Karnataka's Electricity Sector Transformation

India's Leading Renewable Energy State

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Executive Summary

Karnataka is the leading state for renewable energy in India, reaching 12.3 gigawatts (GW) of total installed capacity as of March 2018, having added 5 GW in 2017/18 alone. This was sufficient to overtake Tamil Nadu, which had long been India's top renewable energy performer. Karnataka also is one of the strongest states in India in terms of economic performance, with gross domestic product (GDP) growth averaging 7.8% since 2011/12. Karnataka accounts for 5% of India's population but 10% of its economic activity.

Recent solar tenders in Karnataka have seen near record low bids of Rs2.82-3.06 per kilowatt hour (kWh) (US$41-44/MWh), materially below the average Rs3-5/kWh for domestic thermal power tariffs and the Rs5-6/kWh tariffs required for imported coal fired power. In June 2018, Karnataka announced the introduction of reverse auctions for wind, with an upper cap of Rs3.45/kWh, following the enormous success for consumers of reverse auction wind tariffs in Gujarat and Tamil Nadu in 2017, which saw tariffs fall up to 50% to as low as Rs2.43/kWh.

Karnataka is part-way through building out the 2 GW Pavagada industrial solar park, the second largest solar development currently under construction in the world.

Beyond the move to reverse auction wind tenders, Karnataka has been taking advantage of several positive renewable energy policies (e.g. open access, the introduction of a hybrid wind-solar development policy and significant steps to reverse Karnataka's historic reliance on energy imports).

IEEFA has modelled a likely pathway for Karnataka's electricity sector development over the coming decade to 2027/28. Key modelling parameters include:

- Karnataka is set to move from being a net importer of electricity to a net balance. There is clear scope for the state to become a net exporter, but this is currently constrained by insufficient interstate grid capacity;
- Renewables moving from 12.3 GW or 46% of state capacity (27% of generation) in 2017/18 to 23 GW or 60% of capacity (43% of generation);
- Hydroelectricity at 3.6 GW or 13% of current capacity provides much-needed dispatchable energy to balance the state's growing, but variable wind and solar output. Government planning suggests little scope for this to be enhanced. We recommend evaluation of pumped hydro storage, as well as solar thermal and lithium-ion batteries;
- Thermal power currently totals 10 GW (38% of capacity and 49% of generation), and we expect this to remain steady, but critically this needs to better incorporate more flexible, peaking capacity; and
- For coal power, we model an improvement to a 53% average capacity utilisation rate by 2027/28, on the premise the current 35% utilisation rate is unsustainably low, involving such operating inefficiencies that the alternative is accelerated plant closures.

The financial distress of the thermal power sector is clear and rising. We note:

- Karnataka coal-fired power plants have incurred a massive increase in annual imported fuel costs, which we estimate have risen by almost US$300 million (m) in the last two years;
- With a lack of in-state coal mining capacity, the coal-fired power sector is challenged by the high cost of moving coal by interstate rail up to 1,200 kilometres (km). We estimate this

adds up to US$31/tonne (t) of rail costs on top of mine-mouth Indian coal costs of US$21/t (plus US$12/t tax);
- Unsustainably low coal-fired power capacity factors which we estimate hit Karnataka sector low of just 35% in 2017/18; and
- Given the expensive imported coal-based tariff of Rs5/kWh at the Udupi plant, Karnataka's distribution companies have a major incentive to contract for new solar and wind at below Rs3/kWh;
- Karnataka's decade-long attempts to build a liquefied natural gas (LNG) import facility at have been unsuccessful and there is no in-state gas supply option; and
- Building baseload gas-fired power plants in the state is not a financially viable option, as the attempts at Bidadi and Tadadi demonstrate.

Karnataka's comprehensively negative experiences in high cost imported thermal power generation and LNG import facilities provide clear examples of capital waste and stranded asset risks.

India's National Electricity Plan (NEP) 2018 assumes the retirement of the end-of-life coal-fired Raichur power station. The last 250 megawatt (MW) unit was only finished in 2010, but the first seven units were commissioned progressively from 1985-2002 and all eight units at the 1.7 GW facility utilise entirely out-dated, highly polluting subcritical combustion technology.

We assume the proposed 1.6 GW expansion at the Udupi power plant, which would rely on imported coal, will not be constructed, but we assume the long-delayed 1.32 GW Gulbarga 1.32GW coal-fired plant will be built to replace the retired capacity of Raichur Power Plant for system balancing. IEEFA recommends that the Gulbarga proposal should be redesigned to incorporate modern ultra-supercritical technology with full emissions controls and new flexible ramping technologies. We also assume completion of the 370 MW Yelahanka gas-fired power plant proposal, but only after being converted to a gas-peaking capacity design and incentivised with time-differentiated tariffs. While expensive options, this likely replacement capacity should maintain much needed diversity of on-demand supply while Karnataka continues to transition toward a predominantly renewable energy based future.

In contrast to Tamil Nadu, Karnataka's five state distribution companies (discom) have gone backward financially in 2017/18, missing their close-to-breakeven net profit target, instead reporting a combined net loss of US$180m. However, the discoms' aggregate technical & commercial (AT&C) losses have dropped from 18.06% in 2014/15 to 14.71% in 2017/18. The increasing penetration of low cost renewables provides a major opportunity to procure long term zero inflation electricity supplies below Rs3/kWh and progressively dilute expensive imported coal-fired power (e.g., Udupi at Rs5/kWh). This provides the discoms the opportunity to progressively narrow the average cost of supply to average revenue realisation gap and belatedly reach a positive net profit position.

Karnataka's progressive leadership offers a positive role model of electricity system transformation for the rest of India. As other states follow Karnataka's lead, India is set to take its place as a global leader in decarbonisation. The merits of adopting increasingly low-cost technology innovation and more sustainable development provides India with an alternative path to the now outdated plan of increased reliance on expensive fossil fuel imports, with all the associated externalities of water, air, particulate and fly ash pollution, plus rising current account deficits, ongoing currency devaluation and energy-induced inflation.

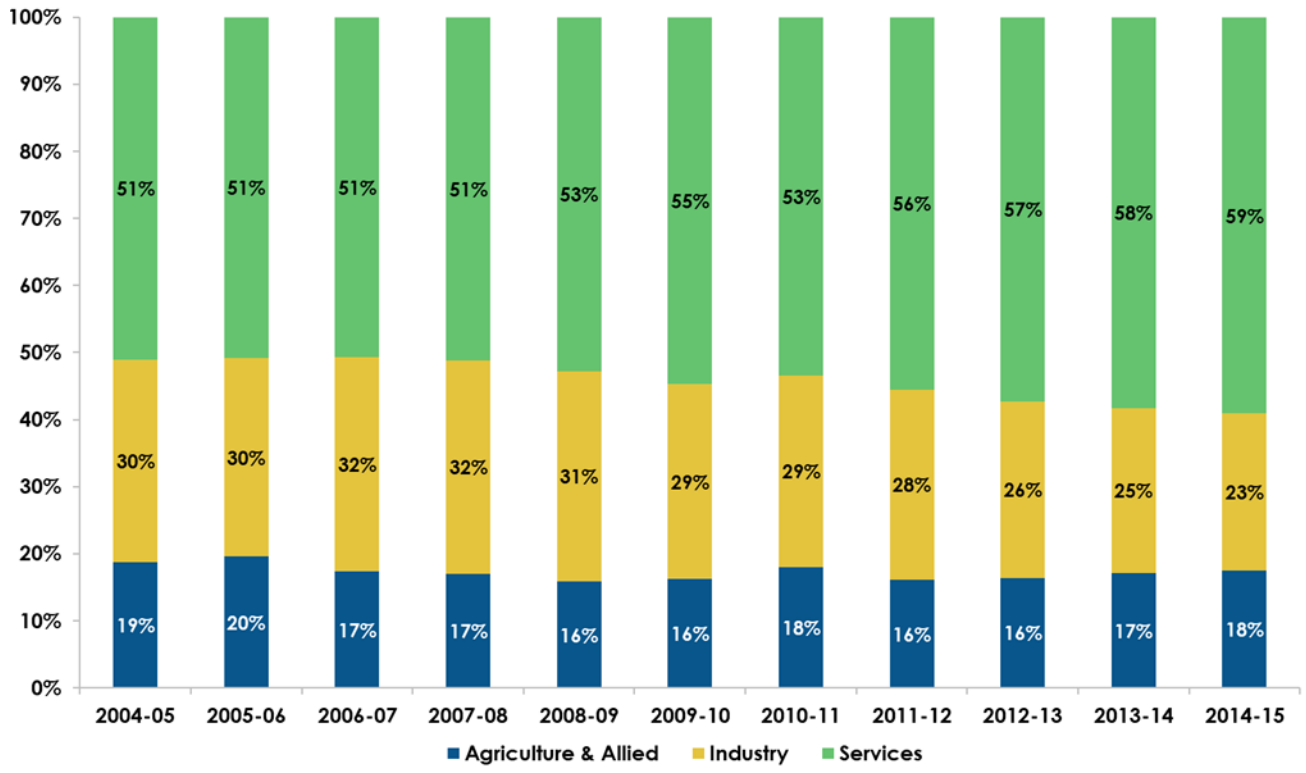
1. Karnataka

Economic Review

The southern Indian state of Karnataka is home to India's Silicon Valley—its capital city Bengaluru. India's well-established Information technology (IT) hub is the world's fourth largest technology cluster. The state of Karnataka has 47 IT special economic zones (SEZs), three software technology parks and dedicated IT investment regions.[1] Favourable policies designed by Karnataka have encouraged industries to set up their research and development (R&D) centres in the state. Karnataka has about 401 R&D centres and about 400 of the Fortune 500 companies have outsourced their IT operations to firms in Bengaluru.

The state's GDP has grown at an average rate of 7.8% in real terms since 2011/12. It is one of the fastest-growing states in India owing to its policy incentives and infrastructure capacity. Apart from its impressive IT sector, Karnataka attracts investments in sectors of biotechnology, engineering, electronics, automotive, textiles, agriculture and food processing.

Figure 1.1: Karnataka's GDP Composition (By Sector)



Source: Ministry of Statistics and Program Implementation of India.

Karnataka is an important economic state for India as it generates almost 10% of the country's total output even though it only accounts for 5% (~66.8m) of the country's population. The state is among India's top-performing states, trailing only Maharashtra and Tamil Nadu in terms of total output and exports.

[1] https://www.ibef.org/states/karnataka.aspx

As it is evident in Figure 1.1, the service sector is the driving force in the state's economy, accounting for more than half of total output since 2004. Despite being heavily reliant on the service sector, Karnataka has been focusing on boosting its industrial sector in recent years. In October 2017, the state government approved a proposal by its industrial development board for a multi-product industrial park in the Ramanagara district.[2]

Karnataka is also the second-largest textile employer in India. To strengthen this key industry, the government launched a textile modernisation program (Nuthana Javali Neeti) in 2013. In the program's five years, the government has provided capital and interest subsidies, helped with an effluent treatment plant and offered capacity building support for marketing, branding and product diversification in an effort to improve the industry's entire value chain.[3]

[2] http://www.business-standard.com/article/economy-policy/green-nod-to-karnataka-s-rs-1-561-cr-harohalli-industrial-park-117100100066_1.html
[3] http://www.karnatakadht.org/pdf/New_Textile_Policy_-_2013-18.pdf

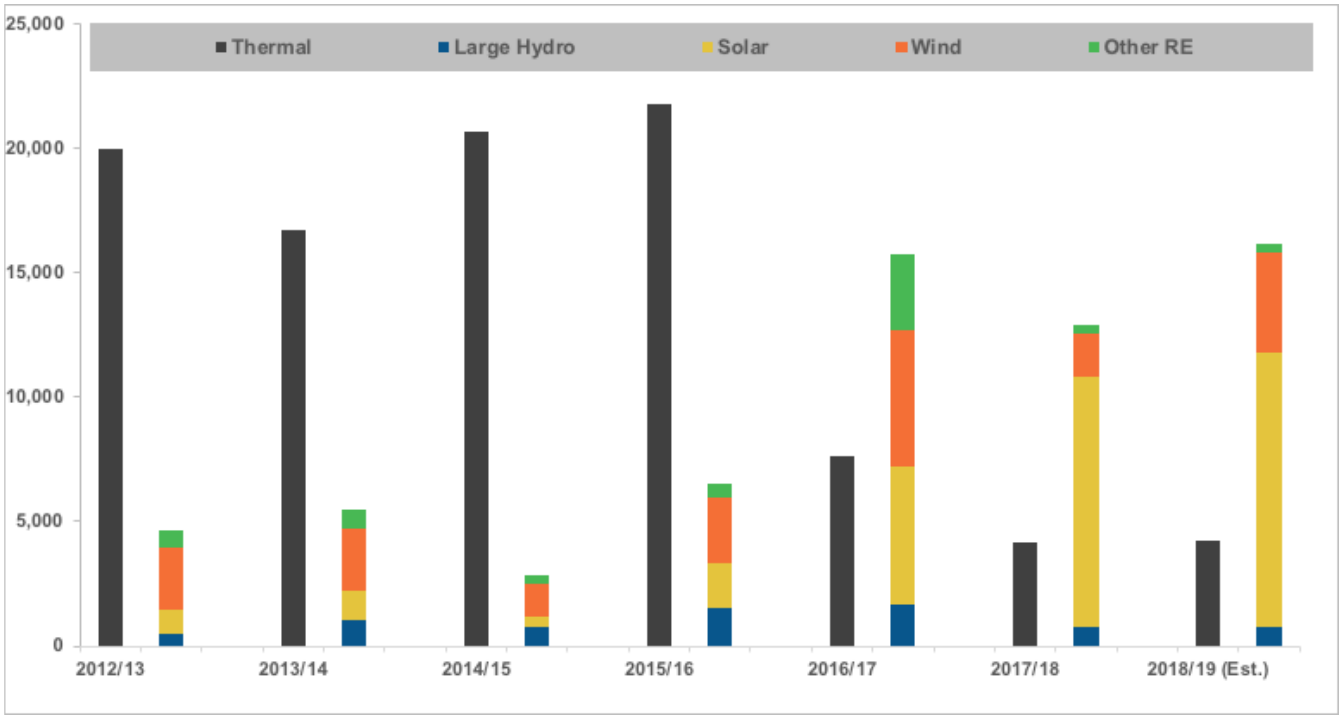
2. Karnataka's Electricity Market

An Indian Electricity Market Primer

The election of Prime Minister Narendra Modi in 2014 ushered in an era of transformation in India's electricity market, pushed largely by his ambitious plan to build 275 GW of renewable energy capacity by the end of 2026/27. Since his election, the renewable sector has grown significantly, doubling in the last three years overall, with a near doubling of its solar portfolio with a record 10 GW of solar capacity installed in 2017/18 alone. At the same time, there has been a drastic slowdown in new capacity construction in the country's troubled thermal power generation sector, particularly where reliant on expensive imported coal and gas.

India's long-term strategy to diversify and decarbonise its electricity supply has been aided by technological improvements, cost deflation, availability of cheaper financing and a growing interest from global renewable energy developers, utilities and investors. In IEEFA's view this ongoing transformation offers a sustainable solution to the country's dire energy poverty and air pollution problems, whilst also reducing its excessive reliance on imported fossil fuels. At the same time, it provides an opportunity to create jobs and boosts the government's "Make in India" program with manufacturing potential in solar, wind, batteries, electric vehicles and the entire energy efficiency value chain (e.g., solar irrigation pumps, solar hot water, heat pumps, air conditioners, etc.).

Figure 2.1: India Renewable and Thermal Power Capacity Additions (MW)



Source: Central Electricity Authority of India (CEA), MNRE India, IEEFA estimates.

Figure 2.2: India Electricity Sector Composition 2017/18

	---- Capacity ----		-- Generation --		Capacity	Increase
	GW	%	TWh	%	Utilisation	GW yoy
Coal-fired	197.2	57.3%	979.4	75.1%	57.4%	5.0
Gas-fired	24.9	7.2%	53.6	4.1%	25.0%	-0.4
Diesel-fired	0.8	0.2%	2.0	0.2%	25.0%	0.0
Large Hydro	45.3	13.2%	126.1	9.7%	32.1%	0.8
Nuclear	6.8	2.0%	38.2	2.9%	64.3%	0.0
Renewables	69.4	20.1%	100.5	7.7%	19.7%	12.1
Bhutan	n.a	n.a.	4.9	0.4%	n.a.	
Total	**344.3**	**100%**	**1,304.7**	**100%**		**17.5**
Capitve Power	51.4					
Total	**395.7**	114.9%				

Source: Central Electricity Authority of India (CEA), IEEFA estimates.

India's National Electricity Plan 2018

India's newest electricity sector blueprint, the National Electricity Plan (NEP) 2018 retains the ambitious core target of 275 GW renewables by 2027 from the plan's 2016 draft. It also includes a timeline for starting to deal with the country's most-polluting coal-fired power plants, which should ease concerns about the lack of visible progress to date by the Ministry of Power in terms of the deferral of tighter air pollution regulations.

The NEP includes a new target for closing 48 GW of end-of-life coal plants. Specifically, the plan forecasts 22.7 GW of coal power plant closures by 2021/22, which includes 6 GW of normal end-of-life retirements and 17 GW of closures due to inadequate space for flue gas desulfurization (FGD) equipment. The plan notes that these retirements "would not likely pose any problem in meeting the demand (for electricity) during 2021/22." An additional 26 GW of coal capacity is slated for retirement in the following five years to 2026/27.[4]

Accounting for these planned retirements and expected new construction totalling 94 GW, the NEP 2018 sees India's coal power capacity hitting 238 GW in 2027, 11 GW lower than the 2016 draft.

Figure 2.3: India Declining Thermal Capacity Share - NEP 2018 Additions & Retirements

			2016/17-2021/22				2021/22-2026/27				National Electricity Plan	
GW	Mar-17	Share	Adds	Closures	Mar-22	Share	Adds	Closures	Mar-27	Share	Draft	Change
											2016 Plan	2018 vs. 2016
Coal + Lignite	192		48	-23	217		46	-26	238		249	-11
Gas	26		0	-1	26		0	0	26		29	-3
Total Thermal	218	**67%**			243	**51%**			264	**43%**		
Total Capacity	327				479				619		650	-31

Source: National Electricity Plan India 2018.

[4] India's National Electricity Plan, Annexure 5.4, 5.5, 5.6

Karnataka's Electricity Sector in 2017/18

Figure 2.4: Karnataka Electricity Sector Composition 2017/18

Source	Electricity Market Composition 2017/18					
	Capacity		Generation		Capacity	YoY change
	GW	% of Total	TWh	% of Total	Utilisation	GW
Coal	9.8	37%	29.7	49%	35%	0.4
Gas	0.0	0%	0.0	0%	n.a.	0.0
Diesel	0.2	1%	0.3	0%	20%	0.0
Hydro	3.6	13%	7.1	12%	23%	0.0
Nuclear	0.9	3%	7.5	12%	98%	0.0
Renewable	12.3	46%	16.2	27%	15%	5.0
Total	**26.7**	**100%**	**60.9**	100%		**5.4**

Source: Central Electricity Authority, IEEFA estimates.

Karnataka overtook Tamil Nadu to become India's number one state for renewable energy capacity in 2017/18. Karnataka had been building its wind energy capacity steadily over the past 10 years, but it moved ahead of Tamil Nadu due to a rapid scaling up of solar capacity in 2017/18, when it installed more than 4 GW of new photovoltaic generation.[5] Currently, the state has 5 GW of solar capacity and 4.7 GW of wind capacity. The remainder of its renewable portfolio (2.6 GW) includes small hydro, biomass, plus heat and power cogeneration.[6]

As detailed in Figure 2.4, almost the entirety of its thermal capacity is composed of coal-fired generation, with only a small amount of diesel capacity. The only thermal project added in 2017/18 was Unit 3 at the Kudgi Super Thermal Power Project, which brought an additional 800 MW of generating capacity online (400 MW of existing coal capacity was taken offline for repairs during the year).

Karnataka's three largest coal-fired power facilities, totalling 5 GW of capacity are owned by Karnataka Power Corporation Limited (KPCL), the state-owned generation company.

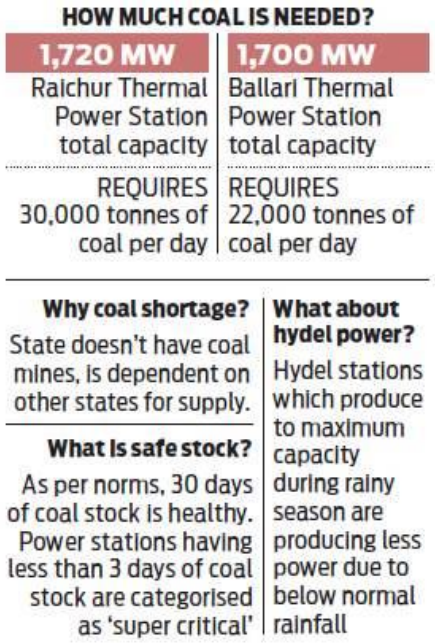
Karnataka does not have any in-state coal production. It is dependent on coal delivered via railways from mines outside the state and on imported seaborne coal. The domestic coal comes from Western Coal Fields Limited (Maharashtra), Mahanadi Coal Fields (Odisha), Singareni Coal Mines (Telangana) and Pakri Barwadih (Jharkhand),[7] mines located 700 to 1,200 kilometres (km) distance from the power plants, introducing severe rail logistics issues and potential additional transportation-related costs for the state's thermal generation.

Relying on distant, out-of-state coal supplies also raises the possibility of supply shortages. It was reported in November 2017 that all three of KPCL's plants were facing severe coal

[5] https://mercomindia.com/karnataka-top-solar-state-india/
[6] http://kredlinfo.in
[7] http://www.newindianexpress.com/states/karnataka/2017/sep/24/karnataka-stares-at-power-crisis-as-coal-stocks-may-last-just-one-day-1661875.html

shortages; with less than half of the daily coal tonnage required for operation (refer to Section 4 for additional information).[8]

Figure 2.5: Coal Shortage in Karnataka



Source: Indian Express, Ashwini M Sripad, 24th September 2017.[9]

The State Load Dispatch Centre (SLDC) also said November 2017 that Karnataka had resorted to hydropower to avoid thermal power outages.[10] Hydropower stations in India normally operate at their maximum capacity only during the monsoon. In addition, Karnataka's 880 MW of nuclear capacity operated at an unusually high capacity factor of 98%, about 15% higher than the programmed capacity factor of 83% for 2017/18.[11] Moreover, IEEFA estimates that the state had to import about 7 TWh of electricity from interstate in 2017/18 to meet its total requirement of 67 TWh for the year 2017/18. These factors indicate that other power sources were needed to cover for the shortcomings and inefficiencies of the state's coal sector, which IEEFA estimates posted an economically unviable capacity factor of just 35% during the year.

IEEFA believes that the state's coal-fired power plants are potential stranded assets that impose additional risk on the distribution companies, the banks and the overall Karnataka economy. We provide a more detailed analysis of Karnataka's thermal power sector in Section 4.

[8] http://www.thehindu.com/news/national/karnataka/coal-crunch-hits-thermal-power-generation/article20557326.ece
[9] http://www.newindianexpress.com/states/karnataka/2017/sep/24/karnataka-stares-at-power-crisis-as-coal-stocks-may-last-just-one-day-1661875--1.html
[10] https://www.deccanherald.com/content/644675/coal-shortage-forces-karnataka-govt.html
[11] http://cea.nic.in/reports/monthly/generation/2018/March/actual/opm_16.pdf Page 23

3. IEEFA's Electricity Sector Model for Karnataka

In IEEFA's view, Karnataka's electricity generation mix, while statistically relatively balanced, is far too heavily weighted toward fossil fuels because of its reliance on poor performing and expensive non-minemouth coal-fired thermal generation for almost 50% of its electricity needs. On the upside, renewables account for 46% of the state's installed generation capacity (although just 27% of the generation). Hydropower at 13% and nuclear power at 3% make up the balance of the capacity mix as of March 2018.

As with southern India overall, Karnataka is a state with abundant renewable energy potential. As such, Karnataka has a massive opportunity to improve its electricity supply whilst doing away with its over-reliance on operationally challenging, expensive non-minemouth coal.

In this section, IEEFA presents a model for Karnataka's electricity supply and demand for the decade up to 2027/28. We predict a doubling of economic activity in the coming decade with steady 7.8% GDP growth that will drive a cumulative 73% increase in electricity demand If the state's aggregate technical & commercial (AT&C) losses can be reduced from 15.3% in 2017/18 to 10.3% by 2027/28, electricity production requirements will rise 63% or 42 terawatt-hours (TWh). Karnataka also imported 7 TWh of electricity in 2017/18. If the state wants to reach net zero imports, its total new supply requirements will climb to 49 TWh by 2027/28. Note that net zero imports by 2027/28 is a conservative estimate; there is ample scope for Karnataka to become an electricity exporter through expansion of its renewable generation resources.

Decoupling GDP Growth, Electricity Demand and Electricity Production

In November 2017, the U.S. Energy Information Administration (EIA) published an analysis showing that there is growing evidence of a decoupling between economic activity and electricity demand,[12] with improving energy productivity keeping growth in electricity demand growth below that of GDP. This transition has been under way in the more-advanced members of the Organization for Economic Cooperation and Development (OECD) for some time, as a result of ongoing energy efficiency improvements and with the ongoing economic shift from low-skilled manufacturing to services and more energy efficient manufacturing.

More importantly for the global picture, there was a major decoupling of economic growth and electricity demand in China post 2013. For the period 2000-2013, electricity demand grew almost in lockstep with China's 10% annual economic growth. Since 2014, the ratio has dropped to roughly half, with economic growth sharply outpacing growth in electricity demand.

[12] https://www.eia.gov/todayinenergy/detail.php?id=33812

In India's case, electricity demand growth also has slowed since 2015. Over the past three years, electricity demand grew at a compound annual growth rate (CAGR) of 5.9%, compared to 7.2% for the nation's annual GDP growth rate—clearly illustrating this decoupling effect. The slower growth in electricity demand can be explained partly by the shift in India's economy away from energy-intensive industries to more service-oriented enterprises that consume less electricity.

Karnataka, where GDP has grown at an average rate of 7.8% since 2011, is a prime example of this phenomena. Services as a sector contributed close to 60% of the total output of the state in 2017/18, up from 53% in 2011, reflecting growth through less energy intensive activities (refer to Figure 1.1).

In contrast, electricity consumption in Karnataka has grown at an average rate of 3.8% since 2011/12. To be conservative in our modelling, we assume that this low 0.5 ratio of electricity demand growth to GDP will be hard to sustain in the long turn and will climb to roughly 0.85 (see Figure 3.1 below).

Figure 3.1: Karnataka Electricity Supply & Demand 2027/28

GDP Growth (%)	7.8%
Electricity to GDP Multiplier Pre-EE	0.85
Electricity Demand Growth (%)	6.6%
Energy Efficiency	-1.0%
Electricity to GDP Multiplier Inclusive Growth	0.72
Reduced Grid AT&C Losses	-0.50%

Year Ended March	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28
Gross Production (TWh)	66.9	67.7	71.1	74.7	78.4	82.3	86.4	90.8	95.3	100.1	105.1	110.4
Gross Production Growth (%)		1.3%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
AT&C Losses (TWh)	10.1	10.4	10.5	10.7	10.8	10.9	11.0	11.1	11.2	11.3	11.3	11.3
AT&C Losses (%)	15.1%	15.3%	14.8%	14.3%	13.8%	13.3%	12.8%	12.3%	11.8%	11.3%	10.8%	10.3%
Reduced Grid Losses		-0.5%	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%
Real GDP Growth (%)	7.8%	7.8%	7.8%	7.8%	7.8%	7.8%	7.8%	7.8%	7.8%	7.8%	7.8%	7.8%
Electricity Multiplier (x)	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Electricity Growth (%)	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%
Energy Efficiency	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%
Net Demand Growth (TWh)	56.8	57.4	60.6	64.0	67.6	71.4	75.4	79.6	84.1	88.8	93.8	99.0
Net Demand Growth (%)		1.1%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%

Source: IEEFA estimates.

Factoring annual energy efficiency gains of about 1%, IEEFA estimates that Karnataka's net electricity growth will be 0.72 times its GDP growth in the coming decade. Introduction of LEDs, energy efficient air conditioners, solar irrigation pumps and better building construction standards all will assist in this least cost, least polluting source of procurement—the electricity production not needed.

Additionally, our model assumes that the state will be able to trim its too-high AT&C losses from the current 15.3% to 10.3% in 10 years, a 0.5% annual decline. Cutting AT&C is a national priority being targeted through India's Ujwal Discom Assurance Yojna (UDAY) program designed to improve the financial condition of the country's distribution utilities. Cutting losses from transmission and distribution by definition reduces needed new electricity production requirements. Reduction in commercial losses, which mostly occurs due to theft of electricity, will require the roll out of a smart metering system that should immediately reduce such losses.

In another energy saving initiative, in June 2018, Power Minister R.K. Singh announced a US$21.5 billion (bn) program, Kisan Urja Suraksha Evam Utthaan Mahaabhiyan (KUSUM), to distribute 2.75m solar irrigation pumps, with a million of these pumps to be connected to the grid. This excellent scheme is of such a scale that it has the potential to progressively eradicate heavily subsidised, imported diesel-based pumps, deliver energy savings and improve energy security to India's struggling agriculture industry.[13]

Taking all this into account, IEEFA projects a net 5.6% CAGR in electricity demand over the coming decade. This translates into a demand increase of 49 TWh by 2027/28 including production requirement to offset about 7 TWh net of imported electricity in 2017/18.

[13] https://energy.economictimes.indiatimes.com/news/renewable/solar-power-scheme-entailing-rs-1-4-lakh-cr-to-be-implemented-from-next-month-rk-singh/64466417

Figure 3.2: Karnataka Electricity Sector Expansion by 2027/28

Karnataka's Waterfall Chart				
Net Electricity Consumed in Karnataka in 2017/18 (TWh)			57	
Net Electricity Imported in Karnataka in 2017/18 (TWh)			7	
Real GDP Growth	7.0%	pa		
Electricity to GDP Multiplier	0.72	times		
Electricity Demand Growth	6.6%	pa	46	
Energy Efficiency	-1.0%	pa	-6	
Growth: Gross Production Losses			7	
Reduced Grid AT&C Losses	-0.50%	pa Grid Efficiency Gain	-5	
Net Electricity Consumed in Karnataka in 2027/28 (TWh)			99	
Net Expansion in Electricity Demand 2027/28 (TWh)			42	
Net Expansion in Electricity Production Required (TWh)			49	

The Increase in Net Electricity Demand is Met by (TWh)	TWh	Uplift
Solar Expansion	13	25%
Solar Rooftop Expansion	3	6%
Solar Thermal Expansion	1	2%
Onshore Wind Expansion	13	26%
Increase in Biomass Generation	1	2%
Increase in Combined Heat & Power Generation	1	3%
Increase in Hydro Electricity	0	0%
Increase in Gas-fired Electricity	1	2%
Increase in Nuclear Generation	4	7%
Change in Coal-fired Power Use	13	26%
Net Expansion in Electricity Production by 2027/28 (TWh)	49	100%

Source: IEEFA estimates.

New Demand Met by Zero Emission Supply

IEEFA's forecast of 4.5 GW of new utility-scale solar capacity in the decade to 2027/28 looks entirely viable after the 640 MW solar auction in March 2018, which included winning bids between Rs2.94-3.07/kWh.[14] Combined with 1.4 GW of new distributed rooftop capacity, solar is set to deliver 33% of the incremental electricity demand in the coming decade. This looks decidedly unambitious relative to the 3.9 GW of solar additions in 2017/18 alone, but needs to be balanced against the context of the unsustainably low capacity utilisation rate of coal-fired power plants in Karnataka (estimated at just 35% in 2017/18). More low-cost utility solar can and should be added, but only as sufficient interstate power grid transmission capacity is added as well to avoid curtailment and boost net exports to states with lower solar radiation potential.

Figure 3.3: Karnataka Coal-fired Power Capacity Factor for 2017/18

Average Coal-fired Capacity for 2017/18 (GW)	9.6
Number of Hours Per Annum	8,760
Generation at Full Capacity (TWh)	84.2
Estimated Coal-fired Generation for 2017/18 (TWh)	29.7
Capacity Factor (%)	35%

Source: CEA, IEEFA estimates.
Note 1: IEEFA has calculated coal fired power capacity utilisation rate by deducting diesel generation (from reported thermal generation) on an assumed 20% capacity utilisation rate. Note 2: India tends to report plant load factors (PLF), but to IEEFA this overstates utilisation rate because it excludes when capacity is reduced by capex downtime, no coal availability etc.

Onshore wind capacity additions could provide about 25% of Karnataka's new production needs in the coming decade. Moreover, commissioning of Kaiga's Atomic Power Station's fifth unit of 700 MW, currently under development,[15] should provide 3.4 TWh (some 7%) of the additional 49 TWh needed, with the balance delivered by small hydro, biomass and cogeneration sources. Karnataka does not have any large hydro, solar thermal or offshore wind planned. Accounting for these changes, total market share for coal-fired generation will drop to 39% in 2027/28 from 49% in 2017/18.

Figure 3.4: Karnataka Electricity Sector Composition 2027/28

Source	Electricity Market Composition 2027/28					
	Capacity		Generation			Capacity
	GW	% of Total	TWh	% of Total	FY18 vs. FY28	Utilisation
Coal	9.4	25%	43.3	39%	-9%	53%
Gas	0.4	1%	0.8	1%	1%	25%
Diesel	0.2	0%	0.3	0%	0%	20%
Hydro	3.6	9%	7.1	7%	-5%	23%
Nuclear	1.6	4%	11.1	10%	-2%	80%
Renewable	23.0	60%	47.3	43%	16%	23%
Total	**38.1**	**100%**	**109.9**	**100%**		

Source: IEEFA estimates.

[14] https://mercomindia.com/ppa-signed-640mw-solar-kredl/
[15] https://www.deccanherald.com/content/596148/kaigas-700-mwe-units-delayed.html

The Solution: Viable Medium-term Coal Capacity Factors

Karnataka does not have any new coal-fired capacity under construction according to Global Coal Plant Tracker July 2018. Further, it only has a total of 2.92 GW of coal-fired capacity in the development pipeline — Adani Power's planned 1.6 GW expansion at its Udupi Power Station (Units 3 & 4) and Power Company of Karnataka Ltd's (PCKL) proposed Gulbarga Power Station, a two-unit plant with 1.32 GW of capacity.

Adani Power Ltd's proposed Udupi expansion is running well behind its initial 2020 completion date and without a multi-billion dollar capital infusion, IEEFA does not expect the expansion, which would rely on excessively expensive imported coal, to be completed.

PCKL's Gulbarga power station still must secure its 'environmental clearance' (EC) from India's Ministry of Environment, Forests & Climate Change (MOEF&CC). Also, with no fuel allocation attained as of now, and the likely high cost of electricity resulting from excessive rail or interstate shipping costs, the commissioning date for this project remains uncertain (Please refer to Section 4 for a detailed appraisal of Karnataka's coal-fired capacity, expansion plans and expected retirements).

Of the two, IEEFA believes there is a greater chance the Gulbarga power station will be completed since the project is backed by PCKL, a state-owned company, and likely has greater political power to gain environmental approvals, secure power purchase agreements (PPAs) and access subsidised state financing. However, in IEEFA's view, the state would be better served if the funds from this proposed investment were redirected into ensuring interstate grid capacity upgrades are accelerated, which would enable an even more ambitious renewable energy investment program in the coming decade and accelerate electricity exports for the state.

India's NEP 2018 forecasts a nationwide end-of-life thermal plant retirement program by 2026/27. The 1.72 GW Raichur thermal plant, owned by Karnataka Power Corporation Ltd (KPCL), will reach end-of-life by 2021/22. This facility, running on entirely out-dated subcritical technology, definitely needs to be retired in accordance with the 2018 plan.

IEEFA's model assumes the 1.32 GW Gulbarga station is commissioned before 2027/28 and that the Raichur plant of 1.72 GW is progressively retired, meaning the state's coal-fired capacity will total 9.4 GW by March 2028 (down from 9.8 GW currently). This slightly reduced net capacity over the coming decade, coupled with an improved average capacity factor of 53%, appears to be the only hope for medium-term viability for the coal-fired power generation sector. Any new build capacity is bound to face impossible-to-beat competition from ever-more deflationary renewable sources. Additionally, Karnataka's overdependence on expensive interstate and international imported coal worsens the economic viability of its coal-fired power plants. Further, this imported coal dependence also poses a major stranded asset risk, both for any new coal-fired plants as well as the state's existing coal-fired power plants over the medium to longer term. Investment decisions on retrofits for much-needed pollution controls will reach the point when policymakers will be forced to consider whether the additional funds should even be deployed given the high imported fuel costs, rising pollution and emissions pressures, ongoing water stress and deflationary renewables undermining already unsustainably low utilisation rates for coal power.

4. Thermal Generation in Karnataka

Power from Imported Coal: An Unreliable, Unviable, Expensive Option for Karnataka

Karnataka has a total coal-based power capacity of 9.8 GW. Karnataka Power Corporation Ltd and NTPC Ltd own the largest coal-fired capacities, of 5 GW and 2.4 GW respectively. Almost 40% of Karnataka's coal-based power generation is aging and operating on out-dated, subcritical combustion technology. In addition, the entire fleet is dependent on expensive interstate or international imported coal.

In the past, and even as recent as May 2018,[16] coal availability has been a serious challenge. The three power plants owned by KPCL, on which the state is heavily dependent for baseload electricity, ran with coal stocks way below critical levels in recent months.[17] Coal shortages, the operational inefficiencies in transporting coal and rising imported coal prices make coal-based electricity generation highly unreliable and an expensive source of electricity over the medium and long term.

Figure 4.1: Karnataka Coal-fired Power Plants, Owners, Technology & Coal Source Linkages

Proponents	Capacity (MW)	Combution Technology	Year of Commissioning	Tariff (Rs/kWh)	Coal Linkages/Supply
Adani Group	**1,200**				
Udupi Power Station	1,200	Supercritical	2010-2011	5.00	Imported Coal
BHEL, KPCL	**1,600**				
Yeramarus Power Station	1,600	Supercritical	2016-2017		No Coal Supply Linkage, Dependent on Coal Supplied to RTPS
BMM Ispat	**235**				
Danapuram BMM Power Station	235	Subcritical	2011-2015		-
JSW Group	**860**				
JSW Vijayanagar Toranagallu Power Station	860	Subcritical	1999-2009		Imported Coal
KPCL	**3,420**				
Bellary Thermal Power Station	1,700	Subcritical & Supercritical	2007-2016	4.55	Western Coalfields Ltd (Maharashtra), Mahanadi Coalfields Ltd (Odisha), Singareni Collieries Co. Ltd., (Telangana)
Raichur Thermal Power Station	1,720	Subcritical	1985-2010	3.99	
NTPC	**2,400**				
Kudgi Super Thermal Power Project	2,400	Supercritical	2016-2018		Pakri Barwadih (Jharkhand)
Surana Industries Limited	**35**				
Vadlur Power Station	35	Subcritical	2008		Imported Indonesian Coal
Total	**9,750**				

Source: Global Coal Plant Tracker, CEA, Press reports, IEEFA estimates.

[16] https://energy.economictimes.indiatimes.com/news/coal/state-owned-power-plants-resume-coal-imports-amid-shortages/64205798

[17] http://www.thehindu.com/news/national/karnataka/coal-crunch-hits-thermal-power-generation/article20557326.ece

Coal-fired Power Plants: KPCL

The state government wholly owns Karnataka Power Corporation Ltd (KPCL), which operates 5 GW of coal capacity and 3.7 GW of hydro, wind and solar capacity.[18]

- The 1.6 GW **Yeramarus Power Station** is owned by a joint venture between KPCL and Indian engineering giant Bharat Heavy Electricals Ltd (BHEL). The station has two units commissioned by BHEL in 2016 and 2017. The plant, which uses supercritical combustion technology, is one of the few newly built plants in Karnataka. The plant does not have any dedicated coal supplies; instead it is dependent on the existing coal linkages of KPCL's other power plants.[19] As reported in November 2017, due to problems with the state's long coal-supply chain, IEEFA estimates the plant operated at less than 50% of capacity during the year.
- **Bellary Thermal Power Station,** totalling 1.7 GW, consists of three units, including the third 700 MW unit commissioned in 2016. The first two units, each 500 MW, run on subcritical combustion technology. The plant's coal supply contract is embroiled in a legal dispute, forcing it to share coal shipments intended for the Raichur plant. This cut its shipments from the 17,000 tonnes required daily for full operation to just 7,000 tonnes/day last year.[20] The power plant also charged an unsustainably high average tariff of Rs4.55/kWh during 2017/18, more than 60% above the state's latest solar auctions.
- The eight units at the **Raichur Thermal Power Station** have a total capacity of 1.7 GW. The power plant is Karnataka's oldest operational coal-based power plant with the first unit commissioned in 1985. The power facility operates on out-dated subcritical combustion technology and is scheduled to be retired over the coming decade, according to the National Electricity Plant 2018. A tariff of Rs3.99/kWh was reported for 2017/18, more than 40% above the state's latest solar auctions.

Figure 4.2: Impact of Coal Transportation on Cost of Electricity Generation

Distance (km)	200	700	1,200
Freight Rate (Rs/T)	490	1,320	2,077
Freight Rate (Rs/Kg)	0.49	1.32	2.08
Coal Requirment (Kg/kWh)	0.80	0.80	0.80
Cost of Coal Transportation (Rs/kWh)	**0.39**	**1.06**	**1.66**

Source: IEEFA Estimates, Indian Railways Freight Operations.[21]

The three plants operated by KPCL source fuel from coal mines operated by Singareni Collieries Co. Ltd. (Telangana), Western Coalfields Ltd. (Maharashtra), and Mahanadi Coalfields Ltd. (Odisha), at 250, 700 and 1,200 km respectively from the plant locations. In India, transportation costs are a major component of final coal-fired electricity prices, adding Rs1.06-Rs1.66/kWh for shipments of 700-1,200 km.

[18] http://karnatakapower.com/en/
[19] http://www.thehindu.com/news/national/karnataka/coal-crunch-hits-thermal-power-generation/article20557326.ece
[20] http://www.thehindu.com/news/national/karnataka/coal-crunch-hits-thermal-power-generation/article20557326.ece
[21] https://www.fois.indianrail.gov.in/FoisWebsite/html/Freight_Rates.htm

Figure 4.3: Cost of Coal in India

Estimated Cost of Domestic Indian Coal Delivered 1,200 km to Power Plant			
	Rs/t	US$/t	Composition
Coal Price (Mine-mouth From Coal India Ltd.)	1,406	21	32%
Coal Taxes (Levies, Excise & Corporate)	845	12	20%
Rail Transport (1,200 km)	2,077	31	48%
Total Coal Cost	4,328	64	
Blending Domestic and Imported Thermal Coal			
	kcal NAR		
Domestic Cost Grossed Up to Import Equivalent	4,000	95	75%
Newcastle Benchmark (Landed)	6,000	127	
Newcastle Benchmark (Fob)	6,000	115	91%

Source: Coal India Ltd, Indian Railways Freight Operations, IEEFA estimates.

IEEFA's analysis of data from Coal India Ltd (CIL) for 2017/18 indicates that the total costs for coal shipped 1,200 km is about Rs4,328/t (US$64/t), with the transportation costs accounting for a staggering 48% of the total (See Figure 4.3 above). Additionally, compared to zero fuel costs for renewables, the coal-fired power generators, and eventually the end-users, have to bear high taxes that account for 20% of the delivered fuel cost.

Figure 4.4: Karnataka's Coal Bills 2017/18

Karnataka Coal Use	km	Quantity Split	Mtpa	US$/t delivered	US$m	RsBn	Increase on FY2017 (US$m)
Interstate	200	26%	6.30	38	241	16	22
Interstate	700	26%	6.30	54	337	23	30
Interstate	1,200	27%	6.32	64	402	27	36
Imported	5,000	20%	3.25	127	412	28	206
Total Coal Purchases		**100%**	**22.16**	**282**	**1,392**	**95**	**294**

Source: IEEFA estimates, CIL, Thomson Reuters.

Figure 4.4 above provides an estimate of the state's total coal bill for 2017/18 based on its generation for the year. Owing to expensive imported coal prices and costs involved in interstate transportation, the Karnataka's coal bill totalled US$1,392m (Rs9,500 crore) in 2017/18. This is an increase of US$294m from the prior year, driven largely by rising costs for imported seaborne coal, which illustrates the massive risks involved in having to bring supplies in from distant facilities.

The imported coal prices have doubled from the lows of US$50 in 2016 to above US$100 in 2018. Recent research from Indian Ratings noted that doubling of imported coal prices combined with rupee depreciation has increased the variable cost of generation from Rs1.86/kWh in the second quarter of 2016-17 to Rs3.43/kWh in the first quarter of 2018-19.[22]

[22] https://energy.economictimes.indiatimes.com/news/power/short-term-power-prices-to-hover-between-rs-3-75-and-rs-4-25-per-unit/64842813

IEEFA estimates that consumers will be forced to absorb a third of these cost increases, with the remainder split by the generation and distribution companies—a sub-optimal outcome for all stakeholders.

NTPC Ltd

India's state-owned NTPC Ltd is the largest power producer in the country with a total coal portfolio of 45.9 GW.[23] NTPC has relatively robust financials and is one of the best thermal power operators in India. The company reported a net profit of US$1.47bn for 2017/18, 5% down from the previous year. NTPC's average coal plant capacity utilisation fell to 67% in 2017/18 from 72% in 2016/17. Increased depreciation, higher debt and hence financing costs plus significant coal availability issues all negatively affected NTPC's performance.

NTPC's one operating coal plant in Karnataka is the three-unit, 2.4 GW **Kudgi Super Thermal Power Project** (Kudgi STPP). Kudgi is the state's newest coal-fired power plant, commissioned between 2016 to 2018, and uses more efficient supercritical combustion technology. Kudgi STPP sources its entire coal requirement from its own captive coal-mining block in Pakri Barwadih (Jharkhand), which is a problematic 1,800 km distant.[24] The project was approved in 2010 but protests from local farmers caused significant construction delays.[25] The plant originally was planned as a 4 GW facility to include five units of 800 MW each, but NTPC decided to not proceed with the last two units in 2017. Declining solar energy prices and years of local protests were reported as the main reasons behind NTPC's decision to cancel the final two units, a planned capacity expansion that previously was considered crucial for power supplies not only in Karnataka but also throughout India's entire southern tier.[26]

Imported Coal Plant: Adani Power

The 1.2 GW **Udupi Power Station** was built by Lanco Infratech in two stages of 600 MW each in 2011 and 2012. Given severe financial distress from disastrous coal sector investments, Lanco sold the plant in 2014 to Adani Power Ltd, which at the time of acquisition proposed adding two new units of 800 MW each. Udupi is designed with older supercritical combustion technology and operates on 100% imported coal. Udupi is supported by a captive jetty with 4 million tonnes per annum (Mtpa) capacity, and an external coal handling system located at the New Mangalore Port in Mangalore, Karnataka.[27]

Adani Power booked a net loss of US$317m in 2017/18. Adani Power operated at a commercially unviable average plant load factor (PLF) of just 37% for the quarter ended March 2018 due to the shut-down of its Mundra power plant in Gujarat, a troubled 4.6 GW facility that relies on costly imported coal.[28] Adani Power's net debt is an unsustainable US$7.2bn against shareholder equity of just US$133m. Figure 4.5 below illustrates the impact on investors of the major problems facing Adani Power, which can largely be traced to over-

[23] https://www.ntpc.co.in/en/power-generation/installed-capacity
[24] https://www.power-technology.com/projects/kudgi-super-critical-thermal-power-project-bijapur-karnataka/
[25] http://www.newindianexpress.com/states/karnataka/2014/mar/21/Green-Tribunal-Halts-Work-on-Kudgi-Power-Project-588763.html
[26] https://economictimes.indiatimes.com/industry/energy/power/ntpc-may-drop-further-expansion-plans-of-kudgi-thermal-project-in-karnataka/articleshow/57859308.cms
[27] http://www.eximin.net/NewsDetails.aspx?name=29089
[28] http://www.adanipower.com/media/media-release/Adani_Power_Consolidated_EBIDTA_Rs_6174_crore_in_FY18

reliance on financial leverage combined with the high costs facing its two facilities relying on imported seaborne coal — Mundra and Udupi.

The shutdown of the 4.6 GW Mundra plant has forced the Gujarat state distribution company to buy expensive power in the open market at prices ranging from Rs3.92-4.70/kWh. Over the last two years, the state's power purchases on the open market have soared 230%.[29] [30]

Adani's proposed expansion at Udupi runs counter to India's long-term plan to reduce thermal coal imports and lower electricity costs, and there is plenty of evidence across India to illustrate the severe financial difficulties associated with such projects. NTPC, for example, in July 2018 announced it has shelved its 4 GW greenfield coal-fired Pudimadaka Ultra Mega Power Project, a facility planned for the coast of Andhra Pradesh that would have relied on expensive imported coal.[31]

Figure 4.5: Adani Power Share Performance (Orange) vs. S&P BSE Index (Purple) Over 10 Years

Source: Thompson Reuters, 15 June 2018.

Coal Plant Closures and Additions

No new coal plants are under construction in Karnataka, but two new projects remain on the books. As such it is important to examine them, particularly in light of the potential stranded asset risk associated with moving forward toward construction and commercial operation (See Figure 4.6 below for a full list of the projects).

[29] https://www.business-standard.com/article/economy-policy/wind-energy-fans-power-short-gujarat-as-adani-and-essar-switch-off-118060300633_1.html

[30] https://timesofindia.indiatimes.com/city/ahmedabad/strong-winds-push-wind-power-generation-to-4280mw/articleshow/64640160.cms

[31] http://www.thehindu.com/news/national/andhra-pradesh/four-mega-projects-shelved-in-the-state/article24196162.ece

Capacity Closures

Raichur Thermal Power Station, 1,720 MW

The National Electricity Plan 2018 (NEP) provides a list of plants whose total age will be more than 25 years by 1st Jan 2022 and have space constraints to install Flue Gas De-sulphurisation (FGD) to meet the emission control norms released by Ministry of Environment, Forests and Climate Change (MOEF&CC). Raichur Thermal Power Station is Karnataka's oldest coal-fired power plant built between 1985 to 2010.

After a long delay, there have been signs that the emission control regulation is enforced in India's power sector. NTPC recently awarded contracts to retrofit its operational plants with FGD controls in Jajjar (Haryana),[32] Dadri (UP),[33] and Ramagundam (Telangana)[34]. NTPC's newly inaugurated Patratu Thermal Plant will also be designed to incorporate the required emission control systems.[35] Adani Power has retrofitted units 7-9 of its 4.6 GW Mundra power plant in 2017/18, ironically just in time for the plant to be closed in the face of the currency devaluation and unsustainable rise in the cost of imported coal. Along with Adani Power, the state owned thermal power operator has taken a much-needed lead and this should force their peers to follow them. It also implies an intent to enforce compliance by the government and the plants that do not meet the standards will have to be retired.

Raichur Thermal Plant, with an expensive tariff of Rs3.99/kWh, has not been a reliable source of electricity supply for the state. On account of the criteria mentioned in the NEP it clearly should be retired by 2022.

Planned Capacity Additions

Figure 4.6: Karnataka Coal-fired Plants Pipeline

Status		Plants	Capacity (MW)	Combustion Technology	Start Year for Operation
Under Construction			0		
Permitted					
	1	Udupi power station Unit 3	800	Supercritical	FY2020
	2	Udupi power station Unit 4	800	Supercritical	FY2020
Pre-permit					
	1	Gulbarga power station Unit 1	660	Subcritical	Not Defined
	2	Gulbarga power station Unit 2	660	Subcritical	Not Defined
Announced			0		
		Grand Total	**2,920**		

Source: Global Coal Plant Tracker, July 2018.

[32] https://economictimes.indiatimes.com/industry/indl-goods/svs/construction/reliance-infrastructure-bags-rs-567-crore-order-from-ntpc/articleshow/62874051.cms

[33] https://www.compelo.com/energy/news/newsbhel-to-supply-emission-control-equipment-for-980mw-power-plant-in-india-150218-6056471/

[34] https://steelguru.com/power/bhel-wins-r-m-order-for-esp-package-at-ramagundam-super-thermal-power-station/507325

[35] https://energy.economictimes.indiatimes.com/news/power/pm-modi-inaugurates-ntpcs-rs-18000-crore-patratu-thermal-power-plant-in-jharkhand/64321640

Udupi Power Station Expansion, 1,600 MW

Adani's planned two-unit, 1,600 MW expansion at Udupi is running way behind its initial 2020 schedule as it only attained environmental clearance for the project in August 2017.

IEEFA believes that Imported coal-based generation is no longer a viable option given the six-year high in imported thermal coal prices and currency devaluation, plus the hyper-deflationary trend in renewable energy prices in recent years. Adani reported fuel costs of Rs3.12/kWh for the Udupi plant in 2017/18, and average revenue realised at Rs5/kWh for the fourth quarter.[36] In contrast, almost all the renewable energy auctions in the state in the last year have been awarded at less than Rs3/kWh.

Coupled with Adani Power's troubled financial situation, IEEFA contends that the project is neither viable nor bankable. Going forward with this expansion would simply add to the lengthy list of India's stranded power assets, further aggravating India's banking stress. In addition, by increasing fossil fuel imports it will reduce the nation's energy security.

Gulbarga Power Station, 1,320 MW

The proposed 1.32 GW Gulbarga Power Station has been on the books since 2007, with no commissioning date yet in sight. Backed by Karnataka's state-owned generation company, PCKL, the facility would use out-dated, subcritical combustion technology. This project was initially estimated at Rs7,500 crore (US$1.1bn).

Since 2007, PCKL has issued four requests for proposals (RFPs) on an own, build and operate basis, but the company's inability to secure a coal contract for the project apparently has turned away potential bidders.[37] The project also still has not received its required environmental clearance from Indian regulators.

IEEFA assumes that once the closure of the Raichur plant is confirmed the Gulbarga project finally will move forward and be completed by 2027/28 to replace the lost capacity. IEEFA does not endorse this option; state consumers would be better served with additional renewables and the construction of pumped hydro storage projects like the ones now under construction at Tehri [38] in Uttar Pradesh and Kundah [39] in Tamil Nadu. Peaking capacity is needed, not expensive baseload.

A Better Option

The biggest challenge for Karnataka's coal sector is the fuel itself. The original proposal for Gulbarga relied on subcritical combustion technology that most definitely fail to meet the government's new emissions control regulations. If it is built using that design, it will require an immediate and expensive emissions control retrofit. Instead, the plant should be redesigned to use ultra-supercritical technology with a focus on enhancing operational flexibility to allow rapid ramping to balance out the state's expanding renewable energy generation.

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[36] Adani Power Limited Q4 FY-2017-2018 Results Investor Call, 04 May 2018, Page 4 & 15

[37] https://www.business-standard.com/article/companies/fresh-global-bids-called-for-1-300-mw-gulbarga-thermal-power-project-112052200022_1.html

[38] http://www.thdc.co.in/project-type/4

[39] https://www.tangedco.gov.in/linkpdf/Kundah%20pumped%20storage%20hydro-electric%20project%20(12.04.2018).pdf

In IEEFA's opinion, the only scenario where Karnataka needs additional coal-fired capacity is to offset the retiring capacity sufficient to secure reliable baseload supplies whilst transmission capacity is expanded. The state needs to better utilise its existing coal capacity by rationalising supply contracts and ensuring sufficient fuel is available for operation. Improving capacity factors at the current coal-fired plants is the only sustainable medium-term plan for the sector to reduce its stranded asset risks since cheap renewable energy already has become the preferred source of power.

There are two recent factors that have significant implications for the coal-fired sector in Karnataka and throughout India; 1) China's recent policy to curtail its solar capacity installation and 2) the government's updated, accelerated plan to install 227 GW of renewable energy by 2022, compared to the original goal of 175 GW.[40]

The Indian solar industry is highly dependent on cheaper imported modules from China, which accounts for 85-90% of module imports into India. China's policy to curtail its solar capacity installations has put downward pressure on module prices as Chinese panel makers look to export their surplus production.[41] The Supreme Court of India, having ruled against a petition to impose an anti-dumping duty on imported solar modules, potentially looks to have eliminated a significant threat to India's least-cost solar capacity building.[42] The final decision still pending with Directorate General of Trade Remedies (DGTR) on the matter, hopefully should be resolved with zero import duties on solar module imports. The combined effect of falling module prices and certainty around import tariffs should support the rate of India's solar capacity installations.

The updated version of India's already ambitious renewable energy target sends a strong signal of rising low-cost competition for the coal-fired sector. With all renewable energy costs forecast to continue falling, compared to the increasing cost of imported/domestic coal and emission controls for the coal-fired sector, the most economic, long-term option for the state of Karnataka's electricity system is clear.

Gas-Fired Electricity Generation

India's government recently announced that it plans to build 11 liquefied natural gas (LNG) import terminals over the next seven years as part of its plans to boost natural gas' share of the nation's energy mix to 15% by 2020.[43] There are only 4 LNG import terminals in the country currently; Petronet's Dahej facility in Gujarat, the Kochi LNG terminal in Kerala, Shell's Hazira plant in Gujarat and the Dabhol terminal in Maharashtra operated by Ratnagiri Gas and Power. The four terminals in import around 20Mtpa LNG, about 6.5% of India's current energy needs.

Karnataka currently does not have any gas-fired generation capacity. Building gas-fired generation capacity in Karnataka would raise the same import issues now confronting its coal-fired facilities. There have been attempts to build LNG terminals in the state for the past 10 years, but concerns about the projects' commercial viability have resulted in a series of

[40] https://economictimes.indiatimes.com/industry/energy/power/india-will-add-225-gw-renewable-energy-project-capacity-by-2022-r-k-singh/articleshow/64461995.cms
[41] https://www.bloomberg.com/view/articles/2018-06-05/chinese-burn-only-makes-the-solar-industry-stronger
[42] https://energy.economictimes.indiatimes.com/news/renewable/india-wont-levy-duty-on-solar-gear-imports/64393880
[43] https://www.maritime-executive.com/article/india-wants-eleven-more-lng-import-terminals#gs.V=oMMYg

delays. Imported LNG is an expensive electricity fuel source for India, and only makes technical and commercial sense if time-of-use pricing signals are developed to incentivise peaking power generation investment.

LNG Assets

Mangalore LNG Import Terminal

In March 2013, Mangalore Refinery and Petrochemicals (MRPL), a subsidiary of Oil and Natural Gas Corp (ONGC), along with its partners Mitsui of Japan and Bharat Petroleum Corp Ltd (BPCL) signed an agreement with New Mangalore Port Trust (NMPT) to study the feasibility of building a US$500-750m LNG import terminal/floating storage regasification unit (FSRU) at Mangalore in Karnataka.[44] As proposed, the terminal would have an initial capacity of 2-3Mtpa, with the potential to expand to 5Mtpa over time.

ONGC in 2006 already had shelved a plan for building a similar terminal due to the change in political leadership. The Mangalore LNG terminal has made no significant progress to date and media reports suggest that the consortium plans to scrap this project as well.

Karwar LNG Import Terminal

This project, initially proposed by Fox Petroleum in 2014, is currently under construction and expected to be completed late this year. The FSRU/LNG import terminal being built at Karwar will have a capacity of 7Mtpa.[45] The FSRU is being built by Hyundai Heavy Industries and has a contract value of US$563m. The linked LNG storage plant will cost an estimated US$495m, bringing Fox's total investment in the facility more than US$1bn.[46]

Other Gas-Fired Projects

The Karnataka government has tried to build gas-fired generation capacity over the years, but most of these projects have been cancelled after sustained delays. The projects discussed below were all proposed by state-owned KPCL and secured the needed approvals for construction, but which have not been completed. Clearly, the lack of in-state gas supplies is an issue that will not go away.

Bidadi Combined Cycle Plant Units 1 & 2, 1,400 MW

Combined cycle gas-based plants are less expensive to build than coal-fired plants and provide greater operating flexibility. The design also boosts overall generation efficiency since the plant uses the hot exhaust gases from the initial gas-fired generation cycle to produce steam that then is used to power a steam turbine, providing additional electrical output.[47]

The two-unit, 1,400 MW Bidadi plant was approved by the Karnataka government in 2001 and 2003 respectively. Initially, the plant was planned for completion in 2012 at an estimated cost of US$1.5bn. According to KPCL the gas supply contract was given to Gas Authority of

[44] https://timesofindia.indiatimes.com/business/india-business/MRPL-plans-to-set-up-LNG-Terminal-at-Mangalore-port/articleshow/49270999.cms
[45] http://www.foxpetroleum.net/Press_Releases.php
[46] http://www.foxpetroleum.net/projects.php
[47] http://www.araner.com/blog/combined-cycle-power-plants/

India Ltd (GAIL), which would draw gas through pipelines from Dabhol (Maharashtra). GAIL reportedly denied any such contracts with KPCL.[48] Mired in controversies, with no update on the project since 2014, the project appears to have been shelved.[49]

Tadadi Combined Cycle Power Plant, 2,100 MW

Like Bidadi, the 2,100 MW Tadadi plant has seen no material progress since being approved by the state in 2009. The estimated cost of the project was US$1.5bn.[50] There has been no update on the project since 2014 and no EPC contract has been awarded to date.[51]

Yelahanka Combined Cycle Plant, 370 MW

After facing disappointments from planned mega sized gas-based generation capacities, in 2015 KPCL was approved for setting up a sub-scale combined cycle gas plant of 370 MW in Yelahanka.[52] The project was planned as a reconfiguration of a defunct diesel based plant to gas at a cost of Rs1,570 crore (US$200m).[53] The construction was inaugurated in June 2016 by the former Chief Minister Siddaramaiah and the plant was supposed to be commissioned by May 2018 by Bharat Heavy Electricals Ltd (BHEL).[54] The plant is still under construction but unlike Karnataka's other planned gas plants, Yelahanka looks on-track for a delayed commissioning. A sub-scale base-load imported gas-fired power plant at an operating rate of less than 25% will be commercially unviable and in our view will result in a stranded asset.

The constant failure of mega-sized gas based plants in Karnataka points at an obvious unnecessity and unviability of gas-fired base-load power. The unviability of mega-sized plants stems from firstly, expensive imported LNG with an additional cost of transporting through interstate gas pipelines and, secondly, low operating rates of less than 25% due to the low and progressively declining average wholesale electricity price.

With rising share of renewables in the country and in Karnataka, a gas plant for peak-power requirements makes more commercial sense. The Yelahanka plant (370 MW) might have to be converted to a flexible peak-hour power facility in order to avoid another commercial fiasco. Gas in the near term could only be an option for peak-hour usage with a differential wholesale tariff in place for peaking gas-fired plants. The cost of renewable energy backed up with battery storage has been rapidly dropping and it is now increasingly considered an option for peak-hour supply.

48 http://www.bfirst.in/big-story/kpcl-bidadi-power-plant-kirloskar-at-bidadi--179895
49 http://karnatakapower.com/en/portfolio/bidadi-gas-based-combined-cycle-power-plant/
50 http://www.thehindu.com/todays-paper/tp-national/tp-karnataka/Tadadi-power-project-dropped/article16507990.ece
51 http://karnatakapower.com/en/portfolio/tadadi-gas-based-project/
52 http://karnatakapower.com/en/portfolio/yelahanka-2/
53 http://www.thehindu.com/news/cities/bangalore/new-gasbased-power-plant-at-yelahanka-to-start-in-2018/article7696197.ece
54 https://www.business-standard.com/article/news-ians/foundation-laid-for-370-mw-gas-based-power-plant-in-karnataka-116062100702_1.html

Figure 4.7: Levelised Cost of Electricity in India– Renewable vs. Thermal

Source	LCOE (US$/MWh)
Wind	39
Solar	41
Coal	68
Combined-Cycle Gas	93

Source: Bloomberg New Energy Finance New Energy Outlook June 2018.

In June 2018, Warren Buffett's Nevada based utility NV Energy of the US signed six PPAs of total 1,001 MW of solar power at a 25-year flat tariffs well below US$30/MWh,[55] less by 35% than proposed tariff of about US$47/MWh (Rs3.20/kWh) for the Tadadi gas-fired plant in Karnataka.[56] Three out of the six PPAs signed by NV Energy included a total of 100 MW / 400 MWh lithium ion battery storage capacity at a tariff range of US$26.50/MWh to US$29.96/MWh, with the cost of this capacity covered by an additional fixed price monthly payment. The lowest tariff came at US$23.76/MWh for 300 MW solar power excluding storage. The deployment of lithium ion batteries to complement variable renewable energy investments is accelerating globally. IEEFA recommends Karnataka progressively facilitate small distributed battery investments, including mandated co-location of batteries at all new variable renewable developments to help with the inevitable growth in balancing, frequency and dispatch issues. Likewise, IEEFA recommends that Karnataka evaluate the solar thermal development by Solar Reserve in South Australia and consider replicating this project if the proposed cost of peaking power is delivered as promised.

[55] https://www.utilitydive.com/news/nv-energy-23-cent-solar-contract-could-set-new-price-record/525610/
[56] http://www.thehindu.com/todays-paper/tp-national/tp-karnataka/Tadadi-power-project-dropped/article16507990.ece

5. Karnataka Renewable Generation

Solar Generation

Open Access Model for Solar Power

In August 2014, the Karnataka Electricity Regulatory Commission (KERC) adopted an order exempting solar power generators from "wheeling charges, banking charges, and cross subsidy surcharges" for projects commissioned between April 2013 and March 2018 selling power directly to consumers.[57] This open access model allows large consumers access to the central transmission and distribution (T&D) network to buy power from suppliers other than their local distribution companies.

It is clear the commission's intent was to catalyse the development of the solar PV sector by encouraging third party open access and captive power transactions apart from the traditional route of energy sales via local distribution utilities. It is also clear that the order, coupled with ongoing price declines, has had a positive impact in Karnataka, which is now the number one state in India for installed solar capacity.[58] Karnataka installed a record 3.9 GW of solar in 2017/18, about 40% of the total installed nationwide.

Karnataka also adopted a plan in 2014 designed to accelerate solar's expansion throughout the state, using fiscal incentives, support for solar parks, grid-tied canal projects and linkages with other renewable projects.[59]

Pavagada Solar Park (Shakti Sthala)

Built under India's solar park scheme, the 2 GW Pavagada solar park is the second largest industrial solar park currently under construction in the world.[60] The project, also called Shakti Sthala, is spread across 13,000 acres in Karnataka's Tumkur district. Land for the solar park is being leased for Rs21,000/acre annually (US$300).[61]

The facility is being developed by the Karnataka Solar Power Development Corporation Ltd (KSPDCL), a joint venture between Karnataka Renewable Energy Development Ltd (KREDL) and the Solar Energy Corp of India (SECI). KSPDCL acquired all the land and the required approvals and then awarded contracts for the solar power capacity, a simplified 'plug and play' model. This facility illustrates how quickly renewable energy infrastructure can be planned, financed and built when a suitable energy policy framework is in place.[62]

As of January 2018, 600 MW was already operational (priced back in 2016 at Rs4.79/kWh, or US$73/MWh).[63] An additional 550 MW was successfully tendered in March 2018 at prices of Rs2.91-2.93/kWh (US$42/MWh) — 39% lower than the first tender just two years earlier.[64] This

[57] http://www.karnataka.gov.in/kerc/Court%20Orders/OO%202014/Final_WB_CSS-18-08-2014.pdf
[58] https://mercomindia.com/top-solar-states-charts/
[59] http://kredlinfo.in/solargrid/Solar%20Policy%202014-2021.pdf Page 13
[60] http://ieefa.org/wp-content/uploads/2018/05/IEEFA-Global-Solar-Report-May-2018.pdf
[61] http://blogs.worldbank.org/energy/solar-energy-bring-jobs-and-prosperity-back-parched-villages-india
[62] https://mercomindia.com/karnataka-top-solar-state-india/
[63] https://www.livemint.com/Industry/UEJYwZQT5m3wNvGupBShZJ/How-the-worlds-largest-solar-park-is-shaping-up-in-Karnatak.html
[64] https://mercomindia.com/lowest-tariff-kredl-pavagada-solar-auction/

section should be operational by 2019. Leading Indian domestic renewable energy developers to win this round were Renew Power (300 MW), Avaada Energy (150 MW) and Azure Energy (100 MW). In May 2018, SB Energy, the joint venture of Japan's SoftBank, Taiwan's Foxconn, and Bharti Airtel won 200 MW of the solar park at an even lower tariff of Rs2.82/kWh,[65] taking the total tendered capacity of the solar park up to 1,250 MW. The remaining 650 MW was tendered in May 2018.[66]

India's First Solar & Wind Hybrid Project

New Delhi-based Hero Future Energie commissioned India's first solar-wind hybrid power generation facility in April 2018.[67] The plant, in Karnataka's Raichur district, includes a 28 MW solar plant and a co-located 50 MW wind farm. The facility will provide captive power to a group of private companies based in Karnataka.

Tariffs for this project were decided through negotiations since there were no existing government regulations. However, in May 2018, the Ministry of New & Renewable Energy (MNRE) released its National Wind Solar Hybrid Policy.[68] The policy's goal is to provide a framework for linking India's existing wind and solar power plants using existing grid capacity and land. This should reduce grid connection capital expenditures, save time and cut land acquisition costs previously needed for new transmission infrastructure. With the likely addition of battery storage, it could be a potential source for round-the-clock electricity supply.

India's draft energy plan from 2016 included a 10 GW target for hybrid capacity by 2022. The final plan does not include a specific but 10 GW should be achievable, especially in the context of MNRE's updated renewables target of 227 GW by 2022. For the state of Karnataka, with its troubled thermal sector, investing in hybrid generation coupled with some small-scale firming battery storage is an option that is domestic, cheaper and reliable.

These two options, open access and hybrid generation, go hand-in-hand for Karnataka, giving it a path forward to boost its use of clean renewable energy.

Figure 5.1: Karnataka's Leading Solar Power Developers

Solar Deveopers	Capacity (MW)
Adani Green Energy	750
Hero Solar Energy	429
Renew Power	340
CleanMax Solar	226
ACME	160
Total	**1,905**

Source: Karnataka Renewable Energy Development, Company Websites.

[65] https://energy.economictimes.indiatimes.com/news/renewable/-sb-energy-wins-secis-200-mw-auction-in-karnataka/64226403
[66] http://kredlinfo.in/scrollfiles/OM%20for%20650MW%20tender.pdf
[67] https://www.pv-tech.org/editors-blog/hero-launches-indias-first-solar-wind-hybrid-project
[68] https://www.pv-tech.org/news/india-finalises-wind-solar-hybrid-policy

Adani Green Energy

Adani Green Energy Ltd (AGEL) was spun out of Adani Enterprises and listed on the Bombay Stock Exchange in June 2018.[69] AGEL currently operates 750 MW of utility-scale solar capacity in Karnataka and has another 60 MW under construction.[70]

AGEL's 648 MW Kamuthi Solar Park in Tamil Nadu, was the world's largest single-site solar facility when it was commissioned in 2016. The company currently has an operational solar generation portfolio of 1,858 MW with another 170 MW of capacity under construction. The company's desire to integrate its Mundra SEZ based solar module manufacturing capacity with its generation capacity may well serve as a model that other large renewable companies in India will follow.

India has a reported module manufacturing capacity of 9 GW as of June 2018.[71] The ambitious solar target of 100 GW by 2022 is largely dependent on imports from countries like China, Taiwan and Singapore. Newly founded domestic giants such as AGEL will play an important role in boosting India's solar module manufacturing and reducing the country's exposure to import risks in the long term. For the company, the prospect of investing in India's promising renewable sector has far better potential of delivering value for its shareholders than expanding its existing expensive imported coal-fired plants.

CleanMax Solar

CleanMax Solar has been India's number one rooftop solar developer over the last three years, installing more than 100 MW of solar capacity serving corporate sector. The company develops projects on a turn-key basis and provides electricity on a kWh basis through long-term PPAs.[72] The developer also owns and operates utility-scale solar farms in Tamil Nadu and Karnataka.

Of India's ambitious 100 GW solar target for 2022, 40% was originally expected to come from rooftop solar installations. To-date, the lack of policy support, the heavily subsidised retail price of residential electricity and lack of accessible incentives has held back the market, making it unlikely that it will reach the 40 GW target by 2022. Despite the difficulties, 1 GW of rooftop solar projects were installed in the country in 2017/18, pushing the total installed rooftop capacity to 2.4 GW.[73]

According to the consultancy firm Mercom India, the rooftop sector is fragmented in terms of market share and 73% of the capacity is being developed by small companies. While the residential rooftop market is stagnant, developers expect demand to grow steadily in commercial and Industrial (C&I) sectors. IEEFA expects C&I rooftop solar to be an avenue of accelerated growth for Karnataka in the coming decade, with installations hitting 1.4 GW.

This is a conservative projection for Karnataka's rooftop solar potential with an assumption that state will reach a net zero imports position.

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[69] https://www.business-standard.com/article/pti-stories/adani-green-energy-shares-up-5-on-debut-118061800729_1.html
[70] http://www.adanirenewables.com/power-generation.html
[71] https://www.indiansma.com
[72] https://cleanmaxsolar.com/
[73] https://mercomindia.com/rooftop-subsidy-delays-india/

Threats to Solar Power in Karnataka

Retrospective Wheeling Charges

The policies that enabled Karnataka to become the leading renewable energy state have come under fire recently. For starters, the electricity commission voted in May 2018 to repeal its zero wheeling charge order, which irked solar power developers. More concerning was the imposition of retrospective wheeling charges, which would increase developers' cost by Rs1.19/kWh (US$0.017/kWh).[74] The same order also said renewable energy developers now would have to pay for any 'line losses' due to their inability to provide the power they had promised, a provision they did not previously have to meet.

The Karnataka High Court has issued an interim stay on KERC's order in response to petitions filed by renewable developers, asking KERC to provide a written response to developers' submissions.[75] It is IEEFA's belief that the recent order will not only disturb developers' finances but also hamper investor confidence. Investors and developers might become wary of concessional policies and incorporate such a financial risk in their pricing going forward. Policy clarity and certainty have been key in Karnataka's renewable energy development and it is important that it remain so to provide stable grounds for continued development.

Lack of Transmission Network Infrastructure

In March 2018, India's Central Electricity Regulatory Authority (CERC) issued an order waiving interstate transmission charges and losses for all solar and wind power projects commissioned by March 31, 2022.[76] The problem is lack of interstate transmission could well prevent developers from taking advantage of this opportunity.

Included in the country's 175 GW of renewable energy target is a plan to establish green energy corridors across India that will enable the transmission of clean energy generated in renewable-rich states to those lacking significant solar and wind capacity.[77]

There has been substantial tendering activity in 2018 for wind and solar projects connected to the interstate transmission system (ISTS),[78,79] but developers have become increasingly worried about the lack of transmission network capacity and needed regulations regarding the granting of ISTS connectivity.[80] To date, roughly 7 GW of solar power auctions have been delayed as a result of requests from the Solar Power Developers Association (SPDA) to MNRE.[81] Parliament's standing committee on energy took up the issue in February 2018, expressing concern that there were not enough funds allocated to build the targeted capacity of interstate transmission lines.

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[74] https://economictimes.indiatimes.com/industry/energy/power/retro-karnataka-charges-irk-green-power-companies/articleshow/64294305.cms?from=mdr
[75] https://economictimes.indiatimes.com/industry/energy/power/hc-stays-karnataka-electricity-commissions-retro-charges-on-green-power-companies/articleshow/64309972.cms
[76] https://mercomindia.com/no-ists-charges-wind-solar-projects-commissioned-2022/
[77] https://mercomindia.com/green-energy-corridor-underfunded/
[78] https://mercomindia.com/seci-ists-solar-3gw-tender/
[79] https://mercomindia.com/seci-tenders-2-gw-ists-connected-wind/
[80] https://energy.economictimes.indiatimes.com/news/renewable/solar-project-developers-ask-ministry-to-defer-auctions/64153133
[81] https://mercomindia.com/ists-connectivity-delay-7gw-solar-auctions/

Continued development of solar energy in Karnataka depends on the commissioning of additional interstate transmission network capacity. This will allow Karnataka to become a net exporter of the electricity and improve investors' return on investment (ROI) by reducing curtailment risks.

Solar Module Import Tariffs of 25%

India's director general of trade remedies (DGTR) recommended in July 2018 the imposition of a 25% duty on solar cells, assembled into modules or not, imported into India from China and Malaysia in the first year, followed by a gradual reduction to 20% in the first six months of that second year and then to 15% in the latter half of the second year.[82] This will likely raise the capital cost of Indian solar projects in the near term by 10-15%, likely offsetting the expected decline in imported module prices over the coming year.

Wind Generation

Karnataka is one of India's leading states for wind power generation as well, adding capacity consistently over the past 10 years. The state added more than 800 MW of capacity in each of the last two years, and now has a total of 4.6 GW of wind power online.

The state's draft renewable energy policy for 2016-2022 envisaged installing 6 GW of non-solar renewable energy by 2021-22. This goal was set in an attempt to over-achieve its MNRE-established renewable purchase obligation (RPOs) by more than 20%.[83] Of that 6 GW total, 4.4 GW is planned to be from wind power. Given its strong installation results in the last two years, Karnataka is well on its way to meeting this goal.

Last June, Karnataka regulatory commission barred the state's distribution companies from signing any new wind energy PPAs until further notice.[84] The distribution companies already had signed enough PPAs to meet the state's RPO, KERC said, and buying more wind capacity would have further weakened the state's already troubled thermal power sector.

In June 2018, KERC set the state's wind power auction ceiling tariff at Rs3.45/kWh, down from the feed-in-tariff of Rs4.50/kWh set in 2015.[85] The order also annulled feed-in-tariffs and compelled the state to buy wind power only through competitive bidding.[86] Before Karnataka, only the states of Gujarat, Maharashtra and Tamil Nadu purchased wind power through competitive bid. In December 2017, Gujarat's 500 MW reverse wind auction resulted in the country's record low tariff of Rs2.43/kWh, an enormous win for Gujarat electricity consumers.[87]

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[82] https://energy.economictimes.indiatimes.com/news/renewable/25-per-cent-solar-duty-would-raise-solar-projects-bid-tariffs-to-rs-3-2-per-unit/65026303

[83] http://www.kredlinfo.in/scrollfiles/Draft%20Renewable%20Energy%20Policy%202016-2022.pdf Page 2

[84] https://economictimes.indiatimes.com/industry/energy/power/karnataka-discoms-barred-from-buying-more-wind-power/articleshow/59100232.cms

[85] https://economictimes.indiatimes.com/industry/energy/power/karnataka-government-regulator-spar-over-wind-power-tariffs/articleshow/61621465.cms

[86] https://economictimes.indiatimes.com/industry/energy/power/karnataka-regulator-caps-wind-power-tariff-at-rs-3-45/articleshow/64566445.cms

[87] https://economictimes.indiatimes.com/industry/energy/power/wind-power-tariffs-in-gujarat-auctions-fall-to-rs-2-43/unit/articleshow/62202966.cms

Opportunity for Wind Power Exports

IEEFA's conservative estimate is that Karnataka must add a minimum of 4 GW of new wind capacity in the coming decade to be able to meet all its electricity needs via in-state generation. According to the rating agency CRISIL, wind power tariffs of Rs2.9-3.0/kWh would provide a sustainable 12-14% internal return on equity in 2018/19.[88] The payment risk has dropped in India since state-owned Solar Energy Corporation of India (SECI) increasingly has assumed the role of counter-party, which lowers the financial risks and hence reduces the tariffs required. SECI has had a superior track record for payments to renewable generators relative to that of the financially distressed distribution companies.

CERC's decision to waive interstate transmission charges presents an opportunity for Karnataka to reduce offtake risk by exporting electricity to states that lack the wind potential to fulfil their non-solar renewable purchase obligations.

MNRE also recently set a national target of 30 GW of offshore wind power capacity by 2030 with an initial target of 5 GW by 2022.[89] Preliminary studies have reviewed offshore wind capacity in coastal regions of Gujarat and Tami Nadu. The extended target of 30 GW comes from the response received by Indian and international developers during the 1 GW auctions in Gujarat and Tamil Nadu, the first ever for Indian offshore wind. The long-term target would improve industry confidence to invest in the offshore wind sector. Karnataka with its 320 km coastline should pro-actively look for offshore wind generation opportunities for development next decade once cost reductions make this a competitive alternative.

The model of procuring power through competitive bidding, technology improvements and innovative long-term financing options have all been successful in bringing down wind power tariffs in India and globally. Similar deflationary gains should be expected in Karnataka's wind power sector.

While the national RPO serves as a driver, IEEFA believes Karnataka should aim for more capacity than its 4 GW compliance target, with the objective of building sustainable electricity export revenues.

Figure 5.2: Karnataka's Leading Wind Power Developers

Wind Developers	Capacity (MW)
Renew Power	463
Enercon	150
Green Infra Power Generation Limited	104
Atria Wind Power	103
Clean Wind Power	100
Total	**920**

Source: Karnataka Renewable Energy Development, Company Websites.

[88] https://energy.economictimes.indiatimes.com/news/renewable/wind-energy-tariffs-likely-to-be-sustainable-at-rs-3-per-unit-in-current-fiscal/64645213

[89] https://energy.economictimes.indiatimes.com/news/renewable/india-announces-30-gigawatt-offshore-wind-energy-target-by-2030/64651102

Renew Power

Renew Power is backed by numerous marquee investors including Goldman Sachs, Abu Dhabi Investment Authority (ADIA), Global Environment Fund (GEF), Canada Pension Plan Investment Board (CPPIB) and Japan's JICA.[90] The company's wind and solar power portfolio totalled 2.3 GW in April 2018 after acquiring Ostro Energy's for Rs10,800 crore (US$1.66bn). The deal was the biggest takeover in India's renewable sector, beating Tata Power's 2016 acquisition of Welspun Energy for Rs9,249 crore (US$1.5bn).[91]

In May 2018, Renew Power acquired India Energy limited (IEL), a wholly owned subsidiary of Infrastructure India Plc (IIP) for Rs36 crore (US$5.5m) that operated 41 MW of wind power assets in the states of Karnataka and Tamil Nadu. As of May 2018, Renew Power owned 800 MW of wind and solar capacity in Karnataka.[92]

The renewable sector in India is moving to a consolidation phase, and Renew Power is leading that effort. It is looking to acquire 700 MW of already commissioned renewable capacity across the states of Andhra Pradesh (437.2 MW), Karnataka (171.9 MW), Rajasthan (60 MW) and Tamil Nadu (16.5 MW).[93]

The recent momentum in India's Merger & Acquisition (M&A) deals is a good endorsement of the viability and interest in renewable businesses in India. The recently updated renewable energy target of 227 GW by 2022, a single 100 GW auction announced by the Power Ministry Mr R. K. Singh, and a constant policy movement points to a profitable opportunity for global investors to take part in India's electricity sector transition.

[90] https://renewpower.in/about-us/our-partners/
[91] https://energy.economictimes.indiatimes.com/news/renewable/renew-power-to-buy-ostro-energy-in-biggest-renewables-deal/63574027
[92] https://mercomindia.com/renew-acquires-indian-energy-limited/
[93] https://mercomindia.com/renew-power-acquire-700-mw-renewable-assets/

6. Distribution Companies

Until 2002, the Karnataka Electricity Board (KEB) handled electricity transmission and distribution across the state. It was then broken up, with Karnataka Power Transmission Corporation Ltd (KPTCL) established to manage the transmission business, and the distribution side split into five companies, referred to as electricity supply companies in Karnataka. (IEEFA uses distribution companies or discoms for broader national context).

- MESCOM – (Mangalore Electricity Supply Company)
- BESCOM – (Bangalore Electricity Supply Company)
- HESCOM – (Hubli Electricity Supply Company)
- GESCOM – (Gulbarga Electricity Supply Company)
- CESC–– (Chamundeshwari Electricity Supply Corporation)

These distribution companies are responsible for the electricity distribution in specific districts across Karnataka.

In June 2016, the Karnataka distribution companies, the state government and the India Ministry of Power signed a memorandum of agreement under a nationwide effort to boost the financial performance of distribution companies across the country. In addition to its financial performance goals, the UDAY program was designed to reduce the cost of electricity generation, boost the development of renewable energy, and improve energy efficiency and conservation.

The program directed state governments to assume 75% of their distribution companies' debt, beginning with 50% in 2015-16 and the remaining 25% in 2016-17. The states would issue bonds to take over the debt and transfer the proceeds to the distribution companies in a mix of grants, loans and equity.[94]

Figure: 6.1: UDAY Targets for Karnataka 2018/19

Targets	FY2014/15	FY2018/19
AT&C Losses (%)	18.1%	14.2%
AT&C Losses at 14.71% for FY2017/18		
	FY2015/16	FY2018/19
Net Income Including Subsidies (Rs Crores)	-501.4	3.5
Loss of Rs1,240 Crore for FY2017/18		
	FY2015/16	FY2018/19
ACS-ARR Gap (Rs)	0.10	0.00
ACS-ARR Gap of Rs0.28 for FY2017/18		

Source: UDAY, MOU between Karnataka DISCOMS, GoK, Ministry of Power India.[95]

[94] https://www.uday.gov.in/Salient-Features.php
[95] https://www.uday.gov.in/MOU/Karnataka_MoU.pdf (Annexure B & C)

Figure 6.1 above presents the targets assigned to Karnataka's distribution companies under UDAY. The state appears to be on track to meet its AT&C goal of 14.2% by the end of 2018/19 (it posted a 14.71% AT&C loss figure for 2017/18). However, the distribution companies' financial performance remains far short of the stated goals: Instead of the targeted net profit of US$29.5m in 2017/18, the five companies posted a US$200m loss.[96] In addition, the average cost of supply (ACS) to average revenue realisation (ARR) gap is at Rs0.28, significantly away from the goal of zero gap by the end of 2018/19.

The UDAY program also sought to improve performance in the country's coal sector. Among the specific goals were:[97]

- Increasing the supply of domestic coal
- Securing new coal supply linkages
- Rationalising coal prices and allowing coal swaps
- Boosting the supply of washed and crushed coal

Given the severe coal supply logistics issues in Karnataka in the last year, it does not appear that the program has made any tangible improvement.

The financial distress of Karnataka's distribution companies can be traced to the high cost of electricity imports, expensive coal imports and transportation costs, unavoidable fixed capacity charge payments to coal-fired power plants, agricultural sector electricity subsidies, unsustainably high AT&C losses and excessive financial leverage. Adding to the distribution companies' financial problems, the state's commercial and industrial companies increasingly are seeking to buy renewable energy directly via open access and/or install captive solar PV rooftops.

These problems will not be solved overnight, but IEEFA believes the distribution companies and the state can take a major step forward by using lower cost wind-solar hybrid generation coupled with batteries to manage peak demand periods and help reduce the state's average cost of wholesale generation. In contrast, continuation of the retrospective tariffs and other similar changes will only relieve near-term financial distress rather than move Karnataka toward a more profitable, cleaner future.

[96] https://www.uday.gov.in/health-card-state.php?id=9 Page 11
[97] https://www.uday.gov.in/Benefits-to-Participating-States.php

Conclusion

The state of Karnataka has been a model for India's service sector-driven growth over the last decade. Its contribution to India's GDP of as much as 10% makes it a crucial state for the country's sustained growth prospects.

In 2017/18 Karnataka became the number one state in India for renewable energy capacity, providing a clear leadership and endorsement of the much-needed electricity sector transformation. A record installation of 3.9 GW of low-cost solar generation capacity in 2017/18 is only a sign of things to come in Karnataka's renewable sector.

The recent renewable energy success in Karnataka is a result of its prudent energy policies and commitment to comply with renewable purchase obligations enforced by the central government. The fully subsidised open access model for solar power has allowed businesses and developers to mitigate payment and offtake related risks, purchase cheaper and more reliable power supplies, whilst overcoming the barriers posed by loss-making state-owned distribution companies.

The state has suffered from an over-reliance on imported coal for its electricity needs in the past decade and has been left with no options but to import electricity from other states or purchase expensive power from the open market. Karnataka does not require any further thermal capacity additions in the coming decade except possibly to replace the 1.7 GW Raichur station, which should be retired per the guidance in the 2018 NEP.

The decade-long ambition to build mega-size gas import capacity and gas-fired power projects has met no success and has rather ended in a waste of capital, land and political effort. The currently under-construction Yelahanka gas power project might have to be considered for conversion into a peak-hour power supply facility and even then, without time differentiated tariffs the project could be commercially unviable.

According to BNEF projections, the levelised cost of electricity (LCOE) for coal and gas-fired generation is projected to be 70-100% higher than that of Indian wind and solar over the coming decade. The competition will force either tariff renegotiations or refusal of expensive thermal power purchase, resulting in more stranded thermal power assets in the state.

The number one renewable energy state of India still has a long way to go. Retrospective tariff amendments and impositions are unwelcome developments for developers and investors, which in turn will raise the cost for Karnataka electricity consumers. The state should ensure optimum utilisation of its current capacity through building more interstate-connected generation and transmission capacity. Protecting investors' confidence with offtake and payment assurances will attract capital into rooftop solar, wind-solar hybrid coupled with storage, and potentially offshore wind.

IEEFA foresees renewable capacity addition of at least 11 GW by 2027/28, a rather conservative ambition compared to the national target. Building more renewable energy grid export capacity will enable Karnataka to better contribute to the nation's economic growth, energy security and climate protection efforts, all highly commendable goals for India.

Institute for Energy Economics and Financial Analysis

The Institute for Energy Economics and Financial Analysis (IEEFA) conducts research and analyses on financial and economic issues related to energy and the environment. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy and to reduce dependence on coal and other non-renewable energy resources. More can be found at www.ieefa.org.

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Tim Buckley, IEEFA's director of energy finance research, Australasia, has over 25 years of financial market experience covering the Australian, Asian and global equity markets from both a buy and sell side perspective. Tim was a top-rated Equity Research Analyst and has covered most sectors of the Australian economy. Tim was a Managing Director, Head of Equity Research at Citigroup for many years, as well as co-Managing Director of Arkx Investment Management P/L, a global listed clean energy investment company that was jointly owned by management and Westpac Banking Group.

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Important Information