

Estimating minimum energy requirement

Comments on the article 'Estimating minimum energy requirement for transitioning to a net-zero, developed India in 2070', published in *Current Science* (2022, **122**(5), 517–527). Some material is also added from IEA Net Zero by 2050, and World Energy Outlook 2021 prepared from COP 26.

Authors (R. Bhattacharyya *et al.*) must be congratulated for bringing out a comprehensive energy policy document after reviewing many previous studies.

While an HDI of 0.9 is a good target, 0.8 would be more realistic. Most of the studies quoted by the authors in Appendix I take a value of 0.8. The average value of India is about 0.68, but many large states have deficit HDI values.

HDI of 0.8 ensures a good standard of living, including shelter, clean water and food, good mobility, entertainment like television and internet and comfortable living conditions at home.

While little doubt exists about the electricity/energy/HDI correlation, wide variations exist. In India, Kerala has an HDI of 0.8 with a per capita electricity consumption of 757 kWh/annum. Gujarat, with 2378 kWh/capita/annum, has an HDI of 0.68, the same as the average value for India.

The 16,000 kWh/capita/annum suggested by the authors seems quite high and will face resource, sustainability and technology problems.

The authors and Net Zero by 2050 and World Energy Outlook 2021 emphasize electrification because solar and wind can only produce electricity easily. For modern 24×7 requirements of electricity, solar and wind cannot do this job without a storage medium. Battery storage at over 100\$/kWh or kW is costly and requires scarce materials.

As the author suggested, using hydrogen as a carrier, fuel and storage medium will face many technical problems and safety issues. This is also true for carbon capture and storage. Carbon capture and storage have been talked about for a long time but have not made much progress.

Operation of stable grid with such large variable sources is not possible without good storage. Natural gas and hydro only can do this job. Batteries remain unviable for large storage.

We must explore the following:

As suggested by the authors, priority must be given to energy efficiency. While BEE and PCRA are doing a good job, they

have few people and financial resources. They must be given much larger resources. The programme of LED bulb has been an outstanding success. Such programmes must be introduced for other equipment and subsidized, if necessary.

Public transport must be given high priority.

High priority must be given railway network development. The railway network today covers 60,000 km. Railways used to carry 70–80% of freight and passenger traffic, the remaining 20–30% is carried by road. The ratios are reversed now. This has led to a huge surge in oil demand. All studies expect oil dependence to be 80–90% in the foreseeable future. Electrification of road transport remains needs to be done. To curb oil demand due to the war in Ukraine, the IEA has suggested overnight trains instead of planes.

For cooking, the authors suggest induction cooking. This does not look feasible. Both Net Zero by 2050 and World Energy Outlook suggest a significant role of bioenergy. Renewable and nuclear energy are other sources.

In India, agricultural waste and cow dung are available, and they are renewable resources. They must be used for cooking with improved chullas and solar cookers. This is a sustainable solution. LPG and electrical cooking depend on non-renewable sources. IEA also emphasizes the role of modern bioenergy.

As per World Energy Outlook 2021 for COP 26, final consumption is 343 EJ. Out of this 169.2 EJ is electricity. Liquid fuels contribute 65.8 EJ. Solid fuel contribute 38.7 EJ. In solid fuel significant contribution is from modern biofuels.

While the authors do not specifically mention emission control, both Net Zero by 2050 and World Energy Outlook 21 depend on capturing emissions from the air and using modern bioenergy. Emissions do not become zero. They are captured.

A target of 30–35 GJ with 60–65% contribution from renewable electricity, 10–15% from biomass, and the rest from conventional liquid fuels and gas will be reasonable to achieve an HDI of 0.8.

Conventional fuel, especially oil, will continue to be used for transport. Natural gas for grid stability, transport and cooking applications.

Net Zero will have emissions but captured and mitigated. Technical breakthroughs

are required in biofuel, energy storage and CO₂ capture.

I would also like to draw attention to Goal 12 of the 'Sustainable Development Goals' of the United Nations. This goal emphasizes responsible consumption and production. It is time for all concerned with policy to start working on this goal. There is little logic in promoting private transport and short-distance air travel. COVID has shown work from home, and virtual conferences are viable solutions. They need to be followed even in normal times.

Again, I congratulate the authors for producing such a monumental study, usually done by IEA, Niti Ayog or CEA.

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Response:

We thank B. G. Desai for the appreciation and interest shown in our work and for the detailed comments provided on it. In performing this study, we have considered a nearly 50-year time frame in setting a target for the HDI. We firmly believe that India should aspire to provide not just a minimum decent quality of life but a high standard of life that is currently enjoyed by the citizens of the most developed economies today, many of whom have HDI exceeding 0.9. We agree that several nations with HDI of about 0.8 do indeed provide a reasonable standard of living to their citizens, but our aspirations and ambition for the India of 2070 (123 years after Independence) are greater than that, and that is reflected in our choice of the target HDI.

We agree that state-wise HDI values vary greatly depending on socio-economic factors, not just energy consumption within the boundaries of the state. For Kerala, HDI is high owing to higher literacy levels and larger foreign remittances from residents working abroad/NRIs. In addition, manufacturing activity has no significant presence in Kerala and purchases all manufactured products from other Indian states.