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Energy Sector Development in Andhra Pradesh during the Post-Bifurcation Period

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Abstract

This paper assesses the development of Andhra Pradesh's (AP) electricity sector from four documents: the CSTEP roadmap to 2040 (2023) and the state's 2008 Wind Power Policy, 2020 Renewable Energy Export Policy and 2023-28 Energy Efficiency Policy. Installed capacity grew from 15,876 MW (FY17) to 23,953 MW (FY22), a CAGR of 8.6%; renewables grew 6.6% a year to 9,939 MW (41.5% of capacity), with solar fastest at 14.4%. Energy sales rose 5.0% a year over FY17-FY21, led by domestic (9.2%) while industrial sales were flat (0.1%). Reported T&D losses fell from 11.65% to 9.76% (FY17-FY22), and DISCOM accounts moved from an INR 11,864 crore deficit (FY19) to an INR 261 crore surplus (FY21), about INR 0.05 per unit. CSTEP's scenarios give a 47-55% renewable share of energy by FY40, 6.4-8.3 GW of storage and a 24-27% lower power purchase cost. We recompute all growth rates and shares and flag the inconsistencies, notably a 20-25% step between FY22 actual and FY23 projected requirement, that must be resolved before the projections are used for planning. The sector's challenge is shifting from capacity adequacy to integration, cost and data quality.

Keywords: *Andhra Pradesh; electricity sector; renewable energy; T&D losses; DISCOM finances; energy efficiency; energy storage*

JEL: Q40, Q41, Q42, Q48, L94

1. Introduction and objectives

AP's GSDP was INR 1,201,736 crore in FY22 (CSTEP, 2023). The state began power reforms in 1998 and, from a FY15 shortage (4.9% energy, 5% peak), reached zero peak shortage and a 726 MU energy deficit (about 1.2% of the 62,334 MU recorded requirement) in FY22. Policy has shifted accordingly: a 2008 wind order sold power to DISCOMs at an administered INR 3.10/kWh; a 2020 order targets 120 GW of renewables for export without DISCOM purchase obligation; and a 2024 order aims to save about 20% of annual demand (13,547 MU, INR 9,835 crore). The objectives are to (i) describe capacity, generation mix and renewables; (ii) analyse demand, losses, finances and tariffs; (iii) derive findings and policy implications; and (iv) document data gaps that need verification.

2. Data and methodology

The study folder held four PDFs and no spreadsheets, so all data are secondary values printed in them, mostly from CSTEP (2023), which draws on APTRANSCO, DISCOM and CEA data. The PDFs were machine-read (OCR) and key tables checked against page images. Calculations: CAGR = (end/start)^(1/n) - 1; shares are component/total; capacity utilisation (CUF) = MU / (MW x 8.76); load factor = MU / (peak MW x 8.76); per-unit finance = INR crore x 10 / MU. Reported figures are separated from modelled ones: FY17-FY22 capacity, sales, losses and finances are historical, whereas CSTEP's FY22 'supply' and all FY23-FY40 values are modelled. Fiscal years run April-March; 1 crore = 10 million; MU = million units (GWh).

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3. Analysis

3.1 Capacity and renewables

Capacity rose 8,077 MW over FY17-FY22. Thermal and gas hold 58.0% (13,882 MW), wind 17.5%, solar 15.1%, large hydro 7.7%, other renewables 1.2% and nuclear 0.6%; total capacity is 2.0 times the FY22 peak of 11,883 MW. Solar and wind had used only about 9.4% and 9.5% of the cited potential (38.4 GW and 44.3 GW at 100 m) by FY22. In CSTEP's state standard scenario (S1) capacity reaches 51,111 MW in FY40, with renewables 71.5% and nuclear 14.2%.

Table 1. Installed capacity (MW) and renewable growth

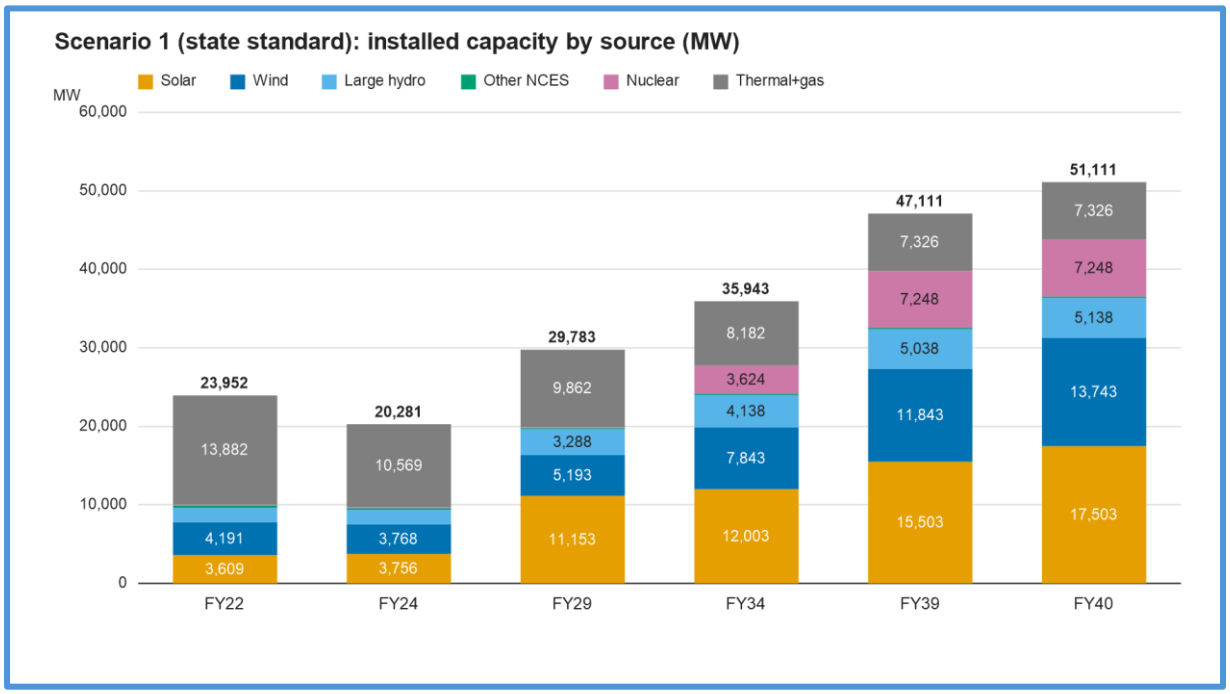
Source	FY17	FY22	CAGR FY17-22 (%)	FY22 share (%)
Solar	1,846	3,609	14.4	15.1
Wind	3,060	4,191	6.5	17.5
Large hydro	1,721	1,848	1.4	7.7
Small hydro + other RE	599	290	-13.5	1.2
Renewables (incl. large hydro)	**7,226**	**9,939**	**6.6**	**41.5**
Thermal + gas	-	13,882	-	58.0
Nuclear	-	132	-	0.6
Total	**15,876**	**23,953**	**8.6**	**100.0**

Source: CSTEP (2023), Tables 1-2 (APTRANSCO); CAGR and shares by the author (CSTEP prints 14.3% for solar). Small hydro (87 to 29 MW) and other RE (512 to 261 MW) are combined.

The 2020 export policy's 120 GW target is 12.1 times FY22 renewable capacity and 45% above the 82.7 GW solar-plus-wind potential cited; it implies 4.2 acres per MW (5 lakh acres). At full build-out the policy's lease (INR 31,000/acre/yr) and Green Energy Development Charge (INR 1 lakh/MW/yr) would yield the State roughly INR 1,500-2,750 crore a year, depending on the land mix, and add about INR 0.13/kWh to a solar project, around 5% of the INR 2.49/kWh SECI tariff. The 2008 order's INR 3.10/kWh was 24.5% above that tariff. Both orders have run their stated terms (April 2018 and July 2025) unless extended.

(IJPS) 2026, Vol. No. 21, Jan-Jun e-ISSN: 2455-6270 p-ISSN: 2455-7455

Figure 1. Scenario 1 installed capacity by source (MW)



Source: CSTEP (2023), Table 29. Total capacity falls from 23,953 MW (FY22) to 20,281 MW (FY24) in the source, which is unexplained.

Table 2. Indicative fiscal terms of the 2020 export policy at full build-out

Item	Policy term	Calculation	Result
Developer lease	INR 31,000/acre/yr	5,00,000 acres x 31,000	INR 1,550 crore/yr
Green Energy Development Charge	INR 1 lakh/MW/yr	1,20,000 MW x 1 lakh	INR 1,200 crore/yr
Treasury share, private land	INR 6,000/acre/yr	31,000 less 25,000 paid to owner	INR 300 crore/yr (all private)
One-time LADF and fee	INR 0.5 lakh and 2,000/acre	5,00,000 acres	INR 2,500 and 100 crore
Burden on a solar plant	Lease + GEDC per MW	(4.17 acres x 31,000 + 1,00,000) / 1,752 MWh	about INR 0.13/kWh

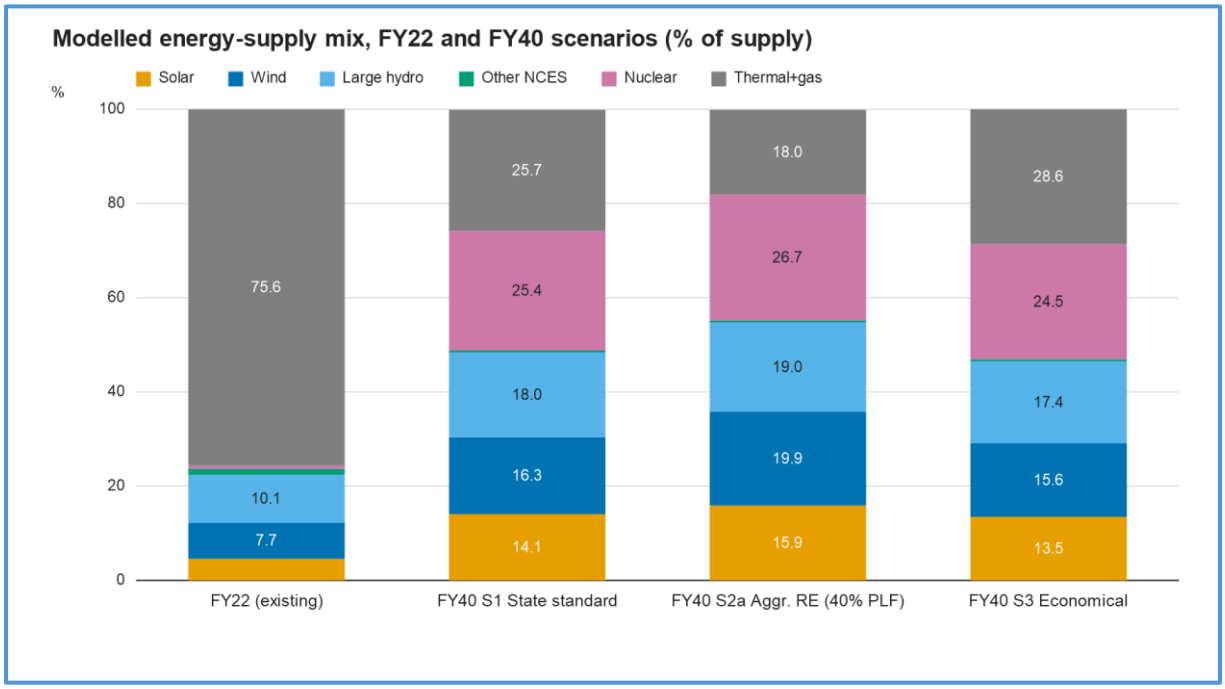
Source: G.O.Ms.No.20 (2020), clauses 8-9; author's calculations at current prices before 5% biennial escalation; 20% CUF assumed for the solar case.

3.2 Generation mix

CSTEP's FY22 'existing supply' of 136,722 MU is modelled, not metered: thermal's 103,368 MU equals 13,882 MW at 85% availability, 1.7 times the recorded 62,334 MU requirement. Shares in Figure 2 are therefore shares of potential supply. In FY40 S1 renewables supply 48.9% of energy, the aggressive RE case (thermal at 40% PLF) 55.2% and the economical case 46.9%; with thermal at 50% and 60% PLF the share is 50.9% and 46.6%. Modelled supply exceeds the requirement by 18-29% in every FY40 scenario, so the reported energy 'gap' is a peak-hour and time-of-day gap, not an annual one. Large hydro is modelled at an 85% CUF (13,760 MU from 1,848 MW); at an illustrative 40% the S1 renewable share would be 43.5% rather than 48.9%.

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Figure 2. Modelled energy-supply mix, FY22 and FY40 scenarios (%)



Source: CSTEP (2023), Tables 30, 33, 37; shares computed by the author. S1 = state standard; S2a = aggressive RE; S3 = economical.

3.3 Demand and consumption

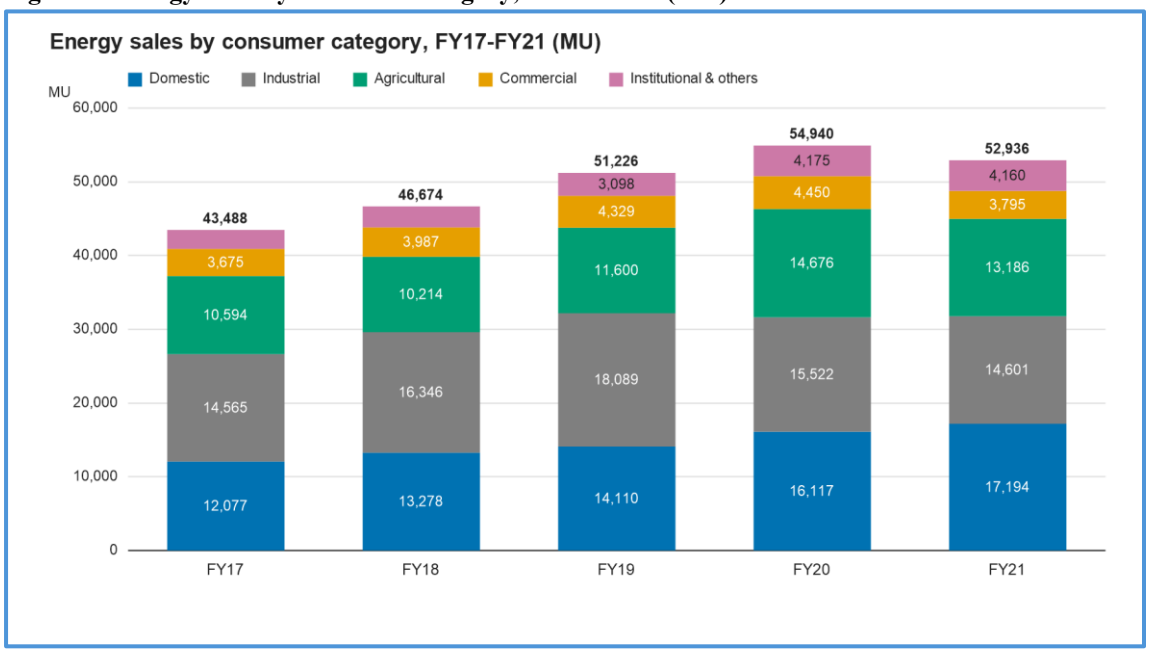
Sales rose from 43,487 MU (FY17) to 54,939 MU (FY20), then fell 3.6% in FY21 to 52,937 MU. Domestic sales (9.2% a year; 32.5% of FY21 sales) and institutional (12.7%) led; commercial grew 0.8% and industrial 0.1%, falling 19.3% from FY19 to FY21. Consumers rose 2.7% a year and connected load 8.5% a year (CSTEP prints both as larger 'CAGRs', which are total changes).

Table 3. Energy sales (MU) and growth

Category	FY17	FY19	FY20	FY21	CAGR FY17-21 (%)	FY21 share (%)
Domestic	12,077	14,110	16,117	17,194	9.2	32.5
Industrial	14,565	18,089	15,522	14,601	0.1	27.6
Agricultural	10,594	11,600	14,676	13,186	5.6	24.9
Commercial	3,675	4,329	4,450	3,795	0.8	7.2
Institutional, other	2,577	3,098	4,175	4,160	12.7	7.9
Total	**43,487**	**51,225**	**54,939**	**52,937**	**5.0**	**100.0**

Source: CSTEP (2023), Table 4 (DISCOM data); FY18 omitted for space; CAGR and shares by the author.

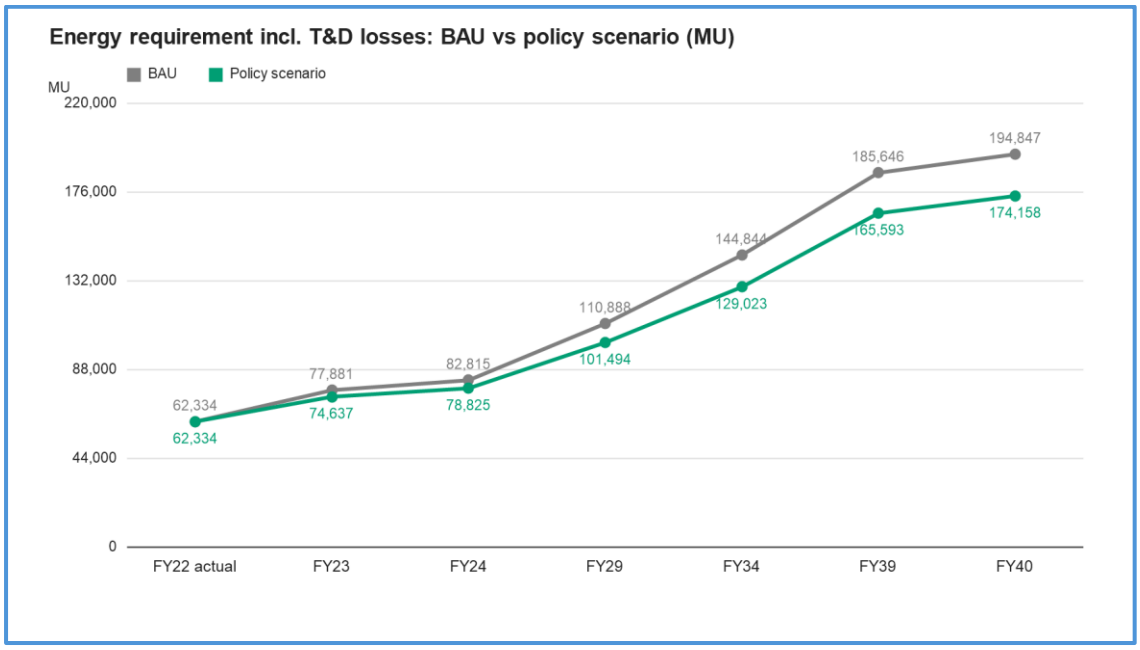
Figure 3. Energy sales by consumer category, FY17-FY21 (MU)



Source: CSTEP (2023), Table 4.

CSTEP's business-as-usual (BAU) requirement, including losses rises from 77,881 MU (FY23) to 194,847 MU (FY40), 5.5% a year. Policy levers cut FY40 requirement by 20,688 MU (10.6%) to 174,158 MU: electric vehicles add 9,874 MU; rooftop solar (2,271 MW) removes 3,581 MU; efficiency saves 6,508 MU (domestic) and 1,828 MU (commercial); agricultural solarisation and efficient pumps save 16,765 MU, 81% of the net saving. Peak demand reaches 28,372 MW, a CAGR of 5.1%. The efficiency policy's 20% potential implies a base of 67,735 MU, whereas CSTEP's levers deliver only 8.6% of BAU consumer demand by FY29, within the policy period.

Figure 4. BAU and policy energy requirement (MU)



Source: CSTEP (2023). Unevenly spaced years.

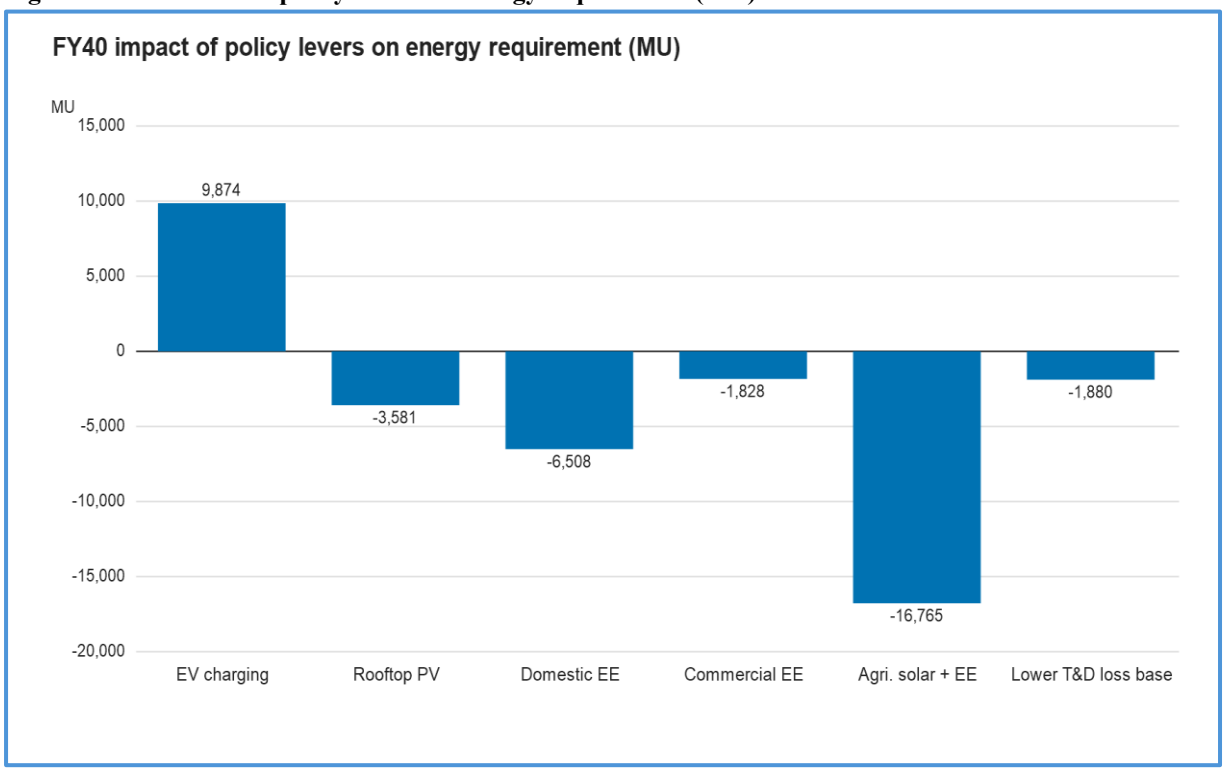
(IJPS) 2026, Vol. No. 21, Jan-Jun e-ISSN: 2455-6270 p-ISSN: 2455-7455

Table 4. Demand projections (energy requirement incl. losses, MU; peak, MW)

Year	BAU	Policy case	Peak (MW)	Load factor (%)
FY22 (actual)	62,334	62,334	11,883	59.9
FY23	77,881	74,637	12,159	70.1
FY29	110,888	101,494	16,534	70.1
FY34	144,844	129,023	21,019	70.1
FY40	194,847	174,158	28,372	70.1

Source: CSTEP (2023), Tables 13, 24-26, Section 3.1. FY22 load factor and all load factors computed by the author. The FY23 step (+24.9% BAU, +19.7% policy) against a 2.3% peak rise is not explained in the source.

Figure 5. FY40 effect of policy levers on energy requirement (MU)

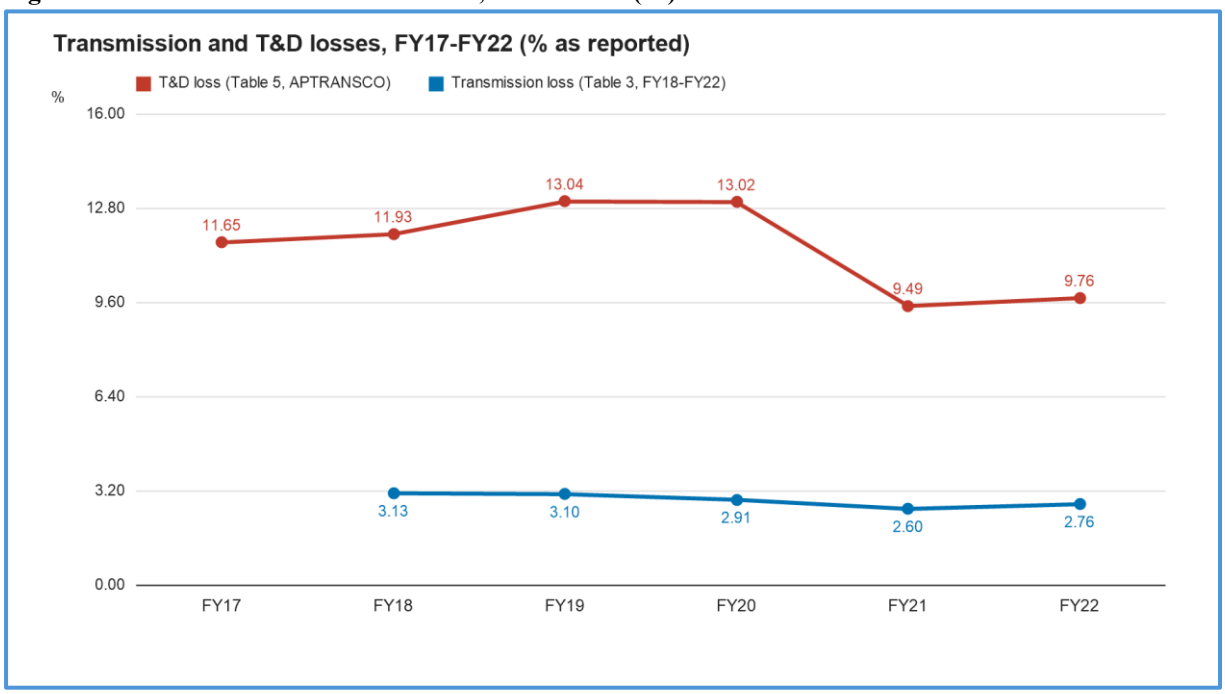


Source: CSTEP (2023), Tables 13, 18-24; loss effect computed by the author.

3.4 Transmission and distribution losses

Reported T&D losses fell from 11.65% (FY17) to 9.76% (FY22), but rose to 13.04% in FY19 and fell 3.5 points in FY21. Transmission loss fell from 3.13% (FY18) to 2.76% (FY22), so about 7 of the 9.76 points are in distribution. CSTEP's text gives FY21 T&D loss as 13.23%, against 9.49% in its table, and its projection (12.9% of sales in FY23 to 10.0% in FY40) is stated on sales, equal to 11.4% and 9.1% of input.

Figure 6. Transmission loss and T&D loss, FY17-FY22 (%)



Source: CSTEP (2023), Tables 3 and 5 (APTRANSCO). FY17 transmission loss not reported.

3.5 Finances and tariffs

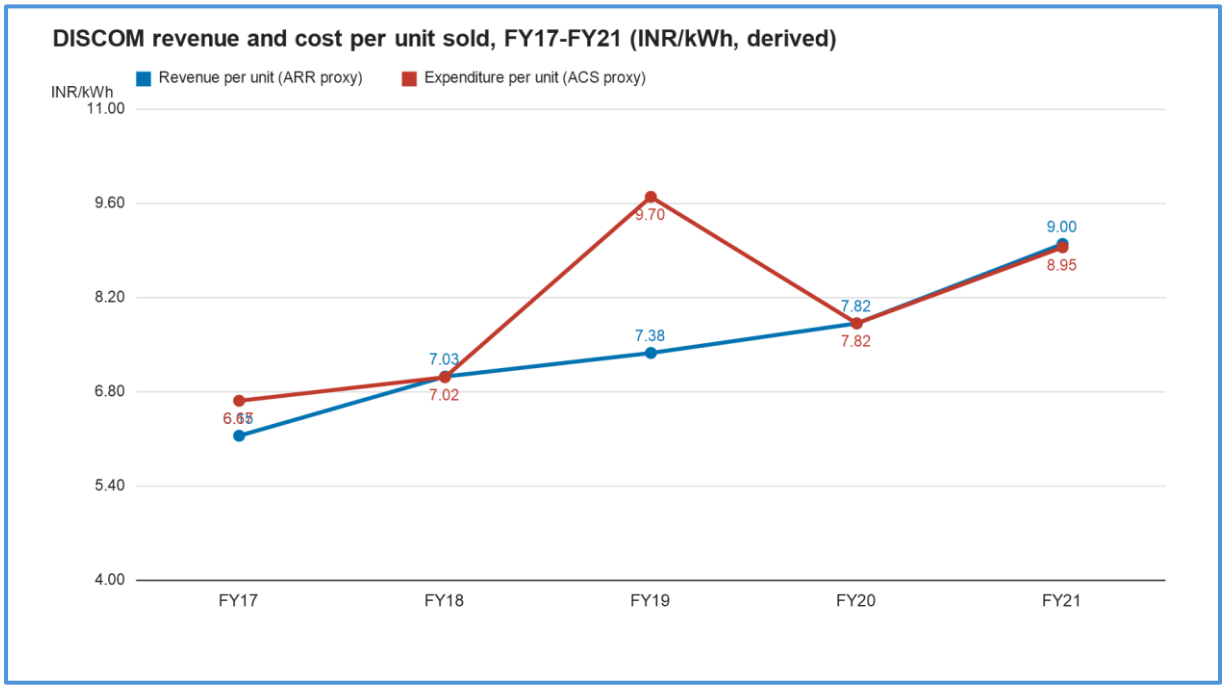
Revenue receipts rose from INR 26,749 crore to INR 47,642 crore over FY17-FY21 (15.5% a year) against sales growth of 5.0%; revenue per unit sold rose from INR 6.15 to INR 9.00 (Table 5, Figure 7). FY19's INR 11,864 crore deficit (about 1% of FY22 GSDP) equals INR 2.32/kWh, which matches the report. The FY21 surplus of INR 261 crore is INR 0.05/kWh; an INR 0.10/kWh cost rise would cost INR 529 crore, twice that surplus. Costs by source are INR 4.48/kWh (thermal), 3.38 (nuclear), 1.67-1.78 (hydro), and 4.28 (solar) and 4.63 (wind) until FY29, after which CSTEP prices new solar and wind at INR 2.49. Average power purchase cost then falls from INR 4.14 to INR 3.01-3.13/kWh by FY40 (24-27%). Storage of 6.4-8.3 GW is needed, including the 1,350 MW Upper Sileru pumped storage project.

Table 5. DISCOM revenue and expenditure, FY17-FY21

Item	FY17	FY18	FY19	FY20	FY21
Revenue receipts (INR crore)	26,749	32,798	37,806	42,938	47,642
Revenue expenditure (INR crore)	28,987	32,765	49,669	42,975	47,381
Net surplus / deficit (INR crore)	**-2,238**	**33**	**-11,864**	**-36**	**261**
Revenue per unit sold (INR/kWh)	6.15	7.03	7.38	7.82	9.00
Expenditure per unit sold (INR/kWh)	6.67	7.02	9.70	7.82	8.95

Source: CSTEP (2023), Tables 4 and 6; per-unit rows by the author.

Figure 7. DISCOM revenue and expenditure per unit sold, FY17-FY21 (INR/kWh)



Source: CSTEP (2023), Tables 4 and 6; derived by the author as INR crore x 10 / MU.

4. Findings

1. Capacity (23,953 MW) is twice the peak, and thermal still holds 58% of it; renewables grew 6.6% a year, solar-led, and had used under a tenth of the cited potential.
2. The 120 GW export target exceeds the cited solar and wind potential (82.7 GW) by 45%; its fiscal terms are modest (about INR 0.13/kWh per project).
3. Demand growth is domestic-led (9.2% a year); industrial sales were flat and 19.3% lower in FY21 than FY19.
4. The planning baseline has an unreconciled 20-25% step between FY22 actual and FY23 projected requirement.
5. Policy levers could cut FY40 requirement by 10.6%, and agriculture supplies 81% of that, yet its pump-set data are inconsistent.
6. The 47-55% renewable share by FY40 depends on thermal PLF and an 85% hydro CUF, and modelled supply exceeds demand by 18-29%.
7. Losses fell to 9.76% but are defined inconsistently; DISCOM accounts turned from deficit to a thin surplus (INR 0.05/kWh).

5. Policy implications

- **Re-base targets and baselines.** Publish the resource assessment behind the 120 GW and 5 lakh acre targets, confirm whether the 2020 policy has been extended, and rebuild the FY23-FY40 forecast from audited actuals so that the efficiency policy and the roadmap share one baseline.
- **Manage the thermal transition.** Publish plant-wise PLFs, review the 1,947 MW of units costing above INR 5/kWh for renegotiation, bundling or retirement, and state whether surplus energy is for export, storage or back-down.
- **Procure storage and nuclear.** Pursue Upper Sileru and 4.8-6.2 GW more pumped storage (potential 33.2 GW) with batteries for the balance, and the state's 3,624 MW share of Kovvada nuclear.
- **Prioritise agriculture and losses.** Solarise pumps with a published buy-back rate, mandate 5-star pumps on new connections, reconcile the pump-set census, and adopt one loss definition (percentage of input, by feeder) with an updated target.
- **Protect DISCOM margins.** With a surplus of INR 0.05/kWh, publish contract-level tariffs (the INR 4.63/kWh average wind cost against INR 3.10 and 2.49 benchmarks), use INR 2.49/kWh as the reference for new procurement, and tie subsidy and APERC tariff data into planning.

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6. Conclusion

AP has moved from shortage to surplus capacity, begun shifting to solar, and turned DISCOM revenue from a large deficit to a small surplus. The next challenge is integrating variable renewables and storage, managing a thermal fleet costlier than new renewables, holding losses and finances steady, and capturing agricultural efficiency. The planning numbers are less firm than their precision suggests: the FY23 projection departs from FY22 actuals, modelled supply is potential rather than dispatch, and utilisation assumptions drive the renewable share. The headline results (47-55% renewables, 24-27% lower power cost, 10.6% lower demand) are scenario outcomes under stated assumptions, not forecasts.

7. Limitations and data issues

The study rests on four documents and no datasets; nothing after FY22 (FY21 for sales and finances) is analysed, and most numbers rest on one modelling report whose inputs were not available. The policy orders give terms, not outcomes, and the 2008 order refers to undivided AP. Items needing verification before use:

- **Baseline:** FY23 requirement is 24.9% (BAU) above FY22 recorded, with peak +2.3% and load factor 59.9% to 70.1%.
- **Modelled supply:** FY22 supply (136,722 MU) is capacity-based at 85% thermal availability, large hydro is at 85% CUF, and FY40 supply exceeds demand in all scenarios.
- **Losses:** FY21 T&D loss is 9.49% (table) or 13.23% (text); the projection uses a sales base.
- **Printed errors:** consumers' '14% CAGR' and load '50% CAGR' are total changes (true 2.7% and 8.5%); efficient pumps are 6.3%, not 2.6%, of 3,352,450; Table 29 capacity falls 3,672 MW from FY22 to FY24 unexplained; nuclear additions are 3,624 MW in one place and 3,264 MW in another.
- **Costs and policy texts:** hydro cost is INR 1.78 or 1.67/kWh; one storage entry (9,703 MU) conflicts with Table 34 (2,867 MU); the efficiency policy's sector shares conflict internally (agriculture 24.2% or 30%).

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