

Introducing CEA_STELLAR: India's Pioneering Resource Adequacy and Capacity Expansion Planning Tool

Central Electricity Authority (CEA) is proud to announce the soft launch of STELLAR, an innovative, indigenously developed resource adequacy and capacity expansion planning tool. This state-of-the-art model marks a significant leap forward in India's journey towards ensuring energy security, affordability, and a flexible, clean energy grid.

STELLAR was officially launched on April 11, 2025, by Shri Ghanshyam Prasad, Chairperson, Central Electricity Authority (CEA), in the presence of esteemed dignitaries including Sh. Alok Kumar, Ex-Secretary (Power) and partner at The Lantau Group (TLG), and various representatives from State Power Utilities.

A Collaborative Effort for a Secure Energy Future

STELLAR is the result of a unique and fruitful collaboration between the Central Electricity Authority (CEA), The Lantau Group (TLG), and the Asian Development Bank (ADB) under its Technical Assistance program. Developed entirely in India with the active guidance of CEA, the tool champions complete transparency in its design and operation.

Empowering States with Data-Driven Decision Making

Recognizing the dynamic nature of energy planning, STELLAR is specifically designed to assist States and Distribution Companies (Discoms) in conducting comprehensive Resource Adequacy (RA) plans. This aligns with the Resource Adequacy Guidelines issued by the Ministry of Power in June 2023.

While CEA has been diligently carrying out RA plans for all Discoms, STELLAR aims to empower individual states. The STELLAR model code, written in GAMS, will be distributed free of cost to all States/Discoms, allowing them to:

- Conduct their own detailed planning exercises.
- Integrate their studies more effectively.
- Contribute to optimal solutions for the entire country.

Key Features and Capabilities of STELLAR:

STELLAR incorporates a sophisticated range of features to support robust and transparent planning:

- **Comprehensive System Modelling:** Explicitly considers the chronological operation of the power system.
- **Detailed Unit Commitment:** Accounts for all unit commitment constraints, including technical minimum, minimum up and down times, and ramp-up/ramp-down rates.

- **Endogenous Demand Response:** Integrates the impact and value of demand-side management.
- **Ancillary Services Optimization:** Optimises energy and ancillary services for grid stability and efficiency.
- **Storage Optimization:** Strategically determines the optimal size and location of energy storage solutions.
- **Open Model Design:** The STELLAR model's GAMS code is designed to be accessible, promoting transparency and allowing for collaborative improvements and state-specific adaptations.
- **Data-Driven Decisions:** Empowers state utilities and planners with robust analytical backing.
- **Advanced Visualization:** Offers best-in-class visualization capabilities, allowing users to visually compare two policy options and perform drill-down analysis.
- **Integrated Planning:** Addresses generation, transmission, and storage expansion in a cohesive manner.

Benefits of Implementing STELLAR:

The adoption and utilisation of STELLAR will yield significant advantages for India's power sector:

- **Ensured Resource Adequacy:** Helps maintain an optimal balance of resources – neither less nor more – to achieve zero load shedding and prevent stressed capacity.
- **Least-Cost Solutions:** Optimizes the cost of power system generation expansion and overall system operation.
- **Enhanced Value of Demand Response:** Clearly demonstrates and quantifies the benefits of demand response programs.
- **Strategic Storage Deployment:** Facilitates the efficient planning and deployment of energy storage systems.
- **Improved Grid Stability:** Through optimized ancillary services and operational planning.
- **Transparency and Collaboration:** Promotes transparent, data-driven decision-making across all levels, supported by the open nature of the model code.

The Path Forward

The Central Electricity Authority is committed to the continuous improvement of STELLAR. Future updates and upgrades will be guided by suggestions and feedback from its primary users – the Discoms and Load Despatchers.

STELLAR represents a transformative step in India's approach to power sector planning. By providing a sophisticated, transparent, and indigenously developed model, CEA is empowering stakeholders across the nation to build a more resilient, affordable, and sustainable energy future for all.

Connect with the STELLAR Community

Stay updated and collaborate with other users through the following routes.

Watch the STELLAR Software Walkthrough

- Get a comprehensive video tour of the software's features and dashboards, from login and data input to running the model and analysing outputs like total capacities, costs, storage operation, and reliability metrics.
- Watch the full video walkthrough on YouTube: <https://www.youtube.com/watch?v=p3z8ecdU0IY>

Join the STELLAR LinkedIn Group

- Connect with professionals, share insights, and stay informed on the latest developments.
- **Group Name:** CEA- Stellar -Generation Modelling and Resource adequacy tool
- Join the group on LinkedIn: <https://www.linkedin.com/groups/10084585/>

Join the Google Group for Support

- This is the forum for questions, discussions, and support.
- **Procedure to Join:**
 1. Log in to your Google account and go to Google Groups.
 2. In the search box, type **CEA-RA tool** and press Enter.
 3. Click on the group and then select **"Ask to Join group"**. Your request will be sent to the administrator for approval.

STELLAR

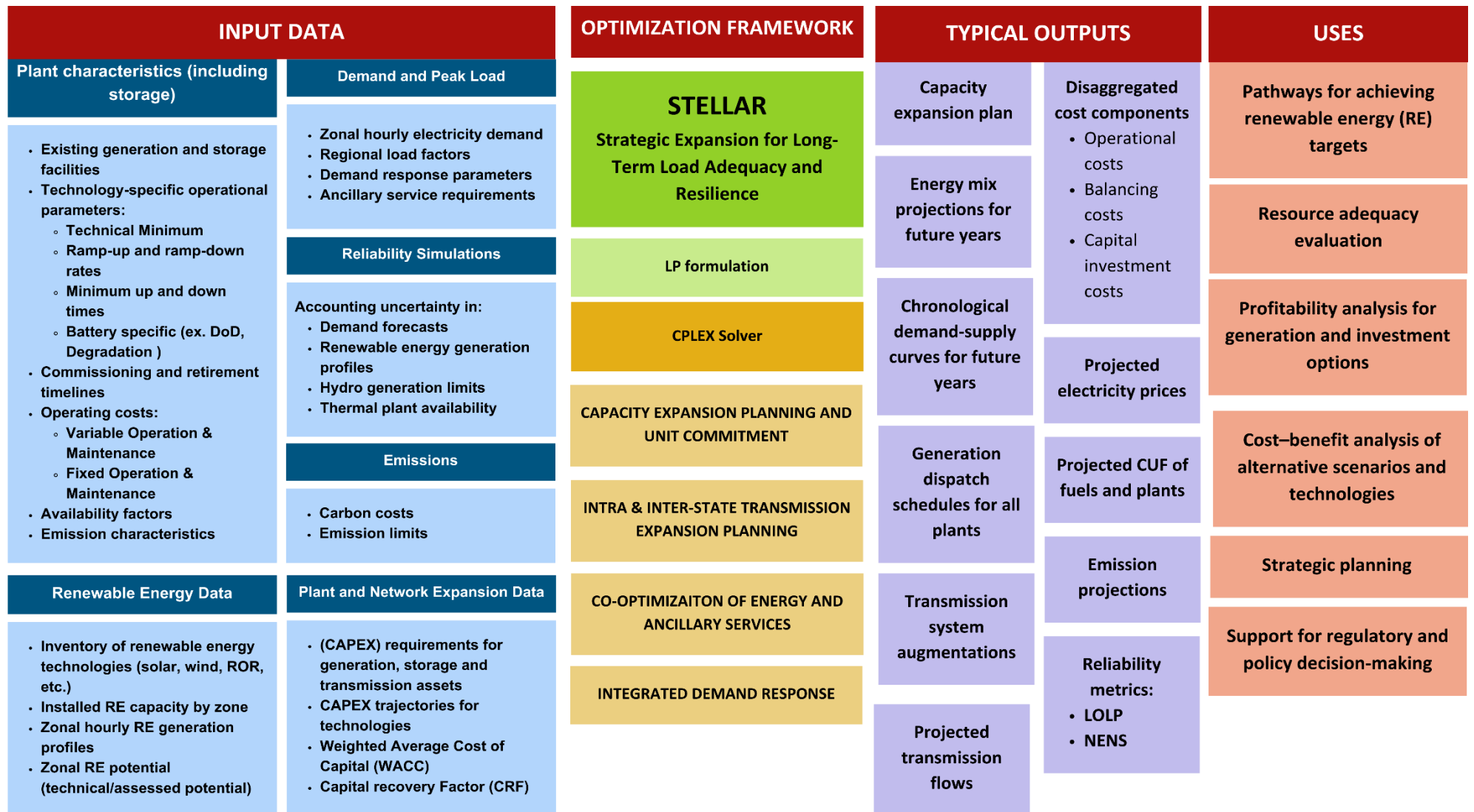
Strategic Expansion
for Long-Term
Resource Adequacy
and Resilience



Government of India
Ministry of Power

Central Electricity Authority

Optimization Model Framework



Defining Features of STELLAR



Chronological modelling



Co-optimization of energy and ancillary services



Unit commitment constraints



Integrated Demand Response



Transmission modelling

Defining Features of STELLAR



Chronological modelling

STELLAR replaces traditional load duration curves with a chronological model using representative days, better capturing demand and renewable generation patterns.



Co-optimization of energy and ancillary services



Unit commitment constraints



Integrated Demand Response



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Co-optimization of energy and ancillary services

The model's integrated framework ensures reserve adequacy while **aligning with real-world power plant constraints, enabling a more reliable and secure energy system.**



Unit commitment constraints



Integrated Demand Response



Transmission modelling

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Co-optimization of energy and ancillary services



Unit commitment constraints

This enables:

- ***Modelling actual generator capabilities***
- ***Avoiding overestimation of operational flexibility***
- ***Ensuring reliable, executable energy strategies***

Enables a capacity plan tailored for high renewable system flexibility



Integrated Demand Response



Transmission modelling

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Integrated Demand Response

The model shifts demand within the day, optimizing both investment and operational costs by reshaping load profiles.



Transmission modelling

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Integrated Demand Response



Transmission modelling

. This enables cost-optimal RE integration by

- optimizing power flows and*
- substation-level asset planning*
- reducing congestion risks.*

Typical Outputs

Capacity expansion plan

Energy mix projections

Utilization/PLF/CUF

Chronological demand
supply curves

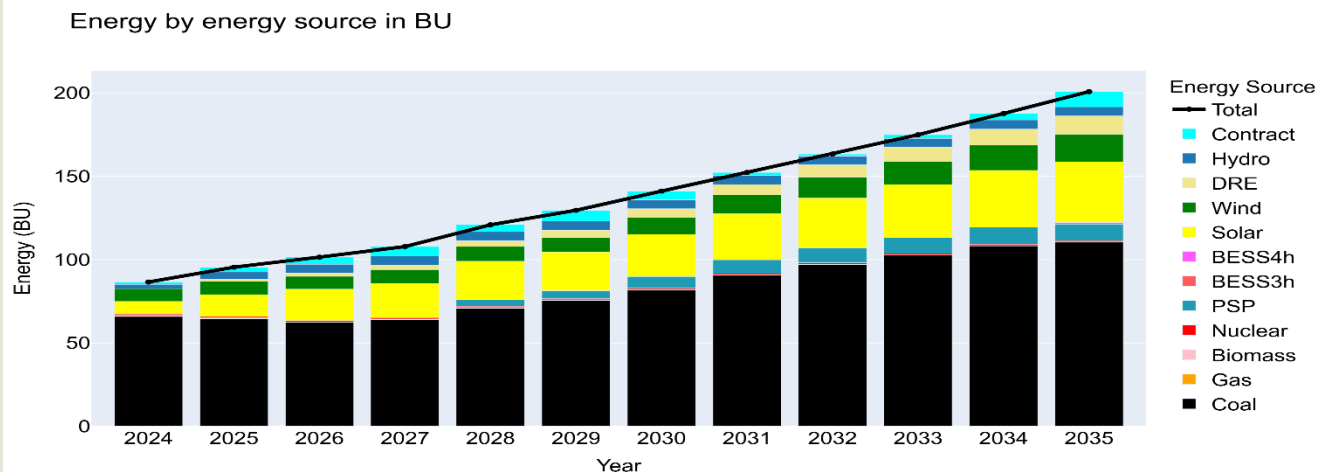
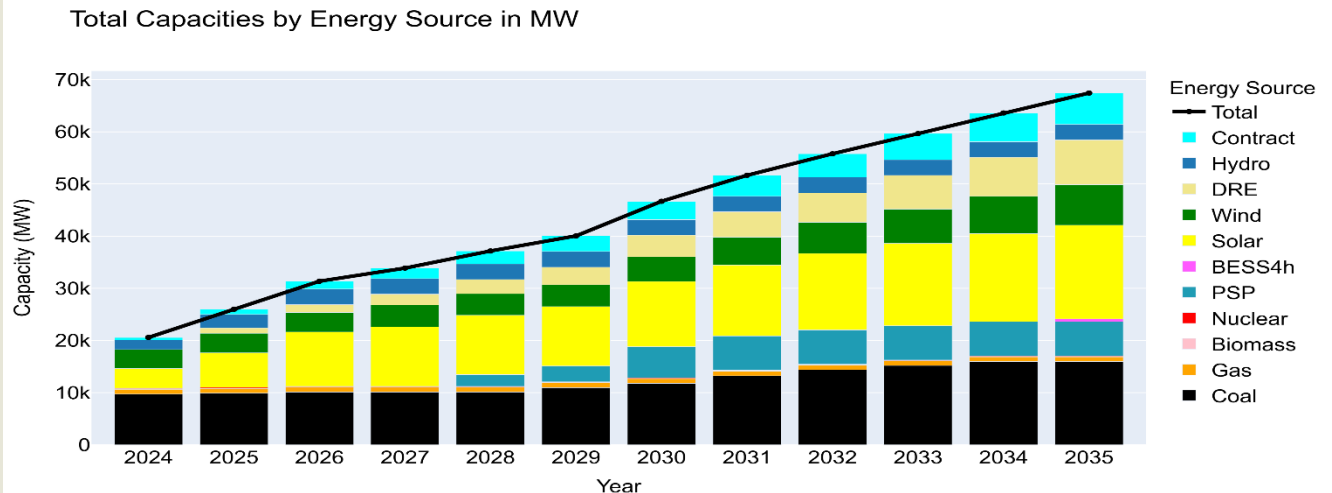
Generation Dispatch
schedules

Energy Prices

Emissions and emission
factor for future

Transmission planning
and projected flows

Reliability – LoLP and
NENS



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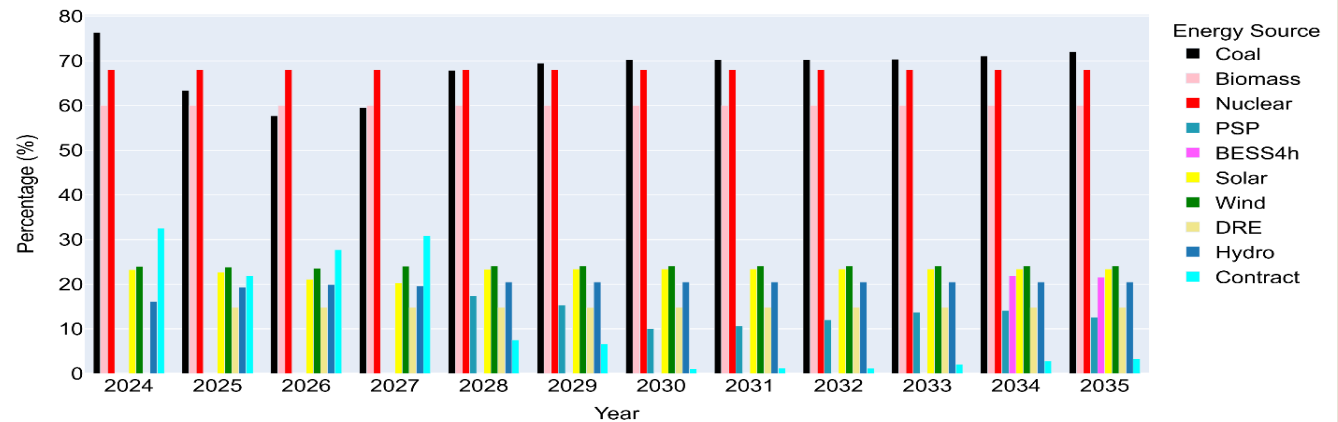
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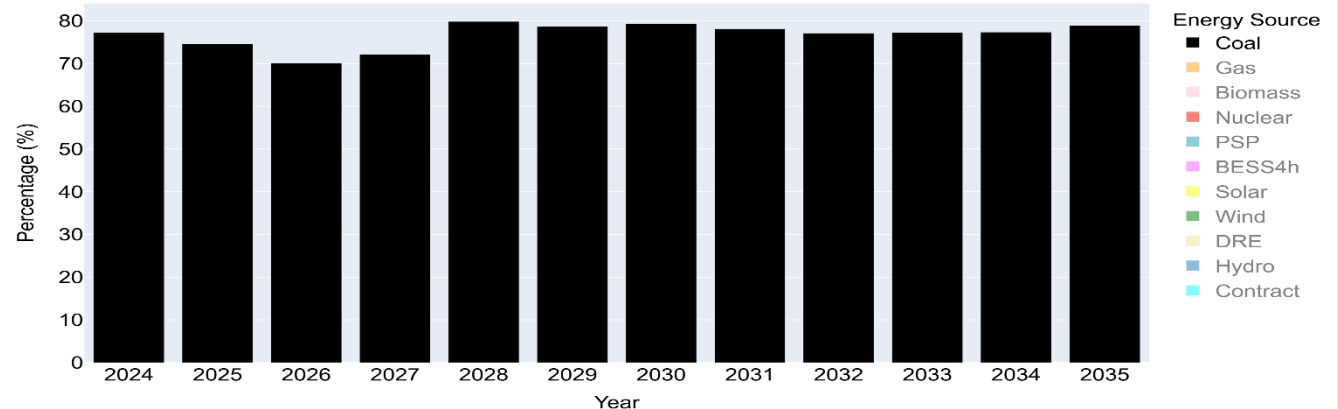
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Utilization by Energy Source (CUF)



Utilization by Energy Source (CUF)



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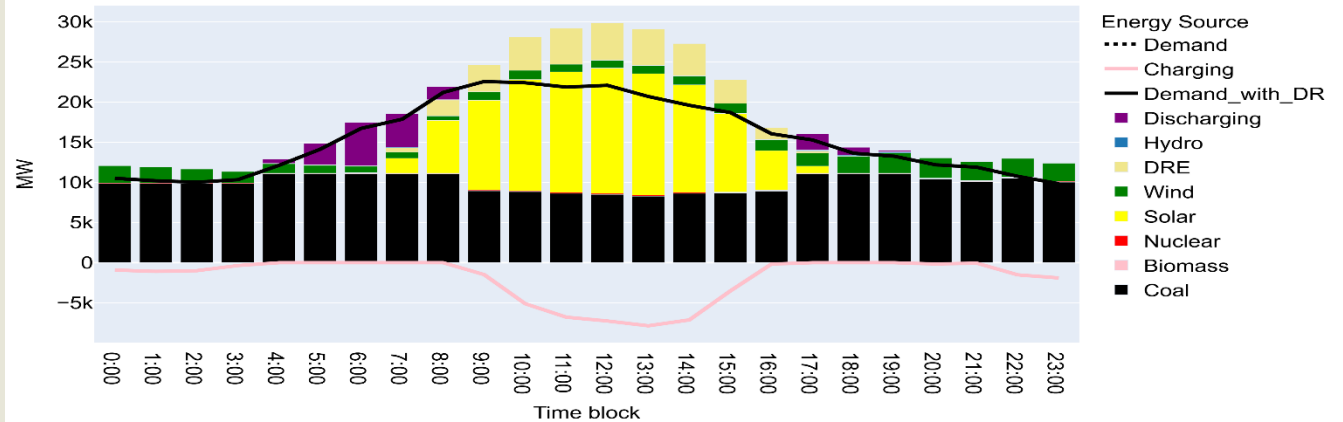
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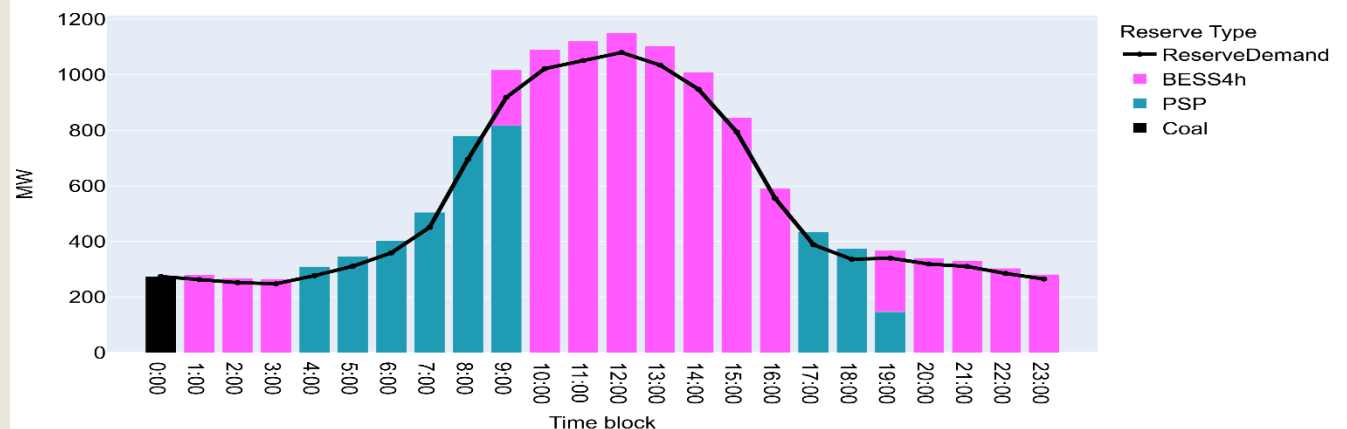
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Daily Demand Supply - Q3 - d2 - 2035



Total Reserves Daily - Q3 - d2 - 2035 - SRAS



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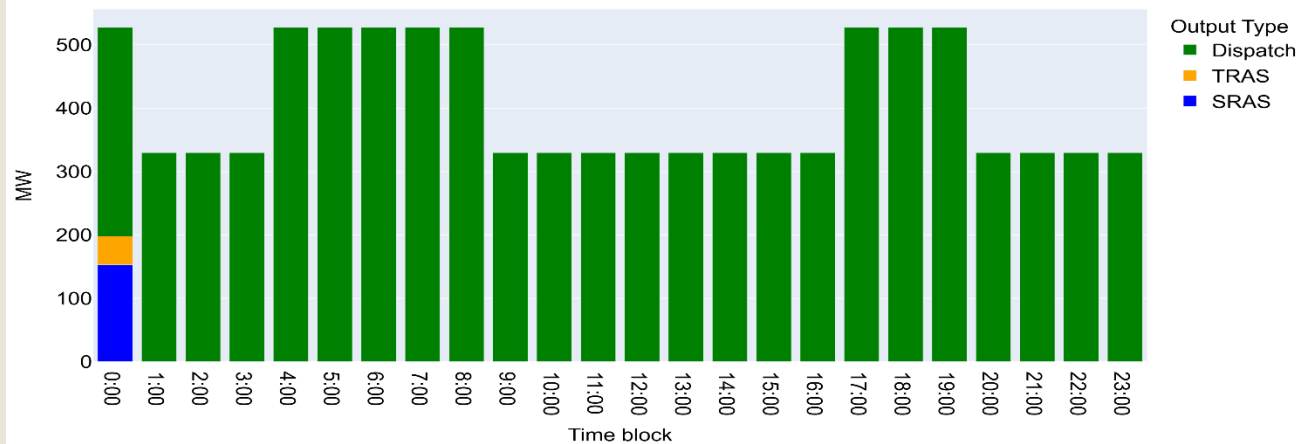
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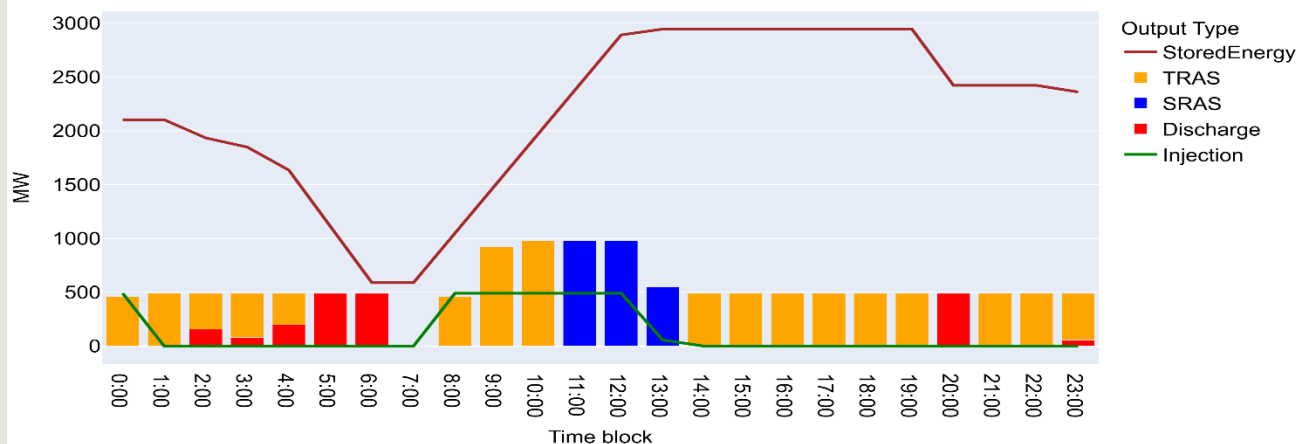
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Plant Operation for RAYALASEEMA TPS Unit 6 - Q3 - d2 - 2035



Storage Output for Cand Battery 6h - Q1 - d1 - 2034 | Power Rating: 491.0 MW, Energy Rating: 2945.0



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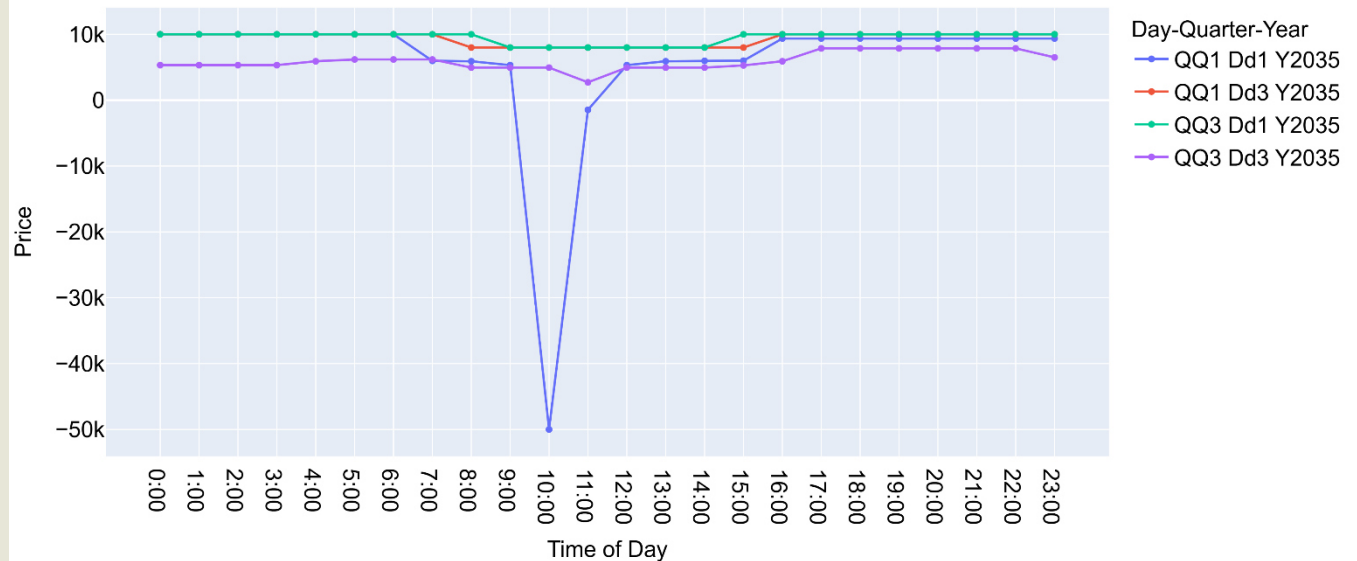
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Energy Prices for AndhraPradesh in Q1, Q3 - d1, d3 - 2035 in Rs./MWh



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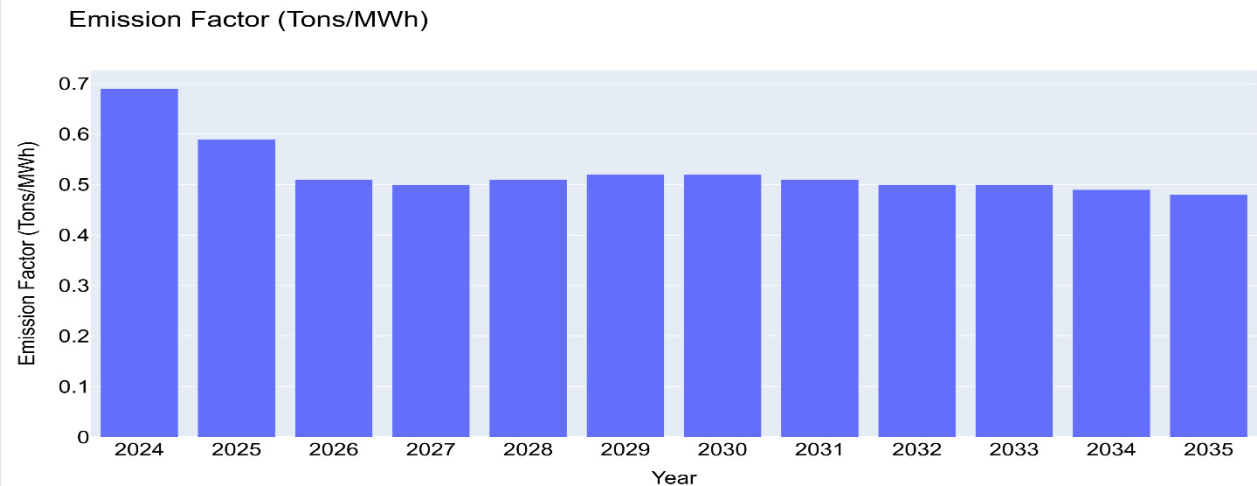
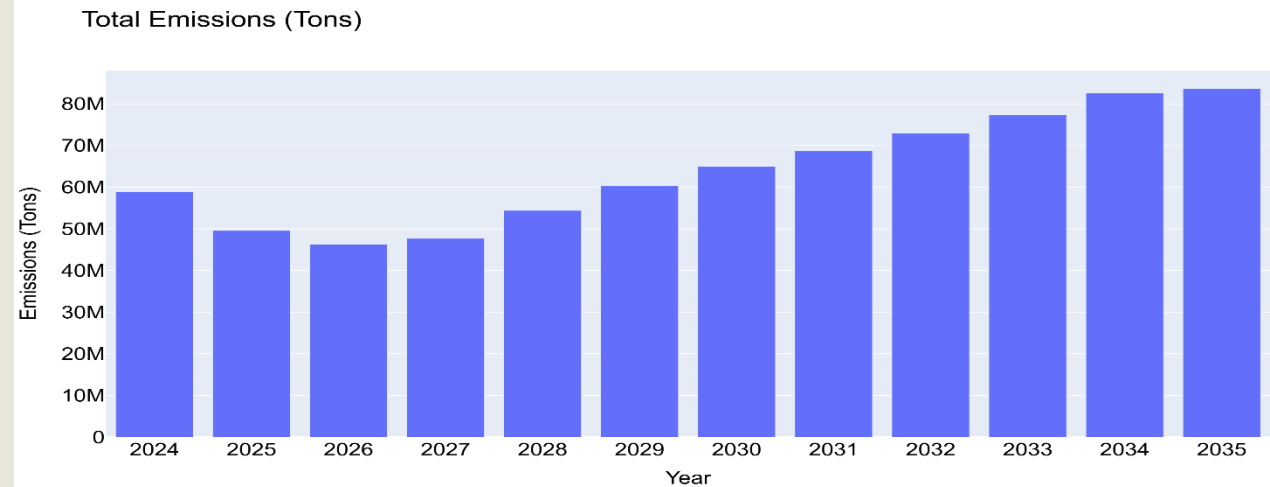
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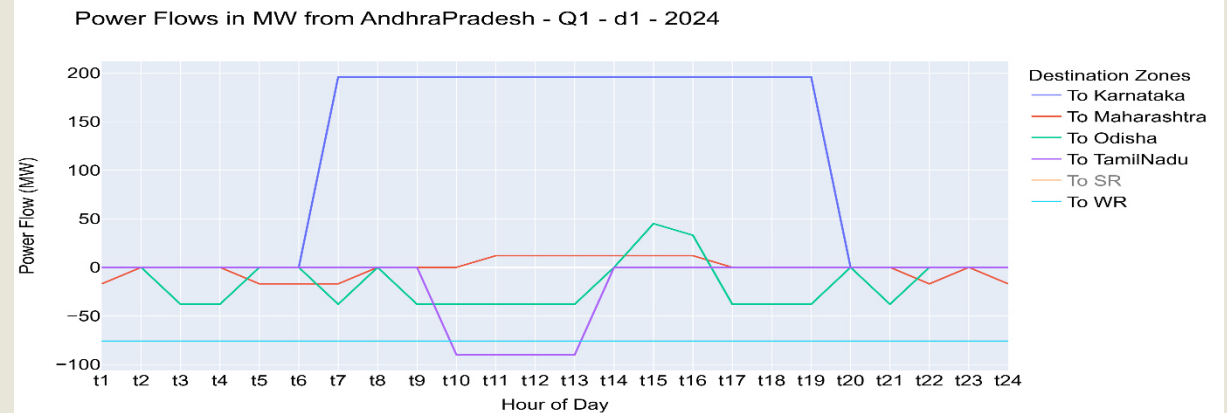
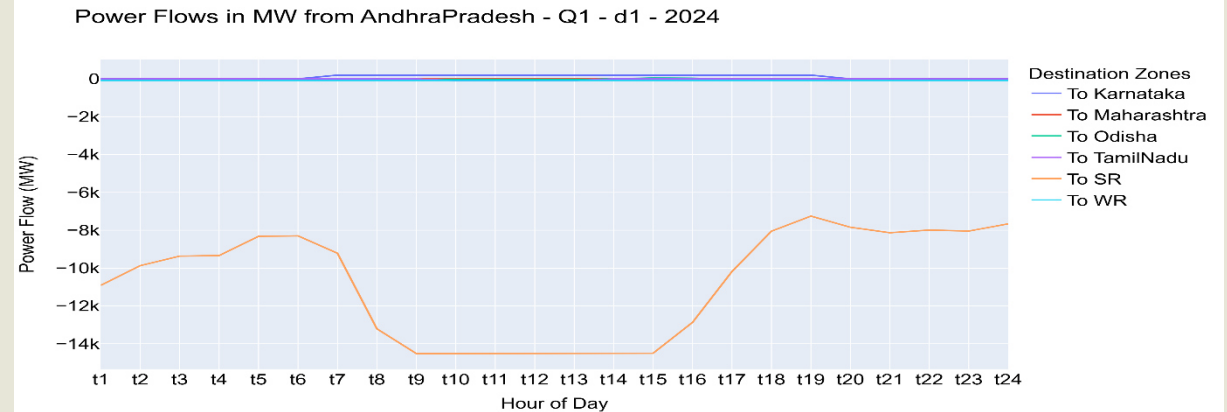
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When modelling transmission, the user can view the transmission flows from one zone to another.

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	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
LoLP - (%) - BASE	2.39	0	0	6.56	1.72	0	0	0	0	0	0	0
ENS - MU - BASE	21	0	0	365	70	0	0	0	0	0	0	0
NENS - (%) - BASE	0.03	0	0	0.35	0.06	0	0	0	0	0	0	0
LoLP - Average(%)	6.6	2.5	1.34	6.06	2.3	0.02	0	0	0	0	0	0
ENS - MU - Average	219	88	50	367	129	1	0	0	0	0	0	0
NENS - (%) - Average	0.27	0.1	0.05	0.35	0.12	0	0	0	0	0	0	0
Max LoLP over iterations (% of total hours)	13.5	8.34	5.57	9.73	7.63	0.7	0	0	0	0	0	0
Min LoLP over iterations(% of total hours)	2.72	0	0	0	0	0	0	0	0	0	0	0
Max ENS over iterations - MU	384	298	258	719	475	24	0	0	0	0	0	0
Min ENS over iterations - MU	79	0	0	0	0	0	0	0	0	0	0	0
Max NENS over iterations - %	0.47	0.33	0.27	0.69	0.43	0.02	0	0	0	0	0	0
Min NENS over iterations - %	0.1	0	0	0	0	0	0	0	0	0	0	0



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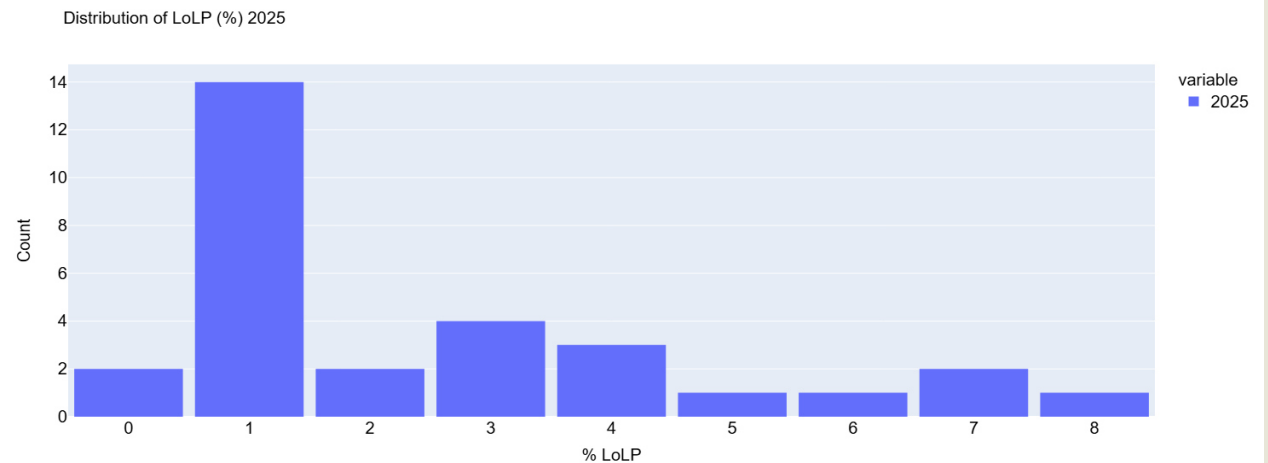
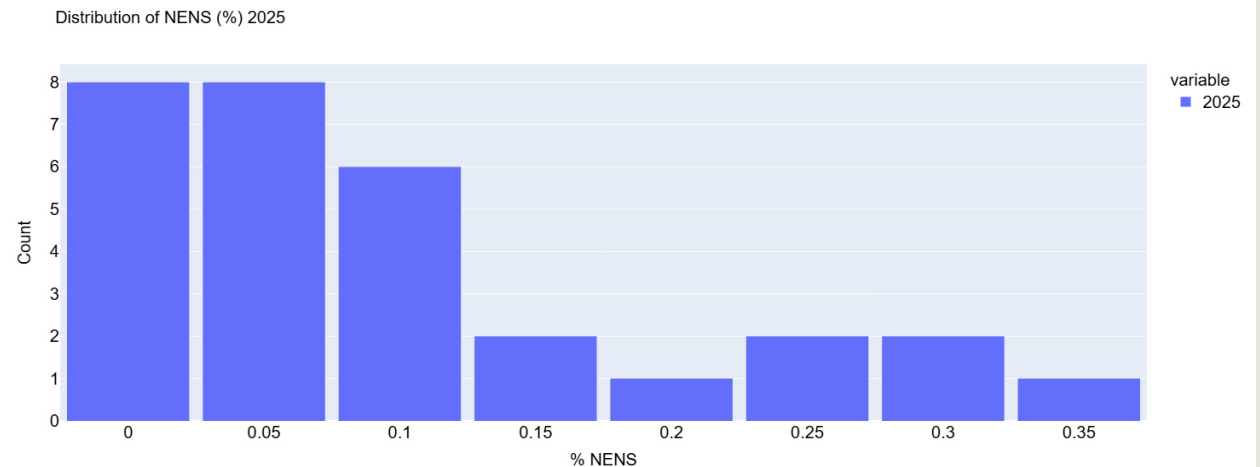
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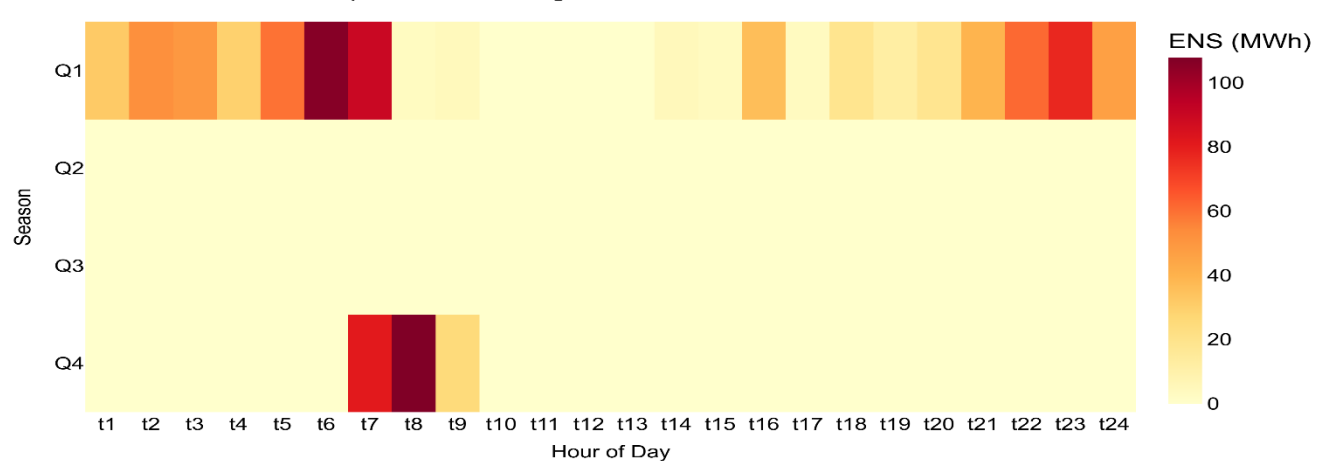
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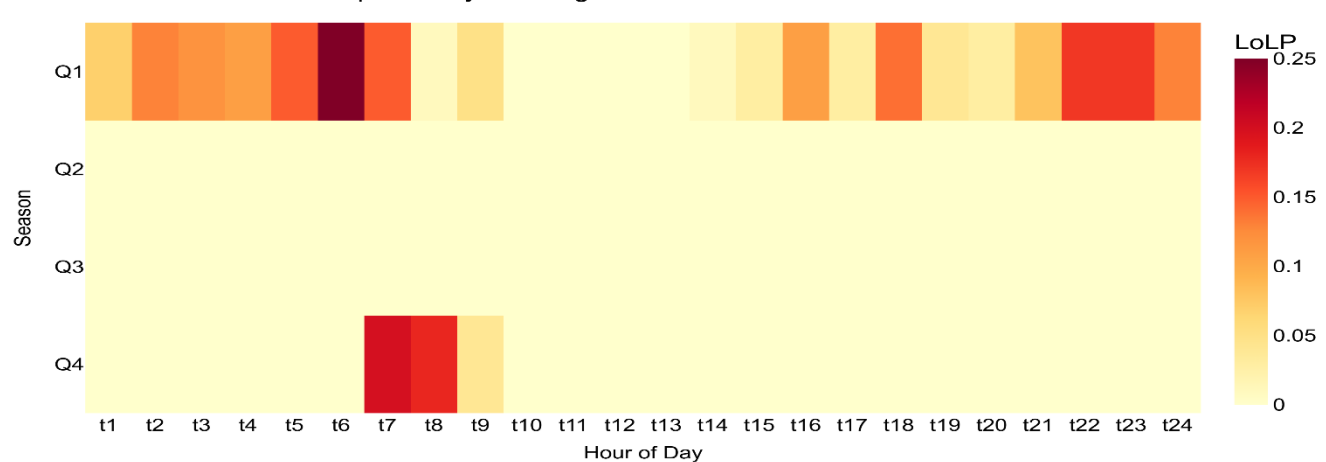
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Seasonal ENS Heatmap - MWh - Average Over Iterations - 2025 - RELIABILITY



Seasonal LoLP Heatmap - Hourly - Average Over Iterations - 2025 - RELIABILITY



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