

R K Dutta Memorial Lecture**Can Renewable Power Really Win in India?****Jawhar Sircar****The Research Centre for Eastern and North Eastern Regional Studies****- Kolkata (CENERS-K), 19th January 2023, 6 pm, Bengal Club**

1. Three fourth of the world's greenhouse gas emissions result from burning of fossil fuels for energy and everyone agrees that the world must rid itself of these fossil fuels that endanger human and other forms of life. Half a century ago, we were told to produce energy at any cost, but in this century, the mission is to move to cleaner renewable energy resources. The important question now is by when will we be able to use only or mainly renewable resources for energy generation. By we, I refer to both India and the world, but in this talk we shall restrict ourselves only to India.

2. Let us get the big picture first. From the latest data provided by the Minister for Power and Renewable Energy on the floor of Parliament on 5th December 2023, it is clear that 186.46 gigawatts of capacity of non-fossil fuel-based energy resources has been installed as on 31st October of 2023. This includes 179 GW (actually 178.98) of renewable power and 7.48 GW of nuclear power — which represents about 43 percent of total installed power sources, covering both fossil-fuel based and others. It is pertinent to remember that, in the power sector, installed capacity represents only the optimum and what is more relevant is actual generation, which fluctuates a lot because of reasons often beyond control. Thus, capacity factor or the ratio of a power plant's average production to its rated capabil-

ity is, therefore, the critical measure — as is the load factor, which is calculated by dividing the average load by the peak load over a certain period of time. To simplify matters, we will focus on installed capacity and estimate annual generation, for purposes of by comparison. Just to understand the peak demand for power in India, we may refer to the minister's reply of 19th December 2023 to a question in Parliament that it was 243 GW in October 2023. This was an almost an 80 percent hike from the peak demand of 136 GW in 2013-14. The installed capacity of thermal power has increased from 140 GW in March 2014 to 206.8 GW in October 2023, while the renewable sector increased from 7.55 GW in March 2014 to 179 GW in October 2023. The increase in generation capacity was, however, by 70 percent from 249 GW in March 2014 to 426 GW in October 2023.

3. India's Prime Minister's has already committed to the world that India's installed capacity of renewable and non-fossil fuel based energy would go up to 500 gigawatts by 2030. This would consist of 450 GW renewables and 50 GW of non-fossil capacity, which would include 280 GW of solar power and 140 GW of wind power. India has promised to reach net zero emissions by 2070 and is pledged to meet 50 percent of its electricity requirements from renewable energy sources by 2030. The ministry is more ambitious and has drawn up a National Electricity Plan that was notified in May, 2023. According to minister's statement in Parliament on 19th December 2023. India's installed capacity is expected to be 900 GW for the year 2031-32. Out of this, carbon free capacity is expected to be 627 GW — with Large Hydro contribution 62.2 GW; Solar 364.6 GW; Wind 121.9 GW, Small Hydroelectricity 5.4 GW; Biomass 15.5 GW and Pump Storage 26.7 GW. Nuclear- power is estimating at 19.7 GW but tour target for Geo-thermal is not clear.

4. Let us try to examine India's firm pledge and what this means vis a vis fossil-fuel based power and pollution. We may try to estimate if the target appears possible, going by current progress. A major factor is whether the private sector finds better profits in renewable power. India's power demand as a whole grew by about 8% in 2022 — which is nearly double the pace of the Asia Pacific region — to almost 150 terawatt-hours (TWh) from the previous year. Demand is going up steadily thereafter as India's economic growth is among the highest in the world, even though it is quite skewed. Demand also goes up as some 50 million new electricity connections are being added each year. This demand is met primarily

by fossil fuel at present and its increasing consumption has pushed up India's annual CO₂ emissions to the third highest rank in the world. India takes solace in the fact that India's CO₂ emissions per person places us near the bottom of the world's emitters, but it is imperative for renewables to change this reality to the extent possible.

5. India has several advantages as it is endowed with factors that favour renewable energy. We have an extensive landmass that totals around 3.3 million square kilometres. We have abundant sunshine, gushing rivers, regions of high wind speeds and beneficial ocean resources and considerable biomass. Thus, India has definitely improved its position in the production of renewable energy recently and is now a world leader. Going by the last reliable statistics of 2022, we find India's 163 gigawatts capacity made it the fourth top nation in renewable power capacity worldwide. Current estimates are over 170 GW, but before we rush to congratulate ourselves, we may note that China's RE capacity was around 1,161 gigawatts in 2022 is seven times the size of India's. The United States has more than double of India's renewable energy capacity and Brazil is also ahead. But that India is forging ahead was recognised by Ernst & Young's in its 2021 Renewable Energy Country Attractiveness Index (RECAI) that ranked India 3rd behind USA and China.

6. At the same time, it is a fact that renewable electricity is growing at a faster rate in India than in any other major economy. The Ministry of Renewable Energy is confident that new capacity additions are on track to double by 2026, even though fell short of its 2022 target of producing 175 GW by 32%, according to the Central Electricity Authority. In 2015, when the target of 175 gigawatt of renewables was fixed by the year 2022 it included 100 gigawatt from solar power (62% achieved), 60 gigawatt from wind power (70% reached?), 10 gigawatt from bio-power (107% achieved) and 5 gigawatt from small hydro power (98% reached) — total of 119 gigawatts out of 175. This will give an idea of where exactly capacities are coming up and who's where.

7. Renewable sources accounted for 20.5 percent of India's electricity generation in 2022, from just 15.2 percent ten years before, in 2010. A heartening development in 2022 was, however, that 40% of new energy capacity installed in that year (160 GW of 400 GW) were in RE. But installed capacity is far removed from actual generation, transmission and

distribution. Government defends its position on targets and claims that It has overachieved its commitment made at COP 21- Paris Summit — by already meeting 40% of its installed capacity of power from non-fossil fuels almost 9 years ahead of its commitment.

8. The shares of solar and wind in India's energy mix have grown phenomenally. In terms of installed capacity, solar and hydropower are currently the leading sources of renewable energy in India. But since hydropower has generated considerable controversy and is not accepted as enthusiastically as before, production in the non-fossil sector is becoming completely skewed in favour of solar. The National Solar Mission was unveiled in 2010 for research and development as well as solar-friendly policy initiatives were given priority. The initial target was set for at least 20 gigawatts of capacity by 2022, but this was reached 4 years ahead of schedule. Thereafter, the targeted capacity was hiked to 100 gigawatts by 2022 and solar energy could reach 63 GW then. Solar structures represented 89% of new renewable capacity installations in 2022, for which we have firm figures, and in 2023 as well. Solar power capacity surpassed 63 gigawatts in 2022 and the trend continues. The first eight months of 2023 saw a 22% rise in installations compared to the previous eight months of the previous year. But this renewable source faces grid integration challenges, because of increasing variability of hourly production and demand and its impact on net demand, short-term frequency variations and local voltage issues. India's solar capacity grew by a factor of about 64, but the National Institute of Solar Energy opines that given India's massive land area and abundant sunshine, India's solar capacity potential is around 750 gigawatts.

9. With an installed capacity of more than 52 gigawatts, India is among the world leaders in cumulative hydropower capacity. But this energy is very controversial because of its adverse impact on environment as they are major emitters of methane, a greenhouse gas 28-34 times more potent than carbon dioxide. Hydel also increases risks of natural disasters and other climate-induced dangers. A month before the climate summit COP26 began in Glasgow, more than 300 organisations across 69 countries urged governments not to use climate funds for "false climate solutions" such as new hydropower dams. They urged that these dams be removed from all the Nationally Determined Contributions (NDCs) targets pledged under the 2015 Paris Agreement that aim to combat global warming. Initially, India's renewable energy goal did not include large hydro power projects (projects with a capacity of

more than 25 megawatts). But, in 2019, India changed its definition of renewable sources of energy, bringing large hydro into its ambit as stable hydel power helps the electricity grid that suffers wild fluctuations from renewables like wind and solar. Government insisted that large hydropower projects, located mostly in the Himalayas and the North-East region, help develop those difficult areas and provide direct employment. Despite its omission from the original target, when the Minister informed Parliament very recently that 165.94 gigawatt, or 95% of the 175 gigawatt renewable target has been achieved a year after, he excluded large hydro power in measuring progress towards this 2022 target. Government's ambiguity is more complicated when the minister boasts that "76.13 gigawatt of hydel is under implementation and a capacity of 36.44 GW is under stages of bidding".

10. Wind installations increased their capacity by only 7% and comprised 10% of all new renewables (RE) installations in the preceding financial year. Installed wind energy capacity in India peaked at almost 41.9 gigawatts in 2022, increasing from around 40.1 gigawatts of the previous year. But wind power is an intermittent source of energy, and it faces grid integration issues in India. This is because the transmission network is not well-equipped to handle the large amounts of wind power generated, that too, in surges. In addition, land acquisition is a major issue as this category of energy installations requires large tracts of land. This is especially true for offshore wind farms, which require access to large areas of coastal waters. Wind turbines are expensive to purchase and install, which make it difficult to compete in the market.

11. Biogas is another crucial renewable energy source. Though biogas capacity in India has not reached the levels of solar, hydro, or wind, biogas use is widespread, with more than five million biogas plants located across the country. Though biogas has great advantages, like reduction of greenhouse gas emissions, sustainable utilisation of organic waste and versatile applications, construction of a biogas plant is costly for farmers. It entails significant investments in technology and infrastructure. Besides, it requires professional expertise to ensure optimal conditions within the fermenter and monitoring gas emissions. The availability of raw materials like biomass, sewage sludge, slurry and other waste is essential for the smooth operation of a biogas plant. This can vary regionally, which can pose challenges for

planning and logistics and plant capacity has to be calibrated according to available resources. The anaerobic breakdown of organic materials can generate unpleasant odours and result in conflicts with nearby residents which pushes expenditure up with suitable measures for odour control.

12. We will skip other minor components of RE like ocean-based sources, and touch briefly upon green hydrogen and geothermal. India is attempting to become a global leader in renewable batteries and green hydrogen and the latter will play a major role in achieving the net zero and decarbonising the hard-to-abate sectors. India aims to become a global hub for green hydrogen production and exports. India could easily create 5 million tons green hydrogen demand thereby replacing grey hydrogen in the refineries and fertiliser sector. This will result in abatement of 28 million tonnes of CO₂ and the proportion is set to grow as we fructify green hydrogen economy, to ensure replace 400 million tonnes of CO₂ by 2050.

13. Geothermal energy is energy tapped from hot geysers that spring from very hot rocks in the Earth's crust. It combines energy from the formation of the planet and from radioactive decay. The steam that hisses out is used to run turbines and produce electricity. But this energy form is not widespread and among the prominent geothermal resources in India we may mention Puga Valley and Chhumathang in Jammu and Kashmir, Manikaran in Himachal Pradesh, Jalgaon in Maharashtra and Tapovan in Uttarakhand. A new location has also been found in Tattapani in Chhattisgarh.

14. Viewing the overall progress of the energy sector, we find that the installed capacity of non-fossil fuels' has been growing faster than that of fossil fuel, for over five years. In general, the hurdles that are common appear to be (a) inadequate funding for clean energy, problems (b) fluctuating production that challenges grid balancing and (c) land acquisition for projects. According to the Council for Energy Environment and Water, other than major difficulties in the integration of renewable energy with the power grid, the biggest obstacles are delayed payments from Discoms (distribution companies) and the buyers' constrained capability to purchase renewable energy. To these, the Centre for Policy Research adds the lack of coordination between national targets and state level enforcement.

15. Grid issues plague RE more than fossils-based energy and transmission, and distribution are, indeed, more problematic than just generation of renewable energy. While transmission systems are connected to large scale power generations, small scale lines are meant for retail distribution of power. Both may suffer from tripping due to fluctuations that solar, wind and some other forms of renewable power entail and VRE or variable nature of renewable energy is, indeed, its stumbling block. Besides, electricity distribution companies are financially bleeding anyway and this fact is impeding the urgent transformation of the sector. Ladakh is a classic case, where abundant solar power generation is quite possible, as installations have proved, but transmission grid is the culprit. The cost burden of legacy infrastructure in terms of high transmission and distribution (T&D) losses have plagued discoms for decades, preventing them from making decisive investments to support renewable energy. The health of discoms, that control the cashflows for the entire value chain, is critical to bringing more and greener energy into tariff setting. Government claims to have connected India into the largest unified grid, which permits the transmission of some 117 GW on one frequency across the country, but problems persist.

16. Grid reliability is struggling because of a massive increase in sources of infirm power, more so because India currently lacks a transition fuel, like natural gas in the West. One solution lies in implementing RES-GGS or Renewable Energy Source Grid-Connected Generation System. This is attracting more attention, but its higher initial investment cost is worrisome. Integration of renewable energy sources to utility grid depends on the scale of power generation and to enhance power extraction ability, an increase in the utilisation rate of the RES is a key. T & D are thus locked into the existing fleet of coal-fired power plants. We must also note that before we can move out of coal, we have to settle critical issues associated with coal mining, transportation, livelihoods, and rehabilitation of those affected. We are really in a Catch-22 situation.

17. A major issue in RE is its glaring disparity in the spread of surplus and deficit states. The International Energy Agency and India's Niti Aayog collaborated in a report entitled *Renewables Integration in India* in 2021 which points to the fact that in this domain "energy penetration is highly variable by state in India. The share of solar and wind in India's ten re-

newables-rich states (Tamil Nadu, Karnataka, Gujarat, Rajasthan, Andhra Pradesh, Maharashtra, Madhya Pradesh, Telangana, Punjab and Kerala) is significantly higher than the national average of 8.2%. Solar and wind account for around 29% of annual electricity generation in Karnataka, 20% in Rajasthan, 18% in Tamil Nadu and 14% in Gujarat (financial year 2020-21). Many states are already facing system integration challenges.”

18. In a parliament reply recently, the Power & Renewable Energy Minister declared that “India has so far installed 66% of its targeted renewable energy installation of 175 GW with only Gujarat, Rajasthan, Karnataka and Telangana meeting State-wise targets, Four States account for the majority, or about 60% of the shortfall, namely Maharashtra, Uttar Pradesh, Andhra Pradesh, and Madhya Pradesh. Since government is committed to increase renewable generating capacity from 175 GW in 2022 to 450 GW in 2030, surplus states will face excess VRE (variable renewable energy) generation problems. RE surplus states demand a policy initiative to facilitate significant exports of more power to other states and allow renewables to displace some coal power plants locally. In fact, renewables-rich states may soon experience periods when wind and solar power make up the majority of generation. It then becomes imperative to monitor local system strength and inertia requirements and they are reaching a stage when they often need to curtail more solar and wind capacity and generation to ensure system security. This, however, implies that India’s installed capacity of RE and generation is affected because of regional imbalance.

19. Government’s plan to add 50 GW of renewable capacity per year, from FY24 to FY28 will call for trillions of dollars. We will also need huge amounts of funding in the long term energy transition and, in this, access to low-cost financing is imperative. India has made multiple calls for low-cost climate financing at global forums. At the same time, India’s transition to clean energy is a huge economic opportunity. These and other low-carbon technologies could create a market worth up to \$80 billion in India by 2030. The international community has already started eyeing it. External participation in technology and financing are essential to help shift India’s development onto a low-carbon path. The International Energy Agency (IEA) estimates that \$160 billion is needed per year to reach net zero emissions by 2070. That is three times the current investment levels. Therefore, access to low cost but long term capital is key to achieve net zero. And, as renewable power capacity

and generation increase, they can cause major fiscal consequences for states, because of higher procurement by state discoms. A recent study of 2023 mentions that 92.5 per cent of all grid-connected RE generation came from eight states. This is largely driven by higher insolation and wind density but also bolstered by favourable state finances and investment environments.

20. That brings us to government policies which matter a lot as the renewables sector is led by private capital. The latter is susceptible to **to** fiscal policies. From April 2022, for instance, renewable installations slowed down considerably, which is attributed to an increase in the basic customs duty on components. By July 2022, India saw the lowest level of new installations since June 2020, before picking up in August as the customs duty issue stabilised. The energy transition, much like any other complex transition, will take time and policy and regulatory consistency are essential — encourage investors, markets and other stakeholders. Their participation and support are absolutely essential in the transition with greater confidence and alignment. As we have seen in India's renewables journey, large goals have had the effect of mobilising policy and markets. India's previous goal of 175 GW of renewable generation (then considered highly ambitious) helped reduce prices drastically. The solar tariff auctions brought down prices by 90 per cent; created demand through off-take commitment and by enforcing them Renewable Purchase Obligations (RPOs) and bankable power purchase agreements brought in waivers for transmission charges, among other incentives.

21. Further, it is imperative to have regulatory side developments, in the form of real-time markets to help balance supply-power demand across India's grids. The General Network Access for improved transmission connectivity to solar and wind energy and the PLI (Productivity Linked Investment) subsidisation scheme for solar PV module manufacturing also appear to have brought efficiencies to how India's power ecosystem generates, transmits, and distributes renewable energy. These must necessarily continue to ensure the 500 GW goal with a sense of optimism. The next phase of India's energy transition will also need incentives and a facilitating regulatory apparatus to both bring new technologies into the market affordably and encourage their deployment. Going ahead, Government has to empha-

size R&D to accelerate adoption of renewable energy technologies and introduce new commercial frameworks — including bids for Pumped Hydro, Battery and other forms of Energy-Storage Systems. Further impetus can come from implementing the envisioned domestic carbon market, and the Electricity Amendment Bill to introduce critical reforms. In his book *Market-craft: How Governments Make Markets Work*, Steven K Vogel emphasises that "modern-day markets do not arise spontaneously, but are crafted by individuals, by firms, and most of all, by governments." Complex relations govern capitalist economies which depend a lot on government's role as the major policy facilitator.

22. The next wave of power plant construction in India is likely the mass construction of renewable energy assets over the coming few decades. While projections from government agencies about India's power future have varied, the Central Electricity Authority's report on Optimal Generation Capacity Mix for 2029-2030 says that solar and wind will make up almost 51 per cent of total generation capacity by 2030. But in terms of generation, it does not appear that RE will be able to cross 31 or maximum 32 per cent by 2030. This may be viewed as a vast improvement from 8.3 per cent in 2019, in a domain where the absolute size of the demand-pie is also growing substantially.

23. Critics, however, argue that if India's coal power dependence in the electricity mix is to reduce from over 70 per cent at present to 50 per cent by 2030, in terms of capacity, we have actually to increase our target for renewable energy from 500 GW to 650-700 GW. This is because both demand and total generation from fossil fuels are going up and this capacity-based target of 500 GW warrants a serious re-look, to enforce higher contribution from RE in actual generation. Though 31 to 32 percent of power from RE may surely be commendable, it also means that in 2030 also, 68 to 69 percent of our total energy will still be from polluting fossil fuels. In other words, India's pledge to meet 50 percent of its electricity requirements from renewable energy sources by 2030 does not appear feasible, even if installed capacity for generation from renewables and "other non-fossil fuel-based sources" may be close to equal the capacity for fossil-fuel based power installations. It is sad but true that transition in energy is generally quite gradual, unless substantial breakthroughs are achieved in new technologies. Even this steady journey needs a sustained policy commitment and continuity to ensure the inflow of investments which is so crucial.

24. We would, however, be rather simplistic in our analysis if we end without touching upon the political economy of capitalism in India and not gauge the power of economics in political decision-making. It is pertinent to note that Adani and other private sector power giants find solar power plants cheaper to build, as compared to coal-based plants. This is very interesting because Adani has sunk in billions in coal handling and is also the largest coal-contractor (officially called MDO, Mine Developer and Operator) across the largest number of private and state public sector mines. These are beyond the remit of Coal India and its subsidiaries. Adani is also India's leader in coal transportation and the biggest and most profitable importer of coal into India. If his units also have the largest capacity in solar energy, he surely knows where to reap when the sun shines.
