Scientific Research Information

Forecasting India’s Renewable and Non- Renewable Energy Generation Capacity Using Linear Trend Analysis

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ABSTRACT: India’s energy sector is witnessing a significant transformation, with increased emphasis on renewable energy for environmental, economic, and sustainable reasons. Forecasts are necessary with pinpoint precision to incorporate the correct data for policy measures, investment planning, and energy security in the country. The study applies linear trend analysis to historical data of renewable and non-renewable energy generation capacities in India from the year 2017 to 2025 to predict their future trends. The linear trend assumes that capacity will change at a fixed rate over time and that one can estimate the future capacity from the slope and intercept obtained from the set of historical data points for capacity and time. It shows that renewable energy capacity is growing at a much faster rate, driven by government promotion, price reductions in technology, and increased environmental consciousness. Non-renewable energy capacity trends depict slower growth, a sign of regulatory barriers and the slow transition to cleaner energy. It is foreseen that by 2030 and 2035, renewable capacity will have sufficiently outgrown the non-renewable capacity, leaving ample room for this transition to a low-carbon energy system in the country. These results are very crucial to policy-makers, energy planners, and investors in making strategic decisions regarding energy infrastructure, allocation of resources, and sustaining development. Data from 2020 to 2025 was interpreted using MATLAB (Figure. 2) . Both systems enjoy a tremendous level of growth according to the forecast result, with renewable energy enjoying more growth.

INDEX TERMS: Renewable energy; Linear trend analysis; Forecasting; MATLAB;

I. INTRODUCTION

Industrialization, digitalization, and electrification have halted the spike of demand for electricity in India. Simultaneously, the national policy had set sights on installing 500 GW of non-fossil fuel capacity by 2030[1], [2], the localization of solar manufacturing, and the modernization of the grids. Newer installed capacities are created much faster than decarbonization of the generation mix, thus creating a wider distance between an inspiringly cleaner capacity mix and a still aggressively coal-heavy generation mix. This study has tackled quantifying the capacity trends separating RE from non-RE sources while understanding their drivers and implications.[3], [4], [5]

As reported by the Central Electricity Authority, the total renewable energy-based electricity generation capacity now stands at 203.18 GW.The achievement is a testimony to India's increased commitment to clean energy[5], [6] and its forward march toward a greener future. With an incredible 24.2 GW increase in total renewable energy installed capacity (13.5%) between October 2023 and October 2024, India reached the 203.18 GW mark against the earlier 178.98 GW. In addition, in 2024, taking into account nuclear energy, India's total non-fossil fuel capacity was 211.36 GW, as opposed to 186.46 GW in 2023.MNRE[7], [8], [9], [10], [12], [13].

The world energy scene is changing fast, kinda because we really have to curb climate change , also to bolster energy security , and to chase sustainable development goals. In this shift, renewable energy tech, like solar photovoltaics (PV) and wind power [11], [14], [15], has become like a main support beam, while their costs have dropped a lot over the last decade. But, the road to truly zero-carbon energy systems is still argued about. People keep debating if it is actually technically feasible, economically worth it, and how quickly the transition should happen.[5], [16], [17]

Rockström et al. propose some kind of " carbon law" framing, suggesting that if we halve gross anthropogenic CO_2 emissions each decade , we could in turn reach net-zero emissions around mid century, which is sort of necessary if the goal is to keep warming well under 2°C[18], [19], [20], [21]. Then the Paris Agreement (2015) kind of builds on that momentum, by pushing international effort further, where participating countries commit through Nationally Determined Contributions, or NDCs, intended to cap the overall temperature rise.[22], [23], [24], [25], [26], [27]

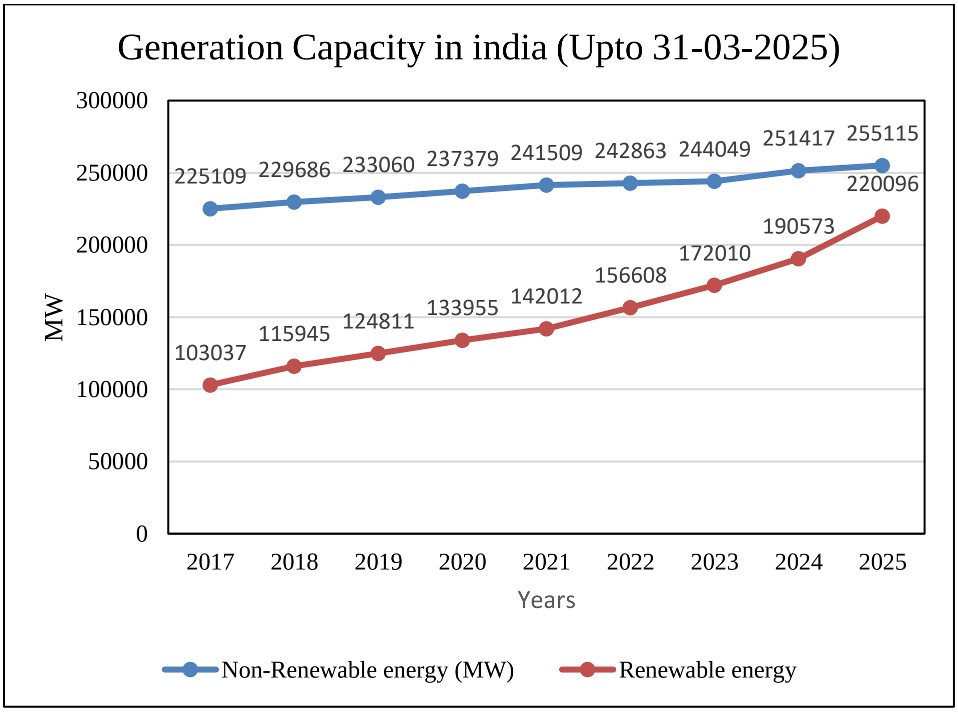

Figure 1:- Trendline of Renewable energy and Non-renewable energy Generation capacity in India

There are still significant challenges when trying to slot these variable energy sources into the current power grids, and it is not really clean or easy. Rajendran et al.[28] they give a broad review of the technical issues tied to solar PV grid integration, like voltage fluctuations, frequency variations, harmonic distortion , and also the fact that grid codes may need updating so they can handle higher levels of renewable penetration. In a similar way Colak et al.[29] show that a hybrid machine learning setup, using Extra Trees, CatBoost, and LightGBM together, can reach better forecasting accuracy for renewable energy output, with R^2 values up to 82.55%.[30], [31], [32], [33], [34]

Zappa et al.[35] critically examine whether a 100% renewable European power system by 2050 is actually feasible, and they sort of conclude that yes its technically possible but then you still need something like 90% more generation capacity and 240% more transmission capacity than what we have now. Costs are also reported to be around 30% higher compared with systems that include nuclear energy or carbon capture and storage. Diesendorf and Elliston [36]respond ,though, basically saying the big barriers to 100% renewable electricity are not really technical or economic as much as political ,

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institutional and cultural instead. They add that the feasibility, and even the best or optimal arrangement of renewable energy systems, changes quite a lot depending on [37] and place.

Aghahosseini et al.[1], [2], [15] they analyse a 100% renewable energy based power supply for North America under 2030 conditions. In their results they say that solar PV and wind end up mostly dominating the generation share, and that levelized costs of electricity drop to a range around 42 to 63 €/MWh. For the MENA region, Aghahosseini et al.[15] show that solar PV and wind energy can deliver, more than 90% of the generation capacity. They also suggest that stronger grid interconnections can reduce the storage requirements , and somehow that lowers the overall system costs as well..

In the Asian context, Kilickaplan et al.[15] model Turkey's energy transition toward one hundred percent renewable energy, and they project that solar PV could cover about 71–73% of total installed capacity by 2050. Meanwhile Keiner [3]et al. investigate the Maldive[3]s as a case study for island nations with limited land availability, showing that floating offshore solar PV and wave energy converters, can together support a fully renewable energy system with costs around 77.6–92.6 €/MWh by 2050. For Bangladesh, Noman et al.[17], [38], [39], [40] forecast energy demand by using linear regression methods, and they project that demand will climb to roughly 24,000 MW by 2025 , which should outpace today's generation capacity by a lot.[26], [41], [42].

II. METHODOLOGY

Forecasting energy demand and renewable generation is kind of essential for proper energy system planning, grid handling, and policy formulation. Between the different forecasting methodologies, a linear trend analysis is still one of the more approachable, and most used approaches, mostly because it's simple, transparent and gives reasonable accuracy for medium term projections.

A. DERIVATION OF LINEAR TREND ANALYSIS FOR FORECASTING

Linear trend analysis is one of the simplest and widely used methods of forecasting time series data. It assumes that the dependent variable (e.g., energy demand) changes approximately in a linear manner with respect to time. The method is based on the least squares principle, which minimises the sum of squared deviations between the observed values and the estimated trend values.

B. DATA COLLECTION

Historical energy generation capacity (GW) from 2000–2025 for Renewable energy (solar, wind, small hydro, biomass, etc.) And Non-renewable energy (coal, natural gas, large hydro, nuclear) in Figure 1. (All Data is collected Source in the Ministry of Power, Central Electricity Authority (CEA), and IEA reports.

C. ASSUMED TREND EQUATION

The linear trend model is expressed as

$$Y_t = a + bt$$

where,
Y_t = estimated (trend) value at time period t,
$a =$ intercept (value of Y when $t = 0$),
b =slope of the trend line (average change per unit of time),
t = time index $(1,2,3 \ldots \ldots, n)$.

D. LINEAR TREND PARAMETERS

(a) Slope (b)

$$b = \frac{N \sum(tY_t) - (\sum t)(\sum Y_t)}{N \sum t^2 - (\sum t\text{^}2)}$$

(b) Intercept (a) :

$$a = \frac{\sum Y_t - \sum t}{N}$$

(Where N is the number of years of data)

E. FORECASTING FUTURE CAPACITY

$$Y_{t+f} = a + b(t + f)$$

(Where f is the number of years ahead for the forecast.)
We have using Linear Trend Analysis for Real data of the generation Capacity of India in forecasting 2030 & 2035. Then we calculate the total energy generation capacity in 2030 and 2035. Analyse the future scope for which is the best.

Table No. 1: Forecasting of Linear Trend Analysis in the generation Capacity of India for 2030 & 2035

Year	**Time Index (t)**	**Generation Capacity (MW)(Renewable Energy)**	**Generation Capacity (MW) (Non-Renewable Energy)**	**Forecast**
2020	1	133955	236,846.5	-
2021	2	142012	240,263.4	-
2022	3	156608	243,680.2	-
2023	4	172010	247,097.1	-
2024	5	190573	250,514.0	-
2025	6	220096	253,930.8	-
-	-	-	-	-
2030	11	**287836.00**	**271,015.1**	**Forecast**
2035	16	**353167.00**	**288,099.5**	**Forecast**

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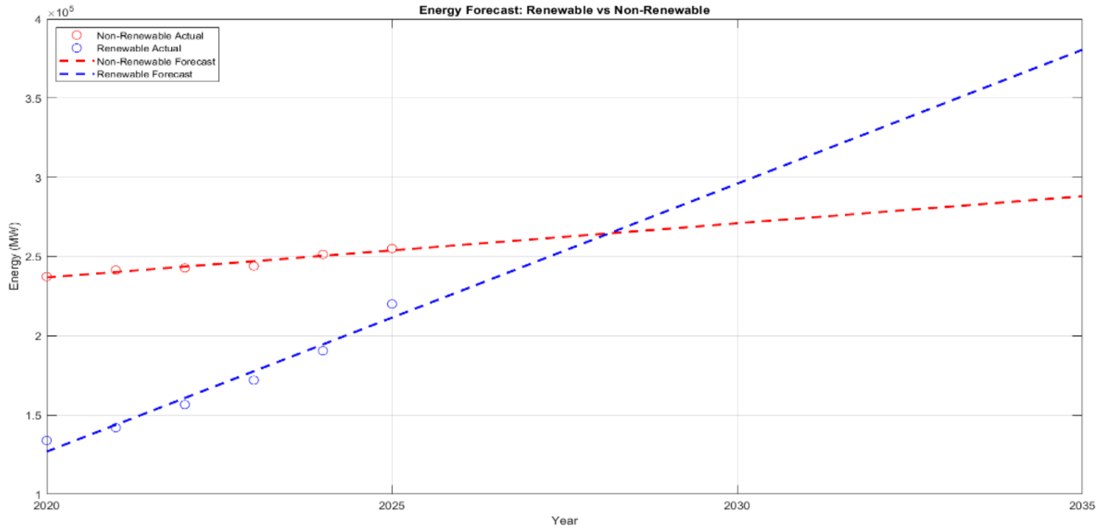

Figure 2: Forecasting of Linear Trend Analysis in Renewable and Non-Renewable Generation in India on MATLAB

III. RESULTS AND DISCUSSION

The linear trend analysis of India's energy generation capacity reveals distinct growth patterns for renewable and non-renewable sources. Historical data from 2000 to 2025 show that renewable energy capacity, particularly solar and wind, has experienced rapid growth, reflecting supportive government policies, technological advancements, and declining costs. Non-renewable capacity, including coal and gas-based generation, shows slower growth, indicating saturation and increased environmental constraints. Forecasting using the linear trend model predicts that renewable energy Generation capacity will reach approximately 287836 MW by 2030 and 353167 MW by 2035 (Table no. 1), while non-renewable capacity is projected at 271015 MW by 2030 and 288099 MW by 2035(Table no:-1) . These projections indicate a clear shift in India's energy mix toward renewables. The total generation capacity in India (both renewable and non-renewable energy sources) is 560 GW in 2030 and 636 GW in 2035. Forecasting results in Linear Trend Analysis.

IV. CONCLUSION

The study concludes that India is moving toward a low-carbon energy system, with renewable energy likely to dominate future electricity generation. Linear trend analysis, while simple, effectively highlights long-term growth patterns and provides a preliminary forecast for capacity planning. However, it assumes historical trends continue and does not incorporate policy changes, economic fluctuations, or technological breakthroughs. Despite this limitation, the findings are valuable for policymakers, planners, and investors, emphasizing the importance of sustained investment in renewable infrastructure, grid integration, and supportive policies to achieve energy security and environmental sustainability in India.

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