CAPTURING INDIA'S CARBON

THE UK'S ROLE IN DELIVERING LOW-CARBON TECHNOLOGY TO INDIA

POVERTY

A Christian Aid report based on the findings of research by the University of Edinburgh and the University of Surrey

christian aid

Christian Aid works in 48 developing countries, including India, tackling problems such as energy poverty and the effects of climate change.[1] We have been campaigning to influence the UK and EU governments on climate change matters, for instance in relation to carbon emissions from coal-fired power stations, for more than two years.

The changing climate is already affecting the lives of the poorest people in countries such as India. They have contributed least to the problem yet are feeling its effects first and worst. In the face of this injustice we cannot remain silent.

Poverty is an outrage against humanity. It robs people of dignity, freedom and hope, of power over their own lives.

Christian Aid has a vision – an end to poverty – and we believe that vision can become a reality. We urge you to join us.

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Front cover photo: Elephants bathing in the Yamuna River in front of a power station in New Delhi, India

Joerg Boethling/Still Pictures

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EXECUTIVE SUMMARY

Climate change is already having a devastating impact across the developing world, affecting access to water and food, destroying homes and taking lives. If poverty is to be over in our lifetime, the world will have to halt man-made climate change. Developing countries – and especially their poorest people – have done least to cause global warming. It is the responsibility of the rich world, which has the capacity to respond to climate change, to support the low-carbon development of poorer countries such as India.

Carbon capture and storage (CCS) has been hailed by many countries – including the UK, Canada and the USA – as an important way of reducing the global greenhouse gas emissions that cause climate change. It is seen as part of the way to ensure energy security in a time of climate crisis. Many believe it will allow countries to continue burning coal without increasing the threat of climate change.

It was a commitment of Barak Obama's bid for the presidency of the United States.[2] Launching the UK's manifesto for the international climate talks in Copenhagen, Prime Minister Gordon Brown stated that 'carbon capture and storage will be a vital new technology in reducing carbon emissions around the world'.[3]

However, CCS technology has not yet been tested at a commercial scale on a power station. The European Union (EU) is committed to demonstrating 10-12 CCS plants before 2020 and the G8 is planning 20 demonstration sites. These demonstrations will provide private power companies with billions of euros to trial CCS technology in new coal-fired power plants or to retrofit CCS on to existing power stations across the EU. The United Kingdom is positioning itself to develop and fund up to four of these CCS demonstrations and has an on-going competitive process to select its first commercial-scale CCS plant.

To justify the expense of the CCS demonstration – rather than investing public money in other low-carbon technologies – the UK and other EU countries argue that India and China will continue to use coal in the foreseeable future, so we need to transfer this technology to them.

Challenging this premise, this report seeks to answer the questions:

- Is CCS the right technology for India?
- Would CCS benefit the people living in poverty in India?
- If transferring technology to poor countries is a central objective of the UK and EU CCS demonstrations, how can they best achieve this?
- If India is to develop the massive coal-fired power stations it has planned in the coming decade, how can the UK and EU help India make them carbon-capture ready?

Context for India

Economic growth in India has led to a rise in energy demand, which in turn has led to an increase in overall CO_2 emissions, as the vast majority of its energy has been supplied by fossil fuels. More than 70 per cent of India's carbon emissions come from the burning of fossil fuels, a significant proportion of them from coal-fired power plants.

To reduce dependence on coal and increase diversity, Indian policymakers are increasingly interested in promoting energy efficiency and renewables. Although these can be expected to reduce annual emissions of greenhouse gases, they are motivated much more by the need to increase the security of supply and meet the country's escalating fuel needs.

More than 600 million Indians live without electricity and more than 700 million still use traditional biomass as their primary cooking fuel. Despite a government target of electrifying all villages by the end of the decade, more than half of rural households in India still lack electricity. This is holding back development in these areas. One way of filling this energy gap would be to develop 'off-grid' renewable energy schemes that are managed locally and provide electricity and fuel for such things as lighting, cooking, telecommunications, heating, pumping water and operating machinery. These are an important alternative to grid-based systems. Any plan to transfer technology from rich to poor countries should consider how best to meet the needs of India's energy-poor. For the vast majority, who have no access to the electricity grid, CCS will not solve their problem.

For India – and other developing countries – to adopt low-carbon energy technologies they will need incentives, including:

- a clear international climate change regime
- industrialised countries taking the lead on demonstrating and implementing low-carbon technologies
- technology training and development for India, so that it can make and implement its own decisions about low-carbon technologies
- assured financial support from rich countries, both up-front and into the future.

Technology cooperation should open choices to allow India to make its own decisions, not demand any specific action of India.

Christian Aid believes that India should work first and foremost towards a renewable and sustainable energy future.

Christian Aid commissioned researchers at the Universities of Edinburgh and Surrey to produce a report – *Investigating the Prospects for Carbon Capture and Storage Technology in India*[4] – exploring these questions. It includes considerable technical data on the Indian energy sector, the feasibility of CCS in India and the results of a questionnaire which was circulated to key stakeholders in the Indian energy sector.

Summary of Christian Aid's recommendations

To achieve a low-carbon future, India will require other countries' cooperation on many technologies, from improved cook stoves to concentrated solar power. **Christian Aid believes that India should work first and foremost towards a renewable and sustainable energy future** that will increase poor people's access to power, improve the country's energy security and decarbonise the economy.

Christian Aid also believes that the UK and EU must reduce their own emissions and test technologies that can contribute to global emissions reductions before urging developing countries, such as India, to use them. Hypocritical arguments tend not to be persuasive.

However, while coal remains 'king' in the Indian power sector, it is important that India is carbon-capture ready and able to develop CCS as part of its low-carbon strategy. The UK and EU CCS demonstrations must deliver results appropriate to the Indian context. **There is a strong belief in India that developed countries must demonstrate and (if the demonstrations are successful) deploy CCS on a commercial scale before projects in India are considered.**

Christian Aid recommends:

- The climate negotiations in Copenhagen must, as a priority, establish a clear framework for international technology cooperation and finance, if countries such as India are to take significant steps towards a low-carbon future.
- The 10-12 EU demonstration projects should test a wide range of CCS technologies and carbon storage methods and produce results that are valuable for specific developing countries such as India.
- The UK must show international leadership by cutting its own emissions: The government's current plan is to allow up to four new coal-fired power stations to be built, with only 25 per cent of their emissions captured, allowing 75 per cent of emissions to be emitted to the atmosphere. This lacks a firm plan B in the event of CCS not being proven effective. Instead, we should only build fully-abated new plants or put CCS on existing power stations.
- CCS demonstrations must produce knowledge that is publicly available and directly applicable to poor countries' needs. This should be a condition of public funding for the demonstration projects. The global agreement on climate change must include key principles for technology transfer and knowledge sharing.
- Intellectual property rights pose a significant barrier to developing countries accessing low-carbon technologies. Given the urgency of climate change this is a barrier that must be removed.
- Indian policy makers, engineers and scientists should be fully engaged in the development and review of the demonstration programmes.
- A national technology assessment and action plan will be essential to allow national decision-making and ownership of its low-carbon energy sector in India. This must have energy access for the poor as a central objective.
- More research is needed on how much capacity India has to safely store captured carbon dioxide. This must include an assessment of the possible wider social and environmental impacts of CO_2 storage, particularly on the poorest and most vulnerable people.
- Finance mechanisms and assurances: The cost of CCS is currently viewed as prohibitively high in India. To make it and other low-carbon technologies a viable option, the Copenhagen agreements will have to deliver sufficient, reliable and long- term finance.

BACKGROUND

'It is this global context to CCS which explains why we are so determined to ensure… that there is a proper EU commitment to investing in carbon capture and storage.'

Rt Hon Ed Miliband, Secretary of State for Energy and Climate Change, December 2008[5]

Coal is the most CO_2-intensive of all fossil fuels and is responsible for more than 50 per cent of historical emissions. Many countries, including India, have built or are planning to build coal-fired power stations the lifespan of which means they will be emitting carbon dioxide (CO_2) at a time when emissions must be reduced in the power sector worldwide to prevent dangerous climate change.

Carbon capture and storage (CCS) refers to processes that capture CO_2 from the emissions produced by fossil fuel- (coal-, oil- and gas-) burning power stations, and then transport the CO_2 by pipe (or ship) to be stored – or sequestered – underground. While this is a relatively immature technology, that has yet to be tested on a commercial-scale power plant, it is already being promoted very widely as part of the solution to climate change.

Many believe it will allow much of the world to continue to burn coal without exacerbating climate change. In his review of the economics of climate change, Lord Stern stated: '[CCS] is a technology expected to deliver a significant portion of the emission reductions. The forecast growth in emissions from coal, especially in China and India, means CCS technology has particular importance.'[6]

There is some discussion about whether CCS can act as a bridge between dirty fossil fuel power and sustainable renewable technologies.[7] **For the UK, CCS should be used during the transition from its existing coal-based power sector to a fully renewable one.** CCS would also allow for continued power generation in countries such as India, while at the same time reducing their carbon emissions and giving them time to develop long-term renewable solutions.

The UK and other EU countries justify much of the huge sum of taxpayers' money they intend to spend on CCS demonstrations with the argument that India and China will continue to use coal in the foreseeable future, so we need to transfer this technology to them. The EU says it is 'Committed to stepping up CCS cooperation with China and extending it to other partners (eg South Africa and India)'.[8]

This report questions this justification for the case of India.

What is CCS?

CCS technologies have the potential to reduce emissions from fossil fuel power stations (and other industrial plants) by at least 90 per cent. They capture CO_2 before it reaches the atmosphere and put it in an underground location. Many of the processes involved in CCS have been demonstrated on a relatively small scale, including some commercial applications in other industries, but they have yet to be demonstrated together on a commercial scale on a power station. Until this is done, CCS will remain too costly to be used widely,[9] and uncertainty will remain about whether CCS can be viable on a commercial scale.

Technology choices

The three methods of CO_2 capture that are closest to commercial deployment at coal-fired power plants[10] are:

- **Post-combustion** processes that separate CO_2 from the exhaust gases produced by the combustion (burning) of fuel (coal, natural gas, oil, or biomass) in air. CO_2 is captured using a liquid solvent, such as aqueous amine solution. Once absorbed by the liquid solvent, the CO_2 is then released by heating. Post-combustion capture has been carried out successfully, but so far on a relatively small scale.
- **Pre-combustion** processes that convert fuel into a gaseous mixture of hydrogen and CO_2. The CO_2 is then separated and the hydrogen can be burned without producing any CO_2 in the exhaust gas. Pre-combustion capture is used in industrial processes but has not been demonstrated in much larger examples of coal gasification.
- **Oxyfuel** combustion processes that use oxygen rather than air for the combustion of fuel. This produces exhaust gas that is mainly water vapor and CO_2. The exhaust gas has a relatively high CO_2 concentration (greater than 80 per cent by volume). Oxyfuel combustion systems are being developed on a small scale, in laboratory or demonstration projects.

All three options are feasible for new coal-burning power plants, though certain coal types – such as the high ash coal often found in India – are unsuitable for pre-combustion technologies. Many existing coal plants could be retro-fitted, probably with a post-combustion technology.

Storing carbon

Once captured, CO_2 is then transported by pipe or, for power plants on the coast possibly by ship, to a site where it can be stored.

Oil fields, gas fields, deep saline formations (aquifers), and un-mineable coal seams have been suggested as geological storage sites. Here, various physical (eg highly impermeable cap rock) and geochemical trapping mechanisms would prevent the CO_2 escaping to the surface. Other ways of using rock formations – such as the potential for mineralisation in basalt rocks – are under investigation.

CO_2 is sometimes injected into declining oil fields to increase oil recovery (known as enhanced oil recovery). While this option has an economic benefit – the additional oil recovered – the environmental cost of extracting more fossil fuels must be seriously considered.

The safety of storage sites – that is how securely they will retain the CO_2 – is still being investigated. There are many sites considered safe, but even these will require continuous monitoring to ensure there is no leakage. It is worth noting that in Germany there has been a large-scale public opposition to transporting CO_2 through pipes and storing it underground near urban areas.

What will CCS cost?

CCS will increase the cost of power from coal for two reasons. First, the additional cost of the CCS infrastructure, equipment and transport pipe work can add one third to the cost of building the power plant. Secondly, capturing and storing the CO_2 makes power generation less efficient, so every unit of power requires more fuel to be burned.

The additional costs of commercial-scale CCS remain unclear. The demonstration projects will help assess the costs involved. A recent study[11] by the Harvard Kennedy School's Belfer Center for Science and International Affairs estimates that for demonstration coal plants, capturing carbon will cost approximately 10¢/kWh more with capture than without. The costs of abatement are found typically to be approximately US$150 per tonne CO_2 avoided. But as more such plants are built, costs will fall to approximately 2-5¢/kWh above electricity generated by conventional plants, and with costs in the range of US$35-70 per tonne CO_2 avoided.

With the current price of carbon at less than US$20 per tonne of CO_2, CCS does not look attractive. It is predicted that carbon prices will rise as global caps on carbon emissions are tightened. There are also a number of low-carbon options – including energy efficiency, small hydro power and wind – that provide lower-cost carbon abatement.[12]

'And we need to be helping to drive forward the key technologies and sharing the know-how about them. This is why action on CCS and coal is so important. It's not just about UK emissions; it is about pushing forward CCS as quickly as possible.'

Rt Hon Ed Miliband, Secretary of State for Energy and Climate Change, June 2009

Context of climate change

In December 2009, countries that have signed up to the United Nations Framework Convention on Climate Change (UNFCCC) will gather in Copenhagen to agree international action on climate change, particularly from 2012 to 2020. Technology cooperation has been central to the UNFCCC since its inception:

The UNFCCC says: 'Recognizing that all countries, especially developing countries, need access to resources required to achieve sustainable social and economic development... including through the application of new technologies on terms which make such an application economically and socially beneficial.'

The UNFCCC defines enhanced action on technology as addressing research and development, deployment, diffusion and transfer of affordable environmentally sound technologies to enable developing countries to cut their emissions.[13]

The Copenhagen meeting is an opportunity to deliver a clear framework on technology cooperation and finance to make this happen.

Developing countries such as India, which has 830 million people living on less than two dollars a day and more than 600 million people with no access to electricity, have to bring their people out of poverty as a first priority. The UNFCCC makes this clear. However, climate change is a global emergency and so both rich countries and large emerging economies such as India must cut their emissions.

Another UNFCCC principle is that the polluter pays. The responsibility for delivering emissions cuts in developing countries is therefore firmly in the hands of the industrialised world. Thus the UK and EU must use CCS as a tool to reduce their own emissions first, and then they can take these technologies to developing countries to help them fight climate change. The developed world must get its own house in order before recommending action to the developing world.

Each developing country should develop a national technology action plan (TAP) – a technology transfer mechanism under discussion at the UNFCCC – which will assess the low-carbon technology priorities for the country. These must also detail the technology cooperation and finance to be delivered by industrialised countries.

The role of the UK and EU demonstration CCS projects

The 2020 EU Energy and Climate Change package has secured a deal expected to be worth €7-12 billion to fund up to 10-12 demonstration of CCS across Europe.[14] The European Economic Recovery Plan currently under negotiation also proposes a little more than €1 billion for CCS demonstrations. These will hand private power sector developers billions of euros to trial CCS technology in new coal-fired power plants or to retrofit CCS onto existing power stations.

The UK is committed to an early demonstration of CCS technology.[15] In its 2009 budget, the UK government announced its intention to support up to four CCS demonstration plants, including both pre-and post-combustion coal projects. The Climate Change Act commits the UK to reducing its emissions by 80 per cent from 1990 levels by 2050. The UK must develop low-carbon technology, including CCS, to deliver its own commitments. However, it must also recognise its responsibility to the developing world, by taking into account the appropriateness of these technologies for poorer countries.

It is essential that all the EU demonstration publicly funded projects should test a wide range of CCS technologies and carbon storage methods, in order to produce results that are useful to the widest possible range of countries and situations.

DEMANDS OF THE INDIAN ENERGY SECTOR

This section draws mainly on the research report *Investigating the Prospects for Carbon Capture and Storage Technology in India*. The quotes are taken from 18 respondents to a detailed survey that was sent to a range of energy stakeholders (from industry, government, business and research) in India.

Energy security

In India, energy security (in various forms, including providing reliable access to electricity for rural poor communities) is generally seen as a higher priority than action to mitigate the risk of dangerous climate change.

India presently has about 138GW of installed capacity, where approximately 70 per cent is generated by thermal (fossil fuel) power plants, with the rest supplied by hydro power, nuclear and from renewable, mostly wind (IEA 2007). By comparison, the UK has installed capacity of about 83GW[16] (for a population an eighteenth the size of India), with 79 per cent from thermal power, 13 per cent nuclear, five per cent hydro power and three per cent renewables.

To reduce dependence on coal and increase diversity, Indian policymakers are taking a growing interest in promoting energy efficiency and renewables.

India is already making significant steps towards developing renewable energy technologies. It recently unveiled its first solar power target, pledging to boost output from a current near zero to 20 giga-watts (GW) by 2020.[17] India has a long-term commitment to wind power with an installed capacity of about 10,000MW. It is also developing innovative technologies such as concentrated solar power. A solar concentrator dish converts energy from the sun and can be used to boil water into steam to drive a steam engine or steam turbine. It can also be used to concentrate the sun on to a solar cell. This has the potential to become a significant source of power globally.

However, the survey results showed that almost all the respondents expected coal to dominate the power sector in India until 2050. In their words 'coal is king'.

Energy poverty

Developing countries are faced with a major dilemma. They have to cope with the adverse impacts of climate change, look towards reducing their own emissions as part of the global effort and at the same time reduce poverty. For example, approximately 2.5 billion people rely heavily on traditional cooking fuels, and around 1.6 billion have no access to electricity in developing countries.

India perfectly illustrates the nature of this challenge. While its middle class has full access to modern energy services and economic growth based on the high fossil fuel-based power systems, the poor are left with no modern energy sources but have to face the worst impacts of climate change.

India has the world's largest concentration of poor people – more than 830 million Indians live on less than US$2 a day, and roughly 370 million of those live in abject poverty on less than US$1 a day.[18] More than 600 million Indians live without electricity, and more than 700 million still use traditional biomass as the primary fuel for cooking.[19] At the same time, the Indian government is committed to the millennium development goals (MDGs),[20] which require a significant increase in the proportion of the population with reliable access to energy.

Improved living standards in India are inextricably linked to an increase in energy demand. The fulfilment of basic human needs, such as education, sanitation, health and communication, depend on modern energy services. At present, women and children spend considerable amounts of time collecting firewood, often keeping children from school. This dependence on biomass for cooking causes more than 400,000 premature deaths (mostly those of women and children) in India annually, because of the smoke pollution from traditional cooking fires.[21] India has had a number of programmes to improve the cooking practices of poor people, but traditional practices remain dominant.

Despite a government target of electrifying all villages by the end of the decade, more than half of rural households in India still lack an electricity supply. This is holding back development in these areas.

One way of filling this energy gap would be to develop locally managed, 'off-grid' renewable energy schemes that provide electricity, biogas or biodiesel for many uses, including lighting, cooking, heating, pumping water and operating machinery. These offer an important alternative to, or perhaps complement, grid-based systems which are usually powered by coal. The double win here is that they

can limit a growth in carbon emissions while also helping to meet the rural poor communities' urgent need for a reliable energy supply.

Survey respondents were clear about priorities for Indian energy supply planning. One noted that 'the priority of any developing country will be to provide electricity to its population through its locally available resources, if developed countries are not providing other options'. Another commented: 'Provide access to the 440 million [sic] without access, so they can get on the first rung of the ladder of development. Once the country is fairly prosperous, climate change will become a priority itself.'

Large investment in coal and CCS will not benefit the energy-poor communities of India who are far from the electric grid. **Christian Aid believes that any national or international low-carbon strategy must bring direct benefits to the poorest people**. This will largely mean investment in decentralised renewable energy systems.

Climate change perspectives from India

In response to the growing concern about the projected impacts of global warming on the Indian subcontinent, India produced its first National Action Plan on Climate Change (NAPCC) on 30 June 2008. It states that the 'Action Plan hinges on the development and use of new technologies', and lays out its strategy to combat climate change by means of eight 'National Missions'.[22] It is important to note that the NAPCC is not a legally binding document, but rather a statement of intent by the Indian government.

The plan clearly asserts a position shared by many developing countries, that: 'India is determined that its per capita greenhouse gas emissions will at no point exceed that of developed countries even as we pursue our development objectives.'

Two missions focus on energy – the National Solar Mission and the National Mission for Enhanced Energy Efficiency. The energy efficiency plans aspire to 'result in a saving of 10,000MW by the end of the 11th Five Year Plan in 2012'. They also propose a new requirement for energy-intensive industries to make specific energy consumption savings, and raise the possibility of a system for companies to trade energy-savings certificates.

The plan is based on the principle that maintaining high economic growth rates is essential in order to raise the living standards of the vast majority, who live below the poverty line.

However, the Indian media has typically concluded that the plan will help neither the poor nor the climate. Particular concerns include the absence of any plans to cut oil and coal subsidises, which distort the fuel supply and electricity markets. There is also a question about how India can maintain high growth rates – 'to increase its power-generating capacity by more than 200,000MW over the next decade and double that before 2026' – at the same time as cutting carbon.

The survey revealed concerns that climate change is not yet perceived as a serious problem by the Indian public. It was noted that the Clean Development Mechanism (CDM) had been 'quite instrumental in spreading more information about climate change mitigation in India'. Nevertheless, one stakeholder commented that from what they had observed in the Indian business and academic communities, climate change was generally regarded as the 'environmental fad of the decade, instead of a serious problem'. They thought that there was still 'an acute lack of awareness' outside a very small group of people in Delhi and other metropolises. Another comment was that 'individual companies view energy security from their own short-term perspective rather than the wider context of [the] long-term future of generations to come'.

On the UNFCCC negotiations, one survey respondent stated: 'There is a lot of propaganda in the western press, clubbing India with China about growth of emission. Most developed countries have failed to achieve their Kyoto targets; the US has not even ratified the Kyoto treaty.'

Another said: 'I tend to agree with the slightly confrontational attitude the Indian climate change negotiating team is taking right now, because the access and poverty agenda should not be forgotten. For India, provision of energy services is and should be the first priority till complete access.'

CCS POTENTIAL IN INDIA

The Indian government continues to see a significant role for coal in the future. India has a large fleet of existing coal-fired power stations with sub-critical (generally low-efficiency) steam conditions. The composition of typical Indian coal requires modifications to standard plant designs used in other parts of the world, due to several factors including high ash content.

More recently, supercritical plants that heat steam to higher temperatures and hence are more efficient have started to be introduced in India. As of February 2009[23] the Indian government has announced plans to invest in 13 coal-fired Ultra-Mega Power Plants (UMPP).[24] Of these, at least seven are planned under international bidding, and it is expected that these plants will come online after 2012.[25]

Contrasting India and China

India and China are often grouped together in respect of their response to climate change. However, there are very significant differences between the two countries, which has meant they are taking very different routes towards a low-carbon future. Just three of these differences are detailed below:

- Poverty levels: India's per capita income is US$1,068, against US$2,912 a year in China.[27] Approximately 80 per cent of its population lives on less than US$2 a day, more than double the rate in China.[28] Both have huge commitments to reduce absolute poverty – but India's challenge is far greater.
- Carbon emissions: Emissions of CO_2 from both countries are growing rapidly but China – which is now the world's largest annual emitter of CO_2 – has far higher emissions per person than India: 4.23 tonnes a year compared to only 1.07 tonnes.
- Readiness to take risks with technology: In recent years, China has been involved in various CCS projects with international partners. Chinese companies have also begun constructing their own demonstration-scale facilities and considering more ambitious CCS projects. In India, activities have generally been strictly limited to research projects, and there has been considerable scepticism about whether CCS is an appropriate option in the Indian context.

Challenges for CCS in India

India has yet to be convinced that it has the responsibility or capacity to adopt CCS as part of the global fight against climate change. The Indian government participates in the Carbon Sequestration Leadership Forum (CSLF)[26] which was founded by the US in 2003. However, it shows minimal interest in CCS demonstration or policy. Comments from industry and government sources indicate that CCS is considered a 'frontier technology', which needs to be developed further in developed countries first, to reduce its cost through research and development and deployment.

This may be due to technical uncertainties about CCS technology, particularly to suit Indian conditions; concerns about a lack of geological storage capacity in India and the cost of financing the construction and the ongoing cost of capturing and storing carbon.

Although CCS is not seen as an immediate priority for the government of India or industry, survey respondents do expect it to become more important in the future, particularly for industry.

In particular, survey respondents typically suggest that developed countries must demonstrate CCS on a commercial scale before any such projects in India are considered. Furthermore, developed countries should also begin widespread deployment first, if demonstrations are successful.

Related to this, the lack of mature technology is seen as the main barrier to CCS being a viable option for India. Survey respondents also highlighted costs, political acceptability and proving the safety of geological storage as key considerations. In the longer term, lack of adequate storage capacity is also a concern.

Respondents also stressed the importance of ensuring that technology transferred in any agreements is likely to be suitable for local conditions, including the low quality of typical Indian coal. The poor quality of many kinds of Indian coal means that they are generally not suited to pre-combustion (gasification) CCS technologies; to use pre-combustion technologies would require India to depend on increased amounts of imported coal.

CO_2 storage concerns

Both the availability of suitable storage sites and the identification of suitable routes for transporting captured CO_2 to such sites require careful consideration. As one survey respondent observed 'India does not have sufficient geological seams for storage, power plants are scattered and pipeline transfer could be costly'.

Initial findings seem to indicate limited geological storage capacity for CO_2 in India, although further characterisation of potential storage sites is needed. They include coal fields, oil and gas fields and deep saline water-bearing rock. The US is sponsoring research into a new but untested storage option in basalt rock formations. **Christian Aid would be concerned if the storage sites were located near communities that do not have access to electricity, so gain no benefit while having to take the risk related to CO_2 storage.**

Another option being considered is that of long-distance transport of CO_2 to other regions of the world, such as the Middle East.

If suitable storage capacity is not available within a particular region, then ship transport of CO_2 to other regions with suitable facilities is possible and is expected to be cost-competitive if long-distance transport is required.

Although there is generally little enthusiasm for commercial-scale use of CCS in India, some initial projects are now being developed, usually by oil and gas companies which see the potential for enhanced oil recovery (EOR) using CO_2. There have been serious discussions about the option of exporting Indian CO_2 for foreign EOR activities, most likely in the Middle East.

Some of the new coal power plants in India – the Ultra Mega Power Plants (UMPP) projects – are planned for coastal sites with large shipping terminals included for coal imports. It may be possible for tankers that currently deliver gas (LPG) to India from countries, such as Qatar, to be converted to take return loads of CO_2 for injection into depleted gas or heavy oil fields.

Cost of CCS to India

The survey gave the general view that CCS technology in its current state is too expensive, not only in construction but also in terms of running costs.

A recent study by Mott MacDonald, funded by the UK Foreign and Commonwealth Office, explores the potential for making the new power plants planned by India – the UMPP projects – 'CO_2 capture-ready'.[29]

Capture-ready is the term used for a plant that can be readily fitted with CCS at a later date. This study reports that making a typical UMPP capture-ready would add no more than one per cent to its cost. It is also suggested that capture-readiness 'would be a commercially attractive proposition', giving power plants the option to retrofit CO_2 capture at minimal, although still significant, cost in the future.

At the time of the study, nine UMPP sites had been identified: three coastal sites using international coal and six inland sites using Indian coal and located at the pit-head. It was concluded that CO_2 capture could be around US$5/t$CO_2$ higher for the inland sites than the coastal sites, mostly because of increased transport distances for CO_2 storage.

It is, of course, also important to consider whether it is economically and technically feasible for existing plants to be retrofitted with CCS in India, even if they were not built capture-ready. The suitability of existing plants will depend on factors, including site-specific considerations such as space, availability for construction and ease of access, to make modifications to the base power plant for integration between the power plant and the capture plant. Recent studies indicate that retrofits to existing plants could be financially worthwhile, as long as they are technically feasible. This option becomes more attractive under global policies to reduce greenhouse gas emissions by charging for the emission of CO_2.

It is expected that the carbon market will deliver much of the finance for the capital and the ongoing cost of CCS. One important mechanism within the Kyoto Protocol has been the Clean Development Mechanism (CDM). However, inclusion of CCS under the CDM has been a contentious issue. A number of questions have been raised, including whether CCS projects contribute to sustainable development. Another concern is that CCS may not be a mature enough technology to be considered for market-based deployment.

'It is not clear that the Indian government has received a serious high-level request to make its new coal plants carbon-capture ready (CCR), and especially one with any meaningful inducement attached to it or a serious discussion of what CCR entails.'

Dr Jon Gibbins, Imperial College, London

The Indian government has started considering certain CCS projects for potential applications for support under the Clean Development Mechanism (CDM), including one that plans to use CO_2 from an offshore sour gas facility at Hazira, Gujarat for enhanced oil recovery (EOR) at an onshore site 70km away. There has, however, been dispute around whether CCS projects should be included in the CDM.

Christian Aid is extremely concerned about the potential use of CCS for enhanced oil recovery being included in carbon finance mechanisms such as the CDM. This method of sequestration is wholly against the principle of paying for reduction in carbon emission, if the process is substantially done in order to increase access to fossil fuels.

The respondents to the survey were doubtful of the potential of the carbon market. The majority of stakeholders (13 out of 18) agreed with the statement: 'The existing financial mechanisms (eg CDM, carbon markets, etc) are insufficient to support and promote clean energy solutions'. In the context of the CDM and carbon markets, it was commented that 'there is very little support and incentives for CDM for SMEs [small and medium enterprises] in developing countries such as India'. One respondent commented further: 'I agree with the view of some of the technocrats in India that CDM and carbon markets of the future will not give enough support to CCS, for which investment is much higher than other low carbon technologies.' Another respondent concurred: 'In my opinion, policy changes that allow CCS to be part of the CDM will be insufficient due to the energy penalty of the technology.'

Interestingly, a stakeholder observed that in the past, organisations such as the World Bank had imposed certain prerequisites before granting loans. A few respondents also gave examples of occasions where previous experience of engagement with the international community had not been entirely positive, partly since some of the conditions required by the international community as part of a deal had dictated changes that Indians did not want. One example given was the precondition to open up the Indian power market to international equipment suppliers and implement technologies that, in some cases, were not suitable for Indian coal.

The role of developed countries in delivering technology cooperation

The survey and research in India have shown that it is expected that industrialised countries – including the UK, EU and USA – must take a leading role in delivering low-carbon technologies. One respondent stated: 'I consider that CCS will eventually become important for India, but not until the technology has been developed and demonstrated in the US, Europe and China.'

The greater part of respondents (14 out of 18) agreed with the statement: 'The international community is not doing enough to create a suitable framework for facilitating technology transfer.'

One commented: 'There has been very limited financing and technology transfer from developed to developing countries. Also, the technologies being given are not necessarily those which developing countries are currently comfortable with at the moment.'

It is clear that this must be within a global framework – to part of the Copenhagen Agreement – which will deliver a clear signal for developing countries as to what support they will get for taking the risks required to transform to a low-carbon energy sector.

Specific assurances are demanded before India will consider CCS a viable technology option:

- tried and tested technology
- effective technology cooperation
- clear financial support for construction and for the on-going increased costs of power production using CCS
- intellectual property rights (IPR) transferred.

One of the survey respondents argued: 'Technology development in India should be promoted with possible IPR with Indian government or public sector so as to make technology available at affordable costs.'

The overall process of technology transfer was also met with some scepticism; it was considered to 'just mean being directed to a private company, which in turn charges large amounts as fees to share the knowledge of the technology'. These are issues that will have to be addressed directly by any new agreement.

RECOMMENDATIONS

India needs assistance from other countries to ensure the security of its energy supply and to increase access to modern energy for millions of its people, without adding to global greenhouse gas emissions. Achieving a low-carbon future for India will require cooperation on a wide range of technologies, from improved cooking stoves to concentrated solar power. **Christian Aid believes that India's priority should be a renewable and sustainable energy future,** which will:

- increase poor people's access to power through decentralised renewable technologies
- increase energy security by using locally available resources
- achieve a low-carbon economy.

However, while coal remains 'king' in the Indian power sector – as suggested by the survey – India must be in a position to be carbon-capture ready and to develop CCS in the future as part of its low-carbon strategy. The UK and EU demonstration plants must deliver knowledge that is relevant to the Indian context. It is vital that the UK and EU reduce their own emissions and test technologies that can contribute to global emissions reductions, before urging them on developing countries such as India.

For India – and other developing countries – to adopt low-carbon technology as an integral part of its energy planning, certain incentives must be in place. These include:

- a clear international climate change regime
- industrialised countries taking the lead on demonstrating and implementing low-carbon technologies
- training and capacity building to allow India to choose and implement the low-carbon technologies that are right for the country
- assured financial support, both up front and into the future.

Christian Aid's recommendations are:

The global climate change agreement struck at Copenhagen must open up a low-carbon development pathway for developing countries

- For countries such as India to take significant steps towards a low-carbon future, there must be a clear international framework to help them do so.
- The Copenhagen agreement must set up clear mechanisms for rich countries to help developing countries with clean technology and finance, to give the reassurances that India and other emerging economies need to re-structure their energy sectors and invest in new low-carbon technologies. The UK and the EU must lead the way on such mechanisms.

The EU/UK CCS demonstrations must produce results for developing countries as well as the rich world

'It is essential to develop CCS not just for the UK but for the world as a whole.' Rt Hon Ed Miliband, Secretary of State for Energy and Climate Change, December 2008

Christian Aid believes the UK's demonstrations of CCS must have two main priorities. They must contribute to achieving our climate change targets and also contribute to the development of relevant technologies for decarbonising other economies (including India's).

There is a strong belief in India that developed countries must demonstrate CCS on a commercial scale before any such projects are considered in India. Furthermore, if the demonstrations are successful, developed countries should also begin widespread deployment first.

- Diversity and effectiveness of demonstrations: It is essential that the 10-12 publicly funded EU demonstration projects test a wide range of carbon capture and storage methods, in order to produce maximum knowledge. They should include testing technologies that are suited to conditions of specific developing countries (such as India).

  The UK should ensure its demonstration plants fit strategically within the EU-wide programme in order to maximise learning, prevent duplication of effort, and achieve results with the greatest possible relevance to countries such as India.

- The UK must also reduce its own emissions if it is to show international leadership: The CCS demonstrations should help the UK to cut its domestic emissions and continue to show leadership internationally.

  The government's current plan is to allow up to four new coal-fired power stations to be built, with only 25 per cent of their emissions captured, allowing 75 per cent of emissions into the atmosphere. This lacks a firm plan B in the event of CCS not being proven effective. Instead, we should only build fully-abated new plants or put CCS on existing power stations.

  Building new, only partially abated coal-fired power stations without a robust plan to ensure they either capture all emissions or close by 2030 poses an unacceptable risk to the world's climate. The lack of a plan means that the UK could be locked into high emissions for decades to come. The committee on climate change, that advises the government on how to reach its targets, has recommended that the power sector must be almost completely decarbonised by 2030.

- What does the UK really need to do in order to demonstrate CCS? It is unclear whether there are any substantial benefits to be had by demonstrating partial post-combustion CCS on new supercritical coal plants, such as those planned for Kingsnorth or Tilbury, as opposed to demonstrating on existing sub-critical plants.

  The UK should instead test innovative CCS approaches, such as the retrofitting of post-combustion CCS on an existing site, for example the one proposed at Longannet. This would help reduce the absolute emissions of the power sector immediately and may well also be implemented more quickly – producing early results that could then be applied to any future plants. An alternative or additional project would be to demonstrate pre-combustion technology on the full generating capacity of a new plant – capturing about 90 per cent of CO_2 from the outset.

Building in technology cooperation from the beginning

- Sharing the results of demonstrations. An important question for India and other developing countries is whether there are appropriate mechanisms to allow them to share the lessons learned from initial commercial-scale demonstration and deployment of CCS (and other key technologies) in developed countries. Governments in wealthy countries such as the UK must define a minimum standard of knowledge and learning that will be publicly available and directly relevant to poor countries' technology needs. This should be a condition of the contracts signed with firms that are given public money to run CCS demonstrations.

- Intellectual property rights (IPR). IPR have the potential to become a very significant barrier to developing countries' adoption of CCS and other low-carbon technologies. Given the urgency of dealing with climate change, this is a barrier that must be removed. Respondents to this study expressed concern about the conditions that might be imposed by intellectual property sharing agreements. The good news is that governments in wealthy countries have considerable leverage in this area, because they will fund their countries' demonstration projects by using taxpayers' money.

  It is vital that governments use this power effectively, to require the companies getting large sums of public money to act in the global interest when it comes to sharing knowledge and technology that can help solve the climate crisis.

- Governments funding CCS demonstrations should also require that Indian policy makers, engineers and scientists are fully involved in their development and review, from an early stage, and in related research and development.

  Most survey respondents thought that rich country governments should also fund initial training projects in developing countries. Private companies in developed countries should also have a significant role in the longer term. A further suggestion was the establishment of local knowledge/training centres within India, to encourage the development and use of clean power technologies

Supporting India to take a low-carbon pathway

Technology cooperation should open choices to allow India to make its own decisions, not demand any specific action of India.

- A national technology assessment and action plan is needed to focus decision-makers' attention and ensure national ownership of the low-carbon energy sector in India. CCS is only one of the possible low-carbon technologies that the country might want to exploit. Central objectives of the plan should include reducing energy poverty and increasing energy security. The Indian National Action Plan on Climate Change is a first step towards such a national technology assessment, but there are concerns about its commitment to carbon cuts and to ending energy poverty.

- Assess India's CO_2 storage capacity. With some doubt about the availability of sufficient safe storage sites in India, it is essential to increase research into India's carbon storage capacity. It seems likely that other countries could assist Indian scientists and engineers to explore and map the country's geological storage potential and to identify alternatives, given concerns about the likely available volumes in the medium term and beyond. This must include an assessment of the possible wider social and environmental impacts of CO_2 storage, particularly on the poorest and most vulnerable people.

- Establish finance mechanisms and assurances. India needs assurances from the international community before it will risk adopting new low-carbon technologies. The cost of CCS is currently viewed as prohibitively high. Most survey respondents suggested that for India to consider CCS, it will need assurances about knowledge sharing, technology transfer and finance. The opportunity cost of developing coal with CCS must also be recognised. The more resources devoted to CCS, the bigger the sacrifice of fully renewable technologies, such as concentrated solar power and wind power.

  To make CCS more attractive to India, there will have to be sufficient, reliable, long-term finance available from the industrialised world. It is needed now to encourage new power stations to be carbon-capture ready and in future to pay for the installation of CCS technology and compensate for the resulting increase in the cost of power generation.

The Copenhagen agreement must include a commitment by industrialised countries to substantial funding of mitigation work in developing countries.

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