getting India ready for carbon capture & storage

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India’s challenge of improving the living standards of its growing population through a low-emission development calls for early adaptation of carbon capture and storage (CCS) though the available storage capacity in India is limited. Early involvement by India in CCS R&D activities to gain from knowledge sharing and technology transfer will open short and long term solution vistas of utilization, sequestration or overseas shipment of CO₂.

However efficiently fossil fuels are used, they still emit carbon dioxide to the atmosphere and each tonne raises the risk of dangerous climate change. Over time the level of that risk is likely to become clearer, and the only way to contain it is, if fossil fuels are used, to employ carbon capture and storage (CCS) so that most of the resulting carbon dioxide emissions do not enter the atmosphere.

CCS typically involves separating out the CO₂ formed from the carbon in the fossil fuels, compressing it into a dense liquid at over 100 atmospheres pressure and then placing it a kilometre or more underground, in ‘sponge-like’ porous rocks with an impermeable rock sealing layer above them, where it is expected to be held permanently over many millennia or longer. A good overview of CCS is given in the Intergovernmental Panel on Climate Change report on CCS⁰. This was published in 2005 but still is a valuable reference document. Indeed, in some respects CCS has appeared to move relatively slowly since then because, as the technology gets close to deploying the first full-scale projects, much of the work is commercially sensitive and does not get published so freely. Introducing legislation to regulate and fund CCS also takes a significant amount of time, compared to undertaking conceptual studies.

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With a rising population linked to an increased energy demand, India is expected to become one of the top three CO₂ emitters in the world by 2030; it is currently ranked sixth. Out of the country’s present installed electricity generation capacity of around 160GW, roughly 55% is generated by thermal power plants, mostly from coal. This capacity is likely to be increased significantly in the next 10-20 years. India has plans to upgrade and extend its current fleet of power plants by investing in thirteen more efficient coal-fired Ultra-Mega Power Plants (UMPPs), which would entail a further 52GW of installed capacity coming on line starting in 2012⁴.

As well as making a vital contribution to economic growth this may also offer some opportunities to lay the foundations for future emission reductions through CCS. The Indian Government has already initiated this process through its National Action Plan on Climate Change (NAPCC)⁵. One worthwhile activity is to investigate how the UMPPs and other industrial projects can be made carbon capture ready (CCR – see Box 1) at the design stage. In addition, India’s involvement at the early R&D stage of capture technology development will enable access to the global knowledge sharing and technology transfer process, encouraging innovation and development of CCS systems designed specifically for Indian conditions.

Carbon Capture and Storage and Capture Readiness – UK experience to date

In the UK most of the major CCS developments so far, since 2005, have been in the field of legislation, taking steps which are essential in advance of CCS deployment. Actual projects are being planned but final investment decisions have yet to be made.

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¹ Intergovernmental Panel on Climate Change, 2005. ² http://www.iea.org/papers/2010/ccs_g8.pdf ³ Source: CCS Ready workshop in Ottawa Canada. ⁴ CC and CCSR, both globally and locally. More specific issues related to this process are being addressed by the CCS Project. ⁵ For instance, in jurisdictions where the Fossil Fuel Power Plants (FFPPs) are the only source of electricity, this approach could prevent installation and operation of CO₂ capture, transport and storage, thus making CCS non-viable.
Definition of carbon capture and storage ready (CCSR)

A CCSR facility is a large-scale industrial or power source of CO₂ which could and is intended to be retrofitted with CCS technology when the necessary regulatory and economic drivers are in place. The aim of building new facilities or modifying existing facilities to be CCSR is to reduce the risk of carbon emission lock-in or of being unable to fully utilise the facilities in the future without CCS (stranded assets). CCS is not a CO₂ mitigation option, but a way to facilitate CO₂ mitigation in the future. CCS ceases to be applicable in jurisdictions where the necessary drivers are already in place, or once they come in place.

Essential Requirements of a CCSR facility

The essential requirements represent the minimum criteria that should be met before a facility can be considered CCSR. The project developer should:

- Carry out a site-specific study in sufficient engineering detail to ensure that the facility is technically capable of being fully retrofitted for CO₂ capture, using one or more choices of technology which are proven or whose performance can be reliably estimated as being suitable;
- Demonstrate that retrofitted capture equipment can be connected to the existing equipment effectively and without an excessive outage period and that there will be sufficient space available to construct and safely operate additional capture and compression facilities;
- Identify realistic pipeline or other route(s) to storage of CO₂;
- Identify one or more potential storage areas which have been appropriately assessed and found likely to be suitable for safe geological storage of projected full lifetime volumes and rates of captured CO₂;
- Identify other known factors, including any additional water requirements that could prevent installation and operation of CO₂ capture, transport and storage.

The timing of these decisions is, of course, linked closely to availability of funds. Early CCS projects cannot be expected to cover their costs from measures that are already in place, such as the EU Emissions Trading Scheme. The time to develop CCS as a proven full-scale technology is well before CO₂ emission caps are made tight enough to require its widespread use. Deploying CCS can then help to achieve the reduction targets while limiting how high the...
carbon price is and, the cost society pays for reducing CO₂ emissions, will rise.

The UK’s Energy Act of 2010⁶, passed with strong cross-party support in April, just before the recent election, includes primary legislation to allow the costs of CCS demonstration projects to be met by imposing a levy on electricity supply. The secondary legislation to define the details of how this money is paid, how projects will be selected and so on, still has to be developed, however. One key question is whether payments are based on the amount of low-carbon electricity produced or on the amount of CO₂ stored. Another is whether or not CCS projects on natural gas will be included on the initial programme of around four CCS demonstrations, as recently suggested by the UK Committee on Climate Change⁷. Although gas produces less CO₂ per unit electricity than coal, each tonne of CO₂ emitted still carries the same risk, and with gas now at low prices, it is generating nearly 50% of the UK’s electricity and it is on the rise.

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A piece of legislation that is even more urgent, however, is one to make all new power plants greater than 300MW capacity ‘carbon capture ready’ (CCR – also sometimes known as carbon capture and storage ready – CCSR). There is only one real chance to make power plants and other large fossil fuel facilities capture ready (or storage ready for oil and gas fields), which is when they are being designed and changes can be made at minimal cost. Capture readiness guidelines have been published⁸ based on an earlier study for the IEA Greenhouse Gas R&D Programme⁹. The first UK power plant has recently been consented under these new guidelines - a natural gas combined cycle unit near Manchester¹⁰.

Work is actively under way to translate the capture ready concepts into detailed engineering designs¹¹. The basic principles for capture readiness are largely common sense – see the latest summary definition shown in Box 1 – but to the extent that all large power plants are different, they have to be tailored to each individual project and site. This need not cost a great deal of money since little or no extra equipment has to be purchased. What is needed is ‘intelligent space’ throughout the plant so that the interconnections and services required by a range of possible types of capture equipment can be put in place without unnecessary costs and with the plant shut down only for normal outages. There also needs to be a larger space available (which can be used for other purposes until required) on which to site the capture plant itself and a pipeline route to storage.

Although it is not clear yet which of the new gas power plants being built in the UK will need to be retrofitted with CCS – some may end up being used only for peaking operations or be closed down altogether – since there is only one opportunity to make a plant capture ready and the costs are low, it is being carried out in all cases as a precaution.

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Carbon capture and storage and capture readiness in India

Similar arguments about having one chance to put ‘intelligent space’ for possible capture equipment apply anywhere that new fossil power plants are being built. Would this be relevant for new Indian power plants too, to help them be capture ready for new CO₂ capture technologies being developed in India and elsewhere?

One obvious issue is - what CO₂ storage capacity would be available in India?. The permanent storage of CO₂ is generally expected to involve the injection of CO₂ into suitable large sedimentary basins with a good impermeable rock sealing layer. This can include depleted oil and gas fields, unmineable coal seams, and deep saline non-potable water-bearing reservoir rocks.

A study conducted for the IEA Greenhouse Gas R&D Programme (IEAGHG) in 2008 looked at the storage capacity on the Indian subcontinent. Areas where there may be significant CO₂ storage potential are highlighted in red in Figure 1. This map also illustrates the existing CO₂ sources as well as the planned UMPPs. The first thing to note on this map is

Figure 1: India’s planned and existing CO₂ sources in 2008, and geological basins with good storage potential (source: IEAGHG 2008)
that the appropriate areas for permanent storage are predominantly oil and gas-bearing sedimentary basins that lie on the coastal margins of the subcontinent. Areas where there may be significant CO₂ storage potential are highlighted in Figure 1. Although it is not clear yet which of the new gas fields (also sometimes known as carbon capture and storage readiness – CCSR). There is only one real chance to make power plants and gas exploration will take precedence over CO₂ sequestration for at least the next ten to twenty years. Scientists in India have also been investigating alternative means of CO₂ storage, chiefly by mineral trapping mechanisms within basalt rock samples, sequestration within terrestrial ecosystems and bio-fixation through micro-algae for fuel generation.

India has been researching clean coal technologies for a number of years, including R&D on CO₂ capture processes, and is actively engaged with carbon sequestration leadership forum (CSLF), an initiative started by the US Dept. of Energy. Scientists in India have also been investigating alternative means of CO₂ storage, chiefly by mineral trapping mechanisms within basalt rock samples, sequestration within terrestrial ecosystems and bio-fixation through micro-algae for fuel generation. Mineralisation in basalt rocks is of particular relevance as a very extensive portion of the central Indian peninsula consists of one of the world’s largest basalt lava flows, known as the Deccan trap formation. However, these studies are laboratory based, and it will be a number of years before the technology could be proven to be safe and deployable at scale.

It is likely that the immediate driver for any Indian CO₂ injection offshore will be hydrocarbon recovery, rather than CO₂ emission mitigation, and that oil and gas exploration will take precedence over CO₂ sequestration for at least the next ten to twenty years. Scientists in India have also been investigating alternative means of CO₂ storage, chiefly by mineral trapping mechanisms within basalt rock samples, sequestration within terrestrial ecosystems and bio-fixation through micro-algae for fuel generation. However, these studies are laboratory based, and it will be a number of years before the technology could be proven to be safe and deployable at scale.

Although the other prospects for geological storage of CO₂ on the subcontinent look limited, a solution for India may be to consider shipping CO₂ to other regions that have more suitable capacity. The shipping of CO₂ is expected to be cost-competitive to pipelines if long distance transport is required and is currently being regarded as an important and emerging industry that could play a key role in developing the CCS chain of technologies in Europe. Exporting CO₂ to the Middle East for enhanced oil recovery is presently being researched and may be an option, particularly as India is keen to develop its shipping terminals for coal imports for the planned UMPPs.

Conclusions
Given India’s ambitions to improve the living standards of its growing population, to the extent that this could be undermined by dangerous climate change, it is also necessary to consider ways to lay the foundations for a low-emission development pathway. Early implementation of CCR on planned UMPPs could help to cut CCS costs in the long term and prepare India for global deployment of CCS. Early involvement by India in CCS R&D activities would allow it to be part of the global knowledge share and technology transfer process, and also ensure that systems suitable for the unique Indian conditions were developed. Storage of CO₂ may prove a challenge in the long term, as there is limited capacity in the coastal margins of the subcontinent, but a medium term solution could be to use CO₂ for enhanced hydrocarbon recovery. Other solutions could be to ship the CO₂ to Middle East, which has large potential storage capacity, or, if it proves technically feasible, to use sequestration in India’s very large basalt rock formations.

References
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