The Energy Report – India:100% Renewable Energy by 2050

Executive summary

This study examines the possibility of a 100% Renewable Energy Scenario for India by 2051. Two scenarios are developed for this purpose; the Reference Energy Scenario (REF) is compared with the Renewable Energy Scenario (REN) with the intent of examining what changes would be required to move toward a 100 per cent (or near-100 per cent) renewable scenario, and whether the country is likely to have the adequate technical potential for moving toward such a transformational change in its energy mix. The REF scenario considers only current trends and policies, and projects these into the future as determinants of energy demand and supply. This scenario includes all current forms of energy – fossil-based, nuclear and renewable – while in the REN scenario, fossil fuels and nuclear-based technologies are phased out and replaced, wherever possible, with renewable options. No new capacity additions of fossil fuel or nuclear-based technologies are considered, except for the ones that are already under construction. Moreover, aggressive efficiency improvements are envisaged in the REN scenario across the entire energy system.

The study suggests that a sustainable, renewable-energy-based economy could theoretically be achieved, where as much as 90 per cent of India's total primary energy supply could technically be based on renewable sources. The remaining 10 per cent would still need to be fuelled by fossil-based sources that are required as feedstock and where a substitution by renewable energy forms is not possible.

In the REF scenario, the economy is likely to remain based primarily on coal, oil and gas. In the REN scenario, solar, wind and hydro are considered to be the main fuels for electricity generation, while second-generation and algal biofuels contribute to meet demands of the transport sector.

Some of the key observations from this study are highlighted below.

- Aggressive efficiency improvements across the energy demand and supply sides bring in large savings – of the order of 59 per cent – by 2051.
- On the supply side, fossil-based plants and technologies need to be phased out in the REN scenario much before the end of their economic lifetime (against the current situation, where old and inefficient plants continue to operate beyond their economic life to meet shortfalls in demand and supply). All renewable energy forms including solar, wind, geothermal and ocean tidal energy resources need to be pushed to their technical limits to achieve a move toward a 100% REN scenario.
- Biofuels would need to play a key role by 2051; they would have to account for 330 Mtoe and meet 90 per cent of the transport fuel requirement in order to move toward the REN scenario.
- Around 10 per cent of the fuel mix would need to be meet by fossil fuels for niche uses such as feedstock in industry, for which there is currently no replacement.

- Concentrated solar thermal technologies (that are still in the R&D phase) would need to play a key role in meeting electricity needs as well as the thermal demand in industries (and also to fulfill the heat requirement for temperatures below 700°C).
- Energy requirements for cooking would need to shift towards electric cooking in urban areas and improved cook-stoves in rural areas, irrespective of individual preferences and lifestyle choices of the households.
- The import dependency of coal and oil rise in the future for both scenarios. However, while in the REF scenario this is because the domestic production is unable to keep pace with the demand, in the REN scenario this is because the requirement of these fuels is so low that all domestic production is stopped and the small requirement is entirely imported. Only gas production continues into the future as it has a comparably higher use, and the import dependency drops from 21 per cent in 2011 to 13 per cent in 2051.
- The cumulative CO2 emissions in the REN scenario are about one-third of those in the REF scenario.
- The total undiscounted technology investment cost for the REN scenario is 42 per cent higher than in the REF scenario, requiring an additional investment of INR 544 trillion between 2011 and 2051. This level accounts for around 4 per cent of the cumulative GDP during this period. The total undiscounted system costs in the REN scenario are only 10 per cent higher than those in the REF scenario. This, however, includes only technology-level substitutions and does not entail costs that may need to be incurred for supporting infrastructure, R&D or improvements in regulatory and institutional set-ups.

The REN scenario is clearly desirable from an environmental as well as an energy security perspective. But achieving such a scenario poses considerable challenges at this point in time and would require several transformational changes, in all sectors, to be undertaken with a sense of urgency. These include not only the timely availability of alternative commercially viable technological solutions across sectors, but also a rapid scaling-up of these options, together with accelerated building-up of supporting infrastructure, appropriate skill-sets, regulatory and institutional frameworks and adequate renewable manufacturing capacities.

- Under the REN scenario, all industrial heating requirements up to 700°C are met through concentrated solar thermal (CST) technologies by 2051. This implies that apart from its wide spread application in electricity generation, CST technologies for thermal applications need to be commercially viable even for small to medium manufacturers by 2031 in order to gain popularity and become the prevalent option in the next two decades.
- Energy requirements in the transport sector are expected to increase rapidly, and a large part of this demand is expected to be met through third-generation biofuels. This technology is still in the R&D phase. In order for it to be available as a major fuel option by 2051, as in the REN scenario, this

technology would have to become commercially viable within the next two decades.

- The REN scenario considers installation of 170 GW of offshore wind capacity by 2051, with its initiation in 2031. At present, there is no estimate of offshore wind potential for India. Accordingly, this implies that within the next two decades, the offshore wind potential would be assessed in detail, comprehensive techno-economic analyses would be conducted and commercial deployment would be successfully initiated.
- The REN scenario envisages that rural households meet their cooking needs completely through improved cook-stoves, while urban households switch to electricity-based cooking. This implies that it would be possible to shift cooking practices to an alternative development path, away from the current mandate of encouraging a higher penetration of LPG.
- Given the large share of renewables in the electricity mix, apart from development of storage technology, improved grid integration and load management systems would be required, with immediate effect.

The REN scenario involves the introduction of technologies, most of which are currently in the R&D phase, by 2031. Therefore, transformational technological and policy shifts would need to be effected with a sense of urgency if India has to realize such a scenario by 2051.