THE ENERGY TRANSITION IN GUJARAT

A Potential Roadmap for the Power Sector

GERMI

contents

Chapter

Executive Summary

The former Chief Minister of Gujarat, in September 2019, announced that the State shall not issue new permits to coal power plants. This study looks at the possibility of implementing the announcement and its ramifications by 2030.

Gujarat plans to issue no new permits to coal power plants.

Two methods have been used to arrive at the results. One, an annual treatment of supply and demand, akin to the annual revenue requirement (ARR) filings at the regulator. And two, a 15 minute analysis using GridPath, an open source analytics platform.

The study models Gujarat's power sector (capacity and energy mix by 2030) along two scenarios. One, a business as usual RE capacity addition and, two, a 450 GW RE roadmap. Two retirement strategies are considered - a planned retirement based on age and an early retirement based on the variable costs of plants.

Executive Summary

Gujarat may not require any new coal plants to meet further demand.

Based on our analysis, it appears that Gujarat may not require any new coal plants to meet further demand, provided renewable capacity addition targets are met. In addition, there is also a possibility of an early retirement of state-owned coal plants.

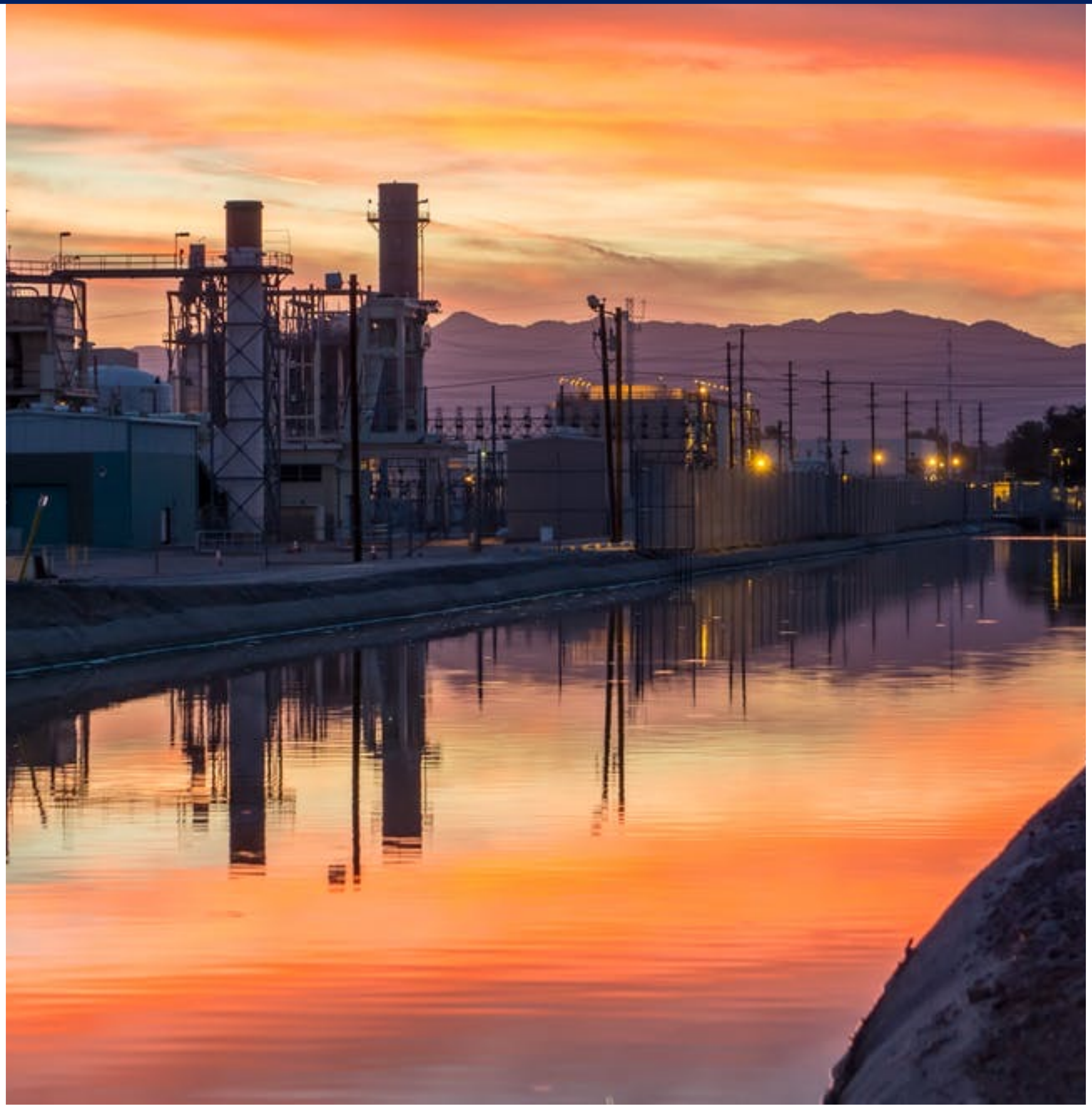
In (450 GW scenario) 24 out of 75 units (amounting to 4 GW) from all the coal plants can be retired based on age (i.e. 40 years) alone, without compromising supply.

There is also a possibility to retire an additional 29 units (7 GW) based on criteria laid out in this report. However, this is contingent to the addition of a moderate amount of battery storage systems (20 GWh) by 2030.

Peak power deficits will be less of a concern (<3% of total supply) whereas RE curtailment is likely to be an issue in some scenarios (>15% of supply) which can however be mitigated through battery installations (5% of total supply).

Chapter

Background



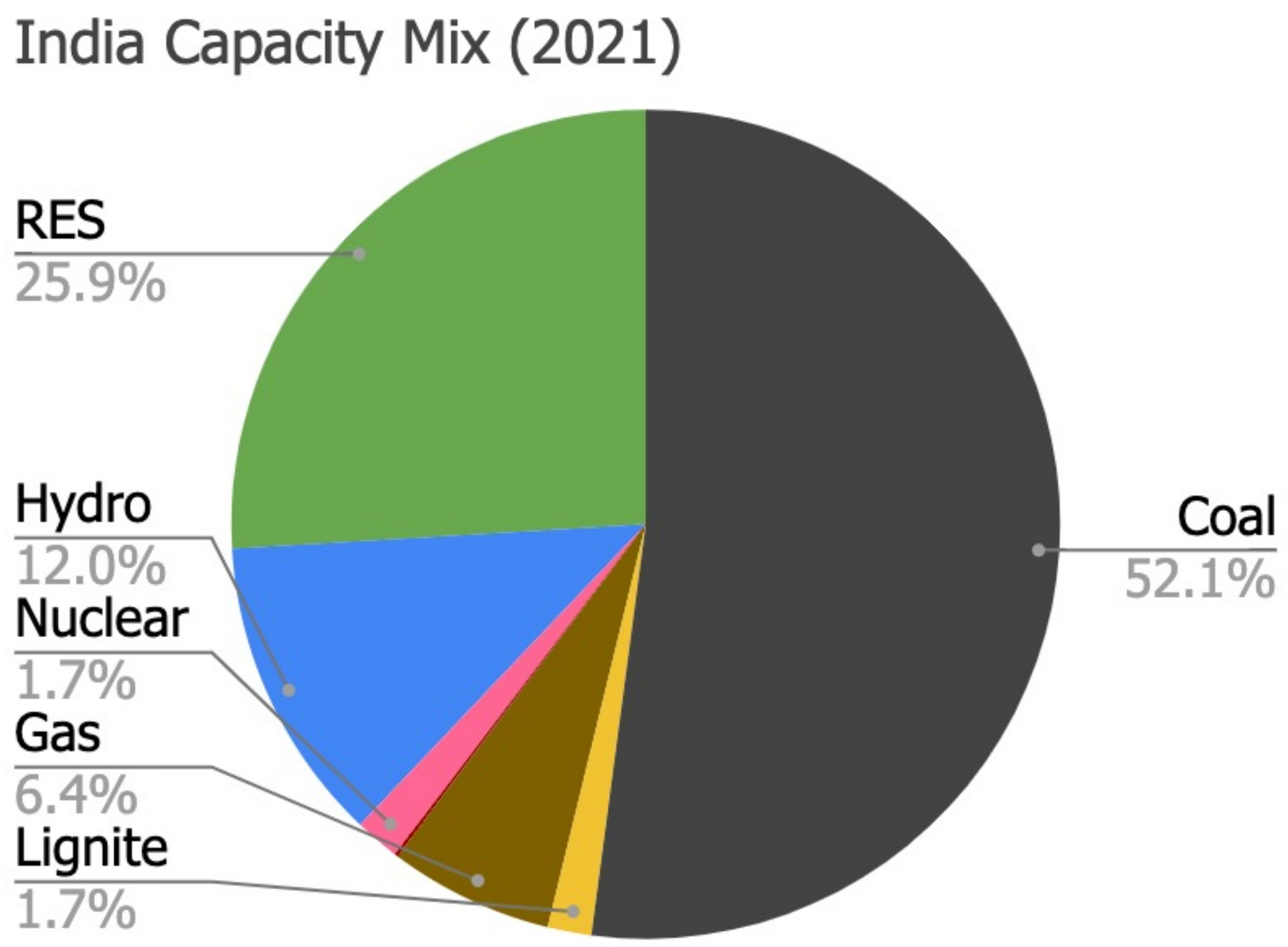
Already **renewable energy from both solar and wind are cheaper** on a levelized variable cost basis from existing and upcoming coal based power plants.

India is facing one of the biggest transformations in the electricity sector amidst a fast growing economy. Perhaps for the first time in history a major economy will meet the growing energy needs of the population from renewables. Already renewable energy from both solar and wind are cheaper on a levelized variable cost basis from existing and upcoming coal based power plants. This is true even without factoring in the fixed costs of thermal power plants. Therefore, the transition of the power sector is imminent and financially viable for India.

Background

More than 52% of India's total electricity is **sourced from coal[3].**

Figure 1



However, the country comes from a baseline of a carbon intensive capacity mix (see Figure 1) and one of the largest coal pipeline plans in the world. More than 52% of India's total electricity is sourced from coal. The average age of the coal based plants in India is 21 years[1] which is close to the end of their lifespan. Many of these plants have accordingly been listed for renovation and modernisation (R&M) plans, the financials of which would affect the tariffs of these plants. Based on the current expansion plans, the total installed capacity of coal generation is expected to reach 266 GW by 2030[2].

The question is can or even should India proceed to continue to expand its coal generation capacity despite the financial and environmental benefits of using RE to meet its growing energy needs. The answer seems obvious, but needs a careful deliberation of the facts to begin to boldly embark on a path of "deep decarbonization".

Each state in India has its own resources and peculiarities. Therefore any energy transition plan needs to be calibrated to the contours of the state in question. Nevertheless, what is evidently clear is that sub-national action is critical and perhaps even imperative if India needs to espouse the energy transition enthusiastically rather than cautiously. In this report we make the case that this enthusiasm is plausible.

GUJARAT
STATE PROFILE

Gujarat State Profile

Gujarat Statistics

Located at the western coast of India, Gujarat is the fourth largest state economy[4] and a key economic contributor to India's GDP. Being a highly industrialised state, Gujarat has witnessed tremendous economic development in the past decade. Since energy is an important component of any development, there has consequently been a steady rise in the electricity demand.

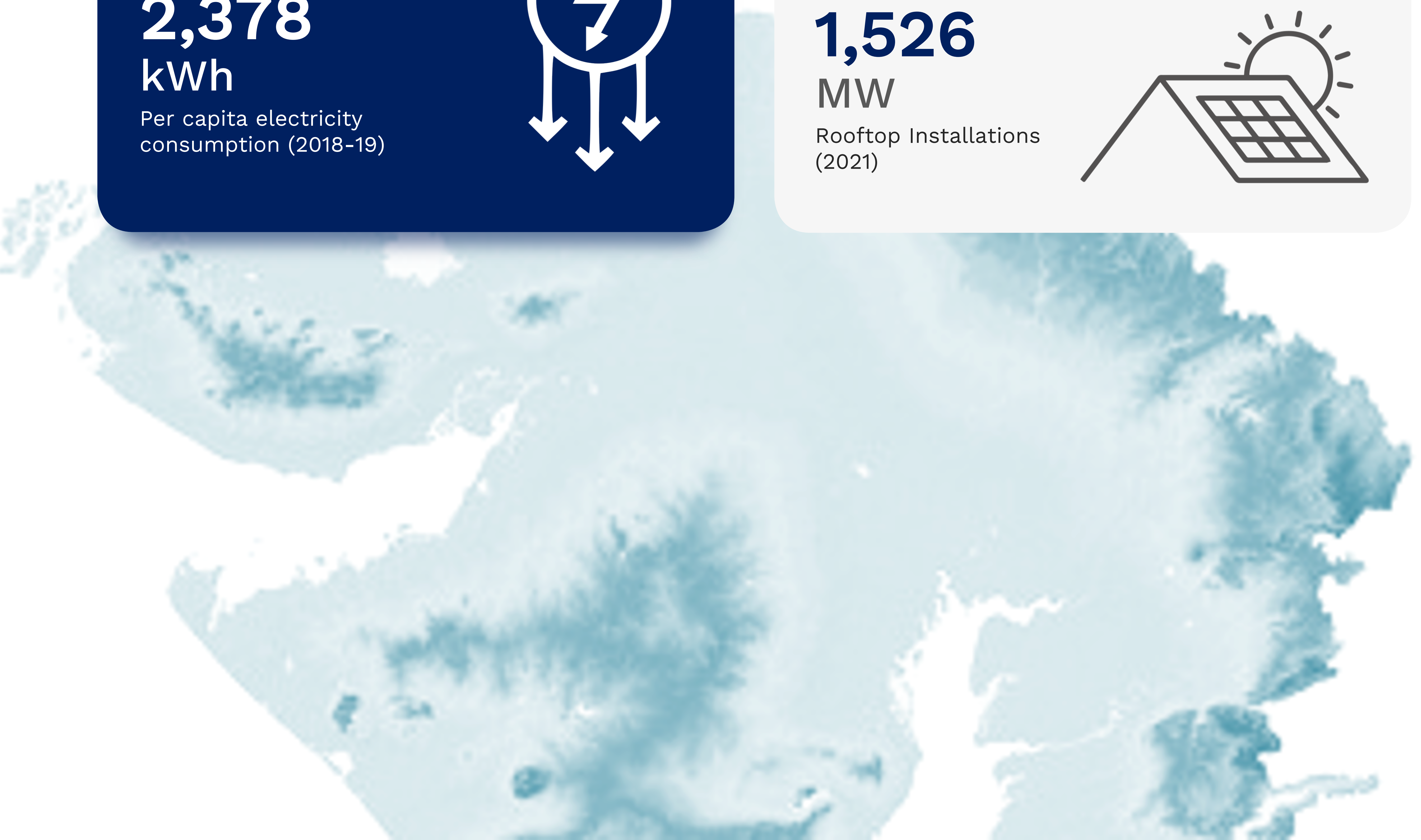
Against the national average of per capita energy consumption of 1,122 kWh, Gujarat has an annual per capita energy consumption of 2,378 kWh in 2018-19[5]. This also validates the fact that Gujarat is one of the highest power consuming states in the country. There is a 3-5% growth in power demand annually which is currently fulfilled dominantly by thermal power sources. However, with a high potential for Renewable Energy (RE), this demand can be met with rapid scale-up of RE along with energy storage systems. The government has announced an increase in the RE targets in line with the national targets. Further, the state also has one of the highest capacity of rooftop solar installations in the country (1,526 MW[6]), indicating that the shift to renewable energy is likely also to be consumer driven.

US$
259.25B
GSDP

3.39
tCO_2e
Per Capita Emission (2013)

2,378
kWh
Per capita electricity consumption (2018-19)

1,526
MW
Rooftop Installations (2021)



Gujarat Energy Insights

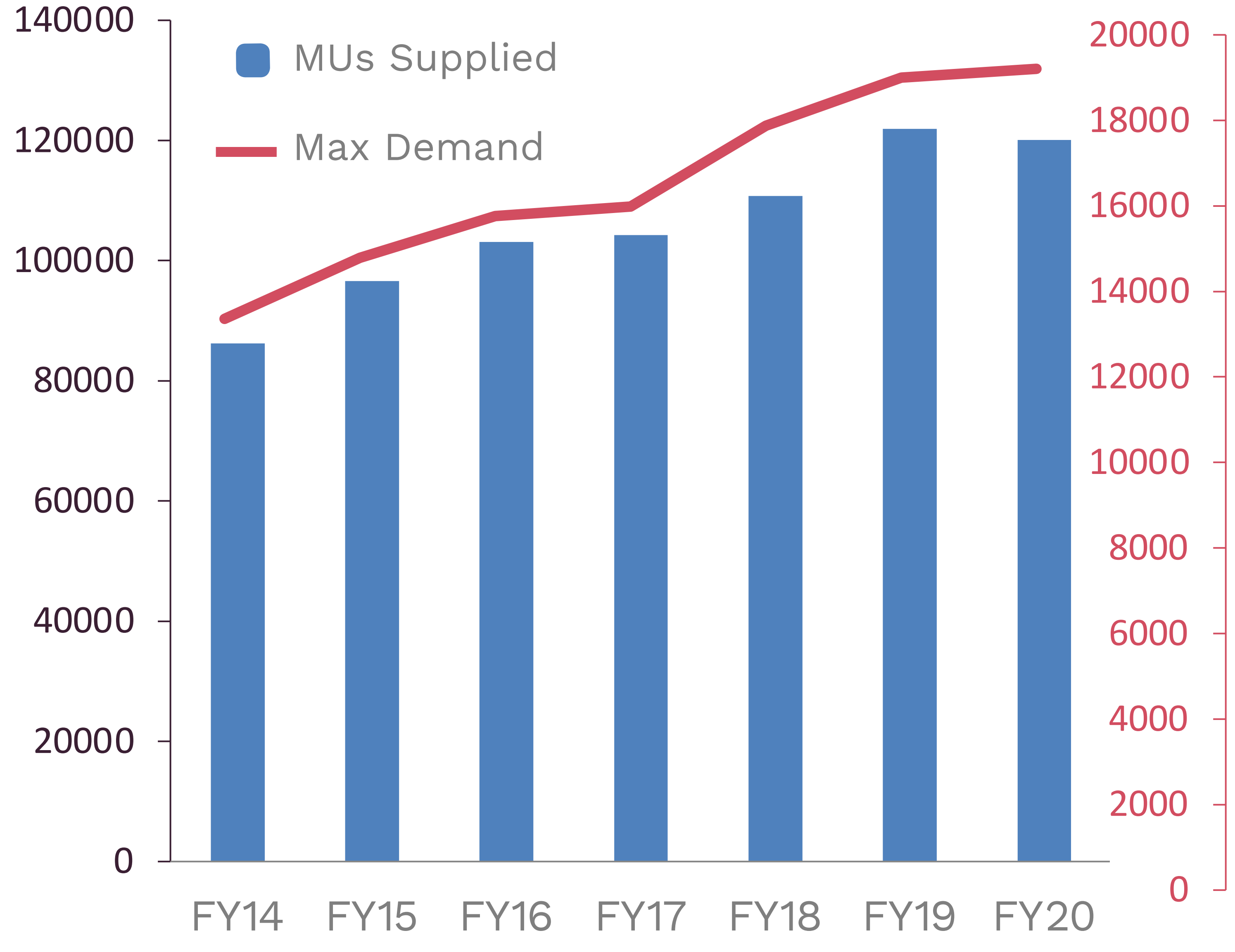


Figure 2

Gujarat : Historic Energy Demand & Supply

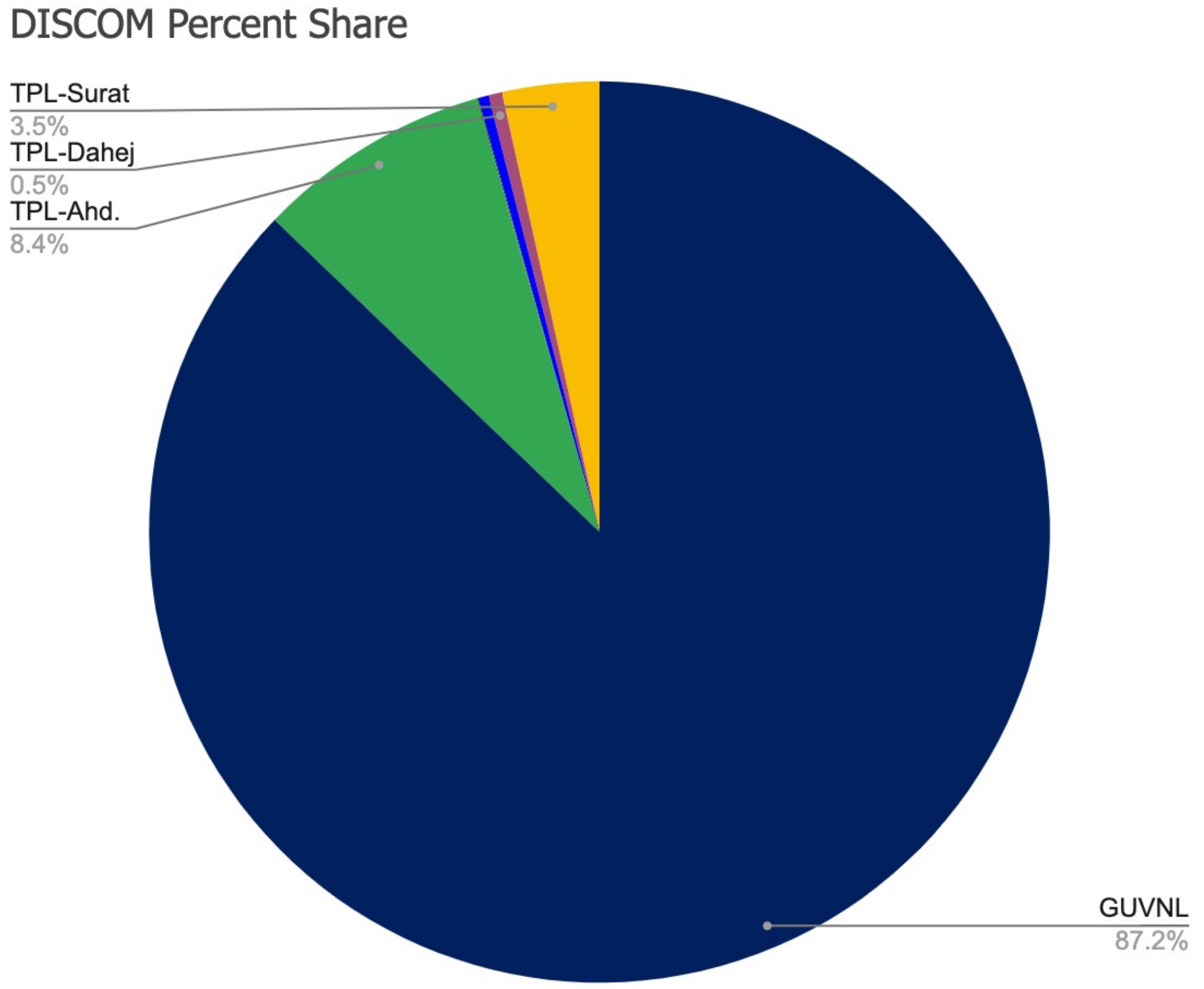


Figure 3

Gujarat : Discom % Share In Demand

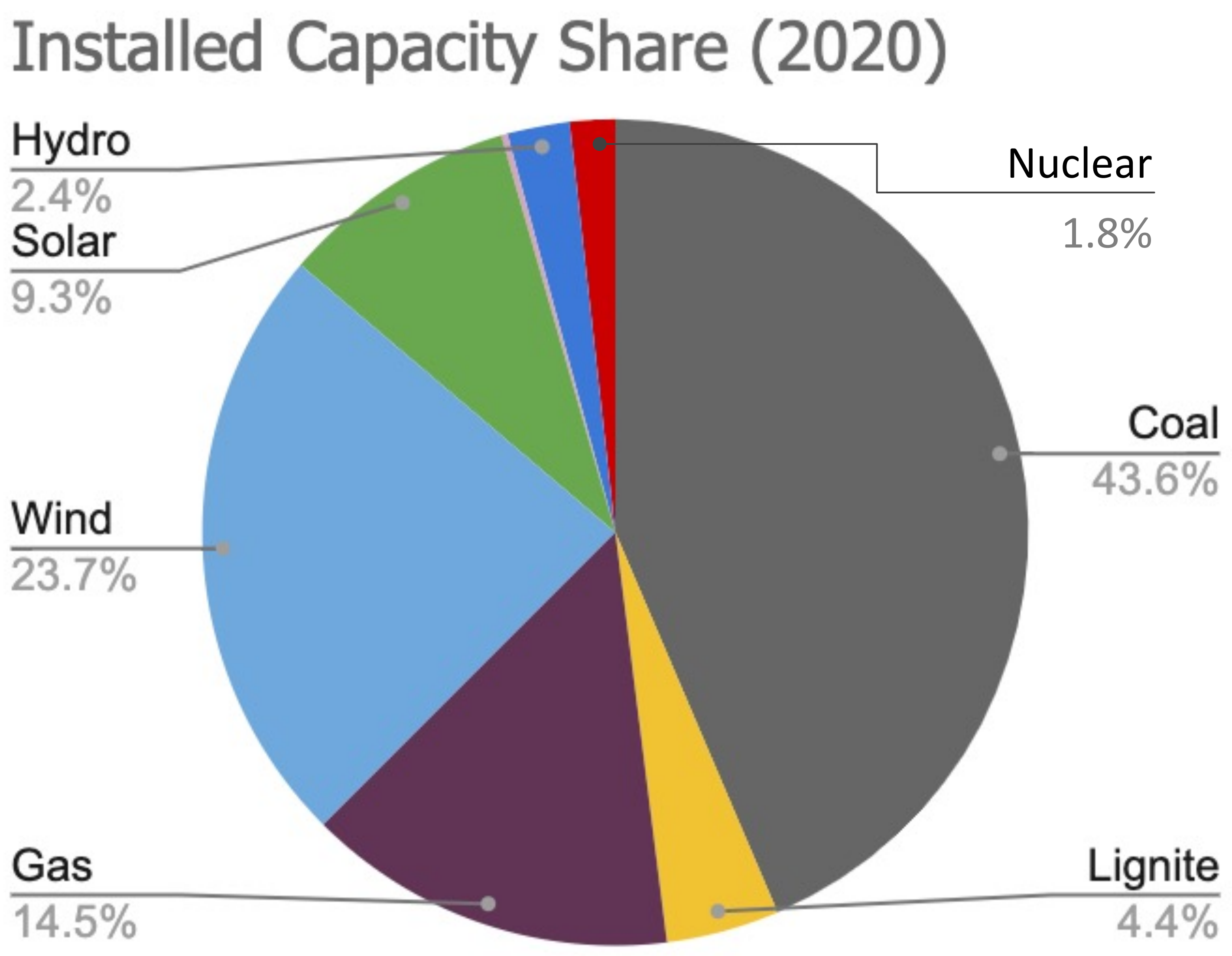


Figure 4

Gujarat : Capacity Share

Gujarat has witnessed a steady growth in the energy demand in the past decade. This demand is met by thermal, renewables (solar, wind, biomass etc), nuclear and hydro power. Thermal sector consists of a major share (more than 60%) of the total capacity mix, followed by renewables (more than 30%).

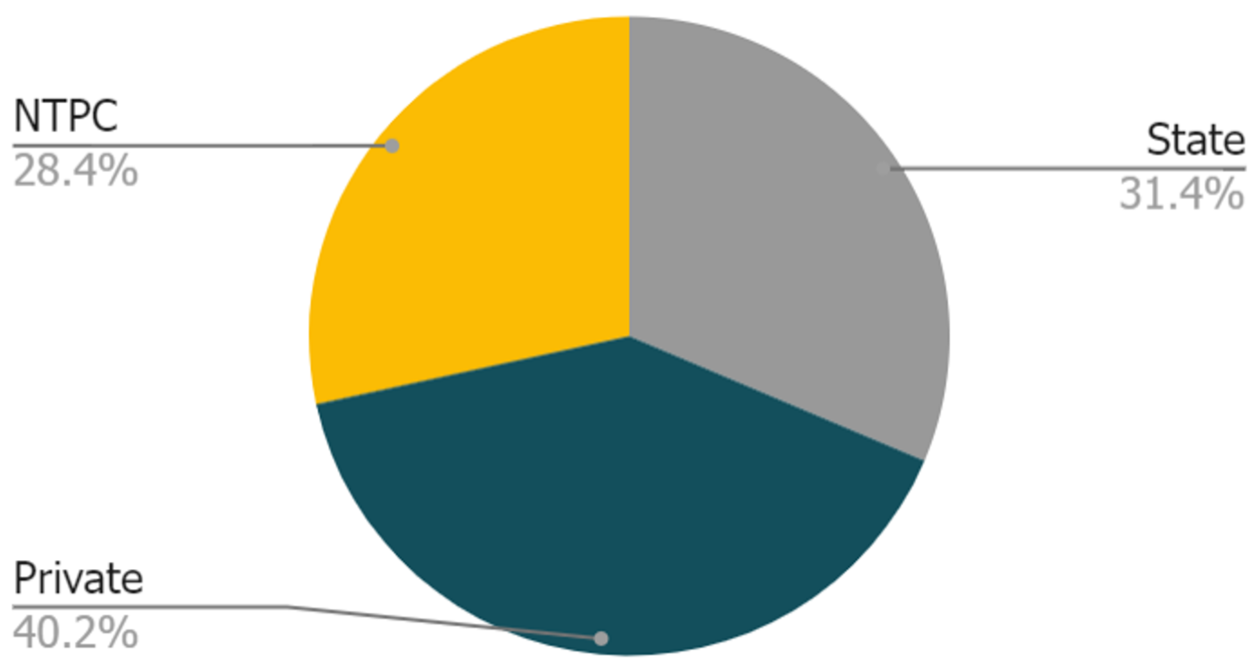
POWER
DEMAND & SUPPLY

Chapter

Power Demand & Supply

Figure 5

Ownership of power plants



The total capacity of Gujarat in 2020 stood at **31.3 GW**

The goal of this study is to check the feasibility of the Chief Minister's statement and whether Gujarat can meet its growing energy demand by 2030 through renewables. In order to do this, the study started with a baseline assessment of the state's power plant profile with a timeline between 2020 to 2030. The main rationale for the 2030 timeline is the announcement of India's 450 GW RE target by that time frame. For the previous 175 GW target, Gujarat has been allocated 17 GW, i.e., nearly 10% of the total target. Accordingly, the same percentage has been assumed for Gujarat from the 450 GW target and been extrapolated. The total capacity of Gujarat in 2020 stood at 31.3 GW out of which, coal and lignite made a total of 14.9 GW (Annexure 1) while RE stood at 10.5 GW. The remaining was fulfilled by gas, hydro and nuclear. The operational coal and lignite fleet can be categorised based on ownership as follows:

- In-state and owned by the state (5,160 MW)
- In-state and privately owned (6,317 MW)
- Out-state and owned by the National Thermal Power Corporation (NTPC) (3,488 MW)

On the demand side, only consumers from the four government owned discoms UGVCL, PGVCL, DGVCL and MGVCL have been considered. They represent nearly 87% of overall electricity demand in Gujarat (see figure 3).

Chapter

Methodology

GridPath is a grid-analytics software for power-system planning that includes functions like **production-cost, asset valuation and capacity expansion**. For this particular study, we have utilised the production-cost function of the software.

The capacity mix and the energy generation of Gujarat was developed for the baseline year of 2020 and extrapolated to 2030. The historical demand growth rate (see Figure 3) is 5% per annum. However, discussions with the state actors suggest that demand may not continue to grow at the same pace. This is largely due to HT consumers moving towards open access and captive options. The demand growth is therefore assumed to be 3% per annum until 2030.

Based on the data sourced from GERC and extrapolations, two models were built to understand demand and supply until 2030. The first model was a static excel based model which looks at annualised treatment of data (similar to the ARR process). An annual treatment is helpful for long term planning of annualised shortages. The annual supply was first fulfilled through must-run sources (RE, nuclear and hydro). The remaining supply was fulfilled through coal and lignite. If the supply was greater than the demand, the oversupply could be curtailed by retiring the extra coal and lignite plants. Accordingly, a retirement list was prepared based on two strategies (explained in the section 3.1.1).

The assumptions and preliminary results obtained from the annual treatment were then validated using a 15-minute production-cost model called GridPath. The second model pointed out particular times of critical short term exigencies like peak shortages, supply and demand mismatches especially during the peak hours which an annualized treatment cannot capture. This model also indicated the requirement of battery based energy storage to cater to the shortages.

Chapter

Retirement Strategies

The **average economic life** of a **coal based power plant** is **25 years**. However, it has been observed that most plants renew PPAs beyond 25 years. The **average age of retirement of a coal plant in India is between 40 - 50 years.**

The curtailment of the oversupply described in section 3.1 could be resolved by retirement of certain coal and lignite plants from the existing coal fleet. This list for retirement was prepared in the annualized model based on two strategies as shown below.

Scheduled Retirement based on age - Retire all plants above 40 years within the 2030 period. If there was still a power surplus situation, then the retirement of very specific state-owned power plants can be considered (refer to point 2).

Early Retirement based on variable cost - Retire plants with a high variable cost which are between 30 and 40 years of age and would be up for retirement in the next decade (2030-40).

KEY NOTES

A key criteria in considering plants for retirement is that there should not be any annual energy deficit.

It is important to note that only in- state plants were considered for retirement since NTPC plants do not fall under the jurisdiction of the State Government. However suggestions based on age have been made for the retirement of a few NTPC plants as a part of the analysis.

Only GUVNL plants have been modeled in the GridPath software and therefore, despite the Torrent plants at Sabarmati which will reach the age 40 by 2030, they have not been listed in the early retirement list.

In addition to this, the CEA has mandated FGD installations in a few plants[7] due to the amended air pollution standards[8]. These costs of installations would inevitably be passed on to the consumer. All of these plants fall in either the scheduled retirement strategy or the early retirement strategy. Therefore, it may be wise to retire these plants anyways (marked in light grey in Annexure 1).

Chapter

Modeling Scenarios

Scenario 1 - RE capacity addition in line with historic growth rates. This scenario is based on the assumption that the RE installations by 2030 is in line with the past performance of the state. This scenario is an important consideration because the existing 2022 target of 175 GW is unlikely to be met. In order to deal with the oversupply, specific coal plants were considered for scheduled (Annexure 2) and early retirement (Annexure 3).

The economic life of a coal plant is around 25 years[9]. However, a common practice is to extend the PPAs until 40 years or beyond. For an energy transition to materialise in Gujarat, the retirement of old plants has to go hand in hand with the deployment of new RE capacity. Based on this, two modelling scenarios anchored around RE capacity addition emerge.

Operational Capacity in 2030

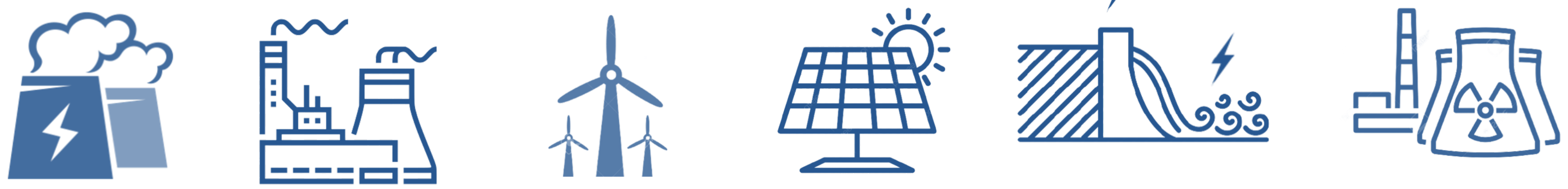
Coal + Lignite	Gas	Wind	Solar	Hydro	Nuclear
8.4 GW	2.1 GW	17.5 GW	12.9 GW	0.7 GW	0.9 GW

Retired Capacity

Scheduled Retirement	Early Retirement	Total Retirement
2,442 MW	**2,930 MW**	**5,372 MW**

Scenario 2 - RE capacity addition in line with the 45 GW target. This scenario is based on 450 GW RE national target by 2030. This is likely to translate to 45 GW in Gujarat. In order to deal with the oversupply, specific coal plants were considered for scheduled and early retirement (Annexure 4) in greater numbers compared to scenario 1.

Operational Capacity in 2030



Coal & Lignite	Gas	Wind	Solar	Hydro	Nuclear
8.4 GW	2.1 GW	20.5 GW	24.1 GW	0.7 GW	0.9 GW

Retired Capacity

Scheduled Retirement	Early Retirement	Total Retirement
2,442 MW	**4,093 MW**	**6,535 MW**

Note that early retirement includes scheduled retirement plants

Results | Scenario 1

Energy Statistics

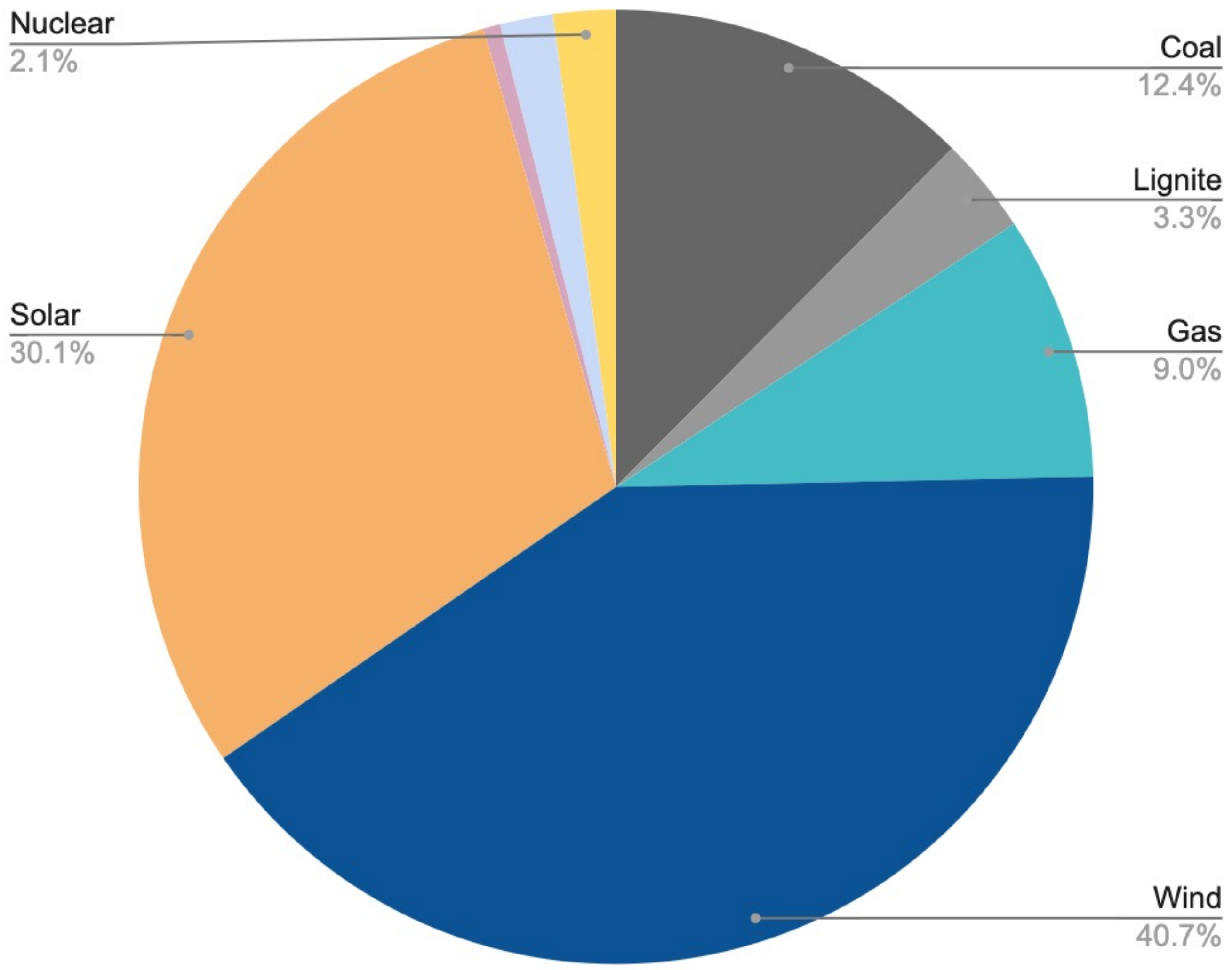


Figure 8

Capacity Share (2030)

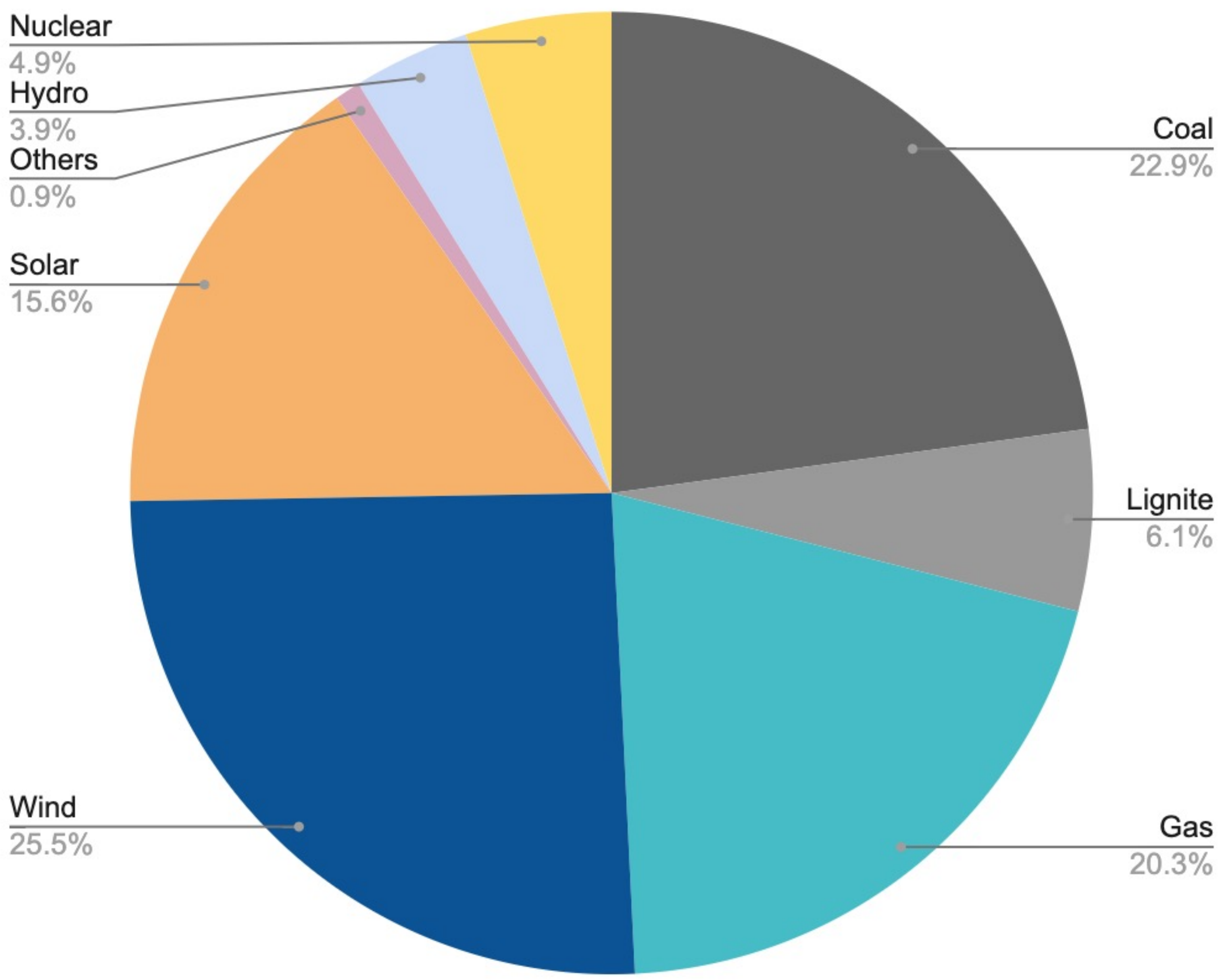


Figure 9

Energy Mix (2030)

Production Cost (GridPath) Modeling Results (Annexure 6)

Shortages	Market Purchases	RE Curtailment	Battery	Average PLF of Plants
1.42 %	6.3%	3.19%	No battery	–

Note that the production Cost (GridPath) Modeling Results of Scheduled Retirement are shown as Annexure 5

Shortages = (Calculated demand – Supply). A positive number shows a deficit of power supply as percentage of the total supply.

Results | Scenario 2

Energy Statistics

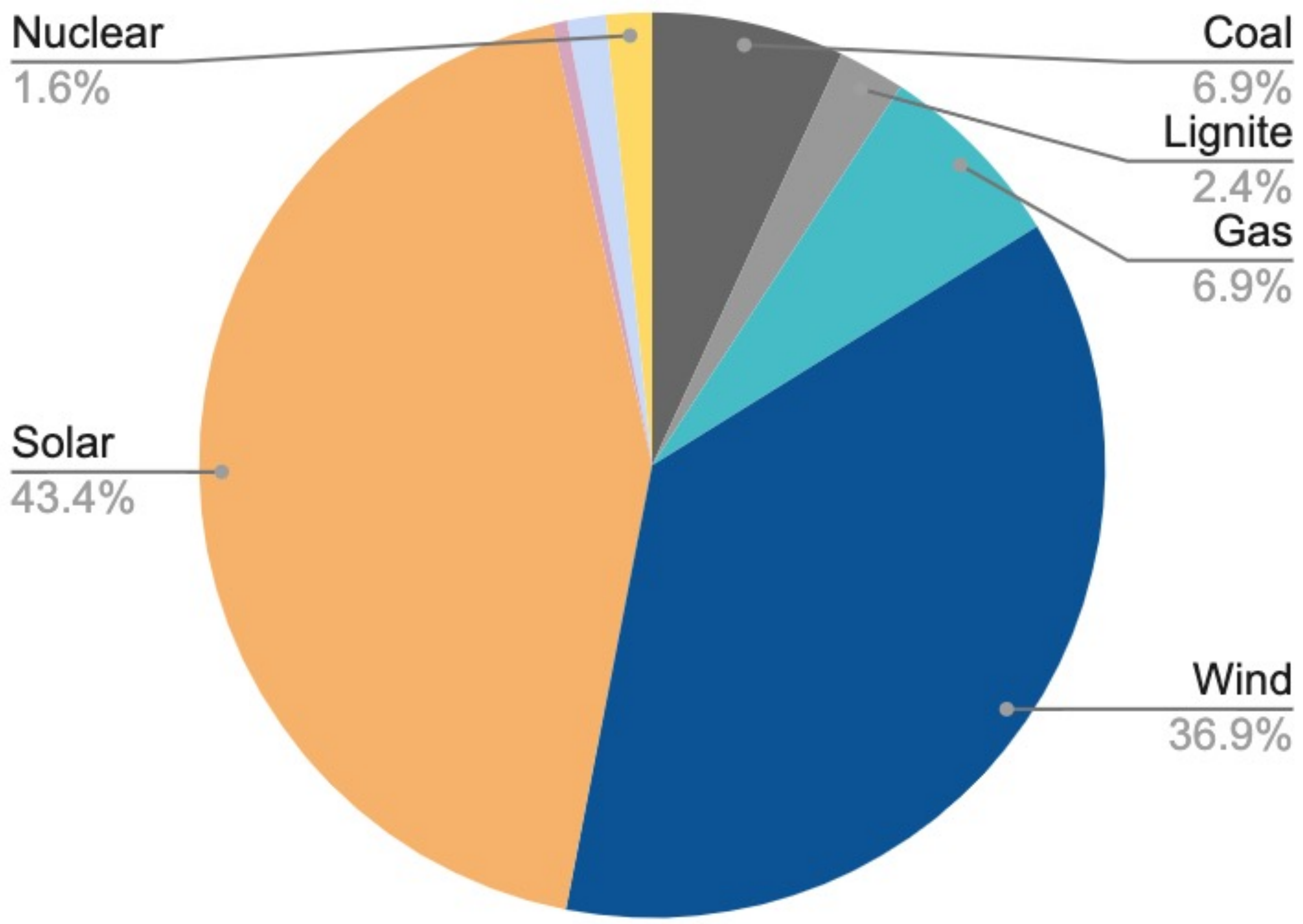


Figure 10

Capacity Share (2030)

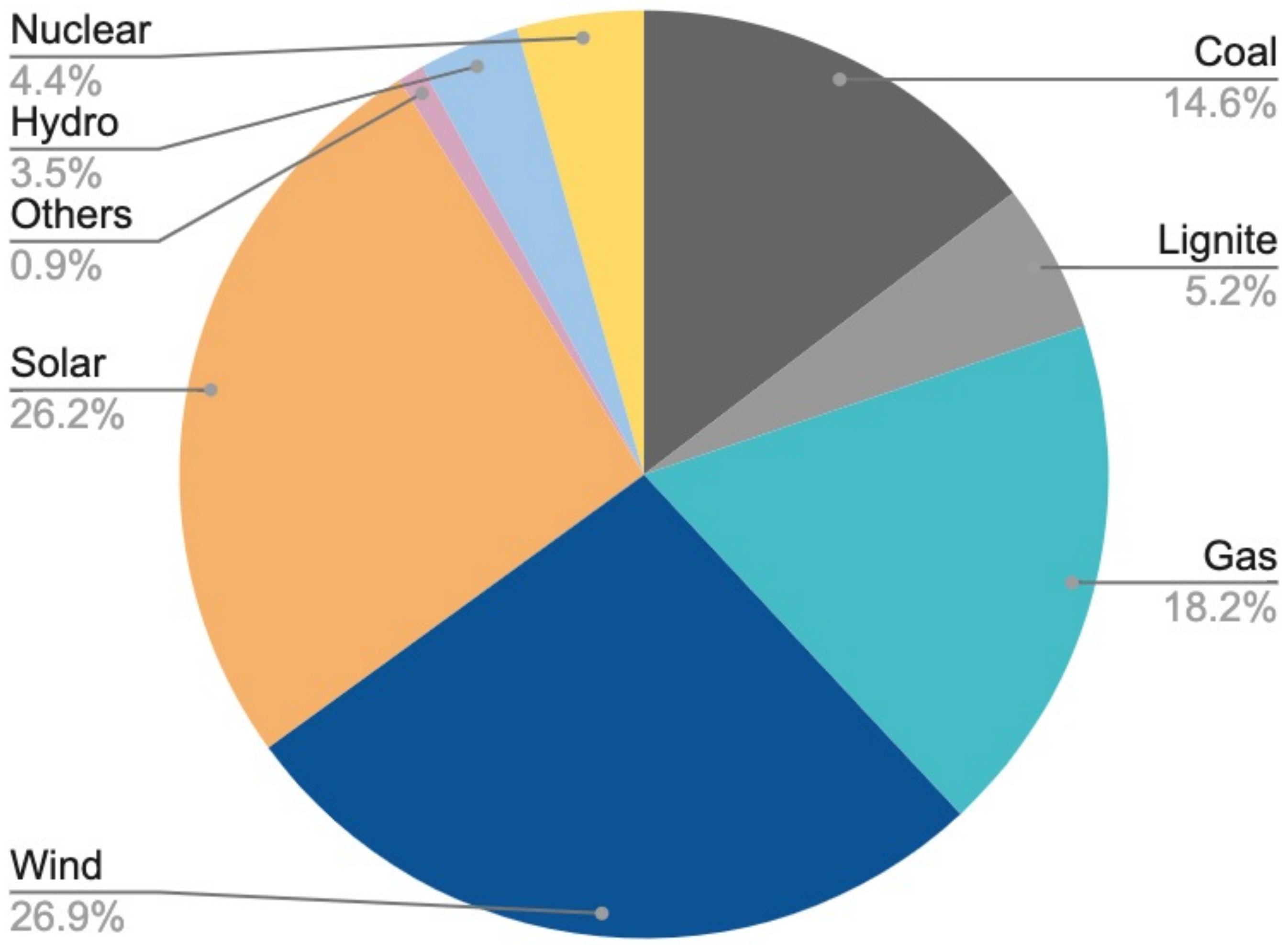


Figure 11

Energy Mix (2030)

Production Cost (GridPath) Modeling Results (Annexure 6)

Shortages	Market Purchases	RE Curtailment		Average PLF of Plants
3.38 %	6.15%	5.05%	20,000 MWh	–

Note that the production Cost (GridPath) Modeling Results of Scheduled Retirement are shown as Annexure 5

Shortages = (Calculated demand – Supply). A positive number shows a deficit of power supply as percentage of the total supply.

Chapter

Key Results

In addition to the state owned plants, NTPC plants like Korba and VSTPS also reach an age of 40 by 2030. These plants can be considered for a scheduled retirement by the central government.

**Note that early retirement includes plants earmarked for scheduled retirement*

	In-State Govt. Owned Plants	In-State Private Plants
Scheduled Retirement	2,080 MW	362 MW
Early Retirement (Scenario 1)*	4,010 MW	1,362 MW
Early Retirement (Scenario 2)*	3,973 MW	2,562 MW

Total 15,626 MW | Scheduled : 2,442 MW | Early - Scenario 1 : 5,372 MW | Early - Scenario 2 : 6,535 MW

ENABLERS & BARRIERS

Chapter

Enablers & Barriers

A secure energy transition

During September 2021, a major coal crisis hit India and affected many states causing a power outage. The crisis was a result of factors such as low levels of coal stock, a drop in imports and unnatural rains. This crisis demonstrated the need for energy security in many states across the country. Since there are no coal mines in Gujarat, almost all of state's coal fired plants are dependent on domestically or internationally imported coal. This emphasizes the need for energy security and should be considered as one of the key drivers of an energy transition in the state.

KEY ENABLERS

Meeting Targets

The current RE capacity in Gujarat share stands at 15.3 GW. As per the state government estimates, the capacity is likely to increase by more than double by 2025[10]. It is critical that targets that are announced are met.

Grid integration

Traditionally, the focus of policy has been on of increasing capacity addition in renewable. While this must be continued, policies, regulations and government tenders must start looking at integration related issues. For instance, transmission linked storage tenders can be explored in those areas where RE curtailment or transmission bottlenecks are likely to arise. Strengthening & augmenting existing transmission capacity to accommodate RE surges must be planned for.

Flexibility in Demand and Supply

Flexibility in RE generation must be brought in formally through regulations. Examples include generation integrated storage that shifts peak generation to evening load peak times, smoothing of generation curves using short-term battery storage and better reactive power support from RE generators. On the demand side, especially for large sections of consumers, an incentive mechanism to shift peak as well as a much more dynamic pricing (or tariff) must be introduced.

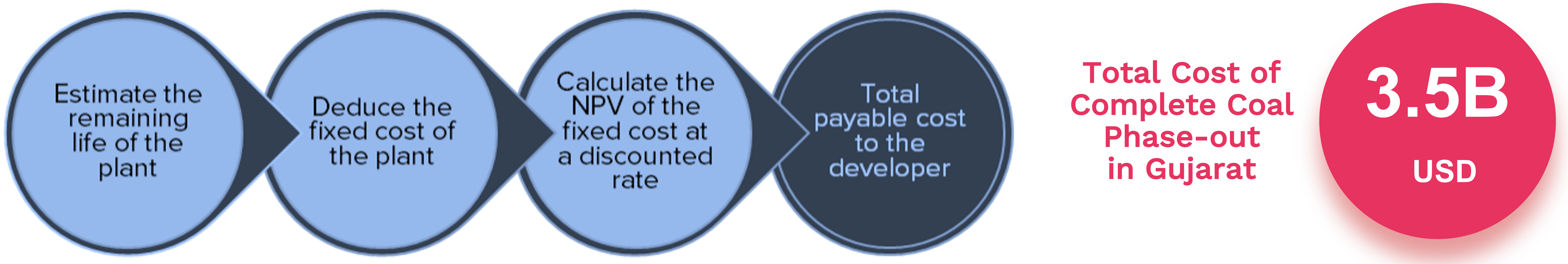
Enablers & Barriers

KEY BARRIERS

Retiring existing coal fired power plants before their planned decommissioning dates is challenging to say the least. Many countries have implemented financial mechanisms for such an early phase-out (See section 5). In order to understand the financial implications to shut down coal and lignite plants of Gujarat, we first calculated the total cost payable to developers using the methodology described in figure 12.

Figure 12

Cost Calculations for an early Retirement



Most coal power plants fall under the two part tariff system, where the distribution companies pay a separate (and guaranteed) fixed cost and a variable (or fuel) cost. The fixed costs are paid whether or not these power plants are dispatched. This ensures that the investors secure their investments.

Seven units are estimated to be online by 2040. As per our calculations, in order to retire all the state owned plants by a timeline of 2040 (in line with Germany's coal phase-out timeline), Gujarat requires an amount of USD 3.5 billion. The details of the plants are given at Annexure 7.

In addition to this, the coal sector generates direct and indirect employment to the mining as well as the power generation sector. A coal transition therefore cannot be separated from its impacts on the working communities. Gujarat does not have a prolific coal mining region. However, there are six lignite mines across the state which are owned by GMDC and GIPCL. Panandhro, one of the major mines located in Kutch and which is owned by GMDC was closed in 2019-20 resulting in a 24% decrease in lignite production. The mining sector also largely employs 'daily-wage' labourers. The drop in the mining activity may have already affected the employment of these labourers. Since there are no rigorous studies indicating the number of employees in this sector, it would be challenging to quantify the cost of compensation. It is suggested that a rigorous baselining activity be taken up to estimate the share of employment and the cost of compensation.

CASE STUDY

The electricity sector across the world is steering away from coal. Many countries have begun transitioning away from coal power generation. For this project, we studied the coal exit strategies of two EU countries - Germany and United Kingdom since they have traditionally been highly dependent on coal and are now on a path on an aggressive coal transition.

Both the countries have unique approaches influenced by historical, social, political and economic factors. The social factors mainly include a public concern over climate change and/or employment issues. The global pressure for emission reduction was one of the major political factor for both countries. In addition to this, economic factors like carbon taxes and electricity markets played an important role in the coal transition of these countries.

There are some lessons in these case studies for Gujarat. However, the energy transition and any coal phase-out must be tailored specifically to the needs of the State and its people.

Germany Energiewende and the Coal Exit Law

Lessons for Gujarat

1. Law

Does Gujarat need a state law to transition away from coal?

2. Phased Retirement

The in-state government and privately owned plants can be retired in a phased manner, keeping in mind the energy supply. A tentative timeline can look like

- Scheduled retirement : 2030
- Early retirement : 2030
- Complete coal exit : 2040

The 2040's complete coal exit have not been examined from an energy demand and supply perspective but are feasible from a compensatory perspective.

3. Compensation

For plants in operation in 2040, owners can be compensated, the calculations for which are explained in section 4.0

For formal and non-formal employees, there needs to be further studies to determine the total compensation costs.

KEY FEATURES

1. Law

The German coal exit law, passed by a multi-stakeholder commission, is a part of the Energiewende. The Energiewende is a strategy devised as early as 2000, designed to enable an energy transition.

2. Phased Retirement

2022	2030	2038
Operational Capacity	Operational Capacity	Operational Capacity
15 GW - Hard Coal	**8 GW - Hard Coal**	**0 GW - Hard Coal**
15 GW - Lignite	**8 GW - Lignite**	**0 GW - Lignite**

By 2038, Germany plans to phase down all of its coal and lignite plants with maximum operational capacities as shown in the timeline above[11].

3. Compensation

a) Hard coal plant operators will receive a close-down premium determined by a market tender process.

b) For lignite plant operators, compensations worth 4.35 billion Euros will be granted.

c) Payments will also be made to older workers in the mining and power plant sector amounting to a maximum of 5 billion Euros.

Chapter

UK Coal Exit Strategy

Lessons for Gujarat

1. Coal Commitment

Gujarat's coal phase out with UK's coal exit would be incomparable since coal is already on a decline. However, since the CM has committed to 'No New Coal', this could be used to accelerate coal phase down in Gujarat.

2. Competitive Pricing

While gas could have been a 'bridge technology' for Gujarat, it would still carry a risk of energy security due to price volatility in gas prices. In comparison, renewables are cheaper than gas today in Gujarat.

KEY FEATURES

1. Commitment by 2024

There is no specific coal exit law in the UK but the government has expressed its intention to introduce a legislation[12] to implement the coal phase out plan. However, the UK government does commit to shut down unabated coal power generation by 2024. However, UK will continue to mine coal for export and use in carbon intensive industries.

2. Competitive pricing and market conditions

Falling gas prices and support for renewables have played a critical role in supporting the energy transition leading to a rise in consumption of gas and a decline in coal[13].

3. Climate Change Act, 2008

The 2008 Climate Change Act legally requires the emissions to cut down 80% by 2050. This led to the introduction of carbon pricing mechanisms making coal power generation uneconomical.

4. Operational coal capacity

Currently, there are only two coal fired plants operating in the UK which make 1.8%[14] of the total energy mix. The Capacity Market has secured the energy supply until September 2023 and will continue to honor the current agreements after which all unabated coal generation will be shut down.

CONCLUSION

- Gujarat's energy transition is already under way largely due to aggressive RE targets. The former chief minister's announcement of 'No New Coal' can be actualized.
- Out of the total 46 units of in-state coal and lignite power plants,

13 Units 2.4GW	18 Units 5.3GW	26 Units 6.5GW
Scheduled Retirement	Early Retirement by 2030 (Scenario 1)	Early Retirement by 2030 (Scenario 2)

- The transition will be driven by the lower cost of renewables vis-a-vis coal power.
- Gujarat can consider a coal phase-out law by 2040 in three phases. A scheduled retirement by 2030, an early retirement between 2030 and 2040 and a complete coal phase-out by 2040.
- A complete coal phase-out by 2040 is likely to cost USD 3.5 billion
- In order to ensure a just transition, both the formal and the informal workforce has to be reskilled and or compensated. The total number of affected people must be baselined in detailed studies.
- The retirement is highly contingent to RE growth in line with policy targets, investments into infrastructure and storage, better grid flexibility and market mechanisms.

Notes/Abbreviations

APL	Adani Power Limited
ARR	Annual Revenue Requirement
CEA	Central Electricity Authority
DGVCL	Dakshin Gujarat Vij Company Limited
DisCom	Distribution Company
EU	European Union
FGD	Flue Gas Desulphurisation
FY	Fiscal Year
GDP	Gross Domestic Product
GERC	Gujarat Electricity Regulatory Commission
GERMI	Gujarat Energy Research and Management Institute
GIPCL	Gujarat Industries Power Company Ltd.
GMDC	Gujarat Mineral Development Corporation
GSDP	Gross State Domestic Product
GSPC	Gujarat State Petroleum Corporation
GUVNL	Gujarat Urja Vikas Nigam Limited
GW	Giga Watt
GWh	Gigawatt hour
HT	High Tension
KLTPS	Kutch Lignite Thermal Power Station
kWh	kiloWatt hour
MGVCL	Madhya Gujarat Vij Company Limited
MNRE	Ministry of New and Renewable Energy
MOSPI	Ministry of Statistics and Programme Implementation
MUs	Million Units
MW	Mega Watt
NPV	Net Present Value
NTPC	National Thermal Power Corporation
PGVCL	Paschim Gujarat Vij Company Limited
PLF	Plant Load Factor
PIB	Press Information Bureau
PPA	Power Purchase Agreement
R&M	Renovation and Modernisation
RE	Renewable Energy
RE4	Renewable Energy, Environment and Energy Efficiency
tCO2e	tonnes of carbon dioxide equivalent
TPL-Ahd	Torrent Power Limited-Ahmedabad
TPL-Surat	Torrent Power Limited-Surat
UGVCL	Uttar Gujarat Vij Company Limited
UK	United Kingdom

References

1. **Do Not Revive Coal, Carbon Tracker Initiative, June '21,** https://bit.ly/3o9vKVC
2. **Report on Optimal Generation Capacity for 2029-30,** CEA, 2020 https://bit.ly/3nKYiVd
3. **Installed Capacity Report, CEA, August 2021,** https://bit.ly/3CPMp4I
4. **MOSPI, 2021,** https://bit.ly/3cM9yKK
5. **Press Information Bureau, 2019,** https://bit.ly/3FJeYml
6. **Physical Progress of RE Capacity, State wise installations, MNRE, Oct. '21,** https://bit.ly/32oDv1v
7. **Quarterly Report of Renovation and Modernization of Thermal Power Plants, CEA, Jun '21** https://bit.ly/3EQ299L
8. **Emission Standards for Thermal Power Plants, Ministry of Environment, Forests and Climate Change, Dec '15,** https://bit.ly/3egcDnn
9. **National Perspective Plan, CEA, Dec '09,** https://bit.ly/3E0Lvmx
10. **Federal Ministry for Environment, Nature Conservation and Nuclear Safety, Aug '21,** https://bit.ly/3EBwNUi
11. **Consultation on Early Retirement of Unabated Coal Generation, Department of Business, Energy and Industrial Strategy, UK Government, Feb '21,** https://bit.ly/3dZT8Pv
12. **UK Energy in Brief, Department of Business, Energy and Industrial Strategy, Jul '21,** https://bit.ly/3p1hdfj
13. **Carbon Brief, Report Oct '16,** https://bit.ly/3y1GPvq

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About GERMI

Gujarat Energy Research & Management Institute (GERMI) is a centre of excellence working in the energy sector, promoted by Gujarat State Petroleum Corporation Limited (GSPC), a Government of Gujarat Undertaking, with four central mandates: Research & Development, Consultancy, Training and Education. GERMI's work bridges both the petroleum and renewable energy sectors. Our aim is towards improving the knowledge base of policy makers, regulators and provides a competitive edge to industry leaders to compete in the global arena.

ANNEXURES

Annexure 1: Complete list of plants for Gujarat

Plant	Fuel	Unit No.	Ownership	% Share going to GJ	Unit wise capacity (MW)	Unit wise GJ capacity (MW)
Coal and Lignite Plants						
Ukai	Coal	3	State	100.00%	200	200
	Coal	4	State	100.00%	200	200
	Coal	5	State	100.00%	210	210
	Coal	6	State	100.00%	500	500
Gandhinagar	Coal	3	State	100.00%	210	210
	Coal	4	State	100.00%	210	210
	Coal	5	State	100.00%	210	210
Wanakbori	Coal	1	State	100.00%	210	210
	Coal	2	State	100.00%	210	210
	Coal	3	State	100.00%	210	210
	Coal	4	State	100.00%	210	210
	Coal	5	State	100.00%	210	210
	Coal	6	State	100.00%	210	210
	Coal	7	State	100.00%	210	210
	Coal	8	State	100.00%	800	800
Sikka	Coal	3	State	100.00%	250	250
	Coal	4	State	100.00%	250	250

Note: Plants marked in light grey are recommended for FGD installations and Life Extension Project

KLTPS	Lignite	3	State	100.00%	75	75
	Lignite	4	State	100.00%	75	75
Bhavnagar Lignite Thermal Power Station (BLTPS)	Lignite	1	State	100.00%	250	250
	Lignite	2	State	100.00%	250	250
Akrimota	Lignite	1	Private	100.00%	125	125
	Lignite	2	Private	100.00%	125	125
Torrent (Sabarmati AMGEN)	Coal	1	Private	100.00%	120	120
	Coal	2	Private	100.00%	121	121
	Coal	3	Private	100.00%	121	121
Essar Power Gujarat Ltd. (EPGL)	Coal	1	Private	83.33%	600	500
	Coal	2	Private	83.33%	600	500
Adani (Mundra Thermal Power Plant)	Coal	1	Private	90.91%	330	300
	Coal	2	Private	90.91%	330	300
	Coal	3	Private	90.91%	330	300
	Coal	4	Private	90.91%	330	300
	Coal	5	Private	75.76%	660	500
	Coal	6	Private	75.76%	660	500
	Coal	7	Private	0.00%	660	0
	Coal	8	Private	0.00%	660	0
	Coal	9	Private	0.00%	660	0
Tata (Mundra Ultra Mega Power Plant)	Coal	1	Private	45.13%	800	361
	Coal	2	Private	45.13%	800	361
	Coal	3	Private	45.13%	800	361

Note: Plants marked in light grey are recommended for FGD installations and Life Extension Project

	Coal	4	Private	45.13%	800	361
	Coal	5	Private	45.13%	800	361
Surat Lignite Power Plant (SLPP)	Lignite	1	Private	100.00%	125	125
	Lignite	2	Private	100.00%	125	125
	Lignite	3	Private	100.00%	125	125
	Lignite	4	Private	100.00%	125	125
Kasaipalli	Coal	1	Private	74.00%	135	100
	Coal	2	Private	74.00%	135	100
Korba	Coal	1	NTPC	17.14%	200.0	34
	Coal	2	NTPC	17.14%	200.0	34
	Coal	3	NTPC	17.14%	200.0	34
	Coal	4	NTPC	17.14%	500.0	86
	Coal	5	NTPC	17.14%	500.0	86
	Coal	6	NTPC	17.14%	500.0	86
	Coal	7	NTPC	19.20%	500.0	96
Vindhyachal Super Thermal Power Station (VSTPS)	Coal	1	NTPC	18.25%	1,260.0	230
	Coal	2	NTPC	23.90%	1,000.0	239
	Coal	3	NTPC	26.60%	1,000.0	266
	Coal	4	NTPC	24.00%	1,000.0	240
	Coal	5	NTPC	18.60%	500.0	93
SIPAT	Coal	1	NTPC	27.27%	1,980.0	540.0
	Coal	2	NTPC	27.30%	1,000.0	273.0
Kahalgaon	Coal	1	NTPC	9.40%	1,500	141

Note: Plants marked in light grey are recommended for FGD installations and Life Extension Project

MSTPS-I	Coal	1	NTPC	24.00%	1,000	240
MSTPS-II	Coal	1	NTPC	22.27%	660.0	147
	Coal	2	NTPC	22.27%	660.0	147
Lara	Coal	1	NTPC	9.75%	800.0	78
	Coal	2	NTPC	9.75%	800.0	78
Gadarwara - I	Coal	1	NTPC	19.00%	800.0	152
	Coal	2	NTPC	19.00%	800.0	152
North Karanpura	Coal	1	NTPC	11.67%	660.0	77
	Coal	2	NTPC	11.67%	660.0	77
	Coal	3	NTPC	11.67%	660.0	77
Khargone	Coal	1	NTPC	18.61%	660.0	123
	Coal	2	NTPC	18.61%	660.0	123
Gas Powered Plants						
GIPCL (Vadodara)	Gas	1	Private	28.97%	145	42.0
	Gas	2	Private	100.00%	165	165
Dhuvaran CCPP-I	Gas	7	State	100.00%	107	107
Dhuvaran CCPP-II	Gas	8	State	100.00%	112	112
Dhuvaran CCPP-III	Gas	3	State	100.00%	376	376
Utran CCPP-II	Gas	2	State	100.00%	375	375
Pipavav CCPP (GSECL)	Gas	1	State	100.00%	351.4	351
	Gas	2	State	100.00%	351.4	351
GSEG, Hazira	Gas	1	State	100.00%	52	52
	Gas	2	State	100.00%	52	52

Note: Plants marked in light grey are recommended for FGD installations and Life Extension Project

	Gas	3	State	100.00%	52	52
Paguthan CCPP	Gas	1	Private	100.00%	138	138
	Gas	2	Private	100.00%	138	138
	Gas	3	Private	100.00%	138	138
	Gas	4	Private	100.00%	241	241
Essar Power, Hazira (CCPP)	Gas	-	Private	58.25%	-	300
GSEG EXT, Hazira	Gas	-	State	100.00%	-	351
Torrent (SUGEN)	Gas	1	Private	100.00%	382.5	383
	Gas	2	Private	100.00%	382.5	383
	Gas	3	Private	100.00%	382.5	383
UNOSUGEN (Torrent)	Gas	-	Private	100.00%	-	383
Torrent (DGEN)	Gas	1	Private	33.33%	400	133
	Gas	2	Private	33.33%	400	133
	Gas	3	Private	33.33%	400	133
Jhanor-Gandhar	Gas	1	NTPC	36.07%	657.0	237
KAWAS	Gas	1	NTPC	28.51%	656.0	187

Note: Plants marked in light grey are recommended for FGD installations and Life Extension Project

Annexure 2: Scheduled Retirement

Power Plant	Unit No.	Capacity (MW)	Current Age (Years)	Ownership
Gandhinagar	3	210	31	State
Ukai	3	200	42	State
Ukai	4	200	42	State
Ukai	5	210	36	State
Wanakbori	1	210	39	State
Wanakbori	2	210	38	State
Wanakbori	3	210	37	State
Wanakbori	4	210	35	State
Wanakbori	5	210	35	State
Wanakbori	6	210	34	State
		2,080		

Annexure 3: Early Retirement (Scenario I)

Power Plant	Unit No.	Capacity (MW)	Current Age (Years)	Ownership
Adani (Mundra TPP)	5	500	10	Private
Adani (Mundra TPP)	6	500	10	Private
Gandhinagar	3	210	31	State
Gandhinagar	4	210	30	State
Gandhinagar	5	210	23	State
Ukai	3	200	42	State
Ukai	4	200	42	State
Ukai	5	210	36	State
Ukai	6	500	8	State
Wanakbori	1	210	39	State
Wanakbori	2	210	38	State
Wanakbori	3	210	37	State
Wanakbori	4	210	35	State
Wanakbori	5	210	35	State
Wanakbori	6	210	34	State
Wanakbori	7	210	22	State
Wanakbori	8	800	2	State
		5,010		

Annexure 4: Early Retirement (Scenario II)

Power Plant	Unit No.	Capacity (MW)	Current Age (Years)	Ownership
Adani (Mundra TPP)	1	300	12	Private
Adani (Mundra TPP)	2	300	11	Private
Adani (Mundra TPP)	3	300	11	Private
Adani (Mundra TPP)	4	300	10	Private
Adani (Mundra TPP)	5	500	10	Private
Adani (Mundra TPP)	6	500	10	Private
Gandhinagar	3	210	31	State
Gandhinagar	4	210	30	State
Gandhinagar	5	210	23	State
KLTPS*	3	75	24	State
Sikka	3	250	6	State
Ukai	3	200	42	State
Ukai	4	200	42	State
Ukai	5	210	36	State
Ukai	6	500	8	State
Wanakbori	1	210	39	State
Wanakbori	2	210	38	State
Wanakbori	3	210	37	State
Wanakbori	4	210	35	State
Wanakbori	5	210	35	State
Wanakbori	6	210	34	State
Wanakbori	7	210	22	State
Wanakbori	8	800	2	State
		6,535		

*Lignite power plant

Annexure 5: Average PLF (Scheduled Retirement)

Fuel	Project	Capacity	Avg	% time plants are working above 75% PLF
Coal	Korba	200	95%	100%
Coal	Akrimota	250	94%	100%
Coal	Kahalgaon	141	94%	100%
Coal	MSTPS - I	240	94%	100%
Coal	Korba (Unit 7)	96	93%	100%
Coal	Surat Lignite Power Plant (Unit 1 & 2)	250	93%	100%
Coal	Surat Lignite Power Plant (Unit 3 & 4))	250	93%	100%
Coal	Khargone (Unit 1)	110	92%	92%
Coal	Gadarwara (Unit 2)	110	92%	92%
Coal	Khargone (Unit 2)	110	92%	92%
Coal	Gadarwara (Unit 1)	110	92%	92%
Coal	Lara (Unit 2)	140	92%	92%
Gas	JHANOR	237	91%	92%
Gas	KAWAS	187	90%	92%
Coal	Tata (Mundra UMPP)	1805	88%	92%

Coal	Essar Power Gujarat Ltd. (EPGL)	1000	83%	75%
Coal	KLTPS (Unit 4)	75	82%	75%
Gas	Dhuvaran CCPP 2	112	81%	75%
Coal	MSTPS – II (Unit 1)	147	81%	75%
Gas	Dhuvaran CCPP 1	107	78%	75%
Coal	BLTPS	500	77%	75%
Coal	North Karanpura (Unit 1)	77	75%	75%
Coal	North Karanpura (Unit 3)	77	75%	75%
Coal	North Karanpura (Unit 2)	77	75%	75%
Coal	KLTPS (Unit 3)	75	74%	75%
Coal	SIPAT (Unit 1)	540	71%	67%
Gas	GIPCL (Unit 1)	42	70%	58%
Coal	Lara (Unit 1)	140	68%	58%
Coal	MSTPS – II (Unit 2)	147	63%	50%
Coal	Adani (Mundra TPP) (Unit 5-6)	1000	61%	33%
Coal	Adani (Mundra TPP) (Unit 1t-4)	1000	60%	33%
Coal	SIPAT (Unit 2)	273	52%	17%
Coal	Ukai (Unit 6)	500	48%	8%

Coal	Wanakbori (Unit 7)	210	33%	8%
Coal	Gandhinagar (Unit 5)	210	33%	8%
Coal	Gandhinagar (Unit 4)	210	27%	8%
Market	Market Non-Peak	2000	23%	0%
Coal	Sikka (Unit 4)	250	22%	8%
Coal	Sikka (Unit 3)	250	22%	8%
Gas	Utran Extension	375	11%	0%
Gas	GPEC(CLPIPL)	655	8%	0%
Market	Market Peak	2000	6%	0%
Coal	Wanakbori (Unit 8)	800	5%	0%
Gas	DhuvaranCCPP3	376	3%	0%
Gas	GSEG Expansion	351	2%	0%
Gas	GSPC Pipavav	702	1%	0%
Gas	GSEG	156	0%	0%

Annexure 6: Average PLF (Early Retirement (Scenario I)

Tech	Project	Capacity	Avg	% time plants are working above 75% PLF
Coal	Korba	200	95%	100%
Coal	Akrimota	250	95%	100%
Coal	Kahalgaon	141	94%	100%
Coal	MSTPS (Unit 1)	240	94%	100%
Coal	Korba (Unit 7)	96	94%	100%
Coal	Surat Lignite Power Plant (Unit 1 & 2)	250	94%	100%
Coal	Surat Lignite Power Plant (Unit 3 & 4)	250	93%	100%
Coal	Lara (Unit 2)	140	93%	92%
Coal	Khargone (Unit 2)	110	93%	92%
Coal	Khargone (Unit 1)	110	93%	92%
Coal	Gadarwara (Unit 2)	110	93%	92%
Coal	Gadarwara (Unit 1)	110	93%	92%
Coal	Tata (Mundra UMPP)	1805	91%	92%
Coal	Essar Power Gujarat Ltd. (EPGL)	1000	86%	75%
Coal	MSTPS – II (Unit 1)	147	85%	83%
Coal	KLTPS (Unit 4)	75	85%	83%

Gas	Dhuvaran CCPP 2	112	83%	75%
Coal	BLTPS	500	81%	75%
Gas	Dhuvaran CCPP1	107	81%	75%
Coal	North Karanpura (Unit 2)	77	79%	75%
Coal	North Karanpura (Unit 1)	77	79%	75%
Coal	North Karanpura (Unit 3)	77	79%	75%
Coal	KLTPS (Unit 3)	75	78%	75%
Coal	SIPAT (Unit 1)	540	74%	75%
Coal	Lara (Unit 1)	140	72%	67%
Coal	MSTPS – II (Unit 2)	147	70%	58%
Coal	Adani (Mundra TPP) (Unit 1-4)	1000	69%	58%
Coal	SIPAT (Unit 2)	273	63%	33%
Coal	Sikka (Unit 3)	250	56%	25%
Coal	Sikka (Unit 4)	250	56%	25%
Market	Market Non-Peak	2000	40%	8%
Gas	GPEC (CLPIPL)	655	38%	8%
Gas	GSEG Expansion	351	24%	8%

Gas	GSPC Pipavav	702	20%	8%
Gas	GSEG	156	14%	8%
Market	Market Peak	2000	11%	0%

Annexure 7: Average PLF (Early Retirement (Scenario II)

Tech	Project	Capacity	Avg	% of time plants are working above 75% PLF
Coal	Korba	200	87%	92%
Coal	Akrimota	250	87%	92%
Coal	Korba (Unit 7)	96	86%	92%
Coal	Surat Lignite Power Plant (Unit 1 & 2)	250	86%	92%
Coal	Surat Lignite Power Plant (Unit 3 & 4)	250	85%	92%
Coal	Lara (Unit 2)	140	85%	83%
Coal	Khargone (Unit 1)	110	85%	83%
Coal	Gadarwara (Unit 2)	110	85%	83%
Coal	Gadarwara (Unit 1)	110	85%	83%
Coal	Khargone (Unit 2)	110	85%	75%
Coal	Tata (Mundra UMPP)	1805	82%	75%
Coal	Essar Power Gujarat Ltd. (EPGL)	1000	76%	67%
Coal	KLTPS (Unit 4)	75	76%	67%
Coal	MSTPS – II (Unit 1)	147	75%	67%
Coal	BLTPS	500	72%	67%
Coal	North Karanpura (Unit 3)	77	71%	67%

Coal	North Karanpura (Unit 2)	77	71%	67%
Coal	North Karanpura (Unit 1)	77	71%	67%
Coal	Lara (Unit 1)	140	67%	42%
Coal	MSTPS - II (Unit 2)	147	67%	42%
Coal	SIPAT (Unit 2)	273	65%	42%
Coal	Sikka (Unit 4)	250	61%	42%
Gas	GPEC (CLPIPL)	655	47%	17%
Marke t	Market Non-Peak	2000	40%	0%
Marke t	Market Peak	2000	14%	0%

Annexure 8: Early Retirement Cost (NPV Analysis)

Power Plant	Unit	Capacity (in MW)	Remaining life at the end of FY40 (in years)	Fixed Cost / MW (in crore)	Total Fixed Cost to be Paid in FY40 (Crore INR)	Total Fixed Cost to be Paid in FY40 (Million USD)
Ukai	3	200	0	0.52	₹ 0	$0
Ukai	4	200	0	0.52	₹ 0	$0
Ukai	5	210	0	0.52	₹ 0	$0
Gandhinagar	3	210	0	0.57	₹ 0	$0
Gandhinagar	4	210	0	0.57	₹ 0	$0
Wanakbori	1	210	0	0.43	₹ 0	$0
Wanakbori	2	210	0	0.43	₹ 0	$0
Wanakbori	3	210	0	0.43	₹ 0	$0
Wanakbori	4	210	0	0.43	₹ 0	$0
Wanakbori	5	210	0	0.43	₹ 0	$0
Wanakbori	6	210	0	0.43	₹ 0	$0
KLTPS	3	75	0	0.98	₹ 0	$0
KLTPS	4	75	10	1.34	₹ 1,005	$132
Gandhinagar	5	210	0	0.57	₹ 0	$0
Wanakbori	7	210	0	0.31	₹ 0	$0
Sikka	3	250	15	1.24	₹ 3,938	$517

Assumptions for NPV analysis:
1) Discount Factor taken at 8%
2) Only state-owned coal power plants have been considered for retirement
3) 1 USD = 76.15 INR

Sikka	4	250	15	1.24	₹ 3,938	$517
BLTPS	1	250	16	1.3	₹ 4,283	$563
BLTPS	2	250	17	1.3	₹ 4,414	$580
Ukai	6	500	13	0.89	₹ 5,243	$689
Wanakbori	8	800	19	0.3	₹ 3,434	$451
					₹ 26,255	**$3,449**

Assumptions for NPV analysis:
1) Discount Factor taken at 8%
2) Only state-owned coal power plants have been considered for retirement
3) 1 USD = 76.15 INR

THE ENERGY TRANSITION IN GUJARAT

A Potential Roadmap for the Power Sector

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