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Science for Affordable and Sustainable Energy for India

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The subject is discussed under (a) cooking energy (b) distributed electricity generation (c) transport fuels with focus on India.

India is characterized by enormous differences in quality of life and what is intended to be addressed here is for the larger section (~60 to 70% households) at the lower spectrum in the quality of life. For ensuring a stable social equilibrium, the minority that enjoys a good quality of life should ensure a minimum quality of life for those with limited affordability. The science that needs to be used as a tool here aims at making new technology accessible and affordable. Many of the issues described here are common to most oil importing developing or emerging nations.

1. Cooking energy

India has about 200 million households (average size ~ 5), of which 140 million households (*hh*) depend on about 250 million metric tonnes (*mmt*) of firewood and 120 *mmt* of agro-residues at considerable inefficiency (2.5 t/hh/yr of firewood and 5.5 t/hh/yr of agro-residues) and poor indoor air quality. The total magnitude of cooking energy in India is about 50 million tonnes oil equivalent – a number that is comparable to the amount of high-speed diesel use.

Development and introduction of (a) new science based affordable devices for domestic cooking that are efficient - with utilization efficiencies about 80% of those with liquid petroleum gas (LPG) and with low emissions, and (b) prepared fuels that use agro-residues is an important area. Large scale commercialization would imply limiting the use of solid bio-fuels to less than 100 *mmt.* Some technology developments and commercialization have been done; more needs to be done with sensitivity to efficiency and emissions. The key point is that unless air for combustion is supplied in a controlled manner, it is neither possible to obtain high efficiencies nor can the emissions be reduced. This requires the availability of electricity – typically a 2W fan can power a 2.5 kW stove (nominal power of a LPG stove). In this strategy, kitchen with good indoor air quality is ensured without compromise on the green house gas emissions to the environment; donor agencies across the world involved in mitigation of cooking problems are to recognize that free-convective based combustion systems for cooking cannot meet this obligation.

2. Distributed electricity generation

This subject is far more debated in India than across the world. The principal issue in India is that random political short-sightedness has led to “free electricity” for the farmers leading to a series of problems over three decades – electricity boards that cannot function in a “profit center” mode, excessive underground water pumping leading to lowering of the water table, and inadequate power supply even for those who can afford in the villages. Among solutions thought over for overcoming these situations is the possibility of distributed electricity generation at power levels of tens of kWe to a MWe. Many field experiments on biomass-based power generation systems have been conducted in India under the aegis of the Ministry of New and

Renewable Energy (MNRE) at low power levels (5 to 10 kWe class). These experiences show the need for commercially sustainable power levels of 250 to 1000 kWe that can be operated either in a stand-alone mode to supply electricity to the villages or to the grid when the power off-take from the villages is small. Professional operation of these biomass based power plants and separation of the activities of generation, distribution and tariff collection form ingredients for sustained operation. It is also important that the state electricity boards be partners in this process. Of course, the political system should function as stabilizing element.

The power generation technologies using biomass gasification with air as the gasification medium have made enormous strides in India because of substantive research, development, and field experiments over the last three decades. This is an area where south-to-north technology transfer is a good possibility. Current developments involve incremental improvements contributing to reduced maintenance cycle and greater user-friendliness in operation.

Research and development into using oxygen-steam gasification technologies for hydrogen and liquid hydrocarbon production has just begun. This may be an area for cooperation between institutions in India and Germany.

3. First generation transportation fuels

The greatest economic issue that remains to be adequately recognized by the Indian government is that one can derive multiple benefits by producing its own oil for transportation from growing oil-seed bearing trees in the waste lands that constitute about 33+ million hectares. This land has been identified by the national remote sensing agency (NRSA) of the Space department of GoI through a systematic and serious effort in 2005. These maps have been integrated into a more detailed land use map by the Indian Institute of Science in a major multi-group and multi-institutional effort National Biomass Resource Atlas project (NBRAP) under the aegis of MNRE and made available for internet access both in the form of tables of data on various aspects of land use and GIS-based maps.

While the idea of growing non-edible oil trees and benefiting from it have been known for some time and explored in India in various ways, systematic exploitation at relevant scale has yet to begin. This requires a public-private partnership (PPP) in which oil produced is bought by a national agency in a sustained mode, land for growing such trees is given to profit-making industries on a lease basis, local authorities and population participate in it as employees with assured income. Such a strategy that is not in conflict with food production should be treated as a tree-culture industry to help production at scales that would make a difference to the economy of the country that uses 50 *mmt* of high speed diesel for transportation annually. The multiple benefits include more than 60 million new wide-ranging job opportunities, environmental protection, better quality of life for the underprivileged apart from preventing out-go of financial resources.

While much has been discussed, the fact that such an operation will also generate solid residues that need to be disposed has not been discussed adequately. It is suggested here that this strategy is integrated with that of distributed power generation to close the loop between availability and demand.