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Climate Changes and Carbon Sinks

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ABSTRACT: Horses were primary means of transport then. Soon technology found the solution for roads clogged with thousands of tons of manure. Automobiles came, replaced the horses and cleaned up roads. Almost a century later, increasing exhaust fumes from automobiles started adding to pollution and in the 1990s became a cause of global concern - the climate change. Crisis of global warming, rising sea levels, intense weather events, water shortages have shaken up the humanity. From automobiles to industries, time is ripe for new technology to resolve the catastrophe. Greenhouse gas emissions including carbon dioxide are potential global warming threats and are accepted physical manifestations of increasing anthropogenic and development activities around the globe. Globally, coal continues to be the fuel of the future (The Economist, April 19th 20 I 4) and is much needed for energy industry. India has 17 per cent of the world's population. As third largest producer of coal and also greenhouse gas (GHG) emissions, its total emissions are only 5 percent of the global emissions.

Keywords: Horse; carbon capture; automobile; greenhouse; carbon dioxide

INTRODUCTION

Climate change mitigation

International protocols and conventions on climate change namely; United Nations Framework Convention on Climate Change and Kyoto Protocol are binding all countries of the world to make greenhouse gas inventories for taking action towards stabilization of CO_2 concentration in the atmosphere. The CO_2 emission reduction commitments/targets of coal dominant countries including India are shown in Table 1.

India as an emerging coal dominant economy has to find its own solutions to climate change. It needs to have a credible response in terms of green technology, to fight greenhouse gas emissions. As a signatory country to Kyoto Protocol, no commitment for reduction of emissions was required to be made then. However, in the Copenhagen Summit, India volunteered GDP intensity reduction of 20-25 percent by 2020 from 2005 level.

Post Kyoto phase, UN secretariat has desired all countries to give their Intendend Nationally determined contributions (INDCs). These will be finalized during the Paris Summit in December, 2015. India's stated objectives in (INDCs) are :

- **(i)** To bring down GDP intensity reduction of 33-35 per cent by 2030 from 2005 level,
- **(ii)** To have 40 percent non fossil fuel based electricity capacity and
- **(iii)** to add carbon sinks for 2.5-3 billion tons of carbon dioxide by 2030.

We have achieved electricity capacity of 272, 432 MW on 31st July, 2015. In this, coal is around 1,65, 000 MW, gas 23,000 MW and diesel 993 MW. We have a total thermal capacity of 1,89,313 MW. From renewable source 35, 776 MW, hydro 41, 632 MW and nuclear is 5717 MW. When we analyze the good and bad of various sources of energy, we come to the conclusion that energy sustainability has to be achieved by exploring all energy sources.

The most significant aspect in this forward looking policy is that technology would have to find ways through new research and optimum resource utilization. Let us have a look at the current perspectives of INDCs three objectives in India.

DISCUSSION

Energy Efficiency Improvement: Under National Action Plan on Climate Change, the National Mission on Enhanced Energy Efficiency (NMEEE) has a focus on improving energy efficiency across the sectors. The first phase of Perform, Achieve and Trade (PAI) mechanism completed in 2015, has nine designated largest energy demand sectors namely; Aluminum, Cement, Chlor-alkali, Fertilizers, Pulp & Paper, Power, Iron & Steel, Sponge Iron and Textiles. Use of energy efficient technologies in fossil fuel based power plants, such as super critical and ultra supercritical boilers has been encouraged. It reduces demand on fuel and the GHG emissions per unit of electricity generated. The second phase of PAI is being launched incorporating three more sectors of Electricity Distribution, Railways and Oil Refineries. Incentivized through participation of private sector, a large number of technologies would have to be implemente4 many of which are existing and can be applied across the sectors.

Efforts towards efficient technology adoption have to be mounted in other demand sectors as well. In the transport sector, new standards have been set for fuel economy and a 15 per cent reduction in fuel consumption is targeted by 2021-22. The 20 per cent blending of ethanol and biodiesel in automobile fuel is the target for 2018. The up gradation of existing technologies including search for alternative fuels and electric vehicles to achieve their commercial viability has to be the main goal towards a climate change solution-

In the building sector, we have National Mission on Sustainable Habitat demand technologies for green buildings and smart cities. When India’s target to create 100 'Smart Cities' with energy efficient transport and energy network water conservation and waste management, many challenges are there before the urban planners. Adoption of new technologies is imperative for making carbon neutral cities. Use of energy efficient home appliances and better heating and cooling systems in offices, use of light emitting diode (led) lights, bioclimatic architectural designs and use of environment friendly building materials are other options to be implemented for achieving the set reduction of 33-35 per cent in GDP intensity.

Non Fossil Fuel Energy Technology: Non fossil fuel energy technologies produce no GHG emissions during operation and if they can be harnessed on large-scale and become cost competitive, they are possible climate change solutions. The Integrated Energy Policy 2006 has projected 800 Gw of electricity installed capacity in2031-32. 40 per cent of this would mean that that 320GW should come from non fossil fuel energy.

Currently, renewable energy, hydro power and nuclear power add to 83 GW. The current share of renewable electricity capacity is 13 per cent in total generations in India. The revised National Solar Mission target is 100 GW installed capacity by 2022. At present, solar energy capacity has reached 3.5 GW which is almost eight times compared to 47 MW in 2010. The goal is to have a total of 175 GW by 2022 from all renewable energy sources. Application of solar photovoltaic technologies viz. solar rooftop and solar parks is being significantly enlarged. 25 solar parks and 4 mega power plants are expected to come up. Research has shown that new materials like gallium arsenide, carbon nenotubes have potential to increase the efficiency to as high as 50 per cent. Key technologies of solar thermal and solar concentrators are also to be pursued. In solar PV energy, solutions have to be found for large land requirement and mammoth use of cells, which would result in severe waste disposal problems in l0-15 years.

For wind energy growth, the energy capacity targets are 50 GW by 2022. It may be necessary to have installation of mega off-shore plants. The technology of wind towers has to be optimized using advance techniques. At the same time, boost to other technology for the growth of bio energy, waste management, geothermal and ocean energies is also necessary. The balancing contribution will come from additions in hydroelectric power and nuclear power capacities. All these would require advancement in technology and planned investment.

Carbon Capture, Storage and Utilization Technologies: In the total energy generations dominance of coal is expected to continue in the coming decades. Targets are 1 billion tons of coal by 2020 and 2 billion tones or more by 2030. India's INDCs envisage additional sinks for carbon dioxide for 2.5 to 3 billion tones in the next 15 years. In this respect development of perspective technologies such as carbon dioxide capture and storage – CO_2 sequestration, becomes inevitable.

The CO_2 sequestration involves capture of excess CO_2 from its point sources and its permanent fixation through storage or utilization away from the atmosphere. Captured CO_2 is sequestered by means of surface processes or by sub-surface storage and or by utilization in recovery of energy fuels and minerals. If the source and the underground fixation sites are not near to each other, transport of liquid CO_2 over long distances is required. The_2 sequestration technology is a multi-disciplinary scientific and engineering topic. As this approach is new, we describe various technology sub sets requiring research inputs from diversified fields in more detail.

Clean Coal Technology: All technologies for reduction of pollution from coal combustion can be termed as clean coal technology. CO_2 can be captured in a coal based plant either in pre-combustion or during combustion or post combustion stages. A11 three processes involve physical, chemical or biological means of separation. ln the pre-combustion capture, coal is first converted into *syn* gas or liquid fuels before the power is generated. The coal *syn* gas comprises mainly of carbon monoxide (CO) and hydrogen (H_2). H_2 is used as fuel for pollution free power generation. For capture of CO_2 processes such as hydrogen membrane reforming, shift gas reaction in association with Integrated Gasification Combined Cycle and Fischer-tropch synthesis are adopted. Pre-combustion CO_2 capture is preferred option at high temperature and high pressure as compared to post combustion capture. Post combustion capture is end-of-pipe alternative in which CO_2 is separated from the flue gas stacks. Chemical separation using amine based CO, capture techniques have been developed, but their application in large-scale operation leads to almost doubling the cost of electricity. Research is therefore needed in developing other processes like use of polymeric membranes for carbon capture, physical adsorbents and using nanotubes.

In-combustion CO, capture has two technology possibilities; (i) supercritical and ultra-supercritical coal combustion, where efficiency is more, CO, emissions per unit of generation are reduced, (ii) advance technologies like oxy fuel combustion and chemical looping which produce higher CO_2 concentrations in the fuel gas. Research is directed towards development of materials for ultra- supercritical boilers and reduction in the cost of oxygen separation from air for oxy fuel combustion technology.

CO_2 Sequestration and Industrial Energy: The industry sector contribution to GHG emissions is 37 per cent of total emissions. Industry consumes about 40 per cent of the total energy generated worldwide. The application of CO" capture and utilization processes for industry are similar to those of power plants. Industrial waste and slag are proving good absorber of CO_2. Appropriate technology needs to be developed for a greater push to carbon management in Post Kloto regime.

Terrestrial CO_2 Sequestration: Terrestrial sequestration of CO- is chiefly biological. Carbon assimilation occurs in forests, trees, crops and soil and act as CO_2 sinks. Currently, research in enhanced photosynthesis fixation in plants, advance technique of micro mediated CO_2 sequestration using algae and carbonic anhydrate enzyme catalysis are being pursued in R & D laboratories and universities. Advances are taking place in genomic sciences and are providing new ways of CO_2 fixation. Reclamation of waste lands together with afforestation has potential for CO_2 sequestration for both below and above the ground, while it may also add to growing carbon markets.

Underground CO_2 Trapping: Research on both active and passive underground trapping of CO_2 is being attempted. CO_2 can be buried in deep saline aquifers as well as in rocks and minerals. CO_2 storage is in demonstration stage and several large-scale experiments have been undertaken worldwide. Sleipner, Norway has proved to be the first successful project in CO_2 storage in the underground deep aquifers under the sea bed. It has injected 1Mt of CO_2 every year in saline aquifers, since 1996. Basaltic rocks offer possibility of conversion of calcium and magnesium silicates into carbonates minerals. In underground spaces, CO_2 is stored in the supercritical phase, which is attained at a temperature of 304.1 K and pressure of 73.8 bars. Each geological setting is different and underground CO_2 trapping studies require geomorphology studies. Various trapping mechanisms under srud1 include physical or stratigraphic trapping, mineralogical trapping, geochemical mixing, and residual gas mixing. There is a need to develop methodologies for long-term tracking of CO_2 injected and carry out 3D seismic studies for safe storage.

Energy Fuels by CO_2 Sequestration: Injection of CO" in depleted oilfields for producing enhanced oil can provide an economic synergy to CO_2 sequestration process. A CO_2 - EOR project designed to minimize CO_2 emissions back to atmosphere with appropriate incentives would have an important role in assuring energy security. Underground storage of CO_2 and consequent changes in the viscosity of fluids in depleting oil reservoirs can provide additional fuel for energy. Like oil fields, unmineable coal seams can also prove to be potential reservoir for CO_2 storage. On average three molecules of CO_2 storage. On average three molecules of CO_2 are absorbed in coal and displace one molecule of methane (CH_4) resulting in enhanced coal bed methane recovery. Research studies are being carried out in USA, Japan, China as well as in India.

CO_2 Utilization Technologies: As a first step towards carbon management, utilization of captured CO_2 makes it an attractive proposition; it is a risk free option and results in value added products. In biological route CO_2 in photosynthesis helps in producing carbon sinks and increase forestation. Chemical reactivity, but it is possible to activate it towards chemical reaction by application of temperature or pressure or by use of appropriate catalysts. CO_2 can be converted into production of fuels like ethanol or methanol or fertilizers, as feedstock in food processing and carbonated drinks, etc. In a bio-reacting medium such as microalgae in waste water or oceans, It can be converted into fuels, pharmaceuticals, and value added products.

Storage of CO_2 in Oceans and Iron Fertilization: The Oceans are mammoth reservoirs of CO_2 and have been suggested as candidate for CO_2 can be injected into sea water at different depths. Dispersal at shallow depths of less than 300m may however release it back to the atmosphere through surface plumes. Injecting it to a depth of 1000m or so is likely to delay the process of atmospheric release, but this may endanger the survival of marine species. Liquid CO_2 in thermohyline zones, CO_2 fixation in marine cynobacteria and use of iron filings on the upper surface of oceans to catalyze production of phytoplankton as well as marine food. Large Scale experiments undertaken to test the efficacy of CO_2 catalyzed ocean fertilization in different marine zones have met with little success. There should be regulations before the experiments are carried out.

India is giving thrust to CO_2 sequestration research through government and industry support. Some of the areas like CO_2 capture and sequestration are getting highlighted while sporadic work is being done in others. Technology is vast and work is required to be pursued in all. We held a capacity building workshop on CCSU in energy industry in Delhi, wherein stakeholders from academic and industry participated from across the country. The following recommendations were made:

A CO_2 capture test facility which can help in making the process cost-effective,

A multi-sectoral research program for development of ammonia based CO_2 capture with the participation from ministries of chemicals & fertilizers, agriculture, steel and power as well as academic institutions.

A nodal institution is needed to organize knowledge sharing among the various stakeholders in order to accelerate the pace of work in the country.

CONCLUSIONS

The energy in 21st century is undergoing transformation. The emphasis is shifting from demand sectors to energy supply sectors. Climate and energy sustainability policies would affect all coal consuming sectors and therefore will go into the core of economic activities. Planners and researchers would have to realign their goals for meeting climate change objectives. New energy equipment has to be manufactured for energy efficiency. Solar thermal generators all concentrators have to be designed. Simultaneous work is also required in multi disciplinary carbon sequestration technology development. These technologies are not commercially proven yet and current S & T perspective among energy industries need to be shared. Integrated look at industrial growth, good agriculture management and agro-forestry practices has become necessary. As India gears to achieve a global presence in energy industry, through such initiatives, investment in R & D would increase and knowledge sharing among the various stakeholders can be organized on the national scene.

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