Transmission Resource Adequacy for Maharashtra

MAHATRANSCO
Maharashtra State Electricity Transmission Co. Ltd.
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Presentation for

Capacity Building Workshop on Resource Adequacy for Maharashtra

05 December 2024

Contents

Overview of RA

- Need for RA
- MERC RA Regulations
- Role of STU

Need for RA (1/3)

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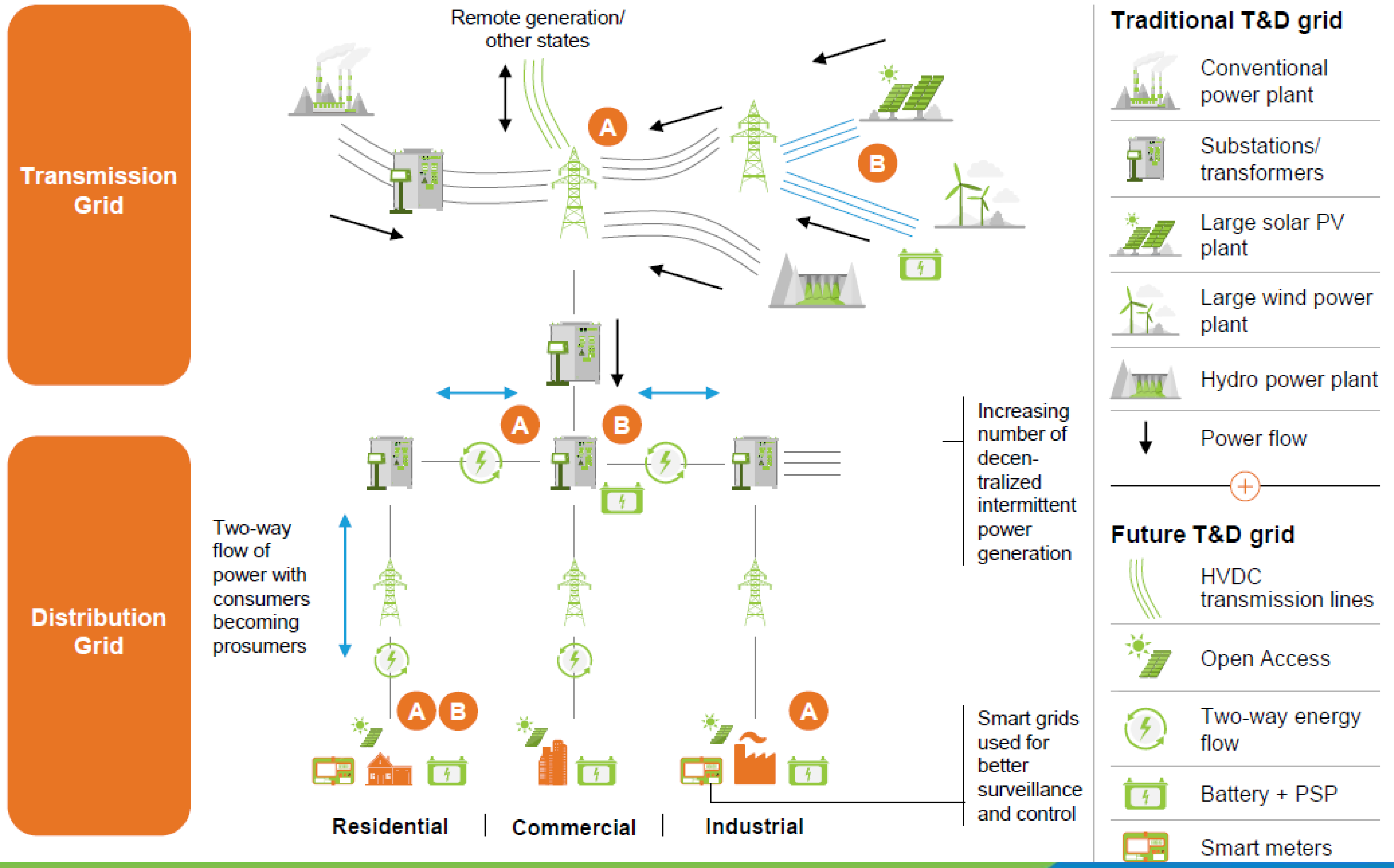
Traditional and future T&D power grid

Illustrative



Key complications for RES integration into power grids:

A. Network inadequacy resulting in lack of capacity for new supply / demand connections due to difficulties to optimize current grid capacity and inefficient grid planning

B. Network instability due to supply-demand imbalances, fluctuations of reactive power creating voltage instability and harmonic distortion of power system impacting frequency consistency

Need for RA (2/3)

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Challenge	Description	Impact on power system
Network inadequacy	**Lack of physical network capacity** for new supply and demand connections (i.e., substations connection capacity) **Inability to optimize current grid capacity due to inefficient grid setup** (i.e., fossil generation-oriented grids) and **operational bottlenecks** **Limited efficiency in building new grid capacity** due to **inefficient grid planning** and ineffective CapEx execution	**Longer lead times** for supply and demand **connections**, **incl. long permitting processes** for granting new grid connections **Curtailments of renewables** power output **Increased development cost** of renewable projects **Delayed phase-out** of emitting technologies (i.e., coal)
Network instability	Increasing **penetration of intermittent power sources** (e.g., solar, wind) causing **voltage variability, frequency fluctuations** and **harmonic distortion** of power system ("electrical pollution") **Decreasing ability to stabilize** the system due to **phase-out of current balancing assets** (e.g., thermal generation)	Increasing need for complex **balancing services** (incl. ancillary services) Need for restructuring of **coordination process** within custodians of energy systems (TSOs/DSOs) Potential **imbalances penalties** **Curtailment of distribution-connected** generation More **complex grid operation**

Need for RA (3/3)

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- Renewable Energy (RE) capacity in Maharashtra has grown from 21% in FY19 to 31% in FY24 and Maharashtra now has the 4th highest RE capacity in the country.
- This trend is projected to continue, with peak demand and energy requirement also projected to grow in coming years.
- Such energy transition can bring with it several challenges from unavailability during peak periods and increasing system ramping needs to network inadequacy and network instability.
- There is urgent need for adopting a comprehensive approach that would plan for meeting peak demand at all times while also optimizing resources among discoms and states.
- In this regard, Resource Adequacy (RA) is an important framework and is defined as:
    - *A mechanism to ensure adequate supply of generation to serve expected demand (including peak, off peak and in all operating conditions) reliably in compliance with specified reliability standards for serving the load with an optimum generation mix with a focus on integration of environmentally benign technologies after taking into account the need, inter alia, for flexible resources, storage systems for energy shift, and demand response measures for managing the intermittency and variability of renewable energy sources.*

MERC RA Regulations (1/2)

- In light of MoP's mandate to SERCs for notifying RA Regulations in accordance with CEA Guidelines and FoR Model Regulations, MERC notified its Regulations in June 2024.
- Objective:
  - Enable the implementation of Resource Adequacy framework by outlining a mechanism for planning of generation and **transmission** resources for reliably meeting the projected demand in compliance with specified reliability standards for serving the load with an optimum generation mix.
  - Provided that the planning of transmission resources shall be consistent with "MERC (State Grid Code) Regulations, 2020" and amendments thereof.
- Resource Adequacy framework entails the planning of generation and **transmission** resources for reliably meeting the projected demand in compliance with specified reliability standards for serving the load with an optimum generation mix.

MERC RA Regulations (2/2)

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- Obligated Entities:
  - Generating companies, distribution licensees, State Load Despatch Centre, **State Transmission Utility**, full transmission Open Access participants, and other grid connected entities and stakeholders within Maharashtra.
  - Provided that distribution licensees shall consider demand of partial open access consumers while forecasting their demand for RA planning.
- Key Steps:
  - Demand forecasting and assessment
  - Generation resource planning
  - Procurement planning
  - Monitoring and compliance

Roles and Responsibilities of STU (1/2)

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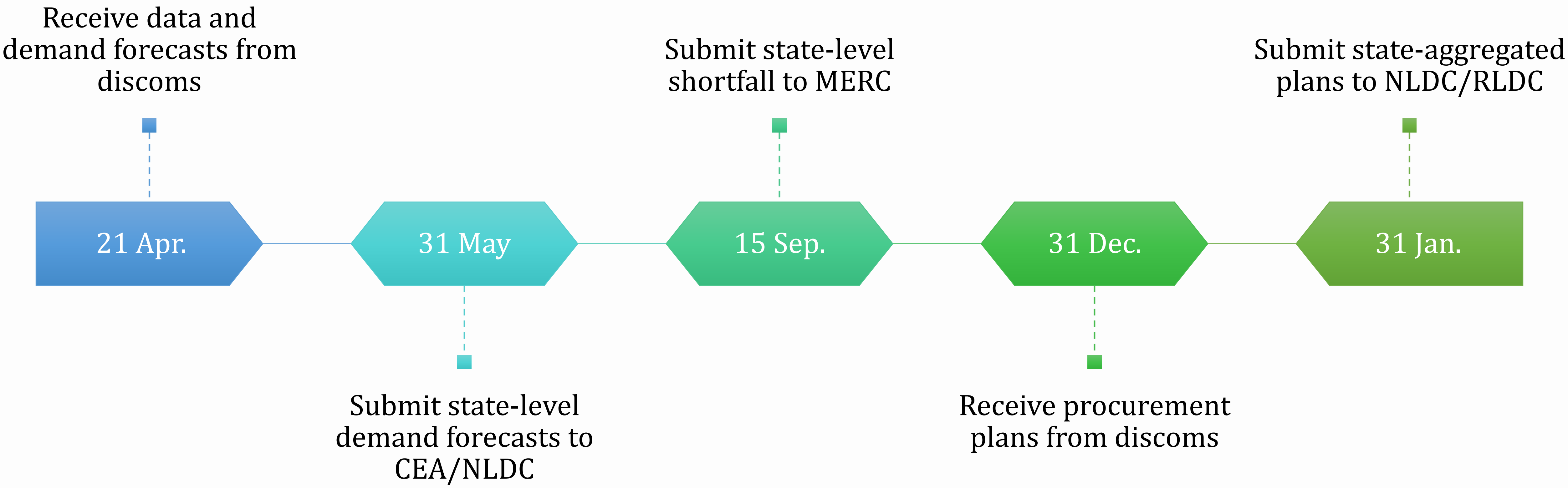
Step	Roles and Responsibilities
Demand assessment and forecasting	• **(Reg. 6.3)** Discoms to provide category-wise data and forecasts to STU by 21st April • **(Reg. 7.5)** STU with inputs from SLDC and based on forecasts by discoms to develop forecast for entire state and submit to CEA/NLDC by 31st May
Generation Resource Planning	• **(Reg. 12.8)** Based on LT-NRAP and avg. of share of discom in state CPD and state NCPD, STU to allocate RA requirement to discom • **(Reg. 19.1)** STU to submit state-aggregated shortfall in RA plan to MERC by 15th September
Procurement Planning	• **(Reg. 15.1)** Discom to consider transmission constraints and costs while determining optimal procurement mix and STU to declare available transmission corridor on web portal • **(Reg. 15.4)** Discoms to consult with STU while developing procurement plan, and STU to verify the plan for consistency with transmission plan • **(Reg. 15.11)** Discoms to submit annual rolling plan to STU by 31st December • **(Reg. 15.12)** STU to submit stage-aggregated RA plans to NLDC/RLDC by 31st January • **(Reg. 16.3)** STU to provide inputs to MERC during approval of RA plans

Roles and Responsibilities of STU (2/2)



On-going Actions

- Planning Framework
- Demand-Supply Hotspots
- Demand Forecasting
- RE Corridors

Planning Framework

	Description	Purpose	Sub-station voltage	Status
Layer 1	High-voltage transmission network	Long distance connection between generation and load sub-stations	765kV ISTS 400kV ISTS 400kV MSETCL	Completed for 10 districts (75% of 2030 peak demand)
Layer 2	Low-voltage transmission network	Short distance connection between generation/ source sub-station and distribution sub-stations	220kV MSETCL 132kV MSETCL 100/ 110kV MSETCL 66kV MSETCL	Exemplary work done for Pune district
Layer 3	Distribution network	Last mile connectivity between distribution s/s and end customer	33kV MSEDCL	Top-down estimates for requirements completed

Key Demand Drivers (1/3)

- Key drivers of Growth by five main drivers
  - Datacenters
  - Metro Projects
  - Green hydrogen
  - PSPs
  - Load shift due to agriculture.
- Nature of load curve expected to change with higher daytime requirement due to agri-solarization, incentivization for off-peak consumption due to ToD tariffs during peak solar hours, unforeseen shocks due to climate change
- Catering to this load would need a mix of long-term and short-term capacity contracting
- By 2030, MH needs 80-85 GW total contracted assets; across 30-32GW thermal, 45-50GW RE; supported by 50-60GWh LDES; with addl. short term contracting for emergency scenarios.
- Additionally, 130-150K MVA T&D network needs to be instituted connecting load centers to supply centers and end customers; while ensuring higher grid stability measures are taken across generation, transmission, and distribution value chain.

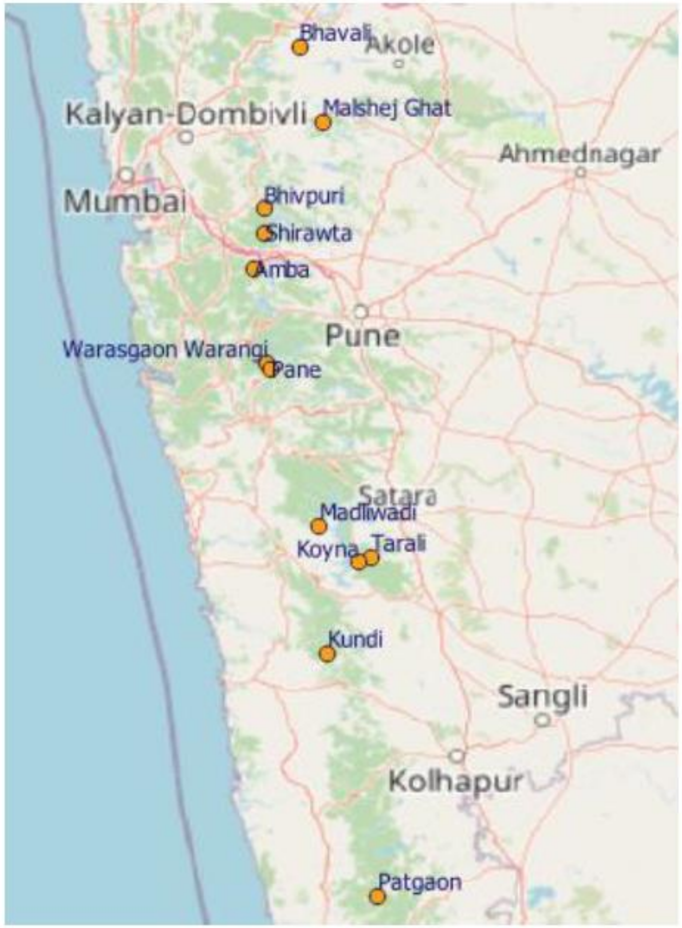
Key Demand Drivers (2/3)

Data centers

Current DC locations

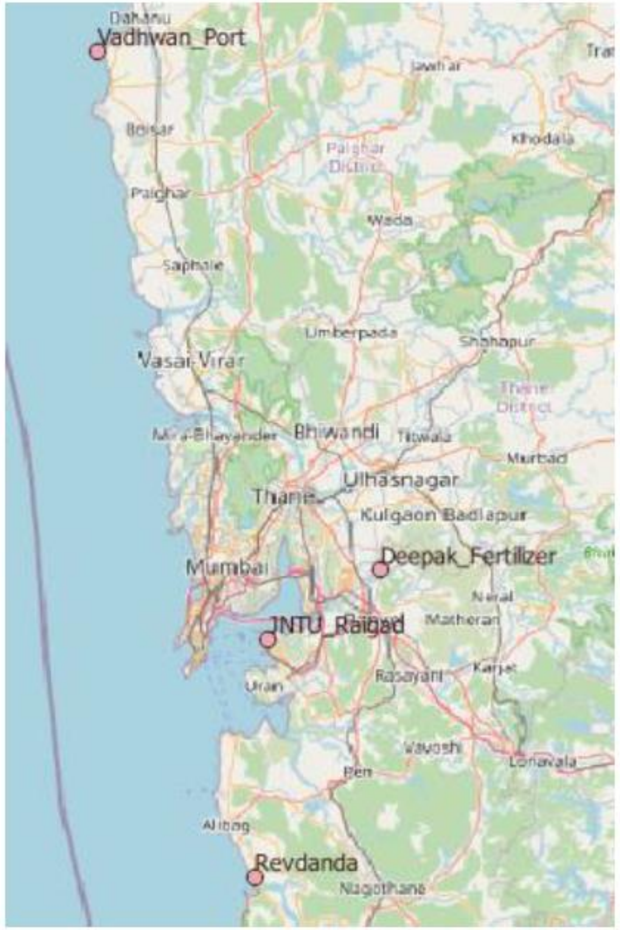
Pumped Hydro storage

Potential locations of PSP



Green Hydrogen

Potential ports for Green H2



Key Demand Drivers (2/3)

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Type of Load	Peak Demand	Agri. Shift	Green Hydrogen	Pump Storage Plants	Data Centres	TOTAL
State Demand (MW)	42,042	5,000	9,000	6,250	7,000	**69,282**

Demand Projections

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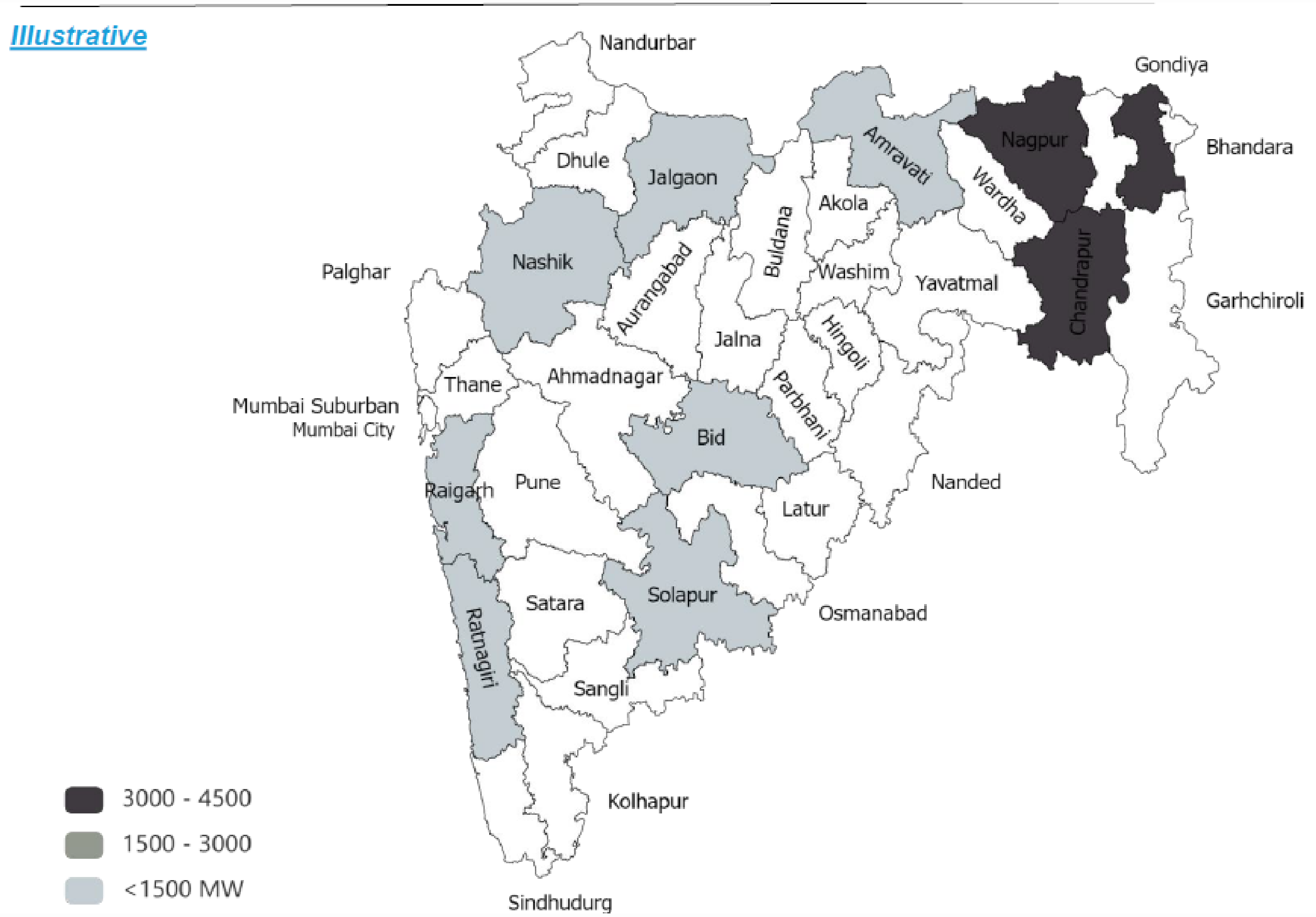
Illustrative

District	Current peak	Peak load in 2030			Internal InSTS generation		Current transmission capacity at (n-1) level			Planned transmission capacity at (n-1) level			Additional unplanned transmission capacity needed		
		Scenario 1: Linear growth + Applications	Scenario 2: Additional data centre growth	Scenario 3: PSP + Green H2 growth	Current	Planned	ISTS	InSTS	Other	ISTS	InSTS	Other	Scenario 1: Linear growth + Applications	Scenario 2: Additional data centre growth	Scenario 3: PSP + Green H2 growth
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)=(C*1.2)-(F+G)-(H+I+J+K+L+M)	(O)=(D*1.2)-(F+G)-(H+I+J+K+L+M)	(P)=(E*1.2)-(F+G)-(H+I+J+K+L+M)
Mumbai	4,000	6,200	6,700	6,700			750	1500	447	500	2500	1000	743	1,343	1,343
Thane	2,366	5,500	6,800	6,800			0	2275		2,000	2600		-275	1,285	1,285
Raigarh	1,099	1,800	1,800	12,750			0	630		315	500		715	715	13,855
Palgarh	991	1,500	1,500	1,500			380	0		850	400		170	170	170
Pune	3,342	6,100	6,100	7,600			315	2610		1,750	500		2,145	2,145	3,945
Nashik	1,552	2,700	2,700	2,700	433	57	100	840	0	0	1250	0	560	560	560
Ahmednagar	1,301	2,000	2,000	2,000	128	39	0	1395	0	0	500	0	338	338	338
Nagpur	1,042	1,800	2,300	2,300	630	84	0	1065	0	0	0	0	381	981	981
Aurangabad	988	2,240	2,240	2,240	89		500	880	0	0	250	0	969	969	969
Jalna	530	1,000	1,000	1,000			0	500	0	0	250	0	450	450	450
Chandrapur	377	610	610	610	100	32	0	815	0	0	0	0	-215	-215	-215

Reliability factor = 20%

Demand-Supply Hotspots (1/2)



- **Load and generation hotspots** are co-incidental for Nashik, Raigarh and Nagpur
- **Generation hotspots with excess generation** are concentrated towards Eastern coast – Nagpur, Gondiya and Chandrapur
- Other **generation hotspots** are located in Jalgaon, Beed and Solapur which are close to at least one demand hotspot (e.g. Solapur to Pune)
- Hence, **East-to-West transmission corridors connect demand and supply centers in MH currently**

Demand-Supply Hotspots (2/2)

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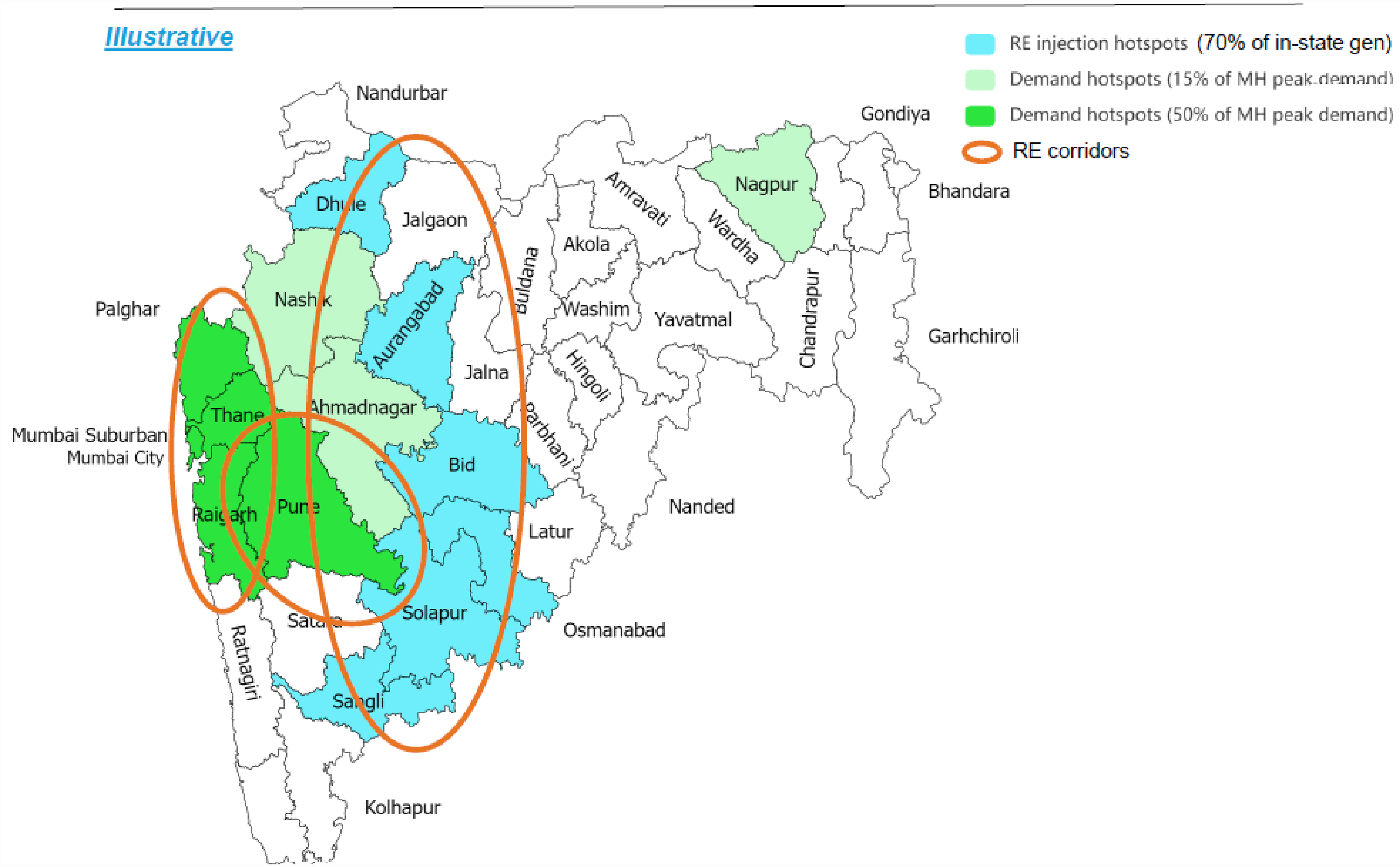
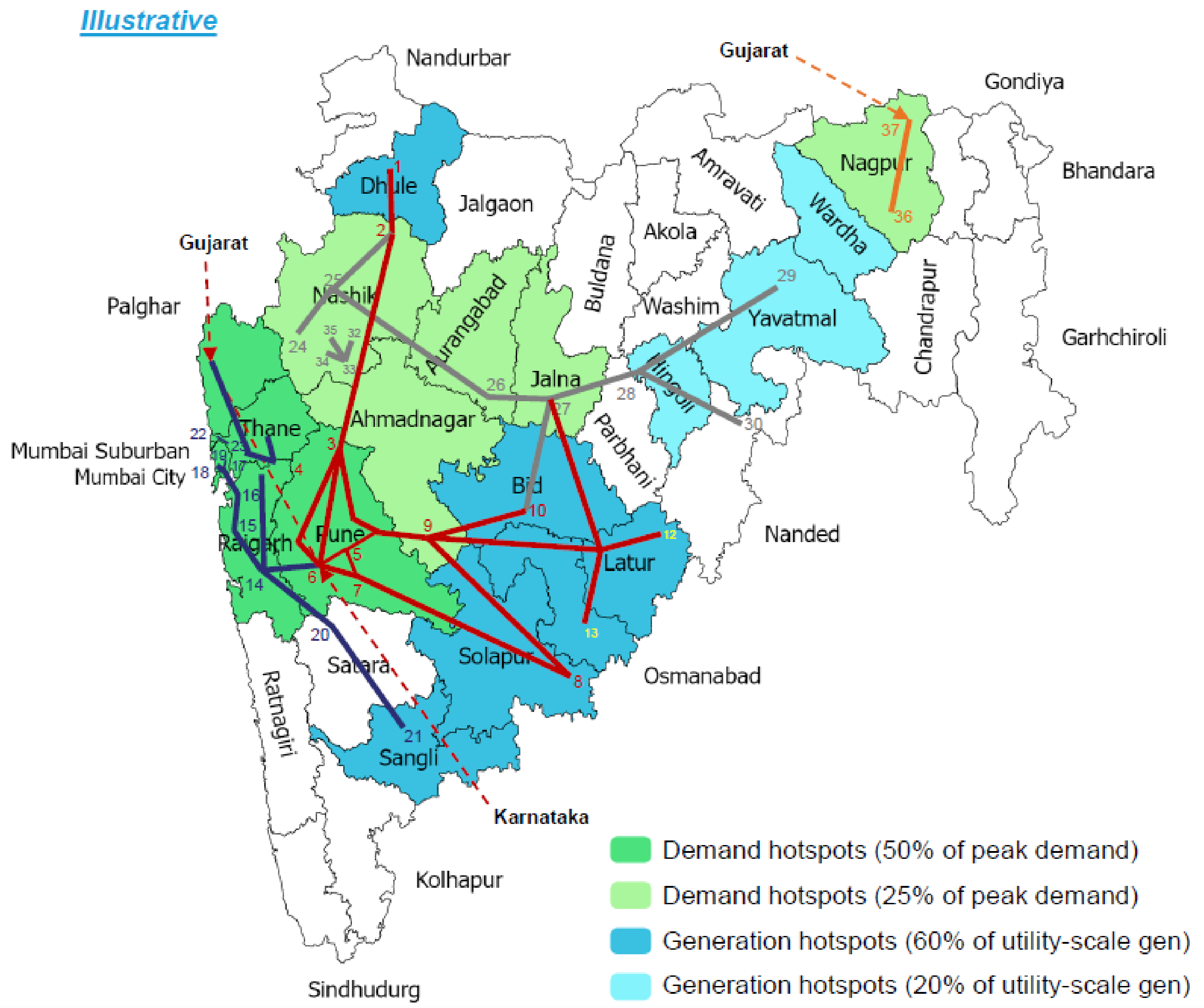


- **Load and RE supply are expected to come in separate districts** in Maharashtra in the coming years
- **Demand hotspots like Mumbai, Pune and Thane are not fully connected to the supply centers** per current transmission network
- On the other hand, **RE injection hotspots are expected to be supply surplus** with lower demand increase
- Hence, **North-to-South RE corridors can connect the two hotspots making Maharashtra future-proof**

RE Corridors



S. No.	Load hotspot(s)	Additional load catered (MW)	Source(s)	Source (MW)
1	Pune	3,000	Dhule	1,500
	Ahmadnagar	500	Beed	1,000
			Solapur	1,000
2,3	Mumbai S/U	2,000	Sangli	1,500
	Raigarh	1,000	Pune III*	1,000
	Palghar	500	Boisar (Guj)	1,000
4,5	Nashik	1,000	Hingoli	1,000
	Aurangabad	1,000	Yavatmal	500
	Jalna	500	Nanded	500
			Nashik IPP	500
6	Nagpur	1,000	HVDC ISTS	1,000
7	Karjat	500	Latur	500
	Jalna	500	Osmanabad	500

Transmission Adequacy Study

- Overview
- Zonal Configuration
- Planned Expansion
- Key Takeaways

Importance of Transmission Adequacy

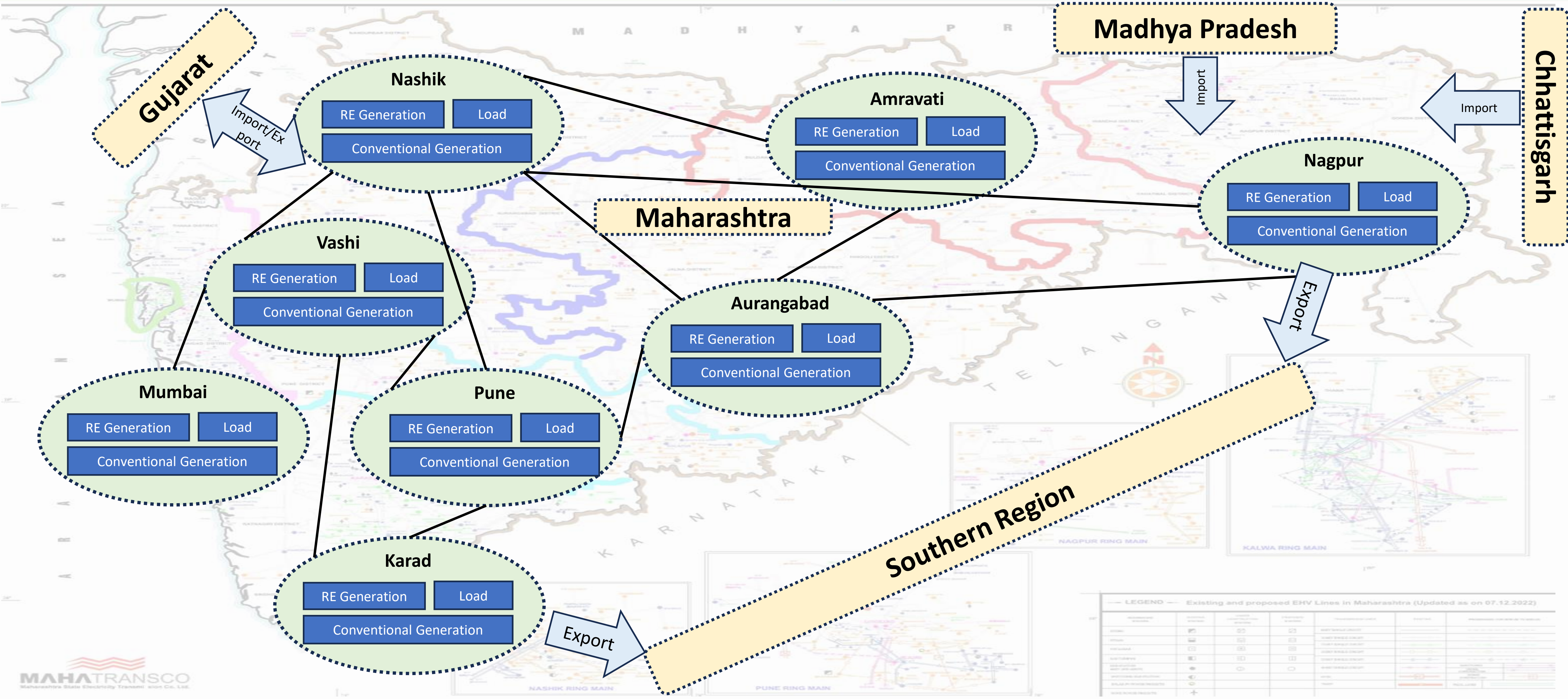
- It is important to ensure that generation resource planning under RA is consistent with transmission network and planning
- Through transmission adequacy studies, following questions can be addressed:
  - Based on generation capacity contracted by the state discoms, what will be the optimal generation capacity to meet projected demand till 2030?
  - What will be the associated dispatch in hourly time frame?
  - Will the existing/proposed 400 kV and 765 kV transmission network be adequate/surplus/deficit to evacuate this generation and dispatch?
- Transmission adequacy studies can be carried out via DC load flow analysis of eqvt. 400 kV and 765 kV network to identify constrained transmission corridors followed by detailed AC load flow analysis of the constrained corridors.
- DC load flow analysis of eqvt. 400 kV and 765 kV network of MH has been carried out for base year (FY23), terminal year (FY30), and interim year (FY27) to identify need for transmission expansion.

Overview of Transmission Adequacy Study for MH

- Approach and methodology:
  - Representation of MH into 8 transmission zones
  - For each zone, mapping of existing and contracted generation sources (with hourly RE generation pattern) and demand projections (with hourly demand pattern)
  - Mapping of zone-to-zone transmission corridors
  - Simulating hourly LGB for each zone along with impact on corridor flows
  - Identifying constrained corridors
  - Recommendations and way forward
- Conducting above analysis for various scenarios

- Scenarios considered:
  - Base (20^{th} EPS projections)
  - MSKVY capacity addition
  - Agricultural load shift
  - Data center load
  - Green hydrogen load
- Data requirement:
  - Generation resources with technical and financial characteristics, incl. hourly RE generation profile, with zonal mapping
  - Hourly demand profile and future projections for each zone
  - Corridor and ISTS flows

Zonal Configuration



Planned Transmission Capacity Additions

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From Zone	To Zone	Voltage Level	Expected Commissioning Year	Number of Lines	Capacity (MW)
Amravati	Aurangabad	400kV	FY29	2	4,320
Aurangabad	Pune	400kV	FY28 & 29	4	8,640
Aurangabad	Pune	765kV	FY28	2	8,000
Karad	Pune	765kV	FY28	2	8,000
Nashik	Pune	400kV	FY28	2	4,320
Nashik	Vashi	765kV	FY28	1	4,000
Pune	Vashi	400kV	FY29	2	4,320
Pune	Vashi	765kV	FY27, 28 & 29	6	24,000
Vashi	Mumbai	HVDC 400kV	FY27 & 29		6,500

Key Takeaway: Most Critical Corridors

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Most Critical	Limited Augmentation	No Augmentation
• Nashik-Pune in FY27 • Nashik-Vashi in FY27 • Vashi-Mumbai in FY27 • Karad-Vashi in FY30 Agrishift	• Nagpur-Nashik in FY30 Agrishift • Amravati- Nashik in FY30 Agrishift • Aurangabad-Vashi in FY30 Agrishift+DC+GH	• Amravati-Aurangabad • Nagpur-Amravati • Aurangabad-Nashik • Karad-Pune • Nagpur-Nashik • Pune-Vashi • Vashi-Nashik

With Data Centre and Green Hydrogen Loads, it is suggested to carry out detailed Resource Adequacy studies of both Generation and transmission system as it impacts all the inter-zonal flows

Key Takeaway: Most Critical Zone

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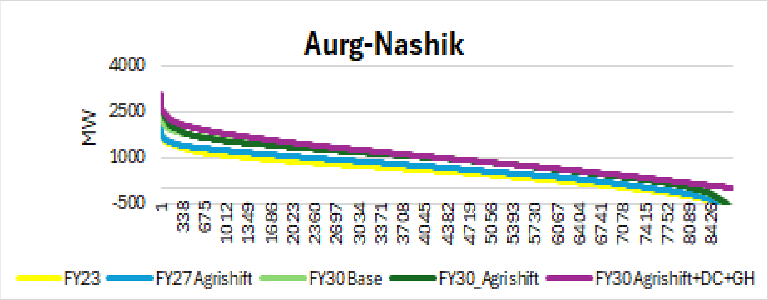

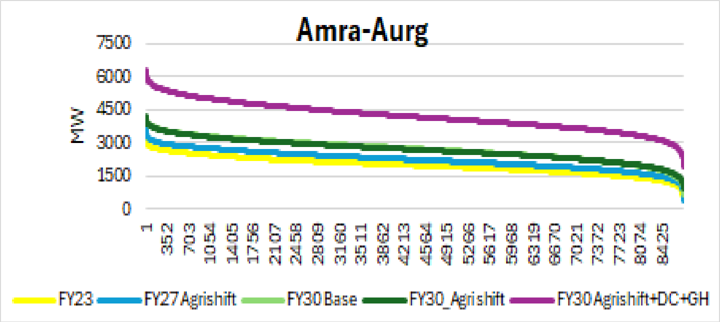

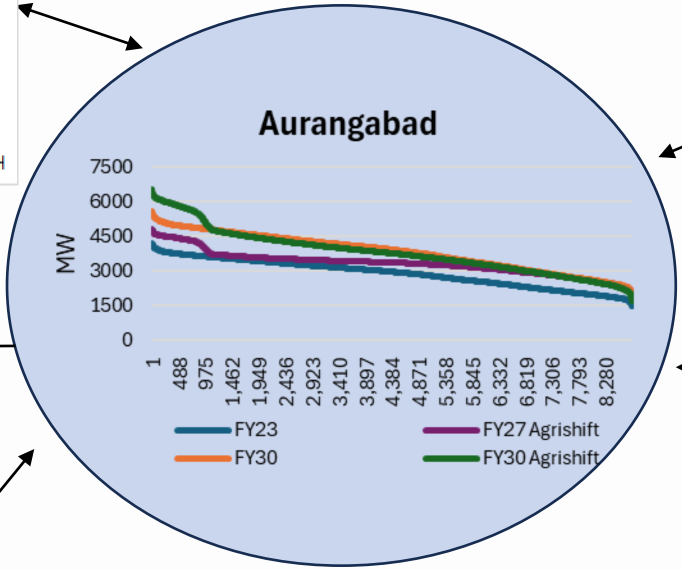

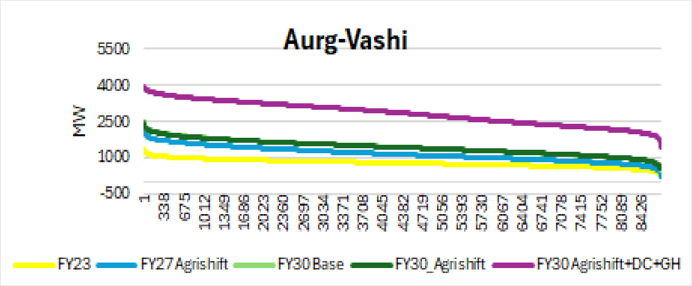

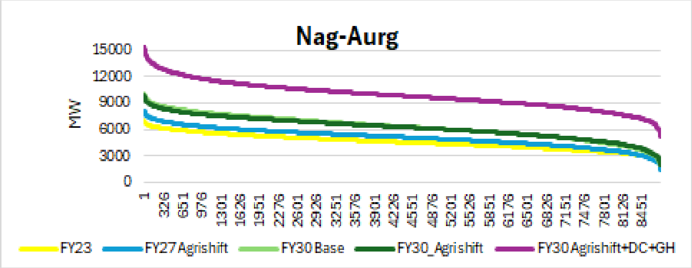

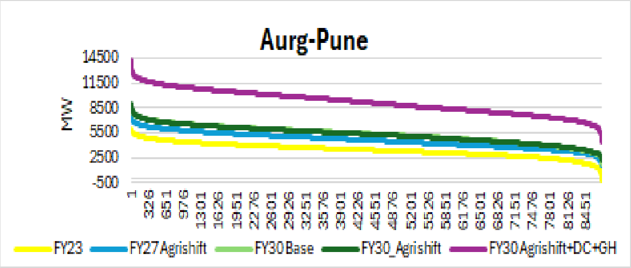

Installed Capacity in Zone (MW)				
Aurangabad	FY23	FY27 Agrishift	FY30 Base	FY30 Agrishift
Solar	1,135	7,241	7,241	7,241
Wind	659	2,368	2,368	2,368
Biomass	511	511	511	511
Hybrid		375	375	375
Coal	750	750	750	750

Recommended Way Forward

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From Zone	To Zone	Voltage Level	Expected Commissioning Year	Number of Lines	Capacity (MW)	Recommendation
Amravati	Aurangabad	400kV	FY29	2	4,320	Continue with plan
Aurangabad	Pune	400kV	FY28 & 29	4	8,640	Continue with plan
Aurangabad	Pune	765kV	FY28	2	8,000	
Karad	Pune	765kV	FY28	2	8,000	Continue with plan
Nashik	Pune	400kV	FY28	2	4,320	Early commissioning in FY27
Nashik	Vashi	765kV	FY28	1	4,000	Early commissioning in FY27
Pune	Vashi	400kV	FY29	2	4,320	Not required by FY27 but required by FY30
Pune	Vashi	765kV	FY27, 28 & 29	6	24,000	
Vashi	Mumbai	HVDC 400kV	FY27 & 29		6,500	Continue with plan
Karad	Vashi	-	-	-	-	Additional capacity required by FY30