Approaches for Resource Adequacy in Maharashtra

December 2024

Contents

RA Study

Approaches for Evaluating Resource Adequacy

Two Approaches

PRM & CC based Approach (Spread sheet-Based)

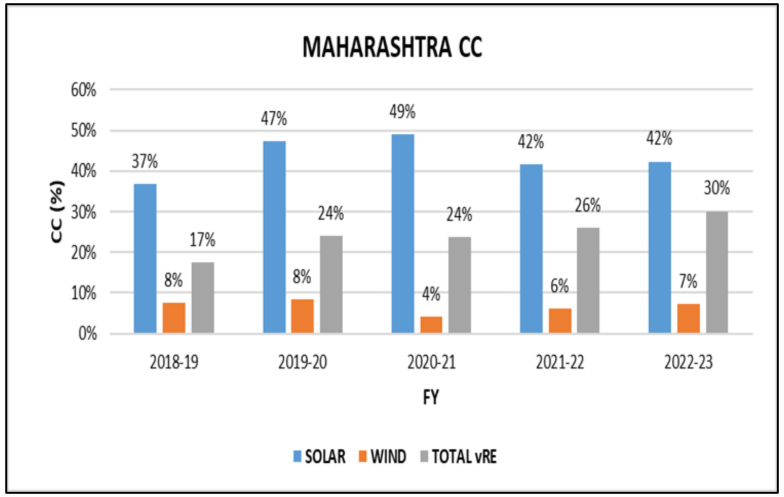
- This approach serves as a simple evaluation tool for the State Transmission Utility (STU) and State Load Dispatch Centre (SLDC) to verify capacity adequacy.
- It can be used to identify resource RA requirements, allocation, and surplus or deficit.
- It uses a PRM & capacity credit method to assess the required capacity each year.
- While straightforward, it does not account for hourly energy balance, capacity trading, or whether energy demand is consistently met throughout the period.

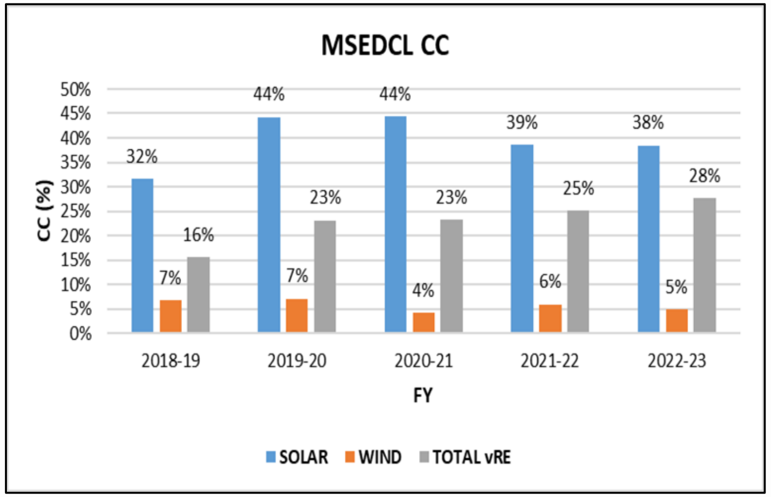
Detailed Modelling Approach (Modelling Software-Based)

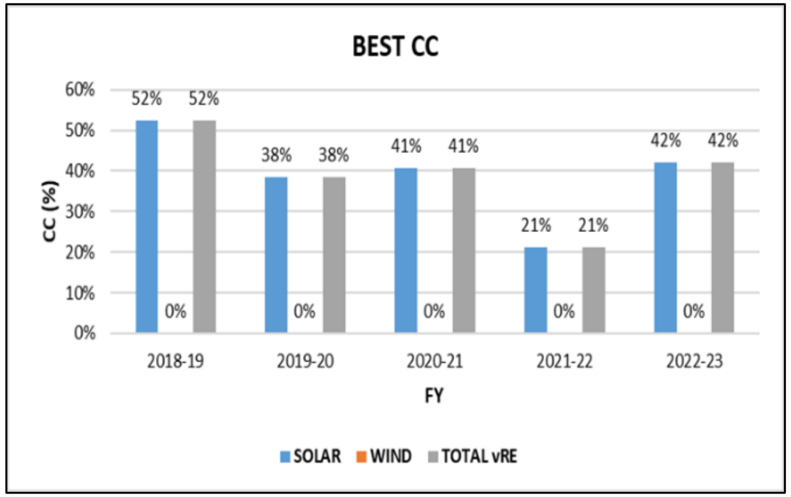
- This approach provides a granular analysis by modeling hourly/sub-hourly energy balance using PLEXOS.
- It incorporates detailed model for each generator, including stochastic hourly generation profiles of renewable energy resources.
- The model ensures reliability criteria are met by considering hourly demand-supply dynamics, capacity trading, and stochastic techniques to address uncertainties.
- This approach enables a comprehensive evaluation of resource adequacy.

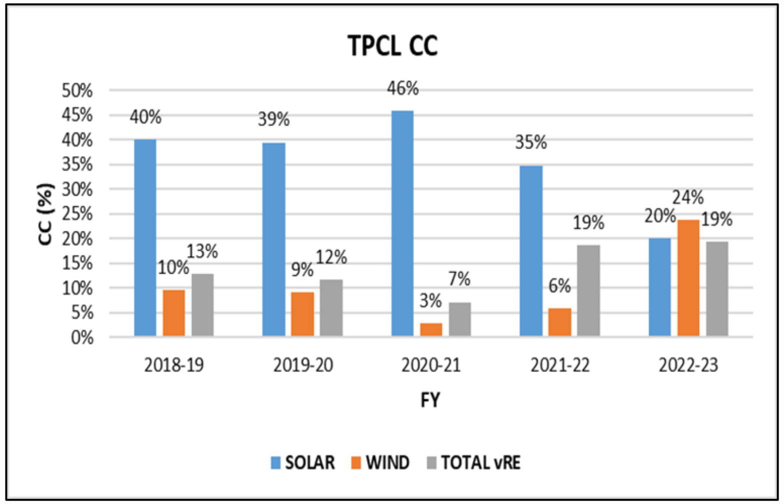
PRM & CC based Approach (Spread sheet-Based)

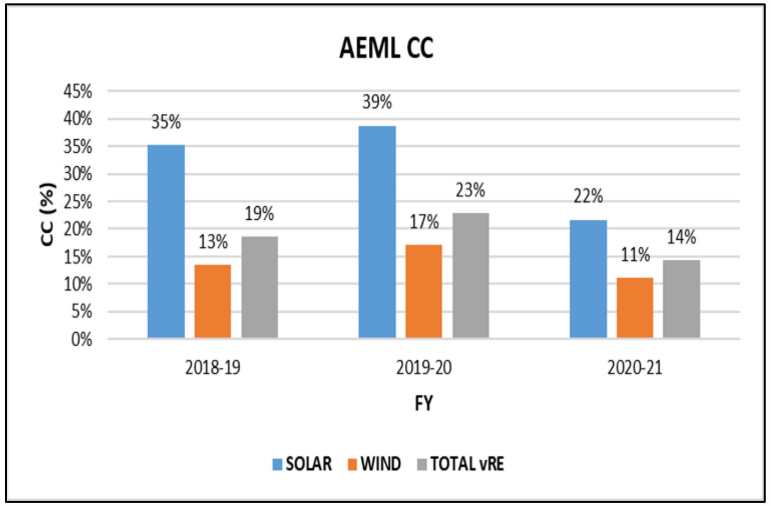
Capacity Crediting

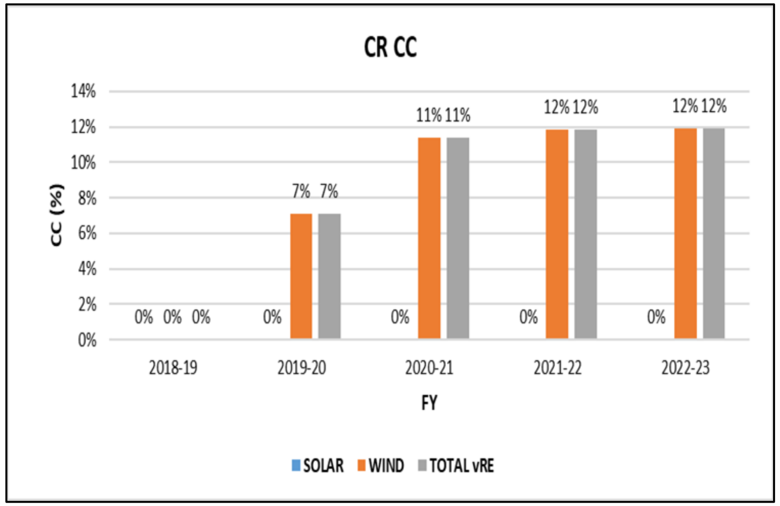






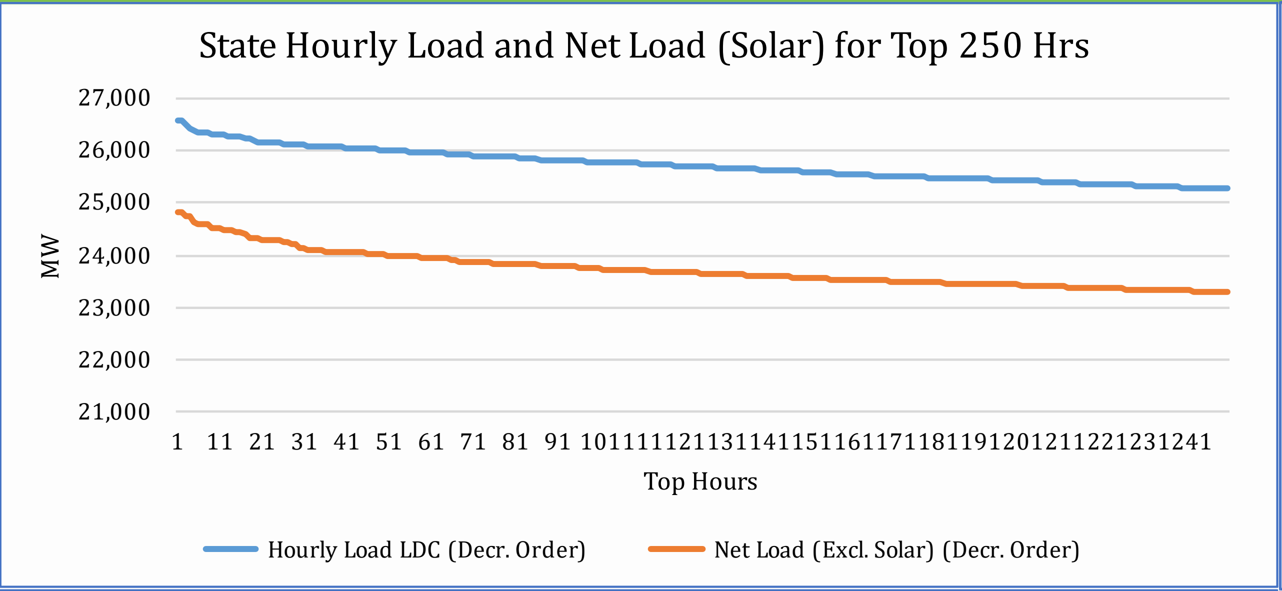


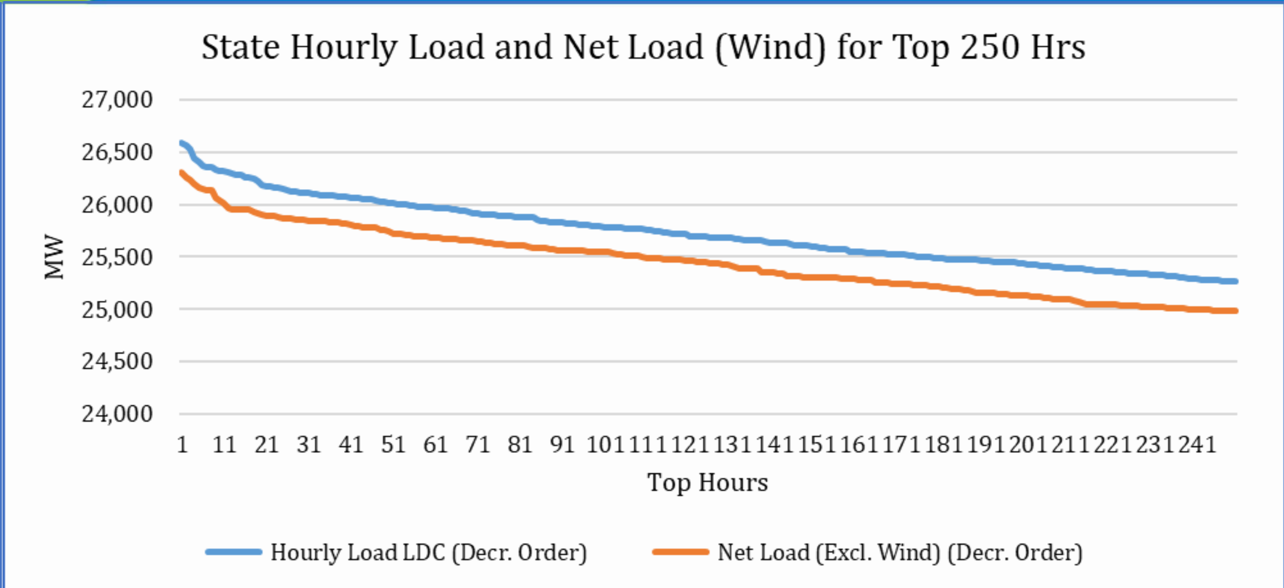


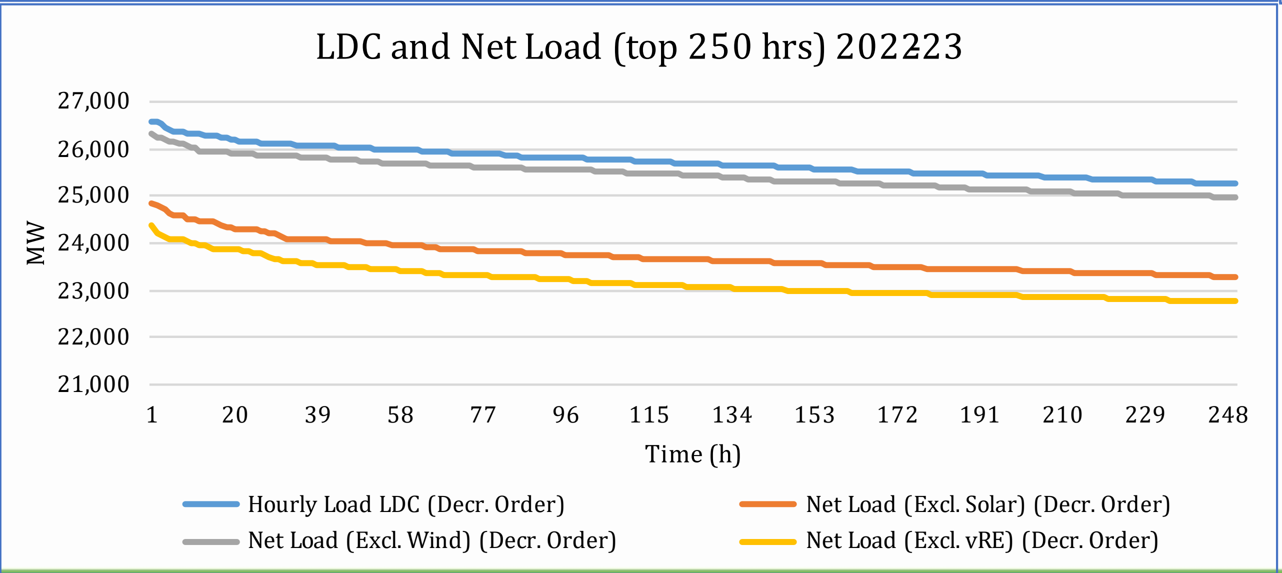


CC computations with Top Net Load Hours based on available data were carried out for illustration and discussion purposes.

Load Duration Curve







The difference between these load duration curves shows the contribution of solar and wind generation.

Capacity requirement (FY30)

Peak Demand (MW) x [1+PRM (%)] = Total Required Capacity (MW)

42,042 MW x (1 + 12%) = 47,087 MW

Resource	Installed Capacity (MW)	CC (%)	Resource Adequacy Requirement (MW)
Coal Existing	23,444	90%	21,100
Gas Existing	1,246	70%	872
Nuclear Existing	1,548	90%	1,393
Hydro Existing	3,020	70%	2,114
Storage Existing	630	70%	441
Solar Existing	3,610	43% (with storage)	1,552
Wind Existing	5,226	7% (with storage)	366
Hybrid Existing	100	50%	50
Other RE Existing	2,813	25%	703
Solar RPO	11,000	50% (with storage)	5,500
Wind RPO	400	15% (with storage)	60
DRE RPO	1,800	25%	450
Solar Upcoming	16,305	50% (with storage)	8,153
Wind Upcoming	1,950	15% (with storage)	293
Hybrid Upcoming	615	70%	431
Hydro Upcoming	557	50%	278
Other RE Upcoming	933	25%	233
Storage Upcoming	5,000	70%	3,500
LTOA	3,100	90%	2,790
MTOA	0	90%	0
STOA	0	90%	0
Total (MW)	**83,297**		**50,278**

Detailed Modelling Approach (Modelling Software-Based)

Modelling Philosophy

Modelling Objectives & Phases

- The objective is to conduct energy modelling is to identify YoY optimal resource mix and hourly dispatch to meet projected load and integrate RE while adhering to reliability standards
- Modelling has been carried out in four stages using PLEXOS:

LT Plan

- **Objective :** Long-term capacity expansion
- **Our Approach :** Modelled Battery & PSH as candidate plants
- **Expected outcome :** YoY capacity buildout and resource mix to meet projected demand and integrate RE while adhering to reliability standards

PASA (Projected Assessment of System Adequacy)

- **Objective : p**lanned & random outages scheduling and reliability modelling
- **Our Approach :**
  - Model generator- wise planned outages as per LGBR report and NENS 0.05%
- **Expected Outcome:**
  - Generator dispatch including maintenance and system reliability

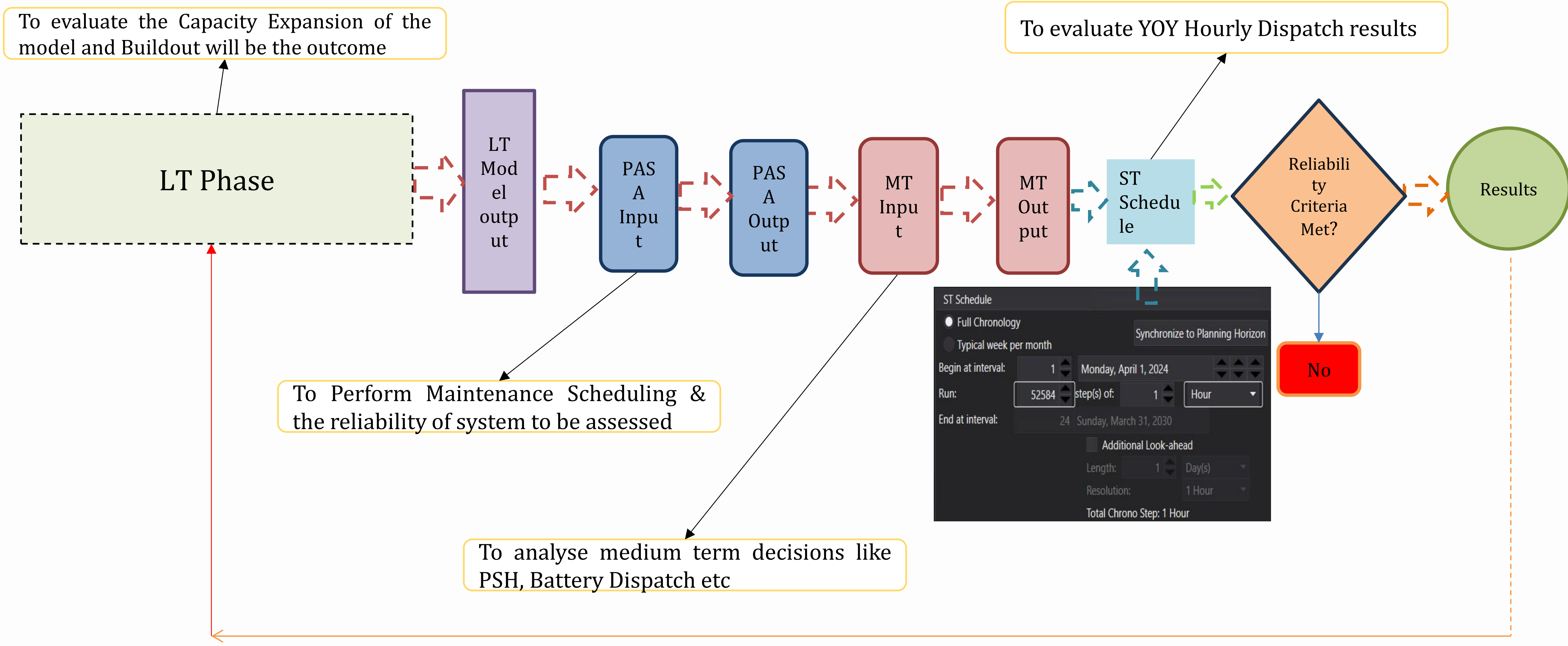
MT Schedule

- **Objective : a**nalysing MT decisions like storage dispatch
- **Our Approach : m**odel PSH head & tail volumes and 1h, 2h, 4h & 6h battery capacities
- **Expected outcome : a**ccurate dispatch of storage plants

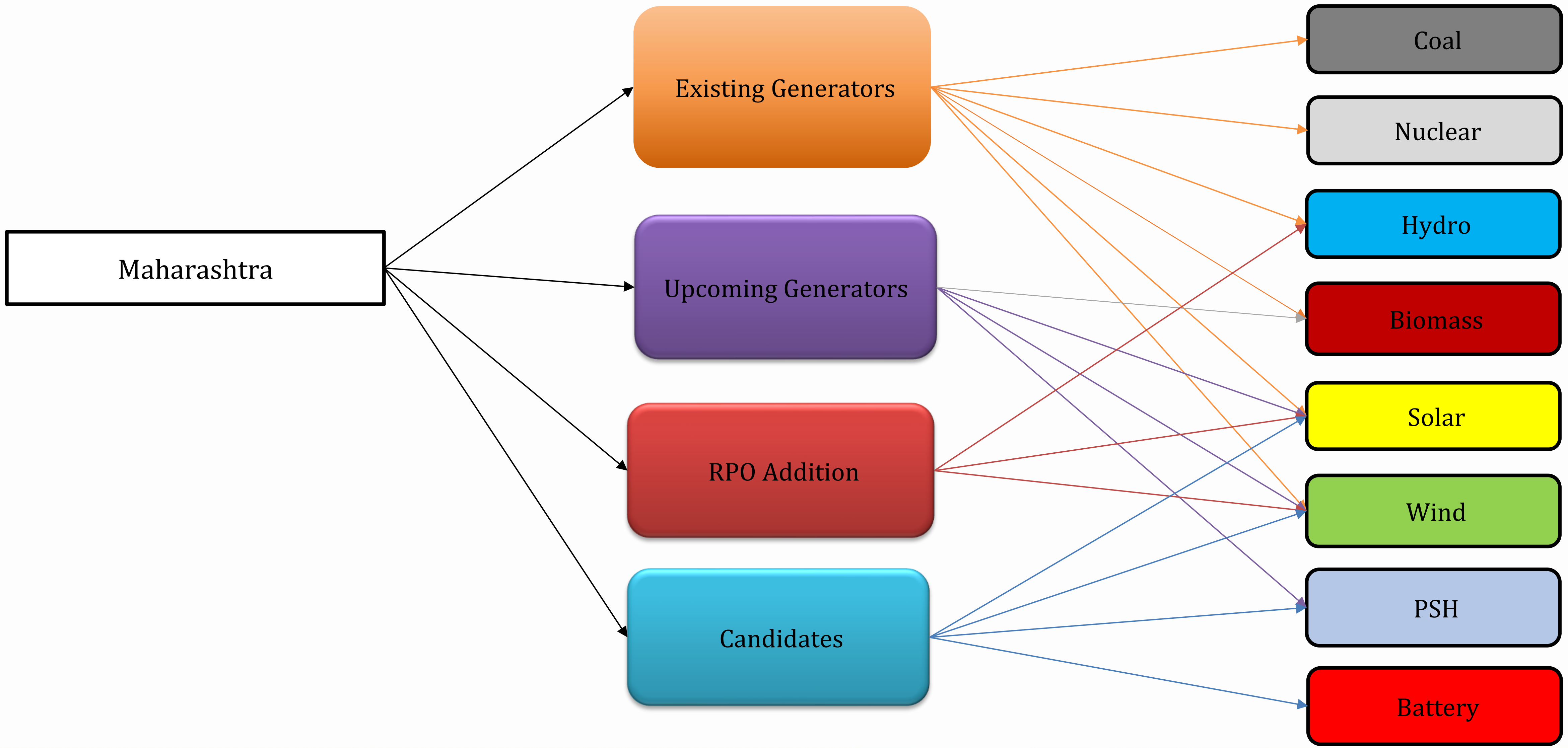
ST Schedule

- **Objective : d**etailed chronological operation and YOY hourly dispatch results
- **Our Approach:** model the simulations in hourly steps
- **Expected outcomes : p**recise dispatching of generating plants

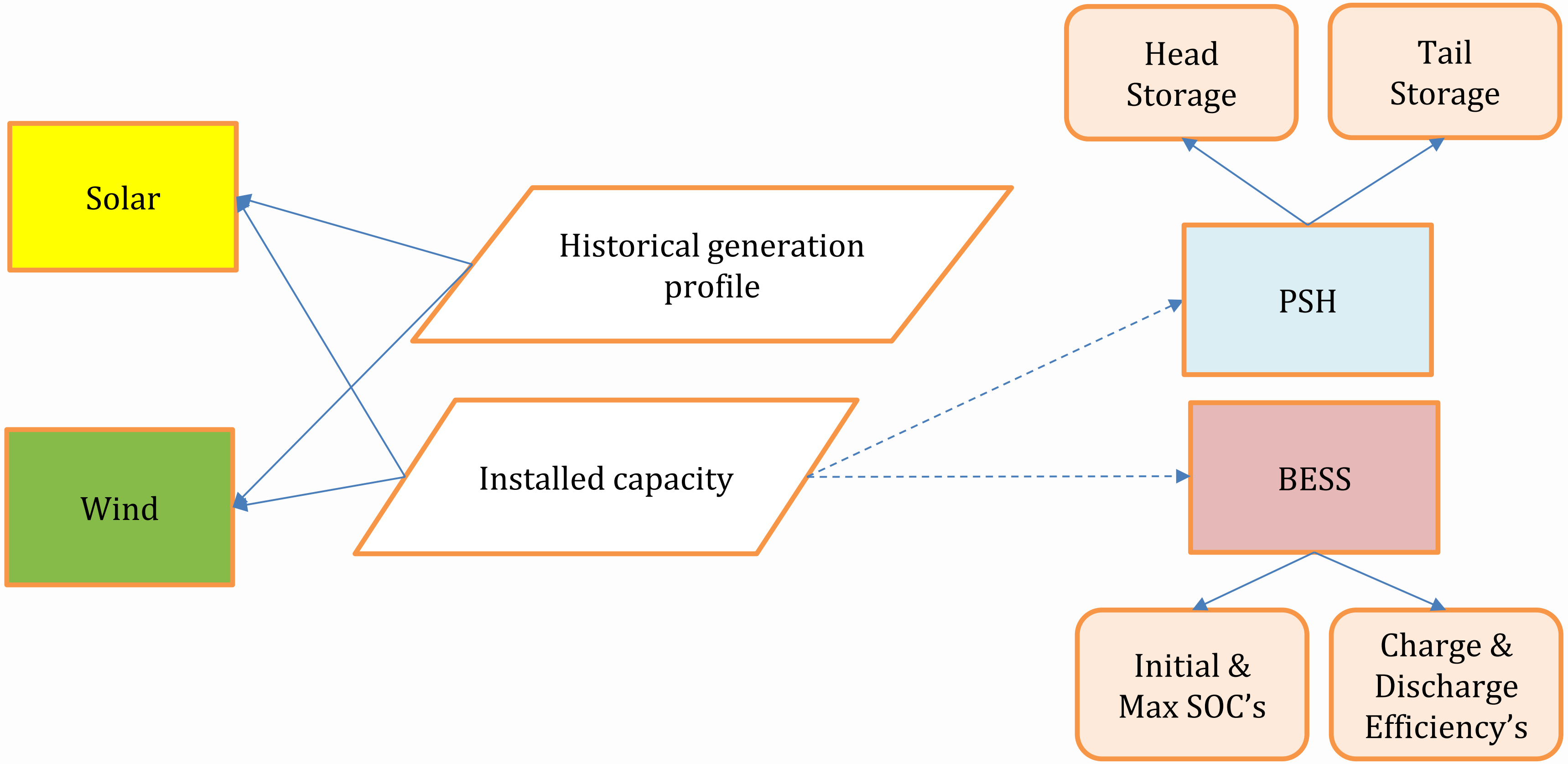
Stage-Wise Modelling



State Model Configuration



Modelling of RE and Storage



- Total installed capacity with historical generation profile of the State is taken as input.
- Based on historical generation profile and installed capacity PLEXOS generates wind and solar output.

- To model Storage , station wise plants with installed capacity as on date with historical generation profile of the State is taken as input. Storage objects are defined for each stations as well.
- Based on historical generation profile, PLEXOS generates output for the installed capacity each year.

Load Building

Objective:
To project load for years considered.

Inputs

Energy and peak demand projections for FY25-FY35

Base : 20th EPS
Additional scenario: State

Base Load Profile : FY24

PLEXOS hourly load built

Input for optimisation Expansion

Load and Generation Report

Generation Units Built

Units Retired

Battery Units Built

Model Output

Data Requirement

Load Projections

Hourly load profile

Peak demand and energy requirement projections (YoY basis for the planning horizon)

Conventional Resources (Existing and Contracted)

Technical Parameters

- Installed Capacity
- Auxiliary Consumption
- Ramp Up/Down rate
- Minimum Up/Down time
- PLF (%)
- Heat Rate

Financial Data

- Variable and Fixed costs
- Start/Shutdown Cost

Renewable Resources (Existing and Contracted)

Installed Capacity (present and envisaged addition)

Storage data in case of Pumped Hydro

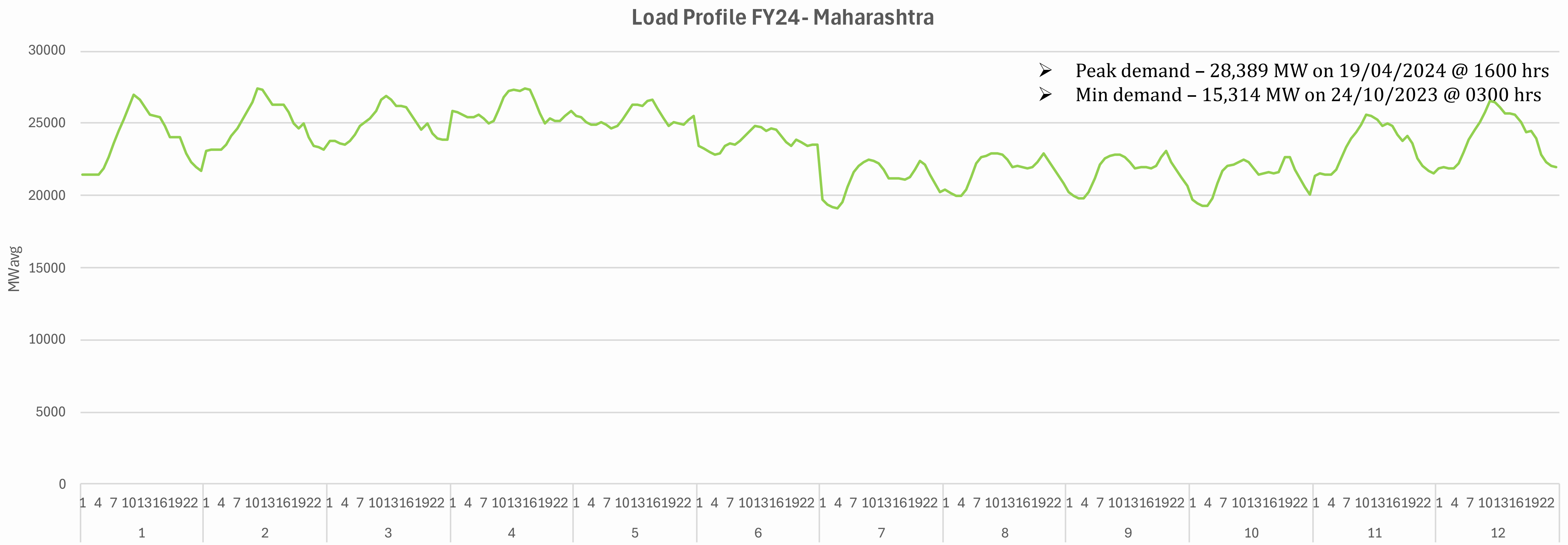
Sub-hourly/hourly/monthly generation profile

Tariffs

Summary of Input Data

Base Load Curve (FY24)

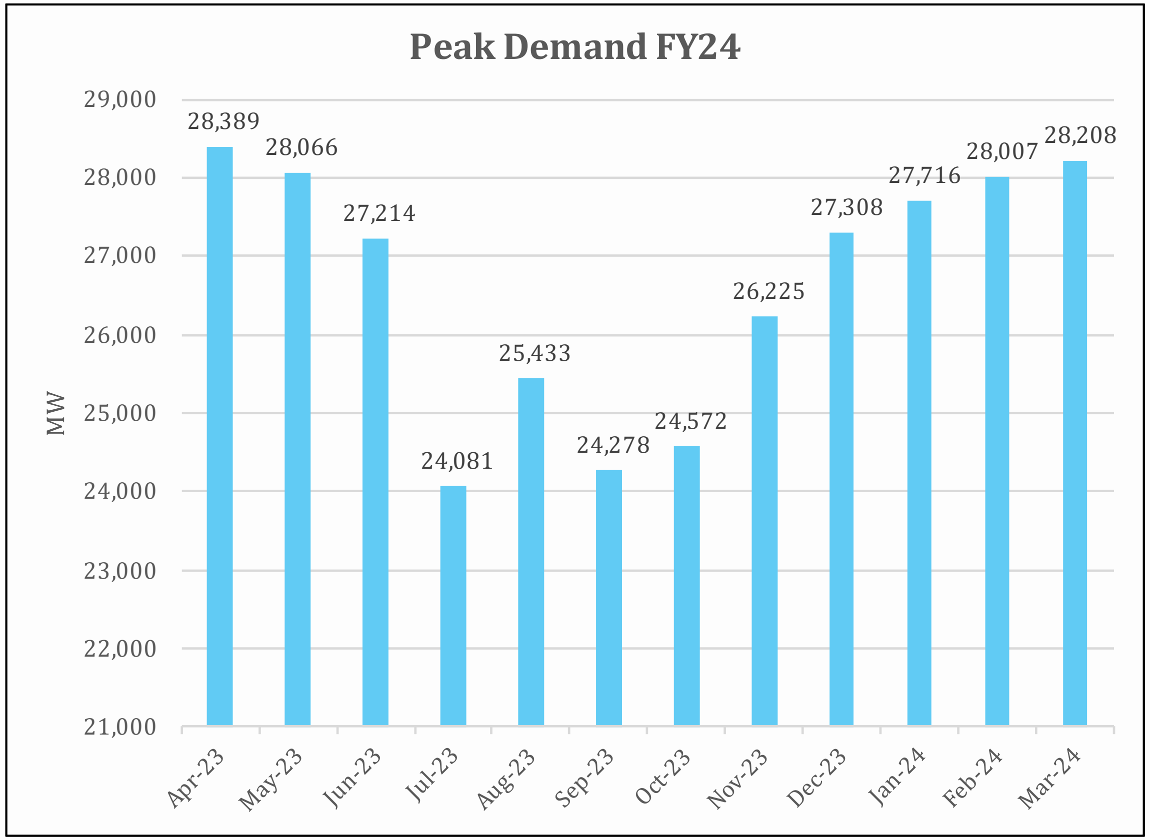
The actual hourly load data for FY24 from MERC is used as the baseline for subsequent years.



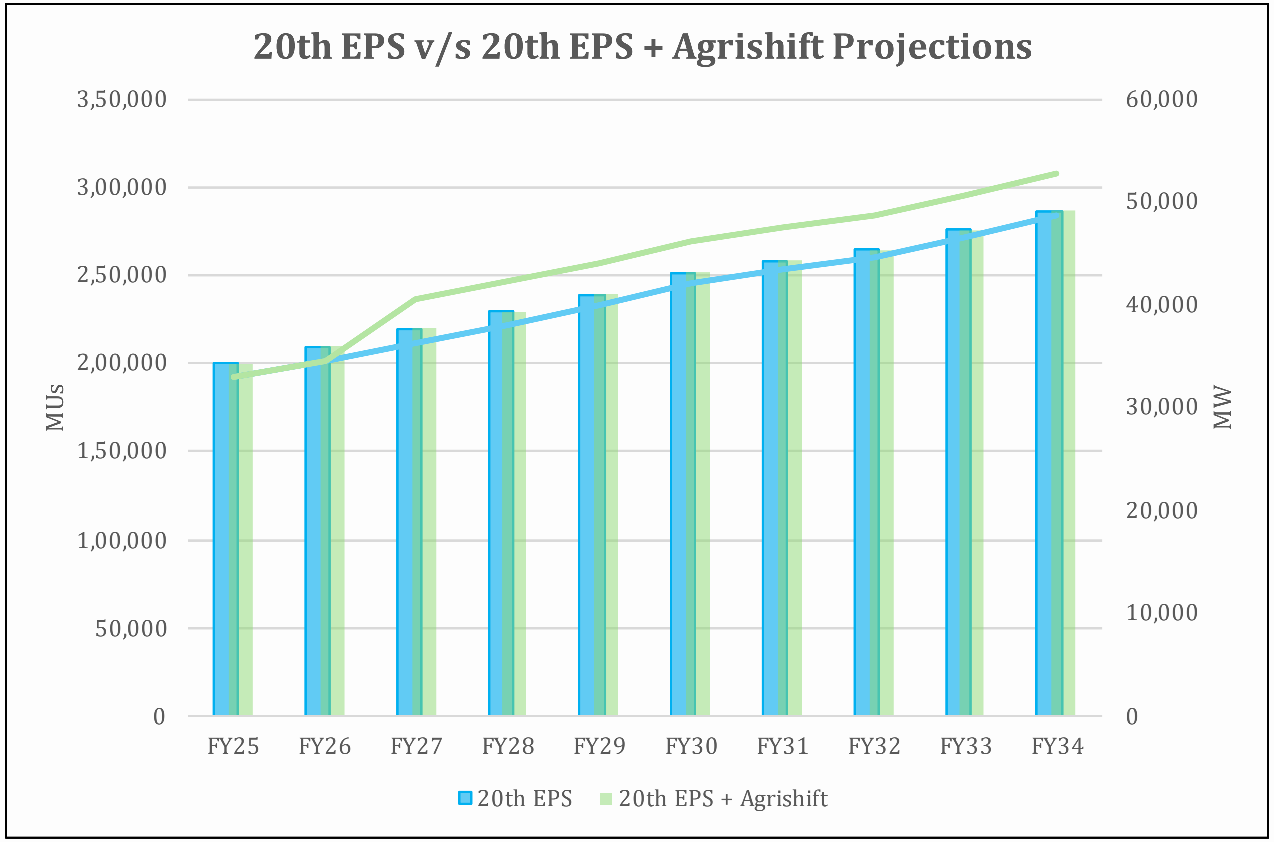
Two scenarios are developed for future annual peak and energy projections: Base Scenario considering 20th EPS and Scenario-1 considering agricultural shift from FY27 onwards. (ref. slide 18)

Peak and Energy Projections (FY25-35)

Monthly Peak Demand for FY24



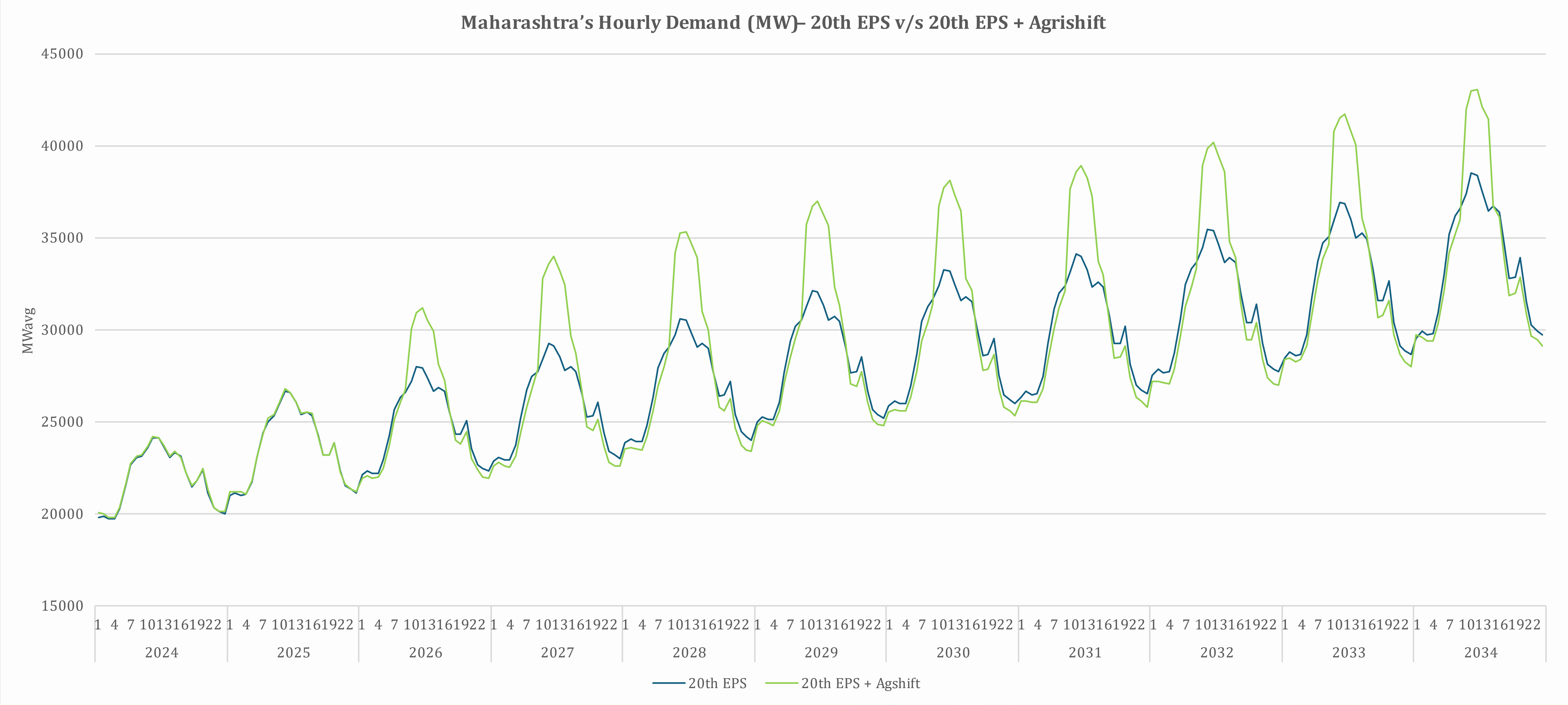
YoY Peak and Energy projections (20th EPS & State)



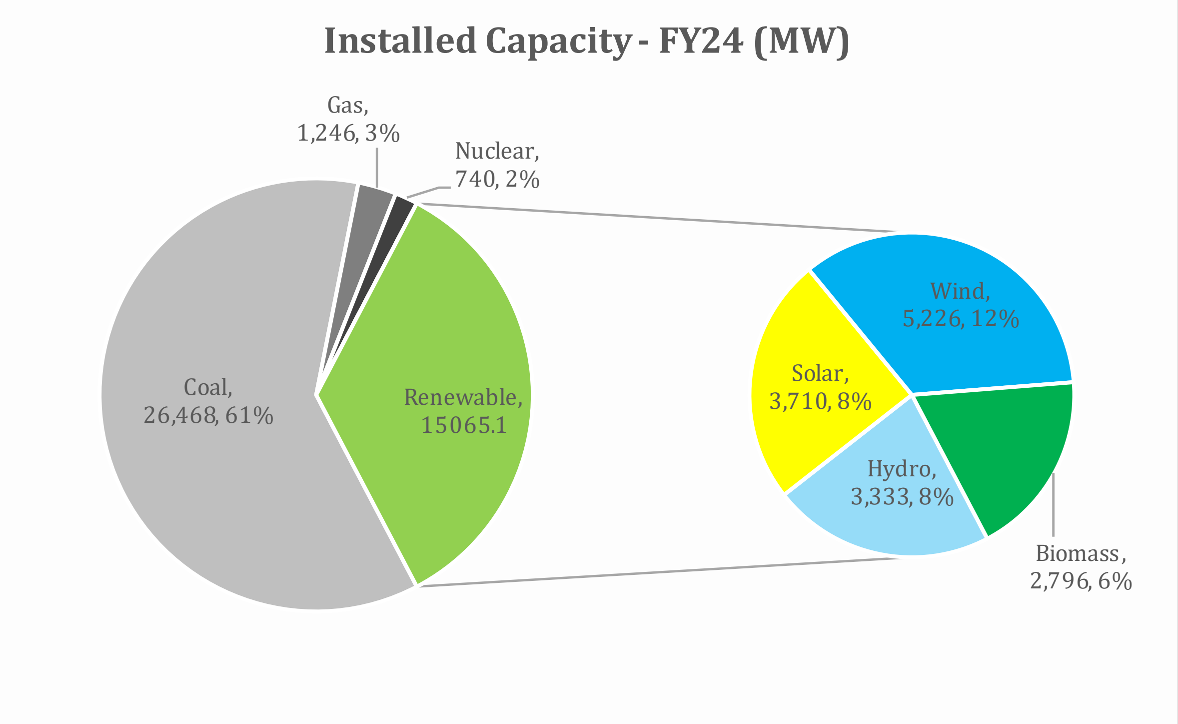
Source: MERC, 20th EPS

The exponential growth in Maharashtra's demand and energy needs to be met for which this study aims to provide potential solutions.

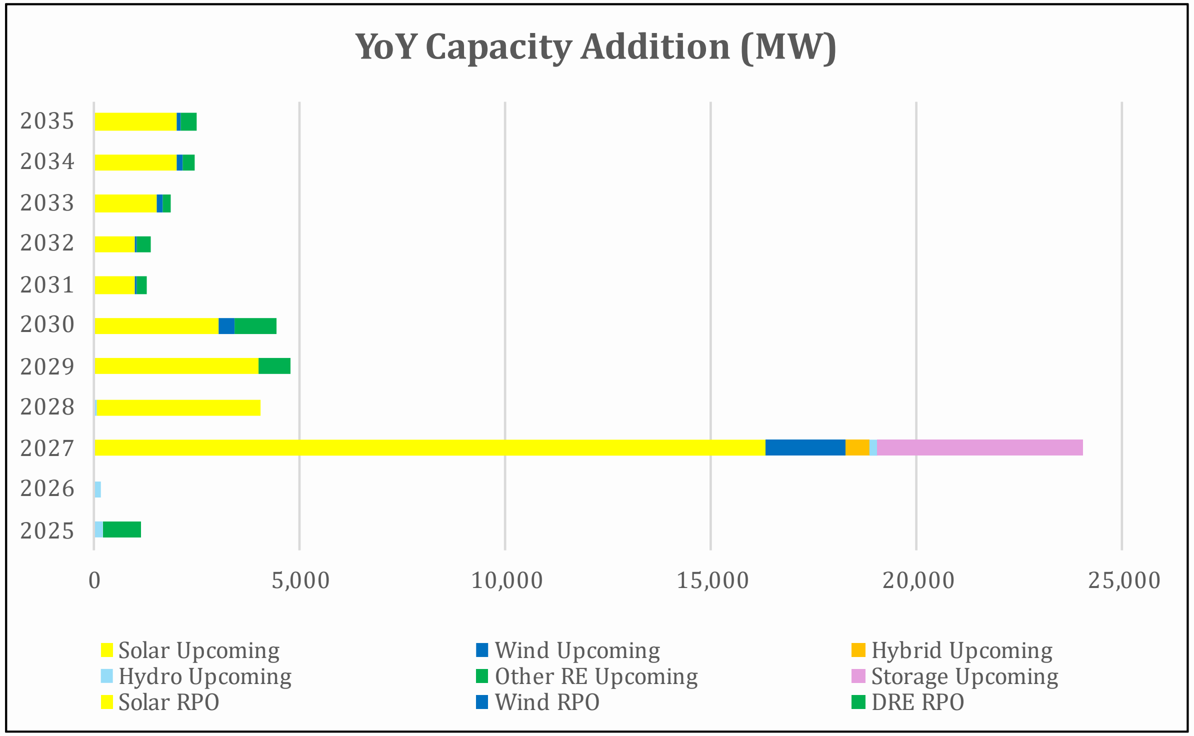
Buildup of Hourly Profile (FY25-35)



Installed Capacity (FY24) and Contracted Capacity



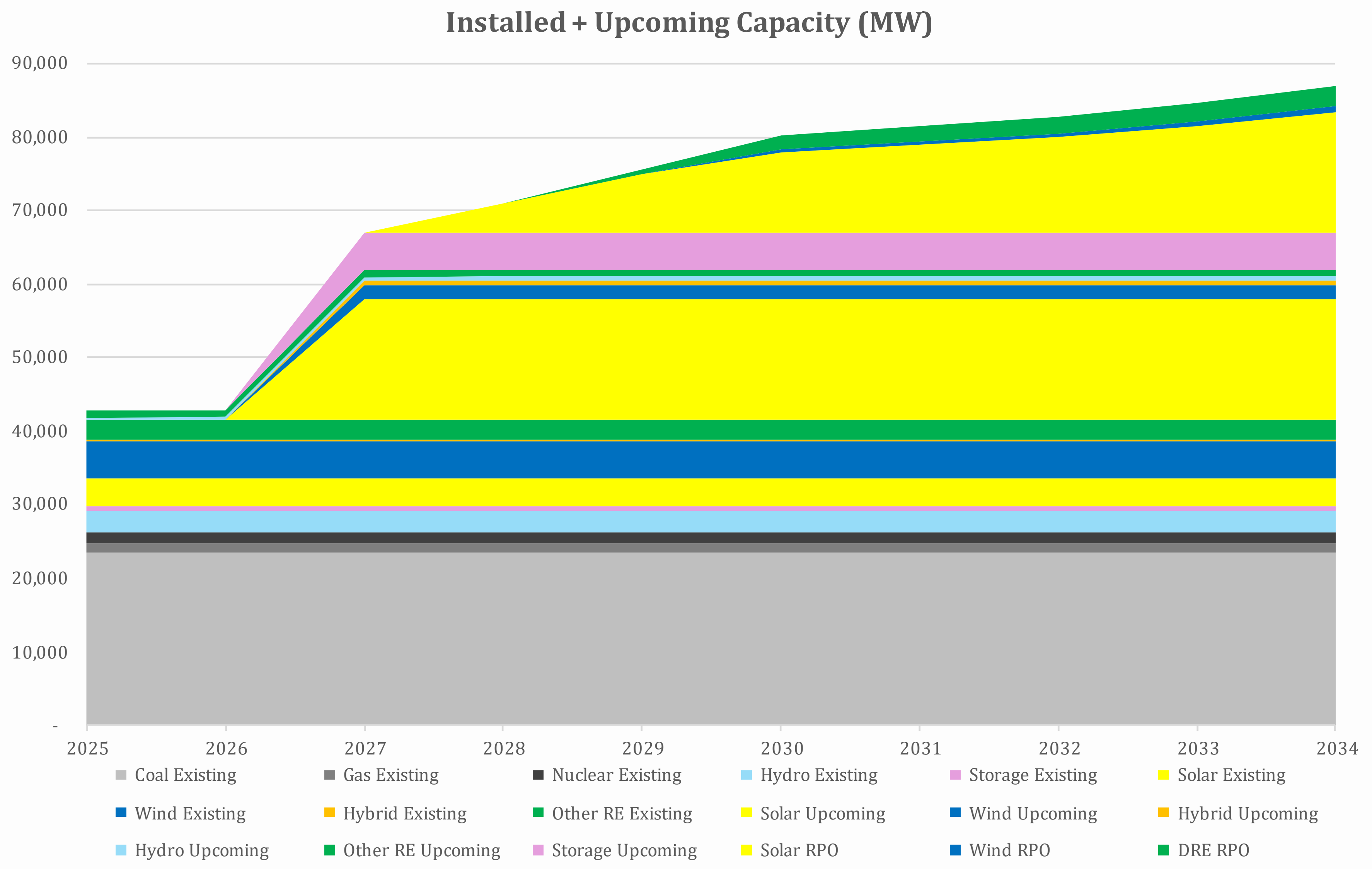
Source: MERC



Source: MERC

- 3rd highest RE installed capacity in India, and share has increased from 21% in FY19 to 34% in FY24.
- As per MNRE, the estimated solar potential is 64 GW and wind potential is 98 GW.
- Maharashtra's Green Investment Plan aims to facilitate the development of up to 5 GW of additional renewable energy projects, with or without energy storage solutions, including initiatives in green hydrogen production, and 2 GW of pumped storage projects to support grid stability.
- Vast potential is untapped, for which a detailed modelling analysis is required for least-cost expansion that ensures smooth integration and reliable operations.

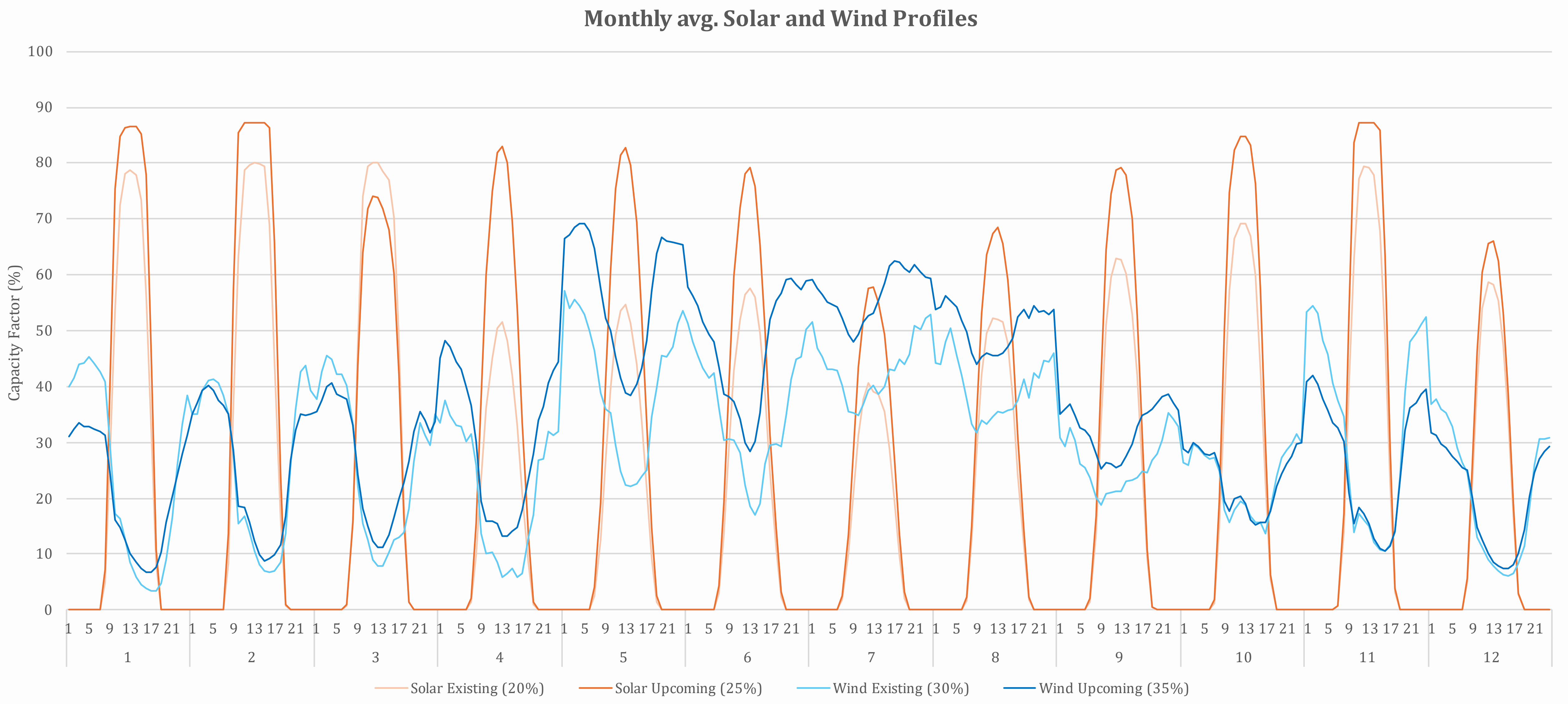
Capacity mix



The state's planned renewable energy (RE) capacities were not meeting Maharashtra's Renewable Purchase Obligation (RPO) mandates, additional RPO capacities were taken into account.

FY	Total IC (MW)	Upcoming Gen (incl. RPO) (MW)
2025	42,760	1,123
2026	42,890	130
2027	66,943	24,053
2028	70,997	4,054
2029	75,747	4,750
2030	80,197	4,450
2031	81,447	1,250
2032	82,797	1,350
2033	84,647	1,850
2034	87,097	2,450
2035	89,597	2,500

Avg. Hourly Profile for Solar & Wind



Scenarios Considered

- Two scenarios have been considered:
  - 20th EPS Projection
  - 20th EPS Projection + Agricultural shift

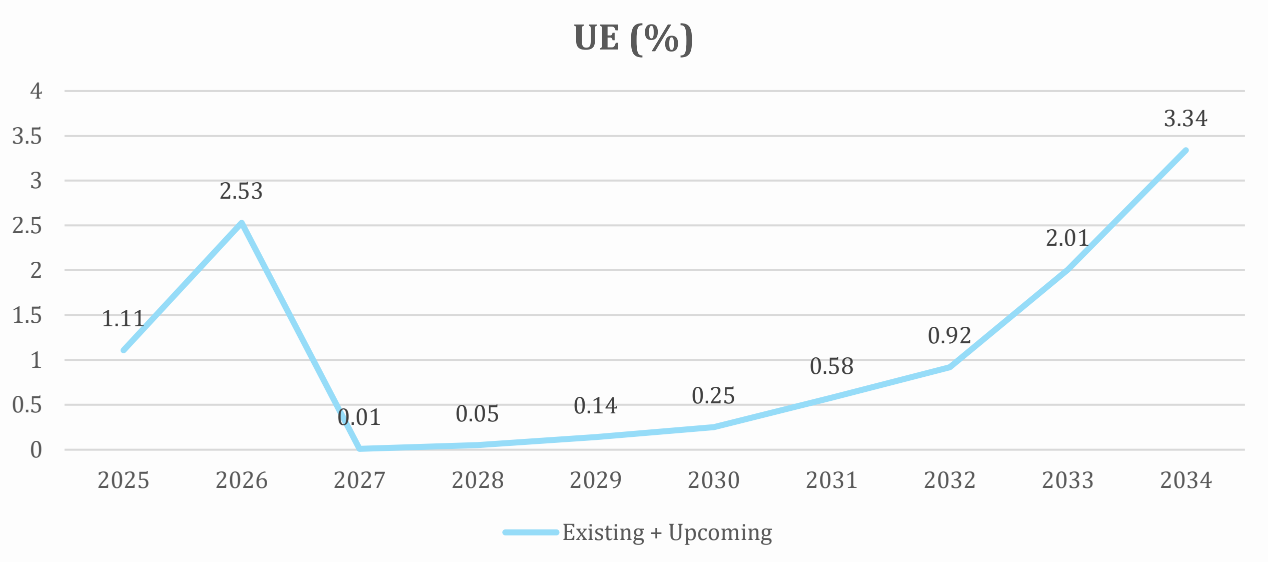
20th EPS Projection		
DateTime	Energy Projection (MUs)	Energy Peak (MW)
FY25	2,00,087	32,999
FY26	2,09,593	34,567
FY27	2,19,726	36,376
FY28	2,29,362	38,105
FY29	2,39,207	39,891
FY30	2,51,578	42,042
FY31	2,58,529	43,373
FY32	2,64,793	44,622
FY33	2,75,609	46,593
FY34	2,86,866	48,651
FY35	2,98,584	50,803

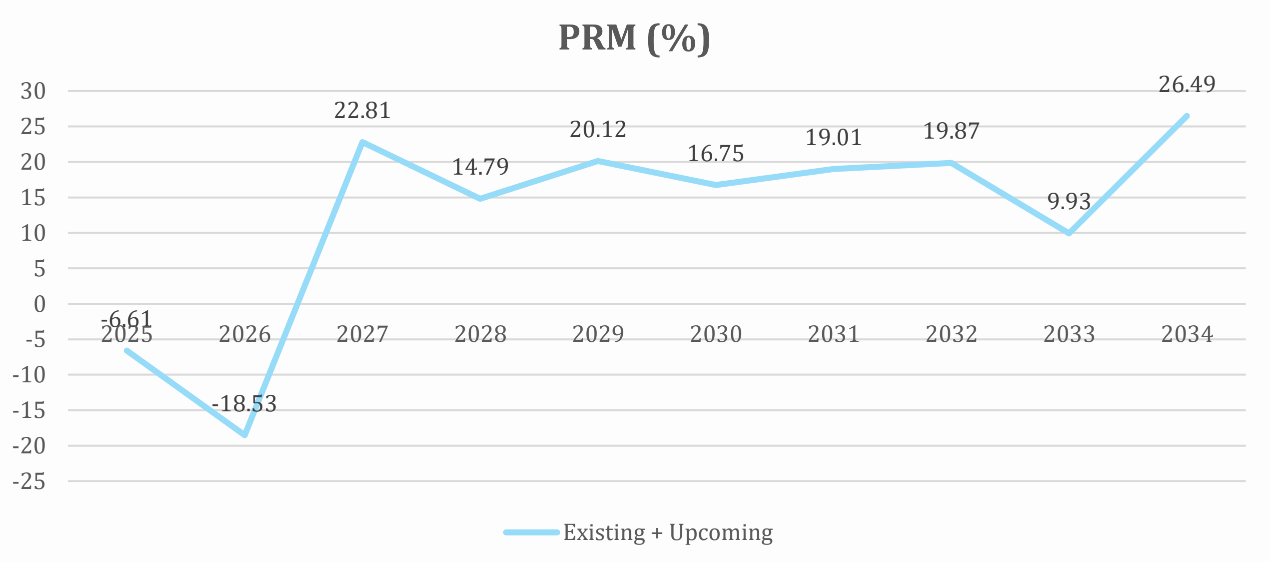
20th EPS + Agricultural shift Projection		
DateTime	Energy Projection (Mus)	Energy Peak (MW)
FY25	2,00,087	32,999
FY26	2,09,593	34,567
FY27	2,19,726	40,502
FY28	2,29,362	42,231
FY29	2,39,207	44,017
FY30	2,51,578	46,168
FY31	2,58,529	47,499
FY32	2,64,793	48,748
FY33	2,75,609	50,719
FY34	2,86,866	52,777
FY35	2,98,584	54,929

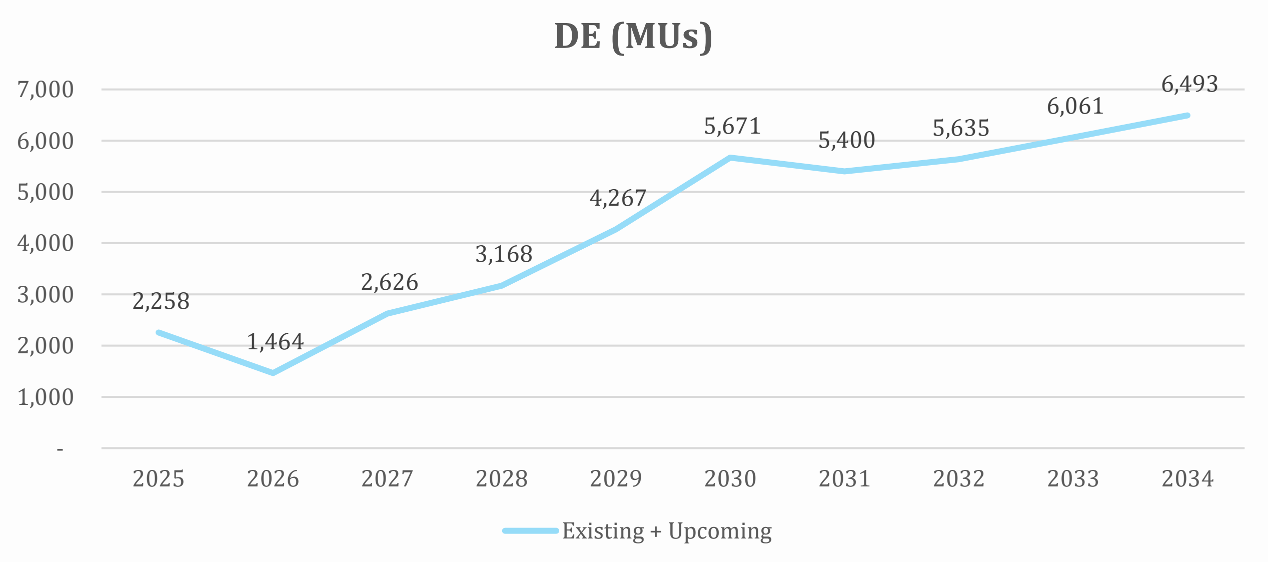
Results for 20th EPS Scenario

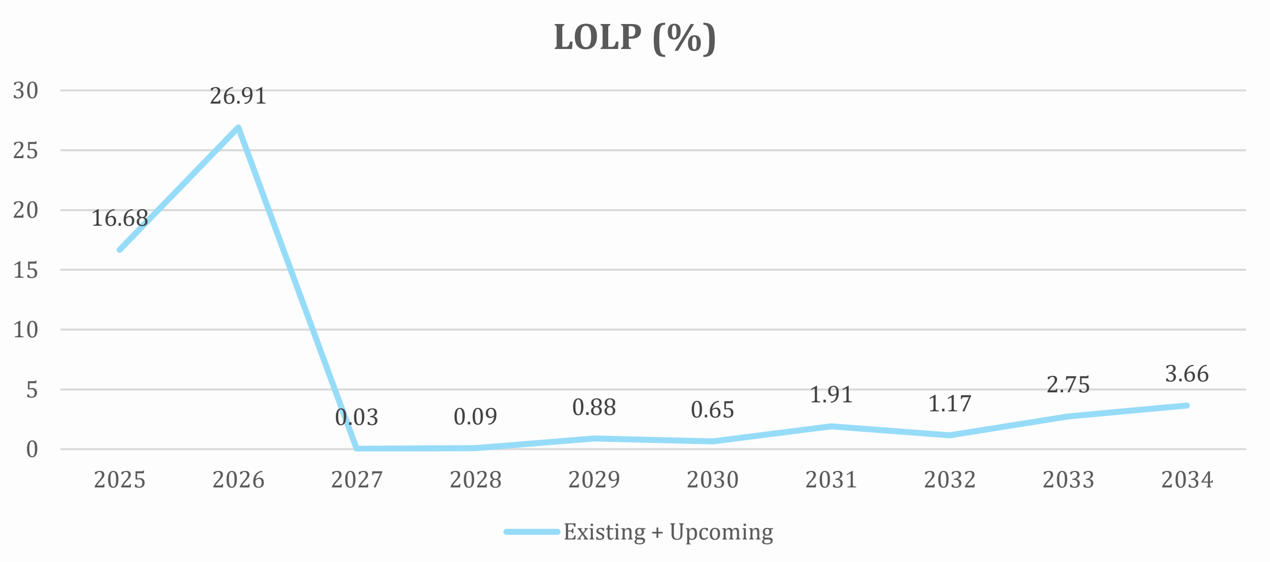
20th EPS Results – Existing + Upcoming

- Reliability Metrics



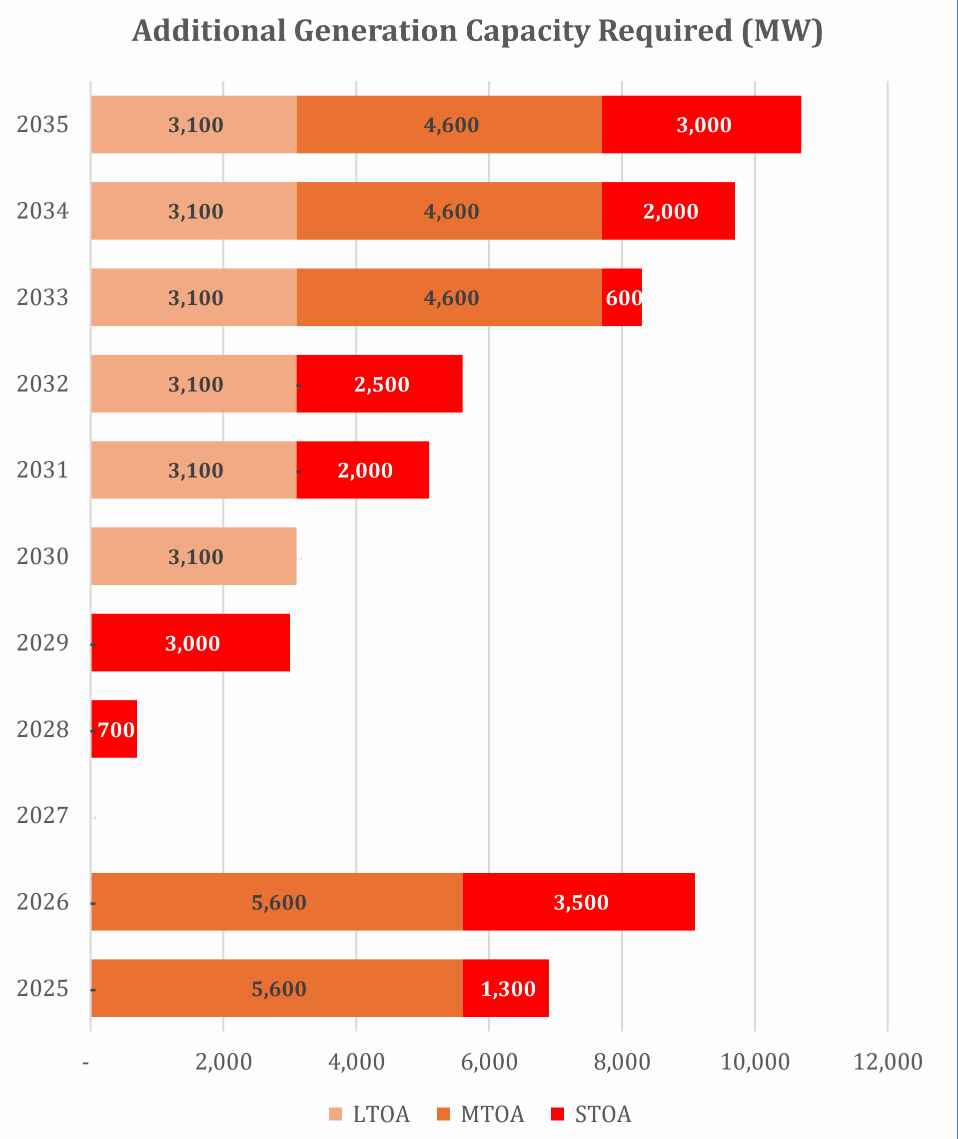






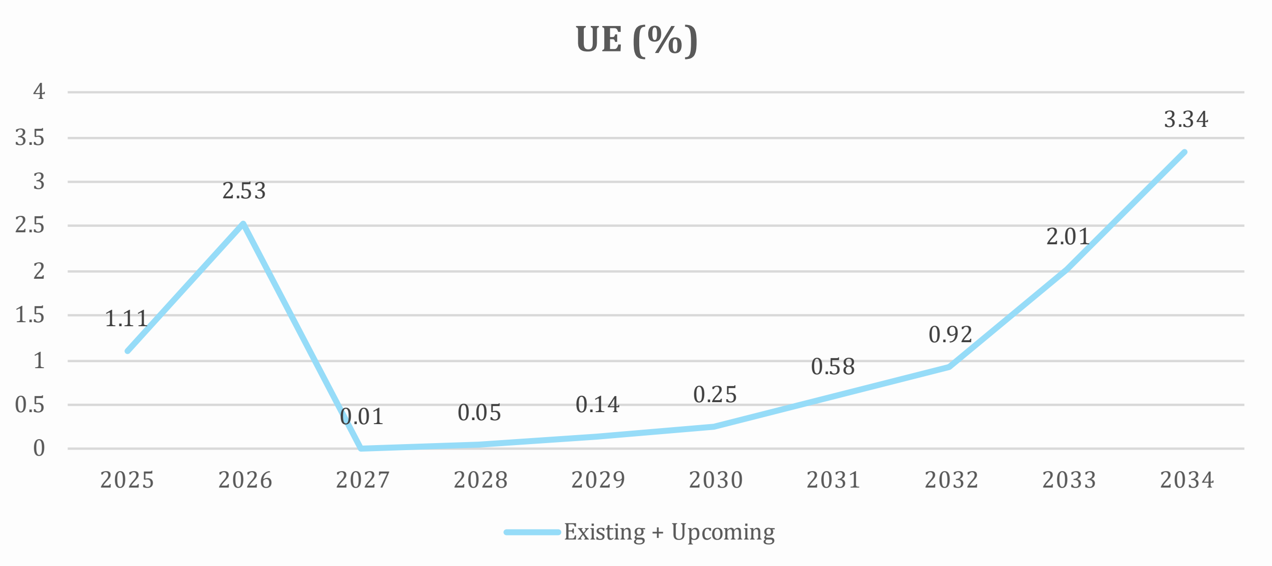
Capacities for Meeting the Requirement – 20th EPS

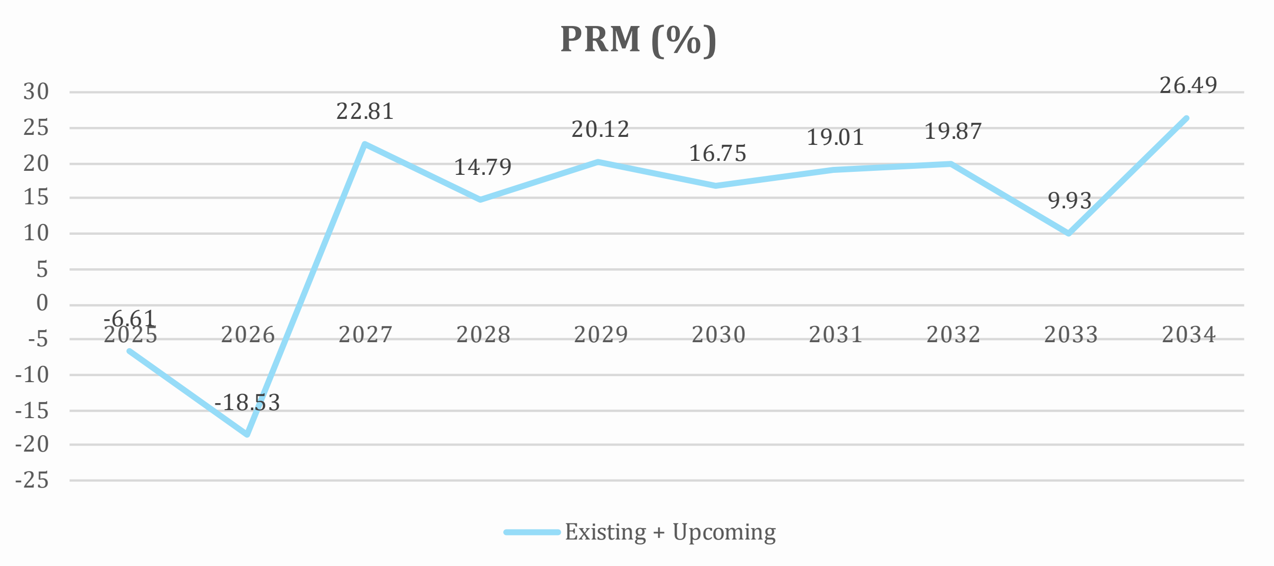
- To ensure a reliable power supply, it is essential to meet reliability criteria. Hence the study considers short-term, medium-term, and long-term req..
  - Short-Term Open Access (STOA): Addresses supply gaps for few hours/days with quick and flexible contracts, typically lasting less than a year, to handle minor fluctuations. Additionally, STOA can involve capacity contracting through capacity trading, providing an efficient way to secure temporary energy needs.
  - Medium-Term Open Access (MTOA): Provides stability for more prolonged unmet demand through contracts spanning two to three years, serving as a transitional solution until long-term measures are in place.
  - Long-Term Open Access (LTOA): Essential for persistent base-level unserved energy, involving the development of new plants or securing extended Power Purchase Agreements (PPAs) with existing Round-The-Clock (RTC) facilities. These steps not only resolve current capacity deficits but also ensure the grid is equipped to meet future demand, maintaining long-term reliability and stability.

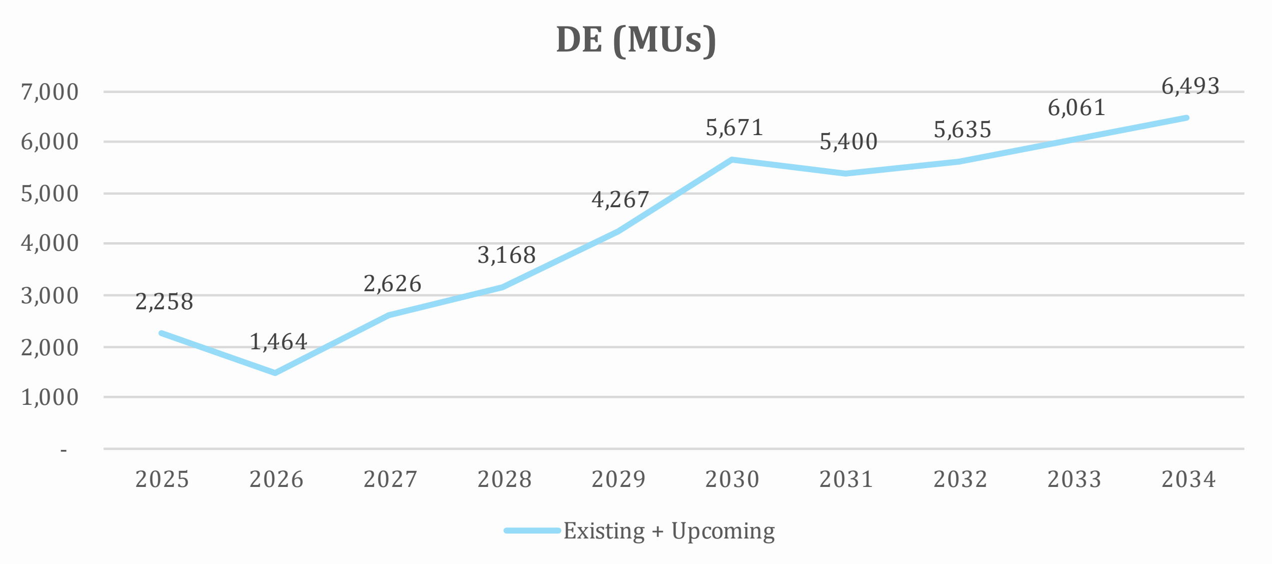


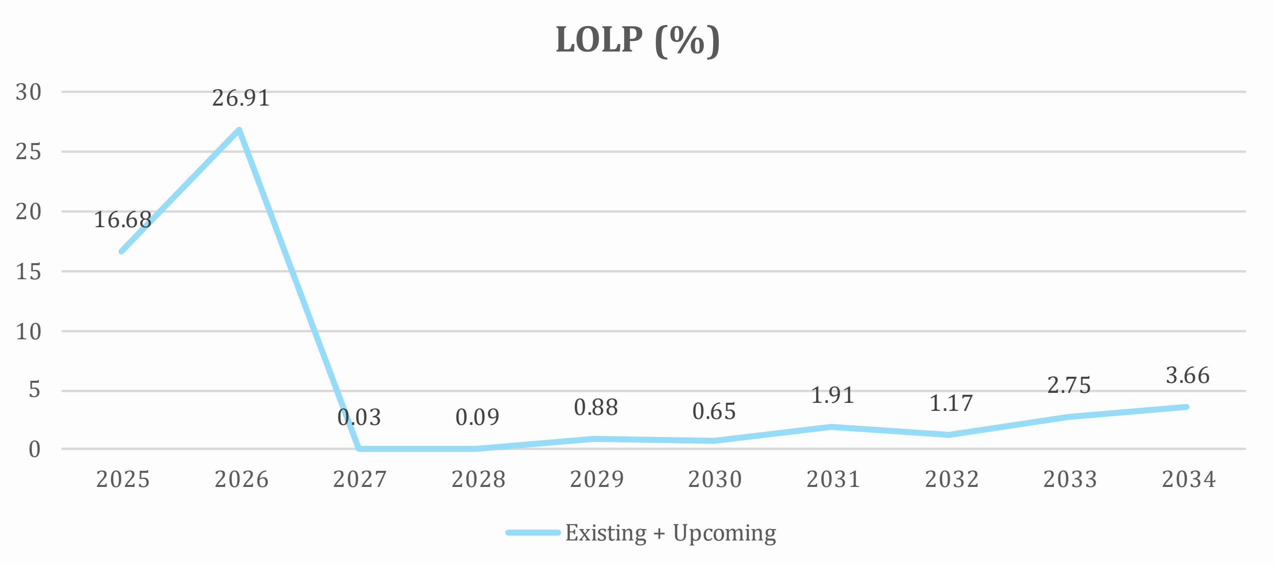
20th EPS Results – Existing + Upcoming + Additional

- Reliability Metrics

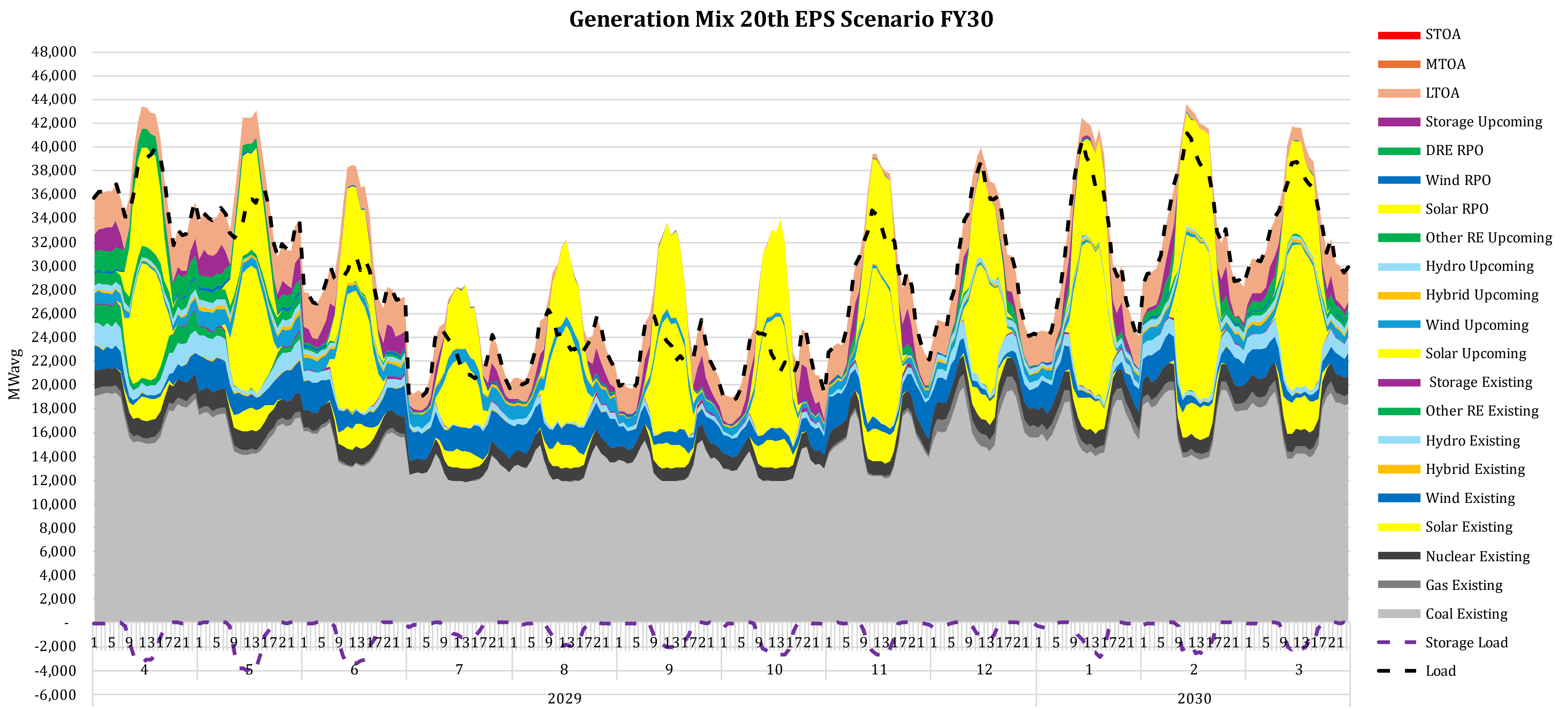








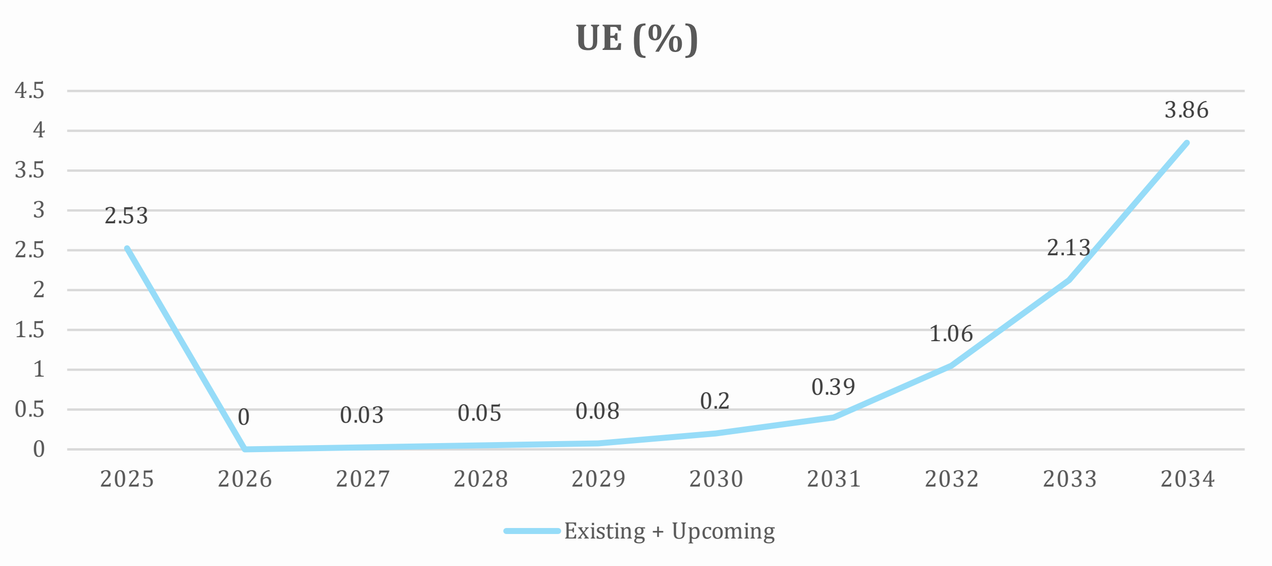
LGB – FY30 : 20th EPS Scenario

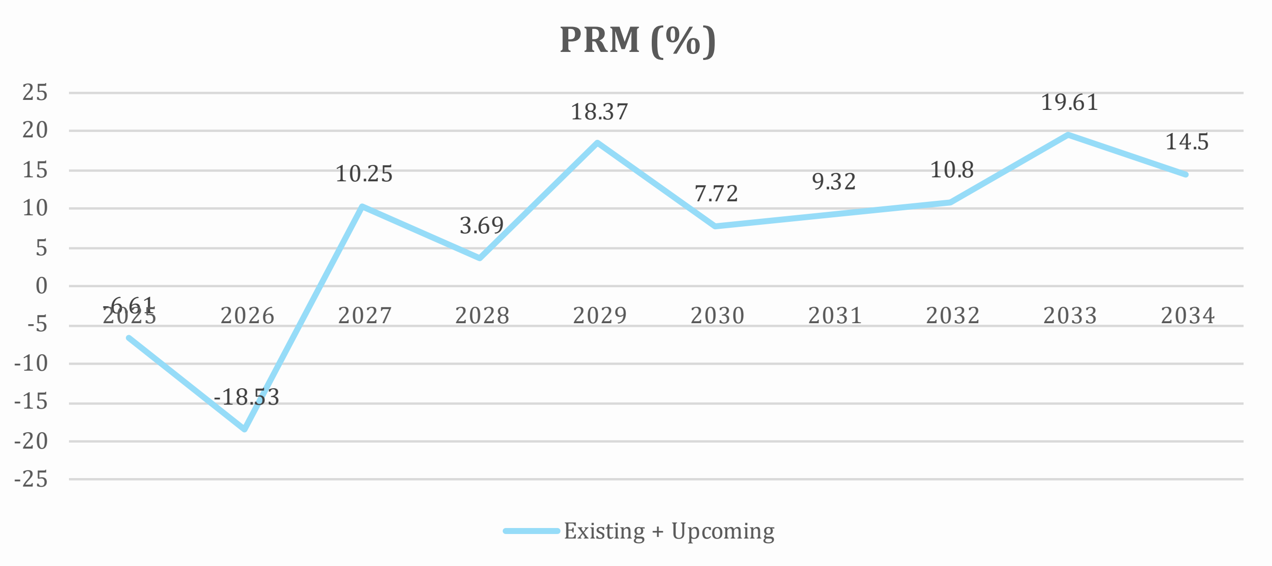


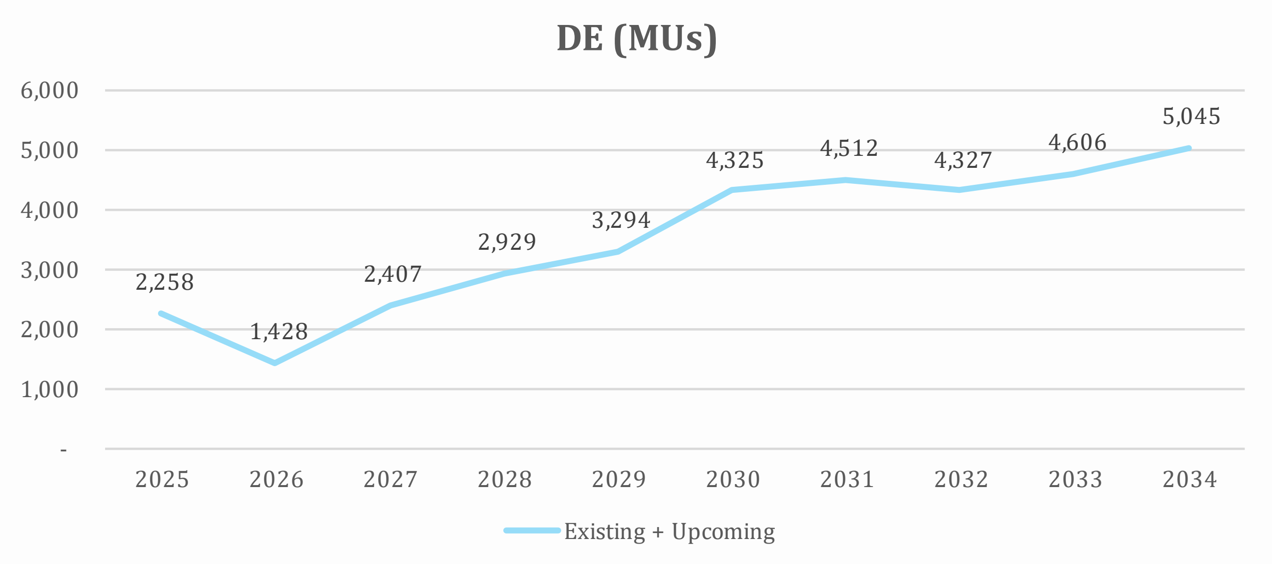
Results for 20th EPS + Agrishift Scenario

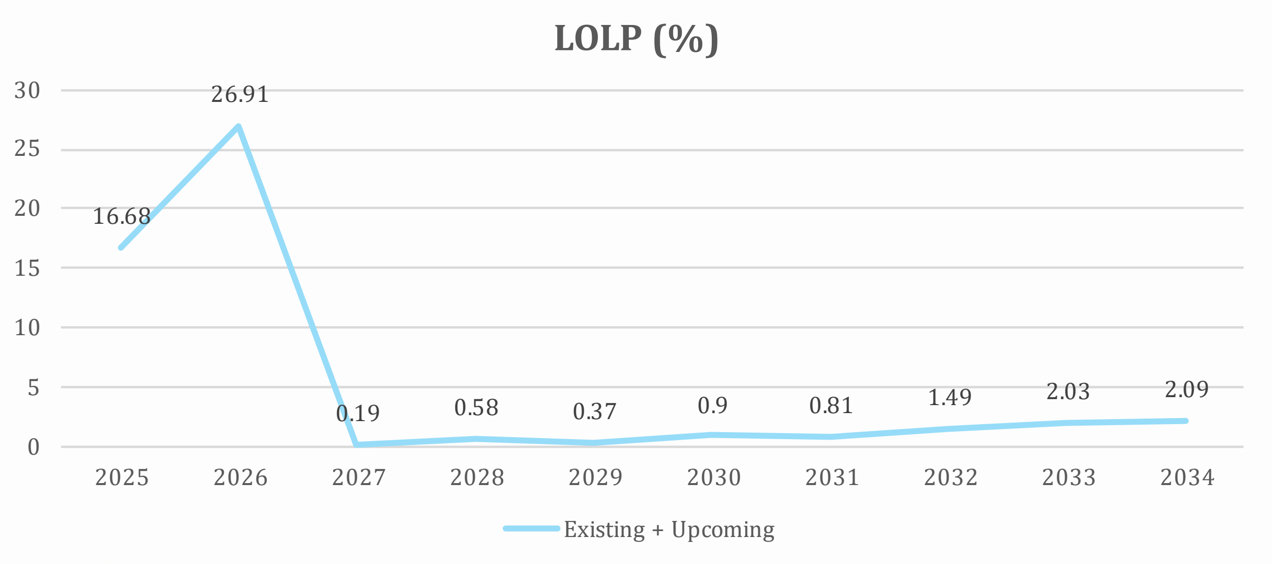
20th EPS + Agrishift Results – Existing + Upcoming

Reliability Metrics









Capacities for Meeting the Requirement – 20th EPS + Agrishift

- To ensure a reliable power supply, it is essential to meet strict reliability criteria. Achieving these standards requires a strategic approach involving short-term, medium-term, and long-term measures.
  - Short-Term Open Access (STOA): Addresses supply gaps for few hours/days with quick and flexible contracts, typically lasting less than a year, to handle minor fluctuations. Additionally, STOA can involve capacity contracting through capacity trading, providing an efficient way to secure temporary energy needs.
  - Medium-Term Open Access (MTOA): Provides stability for more prolonged unmet demand through contracts spanning one to three years, serving as a transitional solution until long-term measures are in place.
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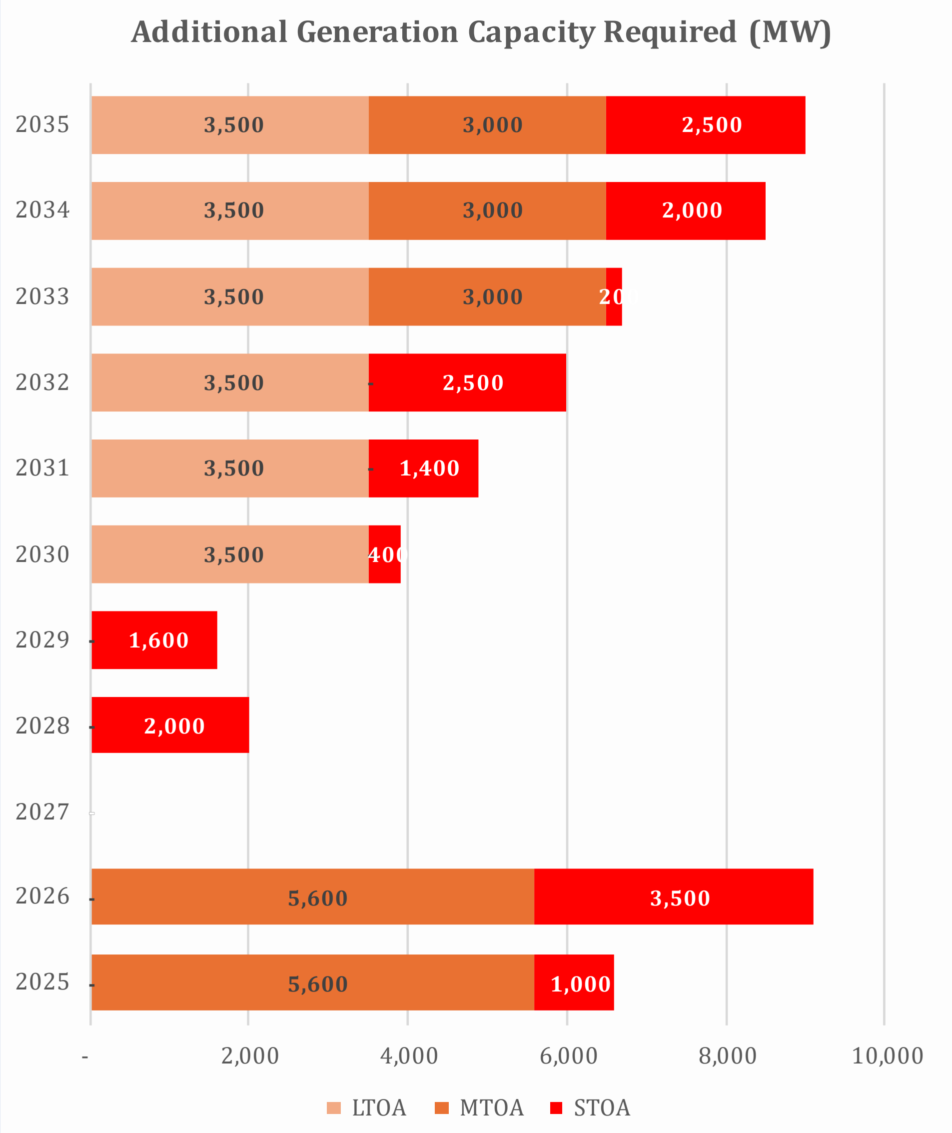
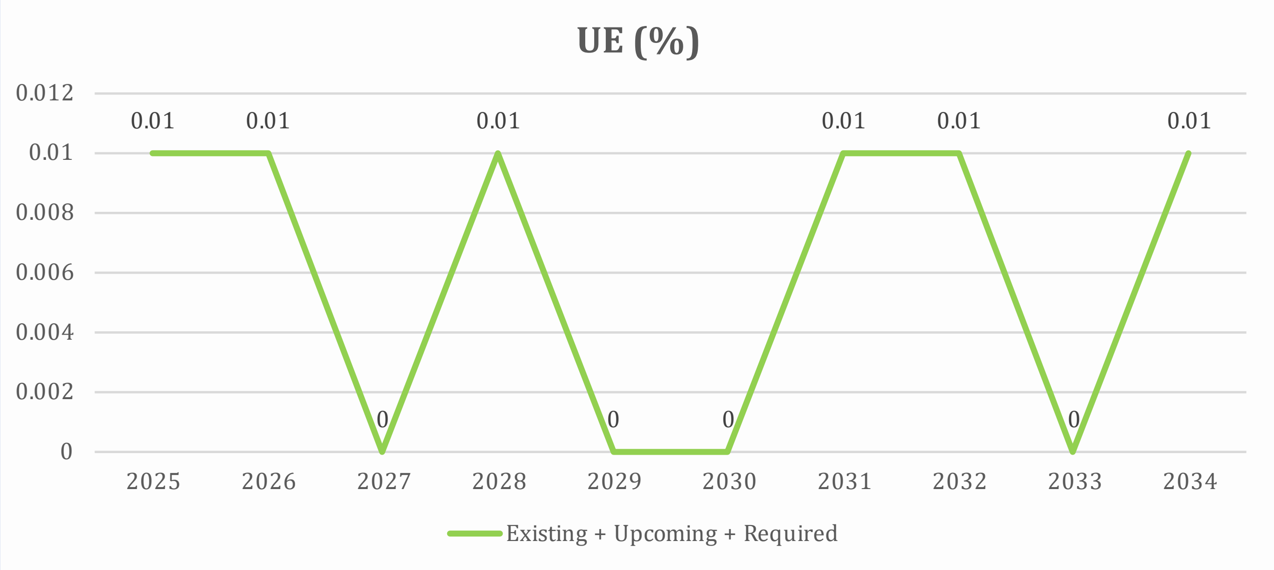
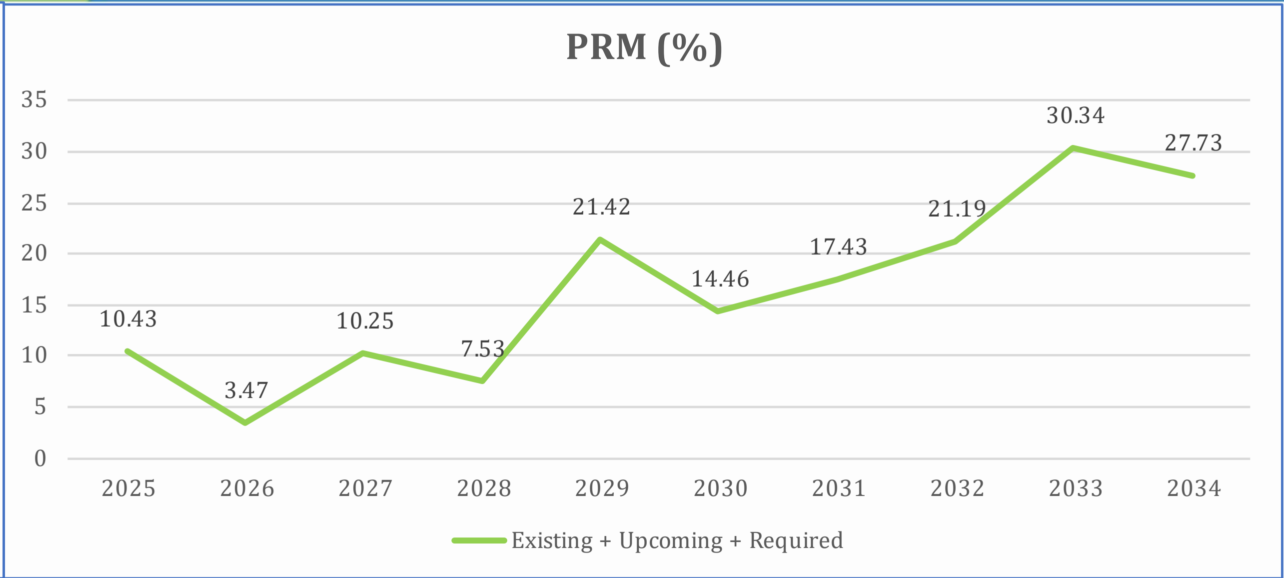
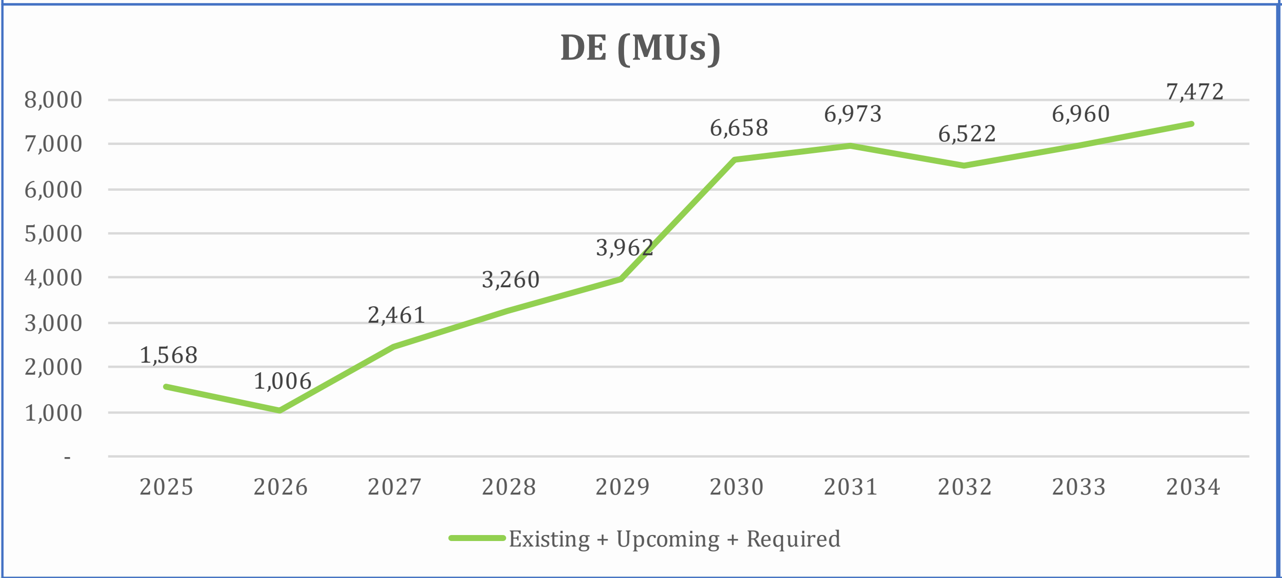


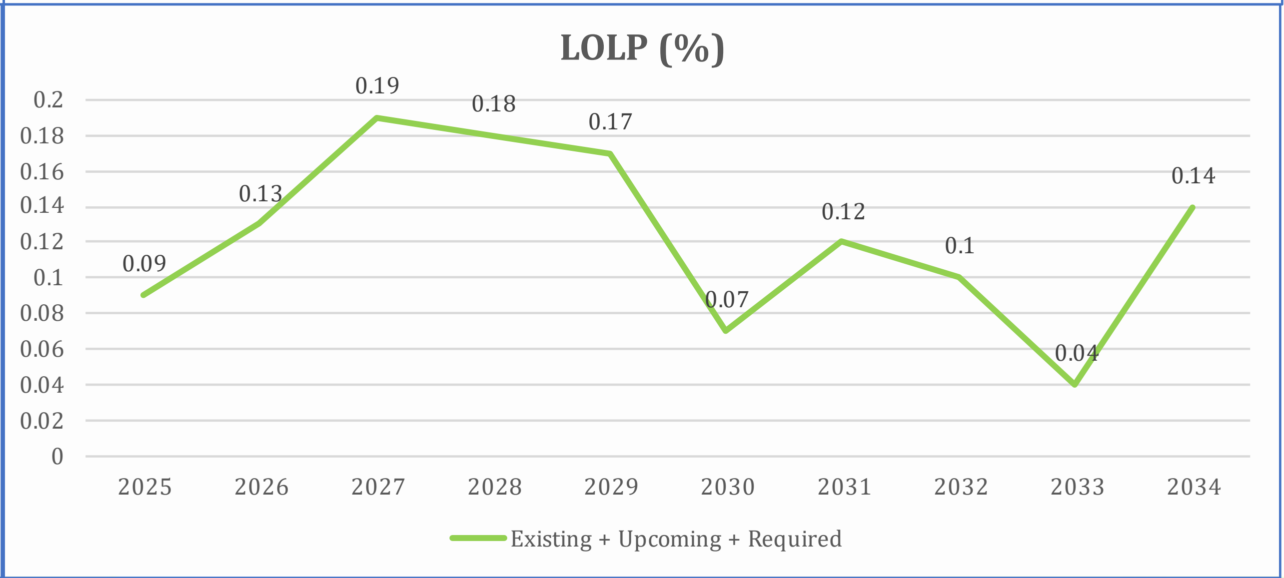
20th EPS + Agrishift Results – Existing + Upcoming + Additional

Reliability Metrics

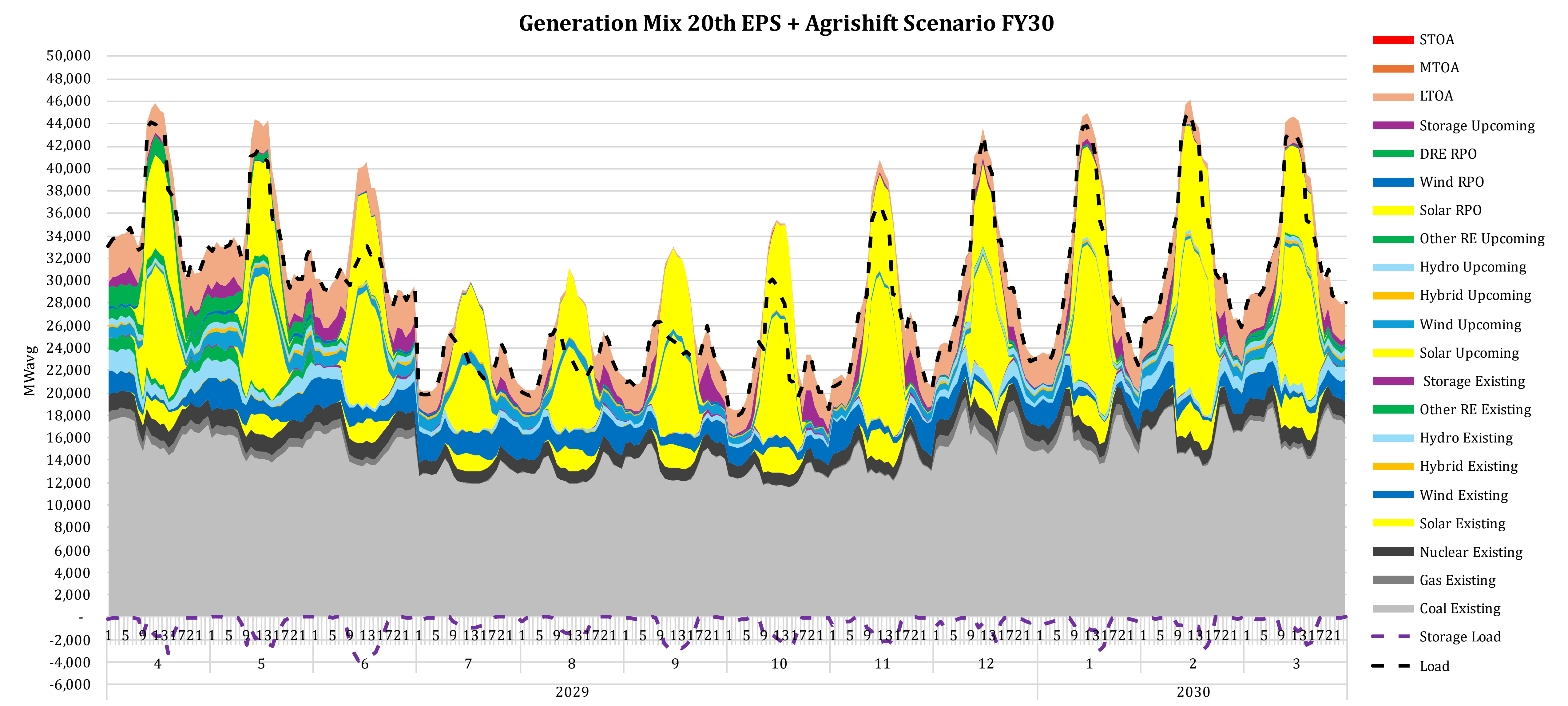








LGB – FY30 : 20th EPS + Agrishift Scenario



APPC

- 20th EPS v/s 20th EPS + Agrishift

FY	20th EPS	20th EPS + Agrishift
2025	**3.3**	**3.3**
2026	**3.3**	**3.3**
2027	**3.3**	**3.3**
2028	**3.8**	**3.8**
2029	**4.1**	**4.1**
2030	**4.1**	**4.4**
2031	**4.4**	**4.4**
2032	**4.4**	**4.4**
2033	**4.6**	**4.7**
2034	**4.6**	**4.7**
2035	**4.6**	**4.7**

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