Supporting India's Clean Energy Transition

Dr. Ajay Mathur

The Energy and Resources Institute (TERI), India

1. Introduction

India currently sources majority of its energy from fossil fuels, including coal, oil and natural gas. As India's economy grows rapidly over the coming decades, the country faces a uniquely difficult challenge in its need to simultaneously increase and decarbonise electricity supply. The Government of India (GoI) has laid out ambitious plans to do this through significant renewables targets, aimed at deploying 175GW of renewable capacity by 2022. Beyond the power sector, the GoI has been similarly ambitious with regards to e-mobility, providing strong support for electric vehicles, including charging infrastructure. India also has an ambitious energy efficiency program that aims to promote energy efficiency in all sectors of the economy through specific and focused interventions. To support these plans, India has a long history of clean energy promotion in the form of renewable energy and energy efficiency programs, mostly spearheaded by the Ministry of New and Renewable Energy (MNRE), and Bureau of Energy Efficiency, Ministry of Power. Other Ministries and Departments like the Ministry of Science and Technology (MST) and Department of Heavy Industry also have dedicated schemes promoting clean energy solutions.

2. R&D activities related to clean energy technology

Since TERI was established in 1974, it has had a significant impact as a research institute supporting the development of clean energy technologies. TERI's work in this field covers everything from early-stage laboratory testing and innovation to pilot plants and facilitating large scale deployment of clean energy technologies, as well as extensive international collaboration.

In the field of renewable energy, TERI's activities related to research & development are primarily in the area of biomass technologies and solar photovoltaics. Activities relate to action research, product development, testing, policy analysis and capacity building. TERI has developed biomass gasification technologies for thermal applications in several small scale industries as well as for electricity generation in a decentralized mode. In addition, the researchers in the area have developed a state-of-the-art bio-methanation technology that converts waste to energy. The application of this technology includes industrial canteens, vegetable markets, townships, food & fruit processing units etc. TERI has also developed pilot scale pyrolysis test unit for conversion of biomass to liquid fuel that can be blended with conventional crude for refinery integration or/and its use as direct alternate transport fuel. Under a program supported by Department of Biotechnology (DBT), GoI, TERI has also recently developed Used Cooking Oil (UCO) based bio-diesel production technology on a pilot scale, which is suitable for blending with diesel. The Environmental and Industrial Biotechnology Division at TERI focusses on basic and applied research for exploring microbial based solutions towards development of bioenergy and bio-fuel based programs. These include development of "Oilzapper" and "Microbial Enhanced Oil Recovery"

technologies for use in the oil sector. All these technologies have strong potential in India given the specific country context, including a large agricultural sector (with large amounts of bio-waste) and high levels of solar irradiation.

Beyond R&D, TERI has strength in supporting innovation policy and program design, through identifying future areas of clean energy potential for India. TERI is doing this effectively by collaborating internationally with other technology leaders and promoting low carbon technologies in India through policy research, capacity building and knowledge sharing.

3. Specific Research activities in hydrogen, CCUS, and related technologies

TERI's research activities on hydrogen can be divided into two main areas: early-stage R&D and desk-based economic and policy analysis. With regards to early-stage R&D, the main focus to date has been on bio-related hydrogen production routes. This includes bio-hydrogen production through fermentation processes and the potential use of these fuels across the economy. TERI has also started looking into the future role of electrolysis for hydrogen production, including work opportunities for direct seawater electrolysis with industrial partners in India. This is especially important given the possibility of generation of cheap electricity from solar route in the near future.

With regards to economic and policy analysis, TERI is currently undertaking work to understand the costs of using hydrogen across the Indian economy, in transport, industry and the power sector. India can also look at studying in depth the potential for hydrogen to partially meet energy demands across sectors, given India's availability of renewable resources, large industrial base and the challenge of electricity supply / demand imbalances. In this work, TERI will assess the costs of different generation technologies, transport and storage infrastructure and end-use applications, including in sectors like iron & steel. In conducting this assessment, TERI would be able to better inform future R&D activity, to target areas of highest value.

Related programs/projects conducted by the institute (further information on programs/projects are found in the template)

- Dark Fermentative Bio-hydrogen Production from Renewable Sources (2010-2013)
- An integrated approach for biohydrogen production through combined dark- and photo-fermentative process (2011-2014)
- Stabilization and Up Gradation of Biomass Derived Bio Oils Over Tailored Multifunctional Catalysts in a Dual Stage Catalytic Process to Produce Liquid Hydrocarbon Fuels and Its Application Studies (2013-2020)
- Development of a pilot scale process for dark fermentative hydrogen production by Enterobacter cloacae DT-1 from lignocellosic biomas, a second generation feedstock (2014-2017)

- Bio-hydrogen production from new 2nd and 3rd generation biomass and biodiesel from marine algae & UCO under the DBT-TERI Centre of Excellence project 'Integrated production of advanced biofuels and bio-commodities' (2018-2021)
- Energy Transition Commission India – Hard-to-abate (HTA) sectors 2019-2022 [with a focus on hydrogen and CCUS technologies across heavy industry]

4. International collaboration

4.1 International alliance/networking development

TERI has a strong international presence and works closely with a number of governments and leading research organisations across the globe. Most recently this includes an MOU with the International Energy Association (IEA), to increase collaboration on research around the energy transition. TERI has many similar relationships in place with research organizations and institutes across the world. During 2017/18, a theme based platform under the aegis of the Energy Transitions Commission (ETC), UK was established with the objective to build and disseminate knowledge and guide the path for energy transition in the country. The collaborative work involves study of various options for supply of clean power to match the estimated demand for the country till 2030 and beyond. TERI also works with a large number of institutions in countries like Germany, Finland, France, Norway, USA, Australia and Japan. By expanding our global network, TERI is able to stay on top of latest technical developments and understand worldwide standards of best practice to help drive forward the energy transition.

TERI regularly organizes several joint workshops, conferences & seminars on various topics of energy, environment and sustainable development. One of TERI's flagship events is the annual 'World Sustainable Development Summit (WSDS)' at New Delhi. It has in its journey of 18 years become a focal point for global leaders and practitioners to congregate at single platform to discuss and deliberate over climate issues of universal importance. The Summit series has emerged as the premier international event on sustainability, which focusses on the global future, but with an eye on the actions in the developing world.

4.2 International joint R&D activities

In the field of clean energy and related fields, TERI has undertaken several collaborative projects in the past. These include partnerships with organizations from Switzerland, Denmark, Norway, UK, Australia and other countries. As an example, TERI in collaboration with Technical University of Denmark (DTU) and Swiss Agency for Development and Cooperation (SDC) developed a two-stage biomass gasifier system for small scale power generation. The main advantage of this technology is that the gas produced is free from tar i.e. the impurities are reduced at the source itself resulting in a simple cleaning system and enhanced reliability. The biomass gasification technology developed by TERI has been implemented in other countries including in Guyana recently. TERI and Deakin University, Australia have come together to set up a Nano-biotechnology Centre to develop pioneering technologies and solutions like nano-pesticides, nano-fertilizers and precision delivery carriers and formulations for the agriculture sector. With institutes in other countries like

Norway, UK and France, TERI is actively working in research projects in the field of renewable energy.

TERI is also actively engaged with many organizations from Japan including New Energy and Industrial Technology Development Organization (NEDO), Institute for Global Environmental Strategies (IGES), Energy Conservation Center, Japan (ECCJ) etc for the past several years. For example, TERI was also the main implementation partner of a four-year project (2010–2014) titled 'Research Partnership for Application of Low Carbon Technology for Sustainable Development' initiated by the Government of Japan along with the Ministry of Environment and Forests, Government of India, The project was funded by Japan Science and Technology Agency (JST) and Japan International Cooperation Agency (JICA) under the Japanese government program titled 'Science and Technology Research Partnership for Sustainable Development'(SATREP). It focused on technology and engineering analysis accompanied by in-field feasibility studies and experimental pilot demonstrations of Japanese LCTs, in Indian Small and Medium Enterprises (SMEs).

5. Future perspectives

India is aiming to rapidly increase the capacity of renewable generation in the near future, with a target of 175GW by 2022. Beyond that, India also aims to reach a minimum 40% share of non-fossil fuel electricity generation by 2030, under its NDC targets. On current trends, the 2030 target should be achievable but this amount of variable renewable electricity on the Indian grid will result in increasing integration issues. To account for the unreliable nature of wind and solar resources, India will need to ensure that the grid is sufficiently flexible, either through back-up reserves (such as flexible thermal plants or energy storage) and demand-side flexibility. TERI believes that hydrogen can also be considered as a possible option that could assist in this integration and help the Indian power sector, and wider economy, decarbonise more effectively.

Moreover, an increasing number of countries are starting to plan decarbonisation strategies for their heavy industrial sectors. These include iron and steel, cement, petrochemicals and aluminium. Early analysis indicates that in these sectors, along with energy efficiency, electrification and increased circularity; hydrogen and CCUS will need to play a vital role. This is due to the high-temperature heat demands, currently met by fossil fuels, and the production of process emissions (e.g. calcination process in cement plants). As a result, TERI and other research institutions around the world will need to collaborate on hydrogen, CCUS and other technologies to drive forward the cost-effective decarbonization of various sectors.

AJAY MATHUR

is the Director General of The Energy and Resources Institute (TERI), New Delhi, and a member of the Indian Prime Minister's Council on Climate Change. He earlier headed the Indian Bureau of Energy Efficiency, and was responsible for mainstreaming energy efficiency through initiatives such as the Star Labeling programme for appliances, the Energy Conservation Building Code, and the Perform, Achieve & Trade programme for energy-intensive industries. He was a leading climate change negotiator, and was the Indian spokesperson at the Paris climate negotiations. He served as the interim Director of the Green Climate Fund during its foundational period.

At TERI, he has spearheaded the move to accelerate action towards a low-carbon and cleaner economy through the adoption of renewable energy in the Indian electricity sector, enhancing efficiency in buildings and industry, and promoting environmental quality through recycling of material wastes and biotechnology -based solutions.

He co-chairs the global Energy Transitions Commission; and is also co-chair of one of the climate initiatives of the One Planet Summit.

Dr Mathur received a Bachelor's degree in Chemical Engineering from the (then) University of Roorkee, and Masters and PhD degrees from the University of Illinois. He has also received the Distinguished Alumnus Awards from both his alma maters.

He was appointed a Chevalier de l'Ordre national du Merite by the President of France in recognition of his outstanding commitment to the preservation of the environment and coping with energy-related challenges.