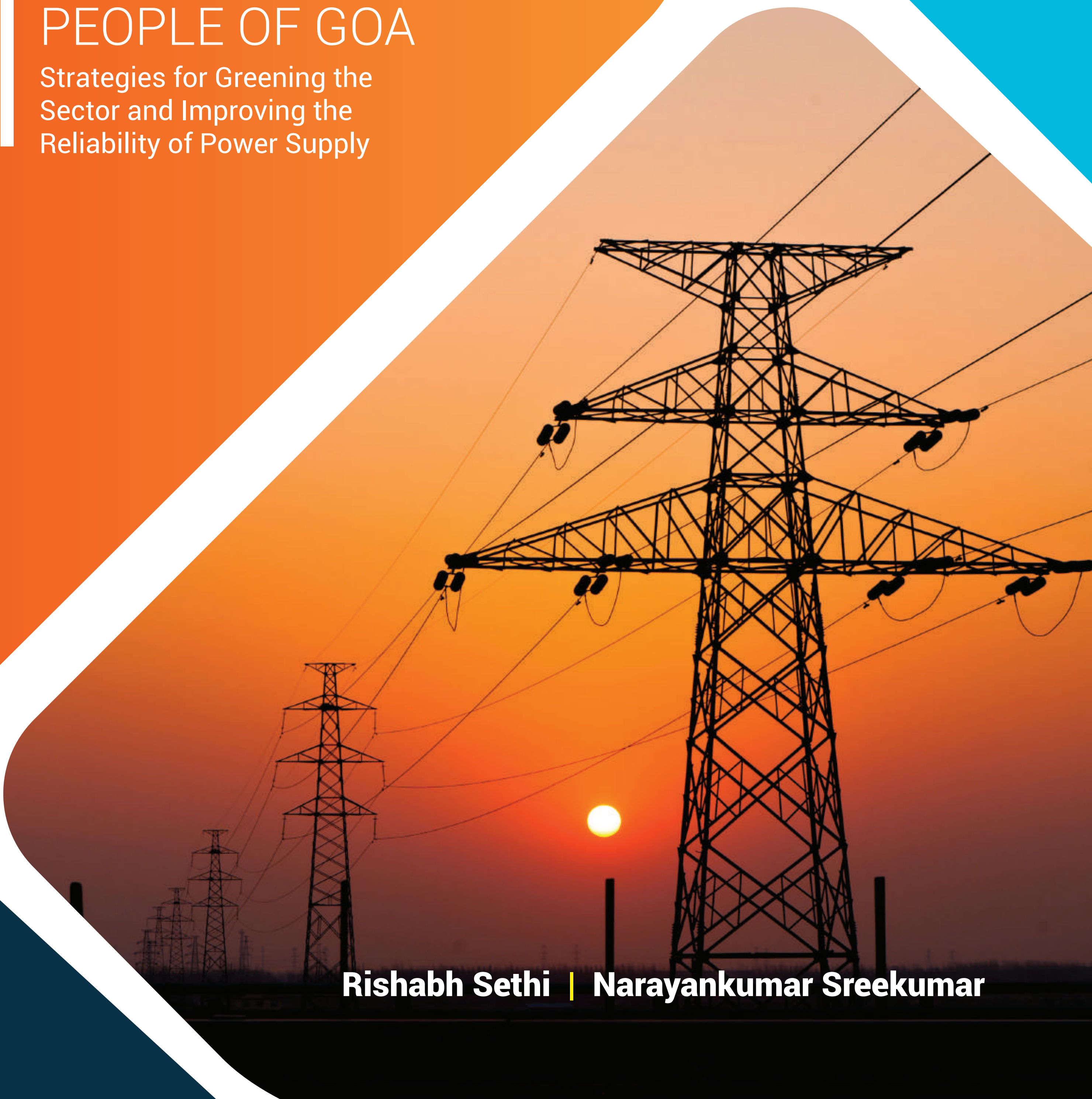
THE ENERGY AND RESOURCES INSTITUTE
Creating Innovative Solutions for a Sustainable Future

ENSURING 24X7 RELIABLE POWER SUPPLY TO THE PEOPLE OF GOA

Strategies for Greening the Sector and Improving the Reliability of Power Supply



Rishabh Sethi | Narayankumar Sreekumar

ENSURING 24X7 **RELIABLE POWER** SUPPLY TO THE PEOPLE OF GOA

Strategies for Greening the Sector and Improving the Reliability of Power Supply

Rishabh Sethi | Narayankumar Sreekumar

CERTIFICATE OF ORIGINALITY

SUGGESTED FORMAT FOR CITATION

R. Sethi, N. Sreekumar. 2021. Ensuring 24x7 Reliable Power Supply to the People of Goa: Strategies for Greening the Sector and Improving the Reliability of Power Supply. New Delhi: The Energy and Resources Institute 73 pp.

DISCLAIMER

PUBLISHED BY

TERI Press
The Energy and Resources Institute
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi-110 003
India

FOR MORE INFORMATION

Project Monitoring Cell
The Energy and Resources Institute (TERI)
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003
India   India +91 • Delhi (0)11
Tel. 2468 2100 or 2468 2111
Fax 2468 2144 or 2468 2145
E-mail pmc@teri.res.in
Web www.teriin.org

Acknowledgment

TERI places on record its sincere gratitude to the stakeholders who were interacted during the study. The interactions and deliberations with various officers from different stakeholder organization including the Electricity Department of Goa, Goa State Industries Association and their industrial members, solar rooftop developers, and consumers who are too numerous to be named individually and their cooperation throughout the study were exemplary and the whole exercise was thoroughly a rewarding experience for TERI.

Lastly, we would also like to express our sincere gratitude towards **Mr. K. Ramanathan**, Distinguished Fellow (Electricity and Fuels Division), TERI, and **Mr. A.K. Saxena**, Senior Fellow and Senior Director (Electricity and Fuels Division), TERI for providing their inputs and advisory support throughout the project. We would also like to thank **Mr. Pawan Kumar Tiwari**, Senior Fellow (Industrial Energy Efficiency Division), TERI, and **Ms. Meghana Jayakumar**, Associate Fellow (Electricity and Fuels Division), TERI for providing their support during the study.

- TERI Team

Contents

Figures

Tables

Abbreviations

ABR : Average Billing Rate
ACoS : Average Cost of Supply
APPC : Average Power Purchase Cost
BEE : Bureau of Energy Efficiency
CAGR : Compound Annual Growth Rate
CEA : Central Electricity Authority
CSGP : Central Sector Generation Plants
DDUGJY : Deen Dayal Upadhyaya Gram Jyoti Yojana
DERs : Distributed Energy Resources
EDG : Electricity Department of Goa
EHV : Extra High Voltage
FMCG : Fast-moving Consumer Goods
GEDA : Goa Energy Development Agency
GoI : Government of India
GSDP : Gross State Domestic Product
IPDS : Integrated Power Development Scheme
JERC : Joint Electricity Regulatory Commission for the State of Goa and Union Territories
LCOE : Levelized Cost of electricity
LT : Low Tension
MNRE : Ministry of New and Renewable Energy
MU : Million Units
MW : Mega Watt
NLDC : National Load Dispatch Center
NPCIL : Nuclear Power Corporation of India Limited
NSDP : Net State Domestic Product
NVVNL : NTPC Vidyut Vyapar Nigam Limited
PPAs : Power Purchase Agreements
PV : Photo-voltaic
R-APDRP : Re-structured Accelerated Power Development and Reforms Programme
RGGVY : Rajiv Gandhi Grameen Vidyutikaran Yojanan
RPO : Renewable Purchase Obligation
SAIDI : System Average Interruption Duration Index
SAIFI : System Average Interruption Frequency Index
SDA : State Designated Agency
SECI : Solar Energy Corporation of India
SLDC : State Load Dispatch Center
SNA : State Nodal Agency
SRLDC : Southern Regional Load Dispatch Center
STPS : Super Thermal Power Station
TERI : The Energy and Resources Institute
UDAY : Ujjwal Discom Assurance Yojana
WRLDC : Western Regional Load Dispatch Center

Executive Summary

Availability, accessibility, and affordability of adequate electricity infrastructure are necessary for ensuring continued economic development, India is no exemption. Alongside the changes on the demand side with the national demand estimated to reach up to 900 GW by 2032, India has also been witnessing a paradigm shift on the supply end due to India's aggressive renewable generation program with the target of 450 GW installed capacity via renewable energy by 2030. With 382 GW of installed capacity, as of March 2021, India's power sector is now the third-largest producer and second-largest consumer of electricity in the world[1], but at the same time faces various challenges in maintaining reliability in the power supply. The importance of reliable power for a growing economy cannot be overemphasized as the economy is becoming more and more dependent on electricity for everything – from e-commerce to industrial process, to the increased reliance on uninterrupted power supply in all walks of life. With this shift, global economies have become increasingly sensitive to power outages. Such disturbances not only result in economic loss which is due to loss in production/outputs but also have social implications which include lack of essential services such as water supply, security considerations on streets, accidents, impact on living standards, among others.

The state of Goa, being no exception, is also witnessing a change in the power sector over the years with per capita consumption of the state nearly doubling the national average. The consumer base for the Electricity Department of Goa (EDG) has observed a significant change over the years. The number of consumers, connected load, and electricity sales have increased with a compound annual growth rate (CAGR) of 2.4 percent, 2.6 percent, and 2.9 percent, respectively. Despite the increase in the consumer base, peak demand for the state has been observed to have sluggish growth over the years.

To identify and address the issues or challenges faced while ensuring a 24x7 reliable power supply to the people of Goa, a detailed study was undertaken to identify measures for effective demand-side and supply-side management. The study was focused on (a) identifying strategies for effective load management to cater to the growing demand, and (b) identifying strategies for increasing the share of green power within the supply mix.

While identifying demand-side management interventions, a system-level load research study for the load data of FY 2019-20 provided insights into the average demand profile and its characteristics for the state of Goa. It has been observed that Goa witnesses an evening peak, owing to the huge demand of domestic and industrial (including hospitality industry) consumers, with minimal seasonal variations. The maximum peak demand is observed during the winter months, which can be attributed to the large inflow of tourists during the season. It has also been identified that there is a huge potential for improving the load factors which are currently in the range of 0.68 to 0.85. Regarding the assessment of the change in demand, while no major change is observed in the demand profile during the last 6 years, the peak demand has been observed to increase, but not substantially, at a CAGR of 2.3 percent. This demand has been projected to double within the next 15 years.

[1] India Brand Equity Foundation (IBEF), Power Sector in India, https://www.ibef.org/industry/power-sector-india.aspx

Looking into the supply-side, the state is meeting its power requirement by procuring over 90 percent of the power from central sector generating plants (CSGP). The present supply mix for the state is observed to be dominated by thermal energy (including coal and gas as the fuel source), having a share of over 94 percent in total installed capacity

It has been analyzed that 78 percent of the total power procurement, during 2021-22, will come from coal-based central power generating stations, with the major contribution from NTPC power plants, and a total average power procurement cost (APPC) of INR 3.35 per kWh. While analyzing the APPC, a difference of INR 0.85 per kWh has been witnessed between old and new NTPC stations; this can be attributed to the old stations in the power procurement portfolio of EDG, which are more than 25 years old and their fixed charges have been already been recovered during the present life of the plant. Despite the efforts made by the Government of Goa to increase the penetration of renewable energy within the state, sluggish growth has been observed in the solar rooftop market with only 4.5 GW of installations till March 2021. Interactions with various key stakeholders brought forth the technical and regulatory barriers encountered, including lack of adequate grid evacuation facilities, grid reliability, intermittent nature of energy source, limited solar PV penetration limits, and low retail tariff among many others. As the state continues to rely on its inter-state transmission connectivity for importing more than 90 percent of the power requirement from the neighboring states, there is a dire need for a robust inter-state transmission system. A preliminary study by EDG has highlighted that various challenges like shortage of land for expansion, availability of single bus systems, dearth of system planning exercises, among others, make the transmission of power from outside the state difficult as all the EHV sub-stations and transformers have been reported to be overloaded and/or inefficient. Being the heart of the power sector for the state, there is a need to look into the network augmentation and/or expansion required to strengthen the network to meet the future growing demand.

As the power system of Goa continues to be plagued with various challenges, there is a need to look into focused strategies to assist in maintaining a reliable power supply to the people of Goa. One of the main recommendations is effective database management as it holds the key to ensure a data-driven process is being followed for successful outage management. For ensuring reliability within the power system, various interventions can be undertaken and implemented from both, the demand side as well as the supply side.

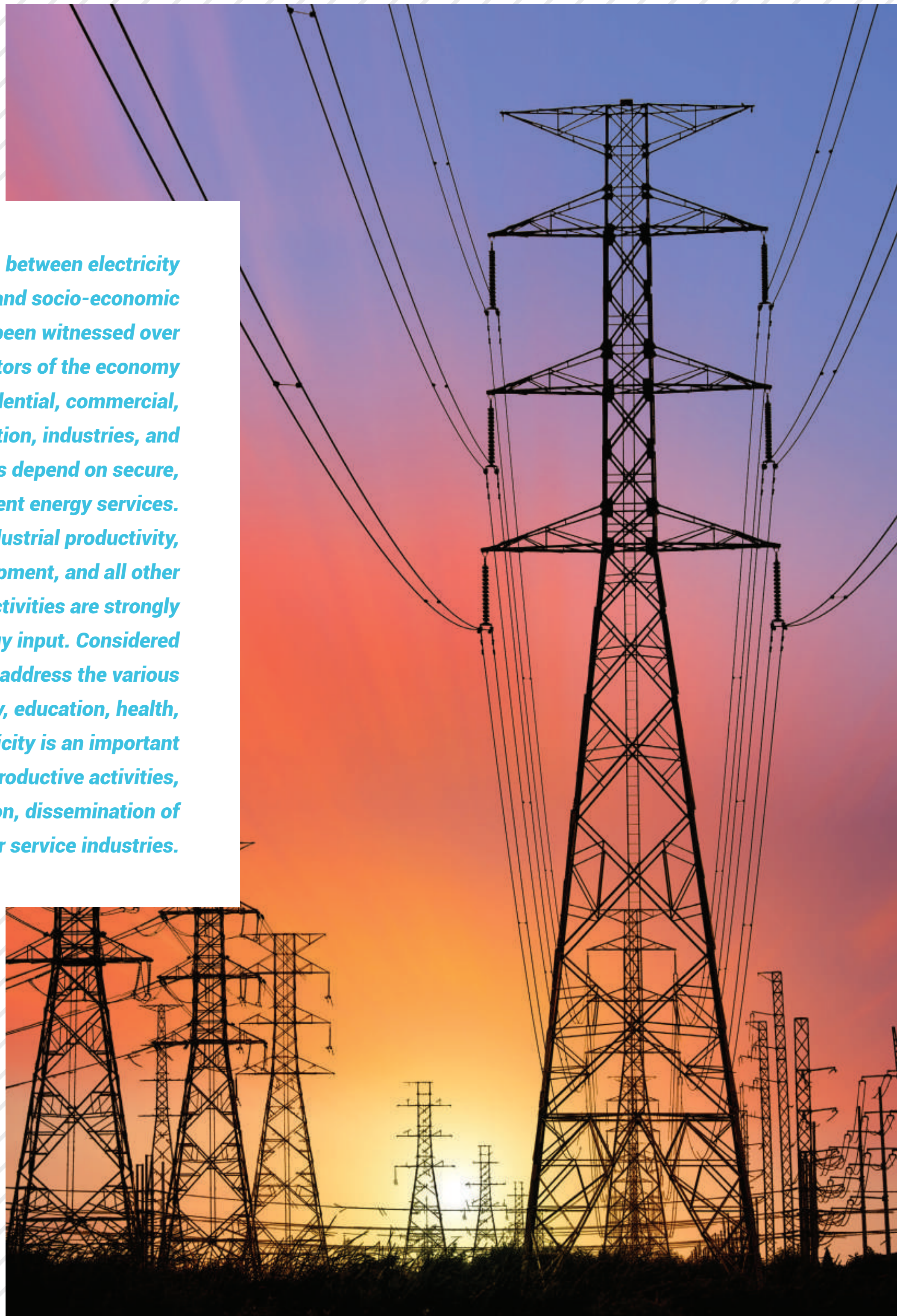
While accelerated promotion of energy-efficient appliances among consumers is one of the crucial demand-side management (DSM) measures, it is important to carry out detailed load research and demand projections studies, from time to time, to identify and modify the demand-side interventions for effective load management. It is also crucial to ensure grid modernization utilizing smart grid technologies as a fault-proof efficient distribution network for maintaining a reliable power supply among the people of the state.

On the supply-side, it is important not only to meet the ever-growing demand for power but also to progressively increase the share of renewable energy (RE) in the generation mix to achieve overall energy security and also to meet the renewable purchase obligation (RPO) as per the target fixed by State Electricity Regulatory Commission from time-to-time. Thus, proper network infrastructure management and a well-defined power planning strategy hold the key to ensuring reliability in the system. Along with realizing the distributed renewable energy potential within the state, 'green' power can be procured from various large-scale competitive renewable energy projects, such as ground-mounted solar power projects, solar parks, and wind farms among others. Various opportunities for floating solar, offshore wind, integrated renewable energy projects, grid-scale storage, and round-the-clock renewable energy projects can also be explored in the future with declining costs of renewable energy technologies. With the increasing push towards RE, there is a need for a long-term strategy, based on cost-effectiveness and availability, for increasing the 'green' energy share in the supply mix.

On the other hand, while conventional fuels offered a continuous generation of energy, renewable energy sources are intermittent. To balance the variability in the generation, grid flexibility takes utmost importance; this can be ensured by bringing in strong regional connectivity of transmission networks. Thus, to facilitate the transition towards a low carbon power sector, the fundamental step is to ensure the development of an adequate, robust, and reliable intra-state and inter-state transmission system. While on the path of sustainable development, a sustainable and reliable supply of power to the people of Goa forms one of the basic steps. Outage management and maintaining reliability require interventions on both sides of the power system. In-depth studies and pilot implementation of identified interventions would help ensure that we are on the track of achieving our end goal – **ensuring a 24x7 reliable power supply to the state of Goa**.

1

INTRODUCTION



A positive correlation between electricity consumption and socio-economic development has been witnessed over the years. All sectors of the economy including residential, commercial, transportation, industries, and agricultural sectors depend on secure, sufficient, and efficient energy services. Job availability, industrial productivity, urban and rural development, and all other major economic activities are strongly affected by the energy input. Considered as a means to address the various dimensions of poverty, education, health, and economy, electricity is an important input to modern productive activities, communication, dissemination of information, and other service industries.

Over the past 15 years, the electricity sector of India has observed exponential growth with the power and energy requirement nearly doubling in the period, thanks to rising incomes and improving standards of living.[2] This has led to India becoming the third-largest electricity producer and second-largest electricity consumer in the world.[3] Despite the incremental rise in the electrification rates over the years, uninterrupted power supply and reliability remain an area of concern.

With the continued economic expansion, expanding access to electricity, urbanization, and increasing stock of electrical & electronic appliances, the importance of reliable power continues to grow as the economy becomes more and more dependent on electricity for everything, thereby, persistently increase the pressures on the power system. In an attempt to relieve the pressure on the system, various initiatives in the form of schemes, such as Ujjwal DISCOM Assurance Yojana (UDAY), Integrated Power Development Scheme (IPDS), Re-structured Accelerated Power Development and Reforms Programme (R-APDRP), Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), and Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) along with "24x7 Power For All" program have been undertaken and implemented by the Government of India along with various measures undertaken by the state governments. Despite these interventions, there is still scope for maintaining continuity and reliability of the power supply.

The state of Goa, being no exception, has been witnessing a paradigm shift in terms of the growth of its power sector. The per capita power consumption of the state has observed a significant increase and is almost double the national average of 1,181 kWh (as of FY 2018-19).[4] On the other hand, sluggish growth has been observed for the peak demand over the past couple of years; the peak demand in the state has increased from 529 MW in FY 2013-14 to 596 MW in FY 2018-19. Despite the increase in power consumption, as highlighted by the increase in the per capita power consumption, the peak demand has not observed a similar growth trend, thus, clearly pointing towards the importance to look into the reliability of power supply.[5]

Being one of the smallest states in the country, the majority of the population of the state of Goa is inhabited near the coastal areas with the far in-land

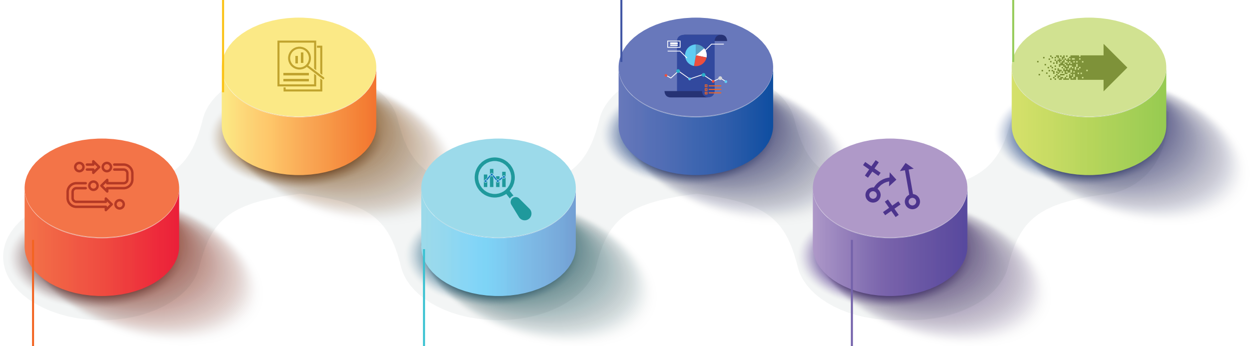
[2] Central Electricity Authority, Growth of Electricity Sector in India from 1947-2020
[3] India Brand Equity Foundation (IBEF), Power Sector in India, https://www.ibef.org/industry/power-sector-india.aspx
[4] Press Information Bureau, Press Release by Ministry of Power (November 2019)
[5] Looking at the reliability of power supply within the state, Goa observed its SAIFI and SAIDI parameters equivalent to 11.72 and 7.5 hours as of October 2020.

areas come under forest cover. The state does not have any major source of power generation of its own and is majorly dependent on the central sector for meeting its power requirement and relies on its connectivity to import power from the southern and western regional electricity grids via the inter-state transmission corridor. However, various challenges have made the transmission of power from outside the state difficult as all the EHV sub-stations and transformers have been reported to be overloaded and/or inefficient.[6] Being the heart of the power sector for the state, there is a need to look into the network augmentation and/or expansion required to strengthen the network to meet the future growing demand.

Intending to address the issues related to maintaining a reliable power supply to the people of the state of Goa, it is important to look into strategies that would, not only, assist the utility in managing the growing demand via effective load management interventions but also ensure sustainability in the interventions by increasing the green energy within the supply mix. The development of such strategies would help the decision-makers to establish the need for additional investments and identify an appropriate mix of resources to meet the system demand. In this context, a comprehensive assessment was undertaken to identify strategies/ measures to aid future demand and supply planning for Goa's power sector by focusing on strategies for increasing green power in the state's energy mix and measures for effective demand-side management.

[6] Government of Goa, White Paper on the Complete Status of Power Situation in Goa

Through this report, the key issues related to ensuring a reliable power supply in the state of Goa have been identified, and a way forward has been suggested for the progression of the power sector of the state. The report is organized into seven chapters:



Chapter 2:

describes the **approach and methodology** adopted for the study including carrying out demand-side and supply-side analysis on the power sector of the state

Chapter 3:

provides an **overview of the state power sector** and focuses on distribution utility and provides an overall profile of the utility including its consumer base, sales, revenue mix as well as loss levels, efficiencies, and reliability indices

Chapter 4:

presents the results of the **demand-side analysis;** it provides an insight into load pattern, peak demand as well as a seasonal and weekly variation for the system demand and the major consumer categories of the utility, including domestic, commercial, and industrial consumer categories

Chapter 5:

presents the results of the **supply-side analysis** on greening the power sector and ensuring robust transmission network

Chapter 6:

presents the **strategies** which may be adopted to ensure reliable supply for the people of Goa; these strategies were focused on managing growing demand and ensuring energy transitions towards low carbon pathways in the state of Goa

Chapter 7:

suggests a **way forward** for the study on how the utility can take forward the results of the study

2

APPROACH AND METHODOLOGY

For conducting a comprehensive assessment to identify strategies/ measures to aid future demand and supply planning for Goa's power sector, some of the important pre-requisites are having a clear understanding of the demand variations along with its future projections, procedures for power supply system planning, infrastructure requirements for increasing demand among other key aspects.

IN THIS REGARD, TERI UNDERTOOK A COMPREHENSIVE STUDY WHICH IS DIVIDED INTO TWO (2) WORK PACKAGES, NAMELY *"EVALUATING CHANGING DEMAND PATTERNS & IDENTIFYING MEASURES FOR LOAD MANAGEMENT"*, AND *"PREPARING STRATEGIES FOR INCREASING GREEN POWER IN STATE'S ENERGY MIX"*. THE STUDY INVOLVED UNDERTAKING UTILITY PROFILING, SYSTEM-LEVEL LOAD PATTERN ANALYSIS AND DEMAND PROJECTIONS FOR THE FUTURE, ANALYSIS OF PRESENT SUPPLY MIX, AND IDENTIFICATION OF STRATEGIES FOR INCREASING RENEWABLE ENERGY POWER PROCUREMENT. THE APPROACH AND METHODOLOGY ADOPTED FOR THE SAME ARE PRESENTED HEREUNDER.

2.1. Utility Profile

A study on the utility profile including the demographic, economic, and electricity supply was carried out to understand various state-specific and utility-specific factors that influence the demand pattern of electricity.

2.2. Demand-side Analysis

The demand-side analysis had been undertaken to evaluate the change in demand patterns taken place over the years and identify measures for effective load management for the future.

System-level load research was carried out with an attempt to understand the demand of the utility, both in terms of quantum as well as pattern. The demand pattern for the utility through the course of a day and during the entire year as well as seasonal variations was studied using system-level load data captured and recorded by the Western Regional Load Dispatch Center (WRLDC). The data collected was analyzed and graphically represented to identify the diurnal, weekly, monthly, and seasonal demand variations for the utility. The system peak and off-peak periods were analyzed to identify appropriate interventions for the utility for effective demand-side management.

Stakeholder interactions with utility officials and the other key stakeholders were conducted to understand the status of load management strategies implemented at present and also capture their perspective in identifying new strategies.

Change in the system-level demand data over the past years was analyzed with the help of computation of month-wise, hourly slot-wise compound annual growth rate (CAGR) for the system-level demand from FY 2013-14 to FY 2019-20. The growth rate, thus computed, was used to forecast the future demand requirement. The future demand projections were made in an attempt to gauge the need for infrastructure augmentation if required to ensure the reliability of supply.

Thereafter, based on the findings of the demand-side analysis, various demand-side strategies were identified for effective load management; these interventions would assist in meeting growing demand while ensuring optimal end-use efficiency levels.

2.3. Supply-side Analysis

While demand-side interventions help in managing the power supply at the consumption end, supply-side interventions hold equal importance in maintaining the power supply position. The broad objective was to explore supply-side interventions to maintain a reliable power supply with the increasing demand, as forecasted under the previous work package. With a push towards large-scale integration of renewable energy into the grid in an attempt to decarbonize the power sector, analysis was focused on identifying measures for "greening" the electricity grid.

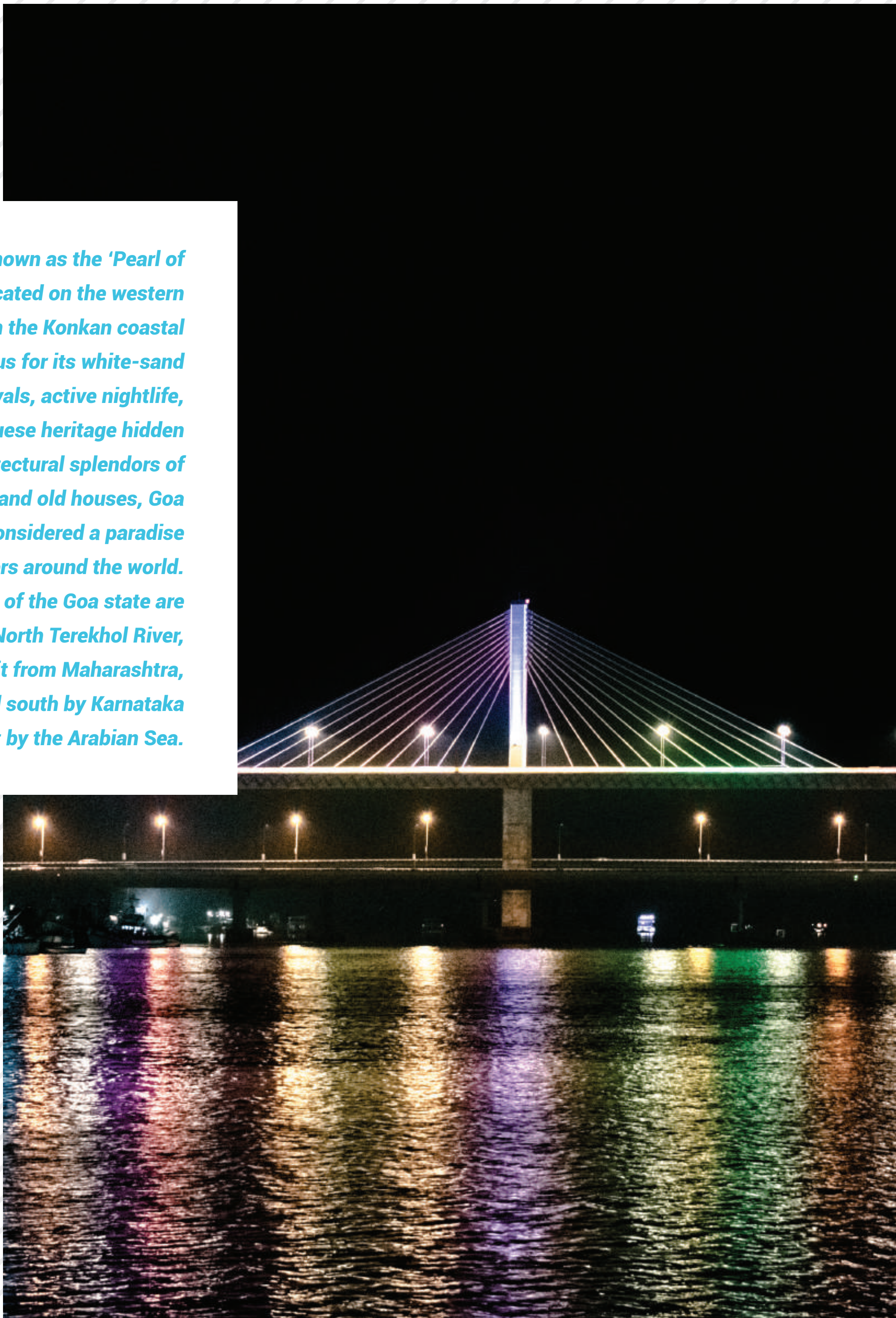
In an attempt to understand the present power supply system planning procedures, analysis of the present supply mix of electricity by various generating sources was carried out. While studying the existing power purchase agreements (PPAs), details related to the age of the power plant, power procurement cost among other parameters were studied to examine the present power procurement strategy. While gauging the potential for integration of renewable energy sources, cost analysis for different scenarios of procurement/ generation of renewable energy among renewable energy procurement within the state from distributed energy resources (DERs) and procurement from other renewable rich states was carried out to assess the need for future network planning exercises. Stakeholder interactions were also carried out to assess the challenges faced while attempting to increase the penetration of DERs within the state.

Thereafter, based on the findings of the system-side analysis, various supply-side strategies were identified to maintain reliable supply to meet the growing demand, while ensuring optimal utilization of green sources of energy.

3

DIAGNOSTIC REVIEW OF GOA POWER SECTOR

Goa, better known as the 'Pearl of the Orient', is located on the western coast of India in the Konkan coastal belt. Famous for its white-sand beaches, carnivals, active nightlife, and Portuguese heritage hidden in the architectural splendors of its churches and old houses, Goa has been considered a paradise for travelers around the world. Boundaries of the Goa state are defined in the North Terekhol River, which separates it from Maharashtra, in the east and south by Karnataka state and west by the Arabian Sea.



While the 105 km long coastline of mainland Goa is characterized by sandy beaches, estuaries, and promontories, the interior region is characterized by low and forested plateaus with two rivers, namely Mandavi and Zuvari flowing through the state. The state of Goa is geographically divided into three natural divisions namely the low lands, the plateaus, and the mountain region. The majority of the population of the state is situated in the low lands area, which is mainly located near the coastal lines.

Formerly a Portuguese territory, Goa, along with the other Portuguese territory of Daman and Diu, was integrated into India, as the Union Territory of India, in December 1962. In May 1987, the Union Territory was split and Goa attained statehood to become the twenty-fifth state of India. The state has a population of 1,458,545 people residing in an area of 3,702 square kilometers; thus, the population density of the state is equivalent to 394 people residing in every square kilometer area.[7]

Following the attainment of statehood, the Electricity Department was created in the year of 1963 as a department under the state government. The department is the only licensee in the state of Goa for the transmission and distribution of electrical energy. Other key stakeholders in the power sector in the state of Goa are the Joint Electricity Regulatory Commission for the State of Goa and Union Territories (JERC) and Goa Energy Development Agency (GEDA).

JERC has been constituted in accordance with the provisions of the Electricity Act, 2003 as a statuary body responsible for licensing transmission, distribution, and trade of electricity with an aim of rationalization of electricity tariff, transparent policies regarding subsidies, promotion of efficient and environmentally benign policies, and other matters relevant to electricity.

GEDA has been established as an autonomous body to undertake all programmes in the field on non-conventional and renewable energy sources; the body acts as the state nodal agency (SNA) which interacts with the Ministry of New and Renewable Energy (MNRE) under the Government of India (GoI) to implement the centrally funded and sponsored schemes.

Chief Electrical Engineer under the Electricity Department of Goa has been appointed as the state-designated agency (SDA) for Bureau of Energy Efficiency (BEE) to coordinate, regulate and enforce provisions of the Energy Conservation Act within the state. It is responsible for the promotion of efficient use of energy and conservation within the state and providing regulatory intervention through the issue of government orders for implementing appropriate energy efficiency and energy conservation measures.

Figure 1 provides an overview of the key stakeholders in the power sector of the state of Goa.

[7] Census 2011

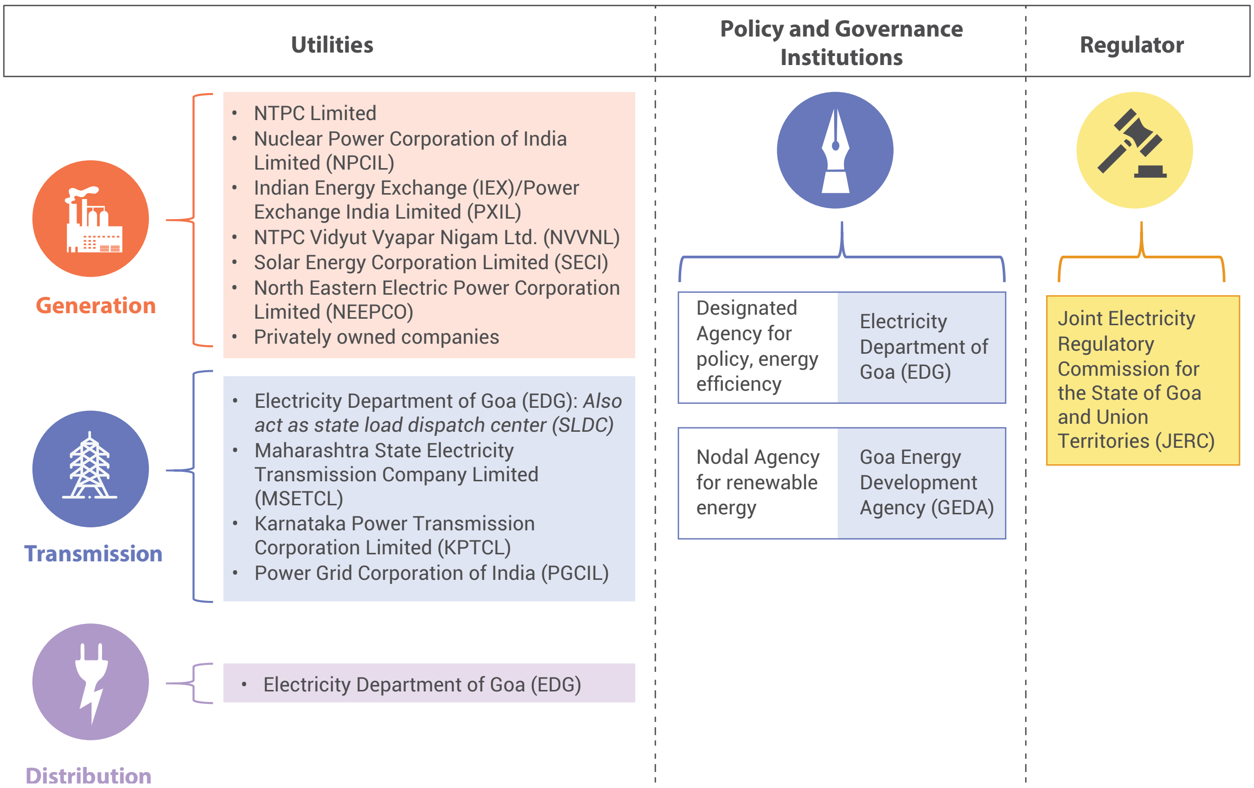
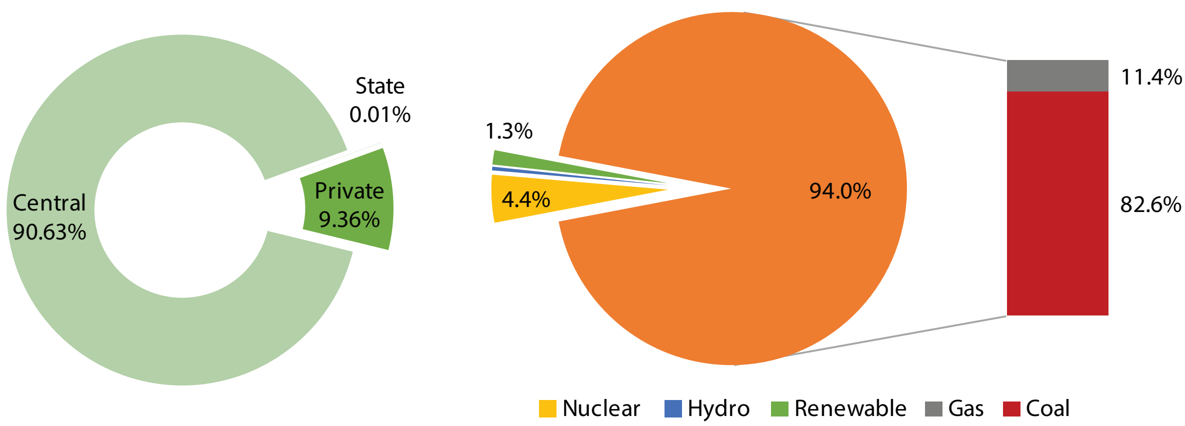


Figure 1: Key stakeholders in the power sector of Goa

3.1. Generation

With the state not having any power generation of its own, it is highly dependent on the central sector for meeting its power requirement with an allocated share of more than 90 percent of its total installed capacity and procuring the balance power requirement from the power market. The total installed capacity of Goa is 595.77 MW (as of March 2021) comprised of 559.94 MW thermal (492.27 MW via coal and 67.67 MW via gas), 2.00 MW hydro, 26.00 MW nuclear, and 7.83 MW renewables.[8] Figure 2 represents the breakdown of the state installed capacity based on ownership/sector and source.



Source: CEA

Figure 2: Breakdown of installed capacity of Goa (sector-wise & source-wise as of March 2021)

[8] Installed Capacity Monthly Report, CEA, March 2021

3.2. Transmission and Distribution

The Electricity Department, Government of Goa (EDG), the only licensee in the state of Goa, was established in the year 1963, within the meaning of Section 2 (17) of Electricity Act 2003 and under Section 14 of the Electricity Act. EDG is serving a consumer base of 0.66 million (i.e., 6.6 lakh) consumers, as of FY 2019-20, with a consumer density of approx. 177 per sq. km. The primary objective of EDG is to undertake the transmission, distribution, and retail supply of electricity in its license area and for this purpose plan, construct and manage the power system network in all its aspects. EDG is further responsible for carrying out the business of purchasing and selling electricity along with activities such as billing and collection in the area.

Regarding the transmission of power, the department has been responsibly playing its role in establishing, upgrading, operating, and maintaining the transmission network at various voltage levels. It has also been assigned the responsibility of running the state load dispatch center (SLDC) which is an apex body to ensure integrated operations of the power system in Goa and complies with the directions of the Western Regional Load Dispatch Center (WRLDC). The department is also responsible for carrying out optimum scheduling, real-time operations for grid control, and dispatch of electricity within the state, in accordance with the contracts entered into with the licensees or the generating companies operating in that state, the grid standards, and the state grid code.

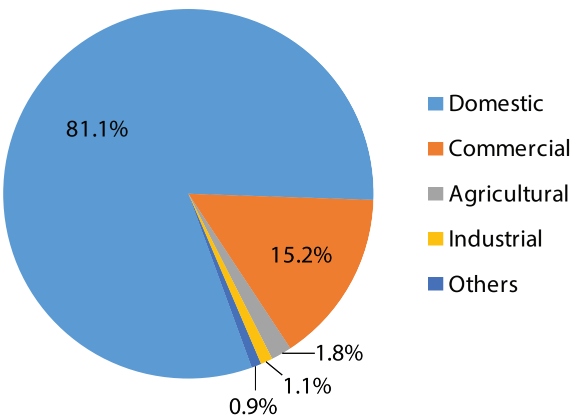
There are no direct link lines between the central power generating stations and the transmission network of Goa. Hence, the power is availed through the grids of the neighboring states of Maharashtra and Karnataka based on payment of wheeling charges to the respective utilities for using their line network for transmission of power from generating stations to Goa. At present, Goa is procuring power from both western and southern grid regions via 400 kV and 220 kV lines. From the western grid region, while 400 kV lines from Kolhapur Talandage sub-station in Maharashtra are feeding power to Colvale sub-station in Goa, 220 kV lines from Konalkatta and Tillari sub-stations in Maharashtra are feeding power to Amona sub-station in Goa. From the southern grid region, 220 kV lines from the Ambewadi sub-station are feeding power to Ponda and Xeldem sub-stations in Goa. The Ponda sub-station in Goa is also fed by four 220 kV voltage lines coming from the western grid region.[9]

The bulk power procured from central sector generation plants (CSGP) and short-term power market and transmitted to the periphery at various interface points of transmission and distribution network is distributed to its consumer base across the state. The license area of EDG is structured into 2 circles which are further distributed into 20 divisions. The incoming power at 400 kV, 220 kV, and 110 kV voltage levels is step-down and distributed at different voltage levels of 33 kV, 11 kV, and LT among the different consumer categories. The department has been working towards the development and maintenance of an efficient, coordinated and economical distribution system intending to meet the growing demand and ensure a 24x7 quality power supply to all its consumers.

9 Power map for the state of Goa

3.2.1. Consumer Base

Figure 3 represents the distribution of the utility's consumer base of 0.66 million consumers (as in FY 2019-20) among various categories. Domestic consumers are having a share of about 81.1 percent followed by commercial consumers with a share of 15.2 percent. This indicates that the utility is highly dominated by the LT consumer segment, majorly by the domestic category. Over the past 4 years, the number of consumers has increased from 0.59 million consumers in FY 2016-17 to 0.66 million consumers in FY 2019-20, with the majority of growth observed in domestic and commercial consumer categories.

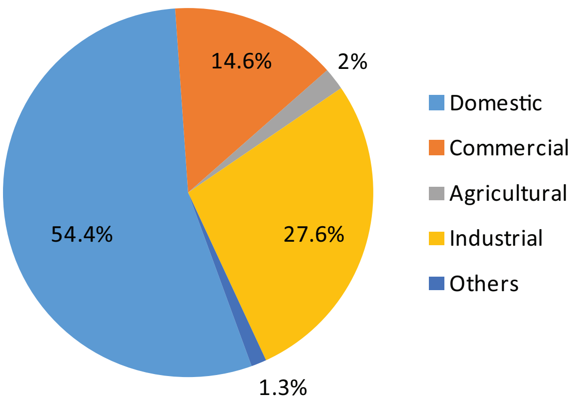


Source: EDG ARR & Tariff Order for FY 2019-20 (JERC Petition No. 266/2018; Dated 20 May 2019)

Figure 3: Consumer category-wise segregation of consumer base

3.2.2. Connected Load

EDG caters to a total connected load of 2,758.2 MW as of FY 2019-20. Figure 4 represents the segregation of consumer category-wise connected load for the utility. As the domestic consumers dominate the consumer base, the domestic category holds a majority share, i.e. 54.4 percent, in the total connected load of the utility. Despite having a small share of 1.1 percent in the consumer base, the industrial consumer categories hold a significant share of 27.6 percent in the total connected load of the utility; this is mainly due to energy guzzlers connected to the industrial consumer categories. Similar to the share of the consumer base, the commercial consumer category holds a significant share of 14.6 percent in the total connected load of the utility. Over the past 4 years, the connected load has increased from 2,331.5 MW in FY 2016-17 to 2,758.2 MW in FY 2019-20, with the majority of growth observed in domestic and commercial consumer categories.

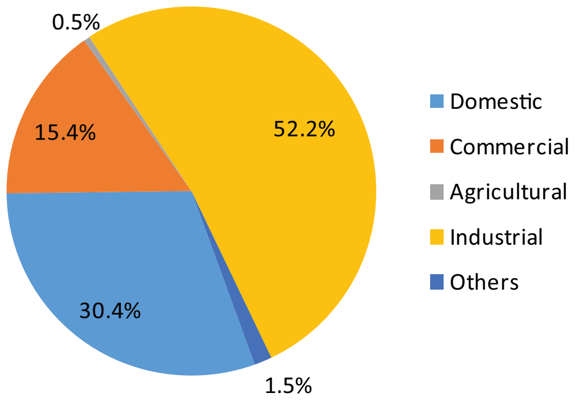


Source: EDG ARR & Tariff Order for FY 2019-20 (JERC Petition No. 266/2018; Dated 20 May 2019)

Figure 4: Consumer category-wise segregation of connected load

3.2.3. Electricity consumption & sales

In the FY 2019-20, EDG had procured 4,459.12 MU at the state periphery, after adjusting the inter-state loss levels, for INR 15.55 billion (i.e., INR 1,555.16 crore) with an average power purchase cost of INR 2.93 per kWh. The total sales of the utility for the FY 2019-20 were 3,979.76 MU. Figure 5 shows the category-wise breakdown of energy sales for EDG during FY 2019-20. The consumption mix in utility is dominated by the industrial consumer category (also including the hospitality industry) at around 52.2 percent, followed by the domestic and commercial consumer categories with the respective share of 30.4 percent and 15.4 percent, respectively. Over the past 4 years, the electricity sales have increased from 3,352.17 MU in FY 2016-17 to 3,979.76 MU in FY 2019-20, with the majority of growth observed in domestic and commercial consumer categories.

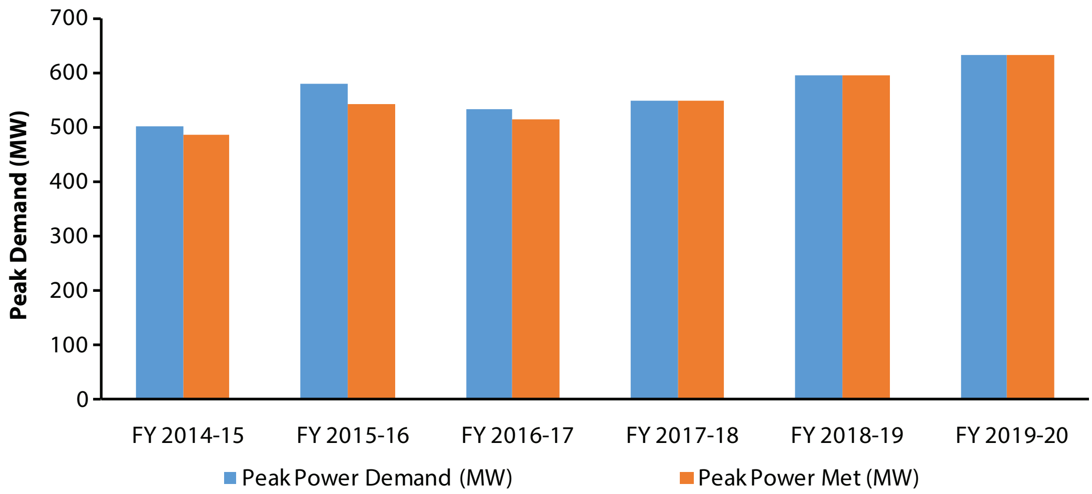


Source: EDG ARR & Tariff Order for FY 2019-20 (JERC Petition No. 266/2018; Dated 20 May 2019)

Figure 5: Consumer category-wise segregation of energy sales

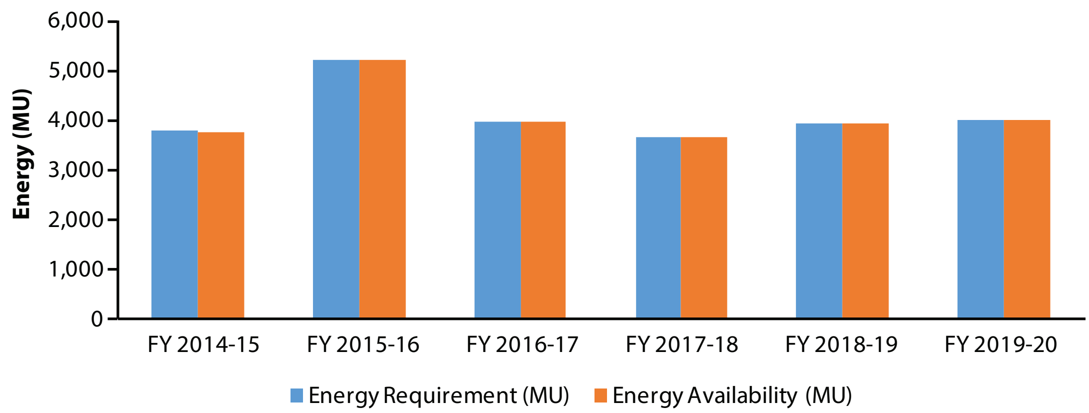
3.2.4. Power Supply Position

Figure 6 depicts the power supply position of the state of Goa. It is evident from the figure that the deficit in meeting the energy and peak requirements has reduced significantly over these years. It has also been observed that the peak and energy demand of the state have grown gradually with the compound annual growth rate (CAGR) of 3.8 percent and 1.5 percent respectively over the last 6 years by the end of FY 2019-20.



Source: CEA

Figure 6: Power supply position (peak power) of the Goa



Source: CEA

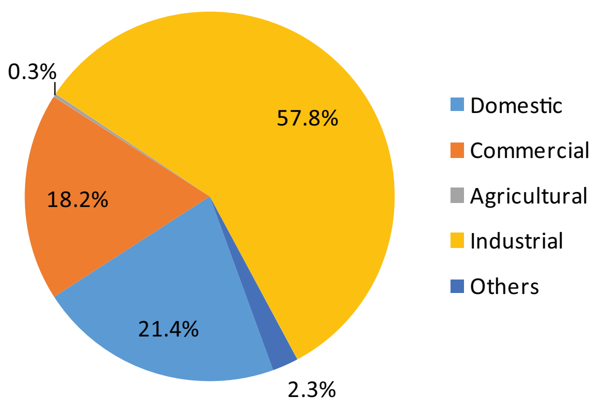
Figure 7: Power supply position (energy requirement) of the Goa

3.2.5. Revenue realization and financial health

It has been estimated and approved by JERC that EDG will collect INR 18.83 billion (i.e., INR 1,882.97 crores) against the actual sales of 3,979.76 MU during FY 2019-20 at the commission approved retail tariff for the consumer categories. Having a share of 15.2 percent and 1.1 percent in the consumer base of the utility, the commercial and industrial consumer categories corresponds to a significant share of 18.2 percent and 57.8 percent in the revenue mix of the utility, respectively. This denotes that these categories are heavily cross-subsidizing other consumer categories. Figure 8 shows the category-wise revenue from the approved retail tariff for EDG during FY 2019-20.

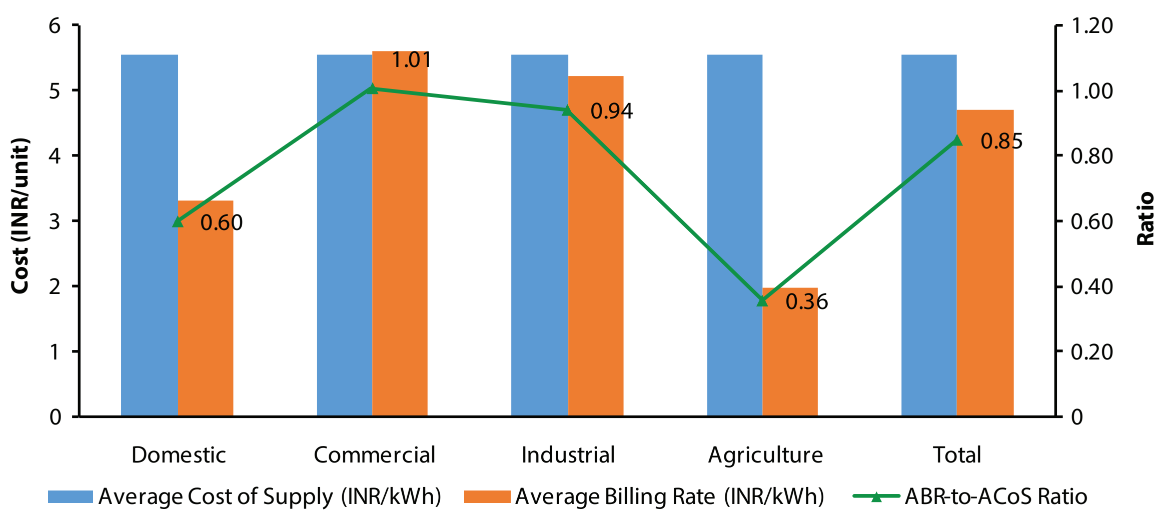
Apart from the factors of persisting revenue deficit and subsidy burden, many other factors are putting pressure on the financial sustainability of the utility. Despite gradually improving over the years, the financial health of the utility continues to have deteriorated with a closing balance of net gap being INR 3.29 billion (i.e., INR 329.25 crores) by the end of FY 2019-20. The Government of Goa continues to provide an upfront commitment to bridge the revenue gap by way of budgetary support, in line with the practice followed in previous years. The government budgetary support continues to provide support in reducing the average billing rate (ABR) to a value of INR 4.73 per unit of electricity, against the average cost of supply (ACoS) of INR 5.56 per unit of electricity for the FY 2019-20; without the government budgetary support, the tariff would have to be increased by a factor of 17.49% to ensure net gap to be zero. Figure 9 represents the consumer category-wise average billing rate and ABR to ACoS ratio for the major consumer categories.

Keeping in mind the growing demand with increasing electrification and the increasing number of consumers, maintaining reliable supply to the consumers would become more challenging. Thus, it is important to ascertain strategies or measures to address the challenges faced by the utility while ensuring access to a reliable power supply to all; these strategies could help in maintaining sustainable growth of the power sector of the state.



Source: EDG ARR & Tariff Order for FY 2019-20
(JERC Petition No. 266/2018; Dated 20 May 2019)

Figure 8: Category-wise revenue from approved retail tariff



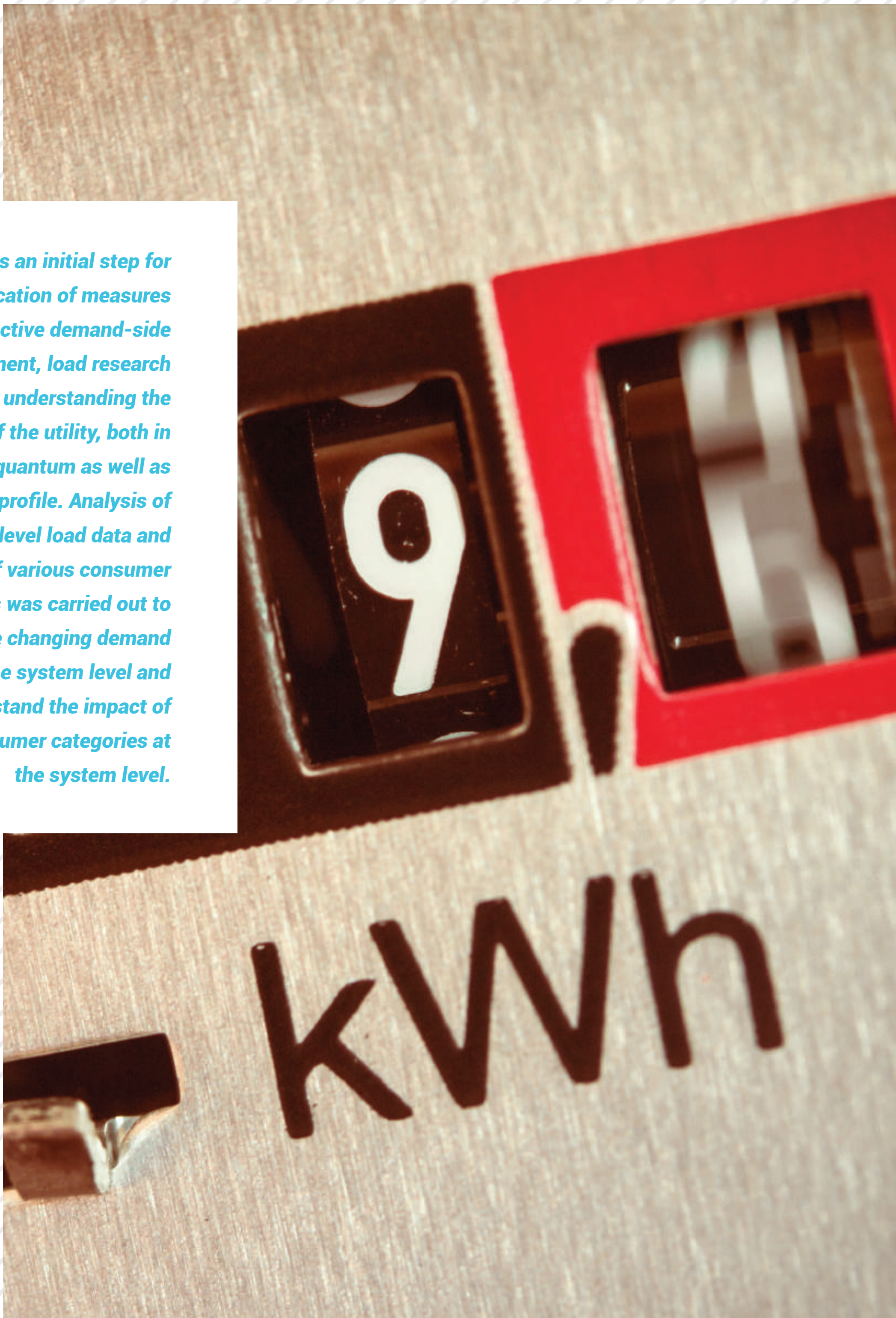
Source: EDG ARR & Tariff Order for FY 2019-20
(JERC Petition No. 266/2018; Dated 20 May 2019)

Figure 9: Category-wise average billing rate and ABR-to-ACoS ratio

4

DEMAND-SIDE ANALYSIS

Considered as an initial step for the identification of measures for effective demand-side management, load research assists in understanding the demand of the utility, both in terms of quantum as well as pattern and profile. Analysis of the system-level load data and growth rate of various consumer categories was carried out to understand the changing demand patterns at the system level and to also understand the impact of various consumer categories at the system level.



THIS SECTION HIGHLIGHTS THE DEMAND PATTERN OF THE UTILITY AT THE SYSTEM LEVEL ACROSS A DAY AS WELL AS SEASONAL VARIATION ALONG WITH THE GROWTH OF CONSUMERS AND THEIR IMPACT ON THE OVERALL DEMAND OF THE UTILITY. FY 2019-20 HAS BEEN TAKEN AS THE BASE YEAR FOR THE STUDY AS FY 2020-21 IS A SKEWED YEAR BEING IMPACTED DUE TO THE COVID-19 PANDEMIC.

4.1 System-level demand

The utility level demand pattern over the day across various months and seasons was analyzed for load data captured by the Western Regional Load Dispatch Center (WRLDC). Variations at intra-day, seasonal, and working vs. non-working days assessed for the FY 2019-20 are presented hereunder.

4.1.1. Load pattern

Figure 10 depicts the monthly average load pattern of the utility during FY 2019-20. It has been observed that the load pattern, peaking time as well as ramping rate for the utility tends to vary across seasons. This can be attributed to various parameters, one of the major ones being the climatic conditions.

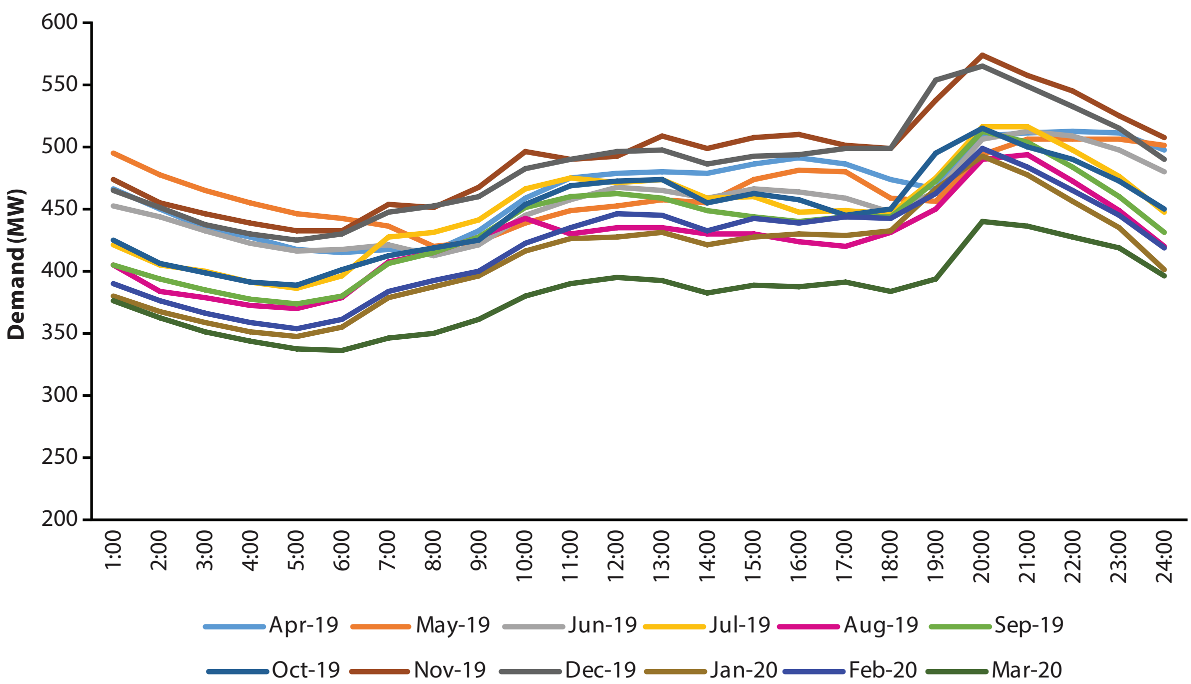


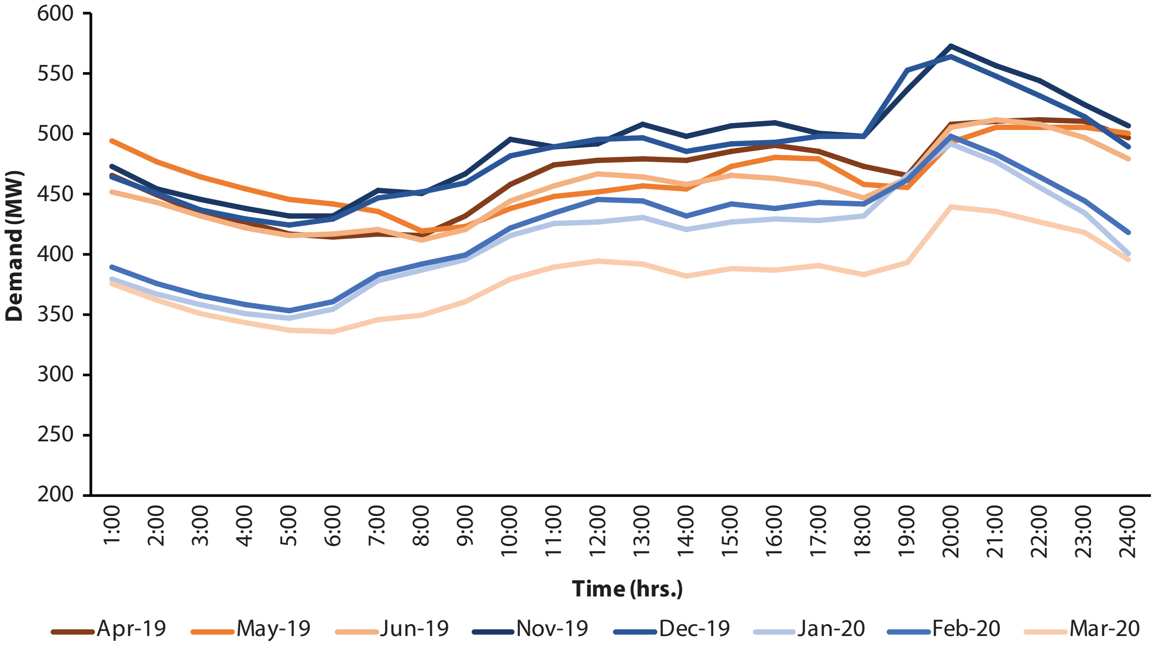
Figure 10: Monthly load curve during FY 2019-20

4.1.2. Seasonal variation

Goa enjoys a tropical climate, moderated by the Arabian Sea located on the western front of the state, with minor variations in the temperature across different seasons. These weather conditions have a minimal impact on the demand of the utility.

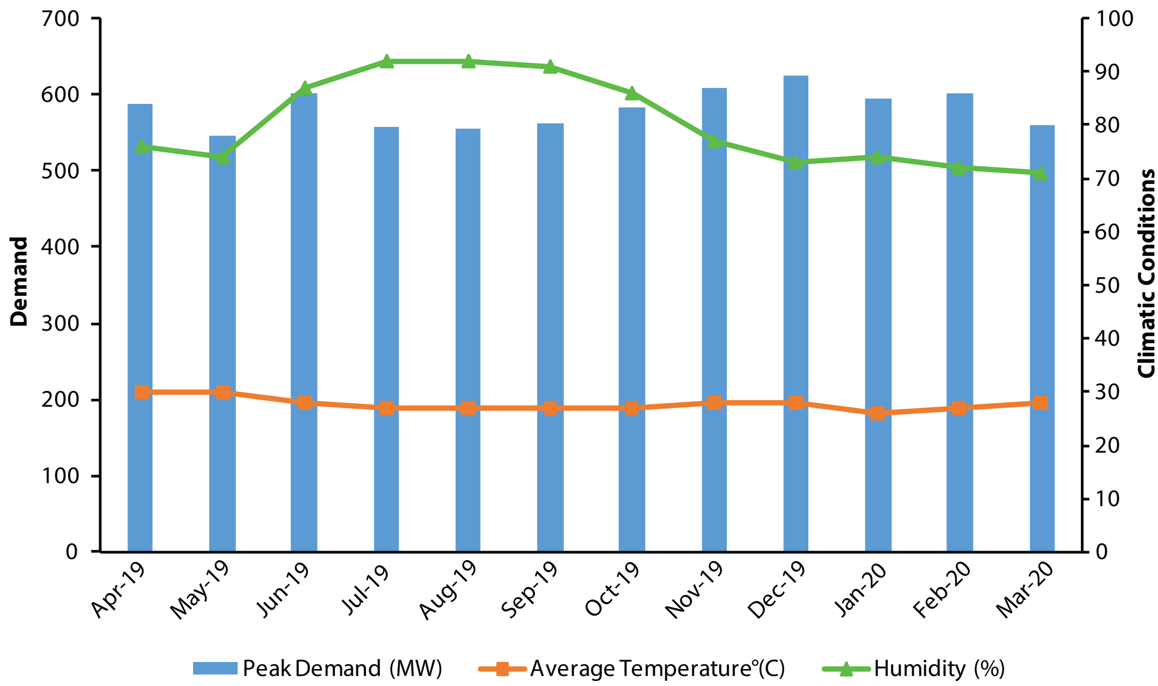
Figure 11 depicts the seasonal variations observed in the load of the utility. The load profile observes minimal variations across seasons in the load pattern irrespective of the significant change in the demand of utility across different seasons for the utility. The winter months (November to February) experience higher demand as compared to the rest of the year, primarily due to an increase in demand owing to the high influx of tourists traveling to the state. It has also been observed that the seasonal variation has minimal impact on the ramping of demand during peak hours for the utility.

Further, it has also been observed that climatic conditions of the state have a direct correlation with the peak demand of the utility. Figure 12 represents the correlation between the temperature, humidity, and the maximum demand of the utility. It has been observed that a minimal seasonal variation owing to changes in the temperature of the license area. However, it has been observed that humidity has a significant impact on the peak demand for the state.



Source: WRLDC

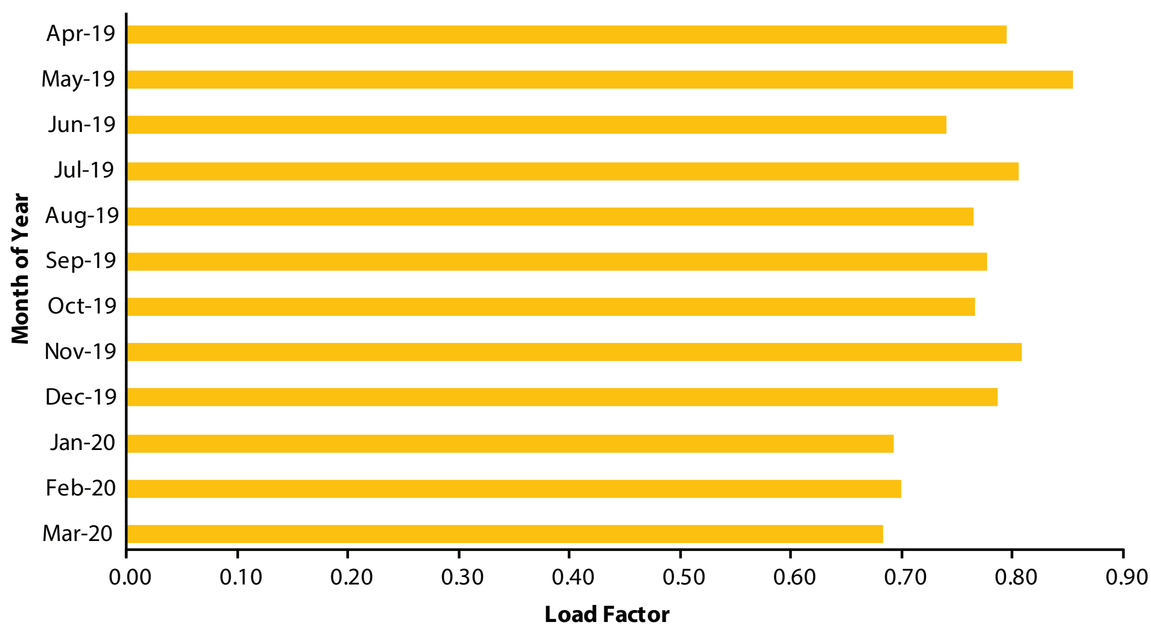
Figure 11: Seasonal variation (summer and winter) in load pattern during FY 2018-19



Source: WRLDC

Figure 12: Monthly variation in electricity demand, mean temperature, and average humidity of Goa (FY 2019-20)

From further analysis, it has also been found out that the load factor varies in the range of 0.68 to 0.85. Both peak summer months (April & May) and winter months (November & December) experience high load factors which signal high power interruptions during these months. Figure 13 depicts the load factor across various months.

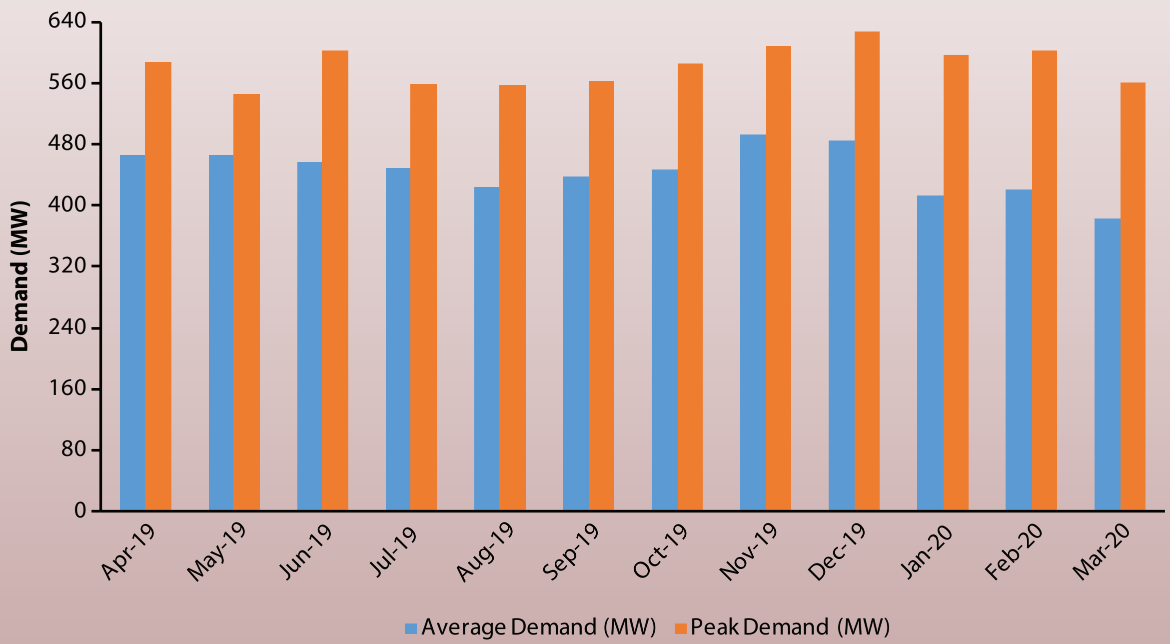


Source: WRLDC

Figure 13: Monthly variation in load factor during FY 2019-20

4.1.3. Peak demand

Although the utility observes a minimal change in the peak demand across the year, the peak demand is comparatively higher during the winter season (i.e. November to February) which is primarily attributed to the huge inflow of tourism traffic within the state complemented with maximum production from various industrial subsectors. The annual peak demand has been recorded to be in December, followed by June and November. The demand varies in the range of 379 – 618 MW during the month of peak demand of utility, with an average demand of 486 MW. The average and peak demand across various months during FY 2019-20 is shown in Figure 14.



Source: WRLDC

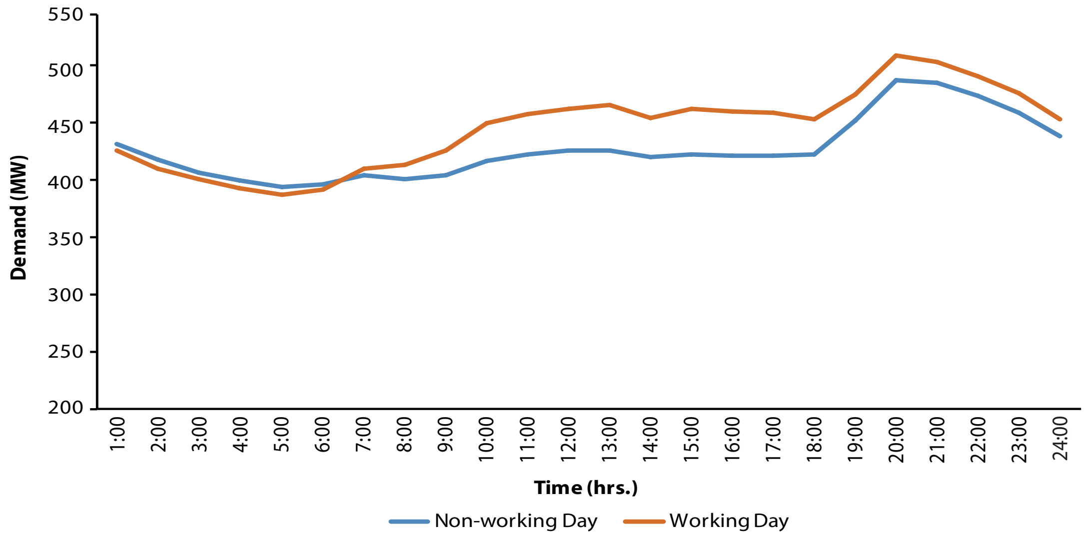
Figure 14: Monthly variation in load factor during FY 2019-20

4.1.4. Weekly variation

Figure 15 depicts weekday versus weekend variations in the demand observed for the utility during FY 2019-20. Significant weekly variation in the demand (i.e., approx. 3 percent to 9 percent) has been observed during working and non-working days, which is primarily due to incremental electricity usage by industrial and commercial consumer categories during the working days.

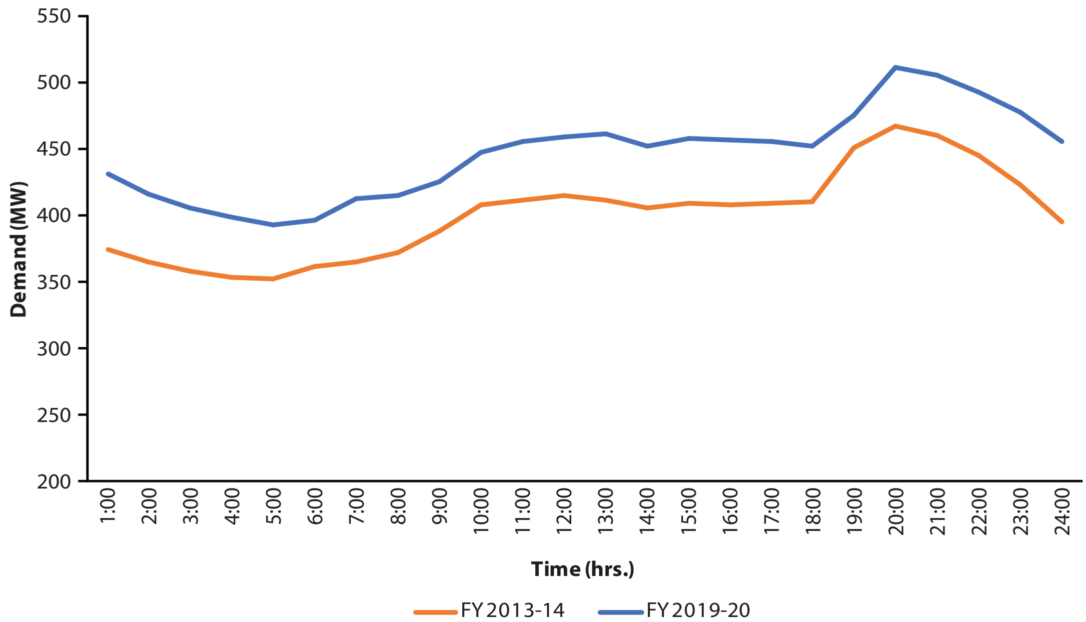
4.1.5. Growth pattern of utility

Over the past few years, an increase in the average load demand has been observed for the utility. The average demand has observed an increase of CAGR of 2.1 percent over the past 6 years, i.e. from FY 2013-14 to FY 2019-20. It is evident from Figure 16 that the load pattern has not observed any major change over the period from FY 2013-14 to FY 2019-20.



Source: WRLDC

Figure 15: Weekly variation across seasons in load pattern during FY 2019-20

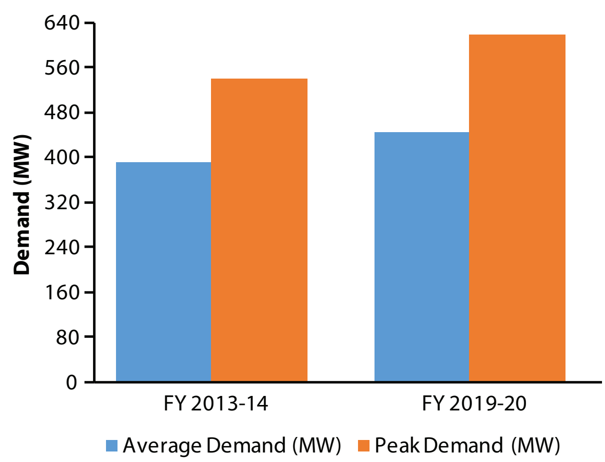


Source: WRLDC

Figure 16: Demand Pattern of FY 2013-14 and FY 2019-20

It is also evident from Figure 17 that the peak demand of the utility has increased, but not substantially, from 539.8 MW (FY 2013-14) to 618 MW (FY 2019-20) with a CAGR of 2.3 percent over the past 6 years. Although the month with the peak demand has shifted from February to December, the peak demand of the utility has continuously been during the winter months; this is owing to tourism-driven demand.

Table 1 defines the month-wise and hourly slot-wise CAGR for average demand from FY 2013-14 to FY 2019-20. It has been observed that the demand significantly increases during peak summer months (attributed to the increase in space conditioning load) and during peak winter months (attributed to the increase in the tourism traffic during favorable travel months). CAGR has been observed to be highest during the late evening and night hours.



Source: WRLDC

Figure 17: Change in average and peak demand from FY 2013-14 to FY 2019-20

Table 1: Month-wise, hourly slot-wise CAGR for average demand between FY 2013-14 and FY 2019-20

		1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	24:00
Between FY 2013-14 and FY 2019-20	April	2%	2%	2%	2%	1%	2%	2%	2%	3%	2%	2%	2%	2%	2%	3%	3%	2%	2%	3%	3%	2%	2%	3%	2%
	May	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	1%	1%	1%	2%	2%	2%	2%	2%
	June	4%	5%	5%	5%	4%	4%	4%	3%	4%	4%	4%	4%	4%	4%	5%	4%	4%	3%	4%	5%	4%	4%	4%	4%
	July	3%	4%	4%	4%	4%	5%	5%	4%	5%	5%	4%	4%	4%	3%	3%	4%	4%	3%	4%	5%	4%	3%	3%	4%
	August	2%	2%	2%	2%	2%	3%	3%	3%	3%	3%	2%	2%	2%	2%	3%	2%	3%	3%	3%	3%	2%	2%	2%	2%
	September	2%	2%	2%	2%	2%	3%	3%	3%	3%	4%	3%	3%	2%	3%	3%	3%	3%	3%	3%	3%	2%	1%	1%	2%
	October	2%	3%	1%	2%	2%	2%	3%	2%	3%	3%	2%	3%	3%	2%	2%	2%	2%	2%	3%	1%	1%	0%	2%	1%
	November	3%	3%	3%	3%	3%	3%	4%	3%	4%	4%	3%	3%	3%	3%	3%	3%	4%	4%	5%	3%	3%	3%	3%	3%
	December	4%	4%	4%	4%	4%	5%	5%	4%	4%	4%	3%	3%	3%	3%	4%	4%	4%	4%	4%	3%	2%	2%	3%	3%
	January	0%	0%	0%	0%	0%	0%	1%	0%	1%	1%	1%	1%	0%	0%	1%	1%	1%	1%	1%	0%	0%	-1%	-1%	-1%
	February	0%	1%	0%	1%	0%	1%	1%	0%	0%	1%	1%	1%	1%	0%	1%	1%	1%	1%	1%	0%	0%	-1%	0%	0%
	March	-2%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-1%	-1%	-2%	-1%	-1%	-2%	-1%	-2%	-2%	-1%	-1%	-1%	-2%	-2%	-2%	-2%

Source: WRLDC

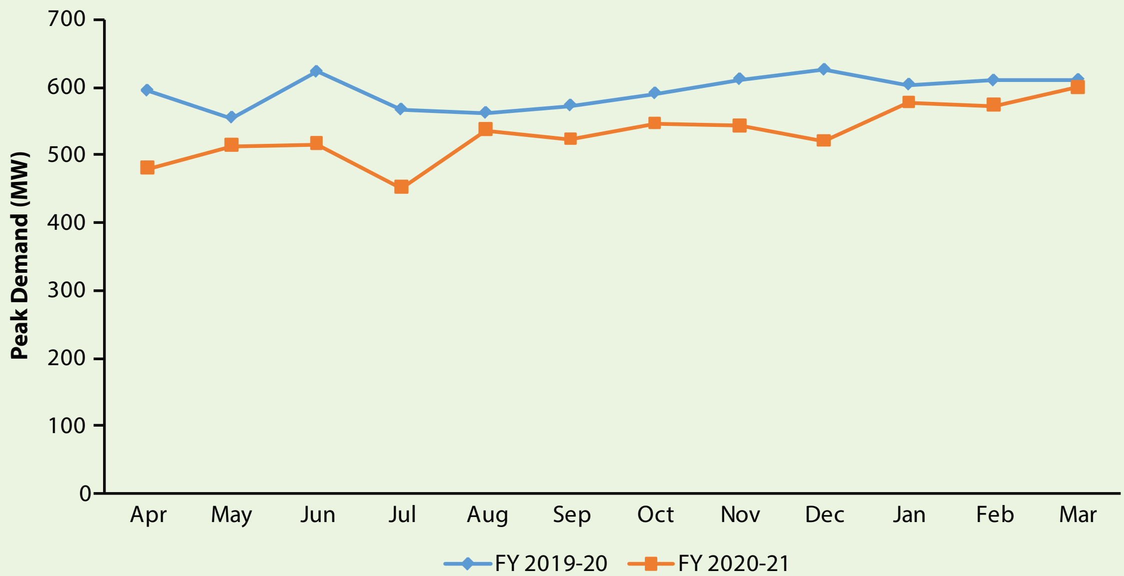
Impact of COVID on system-level demand

From the start of March 2020, the COVID-19 pandemic has put a halt to the development of the nation. In an attempt to fight the disease, lockdowns and curfews have been imposed which has impacted the operations of industrial and commercial establishments. As a result of the same, a reduction in power demand has been observed across the nation.

Being an industry dominant state, Goa has also observed a reduction in the demand for power at the system level. With the operations of the majority of the commercial and industrial establishments, apart from the ones which came under essential services, there was a major decline in the demand for the utility. A reduction of 4.2 percent has been observed in the case of peak demand, i.e. from 625 MW (in FY 2019-20) to 599 MW (in FY 2020-21). Similarly, a reduction of 7.4 percent has been observed in the case of total energy requirement, i.e. from 4,350 MU (in FY 2019-20) to 4.027 MW (in FY 2020-21).

Figure 18 defines the month-wise change in the peak demand from FY 2019-20 to FY 2020-21. The demand has been observed to decrease significantly during the first and second quarters of the financial years with the maximum decline in June and July due to a drop in the demand of industrial and commercial establishments. The demand observed a reversal and started to increase during the last quarter of the financial year with the maximum increase in March. This increase in demand can be attributed to the decline in the number of COVID cases in the nation and reviving of the operations of the commercial and industrial establishments within the state.

However, with the rapid increase in the number of COVID cases in the state during the second wave of infections observed across the country, this increase in demand would have seen a reversal. To capture the in-depth impact of pandemics on the state power sector, a detailed study on system-level as well as feeder-level must be undertaken; such studies would provide insights in effectively managing grid stability and reliability during such pandemics if occurring in the future.



Source: WRLDC

Figure 18: Month-wise change in peak demand from FY 2019-20 to FY 2020-21

4.1.6. Future demand projections

Goa is a well sought-after traveler destination in India, mostly popular for its bright sunny beaches. Presently, the electricity requirement for the state of Goa is predominantly by industrial consumers with a consumption share of 51.1 percent followed by domestic consumers with a share of 20.4 percent. Further, the total load requirement and per capita consumption of the state have been increasing steadily on a year-on-year basis.

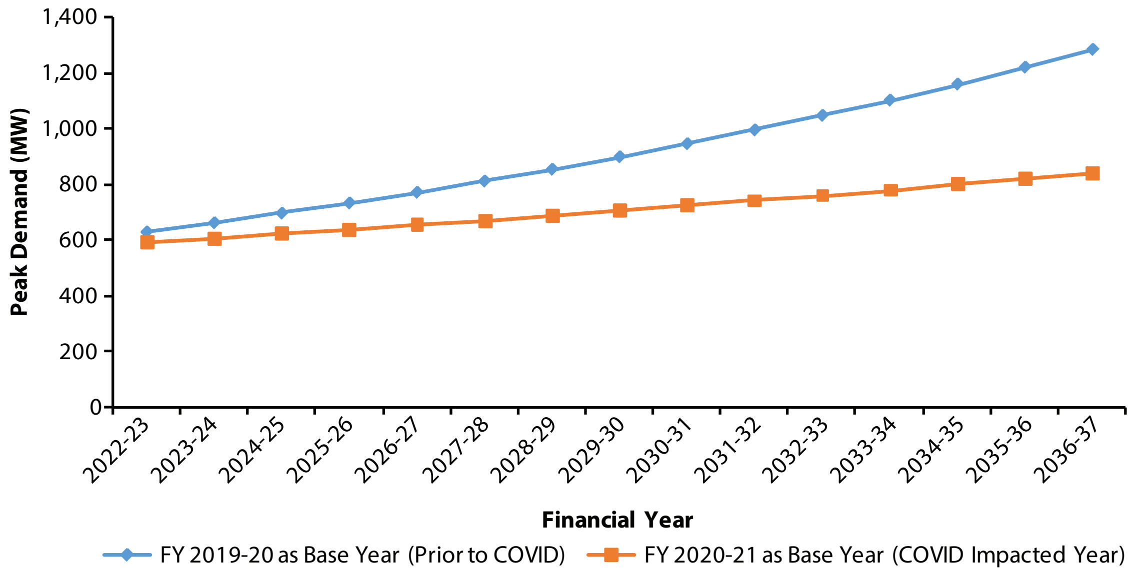
In an attempt to gauge the future demand, Central Electricity Authority (CEA) carried out the computation of future electricity requirement and peak demand projections of the state by utilizing two models, namely partial adjustment model (PAM) and seemingly unrelated regression (SUR) model. As per the estimates, the energy requirement and peak demand are expected to be doubled within 15 years.[10] Annexure I presents the peak demand projections for different scenarios for the state under the CEA study.

Similar findings were observed while undertaking the computation of future demand projections based on the system-level data collected. The future demand was projected for the next 15 years, i.e. from FY 2022-23 to FY 2036-37, under two different scenarios while taking into impact of COVID.

I. **Scenario I: Projection with base year FY 2019-20, i.e. before COVID**
   The demand for FY 2019-20 as the base year and the CAGR computed between FY 2013-14 and FY 2019-20 as the growth rate.
II. **Scenario II: Projection with base year FY 2020-21, i.e. COVID impacted year**
   The demand for FY 2020-21 as the base year and the CAGR computed between FY 2013-14 and FY 2020-21 as the growth rate.

Figure 19 depicts the growth peak demand for the next 15 years under the two scenarios. It is observed that under scenario-I, the peak of average demand is projected to grow with a CAGR of 4.9 percent from 628 MW (for FY 2022-23) to 1,282 MW (for FY 2036-37). On the other hand, the peak demand is projected to grow with a CAGR of 2.3 percent from 593 MW (for FY 2022-23) to 838 MW (for FY 2036-37) under scenario-II.

Assessment of peak demand future projections plays a crucial role in the identification of strategies for future system planning. The power network must be augmented from time to time to ensure the reliability of the power supply. **The system augmentation must be done while taking into consideration peak demand and minimum demand projections along with seasonal variations; these parameters must be assessed at regular intervals to ensure a resilient power network for maintaining the reliability of the power supply.**



Source: WRLDC

Figure 19: Growth in peak demand for the next 15 years, i.e. from FY 2022-23 to FY 2036-37

[10] CEA, Long Term Electricity Demand Forecasting (2019)

4.2 Consumer categories change in demand

As highlighted in chapter 3, EDG has a consumer base of 0.66 million consumers with the majority of the consumers belonging to the domestic category (81.1 percent) followed by the commercial category (15.2 percent). It is also evident from the electricity sales records that despite constituting a minor share of 1.1 percent in the number of consumers, the industrial category accounts for the majority share in the electricity sales with 52.2 percent of the total electricity sales of the utility; this is followed by domestic and commercial categories with 30.4 percent and 15.4 percent share in total electricity sales, respectively.

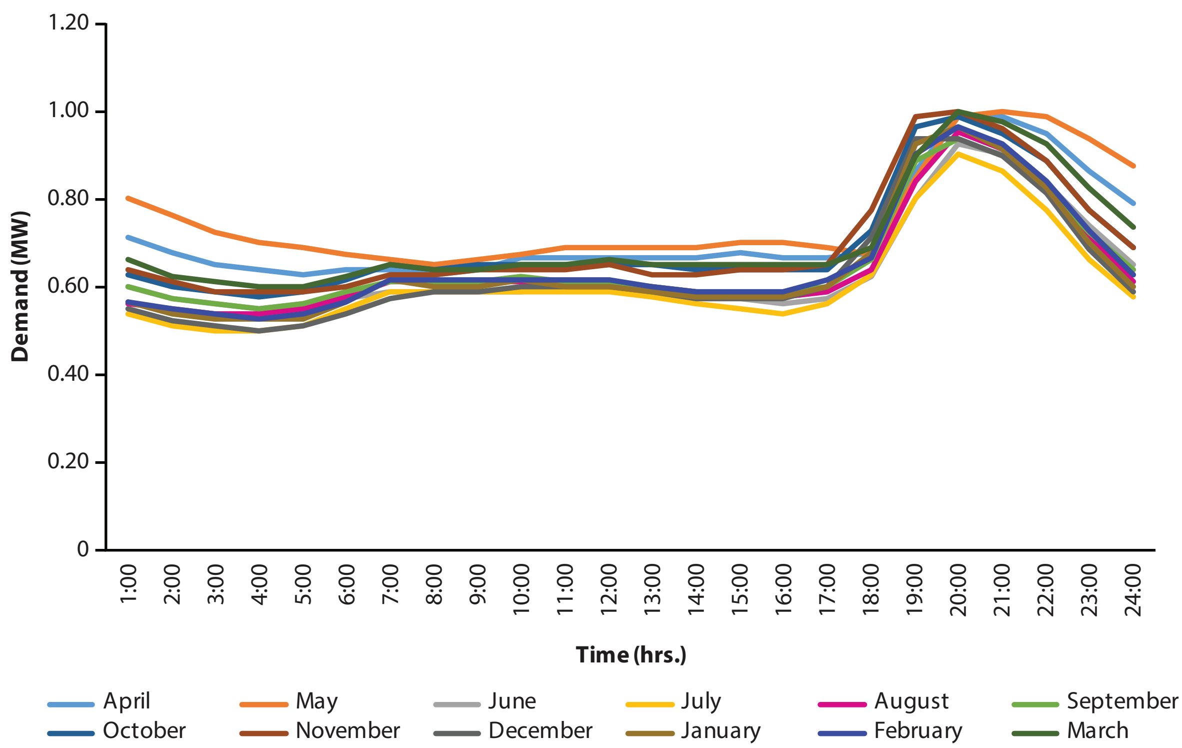
4.2.1 Domestic consumer category

The Electricity Department of Goa caters to a population of more than 14.59 lakh people and more than 3.4 lakh fully electrified households (as per Census 2011). Domestic consumers contribute to a significant share in the consumer mix of the Electricity Department of Goa in terms of the number of consumers and total connected load. Thus, in an attempt to assess the impact of the domestic consumer category on the utility, there is a need for analyzing the load pattern, especially in terms of contribution to peak demand, seasonal variation among others aspects.

The growth of domestic consumers highlights the need for a stronger power transmission and distribution system and better resource planning, especially to cater to the peak demand requirements of the domestic consumer category.

Load profile

Figure 20 represents the load pattern of the domestic consumer category highlighting the average demand and demand profile.



Source: WRLDC

Figure 20: Demand pattern for the domestic consumer category

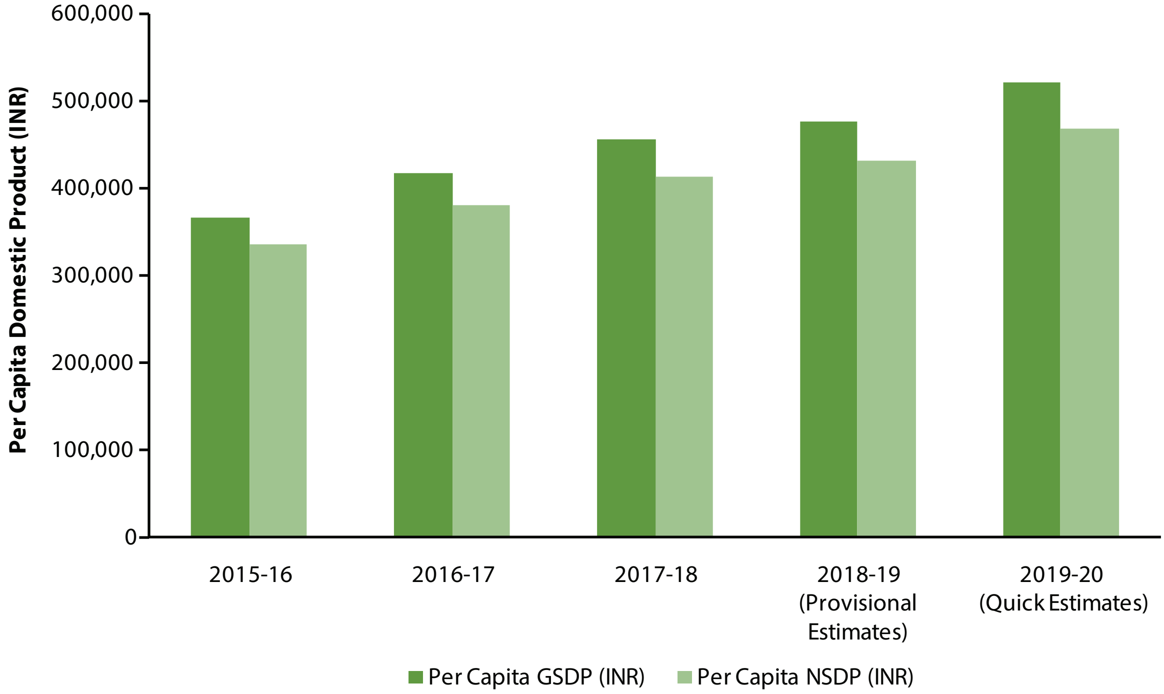
Consumption pattern: The average demand for the domestic consumer category tends to be uniform across the day, with minor peaking during the morning hours which can be attributed to the increase in domestic activities in the early morning hours. The pattern observes a flat demand profile during the day and is observed to start peaking around evening hours, starting from 18:00 hours; this can be attributed to the increase in demand for lighting load, space cooling, and conditioning load along with other miscellaneous loads. The evening peak continues to remain peakier till late night hours of 23:00 hours and, then starts to observe a steady decline in the average demand.

Peaking of demand: Domestic consumer category tends to observe peak demand during evening hours, which ramp up around 18:00 hours and peaks around 20:00 hours during winter months and around 22:00 hours during summer months. The demand tends to remain high till late evening hours and decrease gradually. This peak demand during the evening hours can be primarily attributed to incremental lighting and space cooling & conditioning load.

Seasonal variation: No significant seasonal variation is observed in the demand profile of domestic consumers. The average demand tends to be comparatively lower during the winter months as compared to the summer months. Additionally, there is minor variation in the peaking times across seasons with late-night peaking of demand during summer months (as described above); this can be attributed to comparatively higher consumption for the operation of space cooling & conditionally load in summer months as compared to winter months.

4.2.2 Industrial consumer category

Goa, with this wide connectivity through waterways and inland means by rail and air and through attractive government policies, has welcomed various industrial sectors, making the state one of the fastest-growing states in the country. Between FY 2015-16 and FY 2019-20, the per capita gross state domestic product (GSDP) (at current prices, the base year 2011-12) has observed an increase from INR 3.66 lakh to INR 5.20 lakh with a CAGR of 7.3 percent, while per capita net state domestic product (NSDP) (at current prices, the base year 2011-12) has observed an increase from INR 3.35 lakh to INR 4.67 lakh with a CAGR of 6.9 percent. Figure 21 visualizes the growth in GSDP and NSDP, at current prices (the base year 2011-12), for the state of Goa from FY 2015-16 to FY 2019-20.



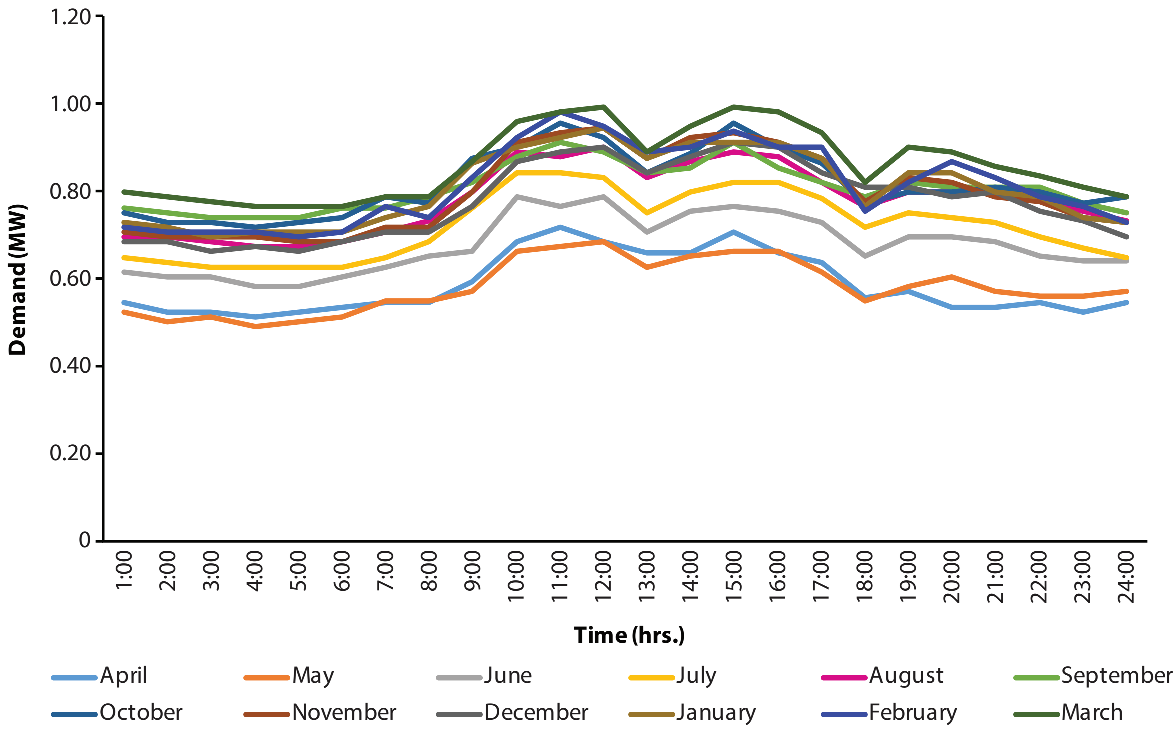
Source: Directorate of Planning, Statistics & Evaluation and Economic Survey 2020-21

Figure 21: Growth in GSDP and NSDP of Goa from FY 2015-16 to FY 2019-20 at current prices (the base year 2011-12)

At present, the industrial consumer category accounts for about 52.2 percent of total electricity sales for EDG. There is a strong presence of mining, tourism, and pharmaceutical industries sectors within the state. While, mining (iron and manganese ores), pharmaceuticals, iron, and steel industries are situated in the district of North Goa, ship-building and mining industries are situated in the South Goa district. Over the years, Goa also acts as the manufacturing base for various companies, especially in the area of manufacturing fertilizers, tires and tubes, cement, electrical and electronic appliances, fast-moving consumer goods (FMCG) among others. Cashew processing continues to a traditional industrial sector for the state of Goa.

Load profile

Figure 22 represents the load pattern of the industrial consumer category highlighting the average demand and demand profile.



Source: EESL

Figure 22: Demand pattern for the industry consumer category

Consumption pattern: The average demand for the industrial consumer category tends to be uniform during the day, with first peaking observed during the morning hours, starting from 08:30 hours which can be attributed to the start of operations for the majority of the industrial consumers. The pattern observes a uniform demand profile during the day with a marginal decrease in demand during afternoon hours from 12:30 hours to 14:00 hours, highlighting a decrease in industrial activity during lunch hours. The demand again starts to ramp up and continues to be uniform till evening hours from when it moderately declines. The ramping and peaking of power demand is not observed to be high as the average demand tends to be uniform across the day; this can be due to the operations of three-shift industries within the state. The space cooling & conditionally load is observed to be one of the major energy guzzlers across the year for industrial consumers.

Peaking of demand: Industrial consumer category tends to observe minimal peaking of demand during morning and early evening hours. Apart from a marginal decline during afternoon hours, the demand tends to remain high till evening hours and decrease moderately. The demand tends to be uniform and observes a flat profile across the night hours.

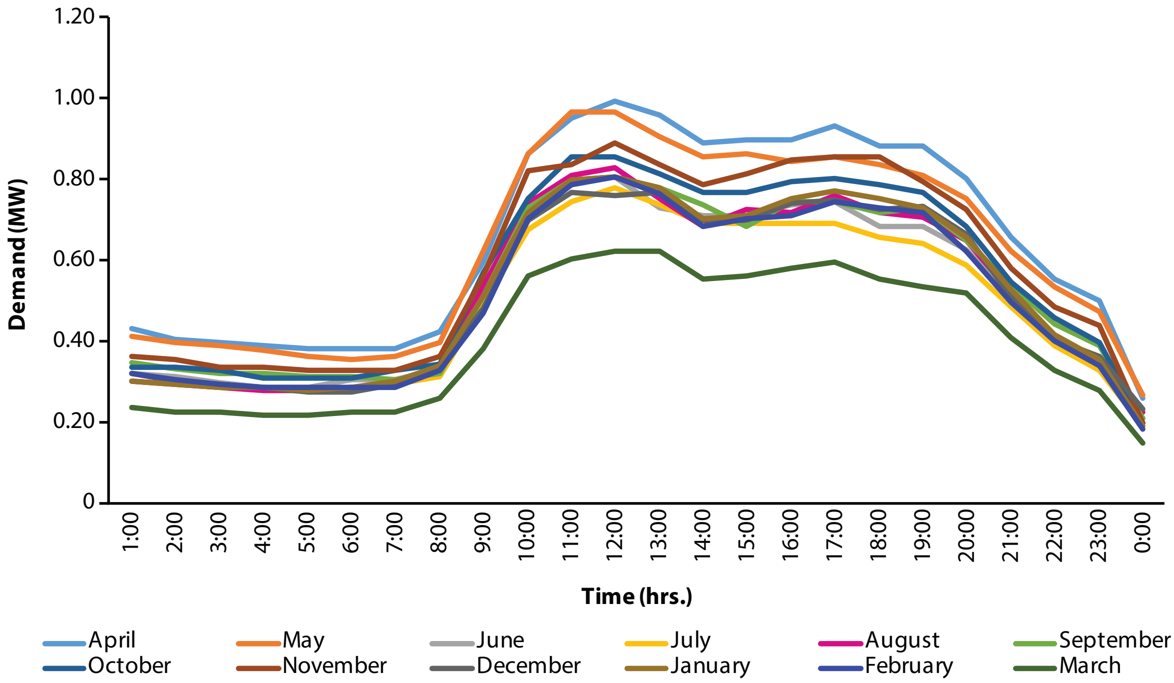
Seasonal variation: No significant seasonal variation is observed in the demand profile of industrial consumers. The average demand tends to be comparatively lower during the start of the financial year as compared to the end of the financial year. This can be attributed to the increase in production capacity to cater to the demand during the closing of the financial year.

4.2.3 Commercial Consumer Category

Goa has been considered as a paradise for travelers, both domestic and international, to explore its famous white-sand beaches, carnivals, active nightlife, and Portuguese heritage hidden in the architectural splendors of its churches and old houses. Goa has been considered to be one of the biggest tourist destinations in India with almost 8 million tourists visiting in the year 2019 from within the nation and abroad; the number of tourists has almost quadrupled over the past 7 years. The commercial establishment, which operates on various energy guzzlers, constitutes a significant share of the consumer base.

Load profile

Figure 23 represents the load pattern of the commercial consumer category highlighting the average demand and demand profile.



Source: EESL

Figure 23: Demand pattern for the commercial consumer category

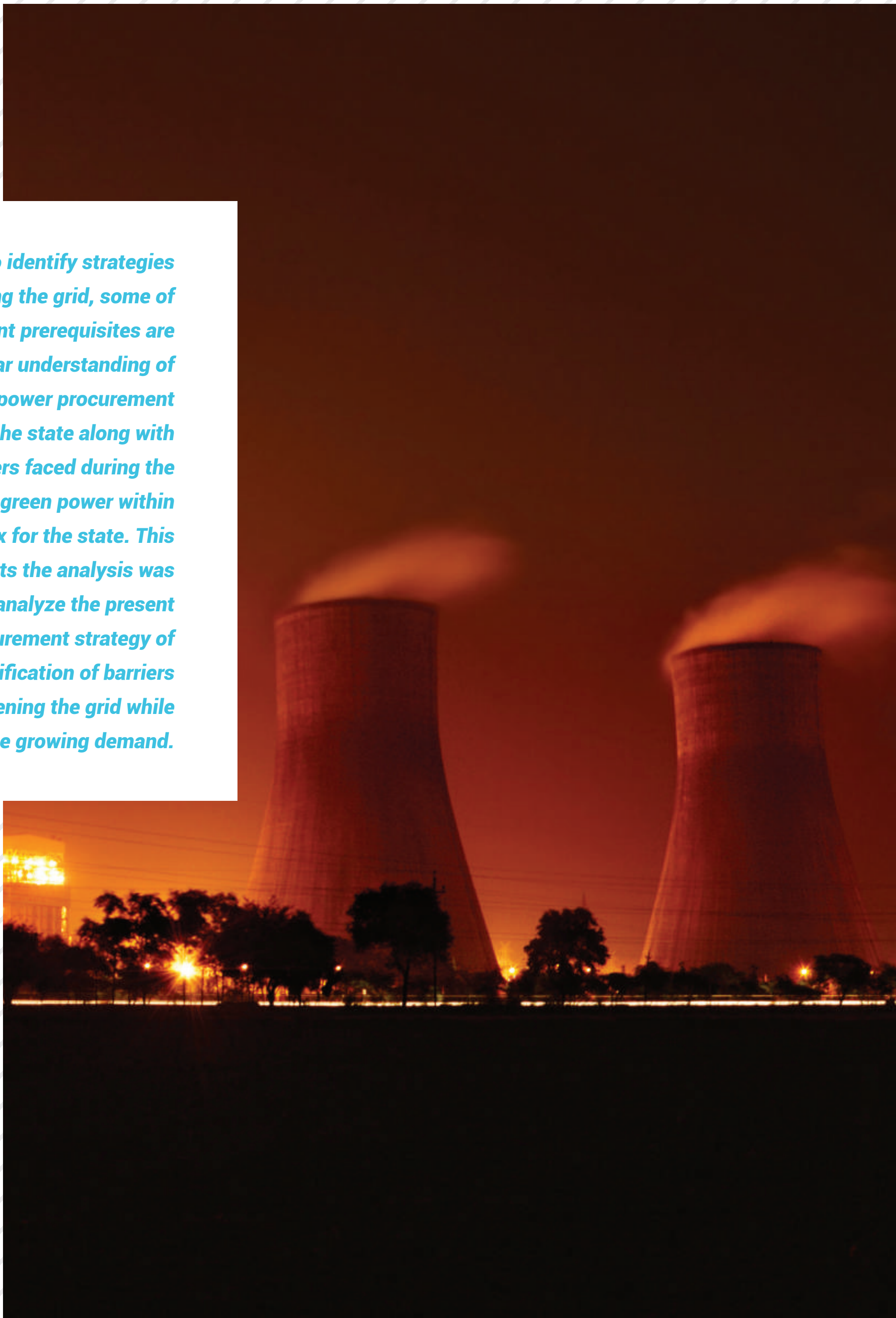
Consumption pattern: The average demand for the domestic consumer category tends to be uniform across the day, with ramping up of demand during the morning hours from 08:00 hours; this can be attributed to the start of the commercial establishments within the state. The pattern observes a uniform demand profile during the day with a marginal decrease in demand during afternoon hours from 12:30 hours to 14:00 hours, highlighting a decrease in industrial activity during lunch hours. The demand continues to be uniform till late evening hours from when it declines gradually from 20:00 hours. The ramping and peaking of power demand are observed to be high; this can be due to the single shift operations of the commercial establishments within the state. The space cooling & conditionally load is observed to be one of the major energy guzzlers across the year for commercial consumers.

Peaking of demand: Commercial consumer category tends to observe significant peaking of demand during the day from morning hours to late evening hours. Apart from a marginal decline during afternoon hours, the demand tends to remain high till evening hours and decrease gradually to indicate a halt in the operations of the commercial establishments. The demand tends to be uniform and observes a flat profile with minimum demand during the night hours.

Seasonal variation: No significant seasonal variation is observed in the demand profile of commercial consumers.

5

SUPPLY-SIDE ANALYSIS



In an attempt to identify strategies for greening the grid, some of the important prerequisites are having a clear understanding of the present power procurement strategies of the state along with the barriers faced during the promotion of green power within the supply mix for the state. This section highlights the analysis was carried out to analyze the present power procurement strategy of EDG and identification of barriers faced while greening the grid while meeting the growing demand.

5.1. Power procurement strategy of the state

Goa has no state-owned power generating stations in the state. During 2021-22, out of 4,716 MU energy requirements, the state is planning to source around 168 MU from its captive power plants located in the industrial facility of Vedanta Limited and Goa Sponge Private Limited. The majority of power comes from coal-based central power generating stations, which contributes to 78 percent of the total power procurement. Further, more than 52 percent of the electricity requirement of the state is met from three major sources viz. Korba Super Thermal Power Station (STPS), Sipat-I Thermal Power Station, and Ramagundam STPS, located at Chattisgarh and Telangana, respectively. This denotes the states' dependency on the central sector for meeting its power requirement. If there is any forced outage/ event in any of these aforementioned power stations occurs, it would severely affect the power position in Goa.

Looking into the power procurement costs, the average power purchase cost (APPC) for the state of Goa during FY 2021-22 was of the tune INR 3.35 per kWh (including renewables), having a major contribution from NTPC power plants. Annexure-II highlights the change in APPC for EDG over the past 6 years. In the case of NTPC plants, there is a difference of INR 0.85 per kWh between old and new stations. The majority of old stations in this power procurement portfolio have machines more than 25 years old as fixed charges have been already absorbed during the life of the plant. Thermal station-wise age is represented in Annexure-III. Moreover, the transactions through power markets have been boomed during the last 6 years with a CAGR

of 33.1 percent. In FY 2016-17, around 1 percent of the total electricity requirement, i.e. 55 MU out of 3,707 MU was sourced from power changes, whereas in FY 2021-22 power market accounted for around 6 percent of total quantum, i.e. 306 MU out of 4,749 MU has been sourced from open markets. The detailed power sourcing pattern of the state over the last 5 years is depicted in Annexure- IV.

With the dependence on central generating stations and the power market to meet its power demand, the state of Goa is highly dependent on its inter-state transmission connectivity with other states/ grid regions. **The growing demand and, thereby, the increasing quantum of power procured from outside the state, strengthens the need for a resilient interstate and intrastate transmission system to ensure a reliable power supply to the state.**

5.2. Efforts towards greening the grid

The state's power procurement strategy is heavily dominated by fossil-fueled power stations. To increase the penetration of renewable power in the grid, the state government has announced Solar Power Policy, 2017 intending to achieve 150 MW by 2022. Under this policy directive, GEDA has been made as to the nodal agency for its successful implementation on the ground. Key incentives/ subsidies offered under the solar policy are:

- The state government shall provide a subsidy of 50 percent (30 percent central share and 20 percent state share) of the capital cost or the benchmark cost provided by MNRE or cost arrived through the tendering process by GEDA, whichever is lower to all the Prosumers.
- For all prosumers, the main tariff meter (bi-directional) and solar generation meter will be installed by EDG and rented to the prosumers by payment on monthly fees to EDG.
- The check tariff meter (bi-directional) will have to be installed by the prosumer.
- Small prosumer opting for gross metering will get the benefit of INR 0.50 in addition to JERC approved solar tariff rates for that year or APPC as per the current year tariff order of JERC, whichever is lower.

The detailed characteristics of the solar policy are provided in Annexure-V. Despite all these efforts, the solar rooftop installation in the state has reached around 4.5 MW[11] in March 2021. Among these installations, more than 90 percent of the installations are under the net-metering arrangement, where the consumer can export the surplus electricity after self-consumption into the grid and get the equivalent amount adjusted in their bills. Based on the in-depth stakeholder interactions with GEDA officials, solar developers, EDG officials, and consumers, various challenges/ barriers have been identified while large-scale promotion of renewable energy in the state. The key barriers identified during stakeholder interactions have been summarized in the section below.

[11] Based on discussions with GEDA officials.

5.2.1. Technical barriers

Lack of adequate grid evacuation facilities

In Goa, heavy forest cover and hilly areas limit the land area available for setting up large-scale ground-mounted solar PV power projects. Among 3,700 square kilometers of total land area available in the state, more than 59 percent is covered with forest and 18 percent is preoccupied with mining activities[12]. Due to right-of-way constraints and environmental clearances, the development of adequate evacuation facilities would become a great challenge.

Grid reliability for solar rooftop systems

Grid-connected rooftop solar PV systems without energy storage support require a high degree of grid reliability and continuous grid availability for optimal operation. If electricity is to be consumed from the rooftop solar system during grid outages, an energy storage system is required, such as a battery storage system. However, these devices add significantly to the cost of the system and therefore make rooftop solar systems too expensive to be financially attractive to consumers. SAIFI and SAIDI indices for EDG are quite high in comparison to the states in the western grid region average and indicate frequent disruptions to grid supply for consumers. Such outages during the daytime would erode the financial viability of rooftop solar projects.

Inadequate forecasting methods and grid support systems to tackle intermittency

Unlike conventional electricity generation, renewable energy is an intermittent source of energy. Solar-based generation can fluctuate widely sometimes dropping to near zero within a span of a few minutes (for example, drop-in solar generation with a passing cloud). Moreover, the behavior of renewable energy resources cannot be predicted accurately. Inadequate forecasting techniques to mitigate the challenges of the variable and intermittent nature of renewables make the scheduling and dispatching complex posing a major threat to the stability and security of the overall grid. The non-availability of renewable sources especially solar during peak load hours, lack of balancing reserves like ancillary services are some of the major concerns for integrating large quantum of renewable power into the grid.

In addition, there are a lot of challenges and issues associated with the connection of distributed energy resources (DERs) to the grid. The biggest challenge is to connect the DERs to the existing distribution system without making major changes or modifications to the intrinsic or inherent nature of the distribution network. Increasing penetration of these DERs within the distribution network of EDG can have various technical impacts on the grid; detailed studies must be undertaken from time to time to reduce these impacts. These challenges made utilities reluctant to accept intermittent energy. However, it may be noted that the issue of intermittency is not specific to Goa; it is intrinsic to the sector as a whole. Therefore, a holistic approach needs to be adopted to address this issue.

5.2.2. Regulatory barriers

Limited solar PV penetration limits as per net metering regulations

In Goa, solar PV penetration levels are limited to 30 percent of the distribution transformer capacity. In India, a large spectrum of penetration levels could be observed ranging from 15 percent to 75 percent. Further, limited distribution transformer penetration limits inhibit consumers from adopting solar PV systems. Therefore, utility-specific technical studies need to be carried out to estimate the penetration limits. Annexure-VI depicts the level of penetration according to state codes and regulations.

Low retail tariff

Grid-connected rooftop solar PV systems generate electricity at a levelized cost of electricity (LCOE) in the range of INR 4.3 – 5.5 per kWh, with a general reduction in LCOE as project size increases due to economy of scale. For a project's financial viability in a Net Metering framework, the electricity tariff of the consumer should be higher than the project's LCOE. In Goa, energy charges for domestic consumers are too low for a rooftop solar system to be a viable investment. In the case of domestic consumers, the tariff is in the range between INR 1.5 per kWh to INR 4.25 per kWh.

[12] https://www.forest.goa.gov.in/node/11
[13] https://www.dmggoa.goa.gov.in/miningarea.

5.3. Present situation of transmission and distribution network

As highlighted in Chapter 3, Goa does not have its generation sources and is procuring most of the power from outside the states, namely from western and southern grid regions. At present, there are 3 injection points for the state of Goa – two from the state of Maharashtra and one from the state of Karnataka; 400 kV and 200 kV lines are responsible for importing and meeting the power requirement of the state. The power is transmitted and received at seven (7) extra-high voltage (EHV) sub-stations located within the state, through which the power is fed to the entire state of Goa. The EHV sub-stations are spread across the state and operate at different voltage levels; these sub-stations are located at Tivim (220 kV), Amona (220 kV), Kadamba plateau near Panjim (110 kV), Verna (110 kV), Cuncolim (220 kV), Ponda (220 kV), and Xeldem (220 kV).

A preliminary study undertaken by the state Government of Goa highlights that there are difficulties in receiving and transmitting the said power to Goa. It has been found out that the transformers and EHV sub-stations are heavily loaded and, thus, face challenges in catering to loads of consumers. The majority of the EHV sub-stations and the feeders feeding power to these sub-stations have been observed to be operational beyond their age and/or overloaded beyond their peak capacity. Any tripping of power renders the majority of the consumers relying on these lines severely affected, thereby, causing outages in these areas for long durations. Looking into catering the future demand, it is observed that these overloaded sub-stations will not be able to cater to the increasing needs of the industrial, commercial as well as domestic consumers. Another major challenge is faced is on account of inter-state transmission lines which feed power to Goa are passing through dense forest covers and deep valleys due to which there are numerous transient tripping of lines.

The study also highlights the challenges being faced on account of power being transmitted through the transmission network of the neighboring states; any fault in the jurisdiction of other states takes a lot of time for restoration. Additionally, being inter-state and inter-regional lines, any tripping takes time to complete restoration and recharging of lines; the time increases in case of inter-regional lines to complete the formalities with different authorities and regional load dispatch centers (RLDCs) and National Load Dispatch Centre (NLDC). Being one of the EHV sub-station being fed from both southern and western grids, the Xeldem sub-station faces this challenge and complete utilization of the network is not been able to be achieved.

Effective transmission and distribution planning must be undertaken to reduce the burden on the present network. Intending to address these challenges, EDG has taken numerous measures, including planning for installation and commission of new transformers and sub-stations, bifurcation of overloaded feeders, underground cabling of lines among other measures, and has been gradually making progress in the direction of ensuring reliable power supply to all.

Strengthening of Power Infrastructure of Goa

In 2015, the Ministry of Power, envisaged the Goa Tamnar Transmission Project Limited (GTTPL) to create an additional source of power for Goa. GTTPL comprises of 4 elements that are related but functionally independent. These together constitute the scheme for ***"Additional 400 kV Feed to Goa and Additional System for Power Evacuation from generation Projects Pooled at Raigarh (Tamnar) Pool";*** these elements include 400kV D/c Xeldem - Mapusa Transmission Line, 400kV D/c Xeldem – Narendra Transmission Line, 765kV D/c Dharamjaigarh – Tamnar Transmission Line and 400/220kV AIS Substation at Sangod, Dharbandora, and 220kV Xeldem – Xeldem Transmission Line.

The GTTPL project, once operational, will play a vital role in meeting Goa's increasing power requirements, providing long-term energy security to the state as well as Goa's standing in One Nation One Grid. It will provide the people of Goa with a highly reliable power feed.

[14] Electricity Department, Government of Goa, White Paper on Complete Status of Power Situation in Goa (2020)

6

STRATEGIES FOR ENSURING RELIABLE POWER SUPPLY

Despite achieving 100 percent electrification, the power sector of Goa is facing the challenge of providing a reliable, quality power supply to all its consumers. The power cuts are generally observed during the evening peak hours, which are contributed mostly by domestic and industrial consumers. With significant SAIFI and SAIDI indexes being observed, especially among industrial and commercial consumers, the consumers need to rely upon alternate sources of power supply, such as diesel generator (DG) sets, to ensure continuous power supply. During the study, it has been observed that approx. 80 percent of the industrial and big commercial consumers rely upon DGs to avoid any interruptions in the power supply, to avoid any economic loss. In this context ensuring reliable 24x7 supply is of utmost importance. To ensure a reliable and affordable electricity supply for all, complementary efforts of demand-side management initiatives, transmission & distribution network up-gradation, and local generation through renewables are crucial.

THIS SECTION HIGHLIGHTS THE STRATEGIES IDENTIFIED TO ENSURE A 24X7 RELIABLE POWER SUPPLY TO ALL THE CONSUMERS WITHIN THE UTILITY IN TERMS OF MANAGING THE GROWING DEMAND AND GREENING THE GRID IN AN ATTEMPT TO ENSURE ENERGY TRANSITION TOWARDS LOW CARBON PATHWAYS.

6.1 Implementing database for effective outage management

Effective outage management is a crucial intervention while ensuring a reliable supply of power to consumers. However, with the growing demand, there is an urgent need to change the present approach adopted towards outage management. Instead of adopting a top-down approach, the adoption of a bottom-up approach would help the utility for effective outage management.

Under the bottom-up approach, feeder mapping and feeder-wise management are undertaken to ensure that the outages faced by the consumers are maintained to the least possible level. The bottom-up approach aims to address the issues in ensuring reliable power supply with the help of analysis on the large amount of data being collected. Thus, database management holds a pivotal role in the bottom-up approach; having a database of data being collected on various aspects such as frequency of outages, duration of outages, the reason for outages, consumers impacted due to outages among others. Analysis of the data on outages along with the reason being the outages, thus, being collected would help EDG officials to undertake various measures to reduce the outages and their impact. Management of such a database at the sub-division level would help in the effective implementation of the bottom-up approach for outage management. Utility officials can also be encouraged to be a part of the programme through an employee incentive plan to ensure effective outage management via the bottom-up approach.

6.2. Managing growing demand

6.2.1. Periodic load research studies and demand profile projections

It is evident from the findings of Chapter 4, the peak demand is expected to almost double in the next 15 years. To successfully cater to the growing demand, it is important to gauge the changes in the demand profile, if any, over the years. Detailed studies on forecasting the future demand profiles must be undertaken periodically to carefully plan suitable interventions at both, demand-side and supply-side. Load research studies undertaken at regular intervals help in gauging the changes that occurred in the demand profile at both, system-level as well as feeder-level.

These findings from these detailed studies would act as the primary step in effective power system planning and help in the identification of strategies and their implementation models for effective demand-side and supply-side management.

Forecasting of future demand profiles using DEFT tool

TERI has developed a DISCOM Electricity Forecasting Tool (DEFT), a unique tool in the segment of electricity demand forecasting to assess the future demand profiles of a DISCOM and enable them to foresee the impact of various improvements in end-user profiles through scenario-based predictive techniques. The tool merely entails the historical load profiles (i.e. demand pattern and amplitude) of a utility to assess its future monthly trends for the next 3 years. It gives valuable insights on the demand of a utility regarding the impact of changing consumption patterns, policy initiatives, emerging technologies, etc. This tool enables the user for distribution infrastructure planning, demand-side management, analysis of changing load at the feeder level, informed policymaking, impact assessment of new policies of government or utilities on the future load curve, tariff design and cost of supply management, open access (from 3 months to 3 years) planning, power procurement planning etc.

For more details, please visit: http://electricitydemandforecast.in/

6.2.2. Accelerated promotion of energy-efficient appliances

Domestic and commercial consumer categories have a share of about 30.4 percent and 15.4 percent respectively in states' electricity consumption. Apart from having a significant share in energy consumption, they have a significant contribution to the peak load during the evening hours. The high growth rate in demand for the domestic and commercial category and significant contribution to peak load lays down the importance and scope for benefits that might accrue from managing demand in this category.

These categories are having the highest penetration of the energy-consuming appliances contributing to the peak of a utility. An interest in energy efficiency and new technology gadgets has been observed during the

stakeholder consultation with consumer groups and retail outlets. The penetration of energy-efficient LED lamps in the domestic category has been reached a significantly high level. More than 1 million LED lamps have been distributed among 0.5 million households in the state with the help of EDG and EESL.[15] However, some of the space cooling appliances such as ceiling fans, and air conditioners (ACs) still require accelerated promotion of energy efficiency among domestic and commercial consumer categories; these appliances act as a major energy guzzler for the utility across the year owing to the hot and humid climatic conditions of the state.

Promotion of Bureau of Energy Efficiency (BEE) star-rated, inverter type air conditioners and brushless DC (BLDC) motor fitted ceiling fans have been identified as a key strategy for managing peak and energy demand in domestic and commercial categories. The highest star-rated ACs have a much higher energy efficiency ratio (cooling output for a given electrical energy input) and, hence, consume less electricity. Similarly, a conventional ceiling fan (1,200 mm/65-80 watt) replacement by a BLDC ceiling fan (1,200 mm/28-35 watt) offers a significant amount of reduction in electricity consumption and demand during the peak.

JERC, in the year 2014, has notified DSM regulations for its distribution licensees aiming to alter the end-use of electricity for achieving multiple benefits like cost optimization, continuous reliable supply, reduced system losses, etc. Hence, the adoption of DSM measures that motivate the consumer to modify their consumption pattern would assist EDG to alter and manage the demand at the consumption end. To date, EDG has adopted limited DSM measures, including promotion and distribution of LED bulbs, replacement of street lights with LED street lights, and implementation of the PAT scheme. With changing dynamics of energy efficiency and DSM interventions, there is the scope of implementation of various other DSM interventions which would help in effective load management.

To devise DSM interventions for the utility, a load research study forms the starting point. Load research study assists the DSM activities through the provision of supporting data of consumer load profiles which are useful in developing and analyzing DSM plans that enable the utility to manage the system loads by motivating consumers to vary the consumption to reduce system peak and increase the off-peak usage of energy. Therefore, developing a DSM action plan based on the load research study will provide a holistic solution for imparting energy efficiency activities among different consumer categories across the state. In this regard, formulation of DSM cell and strengthening the capabilities of state-designated agency (SDA) would be imperative.

Promotion of Demand Side Management Interventions

In 2010, Maharashtra Electricity Regulatory Commission (MERC) has notified DSM regulations and cost effectiveness assessment regulations for all distribution utilities in the state. These regulations are intended to promote energy efficiency and demand side management across the state. Under this regulation, every utility have constituted DSM cell and prepared a detailed DSM action plan based on the load research. These activities helped utilities to develop DSM programmes for targeted consumer categories. Further, the regulator has constituted a DSM Consultation Committee to assist the regulator and utility in implementing DSM interventions as well as to assess the cost effectiveness and to monitor the post implementation benefits. This systematic approach helped utilities in implementing various DSM initiatives like energy efficient lighting, space conditioning, energy audit, demand response etc.

[15] UJALA Dashboard for Goa, http://www.ujala.gov.in/state-dashboard/goa

6.2.3. Strengthen existing government-supported energy efficiency activities among the industrial cluster

In Goa, industrial consumers consume more than half of the electricity sold in the state. These industries are operating within the around 24 industrial estates demarked within the area of the state. Details about industrial subsectors across different industrial estates are represented in Annexure-VII. This points towards the need for strengthening energy efficiency activities on a cluster/estate level.

The Ministry of Micro, Small, and Medium Enterprises (MSMEs), as well as government agencies like the Bureau of Energy Efficiency (BEE) and Indian Renewable Energy Development Agency (IREDA), have funded schemes to promote energy efficiency and renewable energy among industrial estates in India. Key initiatives funded by the government include the Zero Defect, Zero Effect (ZED) assessment and certification scheme, Credit Linked Capital Subsidy Scheme (CLCSS), and Credit Guarantee Fund Scheme for micro and small enterprises in partnership with Small Industries Development Bank of India (SIDBI). In addition to these schemes, two financing schemes have been created by BEE, under National Mission for Enhanced Energy Efficiency (NMEEE), for the financing of energy efficiency projects, namely Venture Capital for Energy Efficiency (VCFEE) and Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE). These funds seek to provide appropriate fiscal instruments to supplement the efforts of the government for the creation of an energy efficiency market.

Indian Renewable Energy Development Agency (IREDA), a non-banking financial institution established by the government is engaged in promoting, developing, and extending financial assistance for setting up projects relating to new and renewable sources of energy and energy efficiency/conservation. The guidelines of IREDA's loan schemes are common across all sectors of renewable energy (wind, solar PV, solar thermal, biomass cogeneration, etc.) as well as energy efficiency. The only difference is in the interest rate which is different for different sectors.

Therefore, strengthening the outreach of these schemes among industrial units will help to intensify the promotion of energy efficiency in Goa. Along with these existing schemes, financial instruments like preferential loans for energy efficiency technologies, equipment leasing, and energy efficiency insurance among others could also be explored to provide easy financing towards these initiatives. The EDG could explore the possibility of utilizing the State Energy Conservation Fund for providing monetary support to the consumers in form of the aforementioned financial instruments.

Preferential loans:

- In the Republic of Korea, the national Government provides preferential long-term and low-interest rate loans to encourage the installation of energy-efficient equipment in industry within the country.
- In Kyrgyzstan, European Bank for Reconstruction and Development (EBRD) established the Kyrgyz Sustainable Energy Financing Facility (KyrSEFF) to provide dedicated loans for energy efficiency to local companies through local financial partners. Successful investments are supported by the European Union through grants.
- In Haryana (India), Haryana Renewable Energy Development Agency (HAREDA) rolled out a scheme for providing financial assistance in the form of interest free loans for implementing energy conservation measures among industrial and commercial consumers by utilizing their state energy conservation fund.

Equipment leasing through ESCOs:

The Government of Thailand supports leasing through the Energy Conservation Fund. Energy service companies (ESCOs) can acquire loans for equipment, which they then lease to small and medium enterprises (SMEs). As a result of reduced energy costs, the SMEs have the funds to meet their lease payments back to the service

Many traditional MSME sectors like engineering, plastic, cold storage, etc. use outmoded and inefficient technologies. Large manufacturers of energy-efficient technologies do not find MSMEs attractive for the ESCO model of implementation due to the small size of the investment, higher cost of intermediation, and risk factors associated with non-payment. In this context, EDG could play a crucial role in supporting the development of local ESCOs. EDG along with local ESCOs could act as the intermediate between large manufacturers and banks in implementing a few pilots on cross-cutting energy-efficient technological solutions in some of the energy-intensive sectors. During the implementation phase, consultancies may be hired for providing technical assistance and hand-holding support to local ESCOs during the identification of possible areas of interventions, the establishment of baselines, and the formulation and implementation of performance guarantee contracts. This utility-based innovative financing approach to developing local ESCOs for introducing energy-efficient technologies among MSMEs will help strengthen the capacities of local service providers (LSPs) at the cluster level.

Under this initiative, EDG can act as demand aggregators for energy-efficient technologies (EET) and implement utility-ESCO-based business models for DSM, jointly with EET vendors, to remove the most significant barrier to the adoption of EETs by industrial consumers—namely, the relatively high costs of initial investments. Under these utility-ESCO-based business models, the utility recovers the costs of the EET from the industrial consumers via the monthly electricity bill. The utility may have a 'cut' or mark-up on the capital investment—ensuring that there is a return on investment (ROI) for the utility as well.

6.2.4. Grid modernizing utilizing smart grid technologies

Ensuring a reliable and continuous power supply is one of the primary parameters for the evaluation of the performance of the utilities. While taking into consideration the national goal of achieving a reliable power supply, the need for suitable information and communication technological (ICT) interventions, to improve the performance of power utilities in India, has been identified and realized at both, central and state levels. In this regard, several initiatives have been undertaken, including the implementation of schemes such as R-APDRP and IPDS, the establishment of the National Smart Grid Mission (NSGM), and the development of smart grid regulation at the national level.

A fault-proof efficient distribution network needs to be maintained as it is the most essential infrastructure requirement for ensuring reliable supply. Even though the reliability indices of EDG are moderate in comparison with the national average, still there is a scope for further improvement.

Adoption of multi-divided multi-connected distribution network

The distribution system in Goa is usually in radial mode around the distribution substation because distribution lines and branch lines are extended according to the increase in electric power demand.

For supply reliability improvement, the distribution lines must be divided into suitable sections by switches placed appropriately to minimize the area of interruption. Each distribution line has interconnections that can supply electric power to healthy sections from adjacent distribution lines. This type of system is called a "multi-dividing, multi-connecting system" (Figure 24). This redefined network helps in the easy identification of fault sections, which can, then, be separated automatically via switches. Electricity supply is maintained to the healthy sections using automatic re-closing of the breaker in the distribution sub-station. Reserve power is needed so that the lines do not run into over current situation of distribution lines while restoring power.

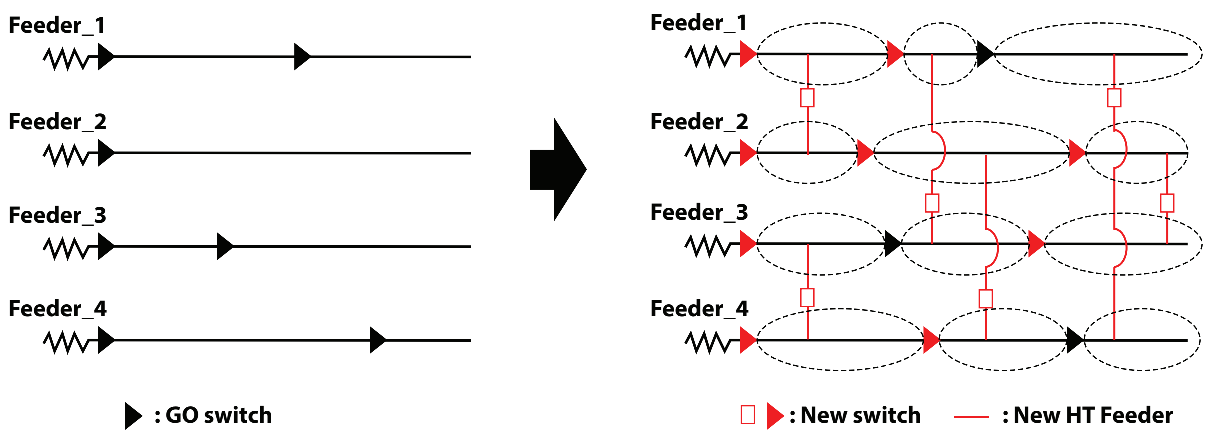


Figure 24: Conventional network vs. multi-divided, multi-connected network

In developed economies like Japan, a 6-dividing 3-connecting system is normally maintained for the overhead distribution lines, while a 4-dividing 2-connecting system is maintained for the underground distribution lines. In India, this technology has been experimented with during the pilot implementation of the Panipat smart grid project for improving the reliability indices of Uttar Haryana Bijli Vitran Nigam (UHBVN).

A similar approach may be adopted by EDG in an attempt to ensure the reliability of the power supply to its consumers. Before implementing such an intervention, it is important to carry out various tasks including identification of feeders and techno-economic feasibility analysis. A value-based planning approach must be adopted for the identification of feeders; value-based planning is an approach for comparing the incremental costs of improved reliability in a power system against the incremental benefits of improved system reliability.

Reduction of DT failure through advanced transformer mending techniques

The high failure rate of distribution transformers is a big concern for the power sector in India. The average operational life of a transformer is between 25 to 30 years; however, transformers are known to be recalled for repair in as early as three years. The failure rate of distribution transformers in India is estimated at 13 percent (in stark contrast to the less than 1 percent failure rate in developing economies like Japan, the USA, and Europe). The additional cost burden on the power sector due to failed transformers at the national level is estimated at INR 5,000 crores, including INR 3,000 crores for repair and INR 2,000 crores for replacement.

This added burden on the power sector can be avoided by efficiently maintaining transformers. This would also improve the quality of service to the consumers greatly by avoiding frequent interruptions in the power supply.

In Goa, distribution transformer failure rate tune-up to around 7 percent which is mainly attributed by overloading, oil leakage & poor maintenance, LV faults, surges, load unbalancing, and low entry barriers in the distribution transformer market leading to unorganized players entering the market, and competing on the price factor. To reduce transformer failure, preventive mending techniques can be deployed using rust removal liquid, primer paste, and putty depending on the severity of the damage. In addition to this capacity building of utility officials for preventive maintenance/mending and development of best-operating manuals for inspection and repair will help to reduce transformer failure to a large extent.

Integrating AMI through smart community projects

Deploying an advanced metering infrastructure (AMI) is a fundamental early step to grid modernization. AMI facilitates monitoring and measurement of consumer information through smart meters installed at customer premises. The information is transferred to the utility control center through various communication modes such as general packet radio service (GPRS), power-line communication (PLC), or low-power radio frequency (RF).

The key objective of AMI is to enable two-way communications between smart energy meter and head-end system (HES) to enable remote reading, monitoring & control of electrical energy meters (consumer, feeder, DT meters, etc.) to serve as a repository of record for all raw, validated and edited data. The sanitized data may be subscribed to other utility functions like peak load management (PMS), outage management system (OMS), and quality management system (QMS) to ensure the quality and reliability of electricity supply. Smart meters will also enable the metering and monitoring of the energy consumption of the consumers and, thus, assist in the implementation of different pricing schemes, such as time-of-day (ToD), critical peak pricing (CPP), and real-time pricing (RTP).

Deployment of AMI among the industrial consumers would also assist in implementing various DSM interventions such as demand response (DR) and dynamic load shifting among others. Owing to the large number of consumers situated in the 24 industrial estates of Goa, there is a potential for shifting non-essential loads from peaking duration to non-peak duration. A detailed study can be undertaken to gauge this load shifting potential at the cluster level. This dynamic shifting of load would help decrease the ramping of demand and, thus, managing the peak demand of the utility.

6.3. Ensuring energy transitions towards low carbon pathways

With the aim of decarbonization of the power sector, there is a push for the large-scale integration of renewable energy into the grid. Each state has notified policy and regulations in place to achieve their respective targets; Goa is no exception to the same. However, despite Goa State Solar Policy, 2017, and JERC (Solar PV Grid Interactive System based on Net Metering) Regulations, 2019 being in place, the state of Goa has achieved approx. 4.5 MW of solar rooftop potential as of March 2021 against the target of 150 MW by 2022. Various factors may be affecting the sector in achieving its potential; these include poor intrastate transmission links, financing challenges, awareness among stakeholders, availability of local developers, and issues on roof rights & area among

other local challenges. Therefore, the challenge before the EDG is not only to meet the ever-growing demand for power but also to progressively increase the share of renewable sources in the generation – mix to achieve overall energy security and also to meet the renewable purchase obligation (RPO) as per the target fixed by JERC from time to time. JERC has been progressively increasing the RPO requirement for EDG to ensure a push towards the increase in the integration of renewable energy for the state of Goa. Table 1 represents the details about RPO targets, RPO met, and REC purchased of the state during the last six years.

Table 2: RPO targets, RPO met, and REC purchased for the state of Goa over the past six years (FY 2016-17 to FY 2021-22)

Particulars		Units	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Resultant Energy Sales for calculation of RPO		MU	3,273.56	3,416.11	3,566.73	3,970.05	4,169.60	4,085.77
RE Obligations	Solar	%	1.2%	1.5%	3.6%	4.7%	6.1%	8.0%
	Non-Solar	%	2.8%	2.8%	5.4%	6.8%	8.0%	9.0%
	Total	%	**4.0%**	**4.3%**	**9.0%**	**11.5%**	**14.1%**	**17.0%**
	Solar	MU	37.65	51.24	128.40	186.59	254.35	326.86
	Non-Solar	MU	91.66	95.65	192.60	269.96	333.57	367.72
	Total	**MU**	**129.31**	**146.89**	**321.01**	**456.56**	**587.91**	**694.58**
RPO Met	Solar	MU	50.56	50.56	52.01	60.66	199.32	63.50
	Non-Solar	MU	34.69	34.69	-	150.30	298.60	308.60
	Total	**MU**	**85.25**	**85.25**	**52.01**	**210.96**	**497.93**	**372.10**
REC Purhased	Solar	MU	-	0.68	76.39	125.94	55.02	263.36
	Non-Solar	MU	56.97	60.96	192.6S0	119.66	34.96	59.12
	Total	**MU**	**56.97**	**61.64**	**268.99**	**245.60**	**89.99**	**322.48**
Total cost for RPO compliance		INR Crores	54.38	55.21	75.04	116.27	189.73	147.29

It is evident from Table 1 that the RPO target of the state got quadrupled in the last 6 years. Moving ahead in this pattern the state would be looking to reach an RPO target of 21 percent by 2022 as notified by the Ministry of Power under Long Term Growth Trajectory of Renewable Purchase Obligations (RPOs) in July 2018. Due to limited renewable power available in the state, EDG is sourcing power from NTPC Vidyut Vyapar Nigam Limited (NVVNL) and Solar Energy Corporation of India (SECI) to fulfill their RPO obligation. In this direction, EDG and GEDA are making efforts to enhance renewable energy generation within the state by promoting hybrid wind-solar systems and solarizing agriculture feeders. However, a long-term strategy needs to be developed for the state to meet future increasing RPO targets.

In January 2021, Convergence Energy Services Limited (CESL), a wholly owned subsidiary of Energy Efficiency Services Limited (EESL), commissioned 1 MW of Goa's first solar energy project. This is CESL's and Goa's first milestone in this 100 MW decentralized solar energy projects on government lands. The project integrates the delivery of clean, renewable, decentralized energy from solar feeders with energy efficient pump sets and LED lamps for rural homes thereby integrating the benefits of energy efficient lighting and irrigation.

In October 2019, Revayu Systems Private Limited has installed Goa's first wind solar hybrid project at the manufacturing unit of Pfizer Limited at Verna Industrial Estate. The system consists of a six-blade, low RPM wind and solar energy system. In the future, Revayu Systems plans to install another 400 kW hybrid rooftop project for United Breweries Limited at Ponda.

Keeping the varying future demand projections in consideration, different sources of procuring renewable energy must be explored in detail to ensure an increasing share of 'green' power within the state supply mix.

Solar Power Policy, 2017 paves a path for increasing the penetration of solar rooftop systems within the state. Declining costs of battery energy systems could help the utility by ensuring an increase in the storage system as a part of the distributed energy resources integrated into the state grid. Apart from realizing the distributed renewable energy potential within the state, procurement of green power from various large-scale competitive renewable energy projects, such as ground-mounted solar power projects, solar parks, wind farms among others, has become at par with procurement of conventional power. This can be attributed to the declining levelized tariff observed during the competitive bidding of projects. Power procurement from such competitive renewable energy projects can be done by undersigning of PPAs, thereby, increasing the share of green power within the supply mix. Owing to the falling prices, opportunities for integration of future technologies for floating solar, offshore wind, integrated renewable energy projects, grid-scale storage, and round-the-clock renewable energy projects must also be explored. The detailed techno-economic analysis must be undertaken from a case-to-case basis to find the optimal option for increasing green power; decisions must be based on the delivered cost of electricity (including the generation and transmission) as well as the time of availability of power. Annexure-VIII provides an indicative cost analysis under different scenarios of procurement/generation of solar energy within the state and procurement from other renewable-rich neighboring states like Karnataka and Maharashtra.

Owing to the variable nature of energy sources and different locations of power projects, it is critical to developing an adequate robust and reliable intra-state and inter-state transmission connectivity, to ensure the stability of the grid and, thus, to facilitate this transition towards a fossil-free generation mix.

MSEDCL seeks 500 MW solar for meeting their RPO targets

Maharashtra State Electricity Distribution Company Limited (MSEDCL) is seeking to procure solar power up to capacity of 500 MW from grid connected solar projects through competitive bidding process. MSEDCL is planning to enter into long term PPA with the winning bidder for the purchase of solar power at a fixed payable tariff, discovered through e-bidding and reverse auction process, for a period of 25 years. The call for selection of bidders underlines that only commercially established and operational technologies will be considered in order to minimize the technology risk and to achieve the timely commissioning of the projects.

6.3.1. Development of appropriate renewable forecasting models

To facilitate large-scale grid integration of distributed renewable energy sources located within the state, it is imperative to develop suitable forecasting models to ensure the safe operation of the grid. In addition, utility-specific system studies need to be carried out to assess technical issues (including protection & safety) that may arise and suitable mitigation measures as solar PV penetration increases. This would also help to set regulatory limits for solar PV penetration.

6.4. Other measures

6.4.1. Training and capacity building of stakeholders

Information gap on energy-efficient technologies and renewable energy applications among major stakeholders (utility officials, MSMEs, local service providers, and financial institutions) is one of the major barriers to scaling up energy-efficient technologies and large-scale deployment of renewable technologies among various consumers groups. While the banks have opened credit windows for energy efficiency and renewable financing there is still a lack of appreciation of the technical opportunities. Hence, there should be a focus on:

(a) Develop cluster-specific technical assistance programs, and

(b) Training and capacity building of all stakeholders on energy efficiency, renewable technologies, and grid maintenance

Manuals based on best practices adopted, both internationally as well as nationally, in the field of energy efficiency, renewable energy, grid maintenance areas could be developed. These manuals could be utilized for the training and capacity building of stakeholders and, thus, act as a guiding document for quick adoption of the best practices in the different areas of interventions.

In an attempt to build the capacity of various stakeholders on the opportunities of energy efficiency and renewable energy among various industrial sectors, it would be useful to support the development of cluster-specific diagnostic toolkits. These diagnostic toolkits would assist the financial institutions as they would act as the source of detailed information on the clusters and identify the scope of energy efficiency and renewable energy interventions within the clusters. The preparation of diagnostic toolkits must be undertaken in close consultation with industry associations and other local-level stakeholders.

Capacity Building Programme on Demand Side Management (DSM) and Energy Efficiency

Bureau of Energy Efficiency (BEE) had initiated a national-level capacity building program on DSM and energy efficiency for utility officials. As part of this, officials from various Discoms were trained through a structured program module on DSM and energy efficiency. The broad objective of this program was the capacity building of utility officials on load management, energy conservation, and development of DSM action plan, and implementation of DSM activities at the state level. Utility officials of EDG also got trained under this initiative.

Using a variety of tools to reach their audience in South Africa

In 2013, South Africa's National Business Initiative (NBI) launched the Private Sector Energy Efficiency (PSEE) program with US$ 13.5 million in support from the UK Government. Under the program, small companies were offered free practical advice on no-cost measures, medium-sized companies were offered free four-day on-site surveys and audits, and large companies received in-depth energy consultancy services subsidized by 60 percent. The program worked with 3,000 small businesses, and identified savings of about 20 percent of energy costs. NBI raised awareness of the program via a website, regular workshops, case studies, program marketing materials (including advertisements), and a regular newsletter that reports on progress.

6.4.2. Increasing resilience of power sector towards disasters

Situated on the western coast of India adjoining the Arabian Sea, the state of Goa is prone to various natural disasters including floods and cyclones. These natural disasters can cause extensive damages to the power infrastructure in the state. Apart from disruptions of economic and industrial activities, the damage to power infrastructure had multiple cascading effects on other interdependent infrastructure and public services, such as transportation, telecommunication, water supply, medical, and banking services.

In an attempt to address the damages and losses faced by the power sector on account of natural calamities, there is a pressing need to develop a detailed roadmap towards building disaster and climate-resilient power infrastructure in the state of Goa. Detailed analysis of the impacts of the natural disasters on power infrastructure in Goa and the technical, organizational, and functional causes behind the extensive damages and subsequent time taken in the restoration of power must be undertaken to gauge the gaps in the existing system. The roadmap developed would, thus, help EDG in ensuring a 24x7 reliable power supply, even in case of disasters.

At present, the western coast of India has been hit by the high speed winds of Cyclone Tauktae. Due to the gusty winds flowing at a speed of about 150 kmph and heavy rains, the cyclone storm has resulted in the uprooting and breaking of hundreds of electric poles and snapping of scores of power conductors in the state. This impact on the power supply has led to over 70 percent of the coastal state to remain in the dark and a reduction of demand from the average 570 MW to 80 MW.

Hybrid solar rooftop systems – ensuring reliable supply through green power

Promotion and adoption of hybrid solar rooftop systems among the consumers of Goa can provide two benefits – increasing the share of green power within the supply mix and ensuring reliability of power supply to consumers, especially in the case of natural disasters like cyclones. The hybrid solar rooftop systems work as a two-in-one when compared to a regular on-grid system which completely shuts down when the power supply fails. The hybrid system works both as an on-grid system which supplies excess power back to the grid and reducing the electricity bills, as well as an off-grid system in case of power failure, in which the solar panels can charge the battery energy storage systems and provide power to the house via a hybrid inverter, thereby operating as a micro grid system.

7

WAY FORWARD

It can be concluded from the above analysis that although priorities of the state are presently reliability improvement, need-based intra-state and inter-state network strengthening, renewable energy integration, etc., the technologies once getting implemented are likely to soon pave way for many advanced applications. It is therefore desirable that a long-term vision should be taken for the application of these technologies.

For outage management, implementations of smart grid technologies like AMI and load management systems are prerequisites. In this context, differential pricing initiatives and a multi-divided multi-connected distribution network need to be designed in an efficient way depending on the consumer mix, socio-economic status, consumption profile, etc. A programmatic study of consumer perception, local needs, and consumer preferences would be required before initiating such a project. Therefore, a pilot project for the demonstration of these technologies needs to be implemented in selected feeders /sub-stations before embarking on a statewide project. The selection of feeders/sub-stations should depend on the consumer mix, condition of existing distribution infrastructure, implementation of IT systems and applications under R-APDRP, IPDS, smart city initiative, etc. Hence, a pre-feasibility study needs to be conducted for the identification of the feeders/sub-stations which can act as demonstration sites for these identified technologies.

Renewable energy is increasingly becoming an important source of the energy mix – meeting the twin objectives of energy security and clean energy considerations. Over the past decade, the costs of renewables in India have dropped substantially—solar power by as much as 70 percent and wind power by about 30 percent—making them economically competitive with conventional fuels. However, it is impossible to control the intermittency of the renewables, i.e. when the sun shines or the wind blows. Therefore, ensuring 24x7 electricity supply utilizing wind and solar power to demand cannot occur the way that baseload-generating plants fueled by coal, natural gas, or nuclear power can maintain; thereby, this creates a conundrum – how to ensure reliable power supply while ensuring energy transitions to low carbon pathways. In this context, introducing flexibility in the grid is crucial while integrating significant levels of green power. One of the most critical measures is bringing regional connectivity via investing in transmission lines that can assist in absorbing a large quantum of renewable energy, thereby, balancing variable energy production across geographies.

Thus, adequate investments in building resilient transmission and sub-transmission systems can be considered as one of the initial steps in ensuring integration of 'green' power with the grid, while maintaining reliable supply to the people of Goa.

ANNEXURES

ANNEXURE-I: CEA PEAK DEMAND PROJECTIONS FOR THE STATE OF GOA

Inertia in power demand is captured by including lagged dependent variables in the model which helps in computing dynamic impacts of key drivers on electricity demand and hence improve upon static models where such impacts are not captured. Such an economic model which distinguishes between short-run and long-run electricity responses to its key drivers is known as the PAM model. This model is dynamic as it does not assume an instantaneous adjustment to new equilibrium values when any independent variable (such as price or income) changes. The PAM model estimates electricity demand within the regional panel framework which assumes that all the states within a region will have the same response for key socio-economic variables included in the model. Thus, to estimate the differential response of each state concerning change in key drivers, the state-specific mode is also estimated using the regional SUR model. This model estimates states specific regression models but takes advantage of the panel data structure to improve the overall efficiency of state-level parameter estimates. It pools panel data observations within a grid region and accounts for correlation in the errors across states within a grid region.

Year	Forecast Model and Scenario					
	PAM Model			SUR Model		
	Baseline	Optimistic	Pessimistic	Baseline	Optimistic	Pessimistic
2023	520	521	515	728	730	700
2024	531	532	524	760	764	726
2025	543	544	533	794	800	753
2026	554	556	542	829	837	781
2027	566	568	552	864	876	810
2028	577	580	561	900	917	841
2029	589	593	571	938	959	872
2030	601	606	581	976	1,003	904
2031	612	619	592	1,015	1,050	938
2032	624	632	602	1,056	1,098	973
2033	636	646	612	1,098	1,148	1,009
2034	648	660	623	1,142	1,201	1,046
2035	660	674	634	1,187	1,256	1,085
2036	672	689	645	1,235	1,314	1,124
2037	684	704	656	1,285	1,375	1,164

Source: CEA, Long Term Electricity Demand Forecasting (2019)

Annexure-II: Plant-wise average power procurement cost for Electricity Department of Goa

S.No.	Power Source	Average Power Purchase Cost (INR/ kWh)					
		2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
1	NTPC Stations						
	KSTPS-III	2.99	3.08	2.55	2.52	2.65	2.59
	KSTPS	1.74	1.77	1.87	2.02	2.14	2.11
	SIPAT-I	2.84	2.92	2.57	2.43	2.64	2.66
	SIPAT-II	2.89	2.98	2.53	2.49	2.69	2.72
	VSTPS-III	2.89	2.96	2.56	2.48	2.81	2.66
	VSTPS-IV	3.34	3.43	3.13	2.94	3.24	3.09
	VSTPS-V	3.14	3.22	3.23	3.02	3.35	3.20
	VSTPS-II	2.35	2.39	2.19	2.16	2.49	2.36
	VSTPS-I	2.34	2.38	2.43	2.48	2.78	2.64
	RSTPS	3.27	3.32	3.32	3.39	3.93	3.37
	Mouda	4.84	4.95	8.12	6.84	7.24	6.71
	Mouda II	3.15	3.16	5.91	7.29	8.84	8.35
	GGPP	6.12	6.26	5.22	4.54	5.16	4.18
	KGPP	5.60	5.72	5.09	4.66	5.08	4.18
	Lara STPP - I & II	3.39	3.39		5.00	5.00	3.27
	Gadarwara STPP - I		3.77		5.00	5.91	4.21
	Solapur	4.04	4.04	5.22	8.94	8.68	7.73
	Khargone STPP				5.00	5.00	3.15
2	NPCIL						
	KAPS	2.37	2.37			2.72	2.63
	TAPS	2.86	2.86	3.04	3.29	3.43	6.27
3	PXIL/IEX						
	PXIL/IEX	3.00		2.97	3.90	3.10	2.72

S.No.	Power Source	Average Power Purchase Cost (INR/ kWh)					
		2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
4	RE Sources						
	Solar RPO						
	NVVNL Solar	8.29	8.29	7.99	8.76	7.99	4.98
	SECI Solar	5.71	5.71	5.50	5.84	5.50	5.32
	NTPC Solar					4.75	
	Non-Solar RPO						
	NVVNL Hydro	4.66	4.66	4.49			
	SECI Wind				3.50	2.72	2.63
	Hindustan Waste Treatment Plant Goa				5.50	5.00	5.00
5	Hydro Stations						
	Kameng HEP		4.00	5.00	5.00	5.00	
6	Co-Generation (Within State)						
	Goa Energy Private Limited	2.40	2.40				
	Goa Sponge & Power Limited	2.39	2.39	2.41	2.41	2.41	2.41
	Sesa Goa Limited	2.40	2.40				
	Vedanta Co-gen Plant-1			2.40	2.40	2.40	2.40
	Vedanta Co-gen Plant-2			2.40	2.40	2.40	2.40
	TOTAL	3.36	3.47	3.33	3.49	3.49	3.35

Source: EDG ARR and Tariff Orders for respective financial years

Annexure-III: Plant-wise year of commission and age under power procurement strategy for Electricity Department of Goa

Name of Power Plant	Year of Commission	Age of Plant (years)
NTPC Power Plants		
KSTPS	March, 1983	38
VSTPS - I	October, 1987	34
VSTPS - II	July, 1988	33
VSTPS -III	February, 1989	32
VSTPS-IV	December, 1989	32
VSTPS-V	March, 1990	31
KGPP	1992	29
GGPP	1994	27
SIPAT- I	June, 2011	10
KSTPS-III	March, 1984	37
RSTPS	November, 1983	38
SIPAT- II	December, 2011	10
Mouda II	March, 2016	5
Mouda I	March, 2013	8
Solapur	April, 2017	4
New Power Plants		
Gadarwara	March, 2019	2
Lara STPP – I & II	September, 2019	2
Khargone STPP	August, 2019	2

Source: EDG ARR and Tariff Orders for respective financial years

Annexure-IV: Plant-wise power sourcing pattern change over the years for Electricity Department of Goa

S.No.	Power Source	Energy Purchase (MU)					
		Energy Available at Periphery (adjusting ISTS losses)					
		2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
1	NTPC Stations						
	KSTPS-III	36.28	36.28	44.70	51.74	51.74	53.49
	KSTPS	1,428.95	1,428.95	1,521.49	1,510.99	1,510.99	1,561.91
	SIPAT-I	154.51	154.51	171.35	208.10	208.10	215.11
	SIPAT-II	73.54	73.54	80.46	91.88	91.88	94.97
	VSTPS-III	76.10	76.10	78.96	90.71	90.71	93.76
	VSTPS-IV	84.75	84.75	92.12	109.36	109.36	113.05
	VSTPS-V	36.54	36.54	43.43	52.11	52.11	53.86
	VSTPS-II	90.16	90.16	92.12	103.57	103.57	107.06
	VSTPS-I	248.88	248.88	247.90	250.47	250.47	258.91
	RSTPS	655.13	655.13	670.51	636.09	636.09	705.75
	Mouda	96.44	96.44	33.57	51.69	51.69	53.43
	Mouda II	48.97	97.93	43.08	34.78	34.78	35.96
	GGPP	39.88	39.88	58.69	48.14	48.14	49.76
	KGPP	38.68	38.68	45.00	39.25	39.25	40.58
	Lara STPP - I & II	37.54	150.15		24.95	49.89	51.57
	Gadarwara STPP - I		55.49		49.65	77.61	102.65
	Solapur	68.55	26.33	78.50	37.21	37.21	38.46
	Khargone STPP				40.10	80.19	82.90
2	NPCIL						
	KAPS	106.96	106.96			105.86	107.04
	TAPS	81.24	81.24	84.14	80.25	80.25	82.95
3	PXIL/IEX						
	PXIL/IEX	55.34		268.78	558.04	282.75	305.61

S.No.	Power Source	Energy Purchase (MU)					
		Energy Available at Periphery (adjusting ISTS losses)					
		2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
4	RE Sources						
	Solar RPO						
	NVVNL Solar	9.43	9.43	10.57	11.22	11.22	12.40
	SECI Solar	39.29	39.29	47.71	49.43	49.43	51.10
	NTPC Solar					132.42	
	Solar Net-metering					6.25	
	Non-Solar RPO						
	NVVNL Hydro	33.42	33.42	85.97			
	SECI Wind				148.30	296.60	306.60
	Hindustan Waste Treatment Plant Goa				2.00	2.00	2.00
5	Hydro Stations						
	Kameng HEP		11.03	19.51	10.88	10.88	
6	Co-Generation (Within State)						
	Goa Energy Private Limited	107.52	107.52				
	Goa Sponge & Power Limited	4.72	4.72	5.82	5.40	5.40	5.40
	Sesa Goa Limited	55.00	55.00				
	Vedanta Co-gen Plant-1			96.28	92.90	92.90	92.90
	Vedanta Co-gen Plant-2			75.21	69.89	69.89	69.89
	TOTAL	3,707.82	3,838.35	3,995.87	4,459.10	4,669.63	4,749.07

Source: EDG ARR and Tariff Orders for respective financial years

Annexure-V: Detailed characteristics of Solar Power Policy, 2017

Sl.No.	Description	Summary
1.	Operative Period	7-Years
2.	Category for Generating SolarPower	1. **Category I: Prosumer** ➲ Small Prosumer is a consumer already having an LT connection i.e.Sanction load//Contract Demand up to 90 kW with EDG. ➲ The Small Prosumer will be billed on net metering up to Sanction load/ Contract demand up to 90 kW such that anticipated generation in the year is not more than 100 percent of the electricity consumption in the previous (12) months. ➲ The Small Prosumer opting for Gross metering will get the benefit of 50 paise in addition to JERC approved solar tariff rates for that year or APPC as per the current year Tariff Order of JERC whichever is lower. ➲ Large Prosumer is a Consumer having an HT connection i.e. Sanction load/ Contract Demand above 90 kW with EDG. Other conditions are similar to small Prosumer. 2. **Category II: Producer (for the sale of power to the Distribution Licensee).** ➲ The Producer is an entity intending to set up a Solar Power plant with a capacity of more than 100 kW exclusively for the sale of power to the Distribution Licensee under Gross Metering as per the tariff discovered by Reverse Bidding. ➲ Producers will have to participate in reverse bidding for Solar quantum of power bid as advertised/published by the Government or its agencies for four sizes of installation i.e. (i) 100 kW to 1 MW, (ii) 1 MW to 5 MW, (iii) 5 MW to 10 MW, and (iv) 10 MW & above. ➲ To keep away speculative bidding and to ensure participation of only interested power producers, the following conditions for bidding shall apply: Price, Eligibility, Permissible delays, and Penalty. » For delay up to the first 12 months, the bidders shall pay a penalty equal to 5 percent of the value of energy committed for every day of delay. » Up to a 10 percent lower supply (short supply), quantum of power will not attract a penalty. » For short supply of power above 10 percent & up to 50 percent, will be levied a penalty at 5 percent of the value of supply that is missing above the 10 percent threshold. » The BG submitted shall be valid for at least 02 years.

Sl.No.	Description	Summary
3.	Solar Power Plantsunder Renewable Energy Certificate (REC) mechanism	1. Under the REC mechanism, the producer will set up the solar plant and sell the power to EDG at the Average Power Purchase Cost as per the current year Tariff Order of JERC. 2. The solar power generator will be permitted to sell the REC as per the market mechanism. 3. The State shall not claim any benefit for REC.
4.	Sale of solar powerto third party	4. The State shall promote the development of a Solar Power Plant for sale of electricity to the third party within or outside the State other than EDG will depend on the availability of Corridor (infrastructure for the flow of power within or outside the state). 5. The producer will have to pay the wheeling charges wherever applicable as per JERC rates. 6. The State Government/EDG reserve the right to procure 10 percent of the power so generated at the agreed price between solar producer and the third-partybuyer or JERC tariff for that year or the reverse bidding price identified for that plant size or Average Power Purchase Cost as per current year Tariff Order of JERC whichever is lower.
5.	Rooftop Solar Power Generation through RESCO	1. The owners of the rooftops will have their agreement with the RESCO. 2. The EDG will enter into the power purchase agreement with the RESCO for 25 years for the purchase of power at JERC approved solar tariff rates in that year or Average Power Purchase Cost as per the current year Tariff Order of JERC, whichever is lower. 3. The purchase by EDG will be limited to the requirement for either fulfillment of RPO or otherwise.
6.	Land for Solar Projects	1. Producer shall be responsible for obtaining suitable Rooftop or Private land for at least 25 years for their projects within the State of Goa. 2. 2 percent of the total area can be used for construction, operation, and office setup subject to a maximum of 200 square meters per MW. 3. For the rooftop installation of 100 kW and above, the Producer will have to obtain the stability certificate for building structure from reputed Chartered Engineers. 4. For setting up of solar plant on Communidade land, the lease rent agreed to between the solar power producer and the Communidade will have to be approved by the General Body of the Communidade and the State Government.
7.	Subsidy/ Incentives	1. The State Government shall provide a subsidy of 50 percent (30 percent central and 20 percent state) of the capital cost or the benchmark cost provided by MNRE or cost arrived through the tendering process by GEDA, whichever is lower to all the Prosumers. 2. For all Prosumers, Main Tariff Meter (Bi-directional) and Solar Generation Meter will be installed by EDG and rented to the Prosumers by payment on monthly fees to EDG. 3. The Check Tariff Meter (Bi-directional) will have to be installed by the Prosumer.
8.	Grid connectivity, safety, and billing cycle	1. The cumulative solar capacity allowed at a particular Distribution Transformer (DT) shall not exceed 30 percent of the peak capacity of the DT. 2. The billing cycle for all Prosumers under NET Metering will be monthly/bimonthly and the settlement period will be six months basis.

<table>
<tr><th>Sl.No.</th><th>Description</th><th colspan="2">Summary</th></tr>
<tr><td>9.</td><td>Administrative modalities</td><td colspan="2">➲ Every Prosumer/Producer in the State will have to enter PPA with the EDG for 25 years and the tariff will remain fixed for five years.
➲ The Prosumer/Producer or EDG shall have the right to terminate the PPA at any time by serving a written notice of 90 days in advance to the EDG except in cases where subsidy or incentives are disbursed.</td></tr>
<tr><td>10.</td><td>Nodal Agency</td><td colspan="2">Goa Energy Development Agency (GEDA)</td></tr>
<tr><td rowspan="4">11.</td><td rowspan="4">The time frame for implementation of the project</td><td colspan="2">For solar projects beyond 100 kW capacity proposed under Reverse Bidding, the schedule of completion and commission will be from the date of approval by the EDG is as follows:</td></tr>
<tr><td>Plant Capacity</td><td>Time Schedule</td></tr>
<tr><td>100 kW – 1 MW</td><td>240 Days</td></tr>
<tr><td>1 MW – & above</td><td>1 Year</td></tr>
</table>

Annexure-VI: State-wise level of penetration of solar rooftop as per state codes and regulations

State or Union Territory	Limits for individual customers	Installed capacity limits as a percentage of Distribution Transformer (DT) capacity
Andaman and Nicobar Islands	<500 kWp	50% of the capacity of the DT
Andhra Pradesh		60% of the rated capacity of DT
Arunachal Pradesh	<1000 kWp	15% of the peak capacity of the DT
Assam	40% of the contracted load (2016) 80% of the contracted load of the individual (2017 draft)	Specified by commission from time to time (2015) 20% of the peak capacity of the DT (2017 draft)
Bihar	<Sanctioned Load	15% of the capacity of the DT
Chandigarh	<500 kWp: 80% of the sanctioned load	50% of the capacity of the DT
Chhattisgarh	Not specified	
Dadra and Nagar Haveli	<500 kWp	50% of the capacity of the DT
Daman and Diu	<500 kWp	50% of the capacity of the DT
Delhi	No limit specified(depends on feasibility)	Not less than 20% of the rated capacity of the DT
Goa	No limit specified(depends on feasibility)	The cumulative solar capacity allowed at a particular DT shall not exceed 30% of the peak capacity of the DT.
Gujarat	< 50% of the sanctioned load	65% of the peak capacity of DT
Haryana	<connected load	30% of the peak capacity of the DT in case of interconnection is at LT and 15% of the peak capacity of the PT in case of interconnection is at HT
Himachal Pradesh	<80% of the sanctioned contract demand for consumers under two-part tariff <30% of the sanctioned connected load for consumers under a single tariff	30% of the rated capacity of the DT
Jammu and Kashmir	<50% of the sanctioned load of the consumer	20% of the rated capacity of the DT
Jharkhand	<100% of the contracted load	15% of the rated capacity of the DT
Karnataka	<100% of the contracted load	If PV plant> 50 kW- 80 % of the rated capacity of the DT If PV >50kW- line current should be less than 80% of the rated current carrying capacity of the line
Kerala	<100% of the contracted load	For generation at LT: 15% of the rated capacity of the DT, above 15%, till the cumulative capacity of the solar energy systems connected to the DT, reached the average load on the said transformer between 8 AM and 4 PM during seven days succeeding the date of submission of application For generation at HT: cumulative capacity connected to the distribution feeder under a particular power transformer is less than 80% of the average load as to 365 days preceding the date of submission.

State or Union Territory	Limits for individual customers	Installed capacity limits as a percentage of Distribution Transformer (DT) capacity
Lakshadweep	<500 kWp	50% of the capacity of the DT
Madhya Pradesh	<1 MWp at HT	30% of the peak capacity of the DT
Maharashtra	<100% contracted load	40% of the rated capacity of the DT, allowed to exceed upon detailed load study
Manipur	<100% contracted load	40% of the rated capacity of the DT
Meghalaya	<100% contracted load	15% of the peak capacity of the DT
Mizoram	<100% contracted load	40% of the rated capacity of the DT
Nagaland	<80% of the sanctioned load	15% of the peak capacity of the DT
Odisha	Not Specified	75% of the peak capacity of the DT
Puducherry	<500 kWp	50% of the capacity of the DT
Punjab	80% of the sanctioned load	30% of the rated capacity of the DT
Rajasthan	80% of the sanctioned load	30% of the capacity of the DT
Sikkim	<100% contracted load	For the generation at LT:15% of the rated capacity of the DT, above 15%, till the cumulative capacity of the solar energy systems connected to the DT, reached the average load on the said transformer between 8 AM and 4 PM during the period For the generation at HT: Cumulative capacity connected to the distribution feeder under a particular power transformer is less than 80% of the average load as to 365 days preceding the date of submission
Tamil Nadu	<100% contracted load	30% of the rated capacity of the DT
Telangana	For Residential and Governance consumers: up to a maximum of 100% of the consumer's sanctioned load; For Industrial, Commercial and other consumers up to a maximum of 80% of the sanctioned load/contracted demand of the consumer	For LT consumers, 50% of the rated capacity of the DT. For HT consumers, 50% of the maximum load permitted on the feeder, allowed to exceed upon detailed load study
Tripura	<100% contracted load	15% of the rated capacity of the DT, allowed to exceed upon detailed load study
Uttar Pradesh	<100% contracted load	15% of the rated capacity of the DT
Uttarakhand	<500	15% of the rated capacity of the DT
West Bengal	>5 kW, injection shall not be more than 90% of the consumption from the licensee's supply in a year	Not specified

Annexure-VII: List of industrial estates and industrial sectors in the state of Goa

S.No.	Industrial Estate	Major Industrial Clusters
1	Bethora	Engineering and Metal Works, Electrical Appliances, Pharmaceuticals, Food Processing
2	Bicholim	Plastics and Chemicals, Electrical Appliances
3	Canacona	Packaging Materials, Food Processing
4	Colvale	Engineering and Metal Works, Packaging Materials
5	Corlim	Packaging Materials, Food Processing, Plastics and Chemicals, Electronic and Electrical Appliances, Storage
6	Cuncolim	Plastics and Chemicals, Electrical Appliances, Engineering and Metal Works, Alcohol, Ice Manufacturing
7	Dharbandoda	Food Processing, Pharmaceuticals
8	Honda	Engineering and Metal Works, Plastics and Chemicals, Alcohol, Pharmaceuticals
9	Kakoda	Packaging Materials, Engineering and Metal Works, Plastics and Chemicals
10	Kundaim	Engineering and Metal Works, Plastics and Chemicals, Pharmaceuticals, Electrical and Electronic Appliances, Packaging Material, Storage
11	Latambarcem	Electrical and Electronic Appliances, Plastics and Chemicals, Pharmaceuticals
12	Madkaim	Food Processing, Plastics, Engineering and Metal Works, Electrical Appliances, Pharmaceuticals, Alcohol
13	Mapusa	Engineering and Metal Works, Electrical Appliances, Medical Equipments
14	Margao	Packaging Material, Plastics and Chemicals, Electrical and Electronic Appliances, Engineering and Metal Works
15	Panchwadi	Plastics and Cement, Engineering and Metal Works
16	Pilerne	Electrical and Electronic Appliances, Engineering and Metal Works, Pharmaceuticals, Plastics and Chemicals, Alcohol
17	Pissurlem	Chemicals, Engineering and Metal Works, Food Processing
18	Quittol	Plastics and Chemicals, Engineering and Metal Works, Pharmaceuticals
19	Sancoale	Plastics, Engineering and Metal Works, Electrical and Electronic Appliances, Chemicals
20	Sanguem	Food Processing, Pharmaceuticals
21	Shiroda	Engineering and Metal Works, Packaging Materials, Plastics
22	Thivim	Pharmaceuticals, Engineering and Metal Works, Plastics and Chemicals, Heavy Machineries
23	Tuem	Electrical and Electronic Appliances, Pharmaceuticals, Chemicals
24	Verna	Pharmaceuticals, Plastics and Chemicals, Electrical and Electronic Appliances, Engineering and Metal Works, Food Processing, Packaging Materials, Storage

Annexure-VIII: Indicative cost analysis for procurement of renewable energy from within and outside the state of Goa

S. No.	Particulars	Units	Solar rooftop in Goa (gross metering)	Solar Park		Ground-mounted solar	
				Karnataka	Maharashtra	Karnataka	Maharashtra
1	Assumed capacity	MW	1	1	1	1	1
2	Capacity utilisation factor (CUF)	%	18%	19%	19%	19%	19%
3	Annual electricity generation	MU	1.58	1.66	1.66	1.66	1.66
4	Inter-state transmission losses	%	0%	0%	0%	0%	0%
5	Intra-state transmission losses	%	10.25%	3.09%	3.18%	3%	3.18%
6	Wheeling losses	%		10.68%	12%	10.68%	12%
7	Energy available at periphery	MU	1.42	1.44	1.42	1.44	1.42
8	Levelized tariff	INR/unit	4.34[16]	2.85[17]	2.51[18]	2.91[19]	2.90[20]
9	Inter-state transmission charges	INR/unit	-	-	-	-	-
10	Intra-state transmission charges	INR/unit				0.69[21]	0.41[22]
11	Wheeling charges	INR/unit				0.78	1.38
12	Total energy cost per annum	INR Cr				0.48	0.48
13	Total transmission and wheeling cost	INR Cr				0.25	0.30
14	Total landed cost of energy	INR Cr				0.73	0.78
15	Landed cost of power at state's periphery	INR/unit	4.34	2.85	2.51	5.07	5.50

Note: The table above provides indicative costs of procurement of solar energy from within and outside the state. These costs are subject to change with changes in the levelized tariff and transmission charges in procuring the green power.

16 http://jercuts.gov.in/writereaddata/UploadFile/ED%20Goa%20Order%202021-22_1760.pdf

17 https://kredlinfo.in/Solarpark/Details%20of%20650mw%20short%20term%20retender%20notifications/LOA%20list%20of%20500MW%20Solar%20Power%20project%20at%20Pavagada%20solar%20park%20of%20remaining%20650MW%20tender.pdf

18 https://india-re-navigator.com/utility

19 As per KREDL tender for 100 MW on January 2019

20 As per MSEDCL tender for 500 MW on March 2020

21 https://karunadu.karnataka.gov.in/kerc/Tariff%20Order%202020/Orders/BESCOM/8-BESCOM%20-%20CHAPTER%20-%20%206_create.pdf

22 https://www.mahadiscom.in/consumer/wp-content/uploads/2020/04/Commercial_Circular_for_MYT_Order-3.pdf

We are an independent, multi-dimensional organization, with capabilities in research, policy, consultancy and implementation. We are innovators and agents of change in the energy, environment, climate change and sustainability space, having pioneered conversations and action in these areas for over four decades. We believe that resource efficiency and waste management are the keys to smart, sustainable and inclusive development. Our work across sectors is focused on (a) promoting efficient use of resources; (b) increasing access and uptake of sustainable inputs and practices; and (c) reducing the impact on environment and climate. Headquartered in New Delhi, we have regional centers and campuses in Gurugram, Bengaluru, Guwahati, Mumbai, Panaji, and Nainital. Our 1,000-plus team of scientists, sociologists, economists and engineers delivers insightful, high quality action-oriented research and transformative solutions supported by state- of-the-art infrastructure.

teri | The Energy and Resources Institute

Creating Innovative Solutions for a Sustainable Future

The Energy and Resources Institute (TERI)
Darbari Seth Block, IHC Complex,
Lodhi Road, New Delhi 110003, India
Tel.: +91 11 2468 2100 or 2468 2111
Fax: +91 11 2468 2144 or 2468 2145
Email: pmc@teri.res.in | Web: www.teriin.org