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Approaches for Resource Adequacy and Reliable RE Integration in Karnataka

December 2024

Contents



Background



RA Planning Study



PRM & CC based Approach



Detailed Modelling Approach

RA Planning Study

Approaches for Evaluating Resource Adequacy

Two Approaches

PRM & CC based Approach (Spreadsheet-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

Capacity requirement (FY28)

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

18,578 MW x (1 + 12%) = 20,807 MW

Resource	Installed Capacity (MW)	CC (%)	Credited available to meet peak (MW)
Coal Existing	9,610	80%	7,688
Nuclear Existing	782	70%	547
Hydro Existing	5,009	30%	1,503
Biomass and Cogen Existing	1,867	30%	560
Solar Existing	8,500	54%	4,590
Wind Existing	6,000	10%	600
Nuclear Upcoming	442	70%	309
Biomass + MSW Upcoming	12	30%	3
Storage Upcoming	1,102	100%	1,102
Solar Upcoming	5,290	60%	3,174
Wind Upcoming	2,000	15%	300
Coal Upcoming	0	80%	0
Gas Upcoming	370	40%	148
MTOA	0	80%	0
STOA	800	80%	640
Total (MW)	41,783		21,165

**Detailed Modelling
Approach (Modelling
Software-Based)**

**Modelling
Philosophy**

Objectives

Reliability

Demonstrate how the energy system meets demand under various conditions.

Optimization

Explore cost-efficient resource allocation while adhering to system constraints.

Resilience

Identify vulnerabilities and ensure system robustness during extreme events.

Modelling Approach

Scenario Analysis

Testing different demand and supply conditions.

Stochastic Inputs

Incorporating variability in renewables, load, and outages.

Reliability Metrics

E.g., Loss of Load Probability (LOLP), Unserved Energy (UE), Reserve Margins, etc.

Stakeholder Relevance

For System Operators

Ensures operational reliability.

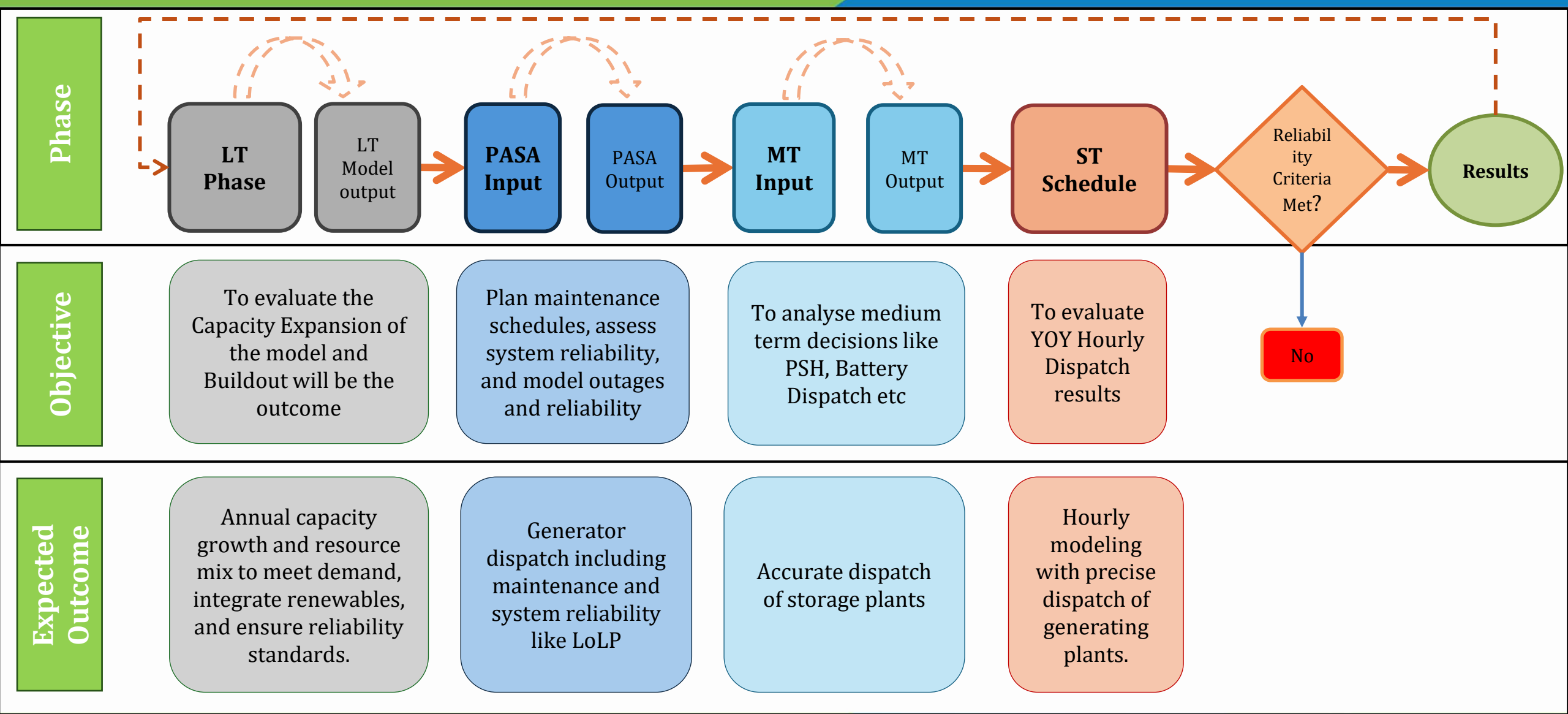
For Policy Makers

Informs planning for future capacity needs.

For Market Participants

Highlights opportunities for investment in resources.

Modelling Objectives & Phases - Stagewise



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)

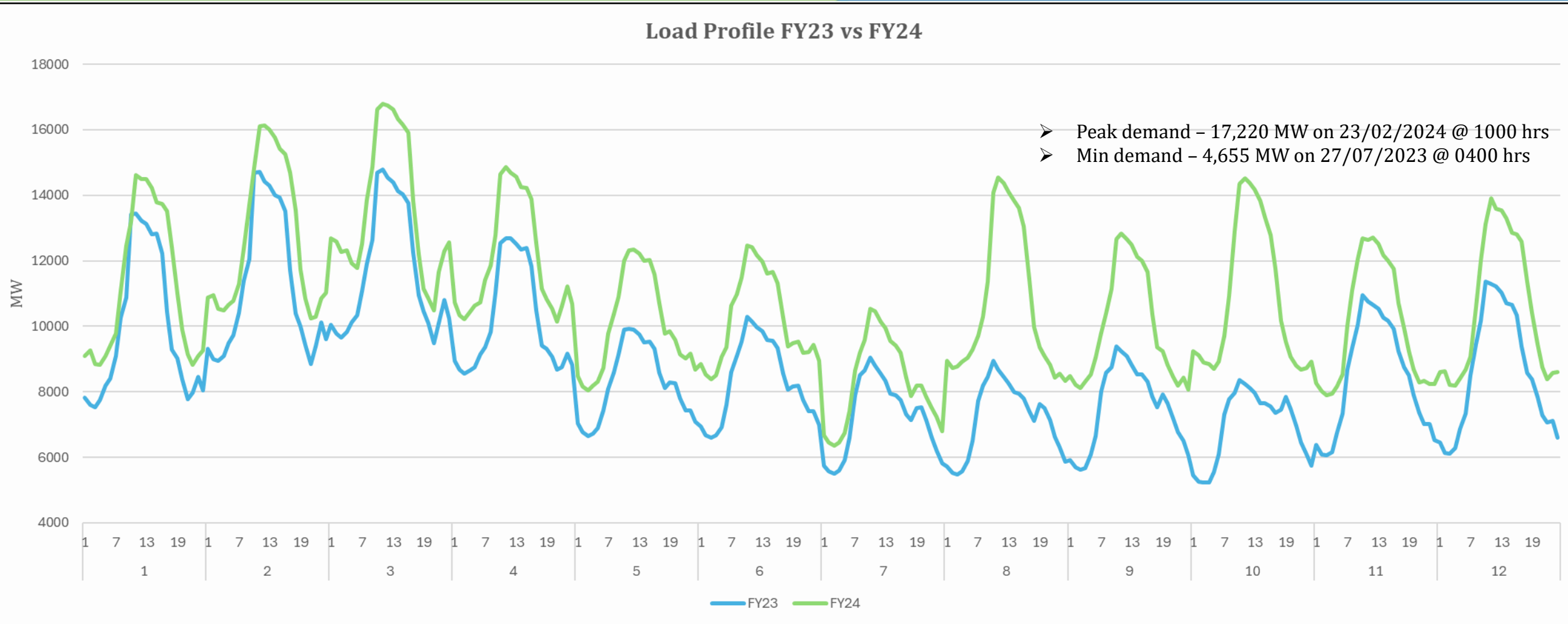
Storage data in case of Pumped Hydro

Sub-hourly/hourly/monthly generation profile

Present Tariffs

Summary of Input Data

Base Load Curve (FY24)



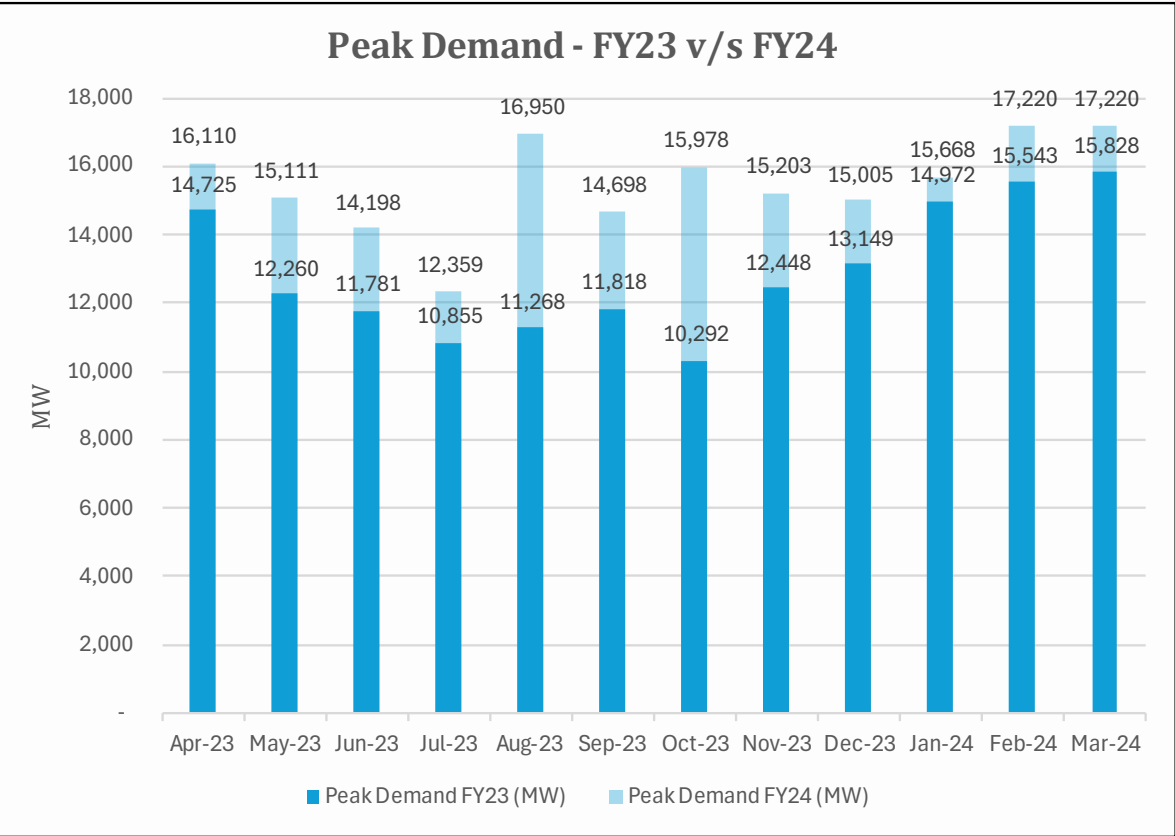
- The actual hourly load data for FY24 from KPTCL is used as the baseline for subsequent years, as FY24 peaks are higher than FY23.
 - Peak demand occurs during solar hours, while demand is at its lowest during nighttime.

Peak and Energy Projections (FY25-35)



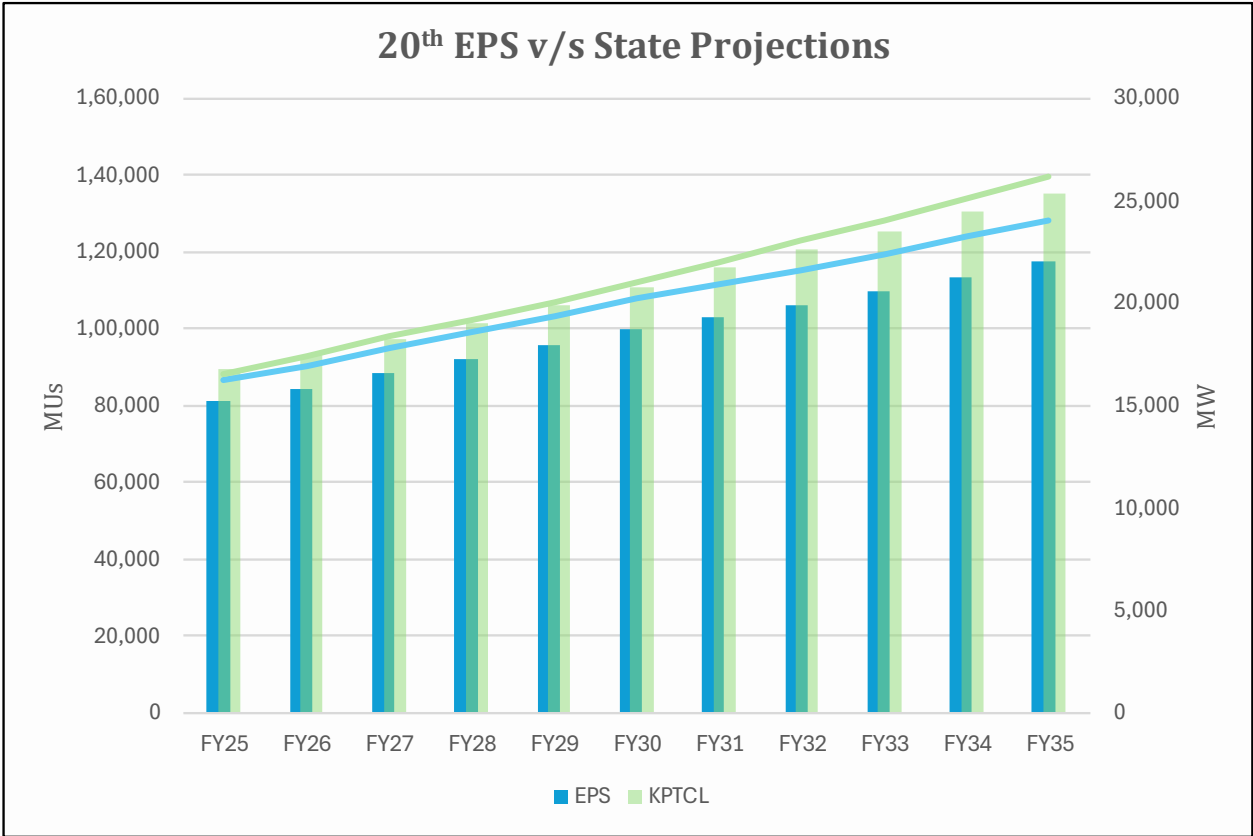
Monthly Peak Demand for FY23 & FY24

Peak Demand - FY23 v/s FY24



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

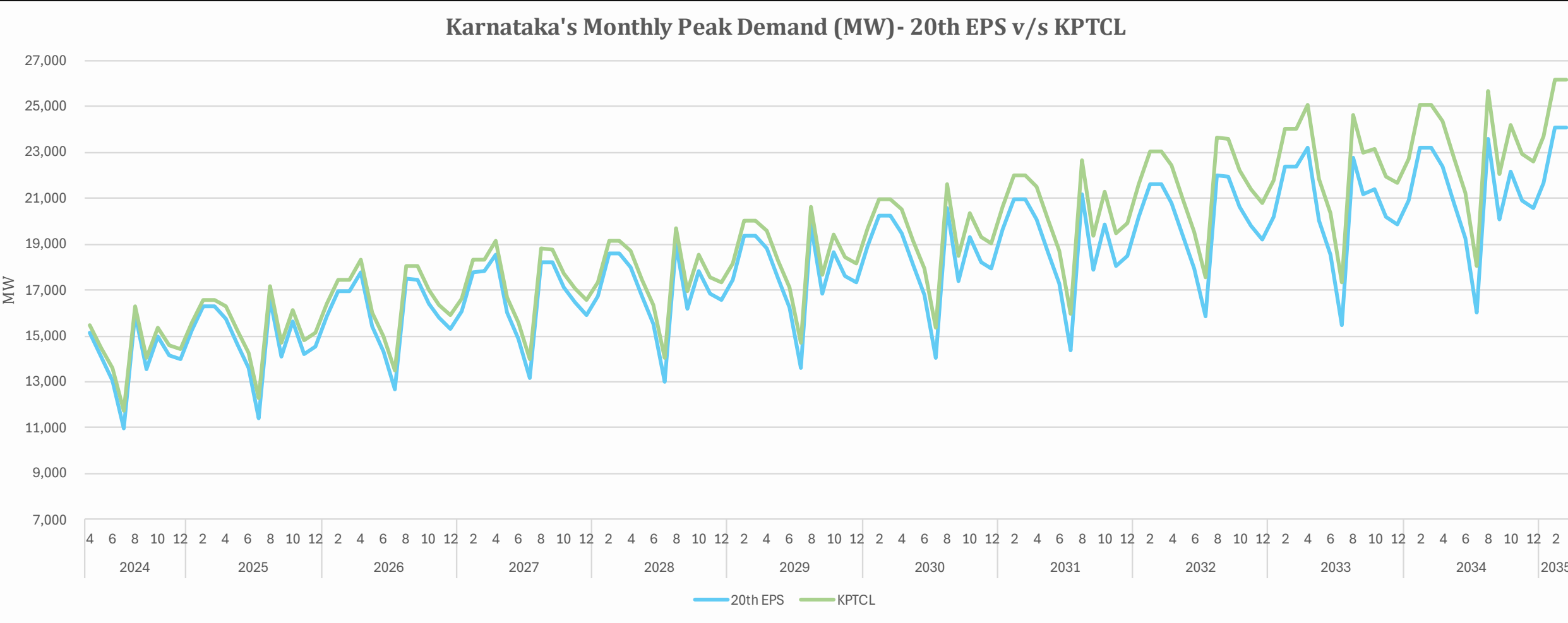
20th EPS v/s State Projections



Source: CEA Dashboard, 20th EPS

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

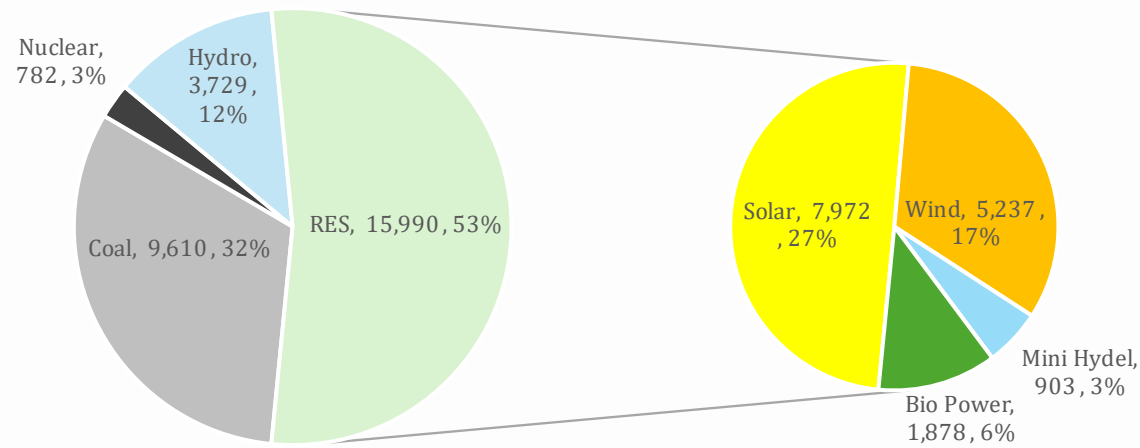
Buildup of Hourly Profile (FY25-35)



FY24 profile is used as base, and the EPS and KPTCL projections are used to build the future profiles.

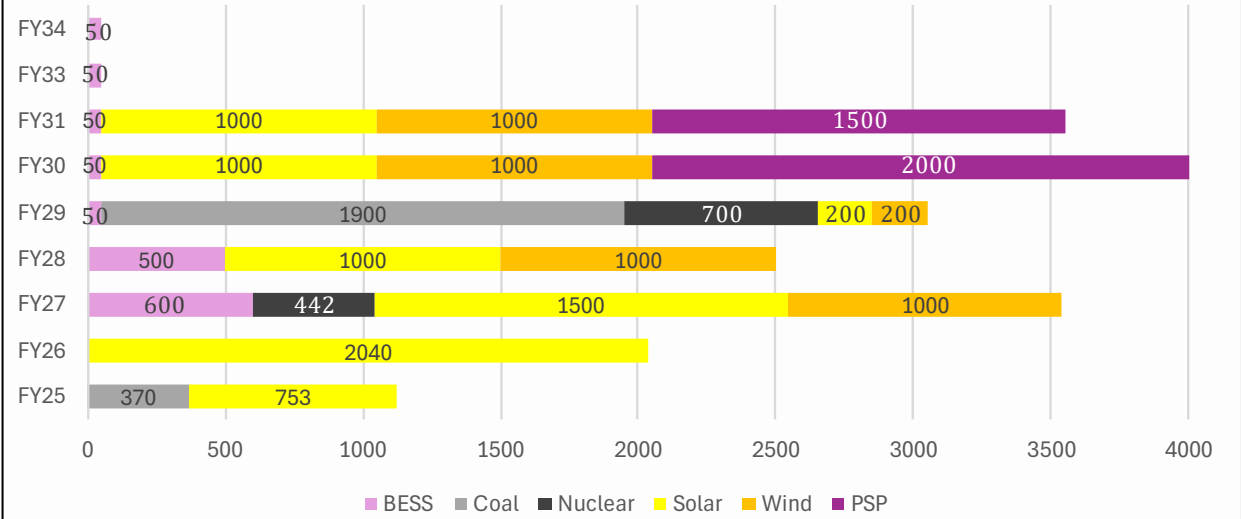
Installed Capacity (FY24) and Contracted Capacity

Installed Capacity (MW)



Source: KERC

YoY Capacity Addition (MW)

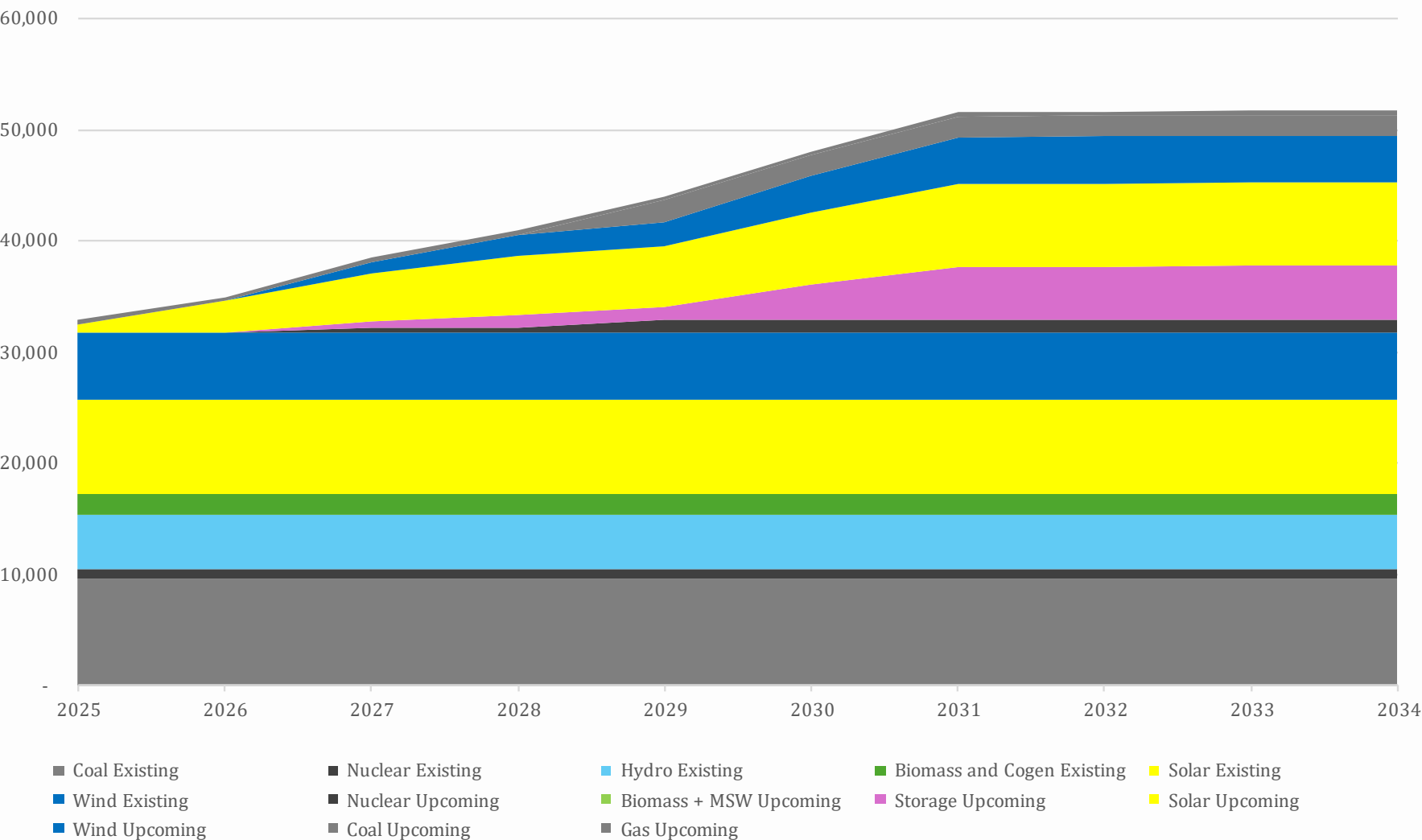


Source: KERC

- ❖ 4th highest RE installed capacity in India, and share has increased from 49% in FY19 to 53% in FY24.
- ❖ As per MNRE and NIWE, the estimated solar potential is 24.7 GW and wind potential is 169 GW (150m hub height).
- ❖ Karnataka Renewable Energy Policy 2022-27 aims to facilitate development of 10 GW of additional RE projects with/without ESS in the State, including up to 1 GW of Rooftop solar PV projects.
- ❖ Vast potential is untapped, for which a detailed modelling analysis is required for least-cost expansion that ensures smooth integration and reliable operations.

Karnataka solar potential could be higher than 24.7GW (it's based on the old study) It may be necessary to re-estimate the solar potential

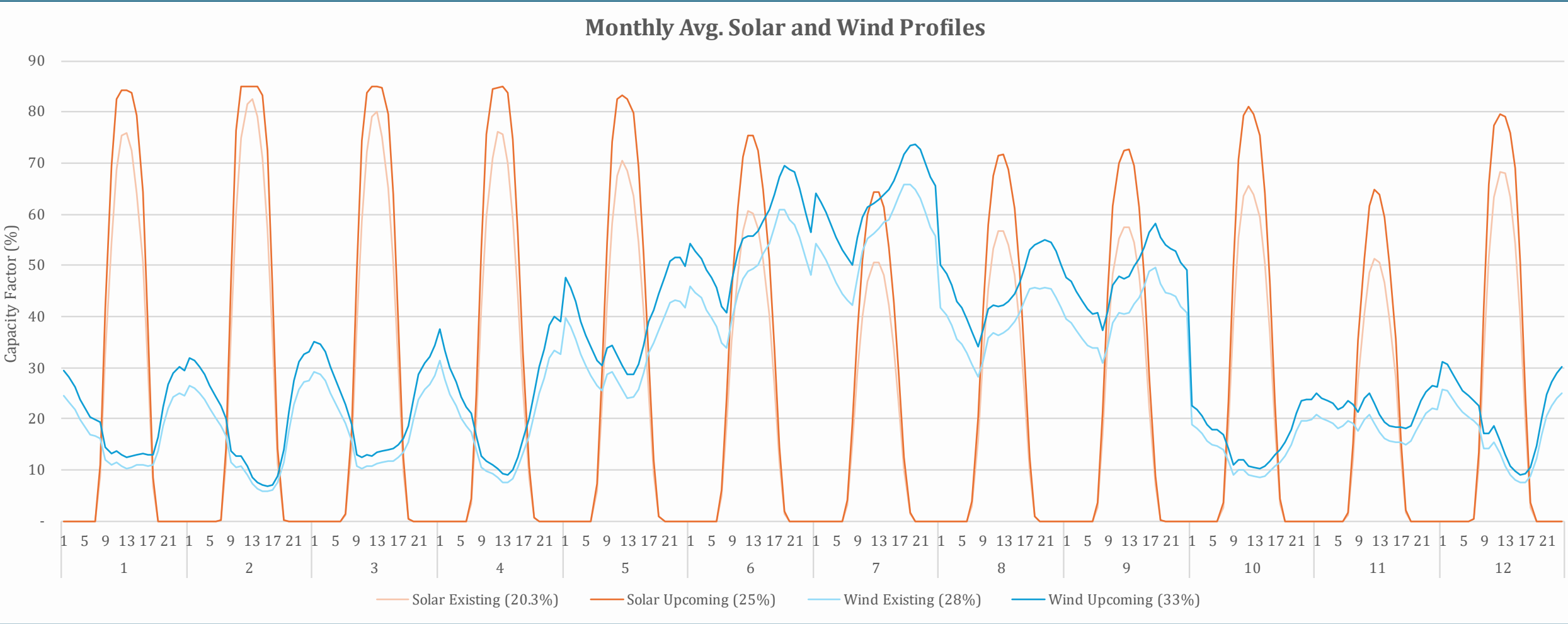
Installed and Upcoming Capacity (MW)



FY	Total IC (MW)	Upcoming Gen YoY (MW)
2025	33,901	1,134
2026	36,641	2,040
2027	39,483	3,542
2028	41,983	2,500
2029	44,533	3,050
2030	48,083	4,050
2031	51,633	3,550
2032	51,683	50
2033	52,033	50
2034	52,083	50

RPO compliance was achieved with the capacity of the upcoming renewable energy plants

Avg. Hourly Profile for Solar & Wind



Wind generation is high during June to September. Solar Generation is slightly lower during this month.

Reliability Analysis

Loss of Load Probability (LoLP)

The probability that the available electricity supply will be insufficient to meet demand at any given time.

$$\text{LoLP} < 0.2\%$$

Normalised Energy Not Served (NENS)

The proportion of energy demand that cannot be met due to insufficient capacity, normalized to the total energy demand over a period.

$$\text{NENS} < 0.05\%$$

Planning Reserve Margin (PRM)

The percentage of extra generation capacity available above the peak demand to ensure system reliability during unexpected events, such as generator outages or demand surges.

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.

Scenario Setup

1

20th EPS Projection

- From FY25 to FY34, the energy projection grows by CAGR of 3.9% and Peak Demand by 4.07%.

20 th EPS Projection		
FY	Energy Projection (MUs)	Energy Peak (MW)
FY25	80,922	16,277
FY26	84,132	16,947
FY27	88,232	17,810
FY28	91,852	18,578
FY29	95,486	19,352
FY30	99,758	20,254
FY31	1,02,973	20,954
FY32	1,05,970	21,613
FY33	1,09,660	22,405
FY34	1,13,478	23,225

2

State Projection

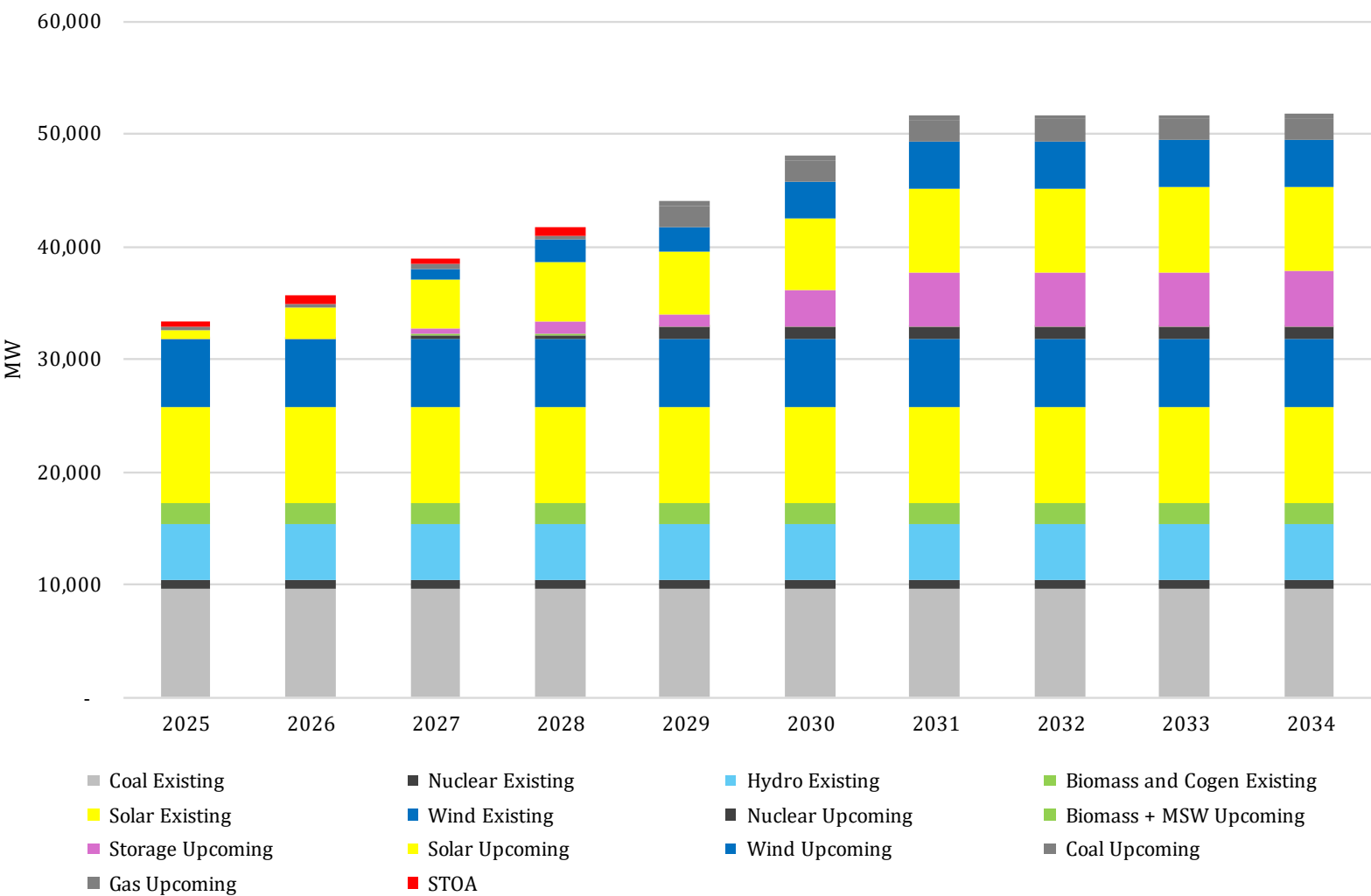
- From FY25 to FY34, the energy projection grows by CAGR of 4.1% and Peak Demand by 4.5%.
- Monsoon Case Study: In this case study, the PSP will operate solely for power generation during the monsoon season from July to October.

State Projection		
FY	Energy Projection (Mus)	Energy Peak (MW)
FY25	89,496	16,580
FY26	93,194	17,439
FY27	97,095	18,353
FY28	1,01,233	19,135
FY29	1,05,943	20,025
FY30	1,10,941	20,970
FY31	1,15,755	21,990
FY32	1,20,778	23,058
FY33	1,25,425	24,052
FY34	1,30,251	25,089

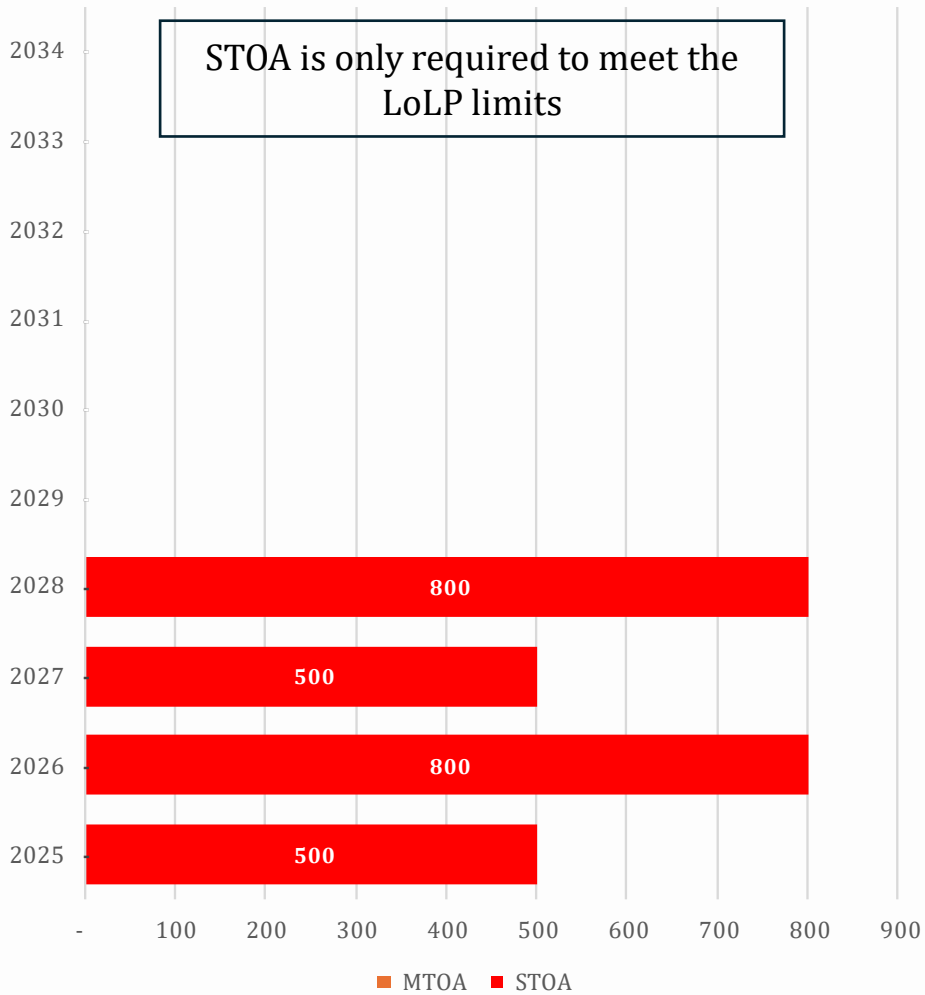
Results for 20th EPS Scenario

Capacities for Meeting the Requirement – 20th EPS

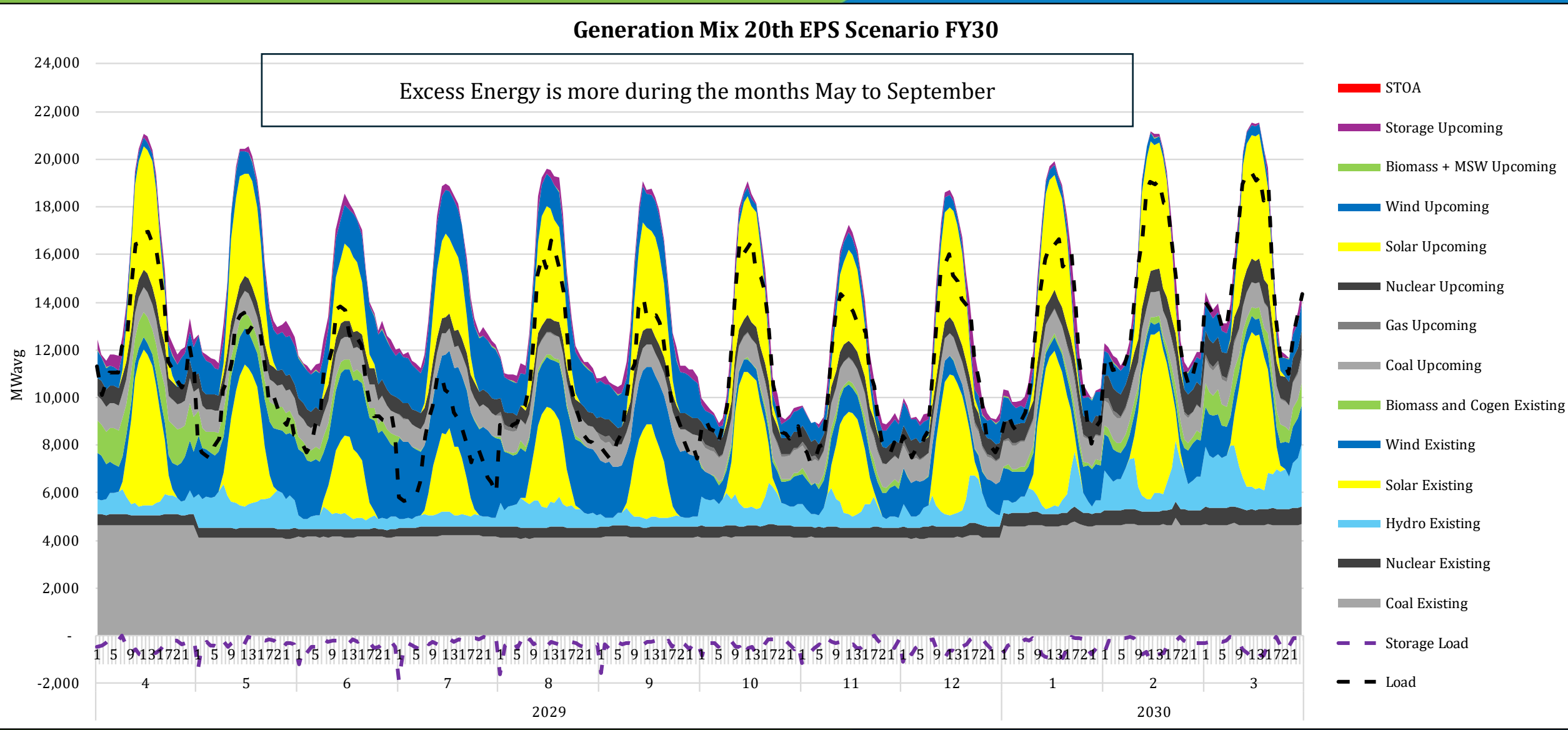
YoY IC - 20th EPS Scenario (MW)



Additional Generation Capacity Required (MW)



LGB – FY30 : 20th EPS Scenario

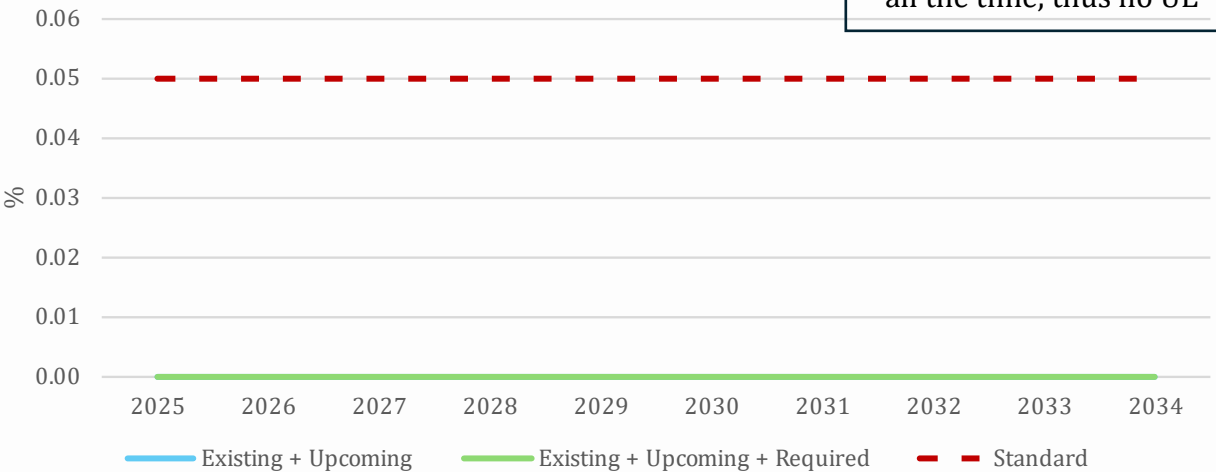


20th EPS Results

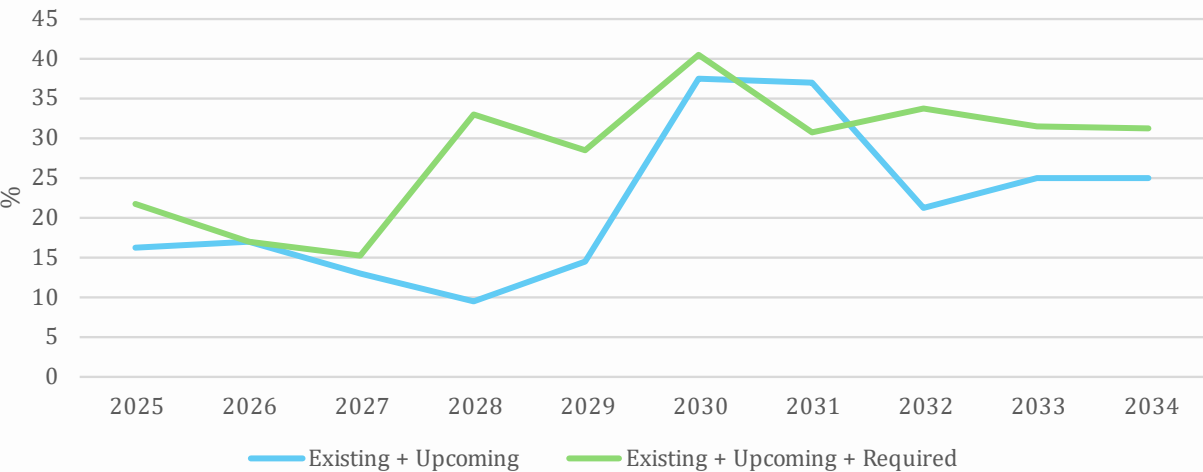


Reliability Metrics – UE, DE

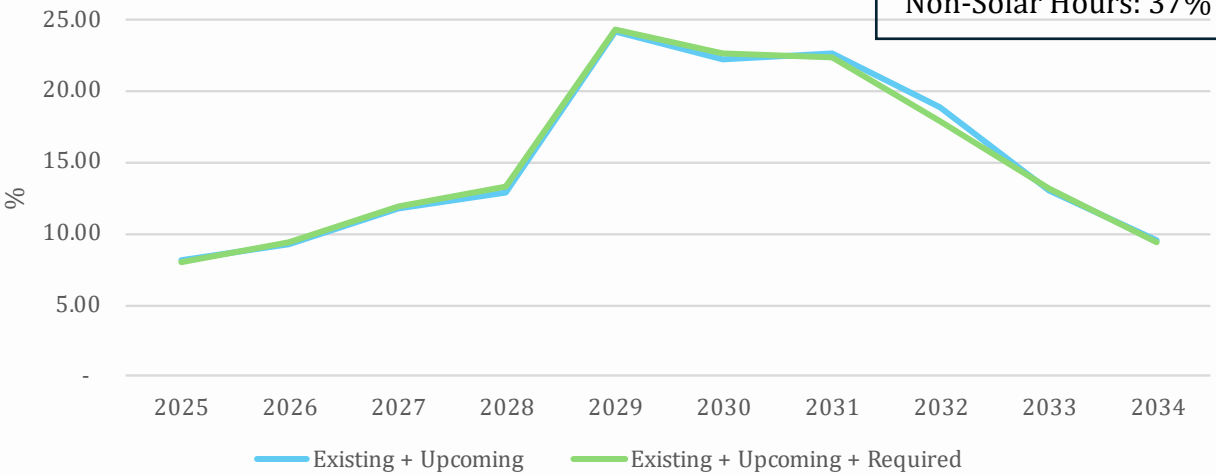
Unserved Energy



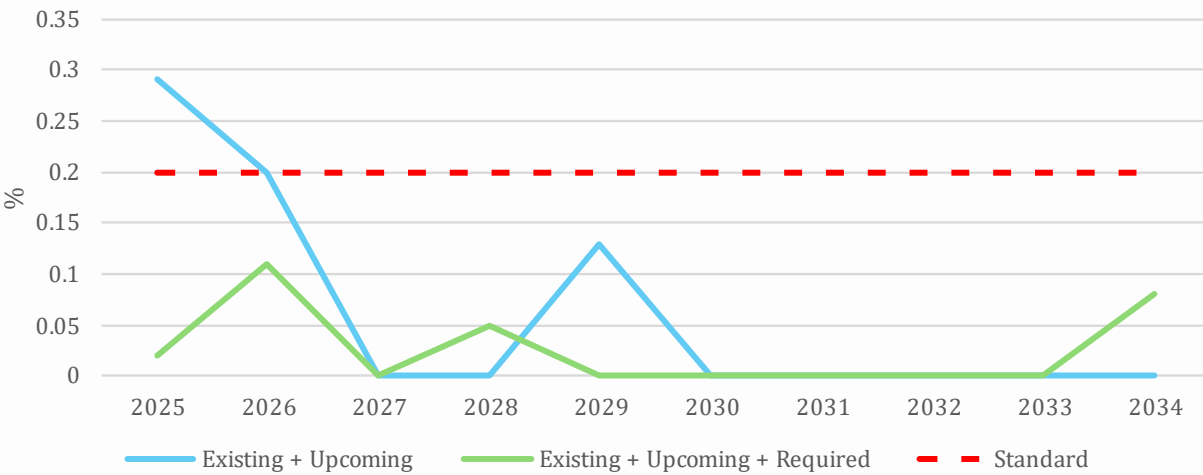
Planning Reserve Margin



Dump Energy



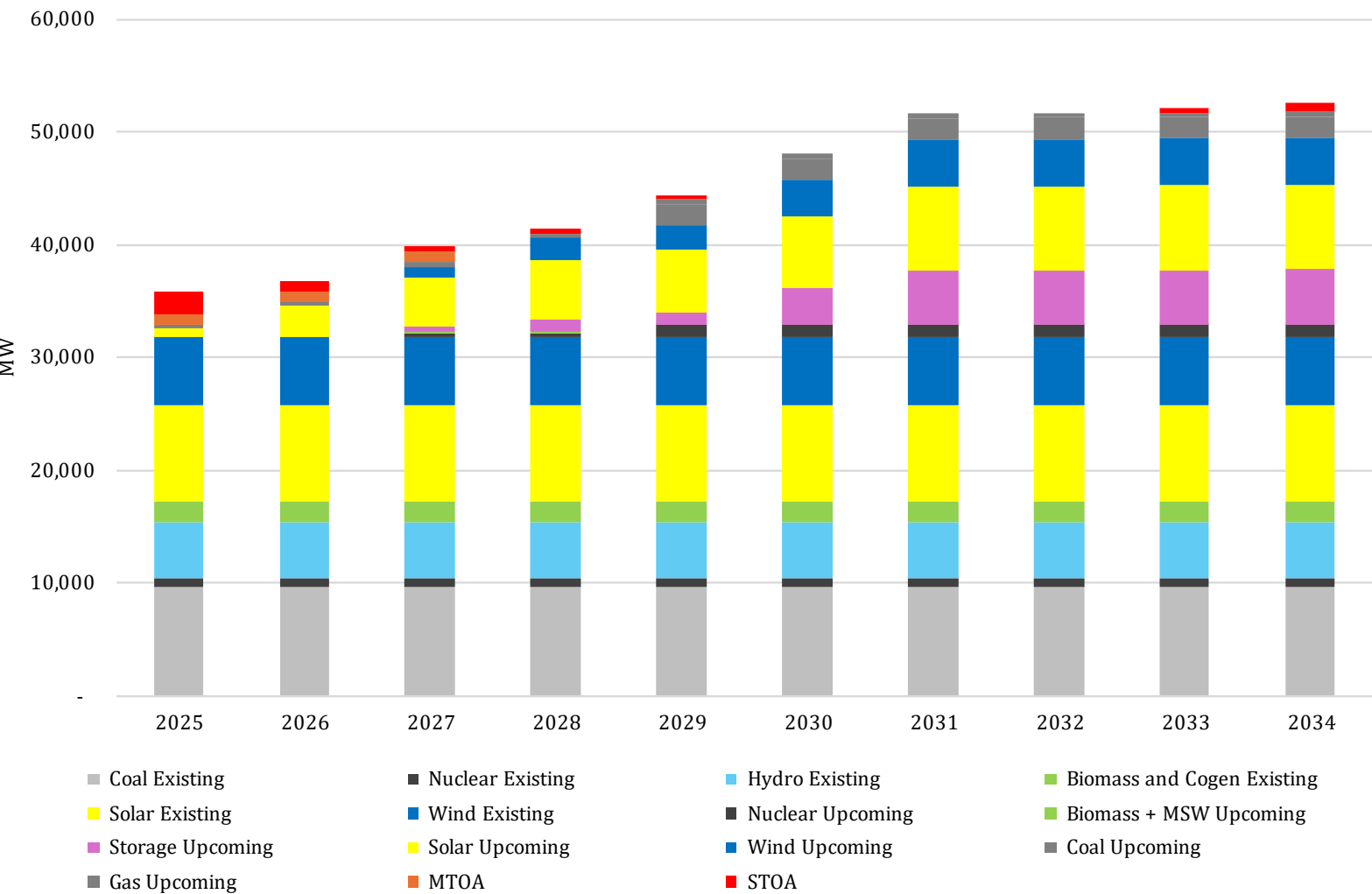
LOLP



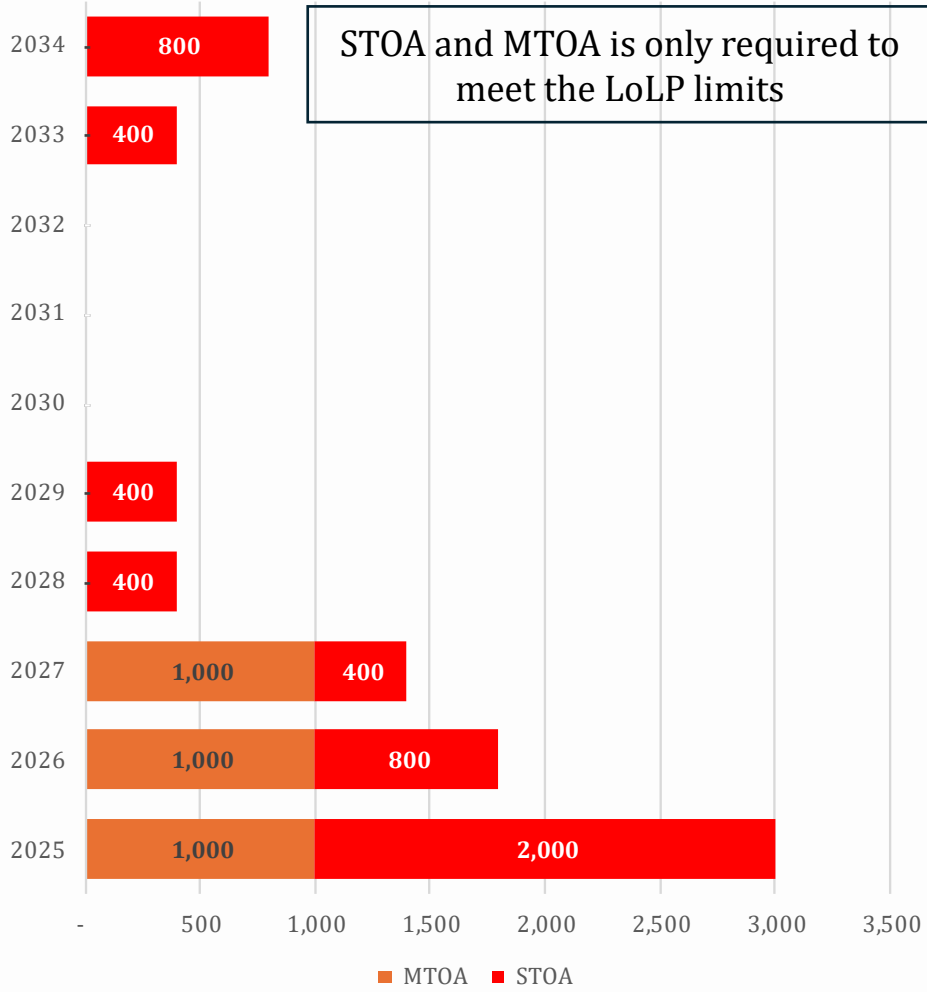
Results for KPTCL Scenario

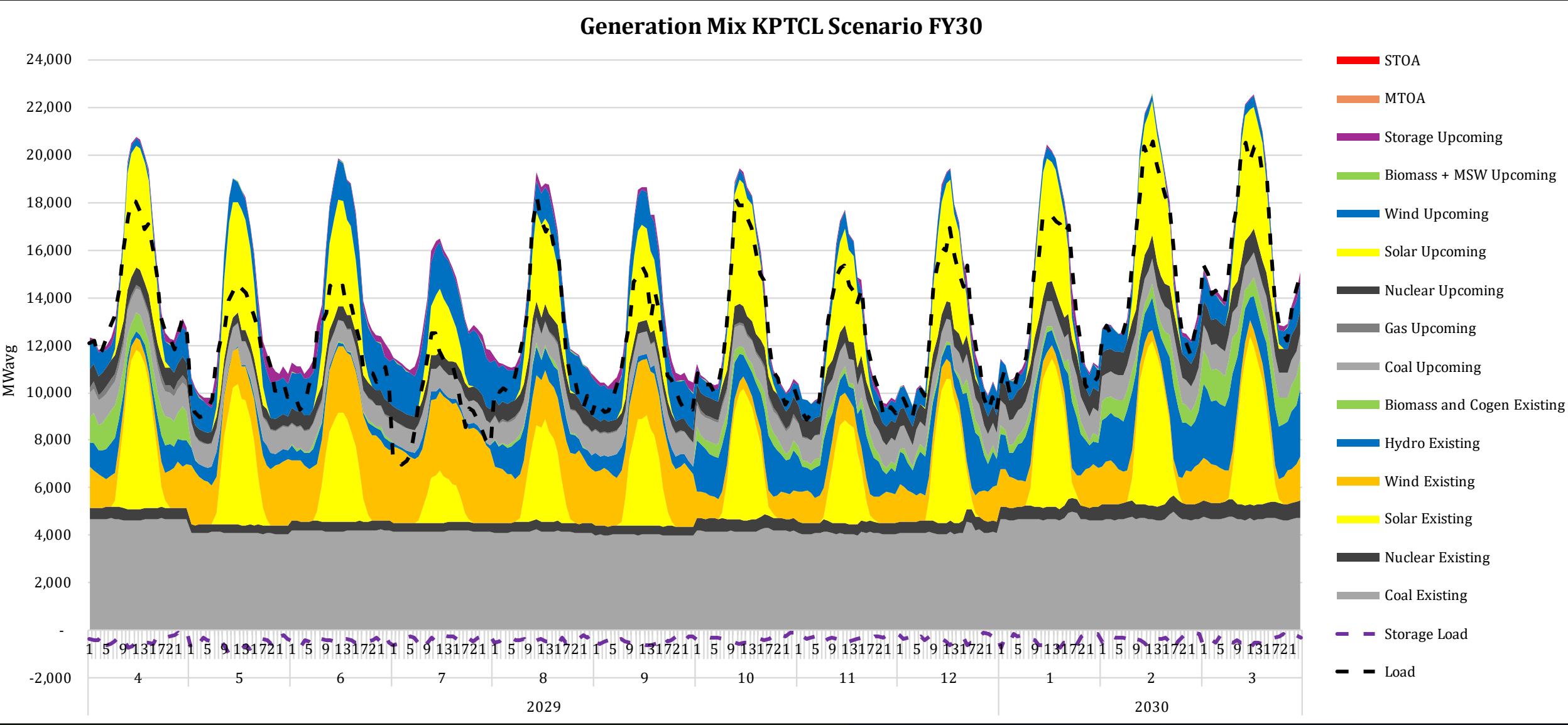
Capacities for Meeting the Requirement – KPTCL

YoY IC - KPTCL Scenario (MW)



Additional Generation Capacity Required (MW)



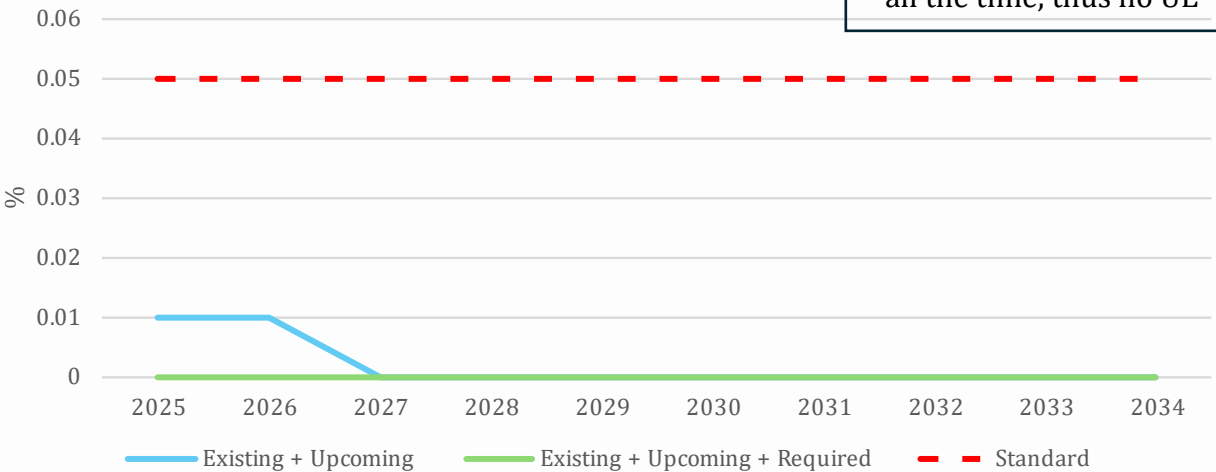


KPTCL Results

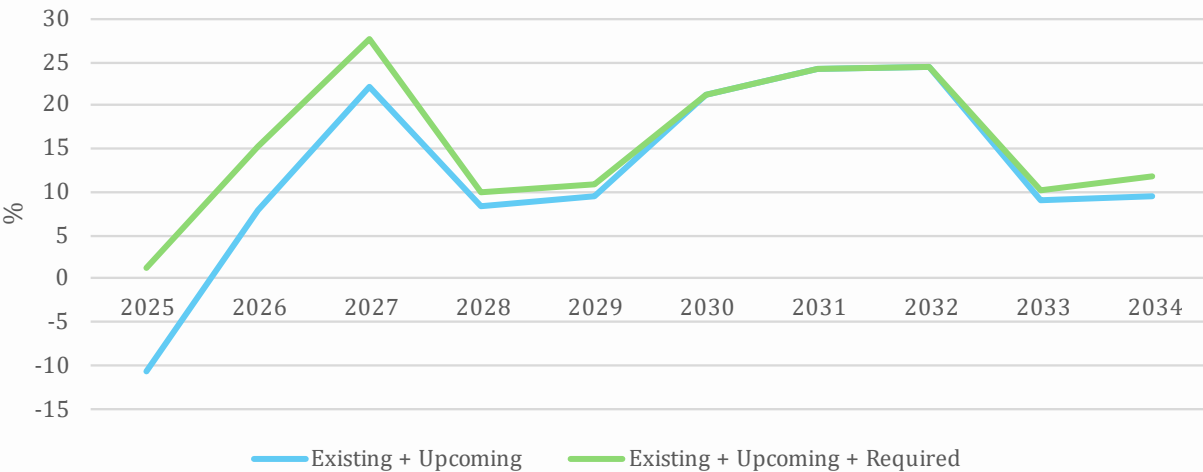


Reliability Metrics – UE, DE

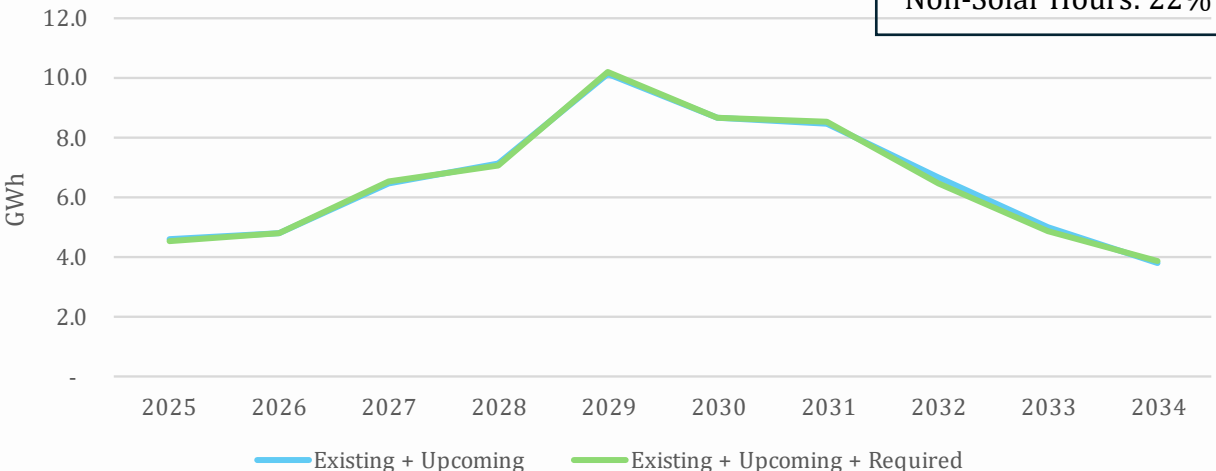
Unserved Energy



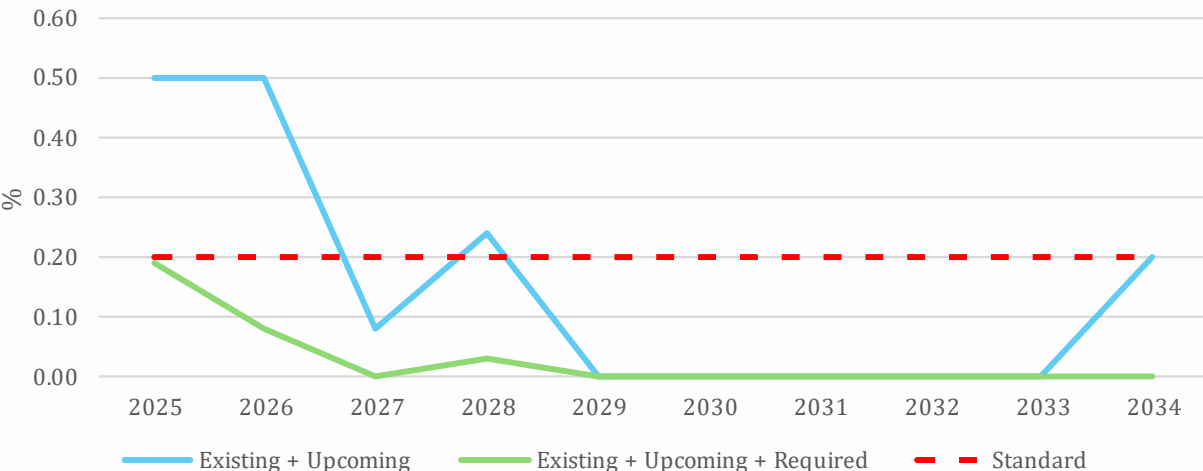
Planning Reserve Margin



Dump Energy



LOLP



FY	20 th EPS	KPTCL
2025	4.2	4.2
2026	4.2	4.2
2027	4.0	4.2
2028	4.0	4.1
2029	4.1	4.0
2030	4.1	4.0
2031	4.1	4.0
2032	4.1	4.0
2033	4.1	4.2
2034	4.1	4.2



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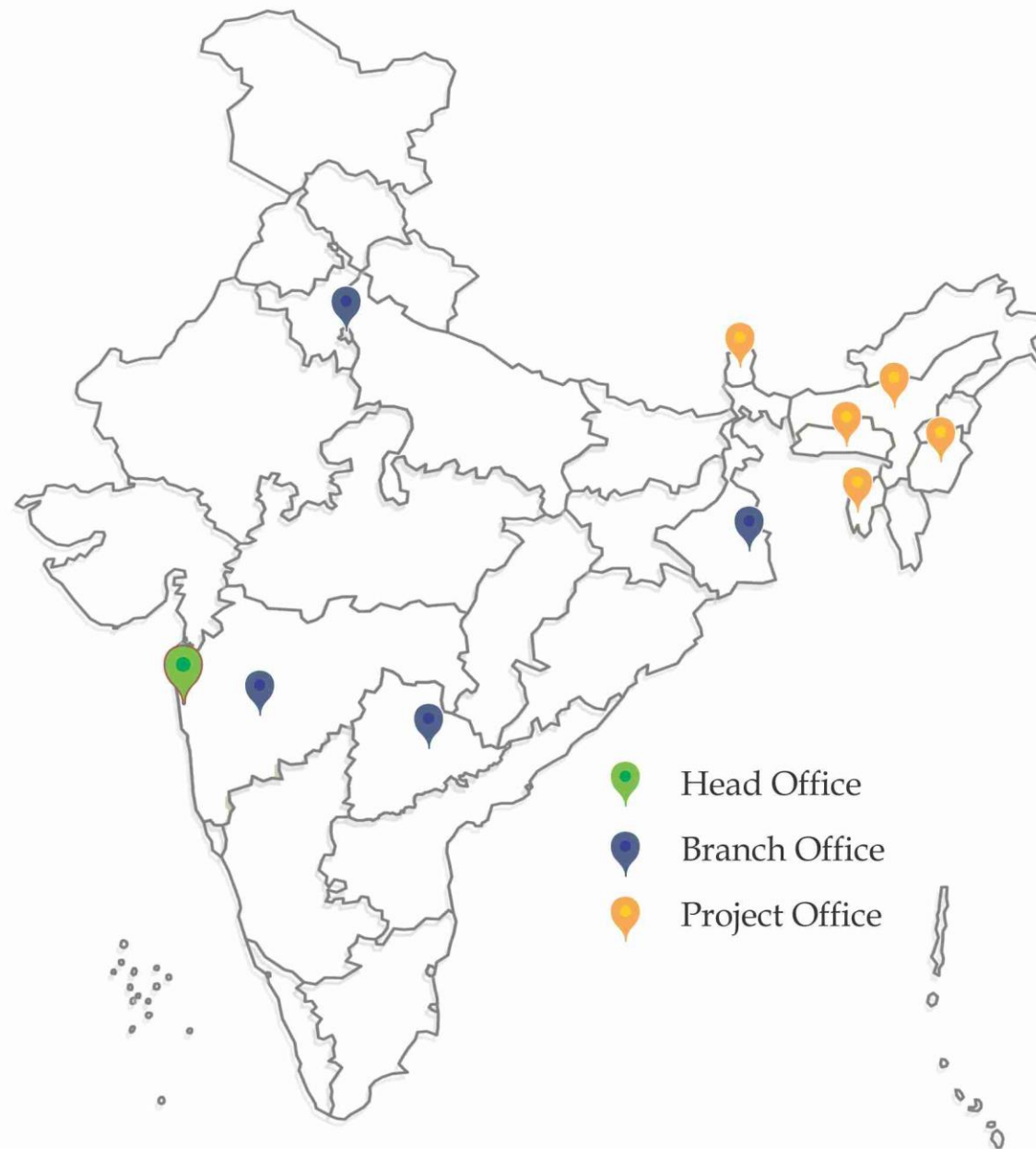
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