Retiring to Save

Retiring old coal units as part of a planned energy transition can save Andhra Pradesh over ₹76,000 CR in the coming decade

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Retiring to Save: *Retiring old coal units as part of a planned energy transition can save Andhra Pradesh over ₹76,000 CR in the coming decade*

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About

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1.0 List of abbreviations

AP	Andhra Pradesh
APCPDCL	Andhra Pradesh Central Power Distribution Company Limited
APEPDCL	Andhra Pradesh Eastern Power Distribution Company Limited
APERC	AP Energy Regulatory Commission
APGENCO	Andhra Pradesh Power Generation Corporation
APSLDC	Andhra Pradesh State Load Dispatch Centre
ARR	Aggregate Revenue Requirement
BCD	Basic Customs Duty
BESS	Battery Energy Storage System
CAGR	Compound Annual Growth Rate
CEA	Central Electricity Authority
CGS	Central Generating Stations
CPCB	Central Pollution Control Board
CR	Crore
CRH	Climate Risk Horizons
DSTPS	Damodaram Sanjeevaiah Thermal Power Station
EPS	Electric Power Survey
ERC	Expected Revenue from Charges
FGD	Flue Gas Desulfurisation
FPV	Floating Solar Photovoltaic
FY	Financial Year
GUVNL	Gujarat Urja Vikas Nigam Limited
GW	Gigawatt
IRENA	International Renewable Energy Agency
KW	Kilowatt

kWh	Kilowatt Hour
LCOE	Levelised Cost of Electricity
LPS	Late Payment Surcharge
MU	Million Units
MW	Megawatt
NTPC	National Thermal Power Corporation
NTTPS	Narla Tata Rao Thermal Power Plant
ODC	Obuladevucheruvu
PLF	Plant Load Factor
PPA	Power Purchase Agreement
PSH	Pumped Storage Hydropower
PV	Photovoltaic (solar)
RE	Renewable Energy
RTPS	Rayalaseema Thermal Power Station
SECI	Solar Energy Corporation of India
TPP	Thermal Power Plant
UMREPP	Ultra Mega Renewable Energy Power Plants

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3.0 Executive summary

Andhra Pradesh distribution companies have cumulative losses of nearly ₹30,000 CR. As of May 2022, the total outstanding had crossed ₹17,000 CR and the state had opted for the Late Payment Surcharge (LPS) scheme to be able to pay these dues off. Lowering power procurements costs is a priority for the state, not just to restore financial health to DISCOMs but also to retain and attract industry by offering affordable power. With its plentiful renewable resources and proactive energy policies, Andhra Pradesh is already playing a leading role in India's energy transition away from fossil fuels and towards cleaner, renewable sources of energy. This analysis shows that the state can go a step further to lower electricity costs and attract investment by retiring old coal units without sacrificing system reliability or incurring cost increases.

An energy transition can help lower power purchase costs at the system level, and prove beneficial for AP DISCOMs, consumers and the state's manufacturing economy

In recent years, different central government authorities such as the Central Electricity Authority and the Finance Minister have opined on the need to shut down old coal plants (over 25 years of age). Most of these old plants are owned and operated by state governments, who have been reluctant to start serious discussions on coal retirement as these plants are generating significant quantities of power, however inefficient or polluting they may be. This analysis shows that careful planning and investments will allow for these retirements at a net reduction in power purchase costs, resulting in long term financial benefits for DISCOMs and the state government.

A convergence of factors today allows for win-win solutions that can deliver desirable outcomes on several fronts: reducing the cost of power purchase (resulting in a reduced subsidy burden on the state government), improving the financial situation of Andhra Pradesh's DISCOMs, reducing air pollution and setting up the state to become an international leader in the energy transition. These opportunities arise due to the convergence of three factors:

1. **Surplus coal power capacity:** AP has significant coal capacity under construction and expected to be commissioned in the near future, in addition to a large existing coal fleet within the state operating at sub-optimal utilisation factors.

2. **Extremely cheap renewables coupled with the declining costs of battery storage systems.** Andhra Pradesh's high solar potential and the rapid decline in the price of renewables and battery storage systems mean that an energy transition can help lower power purchase costs at the system level, and prove beneficial for AP DISCOMs, consumers and the state's manufacturing economy.

3. **The impending deadline (2025) by which all coal plants have to be retrofitted to meet air pollution standards, or incur financial penalties if they are to keep operating.**

Thanks to these factors, Andhra Pradesh is in a position to phase out its older coal plants over the next two years, and replace scheduled dispatch from these plants with power from new renewable energy or from higher utilisation of younger, more efficient coal assets, either state-owned or private. This will result in a net saving to the state.

These savings accrue on account of replacing higher cost power from older plants with cheaper options, as well as avoiding costs from retrofits that are needed to ensure compliance with air pollution laws if the plants are to continue operating beyond 2024/2025. In the absence of retrofits, these plants are liable for financial penalties.

In the longer term, over the coming decade, the state can also examine the potential financial benefits of continuing to phase down its use of expensive coal power and gradually replace it with cheaper, cleaner options. This analysis also enumerates the potential savings from such a longer term project to phase out the most expensive coal power plants, irrespective of age.

Key findings

1

Andhra Pradesh could save approximately ₹9,500 CR over 5 years by retiring 8 old coal units totalling 1,680 MW and replacing their scheduled dispatch with new, cheaper renewable energy.

These 8 old coal units (210 MW each, 2 at the Rayalseema Thermal Power Station, Cuddapah and 6 at the Dr. Narla Tata Rao Thermal Power Station, Vijaywada) either need to be retrofitted with pollution control equipment by 2024 or shut down by 2025 to comply with the Ministry of Environment Forest and Climate Change's notification.[1] However, only two of those units can feasibly be retrofitted per the Central Electricity Authority, at an estimated cost of approximately ₹190 CR. Failure to retrofit or shut down these units will mean paying financial penalties, which though relatively small, would still amount to over ₹140 CR per year.

2

Due to fresh capacity addition in the pipeline (both renewables and thermal) retiring the oldest coal units will not impact ability to meet electricity demand. AP's ambitious renewable energy programme will enable the state to meet even aggressive projections for electricity demand growth from clean energy alone.

3

A longer term project to phase out the most expensive coal power plants (irrespective of age) and replace them with renewable energy can yield significant savings. This analysis provides an indicative roadmap. If scheduled generation from all plants with tariffs at ₹4/kWh or higher were to be gradually replaced with power from renewables at an average of ₹2.7/kWh, there would be a potential savings of over ₹57,000 CR over ten years (based on current power tariffs) in terms of reduced power purchase costs. Tapping into these potential savings should be part of longer term planning, through a gradual phase out of expensive coal purchases.

4

The state is evaluating 33 GW of new Pumped Storage Hydropower (PSH) projects. Such a massive build out of pumped storage could be financially risky. PSH should have a supporting role to play as it is not competitive with co-located renewable energy+battery storage, has a longer gestation period, a greater land footprint and lower overall energy efficiency.

Table 1 | Coal plants in Andhra Pradesh 20 years or older that can be phased out with potential savings, based on FY 2022 tariff and dispatch

Unit	Capacity (MW)	Age	Tariff (₹/kWh)	Savings from replacement with RE (p.a.)	Savings from avoided retrofit (₹/CR, one time)
RTPS Units 1 & 2	420	26–27	5.04	₹525 CR	₹189 CR
NTTPS Units 1–6	1260	26–42	4.24	₹1188 CR	NA*
Total	**1680**			**₹1712.76 CR**	**₹189 CR**

*retrofitting for FGD not feasible per CEA

Table 2 | Summary of potential savings for AP DISCOMs and state government

Avoided retrofits by retiring RTPS Stage 1 & NTTPS	₹189 CR (one time)
Avoided penalties due to emission non-compliance	₹737 CR (5 years) ₹1,620 CR (10 years)
Replacing lost coal generation with RE @ ₹2.7/kWh	₹1,713 CR (1 year) ₹8,564 CR (5 years) ₹17,128 CR (10 years)
Phase out of coal power purchases with tariff above ₹4/kWh and replacement with new RE	₹5,713 CR (1 year) ₹28,564 CR (5 years) ₹57,128 CR (10 years)
Total savings (10 years)	**₹76,064 CR**

Implications for Andhra Pradesh's budget and deficits

This planned transition can save the state tens of thousands of crores. Cumulatively, a 10 year plan to phase out the oldest and most expensive coal power generators can save the state over ₹6,000 CR in Year 1, ₹30,000 CR over the first five years, and approximately ₹76,000 CR over 10 years.

This comes at a time when COVID-19 has caused an unprecedented financial crisis for the state and revenue and fiscal deficits have been far in excess of targets.[2]

These savings can help cover:

1. The ₹32,196 CR budget required to meet the state's target of 10 GW solar PV to provide free electricity for agriculture.[3]

2. The ₹37,352 CR subsidy required for 1.9 crore roof-top solar installations (40% subsidy for 1kW roof-top installations, amounting to ₹18,800/kW).[4]

3. ₹2,340 CR required for the YSR Jala Kala scheme to disburse 2 lakh free water pumps to farmers.[5]

4. ₹5,500 CR required under "YSR Rythu Bharosa" Scheme to provide ₹13,500 p.a. to farming households.[6]

Recommendations

1. Phase out of RTPS (Rayalaseema Thermal Power Station) and NTTPS (Dr. Narla Tata Rao Thermal Power Station) power plants at the earliest and replace scheduled generation with new renewable power purchases. Explore the possibility of repurposing these sites to host RE+battery storage+Synchronous Condensers.

2. Gradually phase out coal PPAs that have total per unit cost higher than ₹4 and replace scheduled dispatch with new renewable energy.

3. Accelerate the deployment of solar, wind and battery storage, including rooftop and distributed clean energy options, utilising competitive bidding, guaranteed offtake and payment security mechanisms to secure the cheapest possible tariffs.

4. Reevaluate the economic necessity and financial viability of the plan to develop 33 GW capacity of PSH in light of cheaper options available.

4.0 Background

Financial health—AP DISCOMs

Andhra Pradesh has three distribution companies, AP Eastern Power Distribution Company Limited (APEPDCL), AP Southern Power Distribution Company Limited (APSPDCL) and AP Central Power Distribution Company Limited (APCPDCL).

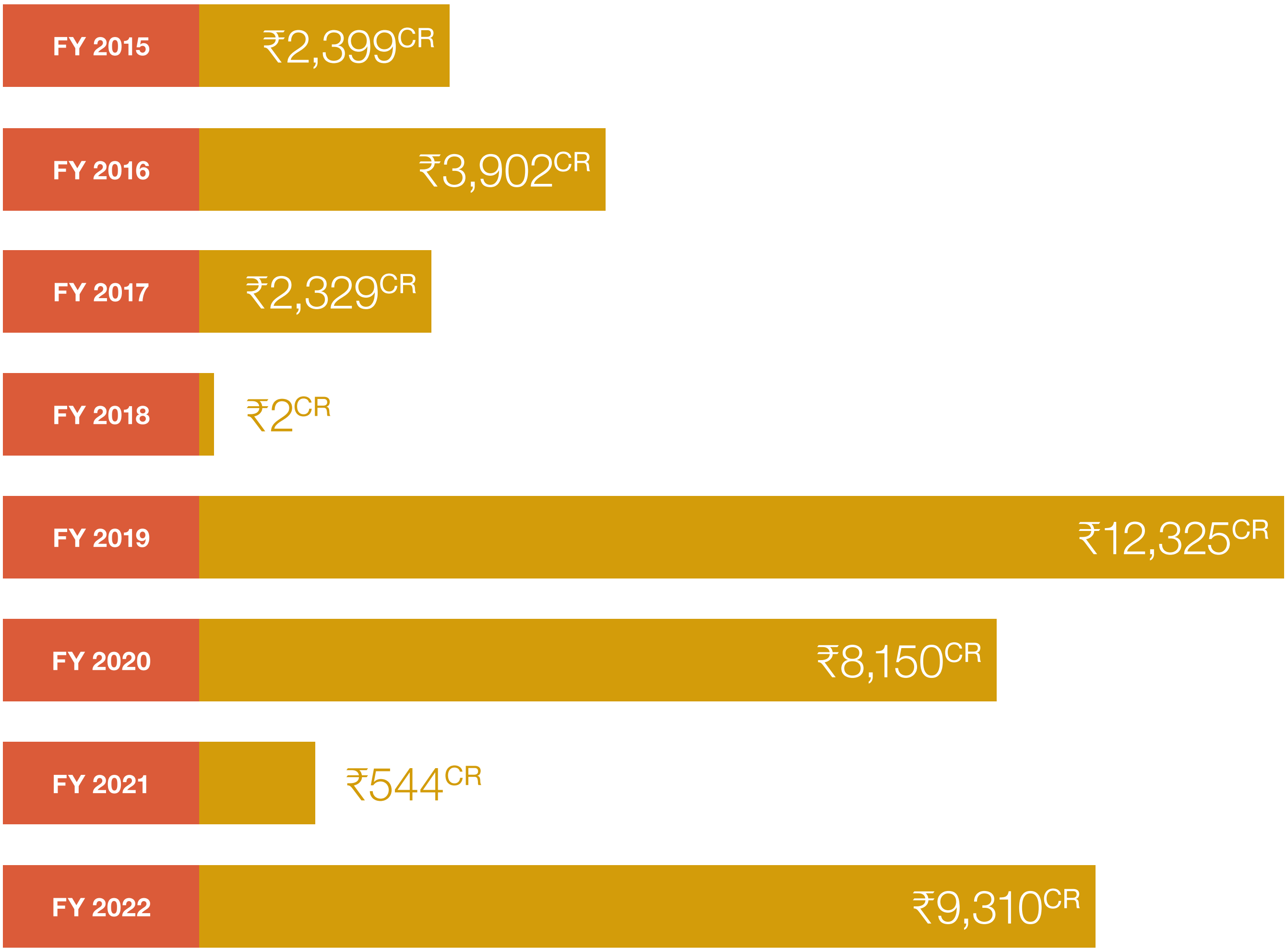
In FY 2021, AP DISCOMs' cumulative losses were ₹28,599 CR. The previous year, FY 2019–20, cumulative losses were as high as ₹29,143 CR[7] or 81% of that year's annual revenue requirement. The reduction in cumulative losses, though a positive thing, might be a result of the ₹1.2 trillion liquidity infusion scheme (issued in 2020). AP has been sanctioned a total of ₹6,600 CR[8] under this scheme. In March 2022, AP DISCOMs' overdue amount crossed ₹8,840[9] CR of which over 85% of the dues are to be paid to renewable energy providers. By May 2022, the total outstanding had crossed ₹17,000 CR and AP had opted for the LPS scheme to be able to pay these dues.[10] The DISCOMs depended on subsidies for 25% of its Annual Revenue Requirement (ARR). This situation can be attributed to a combination of irregular and partial subsidy disbursement, delay in true up charges, insufficient tariff hikes and increasing power purchase costs.[11]

According to media reports, the gap between the average cost of supply and average revenue raised is ₹1.67/kWh, resulting in a ₹10,345 CR revenue gap for 2020–21.[12]

Expensive wind (₹4.63/kWh) and solar (₹5.90/kWh) PPAs signed by the AP government before April 2017 have also affected DISCOMs' revenues negatively. Following litigation, an interim order of the Andhra Pradesh High Court in 2019 fixed a competitive tariff of ₹2.44/kWh for wind and ₹2.43/kWh for solar energy.[13] However, DISCOMs appear to be using the original PPA tariff while calculating dues, increasing their costs.[14]

The poor performance of the DISCOMs becomes even more evident when one takes a look at the Annual Integrated Rating and Ranking by PFC.[15] While APCPDCL (a newly established DISCOM in AP) is excluded from the annual rankings, the other two DISCOMs, APSPDCL and APEPDCL have ranked 51 and 50 respectively (out of 52 DISCOMs considered). All three DISCOMs have a deficit compared to their respective ARR.

Figure 1 | AP DISCOM losses



Source: Prayas Energy Group[16]

Clearly, lowering the average cost of power procurement is essential for AP DISCOMs and the state government. Retiring the state's older coal plants and replacing their scheduled generation with cheaper renewable energy is one way to lower average generation costs.

This has been made possible, and financially remunerative, by three converging factors:

i. a surplus of "firm" generating capacity in the state and on the national grid;

ii. the falling cost of renewable energy and declining costs of battery storage, and

iii. the legal mandate for all power plants to install pollution control technology by December 2024 or pay financial penalties.

The average daily demand in April 2022 was expected to be around 222.8 MU, compared to an average daily demand of 200 MU in February 2022.[17] The average daily demand is expected to reach 240 MU by March

2023. The rolling black outs that the state faced on and after April 9, 2022, was a result of a sudden increase in the daily demand, as well as a shortage of coal supply. The state was able to meet a demand of 180 MU, leaving a deficit of around 40 MU to be met from the open market and power exchange.[18] The state was able to purchase around 20 MU on the open market. However, with high demand for power from the open market, the prices increased to ₹12/kWh. This would amount to around ₹54 CR per day, or ₹1,620 CR over a month. In contrast, developing a 5 GW, 4 hour storage colocated with 5GW RE would provide 20 MU backup power to the state at an estimated cost of ₹4.97/kWh, based on cost estimates for battery storage in Tamil Nadu.[19]

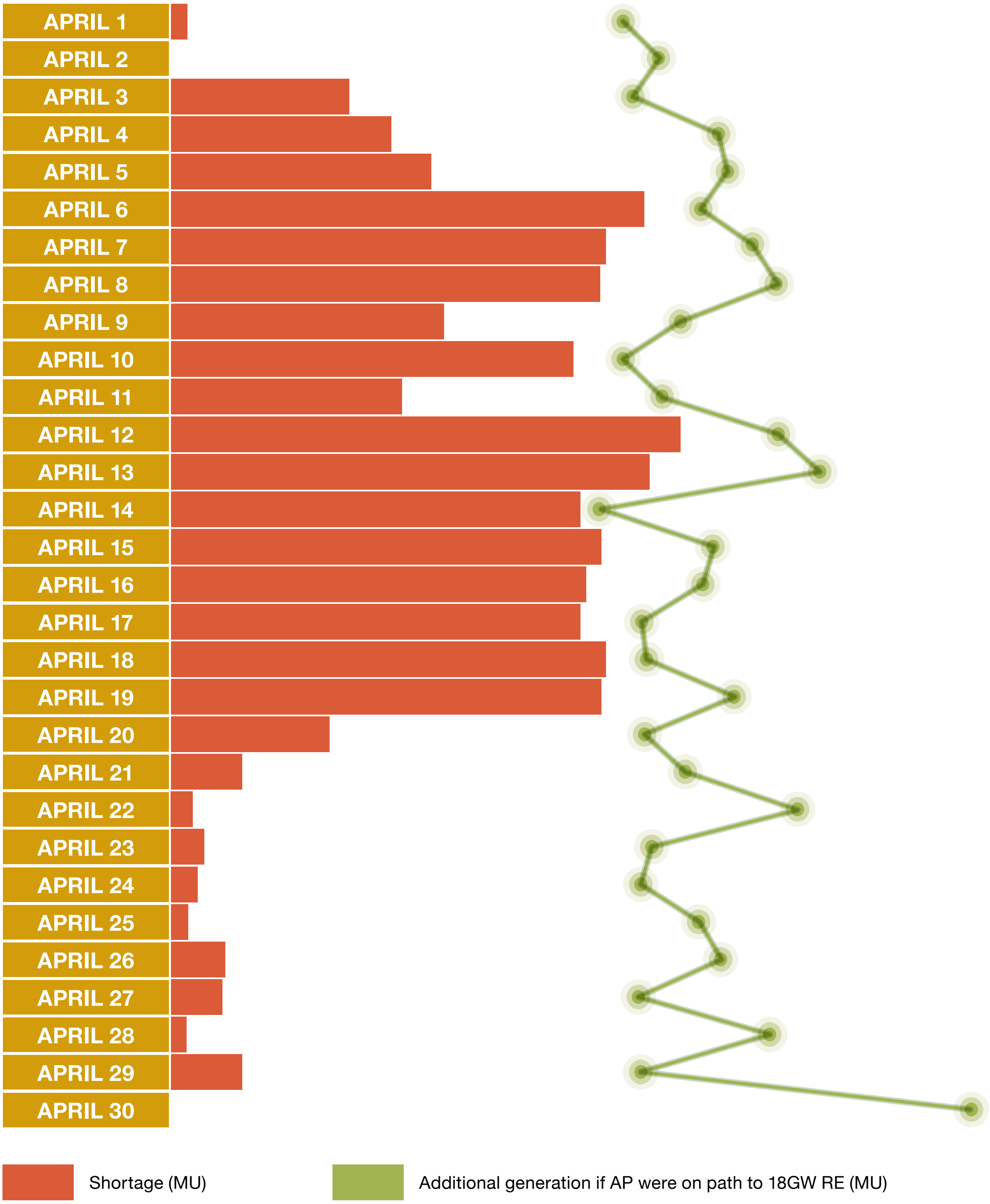
Renewable energy targets

In April 2022, Andhra Pradesh was hit with a power crisis. This crisis could have been substantially averted had the state been on track to achieve its renewable energy targets. As of April 2022, AP had achieved less than 50% of its 2022 RE targets, and had only installed 36 MW of RE capacity between November 2021–April 2022.[20] AP had a target to install 18 GW of RE by the end of 2022. However, as of December 2022,[21] AP had a total RE capacity of about 11 GW, achieving about 60% of 2022's RE capacity targets.

AP's power crisis in April 2022 could have been substantially averted, if the state had met its RE targets

If AP were on track to achieve this target, the state would have had an extra RE capacity of 7.5 GW by April 2022, constituting 2.9 GW of Solar and 4.6 GW Wind. Based on generation during April 2022, and the CUFs for solar and wind in that period, it is estimated that AP could have generated anywhere between 18 MU/day to 44 MU/day in additional electricity if it had been on path to achieve its 2022 RE targets. DISCOMs could have used RE generation during the day to conserve coal supplies to meet evening demand. Further, if AP were to meet its targets by installing 9 GW additional RE along with co-located 5 GW/ 4 hour storage, the additional production of around 20 MU can be utilised at any point of the day.[22]

Figure 2 | Power shortage (April 2022) vs. additional generation if RE targets were met

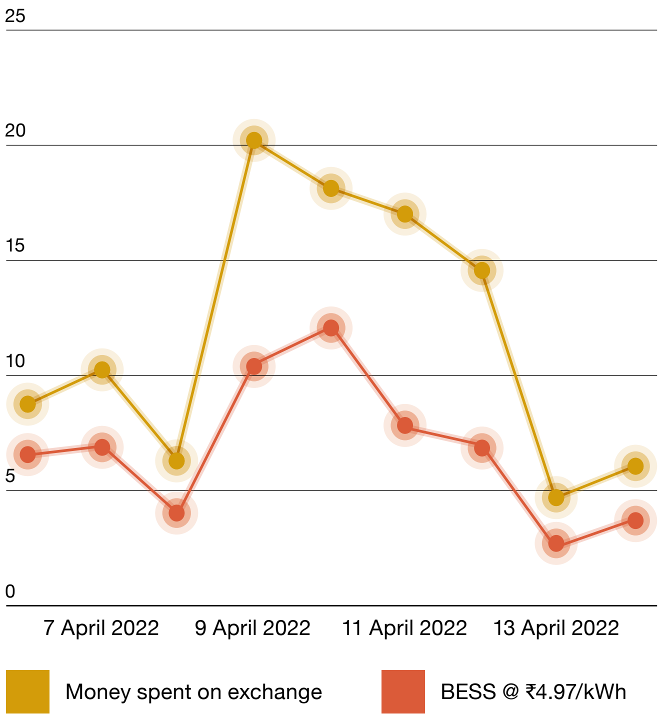


Given long standing issues with coal supply infrastructure and the likelihood of similar supply issues recurring, AP should expedite its RE+storage development, to ensure it can play a vital role in stabilising the grid as well as providing back-up energy during unplanned outages.

Battery storage as a price buffer

Estimates for the LCOE of battery storage in nearby Tamil Nadu are as low as ₹4.97/kWh. Other estimates put the LCOE even lower in coming years, at less than ₹4/kWh. In March 2022 alone, the state bought a total of 1,551 MU from the open market for a total cost of ₹1,258 CR[23] at an average cost of ₹8.11/kWh. By the end of March 2022, unit cost in the open market went up significantly, reaching ₹18.67/kWh on April 25. Meeting this requirement from storage even at ₹4.97/kWh would have saved around ₹487 CR.

Figure 3 | Cost of power from exchange vs BESS (₹ CR)



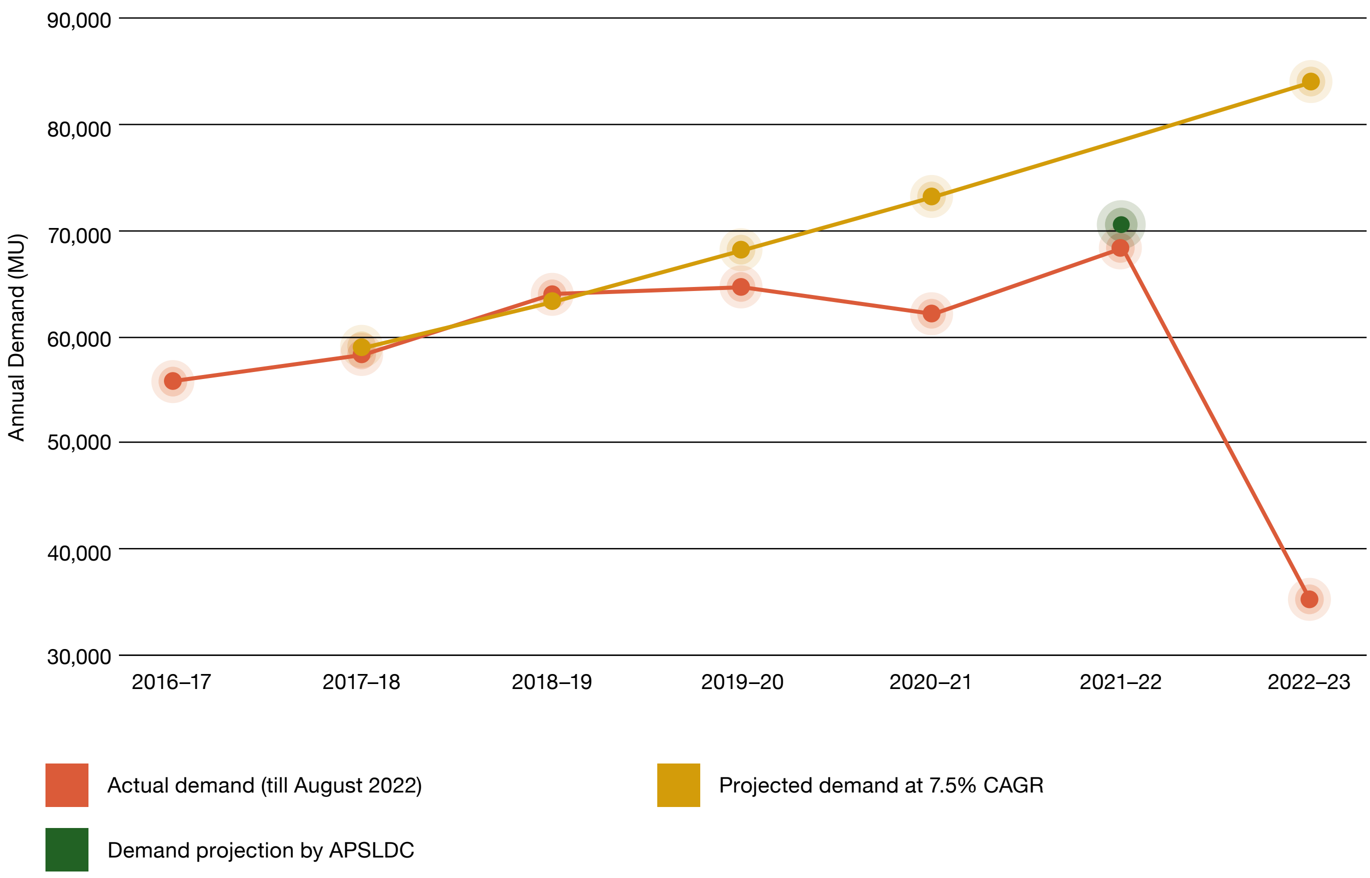
Surplus generation capacity

Between FY 17 and FY 20, power demand in AP grew at a CAGR of 5.96%, before the pandemic-related decline. As with most states however, demand was lower than projected. In FY 2019–20, actual power demand was 64,542 MU compared to the projected demand of 68,034 MU,[24] a deviation of 5.4%. Due to the pandemic, in FY 2021, actual demand (62,134 MU) lagged behind projections by 17.63%.

The State Electricity Plan has predicted 7.5% CAGR of demand from FY 20 to FY 24. On this trajectory, power demand for FY 2021–22 would have been around 78,540 MU; however APSLDC's projected demand for FY 2021–22 was 70,663 MU,[25] and the actual demand was even lower at 68,295 MU.

There was already a significant deviation between projected and actual demand pre-pandemic—this gap has been further accentuated.

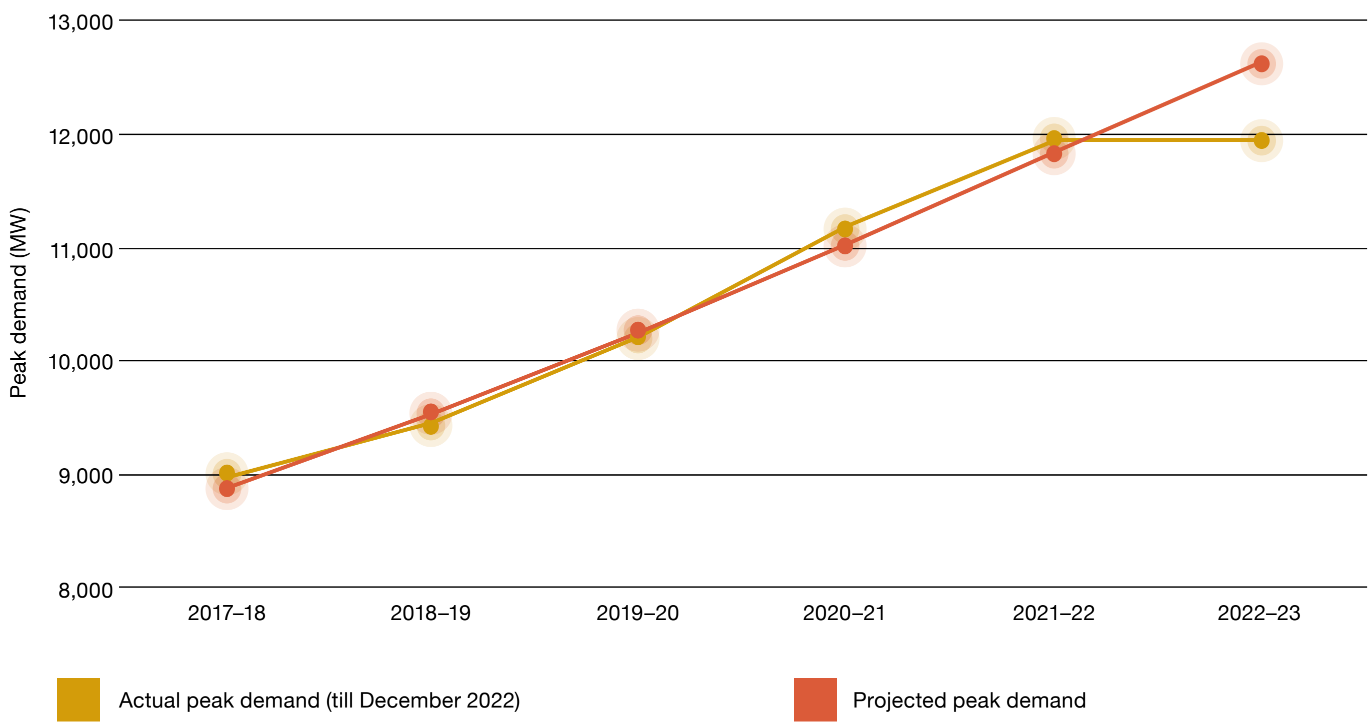
Figure 4 | Actual vs. projected electricity demand in Andhra Pradesh



Source: Projections Andhra Pradesh State Electricity Plan FY 2020–24[26] and actual demand[26]

Peak demand has been steadily increasing with a CAGR of 6.74% since FY 2017–2018 and this is in line with projections made by AP Energy Regulatory Commission (APERC). In FY 2021–22 peak demand reached 11,950 MW, overshooting the projected peak demand of 11,843 MW by 1%. So far, in FY 2022–23, the peak demand reached as high as 11,947 MW.

Figure 5 | Actual vs. projected peak electricity demand



Source: State Electricity Plan 2018–2024[27] and actual peak data[28]

Operating coal capacity

AP has a total installed capacity of 27.3 GW of which 18.1 GW is conventional power capacity. 11.6 GW of the conventional capacity is coal power.[29] Andhra Pradesh has seen a significant rise in installed capacity over the last decade, so much so that the total installed capacity is now surplus to actual requirements. Due in part to the mismatch between actual demand and projected demand, average PLF of the coal powered TPPs in AP has been declining over the years.[30] Since FY 2018–19, overall PLFs have been 56% or lower.

Table 3 | Plant Load Factors of Andhra Pradesh coal fleet[31]

Sector	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
State	70.33	58.41	55.78	55.9	40.86	54.90
Private	55.78	56.69	47.83	53.86	48.69	44.03
Central	80.9	67.2	71.06	60.62	49.54	66.04
Average	**67.44**	**59.29**	**55.28**	**55.91**	**45.45**	**52.52**

Source: CEA monthly generation reports

Coal power expansion

Despite the average PLFs of the state's coal fleet being below 55% since FY 2019, Andhra Pradesh has further coal capacity additions underway. The state currently has two thermal power plants under construction which will be commissioned soon[32]: NTTPS Stage V Unit 8 and Damodaram Sanjeevaiah TPS Stage II Unit 1 with 800 MW capacity each, will add a total of 1600 MW to the state's existing coal capacity. These units were scheduled to be commissioned in 2020, but have been delayed due to several reasons. As per the latest broad status report (November 2022) by CEA,[33] both these TPP units are under construction with DSTPS at 98% completion and NTTPS at 96% completion. DSTPS's new unit entered into a PPA with the AP DISCOMs to sell 90% of the declared capacity. NTTPS's new unit had a PPA with the DISCOMs of the erstwhile undivided AP; as of December 2021, this PPA is still being revised. Once these units are operational, average fleet PLFs can be expected to decline further, if the older coal units are not retired.

Due in part to these new TPPs, the cost of power purchase is also expected to rise by as much as ₹1.12/kWh in comparison to FY 2016–17. The Tariff Order for FY 2020–21 estimated the variable cost alone for these new units to be around ₹3.14/kWh,[34] which would imply a total per unit tariff of well over ₹5/kWh. Other projects that were commissioned in recent years are operating at well above ₹5/kWh; for example, RTPS Stage IV Unit 6, commissioned in 2018, has an approved tariff of ₹5.77/kWh for FY 2021–22.

All state owned TPPs in AP are load centred, situated away from coal mines. The variable cost alone for these plants is well above ₹3/kWh based on the FY 2021-22 tariff order, which is itself higher than the tariff for new renewable energy.

Table 4 | Variable costs of operating state-owned TPPs[35]

TPP	Variable cost (₹/kWh)
NTTPS Stage I, II & III	3.34
NTTPS Stage IV	3.15
RTPS Stage I, II & III	3.86
RTPS Stage IV	3.66
AP Genco Thermal (weighted average)	3.15

Falling cost of new renewable energy

New renewable energy (solar PV or wind) is now reliably available at less than ₹3/kWh, with a record low tariff of ₹1.99/kWh set in December 2020.[36] In March 2021, the winning bids for Gujarat Urja Vikas Nigam Limited's (GUVNL) auction to purchase 500 MW were ₹2.20 and ₹2.21/kWh. These bids were after the announcement of Basic Customs Duty (BCD) of 15% and 25% respectively for solar cells and modules, which will be effective from April 2022, but there is uncertainty as to whether the BCD was incorporated into the bids, with some reports suggesting a tariff that incorporates the impact of the BCD would be closer to ₹2.50/kWh.[37]

Variable cost for all state-owned coal plants are well above ₹3/kWh, which is higher than total tariff of new renewable energy

As per IRENA,[38] LCOE of solar PV is estimated to be at ₹2.44/kWh, whereas onshore wind is estimated at ₹2.37/kWh. However, this analysis assumes a more conservative tariff of ₹2.7/kWh. At this level, renewable energy is cheaper than a large segment of existing coal power generation and less than 50% of the cost of new coal power.

Less recent bids for round the clock renewable energy (with storage) saw a combined tariff of ₹3.6[39]—below a significant proportion of existing coal generation. The Lawrence Berkeley National Laboratory had estimated that solar PV with Li-ion battery storage can deliver electricity at a tariff of ₹3.94 in 2020, dropping to ₹3.32 by 2025 and ₹2.83 by 2030.[40] Even if predicted cost declines do not materialise, existing costs already question the competitiveness and financial viability of any new coal project.

Andhra Pradesh has an ambitious renewable energy plan. The Andhra Pradesh Renewable Energy Export Policy[41] announced in 2020 is formulated to attract investors to develop and run utility scale solar, wind and solar-wind hybrid projects. Under the policy, the producers of renewable energy can export power without any obligation to sell it to DISCOMs. The current shelf of projects include 7 solar/solar-wind hybrid UMREPPs (Ultra Mega Renewable Energy Power Plants) with a total capacity of 17,800 MW.[42] These UMREPPs are expected to be commissioned by 2025.

Table 5 | Proposed UMREPPs[43]

Project Site	Capacity (MW)
Kadiri	4000
Obuladevucheruvu(ODC)	2400
Ralla Anantapur	2400
Badvel	1400
Kalasapadu	2000
OWK	2400
Kolimigundla	3200

In addition to the UMREPPs, the state also has a 10 GW goal for agricultural solar, expressly to provide power to the agricultural sector. This capacity addition is divided into two phases. Phase I includes 6.4 GW capacity addition, for which bids have been invited. The winning bids went as low as ₹2.47/kWh, with a weighted average of ₹2.49/kWh.[44]

Table 6 | Proposed project agricultural solar sites

Project site	Capacity (MW)
Chakrayapet	600
Thondur	400
Kambaladinne	600
Pendlimarri	600
Rudrasamudram	600
CS Puram	600
Uruchintala	600
Kambadur	1200
Mudigubba	600
Kolimigundla	600

AP has very good wind potential, with 44.2 GW potential at 100 m. hub height, the 4th highest amongst Indian states. At 120m., AP has a wind potential of 74.9 GW.[45] The state saw rapid wind power capacity addition between 2016 and 2018. However, since 2019 there hasn't been any significant capacity addition. Of the envisioned 7.5 GW of wind capacity, AP has commissioned 4.1 GW as of April 2021.

Meeting these wind and solar targets, in combination with battery storage, will ensure that the state has sufficient electricity generation capacity to meet even optimistic growth in demand.

Since 2019, 7 out of 8 wind or wind/solar hybrid projects in India have winning-bids below ₹3.00/kWh and the weighted average of all the winning bids for these 8 projects is around ₹2.82/kWh.[46]

Legal liability from failure to comply with air emission norms

The Ministry of Environment, Forests & Climate Change requires air emission controls on all power plants, progress on which has been slow, leading to public protest and monitoring by the courts. COVID-19 has underlined the co-morbidity impacts of air pollution across the Indian population. The public and political pressure to tackle air pollution is growing; all coal power plants will have to install pollution control technologies, or face growing litigation, loss of social licence and public pressure.

The Ministry of Environment, Forests & Climate Change on March 31, 2021 amended[47] the deadline by which all power plants need to be compliant with the 2015 air emission standards. The original date for compliance was 2017, then pushed back to December 2022 and now plants not slated to retire by 2025 will have up to December 2024 to meet emission limits. Plants that do not comply will face financial penalties. While these penalties are currently low, they are not insignificant, and could rise.

The Central Pollution Control Board (CPCB) has notified NTTPS to finish the installation of FGD retrofits by the end of 2020.[48] However, the retrofits have not been installed. Based on the latest categorisation of thermal power plants,[49] NTTPS falls in category 'A'. Given its non-compliance with the emission norms, it was either expected to retire by 31st December 2022 or pay environmental compensation. The compensation factor would add an extra cost of ₹0.125 for every unit dispatched in the first year past 2022, and would add ₹0.2 for every unit dispatched after the first year period.[50] Assuming that NTTPS dispatches energy similar to FY 2021–22 (i.e., 7712 MU per year), the total compensation would amount to about ₹96 CR in the first year and ₹154.24 CR every subsequent year.

CPCB has also sent a notification to DSTPS management in 2020, asking them to deposit a compensatory amount of ₹0.18 CR per month for every non-compliant unit.[51] The retrofit has not yet been installed, implying that a total of ₹9.36 CR could be due as compensation as of February 2022.

Moreover, as DSTPS falls in category 'C', it will be required to pay a total amount of ₹69.62 CR as a penalty for non-compliance in the first year period and an amount of ₹111.4 CR every subsequent year, assuming it dispatches same level of energy as in FY 2021–22 (i.e., 11,139.22 MU).

Table 7 | Payable penalties for non-compliance of air emission norms

Power plant	Category	FY 2021–22 dispatch (MU)	Penalty (₹ CR)	
			1st year	Subsequent years*
NTTPS	A	7,712.22	96.4	154.24
RTPS	C	2,244.22	1.4	22.4
DSTPS	C	11,139.22	69.62	111.4
Total penalty			**167.42**	**288.04 p.a.**

*Assuming same level of dispatch as FY 2021–22

Retrofitting the state owned TPPs, which include NTTPS Unit 7, RTPS Units 1–4, and DSTPS Units 1 and 2, would cost around ₹1,060 CR, based on the estimates provided by CEA.[52] Similarly, retrofitting the centre owned TPPs along with the private TPPs would cost an extra ₹2,208 CR.

Retrofitting all APGENCO plants with FGDs will cost an estimated ₹3,268 CR, with additional expenditure for low NOx burners. This refers to capex only and does not include running costs. Reducing this burden by retiring the older coal plants would be financially prudent for APGENCO.

5.0 Findings

01

₹9,500 CR = savings over 5 years from retiring 8 old coal units totalling 1,680 MW and replacing their scheduled dispatch with new, cheaper renewable energy.

AP has a total of 8 units, each of 210 MW, which are above 25 years of age. 6 of the 8 units belong to NTTPS (Vijayawada) and the rest belong to RTPS (Cuddapah). The units with their ages, utilisation factors and tariffs are shown in Table 6.

Table 8 | Details of old state-owned TPPs in Andhra Pradesh

Plant/unit	Age (years)	Utilisation factor*	Variable cost (₹/kWh)	Total tariff based on FY 22 scheduled generation (₹/kWh)
NTTPS Units 1 and 2	40+	67.8%	3.34	4.24
NTTPS Units 3–6	26+	67.8%	3.34	4.24
RTPS Units 1 and 2	26,27	41.6%	3.86	5.04

*Utilisation factor available only at plant level

According to the CEA, NTTPS Units 1–6 cannot be retrofitted with FGDs.[53] RTPS Units 1 and 2 need to be retrofitted with FGD technology. CEA estimates a cost of ₹0.45 CR/MW for a 210 MW unit. The total cost of retro-fit for the two units would be around ₹189 CR. There will also be an increase in variable cost once FGD is installed.

RTPS Units 1 and 2, totalling 420 MW, are both above 26 years and have been operating at less than 60% utilisation factor. These units have a variable cost of ₹3.86/kWh with an overall tariff of ₹5.04/kWh.

New renewable energy in the state is now available at ₹2.7/kWh or lower. Renewable energy with 4 hour battery storage is available at ₹3.6/kWh. The state could save money by phasing out these old coal units and replacing expected generation with renewable energy and battery storage.

If these plants are retired, based on currently scheduled dispatch, and their scheduled generation met from new renewable sources, there is a reduction in power purchase costs as shown in Table 9.

Table 9 | Coal plants in Andhra Pradesh 20 years or older that can be phased out with potential savings, based on FY 2022 tariff and dispatch

Unit	Capacity (MW)	Age	Tariff (₹/kWh)	Savings from replacement with RE (p.a.)	Savings from avoided retrofit (₹/CR, one time)
RTPS Units I & 2	420	26–27	5.04	₹525 CR	₹189 CR
NTTPS Units 1–6	1260	26–42	4.24	₹1188 CR	NA*
Total	**1680**			**₹1712.76 CR**	**₹189 CR**

*retrofitting for FGD not feasible per CEA

02

₹57,000 crore = ten year savings from replacing all power with tariffs >₹4/kWh with new renewable energy

Affordable power is essential for both industrial and domestic consumers, and predictable, low electricity costs are essential to expanding the small and medium scale industries that provide the bulk of employment and livelihoods across urban and semi-urban India, and to sustain government programmes meant to boost small scale enterprises and industry. Any reduction in power purchase cost also implies a reduction in the state government's subsidy burden, and a reduction in the cross subsidy that industries currently pay. With this in mind, it is useful to assess the savings potential of a 10 year plan to gradually replace the most expensive coal power purchased by AP DISCOMs with new renewable energy.

Recent tariffs discovered for solar and wind in India have been in the ₹2–3/kWh range. Bloomberg New Energy Finance estimates a continued cost reduction for new solar PV by 2025 and 2030 of 14% and 22% respectively, and a decline in costs for solar/wind + battery storage of about 40% by 2030.[54] The CEA also assumes a similar cost trajectory decline for battery energy storage systems by 2030.[55] Despite these expected cost reductions, this analysis errs on the conservative side by assuming a new renewable energy tariff of ₹2.7/kWh and an RE+battery storage tariff of ₹3.6/kWh for the next decade.

Against these RE and battery storage benchmarks, any power plant with a tariff above ₹4/kwh is uncompetitive.

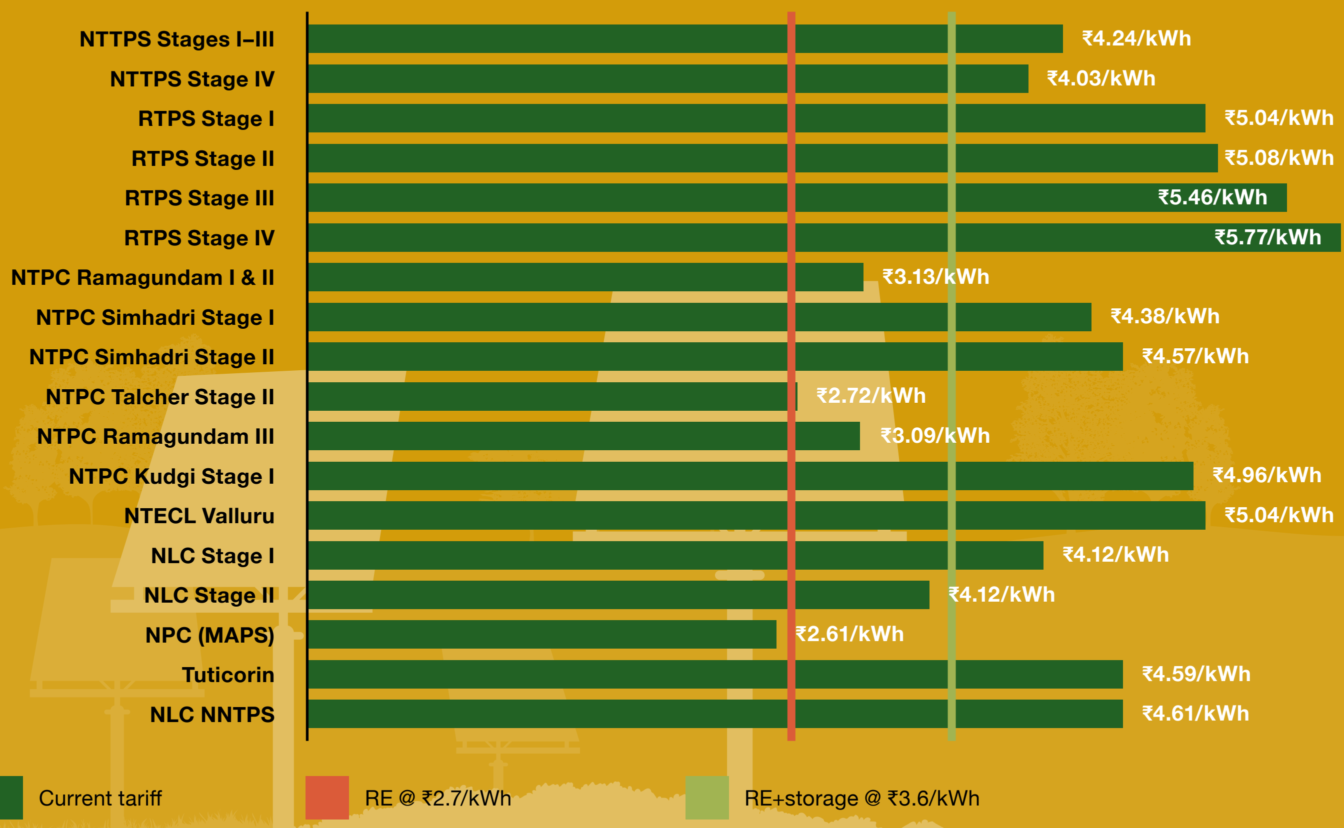
The long term savings potential if Andhra Pradesh gradually phased out power purchases from coal plants charging tariffs above ₹4/kWh and replaced that volume of electricity with renewable power at ₹2.7/kWh (or lower) is obviously significant. Such a massive change cannot be carried out rapidly but should be part of long-term economic planning over a 5 to 10 year horizon by the DISCOMs and state government, in order to lower the cost of electricity and boost investment attractiveness and economic and social indicators.

A longer term project to phase out the most expensive coal power plants (irrespective of age) and replace them with renewable energy can yield significant savings. This analysis provides an indicative roadmap. If scheduled generation (as per the FY 2022 tariff order) from all plants with tariffs at ₹4/kWh or higher were to be gradually replaced with power from renewables at an average of ₹2.7/kWh, there would be a potential savings of over ₹57,000 CR over ten years (based on current power tariffs) in terms of reduced power purchase costs.

Replacing expensive coal power generation with renewable energy can be done on a case by case basis at the end of current contract life. In the case of contracts not due to expire for decades, contracts could also be reconfigured to reward flexible generation through a premium for peaking power supply and a reduction in dispatch when renewable sources are plentiful. In cases where all parties are government entities, early termination of the contract by mutual agreement might be justifiable in order to generate savings across the system, and meet larger objectives of air pollution control, reduced electricity costs and decarbonisation. The possibility of raising transition bonds or securitisation with lower financing charges to retire existing debt/buyout contracts is also gathering interest.[56]

While this is the size of the "savings basket" available, the extent to which these savings can be realised will depend on many factors, including the options available to exit expensive contracts and the political will to explore them.

Figure 6 | Tariffs of operating TPPs in comparison to RE and RE+storage (₹2.7/kWh–₹3.6/kWh)[57]



72% of the TPPs that are scheduled to dispatch energy to AP have a higher tariff than RE+Storage tariff (₹3.6/kWh). 89% of these TPPs have a higher tariff than RE tariff (₹2.7/kWh).

Table 10 | Potential savings from replacement of all thermal power with RE /RE+storage (based on expected dispatch and tariff for FY 2022, per APERC tariff order)

Sector	Power plant	Age	Approved dispatch (FY 2021–22)	Current unit cost (₹/kWh)	Total dispatch cost (₹ CR)	Savings from Switching (₹ CR)	
						RE @ ₹2.7/ kWh	RE+ Storage
Central	NTPC Ramagundam I & II	32–38	1955.25	3.13	612.33	84.08	-91.90
Central	NTPC Simhadri Stage I	18–20	3147.85	4.38	1378.95	528.84	245.53
Central	NTPC Simhadri Stage II	10–11	1447.08	4.57	661.65	270.60	140.37
Central	NTPC Talcher Stage II	19	1241.14	2.72	338	2.48	-109.22
Central	NTPC Ramagundam III	17	497.86	3.09	153.82	19.42	-25.39
Central	NTPC Kudgi Stage I	4–6	1542.87	4.96	766.01	348.69	209.83
Central	NTECL Valluru	10–12	571.67	5.04	288.29	133.77	82.32
Central	NLC Stage I	18–19	344.59	4.12	141.81	48.93	17.92
Central	NLC Stage II	8–35	618.11	3.48	215.23	48.21	-7.42
Central	Tuticorin	31–42	835.22	4.59	383.19	157.86	82.69
Central	NLC NNTPS	2–3	194.23	4.61	89.54	37.10	19.62
Central	**Savings (₹ CR)**					**1679.98**	**564.35**
State	NTTPS Stages I–III	26–42	7,711.74	4.24	3,271.97	1,187.61	493.55
State	NTTPS Stage IV	13	3,241.2	4.03	1,305.68	431.08	139.37
State	RTPS Stage I	27	2,244.22	5.04	1,130.44	525.15	323.17
State	RTPS Stage II	14	2,117.92	5.08	1,075.72	504.06	313.45
State	RTPS Stage III	12	1058.96	5.46	577.94	16.27	10.97
State	RTPS Stage IV	4	3,642.57	5.77	2,101.67	1,118.27	790.44
State	SDSTPS	7–8	11,139.22	4.74	5,279.89	2,272.40	1,269.87
State	**Savings (₹ CR)**					**6,330.84**	**3,526.82**
Overall savings (₹ CR)						**8010.82**	**4091.17**

03

Solar/wind combined with battery storage is a better option than pumped storage hydro

The AP government is planning to develop multiple pumped storage hydro projects. 25 locations have been shortlisted for feasibility assessments. These projects are being developed ostensibly to promote renewable energy integration.[58] The cumulative capacity addition, if all projects are realised, is estimated to be around 33 GW. So far, technical feasibility studies have been conducted for 7 locations, totalling 6.3 GW.

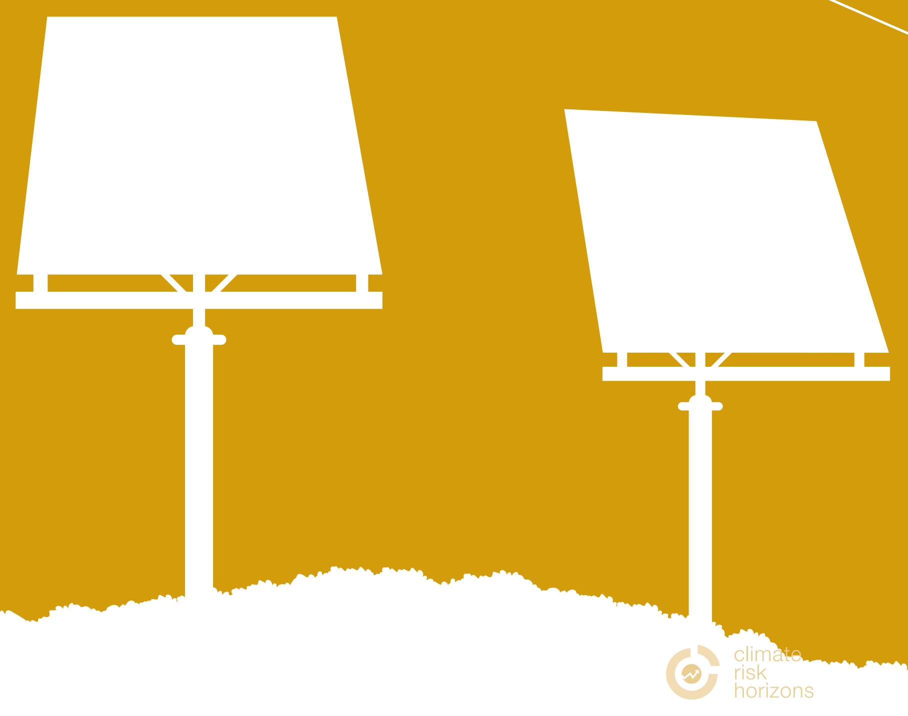


Table 11 | Proposed project sites for PSH

Project site	Capacity (MW)
Gandikota[59]	600
Owk Reservoir[60]	800
Somasila[61]	1200
Chitravathi[62]	500
Yerravaram[63]	1000
Karrivalasa[64]	1000
Kurukutti[65]	1200

CRH's analysis indicates that a massive build out of pumped storage hydro would be financially risky. PSH might have a minor, supporting role to play but it is not competitive with co-located renewable energy+battery storage, has a much longer gestation period, a greater land footprint and lower overall energy efficiency.

PSH vs. BESS: A comparative analysis

Energy storage systems (ESS) become vital once the grid has large proportions of RE. Pumped storage hydro has historically been a go-to solution to counter variability. Developing ESS can benefit the state on two fronts, (i) stabilising the grid (ii) providing cheaper electricity during non-solar generation hours.

However, PSH might not always be the best option for energy storage, at least in comparison to BESS (Battery Energy Storage Systems) for the following reasons:

I. **Lower cost/unit:** The costs of BESS have been declining rapidly. The per unit cost of producing electricity (using PV) and storage (using BESS) is currently estimated by JMK Research to be around ₹4.97.[66] The Lawrence Berkeley National Laboratory assessed the standalone cost of 4 hours of storage in 2025 at ₹4.07/kWh; when blended with RE generation (30 GW of storage for 100 GW of Solar) the LCOE drops to ₹3.32/kWh. For 2020, the same report estimated solar PV with 4 hours storage at ₹4.44/kWh (assuming solar at ₹3/kWh).[67] In August 2021, ReNew power signed a PPA with Solar Energy Corporation of India (SECI) for Round-The-Clock (RTC) electricity supply. The project will be 1,300 MW with 900 MW of wind and 400 MW of Solar supplemented with battery storage. The levelised cost of energy will be between ₹3.55–3.6/kWh.[68] On the other hand, the technical feasibility studies conducted for 6 of the 29 locations for PSH projects estimate the LCOE to be around ₹7.5/kWh to ₹8.46/kWh, with a weighted average of ₹7.99/kWh.

II. **Efficiency:** PSH units have an average efficiency of 80% whereas BESS have an efficiency between 85% to 95%.[69]

III. Source of stored energy: If PSH is reliant on coal or other conventional energy sources to pump the water, per-unit emissions would be at least 20% more compared to per-unit emissions of conventional electricity, due to round trip losses/ reduced efficiency. BESS+PV/wind installations, on the other hand, would have negligible emissions per unit generated. To construct PSH projects even before the state has hit its renewable energy targets would be pointless from the point of reducing emissions.

IV. Ancillary economic costs: PSH can only be built at specific locations. This might require extra expenditure in terms of installing new transmission lines, building roads to the location and other ancillary costs. On the other hand, stand alone BESS is not site specific and can be installed close to existing solar parks or coal power plants (for which the transmission lines etc. already exist) and thus reduce ancillary costs.

V. Ancillary ecological costs: Each PSH project requires significant land area. The 6 PSH projects for which feasibility study has been conducted require a combined area of 3,183 acres of land, raising livelihood, social and biodiversity issues. In comparison, stand-alone BESS for the same capacity would occupy less than 500 acres.[70]

Table 12 | LCOE for proposed PSH projects

Location	Capacity (MW)	Estimated Cost (₹ CR)	Estimated LCOE (₹/kWh)
Gandikota	600	1772	7.72
Owk Reservoir	800	2918	8.16
Somasila	1200	3723	7.83
Chitravathi	500	1511	7.48
Yerravaram	1000	3870	8.18
Karrivalasa	1000	4600	8.46
Kurukutti	1200	4766	7.85

The PSH projects have a combined capacity of 6.3 GW with a 5.5 hour peak operation duration with a total peak demand output of 34.7 GWh. This comparison analysis assumes a 6.3 GW capacity BESS storage with a 4 hour peak operation duration with a total peak demand output of 25.2 GWh.

A basic analysis is carried out to understand how PSH and BESS fare against each other in terms of economic viability. For the analysis, a total of 7 metrics were considered (shown in table 13). As BESS is location agnostic, can be decentralised and can be built near existing or planned solar parks, BESS gets a higher score on site feasibility. The values of the other 6 attributes are estimated/extracted from research papers and feasibility reports. Each attribute is given one of two directions viz. minimum and maximum based on whether the attribute is to be minimised or maximised, respectively.

Table 13 | Attributes and respective values

Attribute	Units	Direction	Weights	PSH	BESS
Site feasibility	Score	Max	10	4	10
Area required	Acres	Min	7	3,183	247
Construction costs	₹ CR	Min	10	23,160	44,300[71]
Life of project	Years	Max	8	40	15
Efficiency	Percentage	Max	7	80%	90%
Peak operation duration	Hours	Max	7	5.5	4
Levelised cost of generation	₹ /kWh	Min	10	7.99	3.6

Each attribute is assigned a weight between 1–10 based on its importance. Values of each attribute are normalised to a scale of 0–10 where the highest value is scaled to 10 and other value is scaled relative to the highest value. For example, for area required, PSH gets 10 (as it is the highest of among PSH and BESS) and BESS gets 0.78. The direction of the attribute (minimum or maximum) decides the sign of the normalised value and hence for area required, PSH gets -10 and BESS gets -0.78.

A viability score for each technology is derived by calculating the weighted average of the normalised values. PSH's viability score is 0.51 whereas BESS' viability score is 1.70. In other words, BESS is more economically viable than PSH by a factor of at least 3.4. Including further attributes such as ancillary economic and ecological costs into the analysis might affect the final score. However, given the relatively large land footprint for PSH projects, one can safely assume that PSH's viability score will be much lower than that of BESS.

6.0 Discussion of other costs and benefits

A gradual phaseout of older coal plants and replacement with renewable energy involves other costs and benefits that need further study. A few of these are discussed below.

Direct job losses: In the case of coal units being shut, there will need to be an assessment of job losses, and the extent to which these can be absorbed by other parts of the generator's operations. Since most of the units proposed for phaseout have other (younger) operating units in the same complex, it is likely that a significant number of "losses" can be absorbed into other operations at the same site, or other thermal plant operations in other locations. However, this needs further analysis and verification.

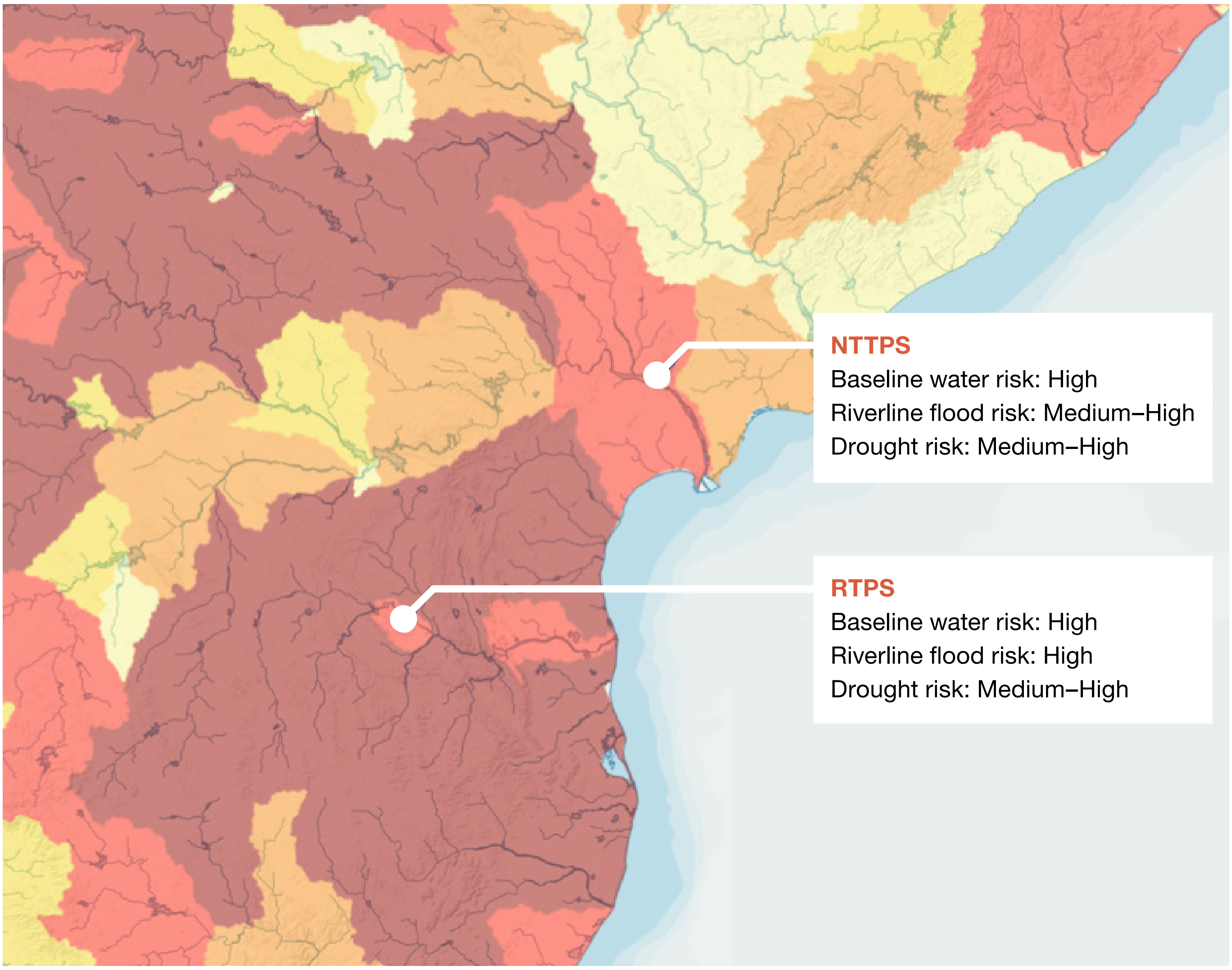
This analysis has not attempted to enumerate ancillary benefits from a phaseout of older coal plants, such as reduction in air pollution, fly ash generation, carbon emissions, etc.

Indirect job losses: This refers to losses in the coal transportation value chain and are harder to quantify due to the informal nature of these jobs. However, due to the fact that most locations will continue to have operating coal units for the foreseeable future, these impacts are likely low.

Capital costs of replacing generation from older coal plants with additional renewable energy: While replacement with cheaper renewable energy will deliver lifetime savings, initial upfront capital costs are high. This can be mitigated by well designed policy and innovative financing.

Environmental benefits: This analysis has not attempted to enumerate ancillary benefits from a phaseout of older coal plants. Briefly, these would be, inter alia, a reduction in air pollution, coal dust, coal transport traffic, fly ash generation, etc..

Water availability: The candidates for retirement operate in high water stress areas, and have experienced water-related conflict or outages. The likely benefits to farmers and communities from a reduction in water consumption consequent to the retirement of these plants deserves further study.



Source: World Resources Institute https://www.wri.org/applications/aqueduct/water-risk-atlas/

Benefits from repurposing of retired coal plant sites and machinery

Decommissioning old coal plants frees up land and offers significant monetary value in terms of scrap. Initial research indicates significant likely financial benefits from retiring coal power plants and repurposing the site and equipment. For instance, one assessment[72] based on data from NTPC's Badarpur plant in Delhi suggests that repurposing decommissioned coal plants for either solar, battery energy storage system and synchronous condenser can yield benefits that can cover between 22.5% to 67.8% of the capital expenditure required (based on a hypothetical 1,000 MW coal plant) depending on what combination of solar, battery storage and synchronous condenser is used.

7.0 Conclusions

1 Phasing out coal plants that are 25 years or older will provide immediate and significant savings to AP DISCOMs and electricity consumers. These savings are in the form of avoided retrofit costs and lower power purchase costs through replacement with new renewable energy.

2 Since all the plants in this age cohort are state government-owned, phasing them out is largely a matter of the state's political will.

3 Short term pain incurred from these measures, (such as government owned generators having to shutter a plant earlier than expected) should be viewed against the significant savings that will accrue to DISCOMs and consumers.

4 Apart from the direct financial savings, there are significant ancillary benefits in terms of reduced pollution, greater water availability for other uses and the possible diversion of land for other productive use.

5 Financing models that can aid the retirement of older, expensive coal plants can play a role in speeding up Andhra Pradesh's energy transition.

6 AP must meet or surpass its renewable energy targets in order to deliver energy security and reduced costs for the state.

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Climate Risk Horizons' (CRH) work highlights the systemic risks that disruptive climate change poses to investors, lenders and infrastructure investments. Through a data-driven, research-oriented approach that incorporates a holistic understanding of climate policy, energy infrastructure and regulatory processes, CRH provides advice on risk management strategies to minimise stranded, non-performing assets and economic disruption in the face of climate change.

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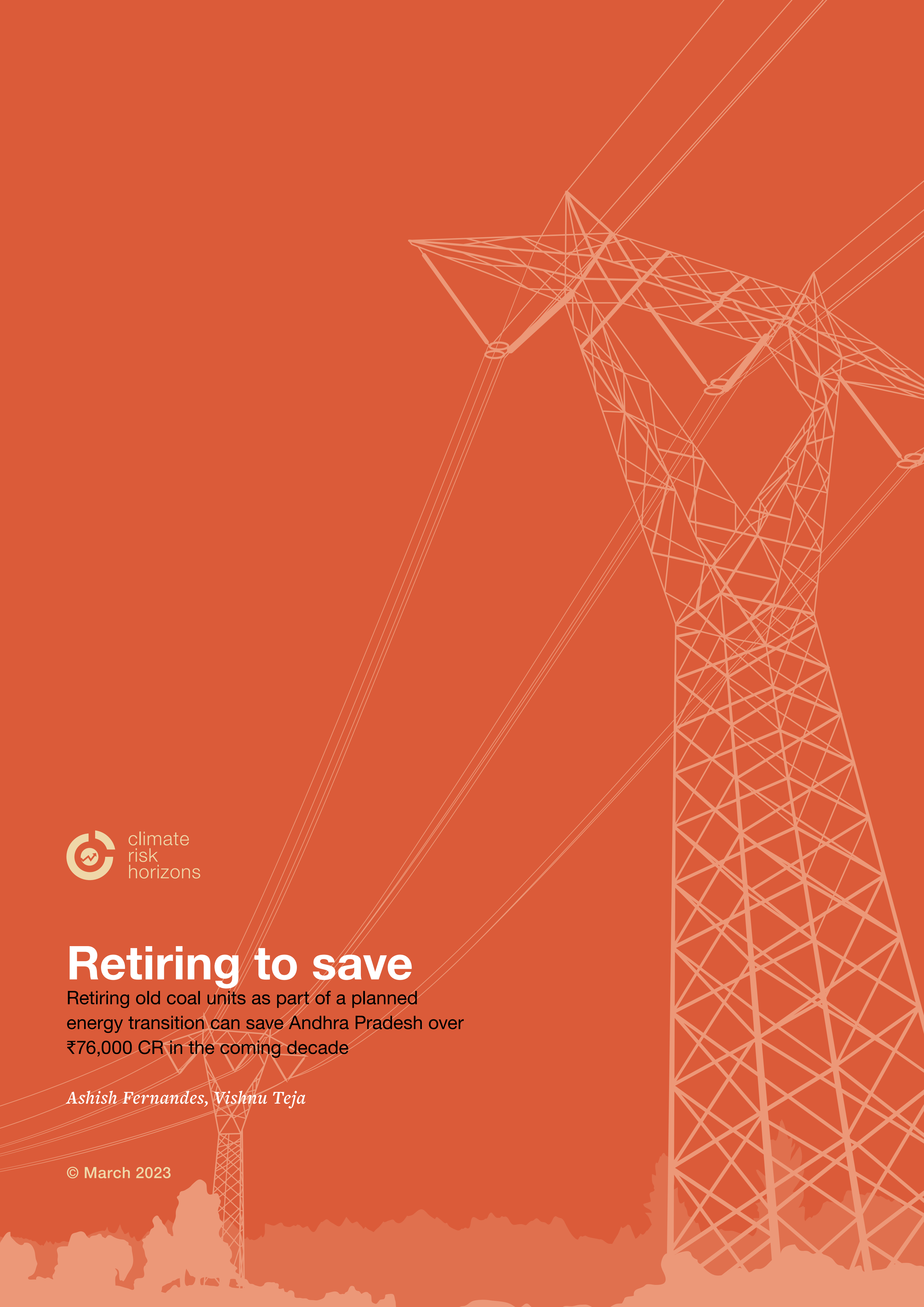

climate risk horizons

Retiring to save

Retiring old coal units as part of a planned energy transition can save Andhra Pradesh over ₹76,000 CR in the coming decade

Ashish Fernandes, Vishnu Teja