

Plenary Session: Science and Technology for the Environment

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The problems related to the environment are scientifically fascinating but complex, whether they relate to atmospheric physics and meteorology or to oceanography and hydrology or any other field. There are numerous environmental issues - the degradation may be local, regional or global - issues ranging from deforestation, air pollution, ground water and river water contamination to auto waste and electronic waste to the looming threat of climate change. The global warming threat has been caused mainly by the emission of greenhouse gases by the already-developed countries since the beginning of the industrial revolution. Considering the nature of this STS Forum meeting, we should perhaps also integrate these environmental issues with economic and social aspects. I would like to focus on energy security and climate change.

2. I have been suggesting for a long time that the appropriate Measures of Development for a developing country like India are only two - per capita electricity or energy consumption and female literacy. Per capita electricity consumption, which is obviously monotonically related to per

capita GDP, is also indirectly related to all health parameters, including life expectancy at birth. Thus two important parameters - per capita GDP and life expectancy at birth – used by the United Nations for calculating the Human Development Index (HDI) can be replaced by just one - per capita electricity consumption. If developing countries have to improve their quality of life and thereby increase the HDI to levels comparable to those existing in the already-developed countries, their electricity production (and consumption) must increase manifold and must be sustained thereafter. This is what we mean by Energy Security. So these are two of the greatest challenges before humanity today: Energy Security and Climate Change. All countries are trying to address these issues in their own ways.

3. Increasing the use of indigenous renewable energy resources, increasing the contribution of nuclear energy and improving efficiency of energy production and use, all this backed by focused Research & Development, form a part of the strategy laid out in the National Action Plan on Climate Change (NAPCC), released by the Prime Minister of India on the 30th of June, 2008. Per capita emission is the only rational measure of the carbon footprint of any country and the ultimate equity is equal access for every citizen of the world to the available carbon space in the future, after making allowance for the historical contributions of the already-developed countries to this damage to the environment.

4. The NAPCC has listed the 8 National Missions that will, when implemented, collectively address India's response to climate change issues. These Missions are on Solar Energy, Enhanced Energy Efficiency, Sustainable Habitat, Water Security, Sustenance of the Himalayan Ecosystem, "Green India", Sustainable Agriculture, and on Strategic Knowledge for Climate Change.

5. Given the importance of high efficiency and low emission coal technologies in mitigating GHG emissions, the Government of India has recently decided to add another Mission, to the above-mentioned 8, on Clean Coal (Carbon) Technologies (CCT). The technologies that could qualify as clean coal or clean carbon technologies include Ultra supercritical technologies, Integrated gasification combined cycle technology, Underground coal gasification, Coal to oil conversion, Coal bed methane, Carbon capture and storage, Conversion of flue gases into methanol, Use of CO₂ in flue gases for promoting the growth of algae, etc. All these will require high R&D inputs. We are in early stages in preparing this Mission profile.

6. And then there is nuclear energy. ***By closing the nuclear fuel cycle, we can make nuclear energy a near renewable option.*** The same quantity of uranium can give several tens of times of nuclear power if

one closes the fuel cycle with plutonium, i.e. if the spent fuel from Light Water Reactors or Pressurized Heavy Water Reactors is recycled in fast breeder reactors; and this potential can be increased by another order of magnitude by closing the nuclear fuel cycle with thorium. In fact, if nuclear is to be a **sustainable** mitigating technology in the context of the climate change threat, I am convinced that you have to close the nuclear fuel cycle. The three stage nuclear programme of India is based on the closed fuel cycle philosophy.

7. In tackling environmental issues through the use of Science & Technology, we need both Research & Development and Innovation, in fact *collaborative* Research & Development and Innovation. We need to share knowledge that exists and to collaborate in generating new knowledge. We need both curiosity-driven research and what I have called “directed basic research”. **"Collaborative Innovation"** was the theme of the January 2008 Davos meeting of the World Economic Forum which I attended as a member of the Faculty. Conventional collaborative innovation involves sharing of IPR. But I would like to suggest that we should also think of **altruistic Collaborative Innovation** while tackling the Climate Change threat, without worrying about IPR issues.
