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Transforming Rajasthan's Electricity Sector

An Opportunity To Power a Green Recovery

Executive Summary

Rajasthan is a renewable energy leader in India and at the end of the last financial year it had a total of 9.6 gigawatts (GW) of renewable energy capacity installed. It also added more solar power capacity (1.7GW) in financial year (FY) 2019/20 than any other Indian state. Karnataka (1.4GW) was next, followed by Tamil Nadu (1.3GW).

Home to the world's largest operational utility-scale solar park in Bhadla, Rajasthan is a solar energy transition leader and is attracting massive ongoing new investment in renewables and supporting grid infrastructure, as well as associated manufacturing opportunities.

Renewable energy formed 43.5% of Rajasthan's total installed capacity and 18% of its total on-grid generation in FY2019/20.

The state has 9.8GW of coal-fired capacity, which makes up 45% of total installed capacity and produces 56.5% of its total on-grid generation.

Roughly 95% of Rajasthan's coal-fired capacity tariffs are above Rs4/kWh. Moreover, even its lowest tariff, for 3.4GW of coal-fired capacity, is contracted at Rs3.1-3.6/kWh – 30-50% higher than the lowest solar tariff of Rs2.36/kWh discovered in the Solar Energy Corporation of India's (SECI) 2GW auction in June 2020.

Now is the time for Rajasthan to transform its electricity sector to a low-emission, low-cost, modern renewable energy-based system.

The combination of expensive thermal tariffs and extremely high AT&C losses have put tremendous financial pressure on Rajasthan's state-owned power distribution companies (discoms). The Rajasthan discoms booked a loss of Rs6,355 crore (US$900 million) in FY2019/20 after accounting for state government subsidies.

Now is the time for Rajasthan to transform its electricity sector to a low-emission, low-cost, modern renewable energy-based system.

The state government should take proactive measures to fully utilise Rajasthan's solar energy potential, to help lift the economy out of the current downturn and build interstate export revenues to sustainably grow its GDP.

In this report we model Rajasthan's electricity sector's generation mix out to FY2029/30.

Accounting for India's economic slowdown in FY2019/20, exacerbated by the COVID-19 pandemic in 2020/21, we project Rajasthan's electricity production requirements to grow by just 42% over the next decade, from 81TWh in FY2019/20 to 115TWh FY2029/30. This growth rate is well below any forecasts set even two years ago.

We also expect a dramatic shift in its electricity sector generation composition with renewables forming 74% of capacity and 63% of total generation by FY2029/30.

Our model incorporates a forecast total of 22.6GW of renewable energy to be added to Rajasthan's grid. This consists of 18GW of new solar capacity, of which 3GW is forecast to be distributed solar capacity. We estimate solar will supply 98% of the incremental electricity demand by FY2029/30; and that 4GW of new onshore wind power capacity will serve 45% of the incremental demand.

IEEFA recommends retiring the state's old-technology-based, end-of-life coal-fired plants, and we model a net reduction in coal capacity of 0.7GW by FY2029/30.

As discoms look to cater to their incremental demand through cheaper renewable energy sources, coal-fired plants will progressively lose out on market share to about 28% compared to FY2019/20 or 13TWh by FY2029/30.

Even with net coal capacity closures over the coming decade, we forecast the coal-fired power sector's utilisation rates will drop to 41% in FY2029/30 from an already unsustainably low 55% in FY2019/20.

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Rajasthan's Economy

Rajasthan, in north-west India, is the largest Indian state by area, covering 342,239 square kilometres, or 10.4% of the country's total geographical area. Rajasthan's population is estimated to be 81 million, according to June 2020 Aadhaar data from the Unique Identification Authority of India.

Figure 1: Rajasthan's Location

Source: Free world maps.

Between FY2011/12 and FY2017/18, Rajasthan's gross state domestic product (GSDP) grew at a compounded annual growth rate (CAGR) of 6.7% – marginally lower than India's GDP growth rate of 7-7.5% for the same period.[1]

Key Industries

Rajasthan is among India's largest mineral-producing states. There are 81 varieties of mineral in the state and 57 are produced on a commercial scale. It also contributes significantly to the production of dimension and decorative stones, such as marble, sandstone and granite.

The value of all minerals produced in the state in FY2018/19 was Rs12,831 crore (US$1.8bn).

Top Indian mineral mining companies operating in Rajasthan include Hindustan

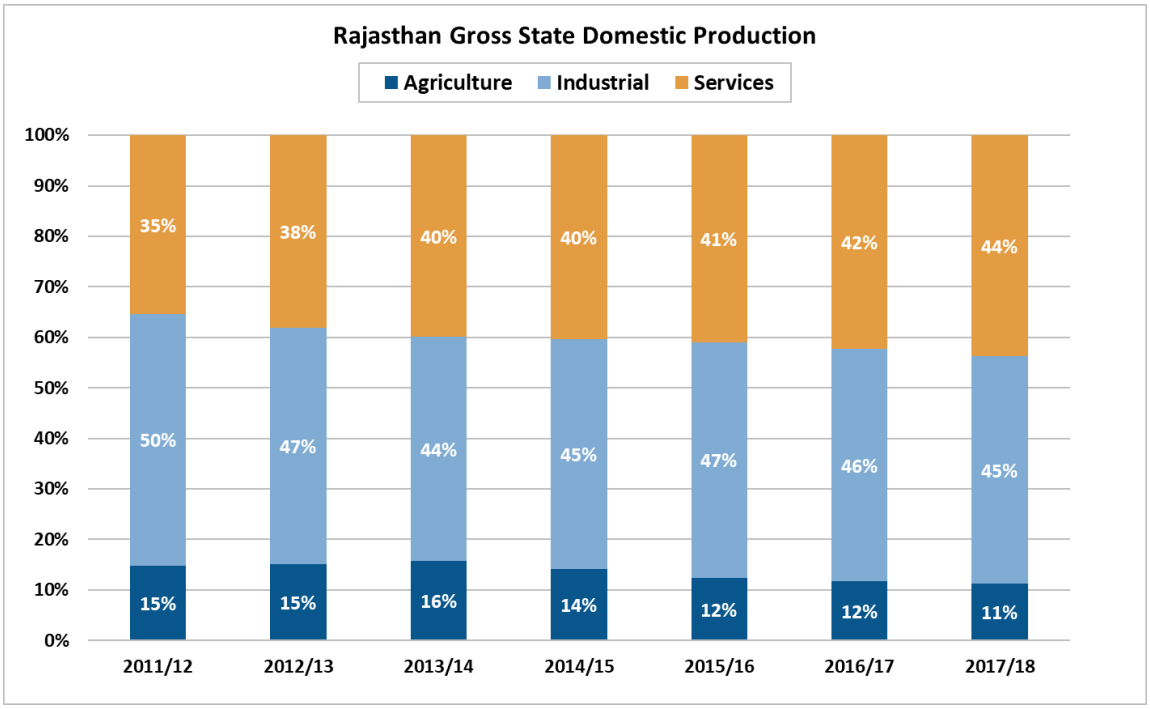
[1] Reserve Bank of India. Handbook of Statistics on Indian States.

Zinc Ltd, Hindustan Copper Ltd, Rajasthan State Mines and Minerals Ltd and Stonex India.[2]

Tourism is another important revenue contributor, accounting for about 15% of Rajasthan's economy. Rajasthan's share of India's international and domestic visitor arrivals is about 11.2% and 3.3%, respectively.[3]

The services sector (including banking and insurance) accounted for 44% of Rajasthan's GSDP in FY2017/18. The service sector's contribution to the state economy grew significantly from 35% in FY2011/12 to 44% in FY2017/18. Rajasthan has experienced economic growth with relatively low energy intensity, because services consume less energy than industry. Its agricultural, industrial and service sectors grew at CAGRs of 0.3%, 2.8% and 7.5% during the same period.

Figure 1.1: Composition of Rajasthan's Gross State Domestic Product (GSDP) FY2011/12 to FY2017/18



Source: Reserve Bank of India Statistics.

The state is also home to a lot of power-intensive industries which play a major role in its economic development. These include steel, mining, textiles, cold storage and food processing, auto and auto components.

[2] India Brand Equity Foundation. Industrial Development and Economic Growth in Rajasthan. June, 2020.
[3] Welcome Rajasthan.

India's Electricity Sector Transformation

While the Indian economy has grown very strongly over the last decade, the country faces a multitude of challenges. It must adhere to international climate commitments to dramatically reduce carbon emissions intensity relative to GDP by 33-35% by 2030 from the 2005 level[4] and reduce its unsustainable reliance on fossil fuel energy imports. At the same time, it must 'keep the lights on' to increasingly support social and economic growth.

IEEFA notes that to tackle these challenges India will need to accelerate the transition to a domestically fuelled, lower-cost, low-emission, less water-intensive energy economy – starting with the greening of its electricity sector and moving on to progressively electrify transport and other energy-intensive industries.

India has set a very ambitious long-term target of 450GW renewable energy of installed capacity by FY2029/30, to improve energy security, diversify into lower-cost domestic energy generation and reduce reliance on fossil fuel imports.[5]

As of March 2020, India had 205.2GW of coal-fired capacity that contributed 55.4% of its total on-grid capacity and 71.3% of total generation. Renewables have expanded to provide 87.0GW or 23.5% of on-grid capacity and 10.2% of total generation.

Figure 2.1: India's Electricity Sector Composition FY2019/20

	---- Capacity ----		-- Generation --		Capacity	Increase
	GW	%	TWh	%	Utilisation	GW yoy
Coal-Fired	205.2	55.4%	986.9	71.3%	55.5%	4.4
Gas-Fired	24.9	6.7%	49.0	3.5%	22.4%	0.0
Diesel-Fired	0.5	0.1%	0.1	0.0%	2.0%	-0.1
Large Hydro	45.7	12.3%	157.9	11.4%	39.6%	0.3
Nuclear	6.8	1.8%	42.8	3.1%	72.1%	0.0
Renewables	87.0	23.5%	141.7	10.2%	19.7%	9.4
Bhutan (Import)	n.a	n.a	4.9	0.4%	n.a.	
Total	**370.1**	**100%**	**1,383.3**	**100.0%**		**14.0**
Captive Power	51.4					
Total	**421.5**					

Source: CEA, IEEFA estimates.

From FY2017/18, India's renewable energy sector saw a dramatic deflation in renewable energy tariffs – achieved through transparent, reverse auctions with well-defined contractual terms and pre-bid registration of qualified participants. Solar power tariffs as low as Rs2.44/kWh (~US$35/kWh) in SECI's Bhadla Solar

[4] India's Intended Nationally Determined Contributions (NDCs) under the Paris Climate Agreement also include having 40% of total generation capacity from non-fossil fuel sources by 2030.

[5] Central Electricity Authority of India. Draft Report on Optimal Generation Capacity Mix for 2029-30. February, 2019.

Park auction in May 2017 reinforced ambition to accelerate capacity building. More than 90% of the 30GW of renewable capacity installed since the beginning of FY2017/18 and an additional 30-35GW auctioned to date, has been contracted for tariffs of Rs2.36-3.00/kWh with zero indexation for 25 years – 20-30% less than average domestic thermal tariffs of Rs4-5/kWh (US$55-65/MWh).[6]

Thermal Power in Financial Distress

As a result, India's thermal power sector is in tremendous financial distress: 563GW of coal plant proposals have been cancelled in the last decade[7] and 34GW of projects remain stranded, plaguing both India's power generation sector and its banking system.[8]

The thermal power sector faces structural issues including a lack of appropriate fuel linkages, an inability to access power purchase agreements (PPA) due to lower-than-expected electricity demand, an unsustainable reliance on concessional financing, and last but not least, growing competition from lower risk, cheaper domestic renewable energy sources.

The thermal power sector's underperformance is exemplified by unsustainably low capacity utilisation rates of less than 60% over the past three years (falling below 45% in Q1FY2020/21),[9] combined with excessive financial leverage that makes debt servicing problematic.

The COVID-19 pandemic has exacerbated the woes of the thermal power sector. The country-wide economic lockdown and coal mining and transportation issues caused a drastic fall in power demand. From April to June 2020, year-on-year power demand was down 12%. During this period, thermal power generation was down 22.7%, whereas renewable generation was up by 5.8% year-on-year.

Renewables Prove Resilient

The strong performance of renewable generation during unprecedented tough economic conditions provides impetus for India to continue its electricity sector transition. There is an opportunity to use a green stimulus to emerge from the economic slump by accelerating investments into renewable energy infrastructure, boosting employment, reducing fossil fuel imports and building India's energy security.

Domestic and global investor interest in renewable infrastructure investing remains robust – demonstrated by the positive outcomes of some recent auctions, despite sluggish progress in renewable energy capacity tendering and commissioning in FY2019/20.

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[6] NTPC. Key Performance Highlights FY2018/19.
[7] Global Energy Monitor. Coal Plants in India 2010-2020. July, 2020.
[8] IEEFA. Risk to India's Banking Sector in Rising Tide of Stranded Assets. August 21, 2018.
[9] CEA. Generation report. June, 2020.

Figure 2.2: Important RE Auctions in India in 2020

	Renewable Energy Auctions	Date	Capacity (MW)	Winning tariffs (Rs/kWh)	Winning Developers
1	**SECI solar projects with module manufacturing facility**	Jan-20	4,000	2.92 2.92	Azure Power (2000 MW) Adani Green Energy (2000 MW)
2	**SECI solar projects with module manufacturing facility (greenshoe extension)** Total 3,000 MW of solar module manufacturing capacity linked	Jan-20	8,000	2.92 2.92	Azure Power (2000 MW) Adani Green Energy (6000 MW)
3	**SECI RE + Storage Peak power supply** (Peak power tariff - Rs6.12/kWh for Greenko and Rs6.85/kWh for Renew)	Jan-20	1,200	2.88 2.88	Greenko (900 MW)) Renew Power (300 MW)
4	**NHPC Solar Tender**	Apr-20	2,000	2.55 2.55 2.55 2.55 2.56	SB Energy (600 MW) Axis Energy (400 MW) O2 Power (380 MW) Eden Renewable (300 MW) Avaada Energy (320 MW)
5	**SECI Round-the-Clock RE power tender** 3% escalation allowed on base tariffs for 15 years (Rs3.59/kwh on levelised basis for 15 years)	May-20	400	2.90	Renew Power (400 MW)
6	**SECI 2GW Solar Auction (ISTS Tranche IX)**	Jun-20	2,000	2.36 2.37 2.37 2.37 2.37 2.38 2.38	Solar Pack (300 MW) Enel Green Power (300 MW) Amp Energy Green (100 MW) Eden Renewables (300 MW) IB Vogt Singapore (300 MW) Ayana Renewables (300 MW) Renew Power (400 MW)
7	**NTPC 1.2GW ISTS Solar Auction**	Aug-20	1,170	2.43 2.43 2.43 2.44	O2 Power (400 MW) Azure Power (300 MW) Tata Power (370 MW) Amp Energy Green (100 MW)

Source: Mercom, IEEFA.

Even so, integrating 450GW of renewable energy by 2030 into India's grid is going to be a significant challenge, not least with the US$500-700bn investment required to build this out and provide grid transmission and balancing capacity.

Renewable Energy Auction Milestones

Given the costs of battery storage are still high, large-scale deployment of utility-scale batteries is currently prohibitive for the Indian market.

However, in January 2020 India held its first RE-plus-storage auction of 1.2GW capacity with a differentiated tariff for peak and off-peak supply, and contracted for 25 years as a way to underpin bankability.

Greenko and ReNew Power won 900MW and 300MW of capacity at an off-peak tariff of Rs2.88/kWh (US$40/MWh). The peak tariff went to Greenko for Rs6.12/kWh (US$86MWh) and to ReNew Power for Rs6.85/kWh (US$96/MWh).[10]

Greenko will reportedly be using pumped hydro storage and ReNew Power will be using battery storage to provide firmed peak-hour supply.[11]

[10] Mercom India. Greenko, ReNew Win SECI's 1.2 GW Solar, Wind Auction with Storage for Peak Power Supply. January 31, 2020.
[11] Mercom India. Greenko Seeks EPC Contractors for a 1,260 MW Pumped Hydro Storage Project in Karnataka. February 14, 2020.

In May 2020, in another first-of-its-kind auction, this time for 400MW of round-the-clock (RTC) renewable power supply, ReNew Power secured a semi-firmed electricity tariff of Rs2.90/kWh (US$39/kWh).[12]

The auction provided an annual escalation of 3% on the quoted tariff up to the end of the 15th year of the contract. This accounts for the Rs4.39/kWh 15- to 25-year tariff (the last 11 years of the PPA), as there is no indexation after year 15.

The tariff escalation provision of 3% in the PPA is lower than India's average consumer price index (CPI) inflation rate of about 5% between 2014 and 2019 (five years).[13]

Incorporating the CPI inflation rate of 5%, IEEFA estimates the levelised tariff (average present value of tariffs from year 1 to year 25) to be Rs2.11/kWh – 27% lower than the year 1 tariff of Rs2.90/kWh.

The PPA mandates an annual capacity utilisation factor of >80% and >70% on a monthly basis.

SECI's solar module manufacturing-linked solar auction also provides another interesting growth opportunity for India's renewable energy industry, as well as signalling clear financial support for the Indian government's 'Make In India' initiative.

The Indian government must continue to tender out planned capacity to keep the renewable capacity pipeline active and to accelerate momentum in the sector.

Adani Green Energy and Azure Power both won bids to develop 2GW of projects with 500MW of solar module manufacturing capacity. The winning tariff quoted by both companies was Rs2.92/kWh (US$40/MWh).

The tender also had a 'greenshoe option', allowing the companies to opt for additional capacity to both develop and manufacture. Adani, under the greenshoe option, offered additional capacity of 1.5GW of solar cell and module manufacturing and 6GW solar capacity.

With the additional capacity, Adani's total allocation comes to 2GW of solar cell and module manufacturing and 8GW of solar capacity, while Azure's is 1GW of module manufacturing capacity and 4GW of solar capacity.[14]

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[12] Mercom India. ReNew Power Wins SECI's 400 MW Round-the-Clock Renewable Tender at ₹2.90/kWh. May 8, 2020.
[13] Macrotrends. India Inflation Rate 1960-2020.
[14] Mercom India. Adani, Azure Win SECI's Manufacturing-Linked Solar Auction, Greenshoe Option Next. January 17, 2020.

SECI's recent 2GW solar auction delivered India's lowest-yet renewable energy tariff at Rs2.36/kWh (US$31/MWh) with zero indexation for 25 years.

Spanish developer Solar Pack won 300MW of capacity, and developers from five other countries were awarded a total of 1.3GW of capacity. They were: Enel (Italy), Amp Energy (Canada), Eden Renewables (France), IB Vogt (Germany) and Ayana Renewable Power (backed by the UK's CDC Group). ReNew Power won 400MW for Rs2.37/kWh.[15]

Although NTPC's 1.2GW tender in August 2020 was oversubscribed, only 80% of the total subscribed capacity (1,170MW) was awarded because some technical bids were disapproved. The auction resulted in winning bids at Rs2.43/kWh and 2.44/kWh (US$32/MWh), just 3% above the record low tariff of Rs2.36/kWh in SECI's June 2020 auction. Winners of the 100MW of awarded capacity included major domestic developers O2 Power, Azure Power and Tata Power, along with Canadian developer Amp Energy.[16]

Over the past two years, India's renewable capacity grew much slower than expected, despite favourable economic conditions in relation to existing thermal power and strong interest from international investors. The ongoing COVID-19 pandemic has stalled construction and growth is expected to remain sluggish in FY2020/21 due to the sector's reliance on interstate migrant workers for renewable construction projects.

In IEEFA's opinion, the Indian government should continue to tender out planned capacity to keep the renewable capacity pipeline active, and to reinvigorate and accelerate momentum in the sector – and Rajasthan should be at the forefront of this investment boom.

[15] Mercom India. SECI's 2 GW Solar Auction Gets India a New Record-Low Tariff of ₹2.36/kWh. June 30, 2020.
[16] Mercom India. Amp Energy, Tata, Azure, and O2 Power Winners in NTPC's 1.2 GW Solar Auction. August 6, 2020.

Rajasthan's Electricity Sector

As of March 2020, Rajasthan had a total coal-fired installed capacity of 12.4GW. However, only 9.8GW is allocated to Rajasthan. Of the remaining coal-fired capacity, 1.2GW is captive but connected to the grid to trade surplus power and 1.4GW is owned by the central government and is serving other states. (Or it could be potentially mothballed by a lack of coal and/or water or by maintenance work.)

Renewable energy sources such as solar, wind and biomass now form a substantial part of Rajasthan's installed capacity mix. With the addition of 1.9GW of new capacity in FY2019/20, Rajasthan's renewable energy capacity reached a total of 9.6GW. This forms 43.5% of the state's total operational installed capacity and 17.6% of its total on-grid generation.[17]

Rajasthan's thermal fleet (including gas-based generation) only provided 57.8% of in-state consumption for FY2019/20 owing to an unsustainably low capacity utilisation factor of 55.2% for coal and just 11.5% for gas for the financial year.

Figure 3.1: Rajasthan's Electricity Sector Generation Mix in 2019/20

	Capacity		Generation		Utilisation	Capacity Adds
Source	**(GW)**	**%**	**(TWh)**	**%**	**%**	**(GW)**
Coal	9.8	44.6%	45.9	56.5%	55.2%	0.7
Gas	1.0	4.6%	1.0	1.3%	11.5%	0.0
Diesel	0.0	0.0%	0.0	0.0%	0.0%	0.0
Nuclear	1.2	5.4%	8.5	10.4%	81.8%	0.0
Hydro	0.4	1.9%	0.6	0.7%	16.8%	0.0
Renewables	9.6	43.5%	14.3	17.6%	19.0%	1.9
Net imports			10.9	13.5%		
Total	**22.0**	**100.0%**	**81.2**	**100.0%**		**2.6**

Source: CEA state-wise and plant-wise generation reports, IEEFA estimates.
Note: The capacity, generation and utilisation rates are based on capacity monitored by CEA in the state.

The 1.2GW Rajasthan Atomic Power Station provided 10.4% of the state's power demand in FY2019/20 with a capacity utilisation factor of 81.8% for the year.

Currently Rajasthan depends on electricity imported from other states because it has a power deficit during peak daytime hours. IEEFA estimates that Rajasthan imported 10.9 terawatt hours (TWh) of electricity in FY2019/20. But as a result of the potentially significant lift in renewable energy investment, Rajasthan should become a net exporter of electricity in the coming decade.

[17] CEA. Renewable Energy Generation Report. March, 2020.

Rajasthan's Power Distribution Sector

Rajasthan's power distribution business comprises three state-owned discoms and their franchises, namely: Jaipur Vidyut Vitran Nigam Ltd (JVVNL), Ajmer Vidyut Vitran Nigam Ltd (AVVNL), and Jodhpur Vidyut Vitran Nigam Ltd (JdVVNL).

The state government-owned power generation company Rajasthan Urja Vikas Nigam Ltd (RUVNL) is also the authorised licensee, operating effectively as a trader between various generation sources and state-owned discoms.

The discoms procure power based on a differential bulk supply tariff (DBST). It involves a single buyer model in which one buyer buys electricity from different generators under a PPA. Under this model, the per-unit cost of electricity on-sold to the discoms by the single buyer (RUVNL) is different for each discom. The differentiation is mainly because of varied sales, the efficiency of the discom, and its consumer mix.

Using this approach, a distribution utility with a customer base that generates low revenues would be charged a lower DBST than the tariff charged to a buyer with a more favourable consumer or revenue mix. For example, the Jodhpur discom (JdVVNL) has a higher share of agricultural consumers who receive subsidised tariff rates which undermine the discom's revenue.

For FY2019/20, the Rajasthan Electricity Regulatory Commission (RERC) approved a DBST of Rs4.67/kWh for the Jaipur discom, Rs4.18/kWh for the Ajmer discom and Rs3.23/kWh for the Jodhpur discom.[18]

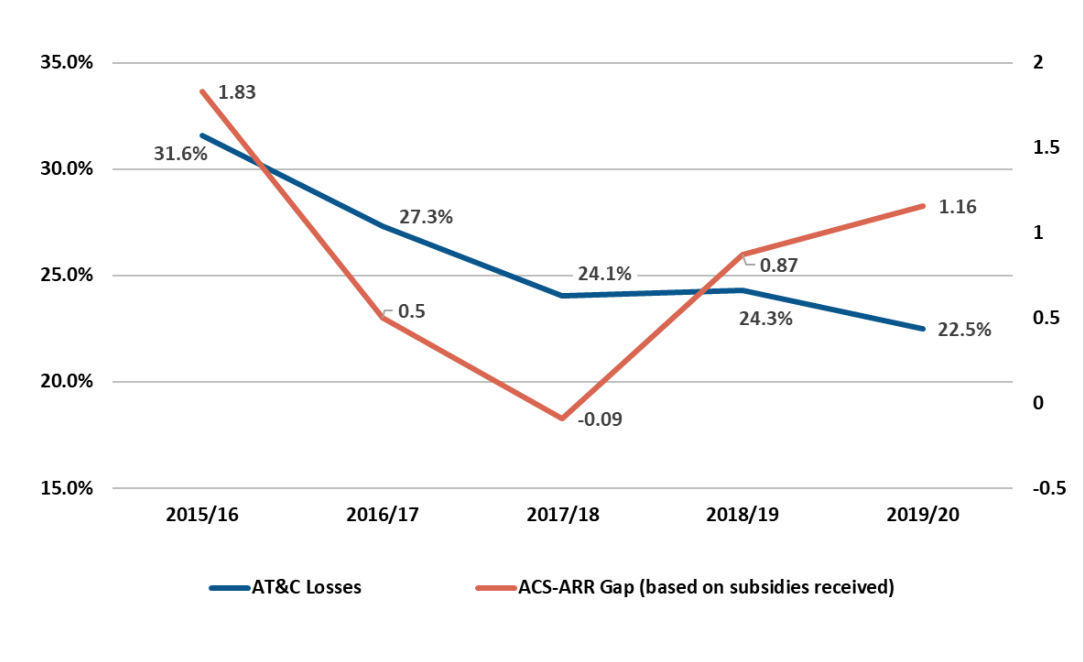
Key Performance Metrics of Discoms

AT&C Losses

In FY2015/16, the Rajasthan discoms faced extremely high AT&C losses of 31.6%, according to Power Finance Corporation's (PFC) utility performance report.[19] As per the MoU signed under the UDAY scheme in 2016, the discoms were given a target of reducing their AT&C losses to 15% by the end of FY2019/20. Although they failed to achieve that target, Rajasthan's discoms have managed to significantly reduce the cumulative AT&C losses to 22.5% as of March 2020.[20] (See Figure 4.1.)

[18] RERC. Tariff Order – Approval of ARR and Tariff Petition of Discoms for FY2019/20, p. 70. February 6, 2020.
[19] PFC. Report on State Power Utilities 2017/18.
[20] UDAY. Rajasthan Dashboard. March, 2020.

Figure 4.1: Rajasthan Key Performance Metrics



Source: UDAY dashboard, PFC, RERC Tariff orders.

The Jaipur discom had the highest level of AT&C losses of 28% in FY2015/16. And three of its divisions – Bharatpur, Dholpur and Karauli – incurred AT&C losses of above 40%.[21] (There is no data available on AT&C losses for divisions in FY2019/20.)

IEEFA notes a discrepancy in data disclosure between UDAY MoUs and PFC discom reports and takes the view that accuracy, timeliness and transparency should be improved to aid accountability and help remedy this unsustainable loss rate.

The UDAY MoU reports that the Jaipur discom's AT&C losses were 28% in FY2015/16 – the highest among the three Rajasthan discoms. However, this is lower than the AT&C losses of 31.6% in the same year for the entire state, as reported by PFC. The Jaipur discom is the largest discom by quantity of power traded, so its AT&C loss for any given year should not be lower than overall state AT&C losses.

In a February 2020 tariff order, submitted by the Rajasthan discoms for the FY2019/20 annual revenue requirement, the discoms claimed 100% collection efficiency. Discoms have filed intrastate and interstate transmission losses of 4.25% and 3.15% respectively for FY2019/20.

RERC has observed a continued failure of the Rajasthan discoms to achieve the targeted reduction in AT&C losses of below 15% in the last five years, despite investment schemes provided by the state and central governments. For FY2019/20, RERC approved AT&C losses of 19% (as opposed to the actual AT&C

[21] UDAY. Jaipur MoU.

loss of 22.5% incurred in FY2019/20), leaving the burden of roughly 3.5% of AT&C losses on the discoms' financials.

ACS-ARR Gap

The gap between average cost of supply (ACS) per unit and average revenue realised (ARR) per unit is one of the most important – and systemically unsustainable – performance parameters for power distribution in India.

A negative ACS-ARR gap – where revenue is higher than the procurement cost – reflects profitability. But most Indian discoms consistently sell power for less than they buy it for. Not only is this financially unsustainable, it acts as a perverse disincentive for the discoms to supply more electricity to customers. In other words, the more they supply, the greater their total losses.

The MoU signed under the UDAY scheme directed the discoms to substantially reduce their ACS-ARR gaps, with targets as follows:

Figure 4.2: Rajasthan Targeted ACS-ARR Gap Reductions under UDAY

(Rs/kWh)	Actual gap in FY2015/16	Targeted reduction under UDAY by FY2018/19	Actual gap in FY2019/20
Ajmer	2.35	-0.15	-0.09
Jaipur	2.04	-0.11	1.15
Jodhpur	1.98	-0.11	2.15

Source: UDAY Rajasthan MoU [22] [23] [24].

The Ajmer discom has managed to become profitable by bringing its ACS-ARR gap to Rs-0.09/kWh in FY2019/20. However, the Jaipur and Jodhpur discoms still incurred ACS-ARR gaps of Rs1.15/kWh and Rs2.15/kWh for FY2019/20.[25] (The revenue includes state government subsidies and grants.)

Figure 4.1 illustrates Rajasthan's collective ACS-ARR gap from FY2015/16 to FY2019/20. At the beginning of the UDAY scheme, the Rajasthan discoms managed to bring their collective deficit down from Rs1.83/kWh in FY2015/16 to a profitable position in FY2017/18 of Rs-0.09/kWh. Since then the situation has deteriorated to a loss-making position, with the deficit at Rs1.16/kWh for FY2019/20.

[22] UDAY. Ajmer MoU.
[23] UDAY. Jaipur MoU.
[24] UDAY. Jodhpur MoU.
[25] UDAY. Rajasthan Dashboard. March, 2020.

Why Are Rajasthan's Discoms Struggling?

There are several key structural and operational reasons for unsustainably high cost-revenue deficits in the Rajasthan state-owned discoms:

Lack of In-State Coal Mining and Hydro Power

Rajasthan has no coal reserves and inadequate sources of water to procure in-state hydro power, which increases overall power purchase costs. Available hydropower capacity is primarily utilised only when dam water is released for irrigation. Even though the discoms can buy cheap hydropower from other states, it only accounted for 9% of power procured in FY2019/20 (refer to Figure 4.3).

For FY2019/20, the Rajasthan discoms' average thermal power purchase cost was Rs4.20/kWh. This made up roughly 79% of the total power procured by the discoms. The higher average per unit cost of Rs4.80/kWh for renewables suggests the Rajasthan discoms still mainly procure power under contracts signed before 2017. Weak power demand growth since 2019 has reduced the ability of the state to procure new low-cost renewable energy below Rs3.00/kWh and hence progressively lower the average cost of supply.

Legacy thermal contracts with fixed-cost charges constrain the discoms from signing new cheaper renewable energy PPAs at below Rs3.00/kWh.

IEEFA estimates the average cost of power procurement for Rajasthan in FY2019/20 was Rs4.10/kWh.

Figure 4.3: Rajasthan Discom Power Purchase Cost for FY2019/20

	MU	Total cost (Rs crore)	Rs/kWh	% of Total power	% of Total power purchase cost
Thermal	61,475	25,637	4.2	79%	81%
Hydro	7,276	1,254	1.7	9%	4%
Nuclear	3,124	1,120	3.6	4%	4%
Renewables	10,291	4,965	4.8	13%	16%
Thermal+RE bundled	2,314	1,009	4.4	3%	3%
Purchased in open market	-6,731	-2,423	3.6	-9%	-8%
Net Total	77,749	31,562	4.1	100%	100%

Source: RERC annual revenue requirement tariff order, pages 207-208

Note: The amount of electricity (MU) is forecast based on 10 months data for FY2019/20; -6,731 MU of short-term power purchase from the open market is deducted from the long-term quantity of contracted power as per discoms' ARR order.

Power Deficit During Peak Hours

In the recent tariff order for the FY2019/20 average revenue requirement, the discoms noted there was a power supply deficit during the daytime, which meant they depended on power from an open-market exchange. At night, however, there was an off-peak surplus that was sold on the exchange.[26]

The cost of power sold on the exchange during off-peak hours is significantly lower than the cost of purchase. The average price of power sold on the power exchange by the Rajasthan discoms from midnight to 7am was Rs2.11/kWh in FY2018/19. The net average cost of power procured in FY2018/19 was Rs4.27/kWh. So as a result, the discoms bore a loss of Rs2.16/kWh on every unit of power sold between midnight and 7am.

No Tariff Hike Since FY2015/16

Rajasthan's electricity tariffs have not risen since FY2015/16. At current tariffs and with the cost of procuring power, the Rajasthan discoms have incurred a revenue gap of Rs7,140 crore. The discoms estimate a tariff hike of roughly 13% would be required to bring the revenue gap to zero. This failure to allow the discoms to recover cost inflation might be politically expedient, but it is financially disastrous for the discoms. If the state government wants to expand subsidies every year it should account for this extra state burden, rather than hiding it in off-balance sheet losses.

Delays in Subsidy Disbursements From State Government

Delays in the payment of subsidies from the Rajasthan state government compel discoms to borrow funds, further undermining their poor financial health. Additionally, the Rajasthan discoms carry an interest burden of Rs7,206 crore (about US$1bn) from loans provided under the UDAY scheme between FY2015/16 and FY2018/19.

This interest debt owed to the government of Rajasthan caused a severe financial crunch for the discoms which, in turn, has led to an accumulation of overdue payments to power generators, especially the state-owned power generation company, Rajasthan Rajya Vidyut Utpadan Nigam (RVUNL). The discoms have also had to take out working capital loans to cope with the interest burden.

Unable to pass on interest costs to consumers, and with no tariff hike in sight, the discoms have staggered repayment of this interest debt over five years – but with no capacity to actually fulfil their obligation because they are losing money with every unit of electricity they sell.

[26] RERC. Tariff Order – Approval of ARR and Tariff Petition of Discoms for FY2019/20. February 6, 2020.

Financial Losses

Because of the high cost of buying power, the severe AT&C losses, the interest burden, and their inability to raise tariffs in line with inflation, the Rajasthan discoms booked a loss of Rs6,355 crore (US$0.9bn) in FY2019/20 after accounting for state government subsidies.[27]

The discoms are highly dependent on state government subsidies and other grants. For FY2015/16, FY2016/17 and FY2017/18, 26-37% of the discoms' total revenue came from subsidies and grants from the Rajasthan government. (Data on subsidies disbursed for FY2018/19 and FY2019/20 is not available.) Moreover, the subsidies and grants received from the Rajasthan government were only 85% of the actual sum of subsidies due to the discoms.

Rajasthan discoms also carry a substantial burden of regulatory assets of Rs0.77/kWh. Regulatory assets are a cost component that a discom must include when filing its annual revenue requirement. They are recognised but deferred by the regulator. Generally, these costs are deferred for the year and are considered to be passed on to consumers in revised tariffs for the coming year. But until passed on to consumers, or funded in the form of a state subsidy, they are an entirely unsustainable financial burden for the discoms.

Overdue Payments

As mentioned earlier, delays in subsidy disbursement from state governments and metering and collection inefficiencies compound existing cash flow problems for the discoms. This further constrains their capacity to pay power generators. As of May 2020, the Rajasthan discoms have Rs32,360 crore (US$4.4bn) in overdue payments to power generators – roughly 28% of the total overdue payments by Indian discoms to power generators.[28]

The state, at some point, has to be accountable for the growing indebtedness of its wholly-owned discoms.

The Rajasthan discoms have reportedly applied for Rs4,064 crore (US$580m) of subsidised loans at an interest rate of 9-9.5% from the PFC and REC under the Indian government's Rs90,000 crore (US$12bn) bailout package. The measure aims to help ease liquidity issues in the power sector exacerbated by the COVID-19 pandemic.[29]

In IEEFA's opinion, the state, at some point, has to be accountable for the growing indebtedness of its wholly-owned discoms.

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[27] UDAY. Rajasthan Dashboard. March, 2020.
[28] Ministry of Power. PRAAPTI. December, 2019.
[29] *Business Standard*. Punjab, Rajasthan, Andhra Pradesh Seek Rs 14,664 Crore to Revive Discoms. June 26, 2020.

Thermal Power Generation

Coal-Fired Generation

According to the Central Electricity Authority's (CEA) installed capacity report from March 2020, Rajasthan has 12.4GW of coal-fired installed capacity (with no additions between April to July 2020). Only 9.8GW of that capacity is allocated to the state of Rajasthan, as disclosed in the CEA's generation reports and the Rajasthan discoms' regulatory filing, 1.2GW is captive but connected to the grid to trade surplus power and the remaining 1.4GW is owned by the central government and is serving other states.

Of the 12.4GW of installed capacity 1.5GW is lignite-based.

Figure 5.1: Rajasthan Coal-fired Power Tariffs

			Rs/kWh		
Plant	Capacity (GW)	Owner	Capacity Charges	Energy (variable) Charges	Total Tariff
Chhabra Thermal Power Station	2.3	RVUNL	2.0	2.1	4.1
JSW Barmer Jalipa Kapurdi Power Station	1.1	JSW Energy	2.5	1.7	4.2
Kalisindh Thermal Power Station	1.2	RVUNL	1.8	2.8	4.6
Kawai Thermal Power Project	1.3	Adani Power	1.7	2.5	4.2
Kota Power Station	1.2	RVUNL	0.6	3.1	4.6
Suratgarh Super Thermal Power Station	2.2	RVUNL	0.8	3.6	4.2
Total	**9.3**				

Source: RERC tariff orders, CEA
Note: RVUNL stands for Rajasthan Vidyut Utpadan Nigam

Figure 5.1 above provides coal-fired power tariffs from Rajasthan's operational plants. Please note that this is not a comprehensive list of coal-fired power plants and their respective tariffs for Rajasthan.

The state-owned power generation company RVUNL owns 7.1GW of coal-fired capacity in Rajasthan. As per Figure 5.1, roughly 95% of Rajasthan's coal-fired capacity tariffs are above Rs4/kWh. For the Kalisindh and Kawai thermal power stations, the variable part of the tariff is Rs2.8/kWh and Rs2.5/kWh. For the Kota and Suratgarh plants the variable charges are Rs3.1/kWh and Rs3.6/kWh – 30-50% higher than the lowest solar tariff of Rs2.36/kWh with zero indexation for inflation for 25 years, which was discovered in SECI's 2GW auction in June 2020.[30]

[30] Mercom India. SECI's 2 GW Solar Auction Gets India a New Record-Low Tariff of ₹2.36/kWh. June 30, 2020.

Figure 5.2: Rajasthan Coal-Fired Capacity Status

Status	Capacity (GW)
Pre-Permit	1.1
Permitted	0.1
Construction	0.7
Operating	9.8
Shelved	1.8
Cancelled	4.4

Source: Global Energy Monitor – Global Coal Plant Tracker July 2020.
Note: Additional 1.2GW of operational captive capacity is excluded from the above table.

Global Energy Monitor's Global Coal Plant Tracker (GCPT) July 2020 revealed a total of 1.9GW of potential new capacity is in the pipeline. This includes the Suratgarh plant's 660MW Unit 8, which is under construction and due for commissioning in 2020. The additional unit is based on now-outdated supercritical combustion technology. The plant's operational units supply power at an exorbitantly high variable tariff of Rs3.6/kWh – 34% higher than the lowest solar tariff of Rs2.36/kWh at SECI's 2GW auction in June 2020.

JSW Energy has proposed doubling its already operational 1.1GW of lignite-based capacity at its Barmer power station in the village of Bhadresh and adding another two 540MW units to the same parcel of land. Terms of reference were approved in December 2019 and the proposal is awaiting environmental clearance[31] – the final regulatory approval before construction can begin. JSW plans to commission the expansion based on supercritical combustion technology.

JSW's plans to source lignite from the Jalipa and Kapurdi mines through Barmer Lignite Mining Company Ltd (BLMCL), a joint venture between Rajasthan State Minerals and Mining Corporation and JSW's subsidiary Raj West Power Ltd.[32]

As per the terms of reference, the water required for the project will be piped 185 kilometres (km) from the Indira Gandhi Nahar Project (IGNP) and the expansion units will use the existing ash pond of the operational units.

The tariff of the plant's operational units is Rs4.2/kWh, Rs1.7/kWh of which is the fixed charge and Rs2.5/kWh the variable charge. Given the proposed expansion would use similar technology and procure lignite from the same mines, IEEFA expects the tariff to be the same – double IEEFA's estimated levelised tariff of Rs2.11/kWh discovered in SECI's latest 400MW round-the-clock firmed renewable power auction (see page 11).

Due to the financial stress of the thermal power sector in India, IEEFA expects JSW

[31] Ministry of Environment, Forests and Climate Change (MOEFCC). Terms of Reference. December 2019.

not to pursue expansion of 1.1GW of its lignite-based Barmer power station. Moreover, Prashant Jain, JSW's joint managing director and chief executive officer, recently talked about JSW's ambition to pivot entirely to renewables by building 4.5GW of renewable capacity in next 3-5 years from an existing capacity of only 10MW.[33]

In September 2020, the Supreme Court of India made the Rajasthan discoms liable for a compensatory tariff to Adani Power for its Kawai plant (1.3GW).[34] The tariff agreed in a PPA signed in 2010 between Adani Power and the Rajasthan discoms was based on domestic coal source.

As per the New Coal Distribution Policy (NCDP) of 2008, the Coal Ministry had assured 100% domestic coal to power plants. However, the Ministry failed to provide a domestic coal linkage for Adani's Kawai plant.

Adani Power used expensive imported Indonesian coal and later appealed for compensatory tariff under the 'change in law' clause of the PPA. Adani's claim was further supported by RERC and Appellate Tribunal for Electricity (APTEL).

The Supreme Court's ruling in favour of Adani Power means additional power purchase cost for the Rajasthan discoms, further deteriorating their ACS-ARR balance.

Rajasthan should take advantage of its renewable energy potential to build its own renewable energy capacity to serve incremental demand.

In IEEFA's view, expansion of Rajasthan's thermal power fleet is not in the state's best interests because it would lock the discoms into expensive capacity charge costs for 25-30 years.

It is IEEFA's opinion that the state should not pursue any new thermal power contracts based on the now-outdated concept of baseload power. Instead, it should take advantage of its renewable energy potential to build its own renewable energy capacity to serve incremental demand. It should also work on the best source of flexible peaking power supply (gas peakers, batteries, demand response management, interstate transmission and/or pumped hydropower) to balance low-cost but intermittent renewable energy.

Gas-Fired Capacity

At 1GW, Rajasthan's in-state gas-fired capacity is small and it operated at an extremely low utilisation rate of 11.5% during FY2019/20.

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[33] *Economic Times*. JSW Energy Pulls the Plug on Thermal Asset Expansion, Focus on Green Energy Now. August 3, 2020.
[34] *ET Energy World.* Raj Discoms Liable to Pay Compensatory Tariff to Adani Power: SC. September 1, 2020.

RUVNL owns 0.6GW of gas-fired capacity with combined cycle gas-fired power plants (CCPP), Dholpur CCPP (330MW) and Ramgarh CCPP (273MW). Dholpur CCPP produced no power during FY2019/20, or potentially discoms refrained from buying power from the plant owing to an exorbitantly high variable charge of Rs6.34/kWh. However, the tariff order for the discoms' annual revenue requirement suggests that they paid Rs201 crore (US$27m) of total fixed charges to the plants despite not drawing any power throughout the year.[35]

Ramgarh CCPP's utilisation factor was better, at 30.6% during FY2019/20. This was because the variable charge of the tariff is much lower at Rs2.80/kWh. Ignoring the capital cost, this is almost competitive with the total cost of new renewable energy.

NTPC owns 0.4GW of Anta CCPP, which also has an expensive variable charge of Rs4.15/kWh. The plant operated at an extremely low utilisation rate of 8.2% during FY2019/20 with capacity charges to the discoms of Rs43 crore (US$5.7m).

Transition To Renewable Energy

Rajasthan is one of India's best states for renewable energy potential. It hosts a desert of approximately 102,000 square kilometres (3% of India's total landmass). It also has high solar irradiance and wind speeds and abundant barren land to deploy utility-scale capacity, all of which make it a top Indian destination for investment into renewable energy.

CEA's National Electricity Plan 2018 suggests 142GW of solar power potential in Rajasthan.[36]

As of March 2020, Rajasthan had already installed 9.6GW of renewable capacity – 5.2GW of solar, 4.2GW of wind capacity and a small run-of-river hydro and biomass generation capacity of 0.1GW.

Rajasthan added the most solar power capacity (1.7GW) of all the Indian states in FY2019/20, followed by Karnataka (1.4GW) and Tamil Nadu (1.3GW).[37]

There have been no wind capacity additions in Rajasthan in the last two financial years. However, in a positive development, Siemens Gamesa recently announced it has a large-scale contract from Adani Green to deliver wind turbines totalling 473MW. The contract includes manufacturing, supply, installation and pre-commissioning of the wind turbines for the project in the Fatehgarh district of Rajasthan.[38]

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[35] RERC. Tariff Order – Approval of ARR and Tariff Petition of Discoms for FY2019/20 (page 207). February 6, 2020.
[36] CEA. National Electricity Plan. January, 2018.
[37] *The Times of India*. Rajasthan Solar Sector Shines Bright Amidst Gloom, Adds Max Capacity in India. August 2, 2020.
[38] Siemens Gamesa. Siemens Gamesa Strengthens its Partnership with Adani Green Energy with the Supply of a 473 MW Wind Power Project in India. August 17, 2020.

Rajasthan's Renewable Energy Policy

In December 2019 Rajasthan released its latest solar, wind and solar-wind hybrid policies. They set a target of 30GW of installed solar capacity by FY2024/25, of which utility or grid-scale solar parks would account for 24GW, distributed solar capacity for 4GW, solar rooftop capacity for 1GW, and solar irrigation pumps capacity for 1GW.[39]

Rajasthan's wind and solar-wind hybrid energy policy aims to achieve 2GW of wind power capacity to fulfil its assigned renewable purchase obligation (RPO) and another 2GW of behind-the-meter capacity by FY2024/25. The hybrid policy aims to build 3.5GW of hybrid power capacity by FY2024/25.[40] Of this, 2GW would be new capacity and an additional 0.5GW of new hybrid capacity would be coupled with storage systems. The policy also sets out a target of hybridising 1GW of existing solar or wind capacity.

Bhadla Solar Park in Rajasthan is the world's largest solar park to date, with a total operational capacity of 2,245MW.

Solar Power

Bhadla Industrial Solar Park, Rajasthan, 2,245MW

Bhadla Solar Park in Rajasthan is the world's largest solar park to date, with a total operational capacity of 2,245MW .[41]

The solar park is located at Bhadla village in the Jodhpur district and covers more than 14,000 acres (56 square kilometres). It was developed by several entities: Rajasthan Renewable Energy Corporation Ltd, through its subsidiary Rajasthan Solar Park Development Company Ltd, constructed 745MW of capacity; Saurya Urja Company of Rajasthan, a joint venture company of the government of Rajasthan and IL&FS Energy Development Company, developed infrastructure for 1,000MW of solar projects; and Adani Renewable Energy Park Rajasthan, a joint venture between the government of Rajasthan and Adani Renewable Energy Park (a subsidiary of Adani Enterprises), developed 500MW of solar capacity.

The SECI auction bid for 500MW in May 2017 saw a then record-low tariff of Rs2.44/kWh. ACME Solar quoted Rs2.44/kWh to win 200MW, and SB Energy (SoftBank) quoted Rs2.45/kWh to develop 300MW.

In IEEFA's view, the headline tariff turned global attention towards India and gave India's renewable energy mission a profound impetus to build out domestic energy

[39] Government of Rajasthan. Rajasthan Solar Energy Policy 2019.
[40] Government of Rajasthan. Rajasthan Wind and Hybrid Energy Policy 2019.
[41] Mercom India. With 2,245 MW of Commissioned Solar Projects, World's Largest Solar Park is Now at Bhadla. March 19, 2020.

resources at record-low prices, thereby building Indian energy security.

Bhadla attracted record-low solar tariffs in the range of Rs2.44-2.62/kWh (US$35-37/MWh), and they remain among the lowest tariffs in India to date.

The table below shows capacities developed by the various developers at Bhadla:

Figure 6.1: List of Developers of Bhadla Solar Park

Developer	Capacity (MW)
SB Energy SoftBank	600
Hero Future Energies	300
NTPC	260
ACME Solar	200
Azure Power	200
Sunseap Energy	140
Engie	140
Avaada Power	100
Fortum Solar	70
Vector Green	70
Renew Power	60
Phelan Energy	50
Electrotherm	5
Aditya Birla	20
LNB Group	5
Roha Dyechem	25
Total	**2,245**

Source: Mercom India.

In February 2020 the Ministry of New and Renewable Energy (MNRE) issued a notification for setting up a total 50GW of ultra-mega solar parks in Gujarat and Rajasthan with 25GW capacity in each state.[42]

Ultra-mega solar parks exemplify India's technological ingenuity and ability to mobilise capital at scale and at least cost. However these projects come with their own set of negative externalities. Although availability of non-agricultural land is not a problem for Rajasthan, without rapid expansion of the grid network there are grid congestion issues to be considered.

In IEEFA's view India needs to strike a balance between utility-scale and distributed ground-mounted or rooftop solar to help keep grid-related challenges in check. But given its huge desert expanse, and the high solar radiation this brings, it makes

[42] Mercom India. Government to Set Up 50 GW of Ultra-Mega Renewable Parks in Gujarat and Rajasthan. February 19, 2020.

sense for Rajasthan to be India's leading solar state, and to export to other states and even internationally in times of surplus.

To reduce grid stability issues, Gopal Lal Somani, former director of Rajasthan Renewable Energy Corporation Ltd (RRECL), suggests commissioning 250MW of solar per district with adequate battery storage systems.[43]

Solar Irrigation Pumps

The central government's PM-KUSUM scheme, introduced in 2018, aimed to deploy 2.75 million solar pumps in the first phase of implementation to produce an additional 4GW of installed solar power, providing a material boost to India's renewable energy deployment.[44]

The distributed generation aspect of such a system provides significant grid network strengthening as well as financial relief from the burden of massive cross-subsidies.

According to data from the Ministry of Power, the agricultural sector receives an annual electricity subsidy of Rs16,303 crore (US$2.2bn) and the investment required for installation and solarisation of pumps in Rajasthan is Rs54,875 crore (US$7.3bn). So the state could recover the cost of free solar pumps in 3.4 years.[45]

Recently, RERC approved a tariff of Rs3.14/kWh (US$42/MWh) for the KUSUM program for capacities of up to 725MW.[46] Again, a tariff lower than existing thermal power tariffs in Rajasthan. As irrigation could be time-managed with peak solar production during the day, it could very well replace thermal power in the agricultural sector.

Growth of Transmission Capacity

The central government's Green Energy Transmission Corridor aims to improve interstate transmission capacity to unlock the potential of new renewable energy-specific zones. India has a geographic spread of renewable-rich states on the western and southern coasts. By improving inter-regional capacity for transmitting power from energy surplus to energy deficit states, India could boost energy security and provide better load-balancing capacity.

In August 2018, a power transmission network committee proposed transmission system infrastructure for renewable energy-specific zones to support 50GW of solar capacity and 16.5GW of wind capacity cumulatively in seven states. The infrastructure is being implemented in two phases, by FY2019/20 and FY2020/21,

[43] The detailed note from Mr Somani on these recommendations is available to be shared via email.
[44] IEEFA. India: Vast Potential in Solar-Powered Irrigation. August, 2018.
[45] The Hindu Business Line. Most States Can Recover Cost of Free Solar Pumps in Less Than 4 years. July, 2020.
[46] Mercom India. Rajasthan Approves Levelized Tariff of ₹3.14/kWh for 725 MW of Solar Under KUSUM Program. July 9, 2020.

with the total cost estimated to be Rs42,235 crore (US$6bn).[47] In July 2019, the Rajasthan power ministry also invoked special powers to declare these transmission projects to be of national importance.[48]

In May 2020, CERC passed an order granting regulatory approval to the Power Grid Corporation of India Ltd (PGCIL) to set up transmission systems under the second phase of its transmission program for solar energy zones in Rajasthan. The first phase comprised transmission capacity for 8.9GW and the second 11.1GW of renewable energy capacity.

The implementation had reportedly already started for 8.9GW of systems in the Bhadla (3.5GW), Fatehgarh (3.5GW) and Bikaner (1.8GW) complexes. Long-term access (LTA) applications were received for 8.6GW of projects, while stage-II connectivity applications were received for 4.3GW of projects.[49]

This capacity will allow interstate power flow from renewable-rich states such as Rajasthan to other states.

In December 2019, the Rajasthan discoms expressed their concerns over the financial implication of the load flow and transmission charges. From the 8.9GW of capacity in Rajasthan targeted under the transmission expansion program none of that power will be consumed in Rajasthan. The Rajasthan discoms are still awaiting clarification from CERC on how these charges will be shared among beneficiary states.[50]

Wind Power

India's National Institute of Wind Energy estimates Rajasthan's wind power potential to be 18.7GW.[51] Currently with 4.2GW of wind capacity installed as of June 2020, Rajasthan's wind power potential is not yet being fully utilised.

RRECL's data suggests that no wind power capacity has been commissioned in the last two financial years in Rajasthan. This indicates the lack of growth in Rajasthan's wind capacity. However, Rajasthan's new wind and hybrid energy policy sets a target for 4GW of additional wind power capacity by FY2024/25.

Wind Repowering

More than 60% of Rajasthan's wind capacity was built before 2010 and wind power technology has transformed in the last few years. Repowering old wind capacity

[47] CEA. 1st Meeting of Western Region Standing Committee on Transmission (WRSCT) – Agenda Note. August 24, 2018.
[48] ET Energy World. Govt Invokes Special Powers to Save Green Projects Worth Rs 40,000 Crore. July, 2019.
[49] Mercom India. CERC Approves Construction of Transmission Systems for 20 GW of Solar in Rajasthan. May 14, 2020.
[50] Mercom India. Rajasthan DISCOMs Weary of Transmission Systems for Solar in the State. December 12, 2019.
[51].National Institute for Wind Resources. Wind Power Potential at 100m agl.

would allow the state to optimise its best wind power resources.

For Rajasthan, replacing near end-of-life 200-500kW turbines with higher towers and new models incorporating the latest 2-3MW technology provides scope for up to a tenfold increase in wind capacity and potentially twentyfold increase in generation (raising capacity utilisation rates from 15-20% to internationally comparable 30-35% rates) from existing projects whilst halving the number of towers required.

Open Access

As large industrial customers, the discoms' biggest revenue source, opt to source power through open access, the discoms have started levying additional charges to compensate for the substantial reduction in their revenue from behind-the-meter self-generation. These measures include transmission charges, wheeling charges, cross-subsidy surcharges and state load dispatch charges.

Cross Subsidy Surcharges

Cross subsidy surcharges form one of the largest components of the overall charges levied by the discoms on open-access customers.

According to the policy directive from state regulators, the cross-subsidy surcharge should not exceed 20% of the actual tariff approved for the given customer category. This year, the Rajasthan discoms applied for a cross-subsidy surcharge which was 35-40% of the approved tariff. The regulator, however, only approved a surcharge that was 20% of the actual tariff. The cross-subsidy surcharge for FY2019/20 was in the range of Rs1.70-2.16/kWh, depending on the customer category and voltage level.[52]

In FY2016/17, the cross-subsidy surcharges in Rajasthan were in the range of Rs1.63-1.88/kWh – materially lower than FY2019/20. However, these charges were relatively higher because they were roughly 23% of the category tariffs approved for FY2016/17 versus the 20% benchmark set for these charges.

Wheeling Charges

For FY2019/20, Rajasthan discoms levied wheeling charges of Rs1.38/kWh for 11kV voltage level, Rs0.11/kWh for 33kV voltage level, and Rs0.04/kWh for 132kV voltage level.

Every year the state regulatory commission revises and approves open-access charges. These charges are supposed to reflect the discoms' actual cost of supplying power and relative loss of revenue from customers opting for the open-access route.

[52] RERC. Tariff Order – Approval of ARR and Tariff Petition of Discoms for FY2019/20 (page 150-151). February 6, 2020.

However, open-access customers have had to deal with regular changes in, and inappropriate levying of, these charges.

In May 2019, the RERC ruled against the Rajasthan discoms for charging open-access customers wheeling charges that claimed a 100% utilisation factor for wind and solar power procurement as opposed to the normative 20% utilisation factor for such projects as per the open-access contract.[53]

In addition to high charges, generators and consumers often cite procedural delays as a critical hurdle to scaling up open access. Regulators often reject applications based on technical constraints, such as a lack of adequate transmission and wheeling capacity on a state's network.

RERC's annual reports suggest that Rajasthan has had varying open-access capacity approved for several years. It was 425MW in FY2015/16, 600MW in FY2016/17 and 550MW in FY2017/18.

Land Tax Policy

Wind and solar developers in Rajasthan have been resisting introduction of a new land tax of Rs2/square meter, effective from the start of FY2020/21,[54] and have taken up the issue with the RERC. They have requested that renewable energy projects be exempt from this tax on the basis that the renewable energy industry is different from other industries in its land usage intensity – renewable energy is all about capturing maximum solar rays and utilising wind resource.

Imposing this land tax on renewable energy projects will disincentivise investments in Rajasthan's renewables sector. The potential capital flight from Rajasthan's renewable energy industry far outweighs the estimated annual tax revenue of Rs55 crore (US$7.4m) from this land tax.

A favourable policy environment and regulation for Rajasthan's renewables industry is essential to the state's economic recovery from the COVID-19 pandemic. In IEEFA's opinion, renewable energy projects should be exempt from this irrational tax.

[53] Mercom India. Rajasthan Rules Against Wheeling Charges for Solar and Wind at 100% CUF for Captive Users. May 1, 2019.
[54] Economic Times. Rajasthan: Solar Power Companies Protest Against New Land Tax. August 22, 2020.

IEEFA's 2030 Model for Rajasthan

Rajasthan currently has a well-diversified electricity system, with generation capacity split between thermal (49%) and renewables (43%). Nuclear and hydro only form 5% and 2% of installed capacity, respectively (refer to Figure 3.1). But the state's overreliance on coal-fired capacity has been extremely expensive for the discoms.

In IEEFA's view, it is time for Rajasthan to make the most of its world-leading renewable energy potential and accelerate its transition to a low-emission, low-cost, modern renewable-based electricity system.

The COVID-19 pandemic and the resulting economic lockdown have immense implications: a recent report from The Energy Resource Institute (TERI) predicts India's electricity demand will be 7-17% lower by 2025. [55]

IEEFA's Rajasthan electricity model for FY2029/30 projects the state's electricity production requirements will grow by just 42% over the next decade, from 81TWh in FY2019/20 to 115TWh in FY2029/30.

We also project a dramatic shift in its electricity sector composition with renewables forming 73% of capacity and 63% of total generation, as shown below in Figure 7.1.

Figure 7.1: Rajasthan Electricity Sector Composition FY2029/30

	Capacity		Generation		Utilisation	Capacity Adds
Source	**(GW)**	**%**	**(TWh)**	**%**	**%**	**(GW)**
Coal	9.1	20.8%	32.8	28.5%	41.1%	-0.7
Gas	1.0	2.3%	1.0	0.9%	11.5%	0.0
Diesel	0.0	0.0%	0.0	0.0%	0.0%	0.0
Nuclear	1.2	2.7%	8.5	7.3%	81.8%	0.0
Hydro	0.4	0.9%	0.6	0.5%	16.8%	0.0
Renewables	32.1	73.2%	72.3	62.8%	25.7%	22.6
Total	**43.9**	**100.0%**	**115.3**	**100.0%**		**21.9**

Source: IEEFA estimates.

IEEFA's model indicates 15GW of new utility-scale solar and 3GW of distributed solar (rooftop PV and solar irrigation pumps) will be added by FY2029/30 in Rajasthan.

Rajasthan will be able to utilise its wind power potential more efficiently by replacing old wind capacity with modern, higher-capacity wind turbines with taller

[55] TERI. Renewable Power Pathways: Modelling the Integration of Wind and Solar In India by 2030. July 2020.

wind poles. This will allow Rajasthan to double its wind capacity from approximately 4GW to 8GW.

We project Rajasthan will add a total of 22.6GW of new renewable capacity with no net new thermal, nuclear and hydro. The expansion in its solar power fleet will require deployment of ample battery storage and the retrofitting of some of its relatively new thermal capacity so it can operate flexibly and provide firmed peak power capacity.

IEEFA recommends retiring 1.3GW of old, end-of-life coal-fired capacity by FY2029/30.

Figure 7.2: Capacity To Be Retired By FY2029/30

Plants	Capacity (MW)	Commissioning Years
Kota Power Station Unit 1-4	850	1983-1997
Suratgargh Super Thermal Power Station Unit 1-2	500	1998-2000
Total Capacity to be retired by FY2029/30	1,350	

Source: GCPT, IEEFA estimates.

Due to the financial stress of the thermal power sector in India IEEFA thinks JSW will not pursue the 1.1GW expansion of its lignite-based Barmer (Jalipa Kapurdi) power station.

Prashant Jain, JSW's joint managing director and chief executive officer, recently talked about JSW's ambition to pivot entirely to renewables by building 4.5GW of renewable capacity in the next 3-5 years from an existing capacity of only 10MW.

With the Suratgarh plant's addition of 0.6GW, which is currently under construction, and the retirement of 1.3GW of its end-of-life plants, there will be net negative capacity addition (-0.7GW) in Rajasthan by FY2029/30.

Decoupling Electricity vs. Economic Growth

Rajasthan's GDP has grown at a CAGR of 6.7% annually between FY2011/12 and FY2017/18.[56] Meanwhile, electricity demand grew at a CAGR of 5.6% annually.[57] This implies a decoupling of electricity vs. economic growth. (In the last two financial years, Rajasthan's power production grew at 12.1% in FY2018/19 before collapsing to 1.8% in FY2019/20.)

In November 2017, the U.S. Energy Information Administration (EIA) published an analysis that noted increasing evidence of a systemic, sustained global decoupling of

[56] Reserve Bank of India. Handbook of Statistics on Indian States. March 3, 2019.
[57] CEA. Generation Reports, FY2011/12 to FY2017/18.

electricity demand from economic growth.[58] IEEFA's analysis shows this same decoupling trend is evident in Europe, the U.S., Japan and Australia.

Above all, China saw a major decoupling of electricity demand from economic growth post 2013. For the period 2000-2013 electricity demand in China grew 10% annually, in lockstep with economic growth; at a ratio of 0.9-1.0x. Since 2014 the ratio has been volatile, almost halving to 0.5-0.6x.

IEEFA projects a far more modest 4.8% CAGR in electricity demand over the coming decade to 2029/30. We refer to Rajasthan's electricity demand growth of 6.7% annually relative to real GDP growth of 5.6%, giving a ratio of 0.83x during the past eight years.

With the current economic situation IEEFA expects a recession in Rajasthan, with negative GDP growth of -1.3% in FY2020/21, consistent with the national headwinds. However, we expect Rajasthan's GDP to recover (aligned with India's economic recovery) from FY2021/22 onwards and to continue to grow at a rate of 6.7% (aligned with the pre-COVID-19 growth rate).

IEEFA assumes a gross ratio of 0.83x over the coming decade. This marginally reduces to a net ratio of 0.82x (electricity demand to economic growth if a 0.05% annual energy efficiency saving can be sustained over the coming decade and also adjusting for recession in FY2020/21).

Our assumed energy efficiency dividend of 0.05% annually does not have a significant impact on electricity production growth. However, the urbanisation of Rajasthan's smaller cities will require greater emphasis on energy efficiency.

With the introduction of LEDs, high-rated air conditioners, solar irrigation pumps and better building construction standards assisting in this least-cost, least-polluting source of procurement, the electricity production growth is not needed.

Another key option for reducing the need for new generation is to reduce AT&C losses across Rajasthan from 22.5% currently to 12.5% by 2029/30, or 1% annually. This is crucial for the Rajasthan discoms to be able to operate sustainably. It is also key to ensuring electricity production grows at a rate below electricity demand through reduced waste of electricity during transmission and distribution. Reduced power theft most likely requires the roll-out of an automated smart meter system to reduce meter-reading bribery, not to mention the efficiency gains relating to any associated investment in distributed, behind-the-meter rooftop solar and/or storage systems.

IEEFA's Rajasthan model assumes an 34TWh or 3.6% increase in electricity production annually to 115TWh by 2029/30. Deducting 10% in AT&C losses in 2029/30 gives net demand in Rajasthan of 101TWh, a rise of 38TWh or 60% over the decade. This is predicated on 6.7% real GDP growth annually (except for

[58] U.S. Energy Information Administration. Link Between Growth in Economic Activity and Electricity Use is Changing Around the World. November 20, 2017.

FY2020/21). The ratio of electricity demand growth to economic growth is forecast at 0.82 net of a forecast 0.05% annual energy efficiency dividend (Figure 7.3).

Figure 7.3: Rajasthan's Production and Consumption FY2019/20 to FY2029/30

GDP growth	6.7%
GDP to electricity multiplier	0.83
Electricity demand growth	5.6%
Energy Efficiency (EE)	-0.05%
GDP to electricity multiplier after EE	0.82
Reduction in AT&C losses	-1.0%

	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30
Electricity Production (TWh)	81.3	79.3	82.7	86.1	89.8	93.6	97.5	101.7	106.0	110.6	115.3
Electricity Production Growth (%)		-2.4%	4.2%	4.2%	4.2%	4.2%	4.2%	4.3%	4.3%	4.3%	4.3%
AT&C Losses (%)	22.5%	21.5%	20.5%	19.5%	18.5%	17.5%	16.5%	15.5%	14.5%	13.5%	12.5%
AT&C Losses (TWh)	18.3	17.0	16.9	16.8	16.6	16.3	16.1	15.7	15.3	14.9	14.4
Real GDP Growth (%)		-1.3%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%
Electricity Multiplier (x)		0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
Electricity Growth (%)		-1.1%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%
Energy Efficiency Gains		-0.05%	-0.05%	-0.05%	-0.05%	-0.05%	-0.05%	-0.05%	-0.05%	-0.05%	-0.05%
Net Demand (TWh)	63.0	62.3	65.7	69.4	73.2	77.2	81.5	85.9	90.7	95.7	100.9
Net Demand Growth (%)		-1.1%	5.5%	5.5%	5.5%	5.5%	5.5%	5.5%	5.5%	5.5%	5.5%

Source: IEEFA estimates.

New Demand To Be Met Through Renewable Energy Sources

IEEFA forecasts Rajasthan will add a total of 22.6GW of renewable energy to its grid. This will consist of 18GW of new solar capacity, of which 3GW will be distributed solar capacity. Solar will supply 98% of the incremental demand by FY2029/30.

On the wind power side, we assume 4GW of new onshore wind power capacity – to serve 45% of the incremental demand.

The renewable energy capacity additions at tariffs below Rs3.00/kWh contracted for 25 years with zero indexation and zero marginal fuel costs mean deflation in real terms. This will ensure a reduction in Rajasthan's average cost of power purchase.

Figure 7.4: Rajasthan Electricity Consumption for FY2019/20 to FY2029/30

Rajasthan's Waterfall Chart				
Net electricity consumed in 2019/20 (TWh)			63	
Real GDP Growth	6.7%	pa		
Electricity to GDP multiplier	0.68	times		
Electricity Demand Growth	5.6%	pa	44	
Energy Efficiency	-1.0%	pa	-2	
Growth: gross production losses			8	
Reduced grid AT&C losses	-1.0%	pa grid efficiency gain	-12	
Net electricity consumed in Rajasthan in 2029/30 (TWh)			101	
Net expansion in electricity demand 2029/30 (TWh)			38	
Net expansion in electricity production required by 2029/30 (TWh)			34	
The Increase in net electricity demand is met by (TWh)			**TWh**	**Uplift**
Solar expansion			29	85%
Solar rooftop / irrigation pumps expansion			4	13%
Solar thermal expansion			0	0%
Onshore wind expansion			15	45%
Offshore wind expansion			0	0%
Increase in biomass & cogeneration generation			0	0%
Increase in hydro electricity			0	0%
Increase in gas-fired electricity			0	0%
Increase in nuclear generation			0	0%
Change in coal-fired power use			-15	-43%
Net expansion in electricity production by 2029/30 (TWh)			34	100%

Source: IEEFA estimates.

Further Collapse of Coal-Fired Power Utilisation Rates

IEEFA forecasts net negative additions of -0.7GW coal-fired power plants in Rajasthan by FY2029/30, as mentioned previously in this section. As discoms look to cater to incremental demand through cheaper renewable energy sources, coal-fired plants will lose out on market share to about 28% compared to FY2019/20 or 13TWh by FY2029/30. Effectively, the coal-fired power sector's utilisation rates will drop to 41% in FY2029/30 from an already unsustainably low 55% in FY2019/20.

Competition from renewable energy, backed by Rajasthan's ambitious capacity targets, will put tremendous pressure on the coal-fired sector.

Competition from renewable energy, backed by the government of Rajasthan's ambitious capacity targets, will put tremendous pressure on the coal-fired sector. The option of flexible operations for coal-fired power plants is not viable given the capital expenditure required for plan modifications. A 2019 study by CEA to evaluate flexible operation for coal-fired power plants concluded an effective tariff increase of Rs2.15/kWh for a 220MW unit, Rs2.20/kWh for 500MW and Rs2.18/kWh for a 660MW unit to operate at 50% minimum load factor.[59] This option will be problematic (without the introduction of a fair, technology-neutral time-of-day pricing model), given the existing high tariffs of coal-fired plants in Rajasthan.

[59] CEA. Flexible Operation of Thermal Power Plants for Integration of Renewable Energy. January. 2019.

Conclusion

Rajasthan, one of India's top solar energy states, is on track to transition to a renewable energy-driven, low-cost, low-emission electricity system. Fully utilising its solar energy potential could help India come out of the current economic downturn.

The state could be one of the largest contributors to India's target of 450GW of renewable energy by 2029/30.

IEEFA predicts Rajasthan will gradually retire and replace its outdated and end-of-life thermal power fleet and commission 22.6GW of new renewable energy capacity.

Incorporating large-scale variable renewable energy onto Rajasthan's electricity network by FY2029/30 will require active measures in smart grid integration and management, as well as leveraging the balancing of interstate electricity trade. It will also require the multi-technology options of battery storage and gas peakers to deal with variability and provide flexible power supply.

Plans to support a renewable energy-based modern system are already underway. A planned expansion of the grid network will connect renewable energy-specific zones to intrastate as well as interstate networks, with the added advantage of broader coverage somewhat smoothing variable renewable energy supply. Grid modernisation and grid digitalisation can support demand-response management.

Home to the world's largest operational utility-scale solar park, Rajasthan is a solar energy transition leader and is looking at massive ongoing new investment in renewables and grid infrastructure, as well as associated manufacturing opportunities.

The Rajasthan discoms currently struggle with three broad issues: high AT&C losses due to inefficient metering and collection processes, high power purchase prices and excessive financial leverage. IEEFA recommends the discoms deploy smart-metering systems to improve energy accounting and distributed agricultural solar irrigation pumps to reduce the average cost of power procurement and better manage on-grid demand growth.

IEEFA is confident that Rajasthan will achieve its long-term electricity sector targets – and be a model for other Indian states to follow.

About IEEFA

The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

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