequently, CO₂ storage capacity in detail.
10. In the Osaka Bay area, there are a small number of deep boreholes, which has permitted a provisional assessment. A storage capacity of around 4.2Gt CO₂ has been estimated. A programme of seismic surveying and targeted deep drilling is now required to make a more realistic estimate of capacity.

Capture

11. The extent of investment by Japanese companies such as Mitsubishi, J-Power, Hitachi, KEPCO, Toshiba and others, in one or more of the capture technologies, was impressive. In a couple of cases, the investment dated back to the early- to mid-1990s. Post-combustion capture technology appears to have been developed incrementally since that time. Not only that, but several companies were exploring all three of the main capture technologies. This portfolio approach keeps the selection of capture technology, for particular circumstances, open. The extent of investment by industry in capture technology reflects a long-term commitment to CCS. This, of course, is instrumental in the involvement of Japanese companies in projects internationally, e.g. in Australia, Germany, Norway, the UK and the USA.
12. Furthermore, a company such as Mitsubishi Heavy Industries (MHI) may be involved in the entire CCS chain up to the point of CO₂ compression for transportation to the storage site. It possesses the capability to design and manufacture the power plant equipment, the CO₂ capture plant and the solvent. This involvement allows the potential for greater integration and optimisation at the plant design stage, as well as the potential for lower transaction costs arising from companies working together along the value-

chain. This integration could, in principle, encourage a 'virtuous circle', in which innovation and learning are facilitated and communicated along the value-chain.

13. For post-combustion capture at large-scale, chemical absorption is likely to be the preferred route for the next several years. Detailed discussions during site visits suggested that it would be possible to scale-up existing amine-based technologies (operating at about 300 tonnes of CO₂ capture per day) to a sufficient size for a typical coal-fired power plant (producing, say, 20,000 tonnes CO₂ per day). A possible constraining factor could be the logistics of manufacturing the CO₂ capture plant; economies of scale favour operation at a relatively large scale. The logistical challenges in assembling or constructing large CO₂ capture removal plant may present a problem in some parts of the world.
14. The IEA's 'Blue Map trajectory' (*Energy Technology Perspectives 2008*, IEA, Paris) anticipates the need for 55 new 500 MW power plants with CCS to be installed every year from 2020 onwards. Based on discussions with MHI, the total amount of amine required on a daily basis (to replenish the solvent) can be estimated. These preliminary calculations indicated that, in principle, there were no constraints to the use of amine-based capture technology with respect to logistics of production and supply of the amine itself. Since some amine-solvents are on the 'red list' of EC₅₀ chemicals (a measure of toxicity), however, there are still questions regarding their environmental impacts that need to be addressed.
15. There were also some encouraging estimates of overall post-combustion CO₂ capture costs (gate costs) from a coal-fired power plant with amine-based solvent of approximately US\$60/tonne CO₂ - assuming that other impurities in the flue gas had been removed. These compare with estimates made in the context of the EU Directive of approximately US\$120/tCO₂ for first-of-a-kind demonstration plants and between US\$30 and US\$55 per tCO₂ when the technology was fully advanced.

Deployment

16. Japanese companies are well placed to exploit opportunities from 'low hanging fruit'. This includes CO₂ capture arising from Clean Development Mechanism (CDM) projects, e.g. at gas processing plants. On the other hand, the Conference of the Parties to the UNFCCC 14th Meeting (COP14) in Poznan, Poland, in December 2008, failed to come to agreement on inclusion of CCS within the CDM. The Japanese firms visited are also investigating CO₂ capture from cement and steel plants.

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