Briefing Note: TANGEDCO's CARBON EMISSIONS AND ENERGY MIX: TRENDS AND INSIGHTS (FY18 to FY24)

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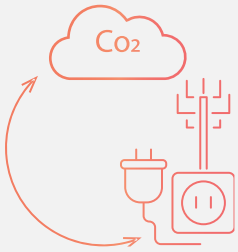

Introduction

This report establishes a distribution licensee-specific CO_2 emission tracking methodology, leveraging the Central Electricity Authority's power plant-wise CO_2 database for fiscal years 2017-18 to 2023-24 (CEA, 2024). This analysis provides a granular view of Scope 2 emissions associated with individual licensees by aggregating and allocating emissions based on power procurement and distribution patterns. The resulting dataset aims to serve as a standardised and readily accessible resource for policymakers, grid operators, and entities mandated to report their environmental footprint, facilitating informed decision-making and accurate emissions disclosure.

Key Findings

- Fossil fuels continue to dominate TANGEDCO's energy mix. Despite fluctuations ranging from 60% to 43%, the combined share of coal, lignite, and gas over seven years accounted for an average of 52% of the procurement, highlighting sustained dependence on high-emission sources.
- Renewable energy (RE) procurement in FY 2023-24 was 9%. Since the beginning of the analysis period, the share has grown, but falls well short of policy mandates, missing the Renewable Purchase Obligation (RPO) target of 27% by 18% in FY 2023-24. RE procurement rose 29% over the assessment period, driven mainly by solar and hydro (72%), while wind and biomass remained minimal at 28%.
- Emissions trends mirror fossil fuel reliance, peaking at 83.05 million tCO_2 in FY 2023-24. Continued dependence on coal and lignite, particularly increasing lignite emissions, has limited emission reduction.
- Emissions intensity has increased in recent years. After dropping to 0.65 tCO_2/MWh in FY 2020-21, TANGEDCO's emission factor (EF) rose to 0.75 tCO_2/MWh in FY 2023-24, exceeding the national average of 0.73 tCO_2/MWh. This increase is attributed to higher coal and lignite procurement and a decline in RE procurement.

Energy Sources

Fossil fuels remain the predominant energy source for TANGEDCO even in FY 2023-24, accounting for 52% of the total energy mix.

Tamil Nadu's energy mix comprises a wide range of sources, including coal, lignite, gas, nuclear, hydro, solar, wind, and biomass. Throughout the assessment period, fossil fuels remained dominant, supplemented by modest but steady growth in nuclear and RE, alongside sharp increases in short-term procurement to fill demand gaps. This section outlines how these sources contributed over time.

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Energy Mix

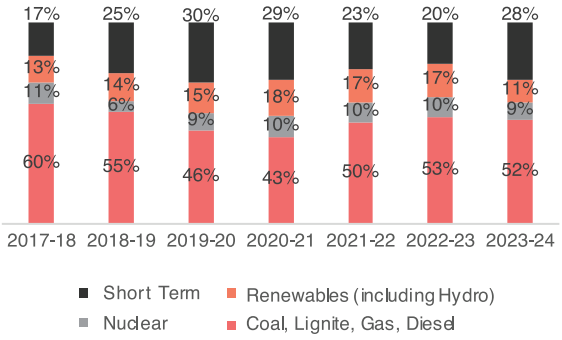
In FY 2023-24, fossil fuels accounted for 52%, RE 15%, and short-term 25%, reflecting a persistent fossil fuel-heavy mix and a sharp rise in market-based procurement.

Demand has fluctuated, varying annually by a maximum of 28% and a minimum of -8%, but consistently remained above FY 2017-18 levels (75,217.94 GWh), justifying reliance on fossil fuel sources to meet baseload demand. Procurement was lowest in FY 2020-21 at 87,048.99 GWh due to the pandemic, but steadily increased, peaking at 110,975.39 GWh in FY 2023-24. This trend shows clear demand growth post-pandemic and indicates a sustained trend inclination.

Must-run sources, constituted of nuclear, RE, and hydro, averaged 24% of procurement, ranging from 20% to 28%. FY 2018-19 and FY 2023-24 recorded the lowest shares, and FY 2021-22 the highest.

Fossil fuels maintained an average share of 52% over the assessment period, followed by short-term procurement at 25%. Nuclear consistently contributed the least at around 10%, while RE, including hydro, averaged 15%.

Figure 1: Procurement by fuel category (%)



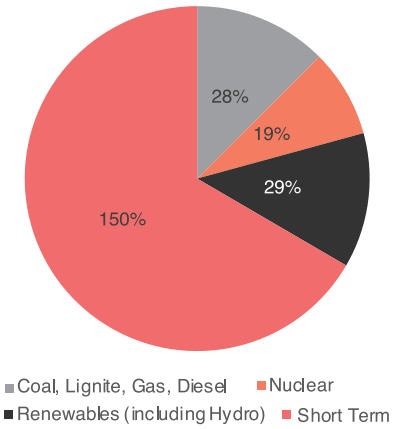
Transition in Energy mix

The energy mix shifted moderately, showing persistent reliance on fossil fuels despite clean energy gains and short-term procurement rising by 150%.

All energy sources expanded to meet an overall 48% rise in demand over the analysis period (FY18-FY24). While fossil fuel, nuclear, and short-term procurement showed occasional year-on-year declines, RE, including hydro, maintained positive growth in quantum until FY 2023-24, when it dropped by 27%.

In FY 2021-22, fossil fuel procurement surged by 34% due to a sharp post-pandemic rebound, followed by modest increases of 8% and 5% in the next two years. Fossil fuel procurement rose by 28% over the assessment period. RE procurement, including hydro, hovered around 17% of total mix for three consecutive fiscal years (FY22, FY23, FY24) before slipping to 12% in FY 2023-24, well below the 27% RPO target. Nevertheless, RE contribution, including hydro to the energy mix, grew by 29% overall since FY 2017-18. Nuclear share of the mix also expanded steadily, marking 19% overall growth. Short-term procurement remains the second-largest source, highlighting TANGEDCO's reliance on market-based purchases to manage demand variability. It grew 150% over the period, with two notable instances: a 92% leap in FY 2018-19 and a second 50% surge in FY 2023-24.

Figure 2: Increase in power demand by fuel source (%)



Thermal Energy Trend

Thermal energy averaged 52% in FY24, driven by a 28% rise in fossil fuel procurement since FY18, mainly coal and lignite.

Thermal energy has been the dominant source, fluctuating with demand and consistently serving as the backbone of Tamil Nadu's power mix. It dropped from 60% in FY 2017-18 to a low of 43% in FY 2020-21, coinciding with pandemic-related demand declines, before climbing back to 52% by FY 2023-24. The hike driven by significant overall increases of 19% in coal (8,536.07 GWh) and 12% in lignite (5,308.61 GWh). Gas-based procurement, peaked in quantum at 3,354.67 GWh in FY 2018-19, saw a steady decline until FY 2021-22, before reversing slightly in the latter years. Despite these small gains, gas procurement fell overall by 1,181.16 GWh across the period, highlighting both the growing reliance on coal and lignite and the persistent volatility in the thermal mix.

Renewable Energy

Renewable Energy increased steadily, but has been stagnating the last 3 years, falling drastically short of RPO targets in FY 2023-24.

Renewable energy (RE) showed steady growth early on but plateaued over the past three years, falling well short of RPO targets in FY 2023-24. RE rose from 13% in FY 2017-18 to 18% in FY 2022-23, with a 29% overall increase over the assessment period. The peak share of 18% was reached in FY 2020-21, but fell back to 12% in FY 2023-24, widening the gap from the 27% RPO target. Solar was the strongest driver, increasing

from 2,903.93 GWh in FY 2017-18 to 7,202.73 GWh in FY 2021-22 before declining slightly in FY 2022-23. Hydro fluctuated, contributing significantly in most years, with a notable spike of 2,410.30 GWh (25% increase) in FY 2018-19. Wind showed moderate variability, peaking at 4,386 GWh (25% of the share) in FY 2022-23 before dropping by over 2,600 GWh (14% of the share) the next year. Biomass remained a minor contributor, averaging 3% of RE. Overall, solar and hydro led growth, but variability in wind and biomass, combined with recent setbacks, highlights the challenges in sustaining RE momentum and meeting policy mandates.

Nuclear Energy & Short-Term and Others

Nuclear rose 19% over the period, peaking at 11% of the total, while short-term procurement grew 150%, underlining volatility and reliance on market-based power.

Nuclear initially fell by almost 50% from the peak share of 11% in FY 2017-18 to 6% in FY 2018-19. Thereafter steadily rose to around 10% in FY 2020-21 but dipped to 9% in FY 2023-24, marking a 19% growth overall. It averaged 10% of the mix over the assessment period, demonstrating steady contributions but limited scale and impact compared to dominant fossil fuel sources. In absolute terms, nuclear generation increased by 1,513.60 GWh across the period, showing moderate but meaningful gains. Short-term procurement peaked at 30% in FY 2019-20, declined to 20% in FY 2022-23, then rebounded sharply to 29% in FY 2023-24. This marks an overall growth of 150% (18,798.16 GWh), highlighting TANGEDCO's reliance on market-based purchases to meet demand variability. The sharp 50% surge in FY 2023-24 alone reflects persistent gaps in capacity planning, highlighting the pressing need for improved demand forecasting and flexible capacity solutions to reduce over-reliance on short-term sources.

Table 1: Procurement by fuel type (GWh)

By fuel type (GWh)	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
Coal	37,028	41,513	34,644	28,702	38,656	42,315	45,564
Short term / others	12,506	24,077	28,481	24,929	23,223	20,814	31,304
Lignite	4,812	8,568	6,309	6,768	10,519	10,885	10,121
Gas	2,985	3,355	2,924	2,174	1,456	1,700	1,803
Diesel	0	0	0	0	0	0	0
Nuclear	8,145	5,573	8,631	8,958	10,129	10,378	9,659
Hydro	3,041	5,451	4,944	5,365	5,493	6,153	3,692
Wind	3,428	3,912	3,841	3,735	3,538	4,386	1,759
Solar	2,904	3,556	4,947	6,115	7,203	6,267	6,580
Biomass	369	378	313	302	364	425	493
Total	**75,218**	**96,383**	**95,035**	**87,049**	**1,00,581**	**1,03,323**	**1,10,975**

CO2 EMISSIONS of TANGEDCO

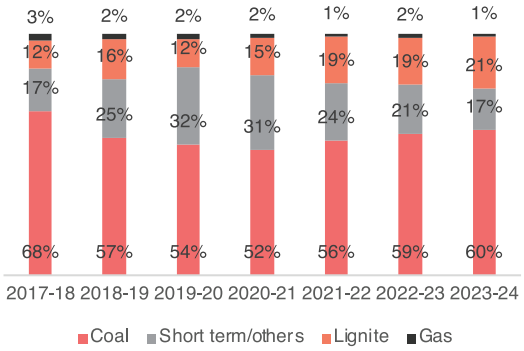
Emissions rose by 47% to 83.05 million tCO_2 in FY24, with coal, lignite, and short-term procurement as key contributors.

TANGEDCO's emissions are driven by coal, lignite, short-term procurement, and gas. Emissions were lowest at 56.39 million tCO_2 during the pandemic (FY 2020-21) but climbed steadily, reaching 83.05 million tCO_2 in FY 2023-24—a rise of nearly 47%. Coal remained the largest contributor, averaging 58% of total emissions across the period, closely tracking procurement volumes. Lignite saw emissions nearly double, rising from 6.50 million tCO_2 in FY 2017-18 to 13.86 million tCO_2 in FY 2022-23 before a slight dip to 12.99 million in FY 2023-24, increasing its share in emissions from 12% to 19%. Short-term procurement emissions peaked at 22.75 million tCO_2 in FY 2023-24, reflecting increased market reliance. Gas emissions were relatively stable, fluctuating between 0.81 and 1.67 million tCO_2, but declining procurement did not yield proportional reductions, indicating either a loss in fuel quality or operational efficiency. The emissions profile displays TANGEDCO's sustained dependence on high-emission sources and highlights setbacks in decarbonisation progress, especially in FY 2023-24 when RE contributions dropped sharply.

Table 2: CO_2 emissions by fuel type (Million tonnes CO_2)

By fuel type	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
Coal	37.07	41.10	34.84	29.28	39.05	42.03	46.46
Short term/others	9.43	17.91	20.28	17.51	16.61	14.84	22.76
Lignite	6.50	11.80	7.49	8.52	13.38	13.87	12.99
Gas	1.48	1.67	1.40	1.08	0.82	1.08	0.84
Total	**54.48**	**72.48**	**64.02**	**56.40**	**69.86**	**71.81**	**83.06**

Figure 3: Share of CO_2 emissions by fuel source (%)



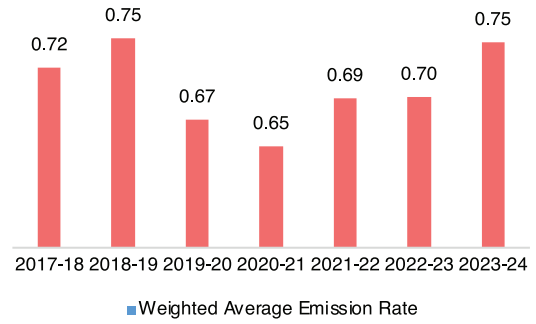
EMISSIONS INTENSITY

TANGEDCO's grid Emissions Factor (EF) peaked at 0.75 tCO_2/MWh in FY 2023-24, reflecting high coal and lignite dependence and insufficient RE contribution to the energy mix.

TANGEDCO recorded its highest EF in FY 2018-19 and FY 2023-24, at 0.75 tCO_2/MWh, exceeding the

national average of 0.74 tCO_2/MWh and 0.73 tCO2/MWh, respectively. On the other hand, arguably the cleanest year of the analysis period was FY 2020-21, where the EF reached its lowest at 0.65 tCO_2/MWh, largely due to reduced contribution of fossil fuel-based energy in the energy mix, during the pandemic, and increased RE penetration, reflected in the procurement energy mix.

Figure 4: TANGEDCO weighted average emission factor (tCO_2/MWh)



However, from FY 2021-22 onward, emission intensity began to worsen. The EF rose to 0.69 tCO_2/MWh in FY 2022-23, and further to 0.75 tCO_2/MWh in FY 2023-24, attributed to higher procurement from coal and lignite, combined with reduced RE and nuclear contribution. Over the entire assessment period, TANGEDCO has maintained a lower average EF than the national benchmark. The operating margin EF also deteriorated, rising from 0.88 tCO_2/MWh in FY 2019-20 to 0.99 tCO_2/MWh in FY 2023-24, further signalling an erosion in emissions intensity.

Table 3: Comparison of weighted average emission factor (tCO_2/MWh)

Comparison	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
India	0.75	0.74	0.71	0.70	0.72	0.71	0.73
Tamil Nadu	0.72	0.75	0.67	0.65	0.69	0.70	0.75

Emissions Intensity by Fuel Type

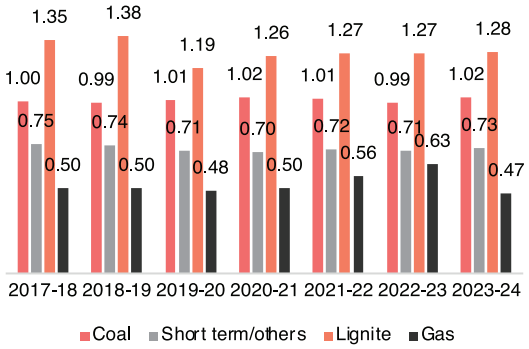
Lignite remains the fuel with the highest emissions intensity of 1.38 tCO_2/MWh in FY 2023-24, while coal stays high and gas indicates declining operational efficiency.

Among all fuel sources, lignite continues to have the highest EF, reaching 1.38 tCO_2/MWh. Coal has remained relatively stable, with EF values fluctuating between 0.99 tCO_2/MWh and 1.02 tCO_2/MWh, reflecting consistently high but controlled emissions. In contrast, gas has shown less favourable trends, with its EF rising from 0.48 tCO_2/MWh in FY 2019-20 to a peak of 0.63 tCO_2/MWh in FY 2022-23, before a massive decline, recording a new low of 0.47 in FY 2023-24. This rise in intensity, despite reduced gas procurement, without a proportional decrease in emissions, indicates a decline in operational efficiency.

Table 4: Emission factor by fuel source (tCO_2/MWh)

By fuel type	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
Coal	1.00	0.99	1.01	1.02	1.01	0.99	1.02
Short term/ others	0.75	0.74	0.71	0.70	0.72	0.71	0.73
Lignite	1.35	1.38	1.19	1.26	1.27	1.27	1.28
Gas	0.50	0.50	0.48	0.50	0.56	0.63	0.47
Total	**0.72**	**0.75**	**0.67**	**0.65**	**0.69**	**0.70**	**0.75**

Figure 5: Emission factor by fuel type (tCO_2/MWh)



Fuel-specific trends highlight lignite as the most emissions-intensive source and deteriorating efficiency in gas-based thermal power plants. While TANGEDCO demonstrated early progress in reducing emissions intensity, performing better than the national averages in several years, the recent increase in coal and lignite dependency, along with plateauing or possibly declining RE and clean energy contribution, has dented efforts in the decarbonisation of the grid.

Core Insights

Tamil Nadu's power demand has remained consistently higher than FY 2017-18 levels, procurement peaked in FY 2023-24. The fluctuations over the assessment period aren't indicative of any particular pattern, suggesting an absence of demand stabilisation at the moment.The consistent rise in procurement post-pandemic, suggests an upward trend for the near future. Additionally, wide gaps between proposed quantum in PPAs and Approved True-ups highlight the need for greater grid flexibility and stronger demand-side management. In meeting this demand, thermal power, particularly coal and lignite, has remained the predominant reliable source of electricity supply, especially in the years following the pandemic. Aiding management of demand flexibility through short-term and other sources.

While solar, hydro and nuclear energy have grown steadily and gradually increased the share of clean energy, these gains were not significant enough to shift the system away from fossil fuels. Additionally, continued dependence on short-term market procurement further reflects the lack of integration of consistent, low-carbon alternatives. Another

concern that requires attention is the efficiency of power-generating stations. In the case of gas, thermal stations' rising emission factors suggest a decline in generation efficiency, raising concerns about their role as a transitional fuel. These inefficiencies, coupled with the resurgence of coal and lignite, have impacted TANGEDCO's overall grid emissions factor. Although there were some improvements after the pandemic, the EF rose again in recent years, reaching 0.75 tCO_2e/MWh in FY 2023–24. This places TANGEDCO above the national average, highlighting the imminent necessity for greater clean energy penetration in order to progress in decarbonising the grid.

RECOMMENDATIONS

Accelerate RE Deployment and Storage Integration

Develop a roadmap to meet RPO targets by expanding solar, wind, and hydro, supported by grid-scale storage and long-term PPAs. RE procurement fell to just 12% in FY 2023-24, far below the 27% RPO target, highlighting a major compliance gap. Solar (7,466 GWh), hydro (5,652 GWh), and wind (3,436 GWh) together contributed the bulk of RE but failed to sustain momentum, with overall RE share dropping despite a 29% rise since FY 2017-18. A focused strategy should strengthen investment in RE infrastructure, improve year-round generation consistency, and reduce volatility seen in wind (dropping by 2,600 GWh in FY 2023-24), to ensure TANGEDCO meets future policy mandates and reduces fossil dependency.

Phase Down Lignite and Modernise Thermal Assets

Gradually reduce lignite use, which rose from 6.50 to 13.86 $MtCO_2$ between FY 2017-18 and FY 2022-23, reflecting its growing emissions impact. Retrofit or replace aging thermal plants to enhance efficiency and lower emissions, targeting lignite's persistently high EF (1.38 tCO_2/MWh in FY 2023-24). This strategy will mitigate rising grid carbon intensity, address stagnation in decarbonisation progress, and help stabilise emissions, particularly as lignite's share of total emissions has increased from 12% to nearly 19% over the period.

Incorporate Emissions Metrics in Planning

Use emissions intensity and fuel-specific EFs as core criteria in procurement and capacity expansion planning to align with decarbonisation targets. TANGEDCO's overall EF rose to 0.75 tCO_2/MWh in FY 2023-24, exceeding the national average of 0.73, driven by rising coal and lignite procurement and falling RE shares. While gas had a lower EF (0.47 tCO_2/MWh in FY 2023-24), its overall impact was limited by declining volumes. Careful planning must balance emissions impact with procurement trends, prioritising cleaner fuels and integrating emissions metrics into power purchase agreements and infrastructure investments to ensure sustained reductions and policy compliance.

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