WAY FORWARD

India's Energy Challenges & Sustainable Development

Ritu Mathur

Attaining energy efficiency across all sectors is one of the key elements to manage India's growth appropriately. More so, developing innovative methods to better manage India's growing urban energy demands – especially across efficient mobility, savings in built-up environments and generating energy from waste would become increasingly important

The understanding of energy security has changed over the years, more so, in the Indian context. In the early 1970s, energy security was more about safeguarding the economy from a situation of energy shortages and consequent spurts of high energy prices. The 12th Five-Year Plan defined energy security as ensuring uninterrupted supply of energy to support economic and commercial activities needed for sustained economic growth. Today, this has evolved further to include broader aspects such as those of ensuring energy access to all sections of society and the need for diversifying the energy basket to hedge against economic and non-economic risks.

More than five decades after independence, 23.6 per cent[1] of India's population still lives below $1.25 per day, the 2004 extreme poverty line based on purchasing power parity. At present, India houses about 18 per cent of the world's population but consumes only 5.7 per cent of the global energy. Per capita energy demand has grown modestly since 2000, but continues to remain about a third of the global average and slightly lower than the levels in Africa. About 75 million households, a third of the total, are still not connected to grid electricity, and 80 per cent of rural households use traditional biomass as a primary source for cooking.

The challenges to India's energy security at this juncture are, therefore, unique and formidable. On one hand, India faces the pressure of having to provide higher levels and better quality of energy, infrastructure and services to its people and fulfil the aspirations of a growing economy. On the other hand, it faces pressure to try and fulfil these aspirations of a growing economy within a constrained environmental space – that has been taken up by countries whose development preceded ours. Further, constraints of land, water and material resource availability may further compound and jeopardise the ability to adopt options that could provide the requisite flexibilities needed for rapid growth. Recognising the implications on human health, discussions regarding the high and increasing levels of local air pollution have also moved from being a subject of limited reach at conferences to becoming common dinner-table conversations. At the global level, the latest IPCC report clearly indicates that the chances of containing global temperature increases to within 2 degree increase is increasingly becoming less likely, and therefore, greater likelihood of climate change related extreme events. With a considerable population dependent on natural resource based livelihoods and with poor coping capacities,

The author is Director (Green Growth & Resource Efficiency Division), TERI. She has led several national and international interdisciplinary projects and has authored several papers, reports and books related with energy use and its implications on the environment at the local and global levels in order to inform and influence various stakeholders in decision making.

India is also highly vulnerable to climate-change related impacts and must remain proactive to be part of the solution. Following the historical Paris Agreement of December 2015, an analysis of the Intended Nationally Determined Contributions (INDCs) submitted by all countries indicates that the combined targets are clearly insufficient to keep the world within the safe limits of 2 degrees increase[2].

Poverty eradication and inclusive growth remain an important agenda for the country. Accordingly, the Indian Government aspires to maintain a high GDP growth rate, so as to double per capita incomes every decade and improve the welfare of its people. Therefore, with a large population base aspiring for growth over the next couple of decades, India's energy sector is on the verge of a huge transformation as the economy expands, incomes rise, energy access improves, manufacturing becomes a bigger part of the economy and the country sees greater urbanisation. India already has the world's third largest electricity generation capacity, and rapid economic growth coupled with a rising share of manufacturing in GDP is likely to spur this growth further. As indicated in Fig 1, there is a strong and inexorable link between energy and the Human Development Index. Therefore as India improves its HDI level, it would be a challenge to contain per capita power consumption levels to reasonable levels by adopting an appropriate suite of technologies and not following the inefficient paths that some of the developed countries have earlier moved along.

Population growth and economic development are the two main drivers of energy demand. Between 2001 and 2011, India's population grew from about 1 billion to 1.2 billion, with economic growth averaging 8 per cent a year. Total primary energy demand grew at 5 per cent a year. Of the total primary energy demand in 2011, 70 per cent was met through fossil fuels. Coal and petroleum were the main fuels on the supply side, contributing 39 per cent and 23 per cent to the primary energy supply respectively, and natural gas contributing another 8 per cent. In terms of energy consumption, the industrial sector was the largest consumer followed by residential and commercial and then the transport sector. India's total useful energy consumption was around 478 million tons of oil equivalent (Mtoe) in 2011.

India's Energy Scenario till 2030

India is among the countries with INDC targets set for 2030. The INDC submitted by India has proposed unconditional target to achieve reduction in emission intensity of GDP by 33 per cent to 35 per cent below 2005 levels and creating cumulative additional carbon sequestration of 3GT by 2030. Further, a conditional target of increasing cumulative share of non-fossil fuel based power generation capacity to 40 per cent has also been given.

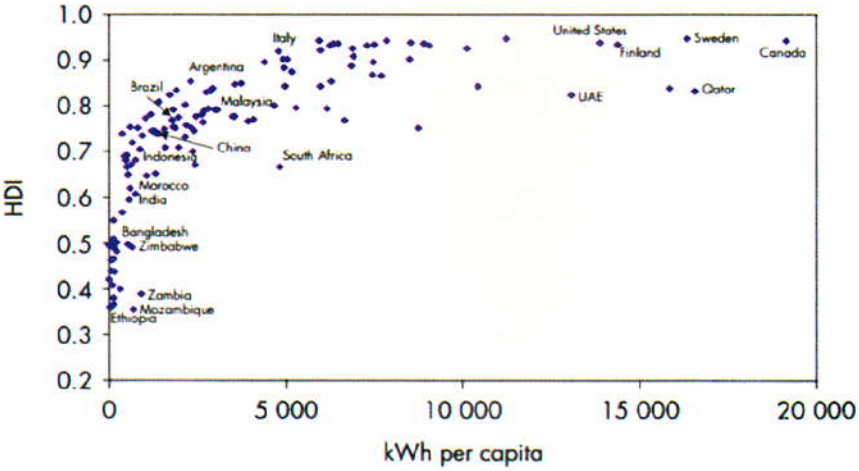

Fig 1.Per capita electricity consumption and Human Development Index

It must be noted that India's INDC targets of emissions intensity reduction are related to greenhouse gases (GHGs) as a whole, but given that CO2 accounts for the largest share in total GHGs and energy sector accounts for the largest share of total CO2 emissions, if we consider this level to be broadly in line with energy sector related CO2 emissions intensity reduction, this translates to a requirement of containing CO2 emissions to a level of around 5 Gt by 2030, depending on the lower/upper range of 33 per cent or 35 per cent emission intensity reduction.

It is also important to understand that India's emission intensity target, is based on the assumption that India achieves and maintains a high average economic growth rate of 8.3 per cent. However, achieving a high economic growth rate should not be seen as being important merely to be able to arrive at the required emission intensity reduction ratio, but more so in terms of a high GDP growth rate being able to provide an impetus to investments in the economy and the ability to push up gross capital formation across appropriate sectors.

By channelising investments in appropriate sectors which have high value addition, and/or those which can generate a stream of additional investments and employment, India could progress towards its intended emissions intensity targets. On the other hand, if India were to progress at a much lower GDP growth, achieving the INDC target would become much more difficult as investments in advanced efficient and clean technologies would also tend to dampen and slow down. Therefore, a closer look at the future structure of the economy and provision of appropriate nudges to create the requisite investment climate is an important aspect in planning ahead in this context.

A range of scenario based modelling studies have been undertaken across research groups to represent India's energy scenarios over the next few decades. Most of the scenarios set

up to examine alternative low carbon pathways for India, converge in terms of the large takeaways from the analysis.

First, that the increase in India's energy requirements and consequent emissions in absolute terms is imminent given its development needs, and that there is no likelihood of India being able to peak within the next couple of decades at least.

Second, that fossil fuels would continue to retain a significant share in the overall primary energy mix of the country even by 2030. Even with very ambitious plans for renewable energy, in the absence of storage technologies being mature/economically viable, the intermittent nature of renewable resources requires that conventional fossil based options continue to be around to provide the base loads and balance the grid supply.

Third, that renewables and energy efficiency are both crucial elements in India's energy transition story and no one single silver bullet can work as a panacea in this sector.

Fig 2 shows the direction of what an INDC scenario for India may look like till 2030, if the country were to move along the lower/higher range of emission intensity reduction INDC target.

Using TERI's MARKAL model[a] to depict possible energy scenarios under the INDC-L (low or 33 per cent emission intensity reduction) and INDC-H (high or 35 per cent emission intensity reduction) scenarios, we observe that even by 2031, India's primary energy mix is likely to rely fairly heavily on fossil based energy.

In the INDC-L scenario, total primary energy increases to around 2044 Mtoe by 2031 from 551 Mtoe in 2006. Coal continues to remain the dominant fuel with its share rising from 33 per cent in 2006 to 53 per cent by 2031, while the share of oil in the supply mix rises from 24 per cent in 2006 to 26 per cent by 2031. Even though the magnitude of natural gas in the supply mix increases from 36 Mtoe in 2001 to 110 Mtoe by 2031, its share remains around 6 per cent. Thus, by 2031 in the INDC-L scenario, 84 per cent of the primary energy comes from coal, oil and gas, 10 per cent from traditional biomass, 1 per cent from nuclear energy, 5 per cent from renewables and large hydro.[b]

In the INDC-H scenario, a further reduction of 4 per cent in primary energy terms is required, which is largely on account of the reduction in consumption of coal and oil which are replaced by cleaner non-fossil options.

Total power generation in the INDC-L and INDC-H scenarios is 3989 TWh and 3927 TWh respectively in 2031 based on differences in energy efficiency levels that need to be undertaken across sectors in the two scenarios.

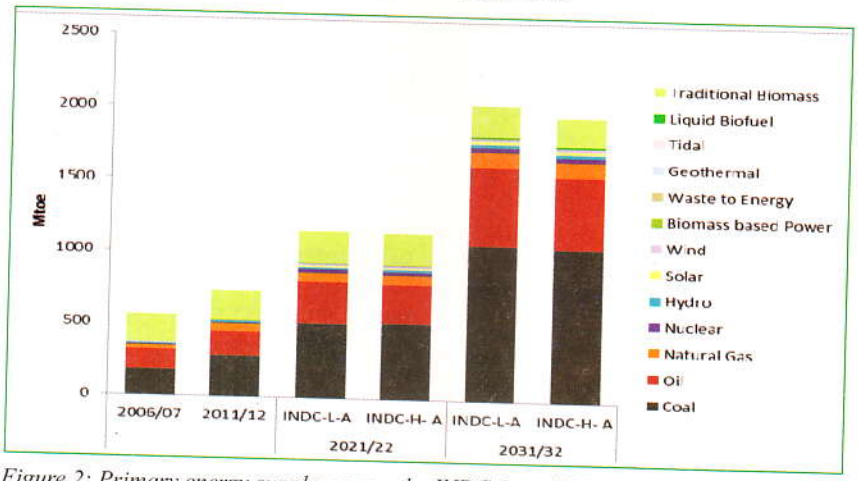

Figure 2: Primary energy supply, across the INDC-L and INDC-H scenarios
Source: Model results

Under the INDC-L and INDC-H scenarios, the generation capacity needs to increase from around 138 GW in 2006 to 843 GW and 829 GW respectively by 2031, increasing by around 6 times in 25 years. Even in 2031, around 57 per cent of this generation capacity is based on coal in comparison to 52 per cent in 2006. Diesel-based generation is, however not, favoured and seen to slowly disappear. As a result of the aggressive push required for inclusion of non-fossil based generation capacity, the share of renewables needs to increase from 6 per cent in 2006 to around 30 per cent in 2031.

The power sector is likely to need the greatest level of transformation in India's energy system until 2030. Moving from minor levels of renewable capacity today to a sizeable share by 2030 requires adequate attention to be focused on understanding future energy demand patterns, planning for appropriate demand-supply matching in a dynamic manner, and planning for appropriate base loaded generation and storage options to manage the intermittent nature of renewables.

While the transformation to low emission pathways requires energy efficiency to play out in a major way across all sectors –implying a strong push to encourage development and adoption of efficient appliances, green buildings, efficiency in industry processes and transportation systems etc., the economy needs to ascertain that adequate injection of capital in appropriate sectors is also mobilised to create the necessary demand for absorption of power generation, both in the short and medium term. This concern is also reflected in the current situation of India's power sector wherein thermal power plants are facing a situation of Plant Load Factors (PLFs) being at an all-time low of 60 per cent and falling over the past few years.

India's Fuel and Technology Choices

The energy choices that India will make in the next couple of decades are critical from several perspectives

– viz. the lock-ins of infrastructure and fuels the country will face over the next 30 odd years, the implications this would have on the emissions (of GHGs and other local air pollutants), and the ability of the fuel-technology combinations to respond to changing demand patterns in the future. There is no single fuel or technology option that seems to be a game-changer to India's energy future at this juncture, and a multitude of options need to be a part of the solution in the long term. However, careful planning is required to manage the transitions in the immediate short term and over the longer term, keeping in mind that most energy infrastructure have fairly large gestation periods and are generally associated with lock-ins of at least 20-30 years if not more.

While coal based power generation remains the most viable option for India as of now, internalisation of the costs of externalities associated with coal may in fact make advanced cleaner coal technologies more viable or indicate gas to be a preferred switch fuel subject to its availability. In any case, given the long term goal of moving towards low carbon options, investing in deep underground mining of coal and washeries with large lock-ins, may not be the best option and it may be preferable to import coal in the short term, specifically to eliminate environmental externalities. Moreover, with water becoming scarce at several locations, leading to disruptions and shutting down of some thermal plants in the past few years, technologies for re-furbishing thermal power plants with air cooled systems instead of water based cooling may gain increasing relevance. Use of integrated analytical methods to better evaluate the life cycle costs, better include the costs of externalities and evaluate the infrastructure lock-ins is desirable to make informed decisions for the future.

India has large markets and the country's growth story in fact needs to be viewed as an opportunity rather than as a challenge – wherein new technologies, innovation and development of new business models need to play a key role in enabling switches to clean and efficient technologies that are most suited to the Indian markets. The example of the market based initiative for LED lighting is a case in point. EESL has, through a model of mass procurement, been able to bring down the costs of LED bulbs to a significant level, resulting in replacement of over 100 million incandescent bulbs, thereby saving around 25 million tonnes of carbon dioxide till now.

India also has the second mover advantage in many cases whereby it can take advantage of technological leapfrogging and move to options that are already mature and tried out in other parts of the world. The Perform Achieve and Trade (PAT) initiative launched by the Bureau of Energy Efficiency is another initiative which mandates the most intensive industrial plants to reduce their energy consumption over a 5-year cycle. With successful completion of the first phase, which led to a CO2 mission saving of over 30 million tonnes, learning needs to be applied across other sectors to scale up such efforts.

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In the renewables sector, there are numerous technologies available in the market today but their viability is contingent largely on their cost, ease of implementation, resource availability and scalability. The Government has laid out very ambitious targets, and had announced a target of adding 175 GW through solar, wind and hydro by 2022.Here again, with the cost of renewable technologies coming down rapidly, it already makes business sense to invest in renewables across certain user groups, especially where there is high reliance on diesel based power generation. Understanding the role of fossil fuels (coal and gas) in providing base load power with intermittent renewables is also pertinent. Given that gas is a cleaner and more efficient fuel, careful evaluation of the domestic coal expansion plans vis-à-vis use of imported coal or gas is also relevant. Simultaneously, technologies for integrating intermittent renewables into the grid need to be adopted while working towards making storage technologies viable.

Again, the provision of clean cooking fuels to all households in the country is an area that requires attention. Although the share of households using LPG as a primary fuel for cooking has increased from 18 per cent in 2001 to 60 per cent in 2011, 65 per cent of the consumers belong to urban households while only 11 per cent of households in rural India use LPG[3]. The continuing use of firewood among rural households has largely been attributed to its easy access to firewood (from nearby forests and farm lands), high costs and difficulty in securing LPG connections and availability of cylinders from LPG outlets[4]. Here again, while the Pradhan Mantri Ujjwala Yojana (PMUY) is making efforts to increase the reach of LPG to BPL households, examining the potential of alternative options such as electrical induction cookstoves, and enhancing piped gas supply in urban centres to release larger number of cylinders to rural areas could further supplement the efforts to move ahead in providing cleaner cooking energy solutions to a larger population.

Attaining energy efficiency across all sectors is one of the key elements to manage India's growth appropriately. More so, developing innovative methods to better manage India's growing urban energy demands – especially across efficient mobility, savings in built-up environments and generating energy from waste would become increasingly important.

In the transport sector, rail based movement is more efficient than road,

but has been losing share due to the convenience that road base transportation offers. Similarly, within road based passenge movement, the use of personal vehicles has been increasin rapidly, eating into the shares of public transport. Here agair innovative models to increase the share of public transpoı need to evolve.

The Road Ahead

Several policies, measures and schemes headed in th right direction have already been launched over the past few years in the energy sector. However, there is a need for carefu planning both in terms of the choices we make and in term of the timing of adoption and scale-up of alternative options in order to bring in careful balance between options that may be more optimal in the shorter or longer term. Planning in this sector therefore needs to be dynamic and flexible over time. making best use of options as they become available and viable both domestically and globally.

Learning from international experiences and practices in other countries can be useful in this regard. At the same time, India should focus on bringing together real-time data to better understand and analyse the options that exist and may become available over time across sectors, develop human and institutional capacity to ensure that appropriate skill sets and capacities exist at all times to manage the transitions in India's energy future; and be open to innovative thinking and development of business models that work in the Indian context.

Last, but not the least, careful planning is also required to direct investments to appropriate sectors of the economy, such that larger benefits of growth and employment can be harnessed to move along a long-term sustainable pathway.

Endnotes

a. MARKAL is a dynamic Linear Programming energy system model that has been used to represent India's energy system and depict alternative energy pathways over the period 2001-2051.

b. Even though the generation mix is 40 per cent non-fossil because of the conversion efficiency of fossils, the primary energy mix is much higher in percentage

References

1 World Bank estimates

2 Spencer, T., Pierfederici, R. *et al.* (2015). Beyond the numbers: understanding the transformation induced by INDCs, *Study* N°05/15, IDDRI - MILES Project Consortium, Paris, France, 80 p.

3 Census 2011, Houses, Household Amenities and Assets Data

4 TERI Research Report (November 2014): Rural Energy Transitions and Inequities.

Readings

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(E-mail: ritum@teri.res.in)