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Gujarat's Electricity Sector Transformation

A Role-model of India's Electricity Transition

Executive Summary

GUJARAT, LOCATED ON THE WESTERN COAST OF INDIA, IS AN ECONOMIC POWERHOUSE that contributed roughly 8% of India's total gross domestic product (GDP) between 2011/12 and 2018/19. It is one of the most industrially focussed states in India, with three quarters of Gujarat's state GDP coming from the industrial sector.

IEEFA also identifies Gujarat as one of the five leading Indian states for renewable energy in terms of both existing generation capacity as well as future potential. There was 2 gigawatt (GW) of solar power capacity, 6GW of wind power capacity and 0.5GW of biomass capacity operational as of March 2019.

India's Ministry of New and Renewable Energy (MNRE) estimates Gujarat's renewables potential to be 72.7GW, equally balanced between solar and wind energy potential. This includes the 5GW Dholera Solar Park, the largest proposed solar development in the world to-date. August 2019 saw NTPC announce plans for another 5GW of solar park at Kutch in Gujarat during its annual investor meet for FY2018/19. This announcement puts Gujarat ahead in the race for building renewables capacity between states such as Tamil Nadu, Karnataka, Maharashtra, Andhra Pradesh and Rajasthan with similar renewable energy potential.

GUJARAT'S CURRENT ELECTRICITY MIX IS DOMINATED BY THERMAL POWER SOURCES. The 22.3GW of thermal capacity comprises 15.8GW of coal-fired and 6.6GW of gas-fired capacity. This in total forms 69% of total capacity and 81% of generation in Gujarat.

Due to the lack of material in-state 'black' coal mining capacity, more than 90% of Gujarat's coal-fired power plants use either expensive imported seaborne thermal coal or domestic coal hauled via railways from mines located at a distance of more than 1,200km in eastern Indian states of Odisha, Jharkhand or West Bengal. There are local mine-mouth lignite-fired power plants in Gujarat.

Some 9.9GW of Gujarat's coal-fired capacity commissioned between 2009 and 2013—including the 4.6GW Adani Mundra Plant, 4.1GW at Tata Mundra Power and the 1.2GW Essar Salaya Power Plant—was unviable until recently bailed out through a massive uplift in the pass-through of expensive imported coal costs to distribution companies (discoms).

IEEFA estimates the bailout, on recommendation from a special three-person committee appointed by the state government, will cost Gujarat discoms US$8.9bn over a 30-year period. Such a loss is equivalent to the capital required to build 8-

10GW of renewable energy projects with 25-year power purchase agreements (PPA) with zero indexation and zero fuel costs.

THE INDIAN GOVERNMENT HAS RIGHTLY IDENTIFIED THE NEED TO REDUCE ITS EXPOSURE TO IMPORTED FOSSIL FUELS (oil, coal and gas). Over-reliance on imported fuels adversely affects India's trade account deficit while putting its energy security at risk.

In the last ten months, Gujarat has awarded 2.5GW of renewable energy (1.8GW of solar and 0.7GW of wind) in a deflationary tariff range of Rs2.44-2.95/kWh with 25-year contracts. Additionally, there is 1.5GW of capacity under the tendering process which will soon be awarded, to be commissioned within the 24 month deadline.

Gujarat is a preferred destination for developers vying for renewable energy contracts due to its excellent natural resources. The central government-backed auctions are conducted by Solar Energy Corporation of India (SECI) and NTPC.

IN THIS REPORT, IEEFA'S MODEL PROJECTS GUJARAT'S TOTAL ELECTRICITY PRODUCTION REQUIREMENT TO GROW 74% IN JUST OVER TEN YEARS, from 116-terawatt hour (TWh) in fiscal year (FY) 2018/19 to 203TWh FY2029/30.

IEEFA expects Gujarat to add a staggering 46GW of new renewables capacity by FY2029/30, in a race to be the top state in India. Renewables additions of 4-5GW annually could ensure all of Gujarat's incremental demand going forward is supplied by renewables. This will be a dramatic shift in Gujarat's electricity sector composition as renewables will form 70% of its capacity and 48% of generation.

Gujarat Electricity Sector Composition FY2029/30

	Electricity Sector Composition FY2029/30					
	Capacity		Generation		Utilisation	Capacity Adds
Source	**(GW)**	**%**	**(TWh)**	**%**	**%**	**(GW)**
Coal	14.0	17.8%	68.7	33.8%	56.1%	-1.8
Gas	6.6	8.4%	14.4	7.1%	25.0%	0.0
Diesel	0.0	0.0%	0.0	0.0%	0.0%	0.0
Nuclear	2.0	2.5%	13.7	6.8%	80.0%	1.4
Hydro	0.8	1.0%	1.4	0.7%	20.0%	0.0
Renewables	55.1	70.3%	97.7	48.1%	24.0%	46.5
Net imports			7.2	3.6%		
Total	**78.4**	**100.0%**	**203.1**	**100.0%**		**46.1**

Source: IEEFA estimates.

For thermal power, IEEFA expects gross additions of 2.1GW of coal-fired capacity currently under construction and in the planning phase to be completed. This will partially offset a retirement of 3.9GW of end-of-life, outdated subcritical technology-based coal capacity by FY2029/30—accounting for a net reduction of 1.8GW over the coming decade. Thermal power will progressively lose market share, halving its generation share from 81% in FY2018/19 to 41% by FY2029/30.

The incorporation of nearly 55GW of intermittent renewable energy on Gujarat's electricity network by FY2029/30 will require very active measures and investment on the grid integration front. IEEFA recommends a multi-technology approach with storage solutions of pumped hydro and battery storage, flexible gas peakers, demand response management, faster ramping coal power, solar thermal with storage, rooftop solar plus behind the meter storage, as well as grid modernisation.

All four of Gujarat's state-owned discoms, under the umbrella of Gujarat Urja Vikas Nigam (GUVNL), have successfully achieved all of the targets set out in the Ujwal DISCOM Assurance Yojana (UDAY). At the end of FY2018/19, GUVNL emerged as the top performing Indian discom with a net income of Rs464 crore (US$65m).

GUJARAT DISCOMS SHOULD AIM TO PROGRESSIVELY DO AWAY WITH RELIANCE ON STATE SUBSIDIES and operate an even more profitable power distribution business.

This report highlights the clear transition of one of India's leading states from an unreliable, expensive, imported thermal power-based electricity sector to a low-cost, low-emission, deflationary, domestic renewable energy driven electricity system—perfectly aligned with India's national objectives of building 523GW of renewable energy by FY2029/30.

Table of Contents

1. An Overview of Gujarat, "The Land of the Legends"

Gujarati: ગુજરાત Hindi: गुजरात

The state of Gujarat is located on the north western coast of India, with the Arabian Sea giving the state its extensive coastline of 1,600km.

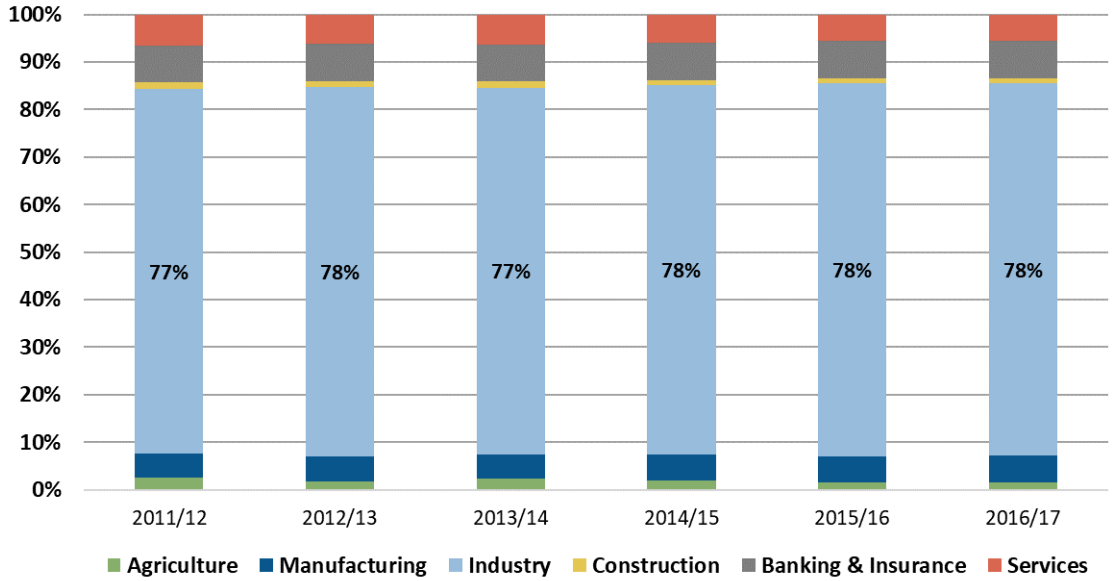
The home-state of Indian Prime Minister Narendra Modi, Gujarat is a key economic contributor to India's gross domestic product (GDP).

Gujarat's gross state domestic product (GSDP) grew at a compound average growth rate (CAGR) of 9.9% between FY2010/11 to FY2018/19 and contributed 8% to India's total GDP. The state's per capita GSDP grew at a CAGR of 8.6% from Rs87,481 (US$1,715) to Rs131,583 (US$2,585) during the same period.

Gujarat is a key economic contributor to India's gross domestic product (GDP).

Foreign direct investment (FDI) inflows into Gujarat totalled US$20.55bn from April 2000 – March 2019, according to the Department for Promotion of Industry and Internal Trade (DPIIT). This was 5% of India's total FDI during the period.[1]

Figure 1.1: Gujarat's GSDP – Industrial Sector's Contribution



Source: Reserve Bank of India.

[1] Department for Promotion of Industry and Internal Trade, Factsheet on FDI, 27 May 2019.

Housing a population of 68 million, Gujarat is one of India's most industrially developed state. The State is a leader in industries such as agriculture and food processing, textiles and apparel, gems and jewellery, oil and gas, pharmaceuticals and biotechnology, as well as chemicals.

In addition to being known as The Land of the Legends, Gujarat is also considered the Petro Capital of India for its dominance in petrochemicals. The state has eight industrial clusters, 18 industrial estates and three special economic zones (SEZ) for petrochemicals.[2]

As illustrated in Figure 1.1, GDP contributions from Gujarat's industrial sector are far more than any other sector, including agriculture, manufacturing, construction, banking and finance, and services.

Gujarat has strived to build important physical infrastructure. As of February 2018, the national highway length was 5,456km. Along with road infrastructure, the Government of Gujarat has focused on growth of the transportation sector. The Gujarat State Road Transport Corporation (GSRTC) delivers transportation services to some 2.4 million people every day.

The state has one of the strongest port infrastructures in India. It was the first state to take up port privatisation. Gujarat has 42 ports including one major port at Kandla and 41 minor ports along its coastline.

Gujarat possesses the largest liquified natural gas (LNG) handling and regasification terminal in India at Dahej. There are two operational LNG import terminals, including Dahej, with a total capacity of 22.5 million metric tonne per annum (MMTPA) and another 10MMTPA of new LNG capacity under development.

Most importantly, Gujarat has a rich labour pool developed through good educational infrastructure with premier institutes in management, fashion, design, infrastructure planning and pharmaceuticals. The state has one of the highest incoming labour migrations from other states of India.

Being one of India's highly developed industrial states, an appraisal of its electricity sector is of great value in IEEFA's opinion. An efficient, modern, domestic energy sector offers better outcomes for its industrial economy.

Gujarat's electricity sector has enormous potential to transition to a low-cost, low-emission electricity system.

This report will focus on Gujarat's electricity sector which has enormous potential to transition to a low-cost, low-emission electricity system based on renewable energy sources.

[2] India Brand Equity Foundation, Gujarat — the Growth Engine of India, June 2019.

2. India's Electricity Sector Transformation

India, with a GDP growth rate of 7-8%, is the world's third largest electricity market behind the U.S. and China. However, its per capita electricity consumption at 1,149-kilowatt hour (kWh) per annum is less than one-fourth of China at 4,905kWh and just one-fourteenth of U.S. at 14,091kWh.

The growing economy of India has a multitude of challenges. These include adhering to international climate commitments of dramatically reducing carbon emissions intensity relative to GDP by 33-35% by 2030 from the 2005 level,[3] and reducing its unsustainable reliance on energy imports, whilst increasingly supporting its social and economic growth by keeping the 'lights on'.

IEEFA notes such challenges demand an accelerated transition to a domestically fuelled, lower-cost, low-emission, less water intensive energy economy, starting with the greening its electricity sector and moving on to progressively electrify transport and other energy-intensive industries.

India has set an ambitious near-term target of 175GW of renewable energy generation capacity by FY2021/22 and 275GW by FY2027/28, which was recently even further increased to 523GW (including 73GW of hydro) by FY2029/30.[4]

India has set an ambitious target of 523GW of renewable energy generation capacity by FY2029/30.

As of March 2019, India had 200.7GW of coal-fired capacity contributing 56.3% of its total capacity and an unsustainably high 74.3% of total generation. Renewables were providing 77.8GW of capacity, delivering 21.8% of generation capacity and only 9.2% of total generation.

[3] India's intended nationally determined contributions (NDCs) under the Paris Climate Agreement also include having 40% of total generation capacity from non-fossil fuel sources by 2030.

[4] Central Electricity Authority of India, Draft report on optimal generation capacity mix for 2029-30, February 2019.

Figure 2.1: India's Electricity Sector Composition FY2018/19

	Capacity		Generation		Capacity	Increase
	GW	%	TWh	%	Utilisation	GW yoy
Coal-fired	200.7	56.3%	1,022.3	74.3%	58.7%	3.5
Gas-fired	24.9	7.0%	49.8	3.6%	22.8%	0.0
Diesel-fired	0.6	0.2%	0.1	0.0%	1.9%	-0.2
Large Hydro	45.4	12.7%	134.9	9.8%	34.0%	0.1
Nuclear	6.8	1.9%	37.8	2.7%	63.7%	0.0
Renewables	77.8	21.8%	126.8	9.2%	19.7%	8.6
Bhutan (Import)	n.a	n.a	4.4	0.3%	n.a.	
Total	**356.3**	**100%**	**1,376.1**			**12.1**
Capitve power	51.4					
Total	**407.7**	114.4%				

Source: CEA, IEEFA estimates.

From FY2017/18 onwards, India's renewable energy sector saw a dramatic deflation in renewable energy tariffs achieved through transparent, reverse bidding auctions. The ambition to accelerate capacity building was reinforced by solar power tariffs as low as Rs2.44/kWh (~US$35/kWh). Of the 21GW of renewable capacity installed since the beginning of FY2017/18 and an additional 35GW auctioned till date, more than 90% of it has been contracted for tariffs between Rs2.43-2.80/kWh with zero indexation for 25 years—20-30% less than average domestic thermal tariffs from NTPC of Rs3.63/kWh for FY2018/19.[5]

On the other hand, India's thermal power sector has seen tremendous financial distress with 34GW of projects remaining stranded, plaguing both India's power generation sector and its banking system.[6] The thermal power sector faces structural issues including a lack of appropriate fuel-linkages, an inability to access PPAs due to lower than expected electricity demand, an unsustainable reliance on concessional financing, and last but not least, competition from lower risk, cheaper, domestic renewable energy sources.

India's thermal power sector has seen tremendous financial distress.

The thermal power sector's underperformance is exemplified by unsustainably low capacity utilisation rates of less than 60% over the past two years combined with excessive financial leverage that makes debt servicing problematic. Distress is exacerbated by loss-making discoms that have often failed to make timely payments or have sought to renegotiate tariffs on PPAs.

[5] NTPC, Key Performance Highlights FY2018/19.
[6] IEEFA, Risk to India's banking sector in rising tide of stranded assets, 21st August, 2018.

Thermal capacity additions hit a decade low in FY2018/19. From the highs of (an average) 20GW of new coal-fired power plants commissioned every year between FY13 - FY16, net capacity additions from coal over the past three years have been 7GW, 5GW and 3.4GW, respectively.

Factors such as rapid improvements in renewable energy technologies, economies of scale, innovative debt and equity financing, and strong government endorsements have provided a great deflationary impetus to renewable energy tariffs.

In IEEFA's opinion, India is well on the way to achieving its energy goals given the clear ambition of the Indian government and an US$500-700bn investment opportunity by 2030 underlying the mega transition.

Forecasting the Energy Mix in India's Electricity Sector

IEEFA models the energy mix in India's electricity sector with reference to the Central Electricity Authority's (CEA's) draft report on the optimal energy mix by 2029/30. However, we attenuate our estimates based on our reading of current market, finance and policy conditions.

IEEFA forecasts India's renewable energy capacity to grow rapidly with 25-30GW of new capacity additions annually through to FY2029/30. IEEFA projects renewable energy capacity to be at 405GW (excluding hydro) by FY2029/30 which forms 54.4% of India's total generation capacity and 33.7% of total generation.

IEEFA recommends a progressive retirement of India's old, end-of-life and outdated subcritical technology coal-fired power plants, and for the completion in construction of modern coal-fired capacity sufficient to replace the retired power plants.

Due to the unrelenting and likely ever cheaper competition from variable renewable energy sources, thermal power will progressively lose market share, taking its generation share from 74.3% in FY2018/19 to just 51.7% in FY2029/30. IEEFA projects net new capacity additions to be some 39.1GW, taking coal-fired capacity to 239.8GW by FY2029/30, a likely peak for India.

Thermal power will progressively lose market share.

Figure 2.2: India's Electricity Sector Composition FY2029/30

	Capacity		Generation		Capacity	Increase
	GW	%	TWh	%	Utilisation	GW vs. FY19
Coal-fired	239.8	32.2%	1211.5	51.7%	57.7%	39.1
Gas-fired	24.4	3.3%	53.3	2.3%	25.0%	-0.6
Diesel-fired	0.0	0.0%	0.0	0.0%	0.0%	-0.6
Hydro	63.4	8.5%	183.4	7.8%	33.0%	18.0
Nuclear	11.9	1.6%	74.1	3.2%	71.2%	5.1
Renewables	405.0	54.4%	789.6	33.7%	22.3%	327.2
Bhutan/Nepal	n.a.	n.a.	31.2	n.a		
Total	**744.5**	**100.0%**	**2,343**	**98.7%**		**388.2**
Battery Storage	34.0					
Capitve power	51.4					
Total	**795.9**					

Source: CEA, IEEFA.

Additionally, the Indian power sector faces a massive structural challenge in the form of loss-making state-owned discoms and unsustainable, largely unfunded cross-subsidies in its electricity tariff structure.

The transition to an electricity system with massive amounts of renewable energy will require even faster grid transmission and distribution expansion, as well as the incorporation of storage technologies, demand response management, flexible on-demand peaking power capacity (both gas peakers and faster-ramping coal technologies), and other reforms such as time-of-day pricing to incentivise continued investment in the concurrent expansion and modernisation of India's electricity system.[7]

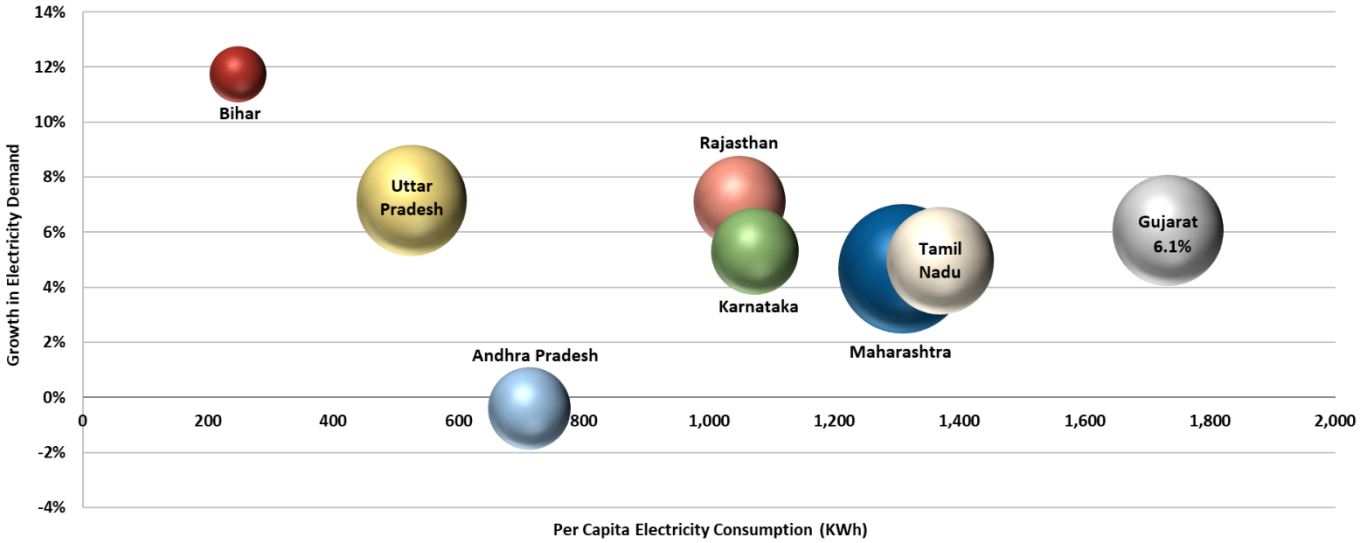
[7] IEEFA & ENERFRA, Flexing India's Energy System, 8 January, 2019.

3. Overview of Gujarat's Electricity Sector

Being one of the most industrial states in India, Gujarat's electricity demand has grown rapidly at a CAGR of 6.1% annually between FY2008/09 and FY2018/19.

In FY2018/19, Gujarat consumed a total of 116.3TWh of electricity making it the second largest electricity market behind the state of Maharashtra. It is the leading state in terms of per capita electricity consumption with 1,733kWh per person in FY2018/19.

Figure 3.1: Gujarat Electricity Sector Total and Per Capita Consumption, Growth FY2018/19



Source: CEA, India census data, IEEFA estimates.

Note 1: The size of the bubble depicts total electricity consumption for the states.

Note 2: Note: The Andhra Pradesh and Telangana split in FY2014/15 reflects in the reduced size of the Andhra Pradesh's electricity market.

Electricity Sector Composition

As of March 2019, Gujarat had thermal generation capacity of 22.3GW comprising 15.8GW of coal-fired capacity and 6.6GW of gas-fired capacity. This formed 69.1% of total generation capacity and 81.1% of the total generation in Gujarat.

In terms of renewable energy, Gujarat is one of the top states for wind with 6GW installed as of FY2018/19. Another 2GW of solar and 0.5GW of biomass capacity makes the total renewable capacity 8.6GW. Renewables make 26.8% of generation capacity and 11.8% of total consumption in Gujarat.[8] New renewable capacity of 1.3GW was added during FY2018/19.

[8] Renewables were 12.5% of total generation in Gujarat in FY2018/19 and 11.8% of consumption which includes net interstate imports of 6.2TWh during the same period.

Figure 3.2: Gujarat Electricity Sector Composition FY2018/19

	Electricity Sector Composition FY2018/19					
	Capacity		Generation		Utilisation	Capacity Adds
Source	(GW)	%	(TWh)	%	%	(GW)
Coal	15.8	48.8%	81.7	70.1%	59.5%	0.2
Gas	6.6	20.3%	12.8	11.0%	22.3%	0.0
Diesel	0.0	0.0%	0.0	0.0%	0.0%	0.0
Nuclear	0.6	1.7%	1.0	0.9%	20.4%	0.0
Hydro	0.8	2.4%	1.0	0.9%	15.4%	0.0
Renewables	8.6	26.8%	13.8	11.8%	19.7%	1.3
Net imports			6.2	5.3%		
Total	**32.3**	**100.0%**	**116.6**	**100.0%**		**1.5**
Off-grid	2.3					

Source: CEA, Western Load Dispatch Centre (India), IEEFA estimates.
Note: Net 6.2TWh of electricity was imported into the state in 2018/19.

Additionally, Gujarat has 0.8GW of large hydro and 0.6GW of nuclear capacity. Commissioned in 1993, Kakrapar Atomic Power Station at 440MW (two x 220MW pressurised water reactors) forms the majority of Gujarat's nuclear power capacity.[9] Units 3 and 4 at 1.4GW (2X700MW) at the Station are under construction and scheduled to be completed by FY2024/25.[10]

Gujarat is one of the top states for wind with 6GW installed as of FY2018/19.

The state has added net zero or negative coal-fired capacity between FY2012/13 and FY2018/19. On the other hand, its renewable capacity has more than doubled during the same period—an indication of the state's transition towards a renewable energy-based electricity system.

Gujarat's coal-fired fleet operated at a prohibitively low capacity utilisation rate of 59.5% in 2018/19. At such low utilisation rates, it becomes harder to service debts leading to an increase in stranded asset risk.

Forecasting the Energy Mix in Gujarat's Electricity Sector

IEEFA models a long-term electricity sector mix for Gujarat to FY2029/30, taking into account its historic electricity demand growth, economic growth and resulting power intensity, plus the relative cost trajectories for various power systems.

[9] The CEA reports Gujarat's nuclear capacity to be 600MW. However, IEEFA has not been able to identify the additional 160MW of nuclear capacity in Gujarat.
[10] Press Information Bureau, Government of India, Department of Atomic Energy, Proposal of New Atomic Plants, 3 January 2019.

Figure 3.3: Gujarat Electricity Sector Composition FY2029/30

	Electricity Sector Composition FY2029/30					
	Capacity		Generation		Utilisation	Capacity Adds
Source	**(GW)**	**%**	**(TWh)**	**%**	**%**	**(GW)**
Coal	14.0	17.8%	68.7	33.8%	56.1%	-1.8
Gas	6.6	8.4%	14.4	7.1%	25.0%	0.0
Diesel	0.0	0.0%	0.0	0.0%	0.0%	0.0
Nuclear	2.0	2.5%	13.7	6.8%	80.0%	1.4
Hydro	0.8	1.0%	1.4	0.7%	20.0%	0.0
Renewables	55.1	2.0%	97.7	48.1%	24.0%	46.5
Net imports			7.2	3.6%		
Total	**78.4**	**31.7%**	**203.1**	**100.0%**		**46.1**

Source: IEEFA estimates.

IEEFA projects Gujarat's coal-fired capacity will reach 14GW by FY2029/30. Net negative additions of 1.8GW capacity accounts for the commissioning of 1.3GW of 'currently under construction' capacity and 0.8GW of capacity under advanced stages of regulatory approvals, to partially replace 3.9GW of end-of-life power plants to be retired before FY2029/30.

Gujarat, with great solar and wind power potential, is one of the preferred destinations in India for renewable energy developers and investors.

Gujarat recently set an ambitious target to install 30GW of renewable energy by FY2021/22 which will require additions of 7GW of capacity annually from FY2019/20 onwards. Given the sluggishness in capacity commissioning in India's renewable sector, Gujarat is unlikely to achieve this near-term target.

IEEFA projects Gujarat's renewable energy to reach 55.1GW by FY2029/30.[11] The incorporation of large amounts of renewables will highlight the need for addressing grid stability issues and will require adoption of energy storage systems as well demand response management, in addition to a significant expansion of interstate grid transmission capacity.

IEEFA projects Gujarat's renewable energy to reach 55.1GW by FY2029.

We detail our model with production and demand growth projections, transmission losses, and resulting capacity growth requirements, in Section 6.

[11] Refer to Sections 5 and 6 in this report for a detailed analysis.

4. Gujarat's Thermal Power Sector

Thermal power capacity formed 69.1% of Gujarat's total generation capacity as of June 2019.[12] The 15.8GW of coal-fired capacity includes 1.5GW of lignite-fired power plants.

Gujarat is one of the very few states in India with lignite production. As of March 2018, Gujarat was estimated to have 2.72 billion metric tonnes (MT) of lignite reserves, which is 6.1% of India's total reserve.[13] In contrast, the state does not have any material in-state 'black' coal mining capacity.

Coal-fired capacity in Gujarat is either based on imported seaborne coal or domestic coal hauled by rail from distant coal mines from the eastern states of India, such as Odisha, West Bengal and Jharkhand.

IEEFA estimates transportation of coal over 1,200km via railways increases the final tariff of electricity produced by Rs1.66/kWh compared to tariffs of mine-mouth coal-fired power plants.

Gujarat's coal-fired fleet operated at 59.5% in 2018/19, well below designed utilisation rates of 80-85%. Such low utilisation rates reduce operational efficiency and hence commercial viability, in turn making debt servicing more difficult and increasing the risk for projects to be a stranded asset.

LNG Import Capacity

Gujarat has 22.5MMTPA of operational LNG handling capacity and another 10MMTPA in the pipeline. The two operational LNG terminals in Dahej (by Petronet LNG) and Hazira (by Royal Dutch Shell) form 60% of India's existing LNG handling capacity.[14]

Figure 4.1: LNG Handling Infrastructure in Gujarat

Terminal	Developers	Capacity (MMTPA)	Status
Dahej	Petronet	17.5	Operational
Hazira	Royal Dutch Shell	5.0	Operational
Mundra	GSPC, Adani	5.0	Fully constructed
Jafrabad (FSRU)	Swan	5.0	Planned
Total		**32.5**	

Source: Petronet.

[12] There has been no thermal capacity addition during the Q1FY2019/20 (April-June Quarter).
[13] Government of India, Energy Statistics 2019, March 2019.
[14] Petronet LNG, Corporate Profile, June 2019.

Gujarat's gas-fired power generation fleet suffers a similar underutilisation as its coal-fired fleet. The gas-fired fleet in Gujarat operated at an unsustainably low utilisation factor of 22.3% in FY2018/19.

Lower than expected domestic production and higher costs of imported LNG are two key factors keeping more than half of India's gas-fired capacity idle in recent times, says the special parliamentary committee on energy in its January 2019 report.[15] Additionally, gas-fired power tariffs lose out on competitiveness as they need to incorporate costs of fuel transportation from expensive inter-state pipelines. The inter-dependability of gas-fired power plants, LNG import, regasification units and pipelines raises overall stranded asset risk in the sector, especially given lower cost domestic gas production is unable to match the demand of the sector.

Coal-fired Power Sector

Gujarat's coal-fired power sector is dominated by private players with two-thirds of its existing operational capacity belonging to top Indian power sector investors such as Adani Power and Tata Power, with state government the other major operator.

Figure 4.2: Coal-fired Power Generation Players

Proponent	Capacity (MW)
Adani Power Ltd	4,620
Essar Power Ltd	1,470
Gujarat Industries Power Co Ltd	500
Gujarat State Electricity Corp Ltd	4,200
Tata Power Co Ltd	4,000
Torrent Power Ltd	515
Total	**15,305**

Source: Global Energy Monitor. Note: The above list excludes plants below 100MW.

[15] Ministry of Power, Standing committee on energy (2018-19), January 2019.

Gujarat State Electricity Corporation Ltd

Gujarat State Electricity Corporation Ltd (GSECL) is a wholly owned subsidiary of the Gujarat Electricity Board and is largest public sector power generation player in Gujarat.

Figure 4.3: GSECL Coal-fired Power Plants

Plants	Capacity (MW)	Year of Commissioning	Fuel Source	Technology	Tariff (Rs/kWh)
Operational					
Dhuvaran Power Station	220	1972	Coal	Subcritical	
Gandhinagar Power Station	610	1990-1998	Coal	Subcritical	6.05/3.98 for unit 5
Kutch GSECL Power Station	290	1990-2009	Lignite	Subcritical	3.38/3.87
Sikka Thermal Power Station	500	2015	Coal	Subcritical	8.85/5.29 for unit 3&4
Ukai Thermal Power Station	1,110	1979-2013	Coal	Subcritical	4.11/4.95
Wanakbori Thermal Power Station	1,470	1982-1998	Coal	Subcritical	4.49/4.05
	4,200				
Under Construction					
Bhavnagar Lignite Power Station	500	2019	Lignite	CFB	
Wanakbori Thermal Power Station	800	2019	Coal	Supercritical	
	1,300				
Pre-permitted					
Ukai Thermal Power Station	**800**			Supercritical	

Source: GSECL, Global Energy Monitor, CEA.

GSECL operates 4.2GW of coal/lignite-fired capacity in the state. Apart from its lignite-based 290MW Kutch Power Station, all its coal-fired capacity is contracted at now uncompetitively expensive tariffs in the range of Rs4.05-8.85/kWh—up to double the average of renewable energy tariffs at Rs2.80/kWh in recent times.

Roughly 80% of GSECL's operational coal-fired capacity is based on out-dated subcritical combustion technology that is reaching its end-of-life. In IEEFA's view, the highly polluting, expensive, out-dated coal-fired capacity will have to be progressively retired and replaced by much lower-cost but variable renewable energy sources.

The company had planned to retrofit its Ukai, Gandhinagar and Sikka power plants commissioned more than 35 years ago.[16] However, GESCL realised this was an extremely sub-optimal investment decision and instead retired a total of 720MW of old units from these three power plants in 2017, and replaced it with new capacity based on slightly more up-to-date supercritical combustion technology.

[16] Times of India, Gujarat thermal power plants set for major overhaul, 1 June 2015.

GSECL currently has two coal-fired power plants under construction—Wanakbori Thermal and Bhavnagar Lignite power stations—and another one in planning. IEEFA expects all three to be extremely challenged financially in the face of low-cost renewable energy. Gujarat would be far better served installing flexible, on-demand peaking power capacity to hasten and balance least cost renewable energy generation.

Gujarat would be far better served installing flexible, on-demand peaking power capacity.

Bhavnagar Lignite Power Station, 500MW, Under-construction

Bhavnagar Lignite Power Station with two units of 250MW (2 X 250MW) is located at Padva village near Ghogha town in Bhavnagar district, Gujarat. The power station is based on Circulating Fluidised Bed (CFB) combustion technology.

The station planned to source lignite local mine blocks from Ghogha-Surka and Khadsaliya I and II. However, in May 2014, the project faced huge civil unrest with local villagers opposing their forceful displacement.[17]

India's Ministry of Power reports the power plant as fully commissioned, however, it is either not yet synchronised into the grid, or still in its testing phase.

Wanakbori Thermal Power Station, 800MW, Under-construction

Unit 8 of the Wanakbori Thermal Power Station is based on supercritical technology, unlike previous units based on entirely out-dated subcritical technology. The station is located on the banks of the Mahi river in Kheda district, Gujarat.

With a final commissioning date of February 2019,[18] GSECL suggests the project is running behind schedule. Absent in-state coal mining capacity in Gujarat, IEEFA estimates tariffs will be higher than the plant's existing unit tariffs of Rs4.05-4.49/kWh.

Ukai Thermal Power Station, 800MW, in Planning

In February 2018, GSECL applied to construct a new 800MW supercritical unit at the site of the Ukai Thermal Power Station. GSECL plans to replace Ukai's 440MW of old units (1, 2 and 3) with the new extension.

Adani, Tata and Essar

Two-thirds of Gujarat's coal-fired capacity built between 2009 and 2013 was unviable until bailed out recently with a massive increase in the agreed pass-through of expensive imported coal costs to discoms. A total of 9.9GW of imported coal based plants includes Adani Power's 4.6GW Mundra Thermal Power Station,

[17] The Times of India, 62 teargas shells lobbed as farmers clash with police, 14 May 2018.
[18] GSECL, Projects

Tata Power's 4.1GW Mundra Power Plant—owned through a special purpose vehicle named Coastal Gujarat Power Ltd (CGPL)—and the 1.2GW Essar Salaya Power Plant.

Adani Power's Mundra Thermal Power Station, 4.6GW

Adani Power's Mundra Thermal Power Station is located in the Mundra taluk of Kutch district in Gujarat. The plant has PPAs with discoms in Gujarat and Haryana.

Tata Power's Mundra Power Plant, 4.1GW

Tata Power's subsidiary CGPL operates the 4.1GW coal-fired power plant at Mundra, Gujarat. The plant is fuelled by imported coal. It has PPAs with discoms of five states: Gujarat, Maharashtra, Haryana, Rajasthan and Punjab. The plant's funders include the Export-Import Bank of Korea, the Asian Development Bank (ADB) and the International Finance Corporation (IFC), the private-sector arm of the World Bank.

Essar Salaya Power Plant, 1.2GW

The Essar Salaya Power plant is owned by the London-based Essar Group, made up of the billionaire Ruia brothers of India. The plant has a PPA with Gujarat Urja Vikas Nigam (GUVNL) to supply the entirety of its production.

Stranded Coal Power Assets

Some 9.9GW of coastal power plants built during India's thermal power capacity boom are vertically integrated with promoters having stakes in Indonesian coal mines. Before 2011, captive Indonesian coal was traded at a significant discount compared to the internationally traded market price of coal. However, in 2011, the Indonesian government benchmarked Indonesian export coal prices against international coal prices, additionally applying a 13% royalty to the market price to ensure some return to the people of Indonesia from use of their public resources.[19]

In the absence of pass-through from higher than expected fuel cost market prices—resulting from price increases in seaborne Indonesian coal—the power plants became unviable at previously contracted tariffs in the range of Rs2.26-2.89/kWh.

The promoters of the power plants applied to India's Central Electricity Regulatory Commission (CERC) for compensatory tariffs to allow pass-through of the higher coal costs. The overturning of binding contracts was initially granted, but then challenged by State discoms who had 25-year PPAs to buy the power at very favourable tariffs. In 2017, the Indian Supreme Court effectively disallowed the compensatory tariffs, leaving 9.9GW of coal-fired power capacity in extreme financial distress.

[19] DNA, Indonesian nightmare for Tata, Adani, JSW, Lanco, 13 June 2011.

Since the plants had been designed to operate on imported coal with low ash content, operating the plants on domestic coal would require additional capital expenditure for a retrofit.

In June 2017, Adani and Tata offered to sell a 51% equity stake in each of these assets to GUVNL—the main procurer of their electricity—for a nominal price of Rs1 in return for its agreement to pay a higher rate for the power produced. GUVNL countered the offer by asking for 100% ownership of the troubled plants.

During FY2017/18 and FY2018/19, Adani and Tata's Mundra power plants operated at prohibitively low utilisation rates of less than 60%.[20] [21] At the end of FY2018/19, debts for Adani Mundra and Tata Mundra were Rs11,552 crore (US$1.6bn)[22] and Rs6,954 crore (US$0.98bn) respectively.[23]

Expensive Public-funded Bail Out

As Tata Power and Adani Power failed in their offers to offload a 51% stake in their Mundra plants for one rupee each, recommendations from a Gujarat government appointed special committee paved the way for a highly favourable bail-out.

In July 2018, the Gujarat state government set up a three-person panel to consider options for the unviable Mundra power plants of Tata Power, Adani Power and Essar Power, totalling 9.9GW. The panel's recommendations included amendments to the plant's PPA's to allow pass-through of high coal costs onto consumers and the option to extend PPAs by up to ten years. Lenders to the projects would also be required to take a haircut.[24] The committee recommended reductions in fixed charges by Rs0.20/kWh, which would necessitate banks reducing debts by Rs4,240 crore (US$600m) for Tata Power, Rs3,821 crore (US$540m) for Adani Power, and Rs2,324 crore (US$327m) for Essar Power.[25]

GUVNL, the Gujarat state distribution company, applied to CERC to approve an amendment to its PPAs along these lines with the Mundra plants and, in October 2018, the Supreme Court allowed CERC to approve such a measure.

In April 2019, CERC officially approved a tariff uplift for PPAs covering 2,000MW of Adani Power's Mundra plant, setting a precedent for the rest of the Mundra coal-fired power capacity of Adani Power, Tata Power and Essar Power.[26] In addition to allowing pass-through of the cost of imported coal up to US$110/t as a partial offset, Adani will need to share the profits from its Indonesian coal mining operation.

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[20] Tata Power, Analyst Call Presentations
[21] Adani Power, Analyst Call Transcripts
[22] ICICI Securities broker report, 6 June 2019.
[23] Coastal Gujarat Power Limited, Annual Report, FY2018/19.
[24] Financial Express, SC relief for Gujarat power plants: CERC may consider PPA revision only after all five states seek it, 4 December 2018.
[25] Financial Express, CERC directs Tata Power arm to get discoms' consent for Mundra PPA revision, 30 May 2019.
[26] ET Energyworld, Fuel cost pass-through for Adani plant positive sign for imported coal-based IPPs, 15 April 2019.

The GUVNL PPA uplift decision is potentially most beneficial to Essar Power's 1,200MW Mundra plant whose entire power output is covered by a PPA from that discom. With the Tata Power and Adani Power plants also supplying various other state discoms in addition to Gujarat, those companies are now negotiating similar PPAs to cover their entire electricity output.

The tariff hikes based on pass-through of escalated fuel costs are reported to be Rs0.4/kWh of Tata, Rs0.8/kWh for Adani and Rs0.6/kWh for Essar's Salaya plant.

Although the arrangement is highly favourable to plant owners, in IEEFA's view it places a massive additional 30-year burden on consumers (including a 10 year extension recommended by the committee).

Figure 4.4: Losses for Discoms as a Result of Fuel Cost Pass-through

Losses for State-owned Discoms (Gujarat, Maharashtra, Haryana, Punjab, Rajasthan)

CERC approved higher fuel cost pass-through in

	Tata	Adani	Essar	
Estimated revised tariff hikes granted (Rs/kWh)	0.4	0.8	0.6	Rs/kWh
New tariff (Rs/kWh)	3.10	3.40	3.50	Rs/kWh
Total capacity of the three projects	4.1	4.62	1.2	GW
Generation at full capacity	35.9	40.5	10.5	TWh
At 70% PLF	25.1	28.3	7.4	TWh
Total generation for the period of 30 years	754.2	849.9	220.8	TWh
Losses for discoms through fuel cost passthrough for the period of 30 years	301.7	679.9	132.5	Rs bn
	4.3	**9.7**	**1.9**	US$bn
Minus benefit through reduction of 0.2/kWh on fixed charges	215.5	242.8	63.1	Rs bn
	3.1	**3.5**	**0.9**	US$bn
Net losses for discoms	**1.2**	**6.2**	**1.0**	US$bn
Cumulative loss to state-owned discoms		**8.5**		**US$bn**

Source: Media reports, IEEFA estimates.

IEEFA notes this US$8.5bn burden is equivalent to the capital investments required to build 8-10GW of renewable energy capacity with zero variable costs of fuel.

Yet even so, the bailout will not be enough to make the Mundra assets viable. Tata Power's Managing Director Praveer Sinha has stated the PPA uplifts would only halve CGPL's losses from the current level of US$225-240m per year.[27]

[27] Economic Times, After tariff relief, our Mundra losses would come down by 50%: Praveer Sinha, Tata Power, 6 December 2018.

Mota Layja Power Station, ~4GW, Proposed

Infrastructure Leasing & Financial Services Company (IL&FS) was founded in 1987 with equity from the Central Bank of India (CBI), the Unit Trust of India (UTI) and the Housing Development Finance Co (HDFC)—organised to fund infrastructure projects in India. The Life Insurance Company (LIC) of India, the ORIX Corporation of Japan, the Abu Dhabi Investment Authority (ADIA) and the State Bank of India (SBI) are among the other major institutional investors in IL&FS.

IL&FS proposed a supercritical 3,960MW coal-fired power plant at Mota Layja village in the Kutch district in Gujarat (the plant is also known as the Nana Layja Power Station).

The plant was proposed to be accompanied by another 2GW of gas-based combined cycle power plant (CCPP) with a captive port for unloading of 17MTPA of coal, and a 60 million litres per day (MLD) desalination plant to meet the plant's water requirements. The plan for an imported gas-based CCPP comprises gas turbines with a 5MTPA LNG terminal and captive jetty for unloading LNG.[28] IL&FS sought a long-term domestic fuel supply contract and additionally 30% of the required fuel to be sourced through international markets.

In 2015, IL&FS sought US$1bn of financing from the Industrial and Commercial Bank of China (ICBC) as part of a project development partnership with China Huaneng Group. This would have been the first instance of direct funding support from China coming to a thermal-based power project in India.[29]

As of September 2018 the group's total debt stood at Rs99,354 crore (US$14bn) with an entirely unsustainable debt to equity ratio of 10:1.[30]

In December 2018, IL&FS declared 90% of its loan assets to be non-performing assets (NPAs).

IL&FS' lending of nearly Rs60,000 crore (US$8.6bn) to infrastructure projects of mainly roads, power and water ran into land acquisition issues and were hit by cost overruns. IL&FS' severe financial distress clearly depicts the financial stress and promotor incompetence in India's thermal power sector.[31]

IL&FS' severe financial distress clearly depicts the financial stress and promotor incompetence in India's thermal power sector.

With no progress on the Mota Layja Power Station and other projects since 2015, IEEFA assumes they have been shelved.

[28] IL&FS, Nana Layja Power Project
[29] Live Mint, IL&FS signs funding MOU; ICICI opens a branch in China, 16 May 2015
[30] Live Mint, IL&FS Financial Services' Gross NPA at 90%: Uday Kotak, 04 April 2019
[31] The Economic Times, IL&FS: The crisis that has India in panic mode, 03 October 2018

In IEEFA's view, the now stranded 4GW of coal-fired capacity and 2GW of additional gas-based capacity coupled with LNG import handling infrastructure is not in the best interest of Gujarat given its expense, which is compounded by the lack of in-state coal capacity, the volatility of imported coal prices, and foreign currency exposure.

IEEFA deems the Mota Layja Power Station project to be extremely risky and a likely loss-making proposition for the proponents, lenders, discoms and Gujarat's economy.

Expensive, import-based, large thermal capacity has forced discoms to rely on expensive power from the spot market. As suggested earlier, the favourable public-funded bail-out will continue to burden discoms, and eventually consumers, with expensive tariffs.

Additionally, these projects have severely impacted the books of some of India's top infrastructure conglomerates, potentially blockading their ability to recycle capital into new projects, and particularly their renewable energy businesses. At the same time, they have put tremendous financial pressure on lenders and the overall financial system of India.

In IEEFA's view, Gujarat does not need any further baseload thermal capacity additions apart from replacing its end-of-life, outdated technology-based coal-fired capacity. This includes GSECL's 1.3GW of capacity already under-construction (500MW Bhavnagar Lignite Plant and 800MW Wanakbori Plant) and the proposed 800MW brownfield expansion of the Ukai Thermal Power Station.

Gujarat does not need any further baseload thermal capacity additions.

IEEFA's model for the Gujarat Electricity Sector by 2029/30 (Refer to Section 6) projects 2.1GW of gross thermal capacity additions and 3.9GW of gross retirements, resulting in net -1.8GW of additions.

In IEEFA's opinion, given the additions are a brownfield expansion of already existing projects where land, domestic fuel supply and PPAs are already in place, they are less risky than greenfield projects based on imported coal.

Flexing of Gas-based Capacity

Gujarat possesses one-fourth of India's gas-fired power capacity and three quarters of India's operational/fully constructed LNG regasification capacity. However, Gujarat's gas-fired capacity operated at a low utilisation factor of 22.3% in FY2018/19, in line with India's overall gas-fired fleet.

Roughly 1.3GW of the gas-fired capacity in Gujarat is contracted at unsustainably high tariffs of Rs6.22 to Rs7.11/kWh (refer to Figure 4.5)[32] in comparison to the state's average purchase price of Rs3.49/kWh,[33] while all of its recent renewable energy tariffs were contracted in the range of Rs2.44 to Rs2.95/kWh.

As listed in Figure 4.5, high tariffs for Dhuvaran CCPP (595MW) and Pipavav CCPP (702MW) reflect prohibitively low utilisation rates of 13.4% and 8.0% respectively.

Figure 4.5: Gujarat's Gas-fired Power Fleet

Gas Plants	Capacity (MW)	Generation in FY2018/19 (GWh)	Utilisation Factor (%)	Tariff (Rs/kWh)
Dhuvaran Gas Based CCPP	595	699	13.4%	6.22
Essar Hazira Power Plant	515	376	8.3%	3.03
Jhanor-Gandhar Thermal Power Station	657	1,573	27.3%	-
Kawas Thermal Power Station	656	2,499	43.5%	-
Utran Gas Based Power Station	374	418	12.8%	-
Pipavav CCPP	702	493	8.0%	7.11
Baroda CCPP	160	0	0.0%	-
Sub-total	**3,659**	**6,058**	**18.9%**	-
Other	2,903	6,744	26.5%	-
Total	**6,562**	**12,802**	**22.3%**	-

Source: CEA, IEEFA estimates.

In August 2018, CEA suggested a plan to test its gas-fired fleet as 'peakers' by operating only in the evening for supply smoothing and to deal with grid fluctuations. The plan envisaged testing of NTPC's 2.3GW of gas-fired capacity to begin with, then gradually operating 20GW of national gas-fired capacity as evening 'peakers' by FY2022.[34] IEEFA supports this proposal, even though it requires a sustained government subsidy, given it best leverages the existing US$20bn, 25GW of currently stranded gas-fired power capacity already installed across India.

India's ambitious plan to build 175GW of renewable energy by FY2022 and 450GW (plus 73GW of hydro) by FY2030 demands massive steps towards incorporating grid

India's ambitious plan to build 175GW of renewable energy by FY2022 and 450GW (plus 73GW of hydro) by FY2030 demands massive steps.

[32] CEA, Executive Summary FY2018/29 (page 36), March 2019.
[33] Financial Express, SC relief for Gujarat power plants: CERC may consider PPA revision only after all five states seek it, 4 December 2018.
[34] ET EnergyWorld, India to test gas-fired plants as 'peakers' to smooth power grid, 16 August 2018.

flexibility and firming of flexible capacity.

For gas-fired power plants, it is easier to ramp on and off its supply levels given it could operate at a low minimum required load (MRL). In other words, gas-fired power plants provide much better flexibility compared to coal-fired power plants as they can easily be turned on and off.

As mentioned earlier, India's gas production is not enough to support a further expansion of its gas-fired fleet. Expensive imported LNG terminals and the required supporting infrastructure takes away the competitive edge of gas-fired power.

Flexible peaking usage of the gas-fired capacity requires a 'time-of-day' pricing mechanism that incentivises better usage of existing gas-fired capacity to provide on-demand firming capacity when most valuable. This pricing mechanism is necessary to incentivise other important facets of cheap intermittent renewable energy integration such as demand response management, storage technologies, solar thermal with storage, as well as grid modernisation coupled with an expansion of interstate and even international grid connectivity.

Gujarat, with its already existing expansive gas-fired power related infrastructure, is in a great position to take a rapid lead on integrating large amounts of variable renewable energy into its grid at relatively low incremental firming cost.

Risk to Thermal Sector from Water Stress

In addition to the dearth in availability of cheaper domestic fuel, another risk that is extremely important to consider is India's growing problem of water stress.

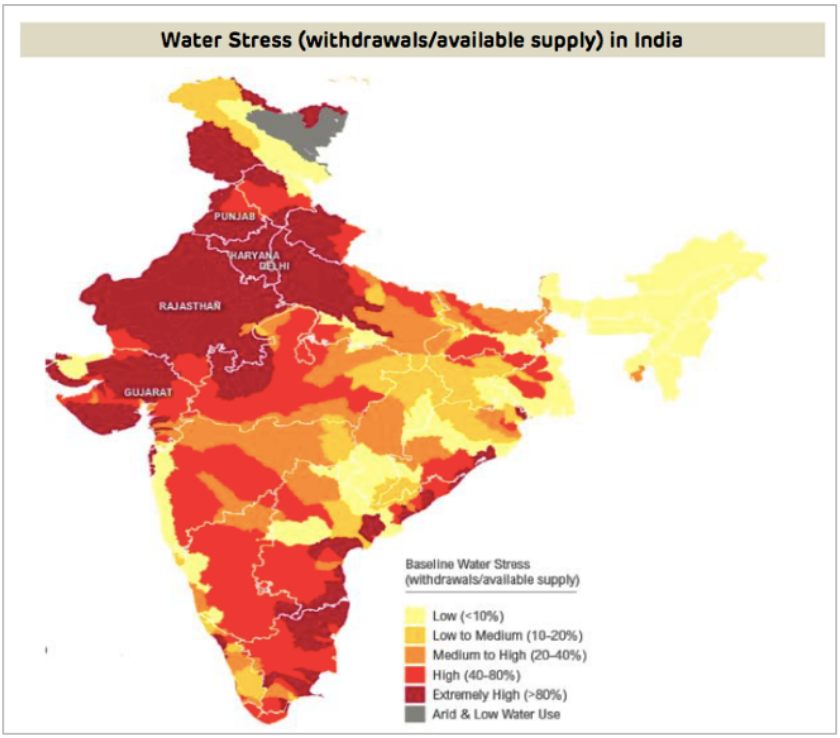
Coal-fired power plants require significant amounts of water for steam to produce energy, cool equipment, perform system maintenance, and clean sites and equipment.[35] Scarce water is becoming increasingly hard to come by in India.

Scarce water is becoming increasingly hard to come by in India.

In India, the amount of rain delivered during the Monsoon season has been declining, dropping by some 20% in recent years.[36] In addition, it has become less predictable while the number of heavy, and often harmful, rainfall events has increased.[37] [38] India's continued population growth coupled with its strong economic growth are also building pressure on the finite, declining scarce resource.

[35] Union of Concerned Scientists, How it Works: Water for Coal, 2014.
[36] Nature Communication, Drying of Indian subcontinent by rapid Indian Ocean warming and a weakening of land-sea thermal gradient. *Nature*, 6, 7423, 16 June 2015.
[37] My India, Climate Change and Its Impact on Monsoon In India, 9 July 2017.
[38] The World Bank, India: Climate Change Impacts, 2018 .

Figure 4.6: Water Stress in India



Source: World Resource Institute.

The World Resources Institute found that fourteen of India's top 20 largest thermal power utility companies experienced water shortage-related disruptions at least once between 2013 and 2016, losing more than US$1.4bn in potential revenue.[39]

As shown in Figure 4.6, Gujarat is one of the most water stressed regions in India exacerbated by its active industry sectors.

A coal-based thermal power plant takes around 3.8 cubic metre/MWh of water as compared to 0.1 cubic metre/MWh for solar, and almost nil for wind.[40]

A coal-based thermal power plant takes around 3.8 cubic metre/MWh of water as compared to 0.1 cubic metre/MWh for solar.

IEEFA recommends that Gujarat aim to reduce its increasing water stress through an electricity sector transition to a more renewable energy reliant system. Water stress is not only a social and economic deterrent to development, but also a financial one.

[39] World Resource Institute, Parched Power: Water Demands, Risks, and Opportunities for India's Power Sector, January 2018.
[40] Live Mint, An evolving risk paradigm in the power sector, 16 May 2017.

5. Renewable Energy Sector

The MNRE estimates Gujarat's renewable energy potential to be at 72.7GW, dominated by 35GW of solar and 35GW of wind energy potential.[41] As of March 2019, Gujarat had commissioned 8.6GW of total renewable energy, including 2GW of solar, 6GW of wind and 0.6GW of small hydro generation capacity.

In July 2019, Gujarat announced in its state budget that its renewable energy target was hiked to 30GW from 17GW, as per the state-wise break up required to achieve the 175GW national target by FY2021/22.[42] The revised target of 30GW envisages a dramatic expansion of inter-state export capacity as a key part of the solution to managing the variability of renewable energy.

The revised target of 30GW envisages a dramatic expansion of inter-state export capacity.

IEEFA was pleased to see that the budget also allocated a corpus of Rs1,000 crore (US$140m) for distributed rooftop solar.

Earlier in 2019, the State's flagship Vibrant Gujarat Global Summit saw a commitment of Rs50,000 crore in Gujarat's renewable energy sector with multiple small and large-scale wind and solar projects being announced.[43]

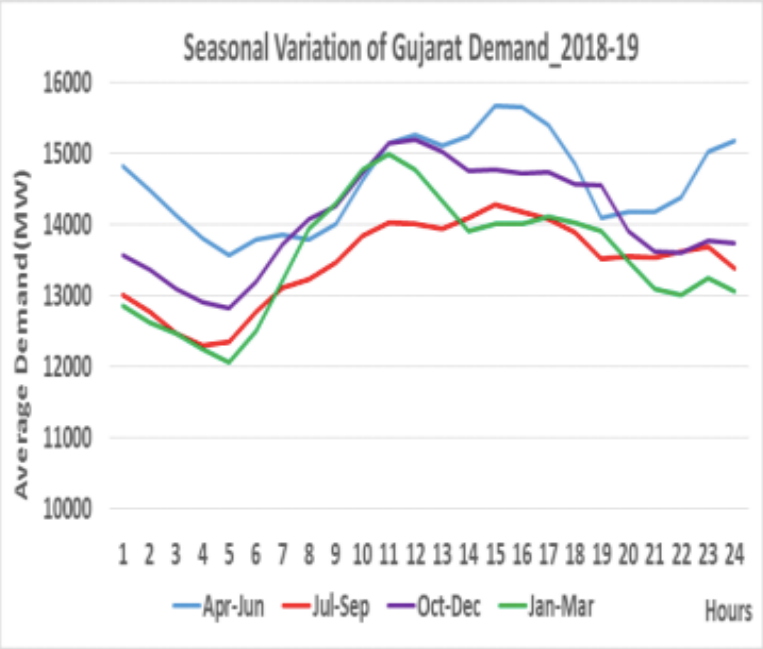
Demand and Supply Profile

Gujarat has high demand for electricity during April to June and then October to December, according to 2018/19 figures. During July to mid-September, Gujarat demand remains low due to the monsoon season.

The highest demand experienced during a particular day in FY2018/19 was 18,221MW on 21 September 2018.[44]

[41] MNRE, National Electricity Plan Page 6.24, January 2018.
[42] ET EnergyWorld, Gujarat to increase green energy capacity to 30,000 MW by 2022, 3 July 2019.
[43] ET EnergyWorld, Vibrant Gujarat summit: MoUs for Rs 50,000-cr renewable power projects likely, 6 January 2019.
[44] Western Load Dispatch Centre Annual Compendium FY2018/19

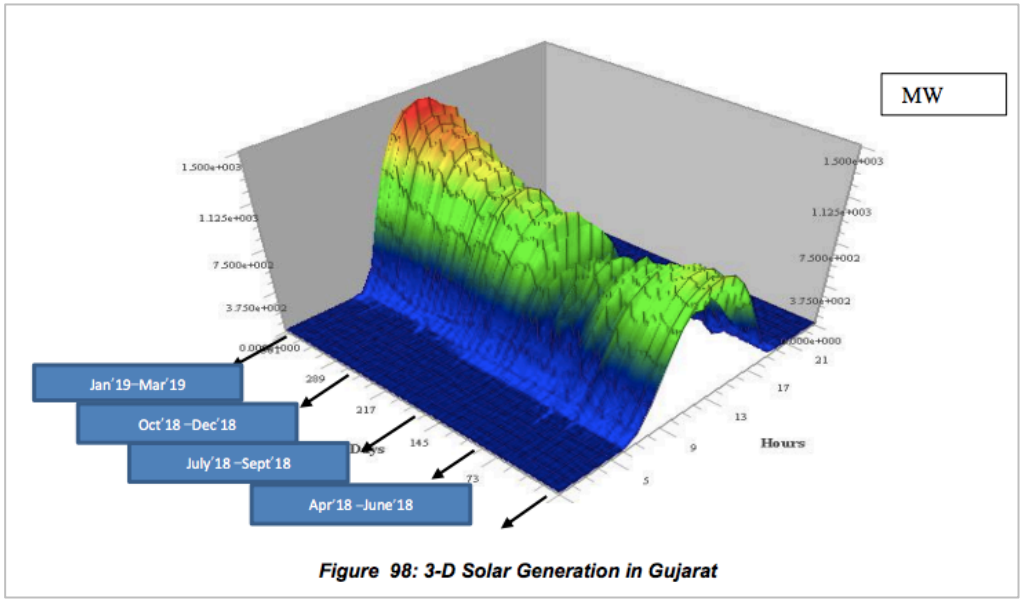
Figure 5.1: Seasonal Variation in Gujarat's Demand FY2018/19



Source: Western Load Dispatch Centre.

Significantly, Gujarat's peak demand occurred between the day hours of 10.00am - 2.00pm, for three quarters of the year from July through to March. During the April to June quarter, peak demand occurred between 2.00pm - 7.00pm, highlighting the value of demand response management and gas-peakers.

Figure 5.2: Solar Generation Pattern in Gujarat

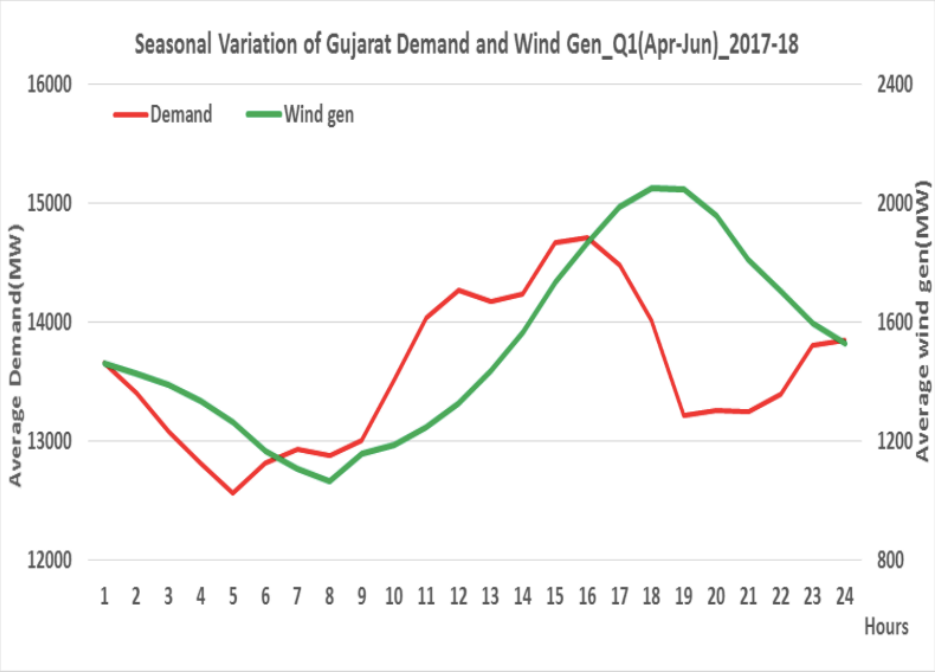


Source: Western Load Dispatch Centre.

Maximum solar generation of 1,481MW was observed on 10 March 2019. As shown in Figure 5.2, peak solar generation in Gujarat occurs roughly between 10.00am to 5.00pm. This indicates Gujarat's demand peak could be entirely supported (on average) by solar power for nine months of the year from July to March.

Gujarat's demand peak could be entirely supported (on average) by solar power for nine months of the year from July to March.

Figure 5.3: Wind Generation vs. Demand Pattern (April to June 2017/18)



Source: Western Load Dispatch Centre.

As illustrated in Figure 5.3, from April to June 2017/18 wind generation favoured Gujarat's demand most of the time and barring a few evening hours, wind pattern is almost following the demand pattern of Gujarat. As observed in Gujarat's seasonal variation in demand patterns (Figure 5.1), April to June were the only months where peak demand was experienced between 2.00pm – 7.00pm.

IEEFA notes building sufficient wind power capacity in Gujarat could support peak hour supply from low cost, low emission power.

Solar Power

Assuming that half of the targeted capacity of 30GW of renewable energy by FY2021/22 will be solar, Gujarat will require about 5GW of capacity additions from FY2019/20.

India's solar sector is currently embroiled in policy uncertainties in the near term due to import duties on solar modules. IEEFA expects capacity commissioning to remain sluggish for FY2019/20.

Gujarat's near-term target of 5GW of annual capacity additions currently looks extremely ambitious.

Gujarat entered into long term PPAs of 1.8GW of solar power capacity between September 2018 - May 2019 within a tariff range of Rs2.44-2.80/kWh, with zero indexation for 25 years. There is also 1.5GW of solar capacity currently under the tendering process which is expected to be auctioned soon.

Ultra-Mega Solar Parks

During the 2019 Vibrant Gujarat Global Summit, Gujarat's Chief Minister Mr Vijay Rupani announced the world's largest solar park with 5GW capacity in the Dholera Special Investment Region (DSIR) in Ahmedabad district.[45] The solar park would be spread across 11,000 hectares of land along the Gulf of Khambhat, and would attract investment of Rs250bn (US$4bn). The DSIR also aims to be a global manufacturing and trading hub.

Dholera Solar Park's first auction awarded 300MW of capacity to Tata Power and Gujarat Industries Power Company Ltd at a tariff of Rs2.75/kWh. However, the tender originally invited 1GW of capacity and was undersubscribed by 700MW amidst multiple cancellations of auctioned capacities, tariff renegotiations and aggressive tariff caps from GUVNL. The 700MW was retendered with the same tariff cap of Rs2.75/kWh in June 2019.[46]

Additionally, NTPC announced a plan for another 5GW of solar park in Kutch, Gujarat during its annual analyst and investor meet for FY2018/19.[47] Gurdeep Singh, Chief Managing Director of NTPC, talked about using Kutch's excellent wind and solar energy resources to implement hybrid wind-solar generation to improve efficiency of generation infrastructure as well as maximise the utilisation of transmission infrastructure. This announcement puts Gujarat ahead in the race for building renewable energy capacity between states such as Tamil Nadu, Karnataka, Maharashtra, Andhra Pradesh and Rajasthan with similar renewable energy potential.

The Power Ministry has approved 6.2GW of solar park capacity for Gujarat, the highest share of the total 26.5GW approved all across India.[48]

[45] PV Tech, India's Gujarat approves 5GW solar park, 11 April 2018.
[46] Mercom India, Gujarat Invites Bids for 950 MW of Projects to be Developed Across Two of its Solar Parks, 25 June 2019.
[47] ET EnergyWorld, NTPC plans 5,000MW ultra-mega solar plant in Kucth worth Rs20,000 crore investment, 20 August 2019
[48] ET EnergyWorld, Gujarat leads India in approved capacity of solar parks, 7 August 2018.

Rooftop Solar

Gujarat recently emerged as the number one state in terms of on-the-meter rooftop solar capacity with 262MW installed as of June 2019.[49] IEEFA optimistically assumes twentyfold growth in rooftop solar to 4.2GW by 2029/30, likely supported by the development of increasingly cost effective, behind-the-meter storage.

IEEFA optimistically assumes twentyfold growth in rooftop solar to 4.2GW by 2029/30.

Recently, one of the discoms in Gujarat, Paschim Gujarat Vij Company (PGVCL) invited a bid for a massive 600MW of residential rooftop solar.[50] This is the largest rooftop solar capacity ever tendered in India.

India's near-term target of 100GW of solar by FY2021/22 envisaged 40GW to come from distributed rooftop solar capacity. At the end of FY2018/19 India's rooftop solar capacity stood at 4.3GW. The ambitious target of 40GW is not likely to be achieved in the next three years. However, the rate of growth of solar installation has been promising. India's rooftop solar capacity additions grew at 89% CAGR annually between 2013 - 2018. The growth in rooftop solar capacity will continue to come from the commercial & industrial (C&I) sector as it seeks to avoid paying for expensive cross-subsidised C&I tariffs in the range of Rs8.0-10.0/kWh.

IEEFA notes India's debt-ridden state-owned discoms' inability or unwillingness to incorporate cheaper rooftop solar capacity has been one of the core issues responsible for slow progress of rooftop solar capacity in India. PGVCL's latest 600MW tender is a great strategic and transitional move in IEEFA's opinion—an excellent skills-based capacity building initiative.

It is critical that India's discoms change their business model sooner rather than later as C&I as well as residential consumers incorporate cheaper rooftop solar options.

[49] ET EnergyWorld, Gujarat tops India in rooftop solar power generation capacity, 24 July 2019.
[50] Mercom India, Gujarat Seeks Empanelled Agencies for 600 MW of Residential Rooftop Solar Projects, 24 July 2019.

Group Captive Model

The open access market allows C&I customers to procure solar energy at competitive prices from offsite solar projects using existing transmission and distribution infrastructure. The open access model has not yet been able to gain ground in India, largely due to restrictive state policies and a myriad of additional charges. According to Mercom India, the open access solar market still accounts for less than 10% of the total installed solar capacity.[51]

The open access solar market still accounts for less than 10% of the total installed solar capacity.

Reportedly, developers have now started to look at group captive power projects as a business model to expand operations in the open access market. Unlike an individual captive or third-party power project, a group captive model is a project developed for the collective usage of one or many corporate buyers. For instance, it can be an arrangement through which a developer sets up a power project for the collective use of multiple C&I customers who have a minimum total of 26% equity in the project, who must off-take 51% of the power produced.

The primary advantage of a group captive model is that cross-subsidies and additional surcharges are not levied on the power procured. Gujarat, with its large base of C&I should benefit from such a model.

Equity ownership from the customer side reduces off-taker risk which has been generally high via the route of state-owned discoms. It potentially provides better return on equity for developers as the project locks in tariffs that are cheaper than the on-grid C&I (RS8.0-10.0/kwh) tariffs, but higher than the wholesale prices (Rs2.44-3.00/kWh) at which discoms buy the power from the project.

With its large base of C&I, Gujarat should benefit from such a model.

Tata Chemicals recently announced a battery manufacturing facility in Gujarat's DSIR with an investment of Rs4,000 crore (US$600m). The manufacturing facility reportedly signed a PPA with Torrent Power to supply power via an open access route at a tariff of Rs4.65/kWh (refer to Section 5).

[51] Mercom India, Is Group Captive the Next Attractive Solar Market in 2019?, 8 July 2019.

Wind Power

As of June 2019, Gujarat, with 6.5GW of wind capacity, is India's second-best state for wind, only behind Tamil Nadu (9.2GW). Gujarat added 430MW of wind power capacity during FY2018/19 and another 519MW during the first three months of FY2019/20.[52]

In May 2019, GUVNL invited bids for 1GW of wind power capacity in Gujarat. GUVNL received bids for 931MW. Only 80% of the total subscribed capacity is allowed to be awarded, according to central government's law, in case the tendered capacity is not fully subscribed by developers.

GUVNL awarded a total 745GW of capacity for tariffs bid between Rs2.80-2.95/kWh. Developers awarded the capacity included the likes of Inox Wind, ReNew Power and Adani Green Energy—India's top renewable energy developers.[53]

Later, GUVNL asked all developers to match their bids to the lowest tariff of Rs2.80/kWh discovered in the reverse auction. Developers have not agreed to the discoms' demand and have expressed their concerns regarding this continued mishandling of auctions and after-the-event rule changes.

India's First Offshore Wind Project

In June 2018, India announced an offshore wind target of 5GW by 2022 and 30GW by FY2030.[54]

In 2018, MNRE invited an expression of interest for 1GW of offshore wind capacity in the Gulf of Khambhat, located off the coast of Gujarat. The invite garnered immense interest from domestic as well as foreign developers. Prominent participants from India included Sterlite Power Grid, Greenko, Mytrah Energy, Inox Wind, Suzlon Energy, and ReNew Power Ventures. Some of the well-known foreign participants included Ørsted, alfanar, Deep Water Structures, E. ON Climate and Renewables, Terraform Global, Macquarie Group, Shell and Senvion.[55]

In July 2018 the National Institute of Wind Energy (NIWE), an autonomous institution under the MNRE, installed a remote sensing instrument—LiDAR (Light Detection and Ranging)—for assessment of offshore wind resources off the Gulf of Khambhat.

It is yet another opportunity to reduce reliance on expensive imported fuels for its energy needs.

[52] MNRE, State wise installed capacity of grid Interactive Renewable power as on (Posted on 10.07.2019), 10 July 2019.
[53] Mercom India, Lowest Tariff of ₹2.80/kWh Wins Gujarat's 1,000 MW Wind Auction, 13 May 2019.
[54] ET EnergyWorld, India announces 30 GW offshore wind energy target by 2030, 19 June 2018.
[55] Clean Technica, India Plans First Ever 1 Gigawatt Offshore Wind Tender For Gujarat, 16 February 2019.

With its 1,600km coastal line, Gujarat possesses abundant potential for offshore wind power. It is yet another opportunity to reduce reliance on expensive imported fuels for its energy needs.

The recent technological developments in offshore wind turbines has been dramatic. The rotor diameter has jumped from 80 metres to 164 metres and average capacity has more than doubled, climbing from 1-2MW in 2012 to 4-6MW today. Leading players like Ørsted are betting on Siemens, GE and Vestas MHI achieving another doubling in size to 10-14MW by 2024.

These technological improvements and cross-sector learnings from other industrial sectors such as maritime, automotive and shipbuilding have pushed costs down significantly in the past 10 years.

Over the coming decade, IEEFA expects offshore wind technology to get close to matching the cost of energy from its onshore counterpart due to its near-limitless size potential, 50-60% capacity utilisation rates, proximity to coastal city load centres, and exceptional utilisation rates plus subsea grid technology improvements by world leaders like Prysmian Cables.

However, in IEEFA's opinion, India should not accelerate its offshore wind capacity commissioning. Rather, the country should wait for the advanced economies of Europe and Asia to take the lead in the learning curve and wait for costs to come down and for offshore wind tariffs to be competitive in the Indian market.

IEEFA recognises that by 2030, Gujarat will definitely need the additional capacity and grid diversification benefits of 50-60% utilisation rated offshore wind projects.

Battery Manufacturing

The government of India has announced ambitious plans to issue tenders inviting global and local companies to set up 50GW of battery manufacturing base in India.[56] NITI Aayog, the Indian government's planning think-tank, will seek proposals from states to identify locations for plants and will provide duty waivers, exemptions and other fiscal benefits to battery manufacturers. This is estimated to be a US$8bn investment opportunity for global investors like Tesla, Contemporary Amperex Technology Co (CATL) and BYD.[57]

A recent report from the CEA projects an optimal energy mix for India's electricity system by FY2029/30.[58] The report estimates India's renewable energy capacity to be 523GW by FY2029/20, including 300GW of solar, 140GW of wind, 10GW of biomass and 73GW of

This generation capacity will require 34GW/136GWh of battery storage capacity.

[56] Economic Times, Companies may soon be invited to set up battery plants, 11 June 2019.
[57] Livemint, Tesla shows interest in India's plans to build battery plants, 18 August 2019.
[58] CEA, Draft Report on Optimal energy Mix by 2030, February 2019.

large hydro power. This generation capacity will require 34GW/136GWh of battery storage capacity.

On the back of the government's declaration, Tata Chemicals announced a 10GW Lithium-ion battery manufacturing plant in Gujarat's DSIR with an investment commitment of Rs4,000 crore (~US$600m).[59]

The facility will be powered at a relatively cheaper C&I tariff of Rs4.65/kWh compared to average C&I tariffs of Rs8-10/kWh. This cost reduction could potentially result in cheaper batteries.

Policy Issues—Auction Cancellations, Tariff Renegotiations, and Land Acquisition

Gujarat fell behind Karnataka, Telangana, Rajasthan, Andhra Pradesh and Tamil Nadu for total solar power capacity in FY2018/19. Cancellations of auctioned capacity, with discoms forcing a tariff renegotiation, have been detrimental for the progress of renewable energy.

GUVNL twice cancelled 500MW of awarded solar capacity in order to achieve even lower tariffs from developers. As mentioned earlier, during the latest 745MW wind power auction, GUVNL demanded developers that were awarded the capacity at Rs2.95/kWh to match it with the lowest tariff achieved to date—Rs2.80/kWh. In IEEFA's view, this is "penny wise, pound foolish".

GUVNL's project cancellations and retendering process took more than 6 months, blockading the progress of the state's renewable energy growth. The reverse bidding auctions have been extremely successful in bringing renewable energy tariffs down, while also bringing transparency and competition into the renewable energy tendering process. Retrospective changes will affect investor confidence and cause deterioration to the state's risk profile.

Reverse bidding auctions have been extremely successful in bringing down renewable energy tariffs.

Land Issues for Renewable Energy Projects

Lack of coordination between centre and state governments in planning for wind energy tenders has created a problem in land availability for wind power projects.

SECI and NTPC, being state-owned enterprises, have played a third-party role to facilitate renewable energy tenders offered by the central government. These tenders are generally flexible and allow developers to commission the project at locations of their preference. On the other hand, state-owned discoms have invited

[59] ET EnergyWorld, Tata Group to set up Rs 4,000cr lithium-ion battery plant, 12 July 2019.

developers to build projects in state specified lands identified for renewable energy proejcts.

Gujarat, being a top destination for solar and wind power potential, has run into land availability issues. Reportedly, project developers had to acquire expensive private lands as the Gujarat government did not provide the land which they had reserved for their own state(province)-backed tenders.[60] The private land is reported to cost five times the land which is generally used for renewable projects. Expensive land costs shrink a developers' margins and return on equity.

Gujarat's Land Policy for Renewable Enegry Projects

In January 2019, the Gujarat government announced its land policy for renewable energy projects. The government allotted land for 30GW of solar, wind, and solar-wind hybrid capacity. Out of the 30GW, 10GW worth of project land has been allotted to state-backed discoms. The remaining 20GW worth of land is available for state as well as centre-backed projects.[61]

This is a welcome devlopment for wind developers in Gujarat who struggled to acquire land area with wind power potential at a reasonable price. This will protect projects from running into cost escalations and penalties payble on commissioning delays.

[60] ET EnergyWorld, SECI project winners buying expensive land as state stays reluctant on leasing for central projects, 11 February 2019.
[61] ET EnergyWorld, Gujarat frames land policy for green energy projects, 28 January 2019.

6. Gujarat Electricity Sector Model 2029/30

Gujarat currently does not have a well-diversified electricity system, with generation capacity dominated by thermal power at 69% of total capacity and 81.1% of total generation. Nuclear, hydro and renewables only form 0.9%, 0.9% and 11.8% of its generation capacity, respectively. The overreliance on expensive imported fuel-based generation capacity has been unreliable.

In IEEFA's view, it is time for Gujarat to transition to a low-emission, low-cost, renewable energy-based electricity system given its renewable energy potential.

IEEFA's Gujarat electricity model for FY2029/30 projects Gujarat's electricity production requirements to grow by 74% from 116TWh in FY2018/19 to 203TWh FY2029/30.

We project a dramatic shift in its electricity sector composition with renewables forming 70.3% of capacity and 48.1% of total generation. Moreover, the two-unit extension of Kakrapar Atomic Power Station currently under construction is expected to be commissioned by FY2024/25. This will add 1.4GW of nuclear capacity to the state's electricity sector, taking the nuclear power generation share to 6.8% of the total generation by FY2029/30.

Gujarat's nuclear capacity operated at an unsustainably low capacity factor of 20.4% in FY2018/19 (refer to Figure 3.1), whilst the utilisation factor for the national fleet was 63.7% for the same period. IEEFA expects Gujarat's nuclear capacity factor to improve to 80%, contributing 6.8% of Gujarat's overall generation in FY2029/30.

IEEFA projects the majority of Gujarat's new generation capacity will come in the form of low-cost, low-emission renewable energy sources including solar and wind. As illustrated in Section 5, Gujarat's afternoon peak demand could be progressively supported by building 20GW of new solar capacity. Gujarat's grid experiences an evening peak between 2.00pm and 7.00pm during the months of April to June—which is also the period for peak wind generation hours during the months of April to June (refer to Figure 5.3). With its abundant onshore and potentially offshore wind, now supported by favourable land policies for renewable energy projects, Gujarat is well positioned to build 10GW of new onshore wind power capacity and 2GW of offshore capacity by FY2029/30.

Gujarat is well positioned to build 10GW of new onshore wind power capacity and 2GW of offshore capacity by FY2029/30.

With improved wind turbine technologies including the increased size of rotor diameters and pole heights, utilisation factors of 30-35% for onshore and 50-60% for offshore wind capacities could be achieved.

On the thermal side, IEEFA expects net negative additions of 1.8GW. Gujarat's 3.9GW of existing thermal capacity operates on outdated subcritical technology and will reach its end-of-life by FY2029/30. IEEFA recommends gradual retirement of this capacity in line with India's National Electricity Plan 2018.

With its lack of in-state coal capacity, Gujarat has and will continue to experience the burden of expensive thermal assets designed to operate on imported coal. Going forward, brownfield expansions backed by the state-owned power developer, GSECL, with existing fuel linkages and PPAs, appears to be a relatively less risky strategy. GSECL currently has 1.3GW of capacity under construction in the form of the Bhavnagar Lignite Power Station (500MW) and Wanakbori Thermal Power Station's unit 8 (800MW). Additionally, the Ukai Thermal Power Plants unit 7 (800MW) extension, still in regulatory approval stage, is a brownfield expansion to replace the plant's unit 1 and 2 which were retired in 2017.

2.1GW (Gross Additions) — 3.9GW (Retirements) = -1.8GW (Net Additions)

Figure 6.1: Gujarat Electricity Sector Composition FY2029/30

	Electricity Sector Composition FY2029/30					
	Capacity		Generation		Utilisation	Capacity Adds
Source	**(GW)**	**%**	**(TWh)**	**%**	**%**	**(GW)**
Coal	14.0	17.8%	68.7	33.8%	56.1%	-1.8
Gas	6.6	8.4%	14.4	7.1%	25.0%	0.0
Diesel	0.0	0.0%	0.0	0.0%	0.0%	0.0
Nuclear	2.0	2.5%	13.7	6.8%	80.0%	1.4
Hydro	0.8	1.0%	1.4	0.7%	20.0%	0.0
Renewables	55.1	70.3%	97.7	48.1%	24.0%	46.5
Net imports			7.2	3.6%		
Total	**78.4**	**100.0%**	**203.1**	**100.0%**		**46.1**

Source: IEEFA estimates.

IEEFA's bearish outlook on coal-fired capacity additions in Gujarat is based on two key reasons: a lack of active coal-fired proposals in the pipeline; and, the structural issue of a lack of instate coal mining and rail capacity.

IEEFA recommends better usage of Gujarat's existing gas-fired capacity by reconfiguring them to be used as on-demand 'peakers', to provide flexible capacity

to meet grid fluctuations and unexpected peaking demands on days of lower renewable power generation. This will require a policy mechanism of 'time-of-day' pricing to incentivise the increasingly important additional value associated with firming and fast-ramping peaking capacity, with the associated grid stabilisation services involved.

Decoupling Electricity vs. Economic Growth

Gujarat's GDP has grown at an unprecedented CAGR of 9.9% annually between FY2011/12 and FY2018/19.[62] Meanwhile, electricity demand grew at a CAGR of 6.6% annually.[63] This implies the need for either a decoupling of electricity vs. economic growth or a significant amount of its electricity demand to be placed behind-the-meter, supplied through captive gas power plants. As shown in Figure 1.1, 77-78% of Gujarat's GDP comes from the industrial sector which is generally more energy intensive compared to the service or agriculture sectors.

In November 2017, the U.S. Energy Information Administration (EIA) published an analysis noting the increasing evidence of a systemic, sustained global decoupling of electricity demand from economic growth.[64] IEEFA's analysis shows this same decoupling trend is evident in Europe, America, Japan and Australia.

Most importantly for the global picture—there was a major decoupling of electricity demand from economic growth in China post 2013. For the period 2000-2013, electricity demand grew in lockstep with economic growth of 10% annually in China; at a ratio of 0.9-1.0. Since 2014 the ratio has been volatile, halving to 0.5.

IEEFA projects a far more modest 5.6% CAGR in electricity demand over the coming decade to 2029/30. We reference Gujarat's electricity demand growth of 6.6% annually relative to real GDP growth of 9.9%, giving a ratio of 0.67 during the past decade. IEEFA projects Gujarat's GDP to reach a long-term sustainable growth rate of 7.0% as opposed to the current growth rate of 9.9% (effectively starting from a lower base).

IEEFA projects a far more modest 5.6% CAGR in electricity demand over the coming decade to 2029/30.

IEEFA assumes a gross ratio of 0.95 over the coming decade. This reduces to a net ratio of 0.80 (electricity demand to economic growth) if a 1% annual energy efficiency saving can be sustained over the coming decade. Moves to introduce LEDs, high-rated air conditioners, solar irrigation pumps and better building construction standards will all materially assist in this least cost, least polluting source of procurement—the electricity production not needed.

[62] Reserve Bank of India, Handbook of Statistics, 03 March 2019.
[63] CEA, Generation Reports, FY2011/12 to FY2018/19.
[64] U.S. Energy Information Administration, Link between growth in economic activity and electricity use is changing around the world, 20 November 2017.

Another key option for reducing the need for new generation is reducing AT&C losses across Gujarat from 12.6% currently to 8.4% by 2029/30, or 0.4% annually. This has been an absolutely core principle of the UDAY program. It is also key to ensuring electricity production grows at a rate below electricity demand through reduced waste of electricity during transmission and distribution. Reduced power theft most likely requires the roll-out of an automated smart meter system to reduce meter reading bribery, not to mention the efficiency gains relating to any associated investment in distributed, behind-the-meter rooftop solar and/or storage systems.

IEEFA's Gujarat model assumes an 86TWh or 74% increase in electricity production to 203TWh annually by 2029/30. Deducting 8.9% AT&C losses in 2029/30 gives net demand in Gujarat of 185TWh, a rise of 84TWh or 82% over the decade. This is predicated on 7.0% real GDP growth annually, in line with IEEFA's forecast for India overall. The ratio of electricity demand growth to economic growth is forecast at 0.80 net of a forecast 1.0% annual energy efficiency dividend (Figure 6.2).

IEEFA's Gujarat model assumes an 86TWh or 74% increase in electricity production to 203TWh annually by 2029/30.

Figure 6.2: Gujarat's Production and Consumption FY2018/19 to FY2029/30

GDP Growth	7.0%
Electricity to GDP multiplier	0.95
Electricity Demand Growth	6.6%
Energy Efficiency	-1.0%
GDP to Electricty Multiplier	0.80
Reduction in AT&C Losses	-0.4%

	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30
Electricity Production (TWh)	116.6	122.6	128.9	135.6	142.6	150.0	157.7	165.9	174.5	183.5	193.0	203.0
Electricity Production Growth (%)		5.2%	5.2%	5.2%	5.2%	5.2%	5.2%	5.2%	5.2%	5.2%	5.2%	5.2%
AT&C Losses (%)	12.6%	12.2%	11.8%	11.4%	11.0%	10.7%	10.3%	9.9%	9.5%	9.1%	8.8%	8.4%
AT&C Losses (TWh)	14.6	14.9	15.2	15.5	15.7	16.0	16.2	16.4	16.6	16.8	16.9	17.0
Real GDP Growth (%)	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%
Electricity Multiplier (x)	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
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	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Net Demand (TWh)	101.9	107.7	113.7	120.1	126.8	134.0	141.5	149.5	157.9	166.7	176.1	186.0
Net Demand Growth (%)		5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%

Source: IEEFA estimates.

New Demand to be Met Through Renewable Energy Sources

IEEFA forecasts a total of 46.4GW of renewable energy to be added on Gujarat's grid. This will consist of 20GW of new solar capacity, of which 4GW will be distributed rooftop solar capacity. Solar will supply 48% of the incremental demand by FY2029/30. We also assume a small first-of-a-kind local deployment of 100MW capacity of concentrated thermal solar capacity with storage which would support peak demand tariffs of around Rs5/kWh.

IEEFA forecasts a total of 46.4GW of renewable energy to be added on Gujarat's grid.

On the wind power side, we assume 10GW of new onshore wind power capacity and 2GW of offshore wind capacity will be added—serving 50% of the incremental demand. Another 700MW of biomass power capacity additions could fulfil another 1% of new demand, again adding firming capacity.

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

Figure 6.3: Gujarat Electricity Consumption for FY2018/19 to FY2029/30

Gujarat's Waterfall Chart				
Net electricity consumed in Gujarat in 2018/19 (TWh)			102	
Real GDP Growth	7.0%	pa		
Electricity to GDP multiplier	0.80	times		
Electricity Demand Growth	6.6%	pa	87	
Energy Efficiency	-1.0%	pa	-6	
Growth: gross production losses			11	
Reduced grid AT&C losses	-0.4%	pa grid efficiency gain	-8	
Net electricity consumed in Gujarat in 2029/30 (TWh)			186	
Net expansion in electricity demand 2029/30 (TWh)			84	
Net expansion in electricity production required by 2029/30 (TWh)			86	
The Increase in net electricity demand is met by (TWh)			**TWh**	**Uplift**
Solar expansion			36	42%
Solar rooftop expansion			5	6%
Solar thermal expansion			0	0%
Onshore wind expansion			34	40%
Offshore wind expansion			9	10%
Increase in biomass & cogeneration generation			1	1%
Increase in hydro electricity			0	0%
Increase in gas-fired electricity			2	2%
Increase in nuclear generation			13	15%
Change in coal-fired power use			-13	-16%
Net expansion in electricity production by 2029/30 (TWh)			86	100%

Source: IEEFA estimates.

Further Collapse of Coal-fired Power Utilisation Rates

IEEFA forecasts net negative additions of 1.8GW coal-fired power plants in Gujarat by FY2029/30, as mentioned previously in this section. As discoms look to cater to incremental demand through cheaper renewable energy sources, coal-fired plants will lose out on market share to about -16% or 13TWh, from ~82TWh generated in 2018/19 to ~69TWh in FY2029/30. Effectively, the coal-fired power sector's utilisation rates will drop to 56.1% in FY2029/30 from an already unsustainably low 59.5% in FY2018/19.

Better utilisation of the existing gas-fired capacity as 'peakers' will serve for 2% of the additional demand by FY2029/30. Further, an expansion in nuclear power capacity will supply 13% of additional demand.

Competition from renewable energy, backed by the government of Gujarat's ambitious capacity targets, will put tremendous pressure on the coal-fired sector. The option of flexible operations for coal-fired power plants is not viable given the capex required for plan modifications. A recent study by CEA to evaluate flexible operation for coal-fired power plants concluded an effective tariff increase of Rs2.15/kWh for a 220MW unit, Rs2.20/kWh for 500MW and Rs2.18/kWh for a 660MW unit to operate at 50% minimum load factor.[65] Given the existing high tariffs of coal-fired plants in Gujarat, this option will be problematic absent the introduction of a fair, technology neutral time-of-day pricing model.

Integration of Renewable Energy

The incorporation of nearly 55GW of variable renewable energy on Gujarat's electricity network by FY2029/30 will require active measures in grid integration. It will require multi-technology storage options ranging from pumped hydro storage (PHS) to utility-scale as well as small-scale batteries.

The renewable energy-based modern system will need to be supported by grid expansion to connect renewable energy specific zones to intrastate as well as interstate networks, with the added advantage of broader coverage somewhat smoothing variable renewable energy supply. Grid modernisation and grid digitalisation can support demand-response management.[66]

[65] CEA, Flexible Operation of Thermal Power Plants for Integration of Renewable Energy, January 2019.
[66] IEEFA, India's Grid Transmission Infrastructure Needs Further Modernisation, Urgently, 22 January 2019.

7. DISCOMs

In 2015/16, the government of India introduced a national scheme to reform the financial and operational performance of debt-ridden discoms. The scheme entailed state governments taking over discoms' debt by issuing non-statutory liquidity ratio (non-SLR) bonds and transferring the proceeds to discoms in a mix of grant, loan, and equity. The financial support from the government demanded discoms improve their operational efficiencies, such as reduced AT&C losses and improved average cost of supply vs. average revenue realised (ACS-ARR) gap, to reduce discom losses.

In the case of Gujarat, the UDAY scheme promised inducements of a better supply of coal to the state-owned power developer, GSECL, and liberal coal swaps between inefficient plants to efficient plants.

Gujarat has four state-owned discoms under the umbrella enterprise of Gujarat Urja Vikas Nigam (GUVNL). As per the UDAY dashboard, Gujarat is the number one performing state on UDAY's performance indicator.[67]

It must be noted however that in FY2015/16, Gujarat was already in a profitable

position with significantly better operational efficiency.[68] In that year Gujarat had relatively low AT&C losses compared to other Indian states at 14.1% with 85% billing efficiency and 100% payment collection efficiency.

Gujarat has well surpassed its AT&C loss target of 13.0% with 12.59% AT&C losses in FY2018/19. The ACS-ARR gap improved from an already profitable position of -Rs0.03/kWh in FY2015/16 to -Rs0.06/kWh in FY2018/19 (with the negative number representing higher revenue vs. cost).

Figure 7.1: Gujarat Discom Performance Indicators

UDAY Performance Indicators		Targets
	FY2015/16	FY2018/19
AT&C Losses (%)	14.05%	13.00%
AT&C losses at 12.59% for FY2018/19		
	FY2015/16	FY2018/19
Net Income including subsidies (Rs Crores)	194.0	456.0
Profit of Rs464 crore for FY2018/19		
	FY2015/16	FY2018/19
ACS-ARR Gap (Rs/kWh)	-0.03	-0.06
ACS-ARR Gap of -Rs0.05 for FY2018/19		

Source: UDAY Dashboard, UDAY MOU.
Note: These are cumulative performance indicators for all the four discoms.

[67] Ministry of Power, UDAY Dashboard
[68] UDAY, Gujarat MOU, February 2016.

An improved ACS-ARR gap reflects in discoms' bottom-line. The profit of Rs194 crore (US$27m) in FY2015/16 has increased at a CAGR of 34% annually for three years to be Rs464 crore (US$65m), surpassing its target of Rs456 crore (US$64m). However, net income includes a state subsidy of Rs1,100 crore (US$155m) which generally accounts for subsidised or free power to agricultural consumers.

In IEEFA's view, Gujarat should mobilise its discoms to further reduce their reliance on state subsidies. The Ministry of Power has sought to introduce new progressive tariff policies that abolish old cross-subsidy tariff structures. Also, direct benefit transfers (DBTs) to low income farmers could provide them with the financial means to buy power and at the same time, encourage significantly more efficient use of electricity.

Gujarat should mobilise its discoms to further reduce their reliance on state subsidies.

The Indian government's rollout of agricultural solar pumps under Kisan Urja Suraksha evam Utthaan Mahabhiyan (KUSUM) will provide farmers energy security along with financial and water security. There is a massive opportunity for Gujarat to fully implement these reforms to further financially strengthen its discoms.[69]

[69] ET EnergyWorld, KUSUM scheme for solar uptake by farmers: A fineprint, 22 March 2019.

Conclusion

Gujarat, one of the largest electricity markets in India at the state level, is on track to transition to a renewable energy driven, low-cost, low-emission electricity system. The state could be one of the largest contributors to India's target of 450GW of renewable energy by 2029/30.

No new net thermal power additions between FY2012/13 to FY2018/19 is reflective of market conditions in the state. New greenfield thermal power project development is unlikely. Further, IEEFA predicts Gujarat will gradually retire and replace its outdated and end-of-life thermal power fleet with less-riskier brownfield developments with supercritical technology. The state's thermal power sector's financial and operational distress are a lesson for Indian states as well as other emerging and developing economies.

Gujarat is a transition leader in the renewable energy sector and is looking at massive ongoing new investment in renewables and grid infrastructure, as well as associated manufacturing opportunities. India's first offshore wind power project and first large-scale Lithium-ion battery manufacturing plant are examples of the state's proactiveness in transforming its energy sector.

The Gujarat government's ambition to transform its electricity sector to incorporate more renewable energy will require the state to stay on track and protect investor confidence through a strong and consistent policy framework. The state has experienced some hiccups during this transition, however, its intent to troubleshoot and keep moving forward is evident.

IEEFA is confident that Gujarat will achieve its long-term electricity sector targets.

IEEFA is confident that Gujarat will achieve its long-term electricity sector targets while being a model for other Indian states to follow.

About IEEFA

The Institute for Energy Economics and Financial Analysis 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. www.ieefa.org

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