Carbon-free energy generation from coal: myth or reality?

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It is well known that certain naturally occurring trace gases in our atmosphere trap radiant heat from the sun and give rise to the greenhouse effect. In the post-industrialisation era, some manmade greenhouse gases are being added to the atmosphere and are contributing to enhanced greenhouse gas effect or global warming. Global warming is not yet fully understood since it's a complex climate phenomenon. Carbon dioxide (CO_2)—both natural and manmade—is the most important greenhouse gas. The generation of energy from fossil fuel combustion is among the main sources of manmade CO_2 emissions today.

Looking at the current energy situation in India, coal is a dominant fuel in power generation as well as for industrial production. Of the total installed electricity capacity of 130 gigawatts (gw) in 2006, coal accounted for 62%. The Indian economy is currently growing at a rate of 8-9% per annum. India is facing formidable challenges in meeting its energy demand, which is a crucial input for all economic activity. The process of economic development essentially requires increasing production and consumption of energy. It is projected that the installed power generation capacity would increase six times by 2031-32, approaching 800 gw, and the coal requirement will grow at least five times and, therefore, CO_2 emissions are bound to increase. The other major greenhouse pollutant from coal use is nitrogen oxide (NOx).

The main challenge is: how to achieve CO_2-free electricity, preferably zero emission, from coal? Coal-based energy technology is rapidly moving from low emissions towards very low and ultra-low emissions. Zero emission is the goal for future. Deployment of more efficient technology as well as capturing and sequestering carbon would become important in the future to minimise carbon emissions.

The technology of carbon capture and storage (CCS) has three major components, starting from the capture of CO_2 in the atmosphere, transporting it to a possible safe storage location and the process of injecting CO_2 for permanent storage away from atmosphere. Research on pre-combustion CO_2 capture, CO_2 separation from the flue gas of a power plant, post-combustion capture, its transport, terrestrial sequestration, geological sequestration, enhanced hydrocarbon recovery, bio-fixation and industrial uses is under way.

Some novel ways to convert CO_2 into fuel through genetically designed micro-organisms are also being pursued. The CCS technology is not yet ready for market-based deployment. Industrialised countries have proposed collaboration in deploy- ment of CCS technologies with developing countries. Such deployment would mean significant addition to the cost of electricity, though. Other barriers include non-existence of suitable geological storage regions and the absence of CCS regulations.

Are there any possibilities, which can help in the adoption of CCS technology as a way forward to deploy clean coal technologies at a faster pace? For long, coal gasification has been considered to be the most efficient method for producing clean synthetic gas from coal.

FutureGen is world's first near-zero emission coal gasification-based demonstration power plant of 275 mw capacity proposed by the US Department of Energy and supported by industry alliance partners. In India, efforts for developing a clean coal technology began more than two decades ago. Efforts are also being made to realise a demonstration-size integrated gasification combined cycle (IGCC). The investment requirement is huge and globally the progress in commercialisation of IGCC has been slow. Moreover, it is yet to be operated successfully in the case of high-ash coal.

On the other hand, the advancement in coal combustion technologies has made it possible to develop super-critical and ultra-supercritical boilers. India is already on the path of super-critical coal combustion mega-plants. Another alternative is combustion in the presence of 100% oxygen in place of air, known as oxy-fuel combustion.

The future choices in third-generation clean coal technology would have to be made between coal combustion and coal gasification technologies based on their relevance to the use of low-grade fuels to suit the Indian situation. Short-term opportunities and challenges for CCS in the fossil fuel sector using advanced clean coal technologies as a bridging option to energy security, if met successfully, could give an impetus to economic growth in the country.

Oxy-fuel combustion has become the focus of high technology activity worldwide in the past two years. The other advantage is that NOx emissions in the flue gas are negligible since nitrogen is removed before combustion. It's estimates that there is 40% lower commercial and less technical risk compared with IGCC. It makes Oxy-fuel a good choice, if oxygen production (used in combustion) becomes cost-effective. Sufficient experience exists in the Indian industry on atmospheric or circulating fluidised-bed coal combustion processes and it needs to tap into these ongoing efforts to make oxy-fuel a sound business proposition.

Clean coal technologies like IGCC and oxy-fuel have the potential to become a CCS technology. In IGCC, CO_2 is separated from gaseous fuel, which is a mixture of CO_2, carbon monoxide and Hydrogen. CO_2 stream in flue gas is highly concentrated (up to 90%) in oxy-fuel plants, making is easier to capture it. Let us now begin with the identification of an outdated plant as a test case to undertake site-specific characterisation and assessment of operational parameters as well as future storage geology.

For the CCS industry to come up in the country, some regulations must be in place in order to effectively manage the risks and liabilities for its adoption. While protection of the environment will be the primary objective, the profit-making for industry will depend on the initially thought-out contracts and regulations. India has already taken voluntary action to contribute to stabilisation of global CO_2 concentrations through participation in the Kyoto Protocol's Clean Development Mechanism (CDM). Clean coal technology is, however, not addressed appropriately in CDM, but can become an additional source of revenue, if acceptable methodologies develop.

It is time to plan a FutureGen for India to make coal-based zero emission a reality.

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