Renewable Energy and Coal-Based Electricity: Impasse, Challenges and Imperatives for India

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Abstract -- **Aspirational India needs increasing use of electricity to run household gadgets like television, fridge, washing machine, computers etc. Currently, per capita annual electricity consumption is 1208 units -- one-third that of China and half of world-average. Despite massive rise in electricity installed capacity, highest consumption of 194 GW in August 2021 was just 52% of total installed capacity.**

In foreseeable future, coal-based generation will continue. States need to retire end-of-life, expensive legacy thermal power contracts to reduce their losses. For all the climate change talks and Net Zero emissions, India needs conservative approach and commitments along with aggressive approach to renewable energy.

Electricity consumption within states exhibits significant inequity at the household level. About 15-20% of all households consume less than 30 units per month. Importance of efficiency in electricity generation and distribution and efficiency in its use at the consumer-end is of paramount importance. India's National Hydrogen Energy Mission launched recently will go a long way in meeting its Nationally-Determined Contributions targets under the Paris agreement.

Keywords: Electricity generation methods, Climate change aspects, Renewable energy, Emission intensity, Hydrogen energy mission

I. INTRODUCTION

ELECTRICITY Scenario in India: As per Energy Review 2020, Electricity use in India is projected to triple by 2040 driven by economic growth, higher and better income distribution, Increasing use of electric appliances and cooling needs (AC-Domestic and Commercial), population growth, and urbanization. Massive shift of oil based uses to electricity based uses, as is evident by two times rise of overall energy use viz-a-viz 3 times is of electricity based uses by 2040.

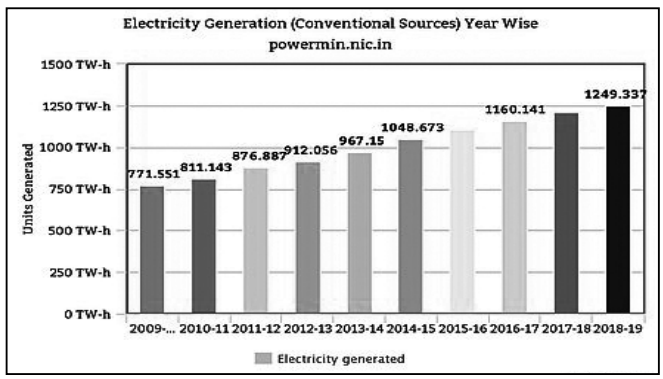
Despite massive rise in electricity installed capacity, highest capacity on bar has never crossed 200 GW (Currently highest capacity 1,94,000 MW in Aug, 2021 just 52% of total installed capacity) and about 50% rise in per capita consumption during the current millennium in about 2 decades, much progress still needs to be covered in terms of electricity consumption by different sections of household and the population strata across the country owing to high disparity in urban and rural households and according to economic strata- basic, poor, lower middle class (non-AC using) and upper middle class and effluent households (using multiple ACs).

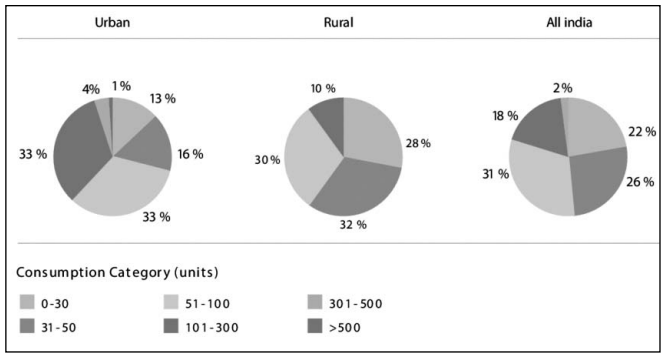
In 2020-21, per capita electricity consumption is 1208 units per capita annually (1/10 of USA and 1/3 of China and about half of world average). However this figure is one of the most misleading and unrepresentative (As compared to all other socio economic data) of socio economic correlation to the electricity consumption which is in direct correlation to economic wellbeing and lifestyle. The percentage of households with access to electricity has increased from 55% in 2001 to more than 80% in 2017 and almost 97% at the end of 2020-21.

In 2014, an electrified Indian household consumed about 90 units (kWh) of electricity per month on an average; enough to run four tube-lights, four ceiling fans, a television, a small refrigerator, and small kitchen appliances with typical usage hours and efficiency levels in India. This is three-fourths of the average monthly household consumption in China, a tenth of that in the USA, and a third of the world average.

Electricity consumption within states also exhibits significant inequity at the household level. Surveys by the National Sample Survey Office, about 20% of electrified households consume less than 30 units of electricity per month, while about 80% consume less than 100 units per month. In rural areas, 90% of the electrified households consume less than 100 units. This distribution varies with states. In most states, about 15-20% of all the households consume less than 30 units per month. The states consuming the least electricity are Karnataka, West Bengal, Bihar and Jharkhand. On all India basis: Generation and Consumption patterns are:-

Households Electricity in India according to monthly consumption





Here is the "Tell it all story" about Inclusive growth in India in terms of electricity consumption (reference blog series-Centre For Policy Research) reflective of lifestyle indicating a great deficit among majority of India's population looking at data that just 2% household have electricity above 300 units per month which use advanced electric gadgets. About 57% Indian households (urban and rural combined) use just in range of 30 to 100 units per consumption month which might cover just very basic bare minimum gadgets like small TV and/or small fridge. This also tells how much road is absolutely essential to cover before India can be said as truly advanced country. Hence for all the climate change talks and Net Zero emissions (thereby curtailing fossil-fuel based energy generation), India needs conservative approach and commitments along with aggressive approach to other RE Technologies (apart from solar, wind and micro hydro) and further renewed boost to solar, wind and micro hydro with emphasis on generation at point of use such as roof top solar, solar water pumps, micro hydro +micro/mini wind in town and villages.

India's 175 GW target of RE capacity by 2022 and 450 GW by 2030 in view of which it is imperative that our energy grid involves other green technologies on a medium-to-long term basis. This will help India lower its emission intensity by 33-35% from the 2005 levels by 2030, another Nationally-Determined Contributions (NDC) target under the Paris Agreement. In this respect, India's National Hydrogen Energy Mission launched in 2021-22 will go a long way in meeting its NDC targets.

Today, climate concerns and simultaneously increasing focus on zero-carbon RE globally, make hydrogen-based energy sources more relevant than ever. Stricter carbon abatement regulations have also pushed hydrogen producers to move away from conventional fossil fuels to green power sources, like wind, solar, biomass, hydro-electric power, and so on. However net zero by 2050 - the concept being pushed may be highly detrimental to the long-term growth interests of India and its energy security considering that India's per capita emission is half of world average and 1/12th of USA and that its steel, cement, coal production are all a fraction of advanced countries.

II. IMPORTANCE OF EFFICIENCY AND ENERGY INTENSITY IMPROVEMENTS

India has also taken significant steps to improve energy efficiency, which have avoided an additional 15% of annual energy demand and 300 million tons of CO_2 emissions over the period 2000-18. India is committed to Climate Change Mitigation and set the goal of 35% reduction in CO_2 emission by 2030 over 2005 data. Importance of efficiency in electricity generation and distribution and efficiency in its use at the consumer-end is of paramount importance. Emphasis is on energy intensity *and* on efficiency/energy intensity in industries which are classified as most polluting and energy-intensive. Accordingly, India does have reservation to Net Zero by 2050 but has serious plans of curtailing coal electricity growth.

III. INDIAN POWER SECTOR

India is the 3rd largest producer of electricity and 3rd consumer of electricity in the world. Electricity sector in India has installed capacity of 371GW as of June 2020 which was 282 GW as of Nov 2015, annual growth of 18 GW/year. Coal Based capacity is 206GW (56%), Gross Electricity generated was 1303.5 billion units (1486.5 BU including grid connected and off grid Solar). Coal based electricity generation is 76%.

TABLE 1 – INSTALLED CAPACITY (MW) AS ON 31ST MARCH 2020

Source: CEA

	Thermal	Nuclear	Hydro	Renewable	Total
State	74216	0	26959	2357	103532
Private	86875	0	3394	82770	173039
Central	69718	6780	15347	1632	93477
All India	230809	6780	45700	86759	370048

TABLE 2 – INSTALLED CAPACITY (MW) AS ON 31ST MARCH 2019

Source: CEA

	Thermal	Nuclear	Hydro	Renewable	Total
State	72849	0	29879	2348	105076
Private	87372	0	3394	73662	164428
Central	66058	6780	12126	1633	86597
All India	226279	6780	45399	77643	356101

TABLE 3 – ELECTRICITY GENERATION (BILLION UNITS)

Source: CEA

	2019-20	2018-19
Thermal	1044.4	1072.2
Nuclear	46.4	37.8
Hydro	156	134.9
Bhutan Import	5.8	4.4
All India	1252.6	1249.3

Thermal generation continues to be the mainstay, accounting for 83% of the generation

TABLE 4 --INDIAN POWER SECTOR AT A GLANCE

ELECTRICITY GENRATION	SECTORIAL CONSUMPTION	INSTALLED CAPACITY
Gross generation 1303 BU (2018-19): 75.3 % Coal 1059.6 BU 9.7 % Large Hydroelectric126 BU 0.4 % Small Hydro 50.5 BU 4.3 % Wind 52.7 BU 2.3 % Solar power 25.9 BU 1.2 % Biomass 15.3 BU 3.9 % Gas 50.2 BU 2.9 % Nuclear 38.3 BU Fossil fuel based Generation : 80.4% Clean Energy Generation: 19.6 %	Residential consumption 24.2% Industrial consumption 41.5 % Agricultural consumption 18 % Commercial consumption 5.5 % Traction /Rail consumption 1.3% Miscellanious mixed sector 9.5% *Per capita consumption of electricity 1181 units (2019-20)*	All India installed capacities 2019-20: 356GW Coal based : 205.9 GW Gas based : 24.9 GW Nuclear. : 6.8 GW Hydro. : 45.7 GW Renewables: 88.8GW *All India capacity 2020-21 (Oct 2020) 372.7GW*

TABLE 5 --GROWTH OF RENEWABLE ENERGY GENERATION MORE THAN 10% CAGR

Years	Non RES Generation (MU)	RES Generation (MU)	Total Generation (MU)	% of RE w.r.t. total generation
2014-15	1048673	61719	1110392	5.56
2015-16	1107822	65781	1173603	5.61
2016-17	1160141	81548	1241689	6.57
2017-18	1206306	101839	1308145	7.78
2018-19	1249337	126759	1376096	9.21

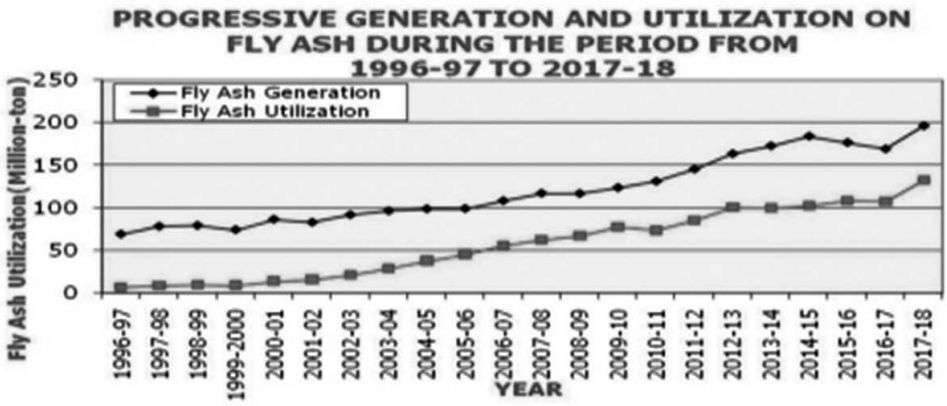
Perception of Coal Based vs Renewable Electricity: India today has very good basket of energy mix with substantial targeted renewable capacity more than 30% by 2025 and to 40% by 2040. While coal termed as most polluting, its share can at best fall to 40% by the year 2040. There can be only temporary lull in new coal capacity for 2-3 years. But as the economy picks up, share of coal based electricity shall pick by another 7 to 12% taking average national PLF to around 62-65% range from the current 50%. Industry's 24/7 energy assurance will remain mostly coal and gas-based power for another 15-20 years. Today RE installed capacity is 22.3% of total installed power generating capacity.

Solar installed capacity is 8.6% of all India installed capacity with CUF less than 20% at an investment around Rs.1.2 to 1.5 Lakh crore. Of Gas based capacity, 24.6 GW at an average investment of about Rs. 1.1 Lakh crore, only 5.2GW (22% of total and 1.4% of all India gross capacity) is allocated gas and generating 49.8 BU (4% of total generation). In contrast, Coal base 206 GW represents investment of about Rs 8.5 Lakh crore driving 76% of all India power generation. Whatever we may say, Coal Electricity will remain the base backbone of Indian Power Sector at least till 2040, and Renewable Energy can be complimentary to it rather than replacing coal capacities in big way.

To reduce financial and operational inefficiencies across India's power distribution sector, with massive overdue payment liabilities of Rs 1,16,340 crore to generation companies and total debt of Rs 4,78,000 crore, shall work with state governments to retire their inefficient and expensive thermal power plants as a key pathway to reduce their average cost of power procurement. The gap between average revenue realization and average cost of supply remained constantly high over the years, causing erosion in the volume of internal resources generation by the Distribution Companies. The level of commercial losses of the DISCOMs depend on the unaccounted electricity losses, subsidies received towards sales to agriculture and domestic sectors, revenue generation through cross-subsidization etc. There is no point in bailing out state discoms again and again without locking in a systemic improvement and permanent solution. Reducing cross-subsidies to decrease the burden on commercial and industrial customers massively and increase the healthy competition.

Longterm Technological Solution for Discoms: By taking steps to retire end-of-life, expensive legacy thermal power contracts, states will reduce their losses and be in more of a position to contract cleaner, cheaper renewable power and invest in new technologies to further reduce losses such as smart meters. There is economic case in not adding fresh capacity rather retrofit the sub critical units to bring the cycle efficiency closer to super critical units at much lower cost. Also suitable interventions/ modification for cycle efficiency improvements at lower loads of 55-70% loads in coal plants need to be adopted which is going to be a case in time to come for coal based power plants with more renewables which is a gross reality

Coal, Fly Ash & Environment :



Other Operational Challenges of Indian Power Sector: It is imperative that coal, which has been the dominant source of fuel for power generation in India (almost three-fourths is currently coal-based), will continue to be a critical source for generating base-load electricity. Various estimates indicate that electricity generated from coal is expected to grow twofold to threefold by 2030.With an average 730 MT of coal consumed by power plants in our country by the end of financial year 2018 which tuned to an average of 210 MT of fly ash generated by then with efforts of ash utilization had resulted in achieving just 59% by the same year end. The industry is currently challenged as utilities strive to meet environmental standards. Consequences for coal ash utilization will include a large increase in the amount of flue-gas desulfurization (FGD) gypsum, mercury-laden activated carbons in the fly ash, and a change in fly ash composition as utilities change fuel supplies in response to new environmental controls.

Status of FGD installation: Out of a total of 448 units that are planned for FGD systems — which removes SO_2 from exhaust flue gases — the ministry is recommending 322 with a capacity worth one lakh megawatt (MW) for an extension. Of the remaining 438, feasibility studies had been conducted on around 416 units (1.57 lakh MW), tender specifications made for 329 (1.31 lakh MW), NITs issued for 294 (1.20 lakh MW) and bids awarded for 130 units (58,000 MW). FGD has been commissioned for four of these units (1,740 MW). After Dec 2016 notification, Off 206 GW coal capacity, existing 166 GW capacity was identified and notified by CEA for retrofitting. Estimated investment required is Rs.1,65,000 crore.

However, biggest folly is the blanket mandate for So_x No_x retrofittings and norms on the basis of absolute values of emissions. It is resulting in huge amount of capital requirement, high impact on tariffs and increased quantities and impacts of water, power and chemicals to drive So_x No_x systems besides huge. Additional requirement of waste management and recycling to minimize the environmental impacts.

Rakesh Kumar, retired General Manager-NTPC, is an expert in Power Sector, Energy and Environment having rich experience of 42 years. Currently serving as honorary Member of Governing Council, IDC Foundation. He obtained BTech (Electrical) from Indian Institute of Technology, BHU and MTech from IIT Kanpur. Advanced Management-ASCI & Corporate Director- IOD. He is Lead Auditor, National Skill Development Program-Electronics Skilling.

His expertise is in energy efficiency & energy conservation & designs (Estimation-Contract BOQ & price variations); environment, renewable energy, CDM, fly ash & safety including management of regulatory affairs, mandatory environmental consent. Also FGD plants, SO_X and NO_X control technologies.

His key capabilities include business management, strategy & process optimization, contracts, franchising & jv; price & cost analysis, marketing & sales strategy , market development, economic feasibility; power plant installation, commissioning, operation, efficiency & energy conservation-all systems; business strategy & project controls, activity alignment, prioritizing & realignment of targets; engineering & price/quatitative data analysis & techno-commercials; environment CDM, renewable energy, climate change aspects & impacts; R&R and CSR.