

# Power Sector Vision 2030

MAHARASHTRA









**Arvind Singh**  
Principal Secretary (Energy)

**INDUSTRY, ENERGY AND LABOUR DEPARTMENT**

**Government of Maharashtra  
Mantralaya, Mumbai 400 032**

**Date : 28<sup>th</sup> June, 2019.**

## **FOREWORD**

Maharashtra contributes nearly 15 percent to India's gross domestic product (GDP) and its power sector has been the key success driver for the state economy. The power sector of Maharashtra has been among the top performers in terms of access to electricity as well as quality of power supply, serving the largest consumption base in India effectively with a focus on environmental as well as financial sustainability. The State has also been in the forefront in promoting clean energy and adopting digital technologies to achieve greater efficiencies and improve customer connect.

Globally, a new paradigm is emerging with new technologies transforming the grid, greater consumer empowerment through decentralized technologies aided by digital means, increasing adoption of electric vehicles, etc. To address the unprecedented opportunities as well as challenges that will follow, the power sector needs to redefine its role and move forward with a well thought out and calibrated approach. In particular, the pace of innovations in technologies and commercial structures would need to accelerate radically. This necessitates a culture of openness, collaboration, agility, accountability and customer orientation which needs to start with the right tone at the top.

The Power Sector Vision 2030 document, the result of an extensive stakeholder consultation exercise, defines the aspirations of Maharashtra's power sector and suggests a way forward for the sector to anticipate and mitigate the emerging challenges, future disruptions and potential opportunities. In particular, the document identifies the key transformation levers for the sector and provides an action plan for responding to future disruptions through synergized efforts.

As the energy industry transitions globally, it will play a critical role in shaping the ambitions of economies. In this backdrop, I am hopeful that this exercise will help the sector to overcome challenges and play a pivotal role in achieving Maharashtra's vision to become India's first trillion dollar state economy over the next few years.

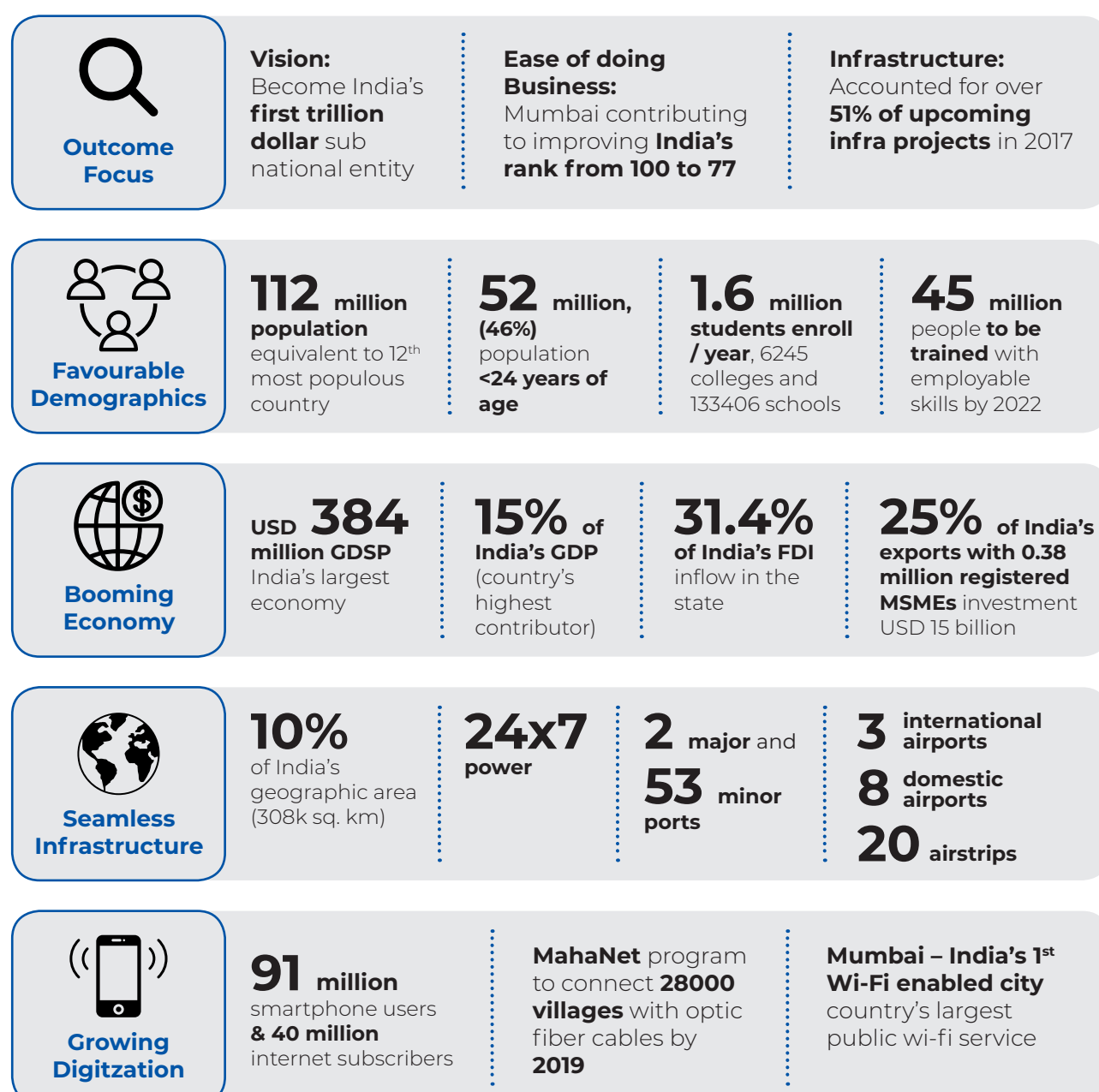
  
**(Arvind Singh)**



# Maharashtra envisions to be a trillion dollar economy by 2025

The state of Maharashtra is home to 112 million people and is India's largest state economy contributing 15 percent to India's gross domestic product (GDP), and aiming to become India's first trillion dollar state economy in the coming few years.

Figure 1: Key highlights of the state of Maharashtra



Source: Magnetic Maharashtra, 2019

## The power sector of Maharashtra has played a critical role in supporting the economic growth of the state

Access to cost effective and reliable power supply is the single biggest catalyst for inclusive growth. It is critical for industrial growth as well as for ensuring social growth of citizens and a high human development index. From FY 14 to FY 18, the GSDP of Maharashtra at current prices has grown at a CAGR of ~8 percent<sup>1</sup>, along with a healthy growth rate of 4.8 percent observed in electricity supply during the same period.

**The state has an ambitious target to grow at a rate of 10 percent per annum. With initiatives like 'Make in Maharashtra' for boosting industrial output, large investments planned for upgrading public infrastructure, increased focus on enhancing output from the agriculture and services sector, reliable uninterrupted power supply is a necessary condition. Hence, the state's power sector will be playing a critical role in achieving the growth rate targets.**

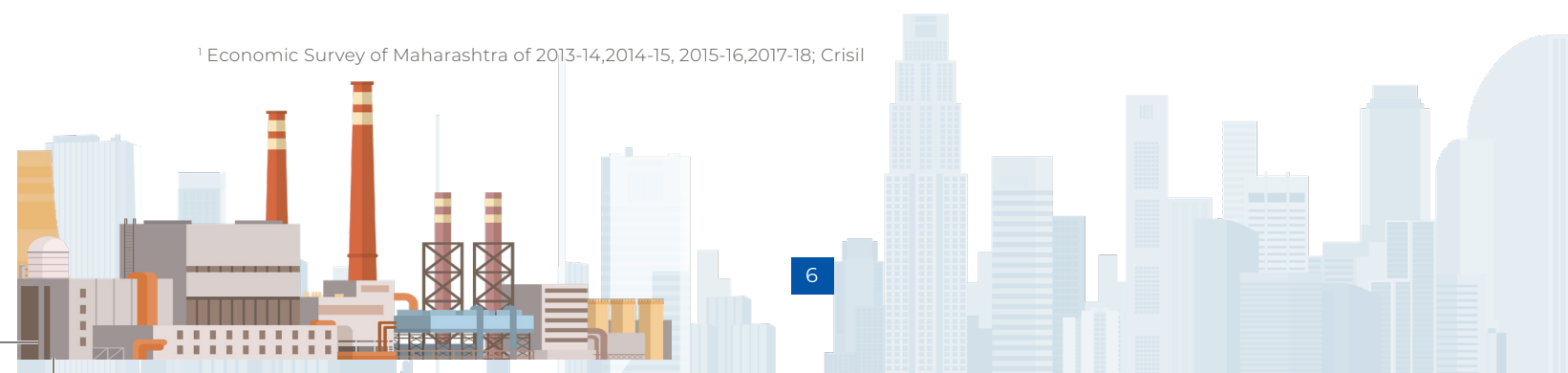
## To continue as a key enabler for growth, the power sector needs to not only overcome the current challenges but also address the emerging disruptions

The Maharashtra power sector is the largest producer and consumer of electricity in India and one of the front runners in areas such as financial performance of state utilities, quality of power supply, adoption of digital technologies and promotion of clean energy. It has achieved 100% household electrification and effectively managed urban as well as rural power supply including handling a large volume of agricultural consumers.

While the performance has been noteworthy, the state power sector needs to continually evolve to address challenges by increasing operational efficiencies, reducing costs of delivery and addressing varying needs of a diverse consumer base.

Further, the state power sector needs to anticipate and plan for multiple disruptions which are rapidly shaping the electricity landscape globally so that it continues to perform its obligations in a manner which is sustainable and at the same time meets the requirements of the new order. The three big global trends that will impact the power sector will be Decarbonization, Decentralization and Digitalization which are elucidated in Figure 2.

<sup>1</sup> Economic Survey of Maharashtra of 2013-14, 2014-15, 2015-16, 2017-18; Crisil

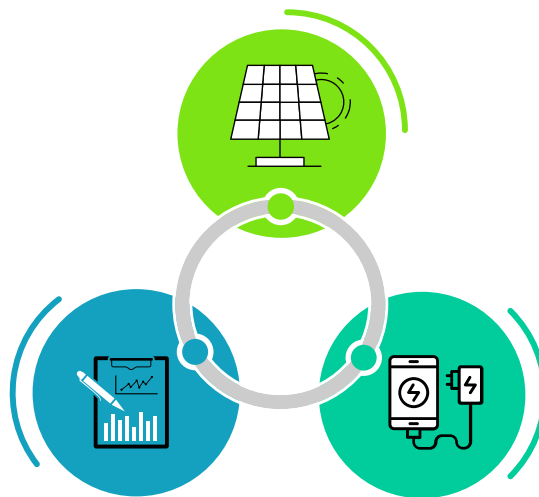


*Figure 2: Global disruptive trends*

### **Decentralization**

**Solar rooftop:** Countries such as Australia have more than 20% household penetration in certain states

**Storage:** Expected reduction in price in the next 4-5 years by over 50% from current prices could further stimulate renewable energy adoption



### **Decarbonization**

- According to the IEA, renewable energy is likely to account for 40% of total generation by 2040
- Coal based capacity growth is expected to be largely limited to assets under construction
- The IEA estimates that electric vehicles will grow from 3 mn in 2017 to 125 mn by 2030, globally (electricity demand growth of 5% by 2040)

### **Digitalization**

- Technologies such as artificial intelligence, machine learning, IoT, etc. are driving higher efficiencies and lowering costs of operation
- Aided by digital, renewable energy technologies and distributed energy sources are further gaining ground and giving rise to new business models

In addition to the above, the Indian power sector could see regulatory and policy evolution to incorporate the above trends and to move to a more efficient and competitive market structure. These include:

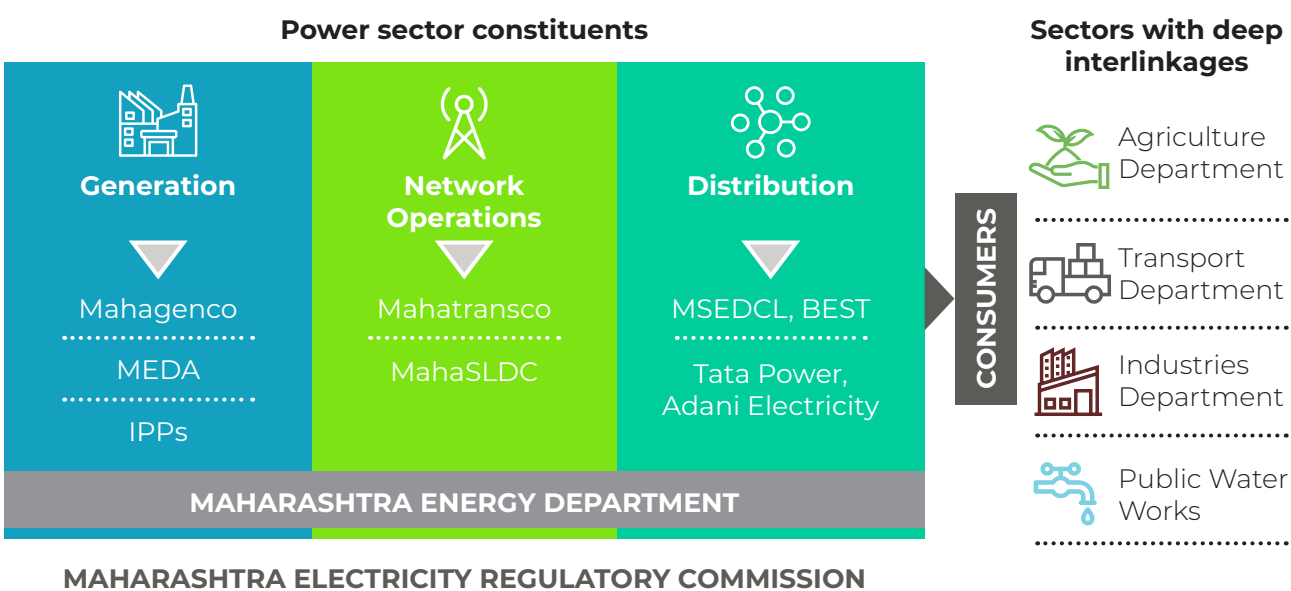
- New market design including ancillary services market development, new contracting structures, product innovation and deeper short term markets
- Carriage and content separation to enable competition in retail supply

**In India, a few states are already witnessing new challenges (for eg, integration of renewable energy during high wind season, etc.) which are likely to become all-pervasive with these global disrupters and impending regulatory changes. Hence, the Maharashtra power sector would need to envision and implement systemic changes. This would begin with a vision statement which aligns stakeholders across the value chain to shared goals, followed by key actions to achieve the vision.**

# There is an imminent need to set a vision for the future to provide a cohesive guiding framework to all stakeholders in a changing paradigm

- A vision document can greatly assist by providing a coherent direction to the sector for strategic planning and decision making and has the following benefits:
- Synergizing efforts between various stakeholders (Figure 3)
  - Guiding decision making as per clearly defined principles and non-negotiables
  - Guiding decision making during sector transitions and disruptions
  - Adopting strategies to leverage emerging technologies and disruptions to the benefit of the sector
  - Tracking progress towards shared goals
  - Strengthening investor confidence

Figure 3: Key power sector stakeholders in Maharashtra



A critical component of the vision setting exercise is to drive alignment right from concept setting stage. To achieve this, an extensive stakeholder discussion was undertaken across all constituents of Maharashtra power sector to arrive at the vision statement as well as the important levers and actions for achieving the vision which are documented in the ensuing sections.



# Vision, mission and values for the power sector of Maharashtra

The vision, mission and values for the power sector in Maharashtra are documented below. The vision statement reflects the aspirations for the sector in the next decade. Similarly, the mission reflects how the sector will achieve its aspirations. The values define key attributes that the sector stands by on the journey to achieve its aspirations.



## Vision 2030

A **sustainable** and **forward looking** power sector providing **high quality customer service** and fostering the **socio-economic growth** of Maharashtra



### Mission

- To make power supply **safe, cost effective and reliable**
- To enhance **customer service**
- To **digitalize** the power sector and bring **efficiency in operations**
- To make power sector operations **financially sustainable**
- To increase **clean energy adoption** in a sustainable manner



### Values

- We aim to provide **exceptional quality to customers**
- We ensure a culture of **respect, trust and accountability**
- We adhere to highest standards of **ethics and governance**
- We encourage **collaboration** and **innovation**
- We are **open** to change

**This document along with defining the vision, mission and values of the power sector also identifies the broad initiatives needed within each of the subsectors to meet the aspirations.**

# Establishing the levers for achieving the vision

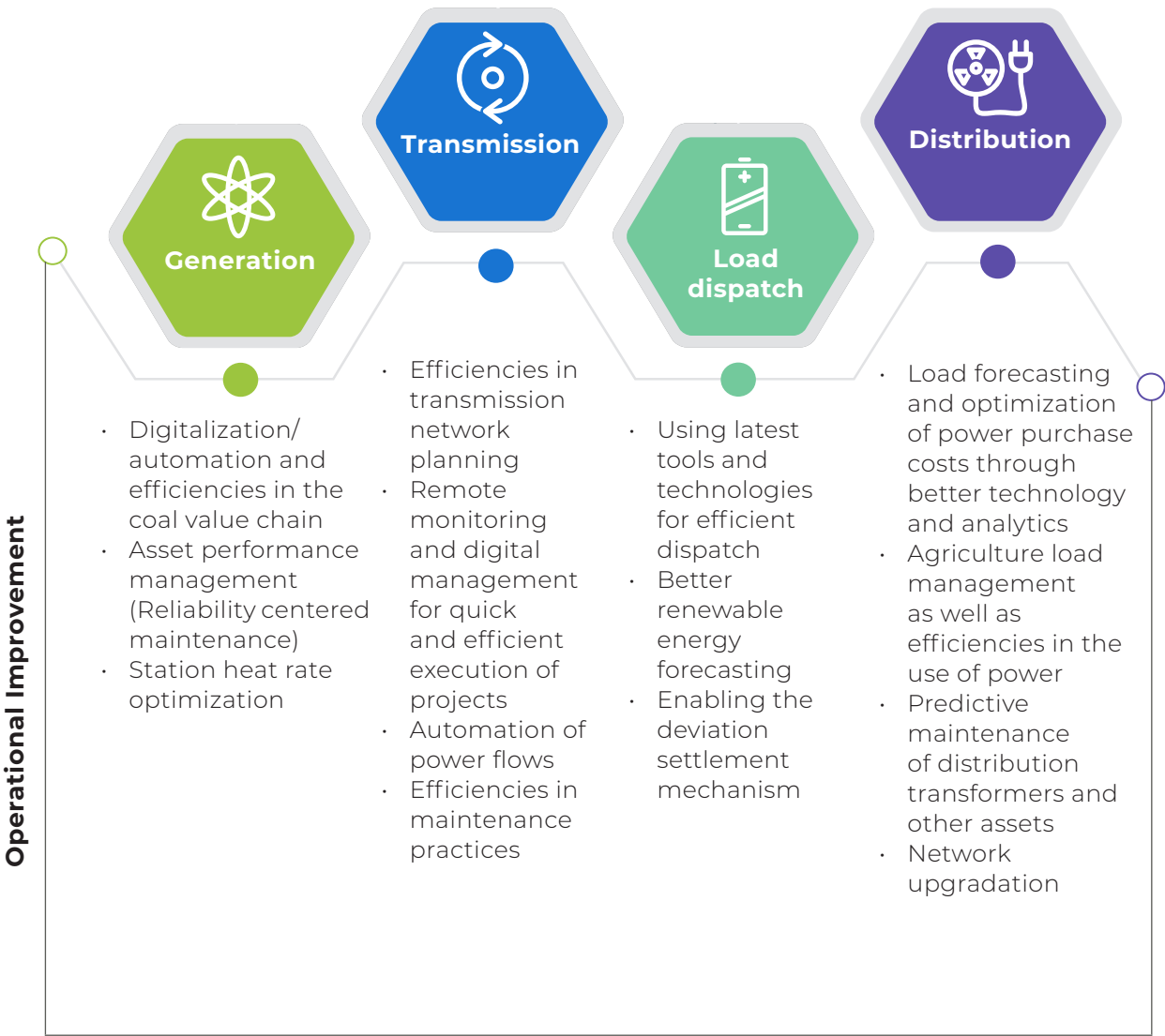
With the changing landscape of the power sector, it is important to identify the levers that can propel the sector towards achieving the vision set out. The stakeholders across the power value chain will have to further establish levers and take appropriate actions to ensure that the goals of the sector are met.

In the following section, key levers have been identified to achieve the Vision 2030.

## A. Improving operational efficiencies and reducing costs

A strong focus on efficiency has to be a fundamental priority as the sector moves towards vision fulfilment. The figure below (Figure 4) highlights some key steps and initiatives for increasing operational efficiency throughout the value chain.

Figure 4: Illustration of measures for operational improvement across the value chain



Measures such as these have successfully realized higher operational efficiencies globally and in India (Box 1).

- A. A coal - fired thermal power plant in China, installed a sensor based plant management solution to achieve 30 per cent reduction in operating costs<sup>2</sup>.

B. Fingrid (Finland power utility) developed a centralized asset management and big data analytics platform to enable predictive maintenance, save costs and improve fault analysis by 99%<sup>3</sup>.

C. Abu Dhabi Water and Electricity Authority (UAE) used asset management solutions to optimize the utilization of its field workforce. This helped reduce annual maintenance cost by 40%.<sup>4</sup>

D. A leading European renewable energy company, leveraged a forecasting solution to predict the operating condition of a wind farm for the coming 120 hours in five minute intervals. This helped to increase productivity by minimisation of unscheduled outages and decrease in maintenance costs<sup>5</sup>.

## B. Leveraging new clean technologies

The sector needs to continue to focus on clean energy adoption. In this context, new technologies that allow better resource utilization, overcome existing constraints (for eg, land, water, transmission, etc) and provide flexible and dispatchable power need to be evaluated. For this, it is critical to continuously track developments in new technologies on the horizon, for instance floating solar, off-shore wind, micro hydel etc. (Table 1) and encourage innovations around these.

Table 1: New clean energy technologies

Technology	Benefits
<b>Floating solar</b>	<ul style="list-style-type: none"> <li>• Panels are installed on water bodies therefore, the technology addresses constraints such as availability of land</li> <li>• May allow higher efficiency of solar panels</li> </ul>
<b>Off-shore wind plants</b>	<ul style="list-style-type: none"> <li>• Large part of India's 127 GW off shore wind potential lies off Maharashtra's 720 km coastline</li> <li>• More efficient than land wind farms since off-shore wind speeds are higher and steadier</li> <li>• Since off shore wind plants are installed on sea bed, constraints such as availability of suitable on-shore sites are addressed</li> </ul>
<b>Hybrids (solar –wind hybrid, renewable energy - storage hybrid)</b>	<ul style="list-style-type: none"> <li>• Solar wind hybrids offer steadier generation curves in certain regions, with lower variability than standalone systems</li> <li>• Renewable energy - storage hybrids offer dispatchable renewable energy based power which is flexible to meet variations in load requirements</li> </ul>
<b>Hydroponics and solar PV</b>	<ul style="list-style-type: none"> <li>• Utilization of land underneath solar PV panels for growing fruits and vegetables</li> <li>• Additional revenue generation</li> </ul>

<sup>2</sup> KPMG India: The Power of Digital: An Enabler and Disrupter

<sup>3</sup> IBM Case Studies

<sup>4</sup> IBM Case Studies

<sup>5</sup> KPMG India: The Power of Digital: An Enabler and Disrupter

## C. Identifying measures for seamless integration of renewable energy sources with the grid

A key attribute of the emerging scenario with high penetration of renewable energy is that it would need the grid to be flexible to adapt to the patterns of generation. This flexibility can be achieved either through demand side or supply side measures or a combination of both supported by adequate network flexibility (Table 2).

*Table 2: Select technologies for flexibility*

Type of flexibility	Technology	Potential role
<b>Supply side flexibility</b>	<ul style="list-style-type: none"> <li>Utility-scale battery storage</li> </ul>	<ul style="list-style-type: none"> <li>Load shifting – charging batteries to avoid curtailment of excess generation</li> <li>Provision of ancillary services</li> <li>Provision of capacity reserve</li> <li>Reliable power supply to isolated grids</li> <li>Offsetting transmission and distribution upgrades</li> </ul>
	<ul style="list-style-type: none"> <li>Flexibilization of thermal power plants</li> </ul>	<ul style="list-style-type: none"> <li>Allows quick ramp up and ramp down of conventional generation plants to meet demand requirements</li> </ul>
<b>Grid flexibility</b>	<ul style="list-style-type: none"> <li>Developing local dispatch centers/ DSOs</li> </ul>	<ul style="list-style-type: none"> <li>Allows grid to be better managed taking into account the increased complexity with high distributed energy resources</li> </ul>
<b>Demand-side flexibility</b>	<ul style="list-style-type: none"> <li>Behind-the-meter battery storage</li> </ul>	<ul style="list-style-type: none"> <li>Enables effective integration of local renewable energy generation</li> <li>Smoothens the peak load profile</li> <li>Facilitates demand-response services and participates in ancillary service market, providing flexibility to the system</li> </ul>
	<ul style="list-style-type: none"> <li>Smart charging of electric vehicles</li> </ul>	<ul style="list-style-type: none"> <li>Smart charging of electric vehicles can help mitigate curtailment of renewables, while avoiding the addition of extra load to peak demand and additional infrastructure costs</li> <li>Vehicle-to-grid (V2G) technologies could bring even greater flexibility in the system by supplying power back to the grid when needed</li> </ul>

Innovations in technologies such as these need to be closely followed in order to continuously evaluate the feasibility of their application to enable a clean energy future for the state.

## D. Creating a culture of innovation, digital orientation and creativity

The advent of technologies such as smart appliances, data analytics, machine learning, robotic process automation etc. are enabling organizations to meet their business objectives more effectively. Key drivers which are making adoption of digital critical for the power sector are:

- 1. Need to integrate renewable energy:** The rising penetration of renewable energy, both at a utility scale and in a decentralized mode, necessitates digital technologies to be interleaved efficiently.
- 2. Need for fundamental shifts in operational efficiencies:** Falling costs and maturity of digital technologies make them critical solutions to improve operational efficiencies, reduce cost as well as improve the quality of power supply in the grid.
- 3. Need to enhance customer connect:** Digital technologies are being leveraged increasingly to improve customer touch points and provide them with value added services in an effort to improve customer connect in an increasingly challenging business environment.

While power sector constituents in Maharashtra are making efforts to incorporate digital technologies in various facets of their operations, it is imperative for them to embrace digital whole heartedly. Further, the sector needs to create an environment that encourages innovation both internally and externally through creating an open platform that attracts new talent and start-ups to provide solutions.

*Figure 5: Key pillars of transformation to an innovative and digitally oriented environment*

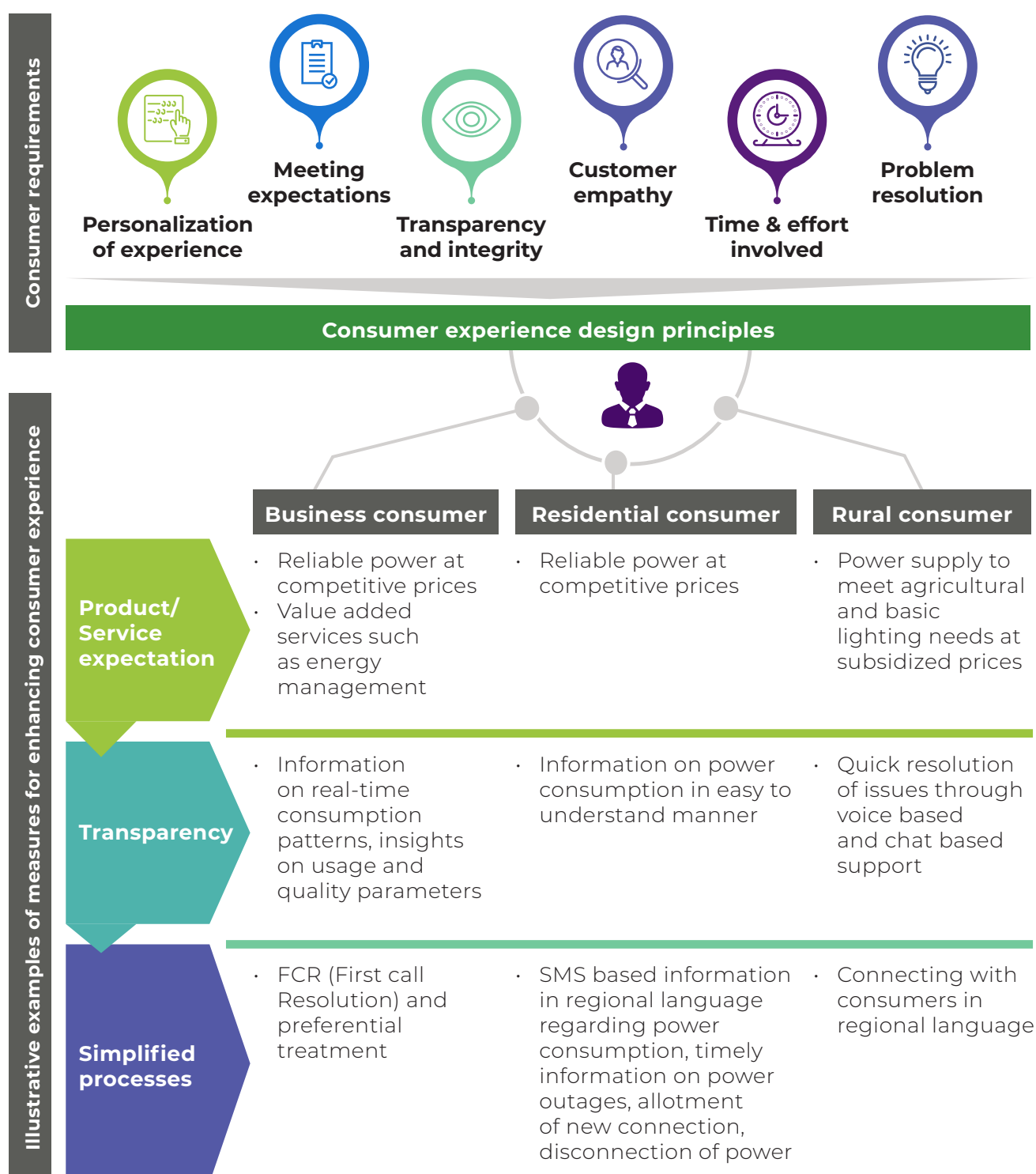




## E. Increasing consumer centricity

As the sector evolves, the role of the consumer is likely to evolve in a way that grants him greater control over electricity generation and usage patterns. Therefore, consumer centricity gains even higher emphasis as the sector transitions. It is critical to map the consumer touchpoints, understand their expectations and implement measures to serve the consumer better.

Figure 6: Principles for designing consumer experience and illustrative examples for interventions based on needs of different consumer groups



## F. Bringing about governance and structural modifications

Finally, the following structural modifications need to be brought about:

1. Governance separation of transmission planning, operations and load dispatch functions to bring greater focus and independence in performing their respective roles. The capacity of these institutions should be strengthened through access to the right technologies and skilling.
2. Exploring competitive forces in various areas, for eg tariff based competitive bidding for transmission lines, franchisee models in certain high loss distribution areas. A study on this may be initiated to identify specific opportunities.
3. Creating a culture of constructive stakeholder discussions and interactions which will strengthen over time with the right environment of trust and mutual respect.

## Identifying key actions for moving towards the vision

Based on discussions with sector constituents, the following key actions have been identified for working towards the Vision 2030.

Priorities	Current status	Key activities	Key enablers	Challenges/Threats
<b>Generation</b>				
<b>Capacity addition (renewable energy and new technologies)</b>	<ul style="list-style-type: none"> <li>Renewable energy capacities being planned both under decentralised and centralized mode including hydro and new technologies such as floating solar</li> <li>Planning for new capacities including retiring fleet with renewable energy capacities, super critical units etc.</li> </ul>	<ul style="list-style-type: none"> <li>Continuing to add renewable energy in alignment with Govt. of India targets</li> <li>Conduct pilot projects for smaller thermal units, gas based plants for peak power management</li> <li>Conduct pilot projects for new technologies such as hybrids, hydroponics in solar PV plants etc.</li> </ul>	<ul style="list-style-type: none"> <li>Successful proof of concept</li> <li>Policy and regulatory support</li> </ul>	<ul style="list-style-type: none"> <li>Integration of higher levels of renewable energy</li> <li>Changes in technology</li> </ul>

Priorities	Current Status	Key activities	Key enablers	Challenges/Threats
Generation				
<b>Operational improvement</b>	<ul style="list-style-type: none"> <li>Coal procurement rationalisation</li> <li>Improvements in in-plant coal handling and logistics</li> <li>Modernization of plants including flexibilization of Mahagenco's Bhusawal (1420 MW) thermal power station</li> </ul>	<ul style="list-style-type: none"> <li>Improvements in coal procurement planning and handling logistics</li> <li>Reduction in operating expenses through remote monitoring, predictive maintenance, automated robotic maintenance, etc.</li> <li>Extending flexibilisation technologies to other thermal power plants</li> </ul>	<ul style="list-style-type: none"> <li>Investment in equipment and digital technology</li> <li>Employee buy-in and upskilling</li> <li>Upgradation of systems and processes</li> </ul>	<ul style="list-style-type: none"> <li>Change management</li> <li>Cash flow for additional capex</li> </ul>
<b>Renewable energy awareness</b>	<ul style="list-style-type: none"> <li>Increasing thrust on dissemination of information about renewables</li> </ul>	<ul style="list-style-type: none"> <li>Set up vocational and internship courses in schools and colleges for renewable energy</li> <li>Conduct awareness programs across districts</li> </ul>	<ul style="list-style-type: none"> <li>Institutional strengthening of key agencies involved in renewable energy promotion</li> <li>Access to information on global technology developments</li> </ul>	<ul style="list-style-type: none"> <li>Change management</li> </ul>

Priorities	Current Status	Key activities	Key enablers	Challenges/Threats
<b>Transmission</b>				
<b>Reduction of operating cost</b>	<ul style="list-style-type: none"> <li>Redundancy in system</li> </ul>	<ul style="list-style-type: none"> <li>Steps to reduce redundancy</li> <li>Measures to improve efficiency and reduce operations cost through remote command and control centres, automation of power flows, predictive maintenance practices etc.</li> </ul>	<ul style="list-style-type: none"> <li>Digital technologies</li> </ul>	<ul style="list-style-type: none"> <li>Organization change management</li> </ul>
<b>Planning for new capacity addition</b>	<ul style="list-style-type: none"> <li>Mumbai transmission corridor planning</li> </ul>	<ul style="list-style-type: none"> <li>Identifying and addressing transmission constraints</li> <li>Coordination with other local bodies for implementation</li> </ul>	<ul style="list-style-type: none"> <li>Timely support from local municipal bodies</li> </ul>	<ul style="list-style-type: none"> <li>Implementation delays</li> <li>Right of way issues</li> <li>Space constraints</li> </ul>
<b>Load dispatch</b>				
<b>Operational improvement</b>	<ul style="list-style-type: none"> <li>Reliant on renewable energy generators to supply information</li> </ul>	<ul style="list-style-type: none"> <li>Tools and technologies for forecasting of renewable power and optimal scheduling of plants</li> <li>Adoption of technologies to enable deviation settlement mechanism with a tightening tolerance band</li> </ul>	<ul style="list-style-type: none"> <li>Policy and regulatory framework</li> <li>Data and analytics tools for renewable energy forecasting and scheduling of power</li> </ul>	<ul style="list-style-type: none"> <li>Accuracy of forecasting techniques</li> </ul>

Priorities	Current Status	Key activities	Key enablers	Challenges/Threats
Distribution				
<b>Reduction of power purchase cost</b>	<ul style="list-style-type: none"> <li>• Zero scheduling for expensive power plants</li> <li>• Solarization of agricultural feeders</li> <li>• Reduction of Point of Connection charges</li> <li>• Convergence between SCADA and Western Region Load Dispatch Centre data to minimize deviation</li> </ul>	<ul style="list-style-type: none"> <li>• Procurement from cheaper renewable energy sources</li> <li>• Procurement of flexible, schedulable power from renewable energy -hybrid projects with storage in a cost effective manner</li> <li>• Power trading to realize additional revenue</li> </ul>	<ul style="list-style-type: none"> <li>• Policy and regulatory enablers</li> <li>• Digital tools for better procurement and trading management</li> <li>• Learning from best practices globally</li> </ul>	<ul style="list-style-type: none"> <li>• Legacy high cost contracts of wind/ bagasse and Solapur thermal power plant</li> </ul>
<b>Operational improvement</b>	<ul style="list-style-type: none"> <li>• Advanced metering infrastructure</li> <li>• Centralized billing and collection</li> <li>• Banking surplus power with other utilities for better peak load management</li> </ul>	<ul style="list-style-type: none"> <li>• Network upgradation</li> <li>• New technologies to reduce AT&amp;C losses</li> <li>• Implementation of technologies for asset lifecycle management</li> </ul>	<ul style="list-style-type: none"> <li>• Digital technologies for predictive maintenance, network automation, remote monitoring etc.</li> </ul>	<ul style="list-style-type: none"> <li>• Fund availability</li> <li>• Change Management</li> </ul>



Priorities	Current Status	Key activities	Key enablers	Challenges/Threats
Distribution				
Increasing consumer centricity	<ul style="list-style-type: none"> <li>Mapping of mobile numbers of &gt;85% of consumer base of MSEDCL</li> <li>Implementation of various initiatives such as omni-channel consumer touch points, dedicated mobile app for consumers, ease of obtaining new service connection, online payment of bills</li> </ul>	<ul style="list-style-type: none"> <li>Identification of key pain points, needs and expectations of customers</li> <li>Implementation of leading global customer engagement practices in power and utilities</li> <li>Value added services to the consumers such as energy management solutions, smart billing etc.</li> </ul>	<ul style="list-style-type: none"> <li>Digital technologies and app development</li> <li>Consumer awareness</li> <li>Learnings from global best practices</li> </ul>	<ul style="list-style-type: none"> <li>Organizational change management</li> <li>Speed of adoption of technologies by consumer</li> </ul>
Organizational change management	<ul style="list-style-type: none"> <li>Employee engagement initiatives such as: <ul style="list-style-type: none"> <li>Web based employee portal for HR processes, filing of expenses etc.;</li> <li>Early retirement scheme; and</li> <li>Training and knowledge sharing</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Programs for upskilling of employees</li> <li>Improving training facilities</li> </ul>	<ul style="list-style-type: none"> <li>Access to global best practices</li> <li>Employee buy-in</li> </ul>	

# While working towards the sector priorities, there is a need to monitor disruptive trends and plan for actions to be undertaken as these unfold

The above actions have been defined by stakeholders keeping in view the current challenges as well as critical actions required for achieving the Vision 2030.

The power sector also needs to gear up to address market driven and regulatory disruptions (as discussed earlier), as these unfold, to function effectively in the new order. For this, it is important to monitor the key triggers which can provide an advance indication of the likely disruptions and enable the sector to plan necessary actions.

The table below discusses indicative triggers and potential actions which will need to be evaluated further and undertaken.

## Market driven disruptions

### A) High share of renewable energy

**Key trigger to watch out for:** >Dispatch challenges being faced due to high penetration of renewable energy

Sub-sector	Action to be taken
Government / Policy	<ul style="list-style-type: none"> <li>Reduce subsidies and policy incentives for renewable energy in the market</li> <li>Formulate policy and regulatory framework for demand and supply side flexibility measures</li> <li>Allow for pass through of costs for digitalization, flexibilization and network upgradation</li> <li>Drive efficiencies and competition in supply</li> </ul>
Generation	<ul style="list-style-type: none"> <li>Scale up flexibilization efforts for thermal power plants</li> <li>Scale up efforts to encourage hybrids and technologies which allow flexible power generation</li> </ul>
Transmission	<ul style="list-style-type: none"> <li>Conduct studies to understand impact of change in power flow and intermittency</li> <li>Evaluate optimization measures for network augmentation/ operations including storage solutions</li> </ul>
Load dispatch	<ul style="list-style-type: none"> <li>Improve forecasting of renewable energy, enforce deviation settlement mechanism with tightening of tolerance band</li> <li>Scale up measures for grid management using demand and supply side flexibility</li> </ul>

Sub-sector	Action to be taken
<b>Distribution</b>	<ul style="list-style-type: none"> <li>• Determine cost of providing backup power to consumers during non -renewable energy times</li> <li>• Procure renewable energy under flexible hybrid models</li> <li>• Scale up efforts for demand response</li> <li>• Conduct interactions with other distribution companies to share/transfer power purchase agreements of base load stations</li> </ul>

## B) High share of distributed generation sources

Key trigger to watch out for >5% share of overall capacity

Sub-sector	Action to be taken
<b>Government / Policy</b>	<ul style="list-style-type: none"> <li>• Market mechanisms paired with regulatory incentives that reward distributed resources where it is most valuable for the system (Feed in tariff, VGF etc.)</li> <li>• Support policies and regulatory framework which support the growth of distributed renewable energy, at the same time, seek to soften the impact on distribution companies in terms of the recovery of sunk costs</li> <li>• Enable new roles for distribution companies</li> <li>• Enable open standards for communication infrastructure of distributed energy resources</li> </ul>
<b>Generation</b>	<ul style="list-style-type: none"> <li>• Measures to achieve higher efficiencies as well as flexible generation</li> </ul>
<b>Transmission</b>	<ul style="list-style-type: none"> <li>• Evaluate impact on network planning and utilization and undertake measures to achieve higher cost efficiencies</li> </ul>
<b>Load dispatch</b>	<ul style="list-style-type: none"> <li>• Employ better technology to support visibility and forecasting of renewable energy or evaluate alternative structures such as distribution system operators to be able to manage the grid locally and integrate with SLDC</li> </ul>
<b>Distribution</b>	<ul style="list-style-type: none"> <li>• Improve the settlement and accounting procedures to manage multi-directional power flows from prosumers for eg. P2P transactions</li> <li>• Develop mechanisms to retain consumers through better customer engagement and value added services etc</li> <li>• Evaluate utility led models for solar rooftop</li> </ul>

### C) High share of electric vehicles

**Key trigger to watch out for:** >10% new sales; Utilization of benefits before expiry of electric vehicle policy

Sub-sector	Action to be taken
<b>Government / Policy</b>	<ul style="list-style-type: none"><li>• Introduce time of day tariff for electric vehicle charging to flatten the load curve</li><li>• Evaluate vehicle to grid (V2G) as a demand response measure for peak load management</li><li>• Provide policy based incentives to encourage development of charging infrastructure and reduction of cost of chargers</li><li>• Develop regulations for new business models to facilitate the scale up of utility led models for EV charging</li></ul>
<b>Generation</b>	<ul style="list-style-type: none"><li>• Support growth of demand with dynamic increase in supply through clean energy sources</li></ul>
<b>Transmission</b>	<ul style="list-style-type: none"><li>• Support additional loads with infrastructure upgrade</li></ul>
<b>Load dispatch</b>	<ul style="list-style-type: none"><li>• Build tools and competencies to manage power system in an increasingly complex grid environment and facilitate demand response solutions</li></ul>
<b>Distribution</b>	<ul style="list-style-type: none"><li>• Support growth of distributed renewable energy based chargers</li><li>• Support additional loads with infrastructure upgrade</li><li>• Conduct study for optimal placement of chargers and maximum utilization</li><li>• Evaluate utility led models for EV charging</li></ul>

## D) Decrease in cost of storage

**Key trigger to watch out for:** Cost of storage <USD 125/kwh; Supporting central policy announcements

Sub-sector	Action to be taken
<b>Government / Policy</b>	<ul style="list-style-type: none"><li>• Create policy and regulation to enable use of storage products at various levels in the value chain</li><li>• Provide policy incentives to support large scale manufacturing of storage products in the state</li><li>• Determine market structure (feed in tariff, viability gap funding, time of day tariff etc.) for integration of storage backed sources of power into the grid</li></ul>
<b>Generation</b>	<ul style="list-style-type: none"><li>• Retrofit old renewable energy plants with appropriate storage capacity</li><li>• Install new renewable energy projects with storage capacity</li></ul>
<b>Transmission</b>	<ul style="list-style-type: none"><li>• Study potential change in power flow and revenue to the transmission utility</li></ul>
<b>Load dispatch</b>	<ul style="list-style-type: none"><li>• Build tools and competencies to manage power system optimizing the storage capacities present across various parts of the value chain</li></ul>
<b>Distribution</b>	<ul style="list-style-type: none"><li>• Scale up deployment of storage at different levels for improving reliability, cost and quality of supply</li><li>• Enhance load forecasting capabilities</li><li>• Study potential change in power flow and revenue to the distribution company</li><li>• Evaluate new business models such as utility driven energy management services etc.</li></ul>



## Regulatory driven disruptions

### A) Carriage and content separation

Key trigger to watch out for: Amendment to the Electricity Act, 2003

Sub-sector	Action to be taken
<b>Government / Policy</b>	<ul style="list-style-type: none"><li>• Develop policy and regulatory frameworks as well as model documents to support utilities in implementing the amendments</li><li>• Develop a clear plan for transition to market based mechanism</li></ul>
<b>Generation</b>	<ul style="list-style-type: none"><li>• Retrofit plants to enable flexible generation from thermal plants</li><li>• Set stringent efficiency targets to reduce cost of generation and become competitive in the new market</li></ul>
<b>Transmission</b>	<ul style="list-style-type: none"><li>• Increase adoption of digital technologies to facilitate power flows and strengthen grid framework</li></ul>
<b>Load dispatch</b>	<ul style="list-style-type: none"><li>• Develop infrastructure and backend system to manage power flow and accounting of sales</li></ul>
<b>Distribution</b>	<ul style="list-style-type: none"><li>• Re-allocating existing PPAs as per evolving mechanisms</li></ul>

## B) New market design

**Key trigger to watch out for:** Adoption of new market design framework at the centre

Sub-sector	Action to be taken
<b>Government / Policy</b>	<ul style="list-style-type: none"><li>· Develop frameworks to align to the overall market design</li><li>· Develop a mechanism to address current cross-subsidy structure</li></ul>
<b>Generation</b>	<ul style="list-style-type: none"><li>· Develop strategy and tools for operating in a new market environment</li><li>· Develop infrastructure to enable participation in providing ancillary services</li><li>· Employ better forecasting tools for renewable energy generators</li></ul>
<b>Transmission</b>	<ul style="list-style-type: none"><li>· Develop mechanisms for cost reflective pricing for transmission projects</li></ul>
<b>Load dispatch</b>	<ul style="list-style-type: none"><li>· Deploy better tools and capabilities for managing the increased complexity in system operations</li></ul>
<b>Distribution</b>	<ul style="list-style-type: none"><li>· Use digital technologies and data analytics for effective participation in new market mechanisms</li></ul>

## An ongoing monitoring mechanism must be developed to keep the power sector vision relevant and effective

Ongoing measures need to be monitored, evaluated and consolidated to identify the future course including the need for their modifications and enlargement. Adoption of any new measure, its pace and sequence should be governed by pragmatism, usefulness and most importantly, by the goals set out at the beginning. A few of the key steps which could be undertaken to keep the power sector vision relevant and effective are:



The power sector of Maharashtra needs to continue to play a critical role in supporting the economic growth of the state. As the sector moves forward in a challenging environment, it is expected that stakeholders will work together as envisaged in the Power Sector Vision 2030 document, in helping the sector achieve its' aspirations to become one of the most sustainable, progressive and consumer oriented power sectors, which strongly supports the socio-economic growth of Maharashtra.

# Annexure: Key achievements and challenges for the power sector in Maharashtra

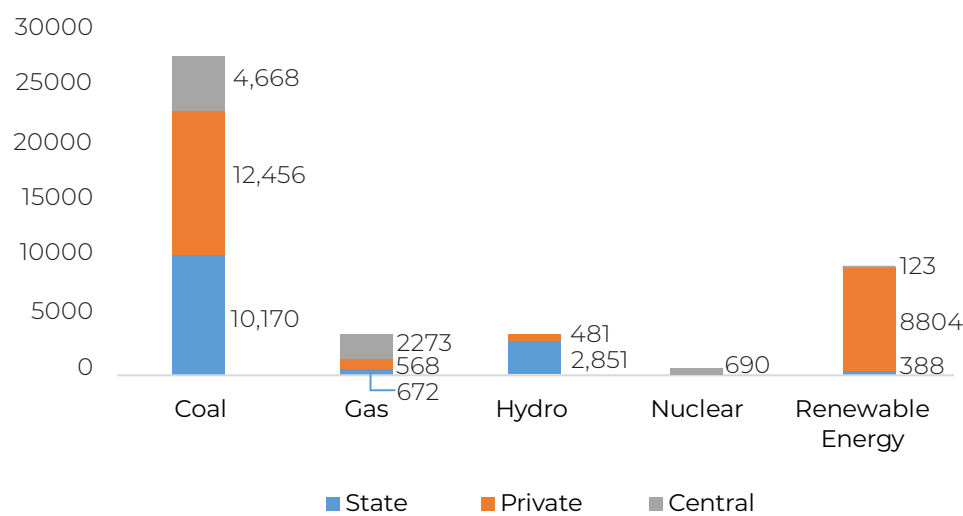
The power sector in Maharashtra has been evolving at a fast pace. Supported by enabling policy and regulatory measures, each of the generation, transmission and distribution segments has implemented various measures to increase access, reliability, reduce costs and serve the consumer better.

## Generation

Maharashtra has the largest installed capacity in India of 44,143 MW<sup>6</sup>. The state owned generation utility, Mahagenco, is the largest public generating company in India with an installed base of 14,080 MW (Figure 7). Nearly 50 percent of the total capacity in Maharashtra is owned and operated by private utilities.

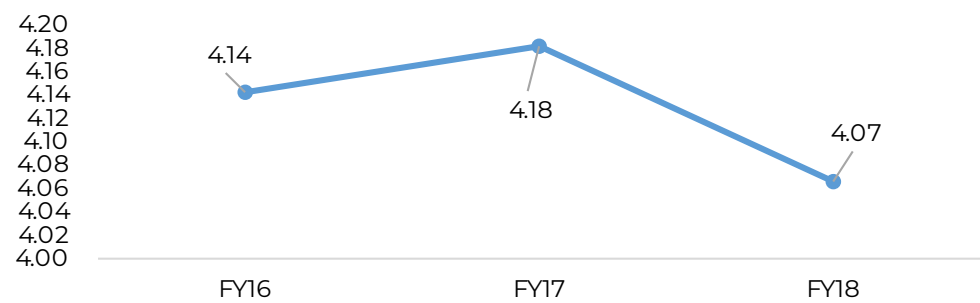
### Achievements

Figure 7: Overall installed capacity breakup - Maharashtra (MW)



Source: Central Electricity Authority

Figure 8: Average cost of generation for Mahagenco



Source: Mahagenco annual reports

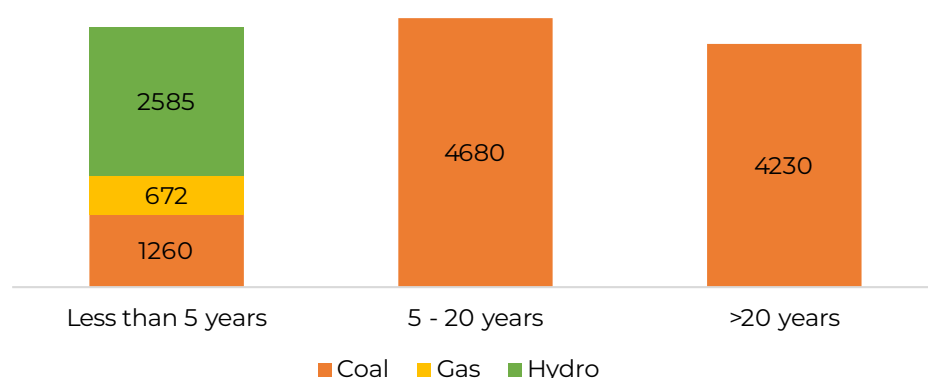
<sup>6</sup> Central Electricity Authority, April 2019



- Maharashtra has the third highest renewable energy capacity in a state in India with a cumulative 9,332 MW forming 21% of the total capacity (Figure 7).
- Overall average cost of generation of power from Mahagenco power plants (Figure 8) has reduced due to measures such as efficiency in coal logistics and planning (including coal swapping between plants), improvements in station heat rate and reduction in auxiliary consumption.
- Mahagenco has replaced smaller old capacities with larger capacities and modern technologies over the past few years.
- Mahagenco has also undertaken steps to diversify their product portfolio by developing pilots in new generation technologies such as floating solar, hydroponic, solar power plants on vacant land at thermal power plants.
- Further, many private generators have adopted measures to realize efficiencies and continue to make investments in business process transformation initiatives, digital tools and technologies including data analytics, artificial intelligence and machine learning, for achieving better efficiency, costs savings, and improved uptime.

## Challenges

*Figure 9: Remaining life of Mahagenco power plants (on 1st April, 2019) in MW*



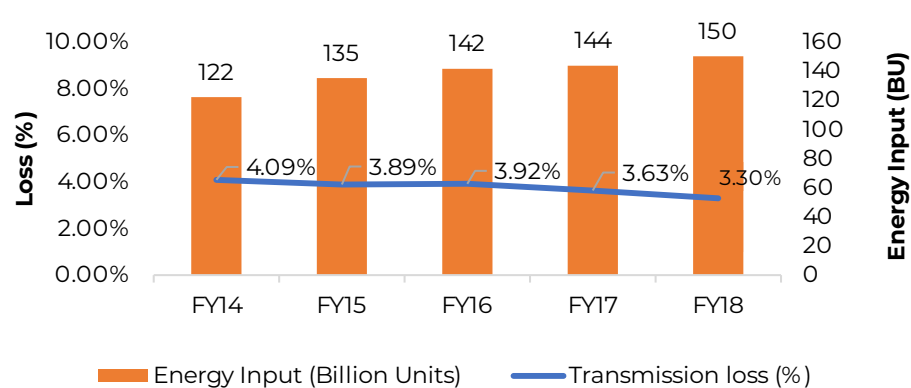
Source: Mahagenco annual reports

- About 4,200 MW (Figure 9), of Mahagenco's installed capacity has a remaining useful life of less than 5 years which require investments in order to comply with new environmental norms as well as to work efficiently.
- Embedded private generation capacity of 2,377 MW in Mumbai is close to the end of its useful life. Suitable replacements would need to be identified while considering the transmission constraints of procuring power from outside Mumbai.

## Transmission

Maharashtra's transmission network currently stretches over 46,217 circuit km and has a transformation capacity of over 1,23,846 MVA and 660 substations. The network is operated by the state's transmission utility, Mahatransco, which is also the largest state owned transmission utility in India.

Figure 10: Historical power transmitted and transmission loss for Mahatransco



Source: Mahatransco

Key achievements of the utility over the past few years are:

- Investments of over INR 7,700 crores in network development over the past 5 years with real-time visualisation of network and power flow.
- Reduction of the transmission loss in its system over the years despite the increase in power transmitted through its network (Figure 10).

## Challenges

- Efficient planning for transmission to avoid stranding of assets and to enable efficient power flows and dispatch.
- Constraints in sourcing of power for Mumbai from outside as the available transfer capacity of the intra-state transmission network connecting Mumbai is less compared to the demand.
- Reduction of overall costs of transmission and improvement of operational efficiencies to improve cost effectiveness of power supply to the consumer.
- Reduction of redundancies in the system through automation of power flows in the network.

## Distribution

Maharashtra has one of the largest consumer bases in India with the largest number of agricultural consumers (~42 lakh). The distribution sector consists of the state owned distribution licensees MSEDCL and BEST and private distribution licensees Tata Power and Adani Electricity which operate in Mumbai. It is the first state in the country with competition in the distribution sector where distribution licensees operate in parallel in Mumbai to serve the same set of consumers.

## Achievements

- Demand supply deficit for the state has been reduced to almost 0% since FY 16.
- Overall AT&C losses for MSEDCL has reduced by 50% from a total of ~35% in 2005 to ~17% in 2018 through initiatives including feeder segregation, metering, energy audits, implementation of distribution franchisee model (in Bhiwandi & Nagpur), etc.
- Mahadiscom has adopted power cost optimization measures such as zero scheduling, banking of surplus power with other utilities, competitive RE procurement, petitioning for technical minimum reduction of state genco plants, etc.

- Several steps have been undertaken by MSEDCL for improving consumer experience (including mapping of more than 85% of mobile numbers of over 2.5 crore consumers), consumer centric IT initiatives such as omni-channel consumer touch points (such as mobile app, social media, facilitation centres), etc.
- Steps have been undertaken to increase operating efficiencies through adoption of digitalization measures such as centralised billing and collection, online vendor payments, online cash collection service, automated metering for high value HT and LT consumers, meter reading for LT consumers using mobile app etc.
- Private distribution companies are adopting digital technologies across network planning, asset deployment and management, grid operations, revenue management, energy audits and customer management to bring efficiency, improve up time, reduce cost and improve customer experience.

### Challenges

- Retention of subsidizing consumer base of industrial and commercial consumers is a concern.
- Reduction in AT&C losses in rural areas, especially through better collection efficiency, remains a challenge.
- While Mahadiscom needs to continue to undertake measures to improve operational efficiencies and reduce costs, the reduction of power purchase cost which is a key cost constituent is also interdependent on the efficiencies achieved in the entire power sector value chain.
- For Mumbai based distribution companies, efficiency and cost of network maintenance and reduction in downtime continue to remain a challenge owing to the underground cabling in Mumbai. Further, their ability to decrease power purchase costs is constrained owing to intra-state transmission bottlenecks.

## List of Stakeholders

During the course of development of this document the following stakeholders were consulted:

1. Energy Department, Government of Maharashtra
2. Maharashtra State Power Generation Company Limited (MSPGCL)
3. Maharashtra State Transmission Company Limited (MSETCL)
4. Maharashtra State Electricity Distribution Company Limited (MSEDCL)
5. Maharashtra State Load Dispatch Centre (MahaSLDC)
6. Maharashtra Energy Development Agency (MEDA)
7. Brihanmumbai Electric Supply and Transport (BEST)
8. Maharashtra Electricity Regulatory Commission (MERC)
9. Private power generation companies in Maharashtra
10. Private power distribution companies in Maharashtra
11. Transport Department, Government of Maharashtra
12. Prayaas (Energy group) – Consumer forum
13. Nuclear Power Corporation of India Limited (NPCIL)

© 2006 The Authors  
Journal compilation © 2006 Blackwell Publishing Ltd



