Report on

Capacity Building Workshop on Resource Adequacy for the State of Karnataka

Submitted By

Idam
Enabling Carbon Minimal World!

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1 Introduction

India has set five ambitious clean energy targets for its power sector, also known as five nectar elements or "Panchamrit", as follows:

1. India will reach its non-fossil energy capacity to 500 GW by 2030.
2. India will meet 50% of its energy requirements from renewable energy by 2030.
3. India will reduce total projected carbon emissions by one billion tonnes from now onwards till 2030.
4. By 2030, India will reduce the carbon intensity of its economy by less than 45%.
5. By the year 2070, India will achieve the target of Net Zero.

India is committed to achieving approximately 50% of cumulative electric power installed capacity from non-fossil fuel sources by 2030. It has set targets for CO_2 reduction and aims to reach net zero emissions by 2070[1]. Between FY15 and November 2024, the renewable energy (RE including hydro) capacity increased around five times from 40 GW to almost 205 GW[2], supplying nearly 23% of the total electricity generated as November 2024[3]. Various studies suggest a significant increase in the share of RE in the next 10 years. Karnataka is among the RE-rich states in India, boasting an installed RE capacity of 16 GW, making up 53% of the total installed capacity as of FY24[4]. RE is only expected to expand, with untapped potential of 25 GW[5] of solar and 124 GW of wind across the state[6]. Karnataka is set to play a pivotal role in India's energy transition and commitments.

As Karnataka embarks on this RE expansion, its electricity sector faces several challenges, such as:

- Variability at multiple levels (day/night, seasonal etc.)
- Unavailability during peak demand periods
- Increased ramping from conventional plants
- Creation of "duck curve" situations and high peak power requirement

In such situations, ensuring sufficient firm capacity on the grid to always meet the demand becomes critical. At the same time, procurement of thermal capacity to meet peak load without considering RE or other flexible resources can result in an oversized system and inflated costs. Hence, a scientifically and mathematically driven system simulation and optimization is important to ensure that ramping needs and load curve are reliably always met in a least-cost manner. Resource Adequacy (RA) considering flexibility in demand profile and conventional generation coupled with flexibility resources would be key to large scale integration of RE.

RA 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 optimum generation mix. This would also facilitate the scaling of RE while considering the

1 Press Information Bureau Release | 28 Sept 2023
2 NPP Dashboard
3 NPP Dashboard
4 NPP Dashboard
5 Potential could be higher and limited to land availability
6 Akshayurja

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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. RA analysis provides the tools to determine whether there are enough resources and, if not, what type of resource is needed to meet reliability needs and contract these capacities. At the same time, any surplus resulting in the analysis would facilitate the trading of the same with other constituents ensuring optimal capacity utilisation.

1.1 Evolution of RA

On 29 December 2022, the Central Government published the Electricity (Amendment) Rules, 2022, mandating State Electricity Regulatory Commissions (SERCs) to frame RA Regulations in accordance with Guidelines issued by the Central Government and Model Regulations by the Forum of Regulators (FoR). Accordingly, in June 2023, the Central Electricity Authority (CEA) notified "Guidelines for Resource Adequacy Planning Framework for India" (CEA Guidelines) and the FoR published State Model Regulations. Subsequently, in September 2024, Karnataka Electricity Regulatory Commission (KERC) notified KERC (Framework for Resource Adequacy) Regulations, 2024. Many other states have notified Final/Draft Regulations.

1.2 Key Aspects of RA

Following are the key aspects of RA framework:

1. Demand assessment and forecasting
   In this step, the future demand requirement is assessed and forecasted considering various input parameters, policies and drivers, uncertainty analysis, and scientific forecasting methodologies.
2. Generation resource planning
   Based on the forecasted demand, it is important to assess existing available capacity for identifying the need for incremental capacity for meeting RA requirement. This process will involve the following three sub-steps:
   a. Capacity crediting (CC)
   b. Planning reserve margin (PRM)
   c. RA requirement and allocation
3. Procurement planning
   Once the RA requirement has been identified and allocated, it is important to plan out procurement of the same. This will involve the following three sub-steps:
   a. Procurement resource mix
   b. Procurement type and tenure
   c. Capacity trading/sharing constructs
4. Monitoring and compliance
   This will involve the development of an overarching framework, process flowchart and timeline, matrix for roles and responsibilities, and matrix for deliverables to ensure smooth and successful implementation of the RA framework.

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1.3 Objective of Workshop

RA is a relatively new concept and has evolved only in the last 2-3 years in India. Hence, there is need for capacity building and handholding at state level to ensure successful and sustainable implementation going forward. Through this workshop, we aim to help stakeholders understand key aspects of RA Regulations as well as optimal approaches for RA planning and reliable RE integration for the state of Karnataka.

2 Workshop Sessions

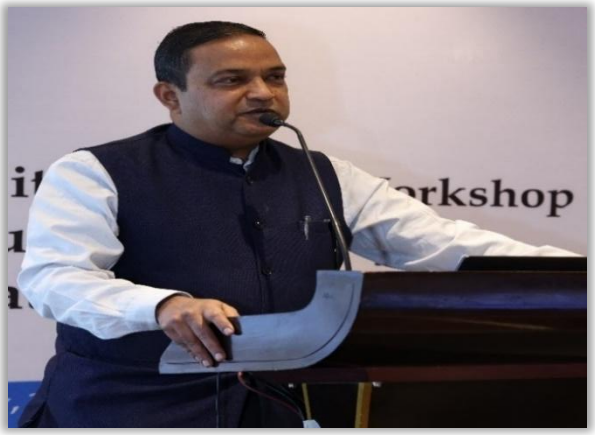
2.1 Inaugural Session

The Inaugural session of the workshop was graced by esteemed dignitaries, including :

- Sh. P. Ravi Kumar IAS, Chairperson, KERC
- Mr. Balawant Joshi, Managing Director, Idam Infra
- Mr. Ajit Pandit, Founding Director & CEO, Idam Infra
- Dr. K. Balaraman, Executive Director, Idam Infra

Lamp Lighting Ceremony

The workshop began with a ceremonial lamp-lighting led by the distinguished dignitaries: Sh. P. Ravi Kumar IAS, Mr. Balawant Joshi, Mr. Ajit Pandit, Dr. K. Balaraman symbolizing the initiation of the discussion ahead.



Welcome Address
***Sh. Balawant Joshi**, MD, Idam Infra*

Sh. Balawant Joshi commenced the workshop by welcoming esteemed attendees, including Mr. P. Ravi Kumar, colleagues from Idam Infra, representatives from KPTCL, BESCOM, HESCOM, private organizations, and CSOs like WRI, CSEP, and CSTEP. He set the stage by addressing the importance of resource adequacy in the context of the power sector's significant transformation. Highlighting the large-scale integration of renewable energy, he noted the necessity of maintaining some level of thermal capacity to ensure grid reliability. He emphasized that renewable energy, while variable and intermittent, is not unpredictable, thanks to advancements in forecasting accuracy. However, these changes demand new approaches in planning and management. Mr. Joshi further reinforced the shift from centralized large-scale generation to distributed generation, driven by initiatives like the Pradhan Mantri Rooftop Solar Scheme, which aims to add over 30 GW of capacity at the 220-volt level. This shift requires DISCOMs to adjust their demand forecasting practices. The democratization of energy, facilitated by consumer ownership of renewable energy assets through net metering and declining battery storage costs, empowers consumers to manage their energy use. Electrification across sectors, including mobility, railways, and cooking, further increases electricity demand, while emerging technologies like green hydrogen and green ammonia add new dimensions to the power sector.

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Mr. Joshi stressed the need for modern tools and scientific methodologies to address these complexities, as traditional approaches are inadequate. A comprehensive understanding of consumer demand profiles and coordinated planning across states and regions is essential to avoid stranded capacities and optimize resource utilization. He highlighted the diverse renewable energy profiles across states like Rajasthan, Maharashtra, and Tamil Nadu, which present opportunities for inter-state collaboration. The workshop aimed to build capacity among DISCOMs, transmission companies, and procurement entities to adopt innovative tools and processes for resource adequacy planning. He shared insights from a similar workshop held in Mumbai, where discussions with Maharashtra Regulatory Commission Chairman Sh. Sanjay Kumar focused on generation and transmission planning in RE-intensive states. Mr. Joshi expressed gratitude to Sh. P. Ravi Kumar for his guidance and urged participants to engage actively, underscoring the need to embrace change, foster collaboration, and adopt innovative strategies to navigate the transition to a renewable-energy-dominated grid.

Overview of RA Framework

***Sh. Jitendra Meena**, Director (IRP), CEA*

Sh. Jitendra Meena began his presentation by expressing gratitude to all attendees and esteemed dignitaries. He set the tone by emphasizing the importance of defining resource adequacy (RA) and shared a Hindi interpretation that resonated deeply with him. This introduction paved the way for a comprehensive discussion on the evolution, framework, and implementation of resource adequacy in India, with a special focus on Karnataka.

Sh. Meena traced the origins of RA to the period between 2018 and 2021, when many DISCOMs surrendered power from aging central generating stations. The power crisis of September 2021, characterized by capacity shortages and deferred plant maintenance, highlighted the critical need for RA, prompting the Ministry of Power to amend Rule 16 in December 2020. This amendment mandated RA guidelines, issued on June 28, 2023, assigning responsibilities to state regulators, distribution licensees, and load dispatch centres to ensure compliance and optimize resource planning. The RA framework assigns specific roles to various entities such as Central Electricity Authority (CEA) is tasked with publishing a 10-year National Resource Adequacy Plan (NTNRAP), which includes national peak demand forecasts, reliability indices, planning reserve margins (PRMs), capacity credits, and generation mixes. The National Load Dispatch Center (NLDC) prepares a Short-Term National Resource Adequacy Plan (STNRAP), addressing grid security and operational reserves. Distribution licensees are required to develop 10-year rolling Resource Adequacy Plans (RAPs), detailing demand forecasts and contributions to national peaks. State Transmission Utilities (STUs) and State Load Dispatch Centers (SLDCs) provide granular data to optimize planning, while State Regulatory Commissions monitor compliance and enforce penalties. Sh. Meena also highlighted significant progress in RA implementation, noting that 12 to 13 states have issued draft or final RA regulations, with Karnataka finalizing its regulations in September 2024. The guidelines emphasize a mix of long-term (70-80%), medium-term, and short-term contracts, with long-term contracts prioritized for coal, hydro,

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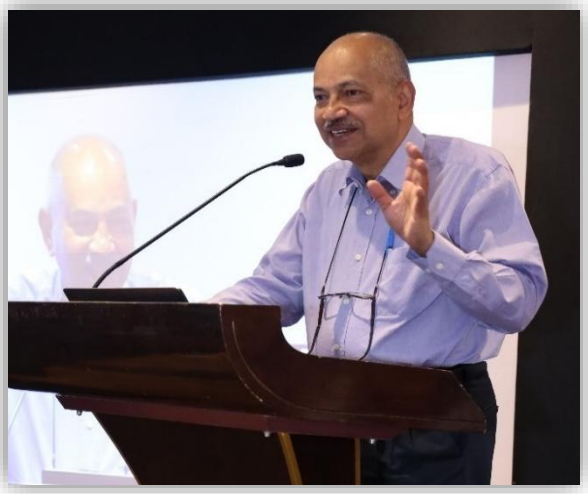
and nuclear projects, requiring 7-9 years of advance planning. The RA methodology integrates demand forecasts, resource availability, and reliability indices like loss of load probability (LOLP) and energy not served (ENS). Stochastic simulations address uncertainties in renewable energy (RE) generation and demand variations, ensuring reliability and sustainability. He underscored the complementarity of load profiles across regions, citing Punjab and Madhya Pradesh as examples where contrasting demand patterns facilitate resource sharing. For Karnataka, RA studies predict a rise in peak demand from 16 GW in 2023 to 21 GW by 2030, with energy requirements growing from 75 TWh to 110 TWh. While coal's share in the energy mix will remain stable at around 30%, contributions from wind and solar are expected to increase. Recommendations for Karnataka include adding coal capacity and leveraging short-term contracts to address incremental demand.

With this he commended Karnataka's proactive approach to RA planning and highlighted the importance of integrated resource planning and regional coordination. He emphasized that continued collaboration among stakeholders is crucial for ensuring a reliable, sustainable energy future for India.

Inaugural Address
***Sh. P. Ravi Kumar IAS**, Chairman, KERC*



Sh. P. Ravi Kumar delivered an engaging inaugural address during the workshop, reflecting on the evolving significance of resource adequacy (RA) in India's power sector. He highlighted how the evolution of demand patterns, generation technologies, and improved efficiencies have made resource adequacy a critical element in ensuring reliable energy supply. Recalling his experiences from the early 2000s, Sh. Ravi Kumar emphasized the stark contrast between the past and present. He reminisced about a time when load shedding was the primary challenge faced by the power sector, and decisions were centered solely on managing power shortages. Over the last two decades, significant advancements have transformed the sector, shifting the focus from load shedding to ensuring uninterrupted power availability. This transformation underscores the need for effective resource planning to meet growing energy demands sustainably. Looking ahead, Sh. Ravi Kumar envisioned a future marked by the democratization of energy generation and consumption. He noted that advancements in renewable technologies and decentralization might reduce dependence on traditional utilities. He cited examples from Bangalore, where some individuals are already living off-grid, demonstrating the potential for localized, self-sufficient energy systems. However, while acknowledging this long-term possibility, he stressed the importance of addressing short-term challenges through robust RA frameworks. He pointed out the complexities of developing RA plans, which require accurate demand

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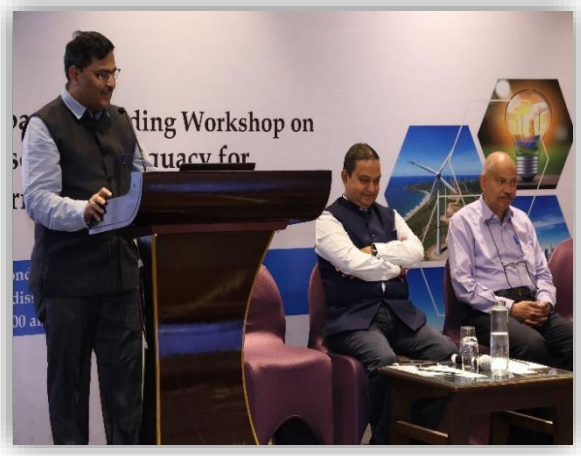
forecasting, meticulous generation planning, strategic procurement, and continuous monitoring. He candidly noted that the current system lacks sufficient capacity to handle such complexities effectively. To address this gap, he encouraged young professionals in the sector to seize the opportunity to learn and adapt to modern techniques. He expressed optimism that the younger generation could lead the way in developing innovative solutions for resource adequacy, given their openness to change and adoption of new technologies.

Sh. Ravi Kumar underscored the importance of workshops like these in enhancing the understanding and application of resource adequacy. He expressed confidence that the deliberations during the technical sessions would further enrich the participants' knowledge and contribute to achieving India's energy goals. With this, he concluded his address, paving the way for the technical discussions ahead.



Vote of Thanks

Sh. Ajit Pandit*, Founding Director & CEO, Idam Infra*

Sh. Ajit Pandit expressed his gratitude in the "Vote of Thanks" following the inaugural session of the workshop. He began by acknowledging the unwavering support of senior leaders, particularly Sh. P. Ravi Kumar, at both state and national levels, including his contributions to the Forum of Regulators' Resource Adequacy Working Group. He noted that these efforts have culminated in the development of the FR model regulation, which is now being implemented across multiple states. Sh. Pandit extended thanks to the Central Electricity Authority (CEA) and other partners for their ongoing support, emphasizing their critical role in organizing capacity-building workshops. He highlighted the workshop's collaborative nature, mentioning previous sessions in Maharashtra and plans for future sessions in Rajasthan. He also acknowledged the active participation of DISCOMs, including BESCOM, HESCOM, and MESCOM, and the presence of PCKL's MD, recognizing their efforts in addressing on-ground challenges related to RA planning and compliance. He stressed the importance of collectively tackling implementation challenges, ranging from RA planning to RPO compliance and green energy open access. Mr. Pandit emphasized the workshop's role in fostering a shared learning environment, acknowledging the diverse challenges faced by different states and DISCOMs. Finally, he thanked the organizers and his team, for their dedication to the Karnataka initiative.

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2.2 Technical Session-I: RA Rules and Regulations

The inaugural session was followed by the Technical Session with key presentations by:

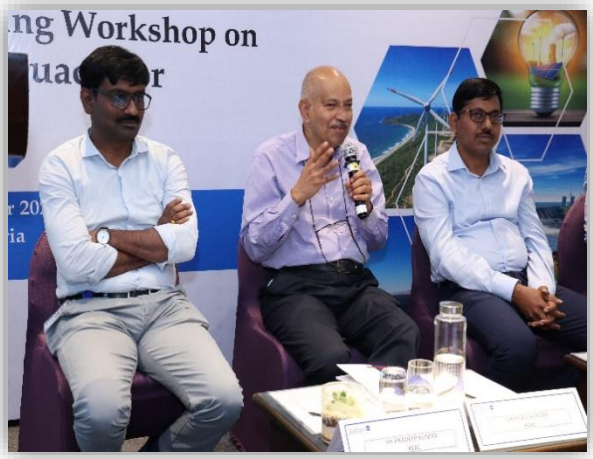
- Sh. Ajit Pandit, Idam Infra
- Sh. Pradeep Kumar, KERC
- Dr. Chandrasekhar Reddy Atla, PRDC
- Sh. Girija, CEA

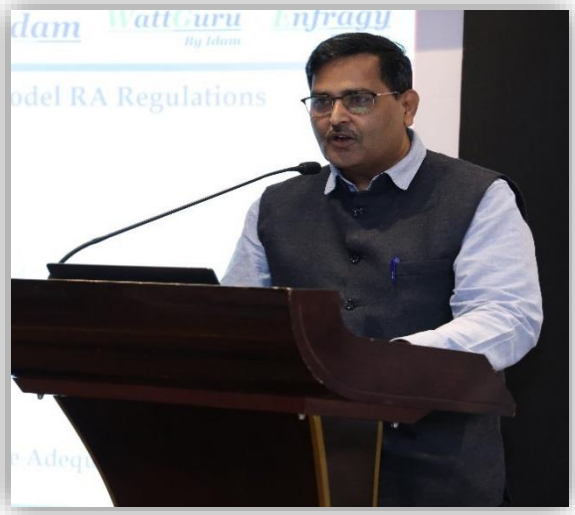
This session was focused on the RA rules and regulations including roles and responsibilities, framework of RA assessment, implementation, challenges, capacity credit and its key steps.

Session Chair

***Sh. P. Ravi Kumar IAS**, Chairman, KERC*

Sh. P. Ravi Kumar IAS delivered the opening remarks by emphasizing the significance of resource adequacy and the importance of establishing a robust framework for its implementation.





National RA Framework and Model RA Regulations & State Experiences

***Sh. Ajit Pandit**, Founding Director & CEO, Idam Infra*

Sh. Ajit Pandit discussed the evolving landscape of power system planning, noting the shift from traditional approaches focused on meeting peak demand with predictable supply to the need for hourly load balancing due to the integration of variable renewable energy sources (VREs) like wind and solar. This shift requires a robust Resource Adequacy (RA) framework to ensure reliable and cost-effective power supply while accommodating VRE integration.

Key aspects of RA include comprehensive and dynamic assessments, resource diversity, and interstate collaboration. Sh. Pandit outlined the role of ACRCs in formulating regulations, the responsibility of licensees to comply, and the importance of operational-level planning. He stressed the need for integrated resource planning, considering both generation and transmission adequacy, and provided a detailed roadmap for RA planning. This includes

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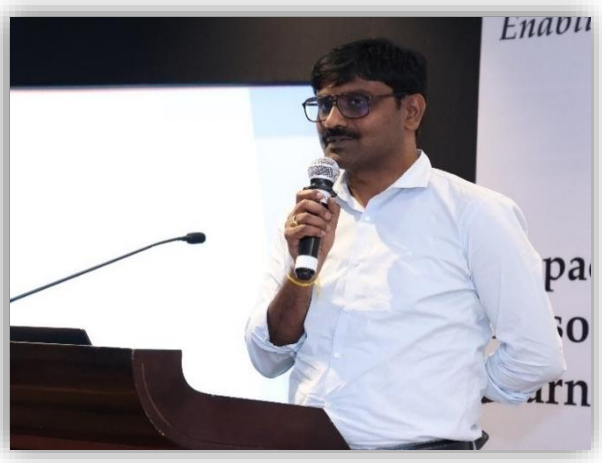
reliability indices, long-term and short-term planning horizons, and optimization methodologies.

The RA planning process also involves demand forecasting, capacity crediting, planning reserve margin, resource adequacy requirements, and procurement planning. He identified challenges in implementing RA regulations, such as data standardization and exchange, capacity building, and inter-agency coordination.

Overview of KERC RA Regulations
***Sh. Pradeep Kumar**, EE, KERC*



Sh. Pradeep Kumar presented an overview of the Karnataka Electricity Regulatory Commission's (KERC) Resource Adequacy (RA) regulations, emphasizing its alignment with central guidelines and the importance of accurate data and robust planning. Key areas that he covered are as follows:

- **National Perspective:** He highlighted the need for national-level adequacy, emphasizing the importance of resource sharing and avoiding regional surpluses or deficits.
- **Data Accuracy:** Stressed the critical role of accurate data, including demand forecasts, generation tie-ups, and technical parameters (outages, ramping rates) in ensuring reliable RA planning. He emphasized that inaccurate data could lead to erroneous planning decisions.
- **Transmission Constraints:** Underlined the crucial role of transmission planning in RA, emphasizing that generation plans must be feasible considering transmission constraints and evacuation capabilities.
- **National vs. State Level Planning:** Explained the distinction between Long-Term National Resource Adequacy Plan (LTNRAP) by CEA and Long-Term State Resource Adequacy Plan (LTDRAP) by states. He emphasized the importance of meeting both national and state-level peak demands with adequate margins.
- **Procurement Timelines:** Highlighted the importance of aligning procurement timelines with project lead times for different technologies (coal, hydro, solar, wind) to ensure timely availability of resources.
- **Data Sharing and Transparency:** Advocated for greater data transparency and sharing among stakeholders to facilitate better planning and analysis.

Following key questions asked by attendees to which Sh. Pradeep Kumar responded powerfully:

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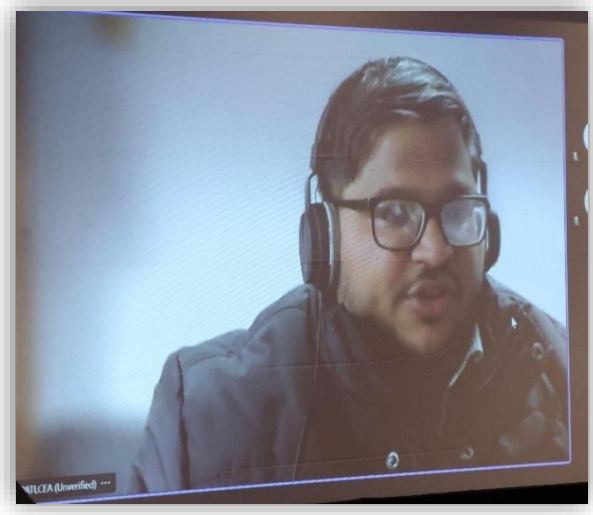
- In response to a question about the limited public availability of crucial data (demand, transmission), Sh. Kumar acknowledged the need for improved data transparency and suggested that the Forum of Regulators (FoR) could play a role in establishing standardized data formats and promoting data sharing among states
- Responding to a question about the availability of specific tools for RA planning, Sh. Kumar mentioned that while the CEA guidelines outline methodologies and simulations (Monte Carlo, MILP), they do not prescribe specific tools. He indicated that a separate technical session would delve deeper into available tools and their applications.
- Addressing a question about the timeline discrepancy between the ARR publication and the demand forecast submission deadline, Sh. Kumar clarified that the timelines were likely adjusted in the most recent iteration of the regulations.



Capacity Crediting Mechanism

***Sh. Girija**, Asst. Director (IRP), CEA*

Sh. Girija's presentation focused on the key aspects of capacity crediting and coincident peak requirements within the framework of the Central Electricity Authority's (CEA) Resource Adequacy Guidelines. He briefly pointed out the key aspects of resource adequacy framework including its objectives and CEA's role for publishing LTNRAP, determining capacity credits for various resources, publishing national and state-level PRMs, and specifying state contributions to the national peak. Key areas focused during his presentation are as follows:

- **Definition of Coincident Peak:** Coincident peak refers to a state's contribution to the national peak demand during the top 5% of national peak demand hours.
- **Significance:** States are required to secure sufficient firm capacity to meet their coincident peak demand plus the national Planning Reserve Margin (PRM).
- **Calculation Methodologies:** He detailed the calculation methods, including the Top 5% methodology and the Solar vs. Non-Solar methodology.

Presentation provided an example of Karnataka's coincident peak requirement, demonstrating the variation between state peak and coincident peak. Jumping into the Capacity Crediting, starting from definition and focusing to its challenges with VRE. Sh. Girija also mentioned about its adopting methodologies with conventional and VRE resources include traditional approach, solar vs. non solar approach, and critical day analysis. He further, presented his key findings including:

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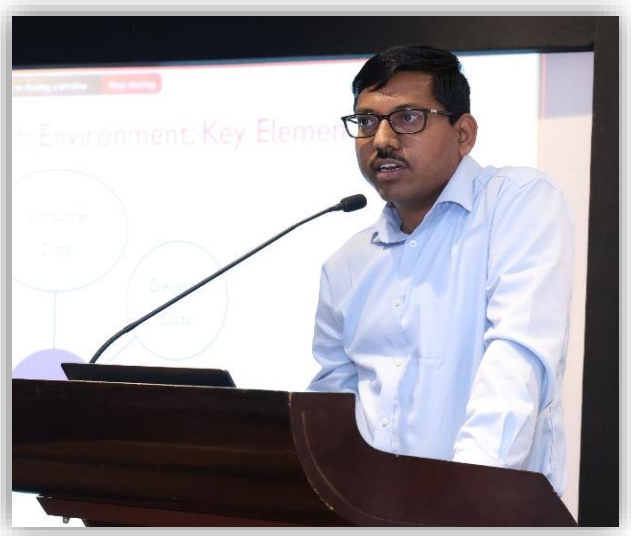
- **Solar vs. Non-Solar Variation:** The presentation highlighted the significant variation in wind capacity credit between solar and non-solar hours, emphasizing the importance of differentiating these periods in the calculation methodology.
- **Importance of Critical Day Analysis:** Critical day analysis, which considers periods of low RE and high demand, provides a more robust assessment of VRE capacity credit, capturing the impact of extreme weather events and ensuring system reliability
- **Data Requirements:** Accurate and granular data on demand, generation, and transmission is crucial for effective RA planning and accurate capacity crediting.

Sh. Girija's presentation provided a comprehensive overview of the key considerations for capacity crediting and coincident peak requirements within the CEA's Resource Adequacy Framework. The emphasis on data accuracy, the importance of differentiating solar and non-solar hours, and the introduction of critical day analysis for VRE capacity crediting were significant takeaways from the presentation.

Demand Forecasting Techniques and Tools

Dr. Chandrasekhar Reddy Atla*, Deputy GM, PRDC*



Dr. Chandrasekhar Reddy Atla from PRDC presented on demand forecasting techniques and tools, emphasizing the importance of accurate forecasting for effective resource planning. He highlighted that accurate long-term demand forecasting requires a comprehensive analysis of various factors, including consumer data, demographic variables, weather patterns, economic indicators, and policy interventions. Key aspects of the demand forecasting process include accurate data collection and rigorous cleaning, encompassing consumer connections, consumption patterns, demographic trends, and economic indicators. Various forecasting techniques are employed, ranging from univariate methods like CAGR and trend analysis, which rely on historical demand data, to multivariate methods that consider multiple factors such as economic indicators, demographic changes, and policy interventions, often utilizing econometric models. End-use methods focus on analyzing specific electricity end-uses and their associated consumption patterns. To account for uncertainties, scenario analysis is crucial, incorporating factors like varying economic growth rates, rainfall patterns, and policy changes. Utilizing data-driven tools like MyPSO, which incorporates various forecasting methods and allows for scenario analysis, can significantly enhance the accuracy and efficiency of the forecasting process.

Dr. Atla emphasized the challenges associated with forecasting demand in the presence of evolving factors such as open access, distributed energy resources (DERs), and electric

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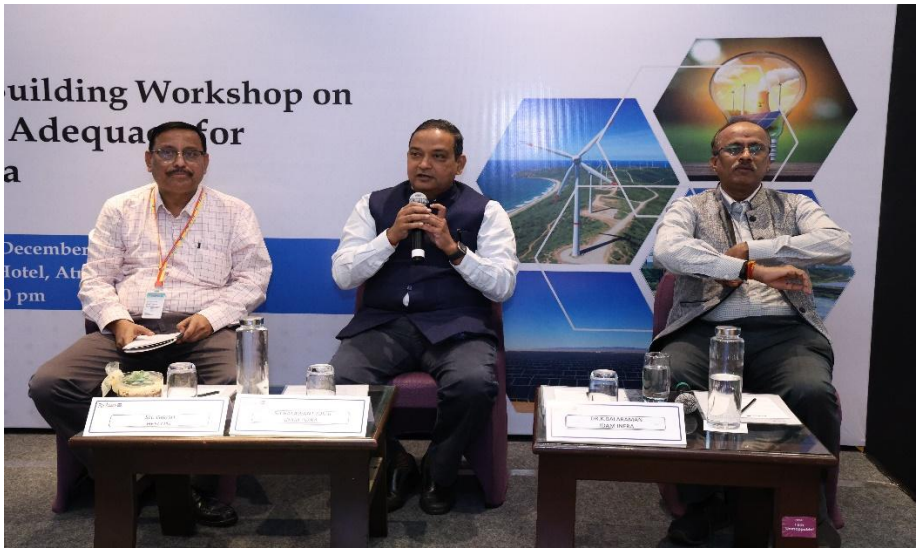
vehicles. He acknowledged the difficulty in accurately predicting the impact of these factors on future demand patterns. The presentation concluded with a discussion on the importance of considering uncertainties and incorporating scenario analysis into the forecasting process. It highlighted the need for continuous evaluation and refinement of forecasting methodologies to adapt to the evolving energy landscape.

2.3 Technical Session-II: Generation RA Planning for Karnataka

The Technical Session II featured key presentations by:

- Dr. K. Balaraman (IDAM)
- Sh. Girish V. (HESCOM)
- Sh. Ashwin Gambhir (Prayas)
- Sh. Aniket Ghosh (AFRY)

This session focused on generation RA planning, including approaches, findings, and associated challenges.



***Sh. Balawant Joshi**, MD, Idam Infra,* Introduced the session by providing an introduction of RA plans and its key areas, along with key speakers delivering the presentations in the session, setting the stage for discussions on generation planning approaches and challenges.

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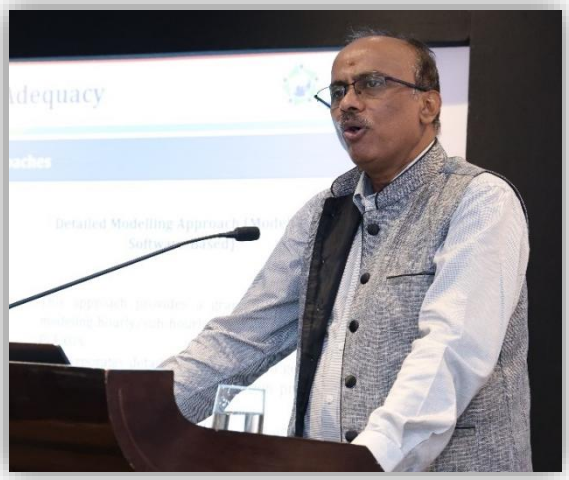

Multiple Approaches and Scenarios for RA Planning in Karnataka

***Dr. K. Balaraman**, ED, Idam Infra*

Dr. K. Balaraman discussed IDAM's approach with to RA studies, presented on the multiple approaches and scenarios for Resource Adequacy (RA) planning in Karnataka. He emphasized the need to move beyond simplistic approaches like PRM-based assessments and utilize detailed modeling techniques to accurately evaluate resource adequacy. The presentation highlighted the importance of stochastic modeling, which considers the variability of demand, wind, and solar generation, to assess system reliability. This involves running simulations with varying input parameters, such as weather conditions and plant outages, to determine the adequacy of available resources. The presentation discussed the use of tools like Plexos for conducting detailed RA studies, which involve long-term, medium-term, and short-term planning horizons. Dr. Balaraman compared a simplified PRM-based approach with a more detailed modeling approach, highlighting the limitations of the former in accurately capturing the impact of variable resources and uncertainties.

The presentation emphasized the importance of stochastic modeling, which incorporates the variability of demand, wind, and solar generation, to assess system reliability. Scenario analysis, considering variations in demand growth, rainfall patterns, and policy interventions, was crucial to evaluate the robustness of the system under different conditions. The analysis revealed potential shortfalls in capacity in the near future, necessitating short-term capacity procurements, and underscored the need for careful consideration of the impact of high renewable energy penetration on system reliability and costs. The presentation acknowledged the challenges associated with accurate forecasting of demand, particularly in the presence of evolving factors such as open access and the increasing penetration of electric vehicles. The presentation concluded by emphasizing the need for continuous monitoring and evaluation of the RA plan, as well as the importance of incorporating the insights from these analyzes into future planning decisions

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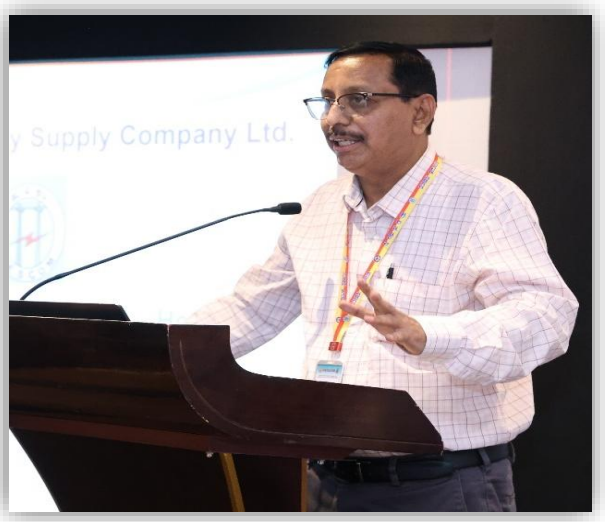
RA Plan – Discom Perspective
Sh. Girish V., *EE, HESCOM*



Sh. Girish highlighted the challenges faced by DISCOMs in ensuring resource adequacy, particularly the uncertainty of demand, renewable energy variability, and regulatory constraints. He emphasized the need for accurate demand forecasting, considering factors like agricultural load fluctuations and economic indicators. He shared his experience with the recent demand surge in Karnataka, highlighting the need for robust planning to address such unforeseen events.

Sh. Girish also discussed the importance of optimizing the generation mix, considering factors like RPO targets and the need for long-term PPAs. He emphasized the need for improved data analytics, capacity building, and collaboration with grid operators to effectively address the challenges of resource adequacy planning. Finally, he discussed the specific challenges faced by HESCOM, including the significant impact of agricultural load and the need to explore alternative procurement strategies to address potential shortfalls. He highlighted that accurate demand forecasting is crucial, considering factors like agricultural load variability and economic indicators, collaboration with grid operators and other stakeholders is essential for effective RA planning, capacity building and training are necessary to enhance the capabilities of DISCOM personnel in RA planning and analysis and Exploring alternative procurement strategies and considering the potential of technologies like energy storage are crucial for ensuring long-term system reliability.

Emerging Issues in RA Framework
Sh. Ashwin Gambhir*, Fellow, Prayas*

Sh. Ashwin Gambhir emphasized the critical importance of accurate demand forecasting in resource adequacy (RA) planning. He highlighted the challenges posed by factors like sales migration due to open access and captive generation, which can significantly impact DISCOM demand. He stressed the need for high-granularity demand forecasting, ideally at the hourly or 15-minute level, to accurately reflect the impact of these factors. He emphasized the importance of data transparency and open-source modelling platforms to enhance the credibility and robustness of RA studies. He advocated for harmonization of regulations across sectors to ensure consistency in demand forecasting methodologies and facilitate effective resource planning. The presentation also discussed the challenges associated with capacity crediting, particularly for variable renewable energy sources. He highlighted the need for more refined methodologies, such as considering seasonal variations and the impact of storage on capacity credit values. The importance of scenario-based analysis and the consideration of non-power sector risks were also emphasized.

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The discussion also touched upon the challenges posed by open access mechanisms, particularly partial open access, which can create uncertainties for DISCOMs in terms of demand forecasting and resource adequacy planning. The need for long-term open access contracts and appropriate cost recovery mechanisms for DISCOMs was discussed. Finally, the presentation emphasized the importance of a holistic approach to RA planning, considering factors such as demand-side management, energy efficiency, and the integration of various renewable energy sources. It was suggested that a trial period be implemented before strict enforcement of RA compliance penalties to allow for the development and refinement of RA planning methodologies.

Some of the key questions covered by Sh. Gambhir are as follows:

- **Non-Compliance Penalties:** In response to a question about the appropriateness of non-compliance penalties for RA, Sh. Gambhir suggested that penalties for non-compliance with data sharing and adherence to timelines could be implemented initially, while allowing some flexibility for the initial implementation of RA planning processes.
- **Open Access and Demand Forecasting:** The discussion touched upon the challenges posed by partial open access and the need for long-term open access contracts to ensure better demand forecasting and resource adequacy planning for DISCOMs.

Review of Various RA Tools
Sh. Aniket Ghosh, *AFRY*

Sh. Aniket Ghosh began by underlining the importance of understanding the core concepts of resource adequacy (RA). He explained that RA aims to ensure that the power system has sufficient capacity to meet demand reliably, while minimizing the risk of load shedding. He illustrated this with simple graphical representations, demonstrating the relationship between demand, supply, and the reserve margin. He then outlined the key steps involved in the RA planning process, including capacity expansion planning, generation resource adequacy assessment, production cost modeling, and network stability analysis. The presentation delved into the different types of models used in RA planning, namely capacity expansion models, production cost models, and generation resource adequacy models. He discussed the inputs and outputs of each model type and highlighted the importance of selecting the appropriate tools based on the specific objectives of the study.

Sh. Ghosh emphasized the need for a comprehensive and integrated approach to RA planning, considering factors such as demand forecasting, renewable energy integration, storage technologies, and demand-side management. He also discussed the importance of data quality and the need for robust data management systems to support accurate and reliable RA assessments. The presentation concluded with a discussion on the selection of appropriate tools for RA planning. A prioritization framework was presented, considering factors such as ease of use, data requirements, and the availability of open-source options.

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2.4 Technical Session-III: Transmission RA Planning and Operational Challenges

Technical Session III focused featured key presentations by:

- Sh. Shashank Jewalikar (M SLDC)
- Sh. D. Chethan (KPTCL)
- Sh. Malleshappa (SLDC)
- Sh. Daljit Singh (CSEP)

The session addressed the importance of transmission planning, challenges, and strategic approaches.

Session Chair
Sh. Srinivasappa*, Director (Technical), KERC*

Sh. Srinivasappa emphasized the increasing importance of transmission planning and operation in ensuring resource adequacy. He highlighted that while resource adequacy focuses on ensuring sufficient generation capacity, the effective transmission and distribution of this power is crucial for reliable and efficient grid operation. He pointed out that the integration of variable renewable energy sources has introduced new challenges for transmission systems, such as increased variability and multi-directional power flows. Addressing these challenges requires significant investment in network upgrades and advancements in grid management technologies. He then introduced the upcoming presentations by various speakers, focusing on the perspectives of KPTCL, SLDC, and industry experts on addressing these challenges and ensuring a reliable and efficient grid.

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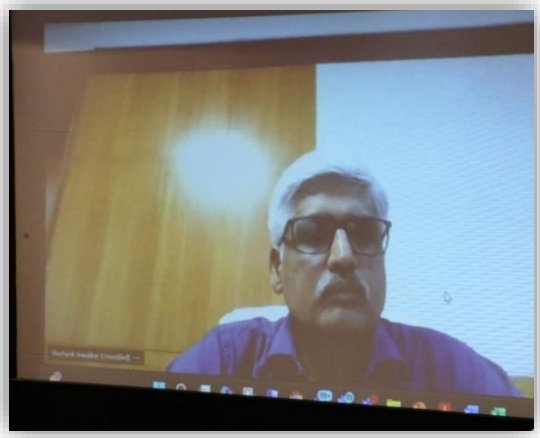


Short-term RA and Operational Challenges

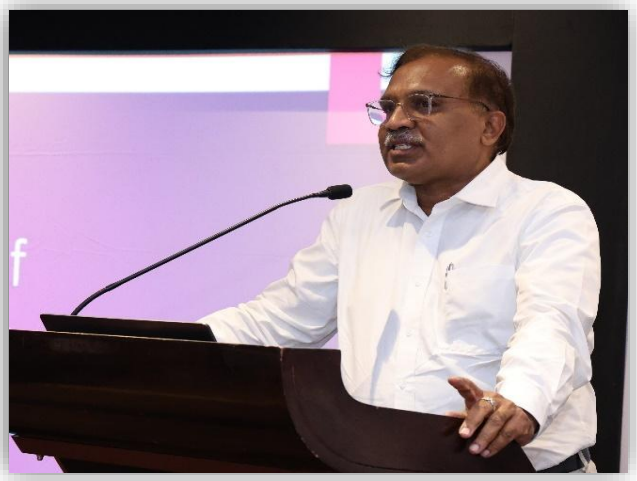
***Sh. Shashank Jewalikar**, ED, Maharashtra SLDC*

Sh. Shashank Jewalikar began by acknowledging the evolving nature of the power system, driven by factors such as climate change, technological advancements (e.g., increased penetration of renewable energy sources), and changing consumer behavior. He emphasized that these changes necessitate a re-evaluation of traditional approaches to resource adequacy planning.

He highlighted that while resource adequacy traditionally focused on ensuring sufficient generation capacity, it now needs to encompass a broader perspective, considering factors such as flexibility, reliability and resiliency. Sh. Jewalikar discussed the challenges associated with defining and achieving resource adequacy, highlighting the need for a comprehensive and holistic approach. He highlighted the importance of considering: Uncertainty, Data Quality, Stakeholder Collaboration, Technological Advancements. He also discussed the importance of considering the impact of evolving regulatory frameworks and market mechanisms on resource adequacy planning. He emphasized the need for continuous learning and adaptation, given the dynamic nature of the power system. Sh. Jewalikar shared his observations on the challenges faced by Maharashtra in addressing resource adequacy, including Integration of Variable Renewable Energy Sources, Demand Variability, and Data Availability and Quality. He emphasized the need for continuous learning, adaptation, and innovation to address the evolving challenges of resource adequacy planning and ensure a reliable and sustainable power system.

Overview of Transmission Adequacy

***Sh. D. Chethan,** SEE (Planning), KPTCL*



Sh. D. Chethan delivered an insightful presentation on the importance of transmission planning in ensuring a reliable and efficient power system. He highlighted the challenges posed by renewable energy integration, the significance of advanced grid technologies, and the need for collaborative efforts among stakeholders. Below are the key takeaways from his address:

- **Role of Transmission Planning in Resource Adequacy:**

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Transmission planning is vital for delivering generated power reliably to consumers. While resource adequacy focuses on securing sufficient generation capacity, coordinated planning between generation and transmission ensures the power supply meets consumer demands efficiently.

- **Importance of Accurate Data for Planning:**
  Effective transmission planning depends on accurate and timely data, including demand forecasts and generation plans from distribution companies. It is equally important to account for spatial and temporal variations, such as peak demand periods and regional differences, to optimize infrastructure and resource utilization.
- **Challenges in Integrating Renewable Energy Sources:**
  Integrating large-scale renewable energy into the grid introduces challenges like increased grid volatility and the need for reactive power support. Incorporating flexibility mechanisms such as energy storage and demand response can help stabilize the grid and accommodate renewable energy's intermittency.
- **Right-of-Way Acquisition and Timely Execution:**
  Expedited right-of-way acquisition and streamlined project timelines are crucial for ensuring timely grid upgrades. Addressing these challenges will help meet the growing demand for electricity and support the integration of new generation capacities.
- **Adoption of Advanced Grid Technologies:**
  Advanced technologies like high-voltage direct current (HVDC) transmission and flexible AC transmission systems (FACTS) enhance grid flexibility and efficiency. These technologies play a key role in integrating renewable energy sources seamlessly into the grid, ensuring a reliable power supply.
- **Collaboration Among Stakeholders:**
  A collaborative approach involving generators, transmission and distribution companies, regulators, and researchers is essential for addressing evolving challenges. Continuous engagement and alignment among these stakeholders enable effective planning and execution of grid operations.
- **Focus on Research and Development:**
  Ongoing research and development in grid technologies and operational strategies are critical for meeting the demands of a modern, decarbonized energy grid. Investment in innovation ensures the grid remains resilient, adaptable, and capable of supporting the transition to sustainable energy.

Sh. Chethan's address provided a holistic view of the complexities and opportunities in transmission planning, emphasizing the need for proactive measures, advanced technologies, and stakeholder collaboration to build a future-ready power system.

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Operational Challenges with RA

***Sh. Malleshappa**, CEE, SLDC*

Sh. Malleshappa began by outlining the increasing challenges faced by grid operators in Karnataka due to the high penetration of renewable energy sources. He highlighted the significant increase in renewable energy capacity in the state, which is expected to reach 55 GW by 2034-35, constituting approximately 59% of the total installed capacity. He discussed the operational challenges arising from this high RE penetration, such as Grid Stability and Frequency Control, Maintaining grid stability and frequency control in the presence of highly variable renewable energy sources poses significant challenges, Balancing Supply and Demand, Reactive Power Support, Market Challenges. Sh. Malleshappa emphasized the importance of accurate and timely data for effective grid operation. He highlighted the need for accurate demand forecasts, real-time data on renewable energy generation, data on grid conditions. He also discussed the need for improved forecasting tools, enhanced grid infrastructure, advanced grid technologies.

Sh. Malleshappa emphasized the need for continuous collaboration between grid operators, generators, distribution companies, and regulators to address the challenges of integrating high levels of renewable energy and ensure a reliable and efficient power system. He highlighted the importance of data sharing, improved communication, and the development of innovative grid management strategies to meet the evolving needs of the power sector.

Implementation Challenges with RA

***Sh. Daljit Singh**, CSEP*

Sh. Daljit Singh, addressed the growing complexities of resource adequacy (RA) planning in the context of a grid increasingly reliant on renewable energy. He emphasized the limitations of traditional approaches and the need for innovative strategies to address challenges such as variability, intermittency, and data inadequacies. Below are the key points from his discussion:

- **Complexity of Resource Adequacy Planning:**
  Sh. Singh highlighted the increasing complexity of RA planning in modern grids with high renewable energy penetration. He noted that the variability and intermittency of

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renewable sources introduce challenges that the current MoP framework does not fully address, requiring more adaptive strategies.

- **Limitations of Traditional Metrics:**
  Traditional metrics used for RA planning may not effectively capture the unique challenges of renewable energy-based grids. Sh. Singh suggested exploring alternative metrics, such as Loss of Load Hours (LOLH), to better assess the depth, duration, and frequency of outages in these evolving systems.
- **Challenges of Correlated and Long-Duration Outages:**
  The potential for correlated outages (e.g., due to weather events) and prolonged outages adds further complexity to RA planning. Addressing these issues requires more sophisticated modeling techniques and scenario evaluations to ensure system reliability.
- **Need for Sophisticated Modeling and Planning Processes:**
  Sh. Singh emphasized the importance of developing robust and flexible planning processes. This includes evaluating multiple scenarios, considering alternative resource adequacy strategies, and accounting for the dynamic behavior of renewable energy sources in grid operations.
- **Strengthening Data Collection and Analysis:**
  Data limitations are a significant barrier to effective RA planning. Sh. Singh advocated for enhancing data collection and analysis capabilities to provide a more accurate and detailed understanding of grid dynamics, enabling better-informed decision-making.
- **Importance of Stakeholder Collaboration:**
  Collaboration among stakeholders, including regulators, utilities, and grid operators, is essential to address the complexities of RA planning. Sh. Singh called for a unified approach to developing and implementing strategies that meet the unique demands of modern grids.
- **Investment in Grid Modernization:**
  Modernizing the grid infrastructure is critical for supporting RA in renewable-dominant systems. Sh. Singh stressed the need for investments in advanced grid technologies, smart systems, and improved operational frameworks to ensure long-term grid resilience.

Sh. Daljit Singh's discussion underscored the urgent need to evolve RA planning frameworks and processes to address the unique challenges posed by renewable energy integration, ensuring a reliable and efficient energy future.

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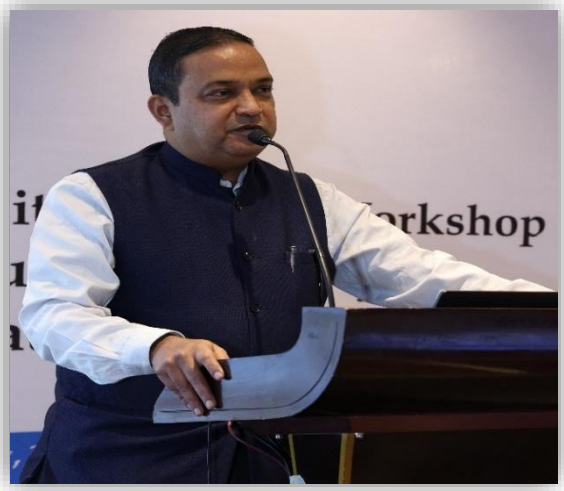

Closing Remarks

***Sh. Balawant Joshi**, MD, Idam Infra*

Sh. Balawant summarized the session by how to challenges need to be tackled, use of storage to address variability issue, and sharing Idam's perspective on working in different combination of resources to handle intermittency issues. He encouraged Karnataka to continue its proactive efforts, so that other states can learn and implement. He concluded by thanking the speakers and other stakeholders for their valuable contributions and being the part of the workshop.

3 Key Takeaways

- **Importance of Accurate Demand Forecasting:**
  - Several speakers emphasized the critical need for accurate and granular demand forecasting, considering factors like economic growth, agricultural loads, and the impact of emerging technologies like electric vehicles
  - Highlighting the limitations of traditional methods and the need for more sophisticated approaches, including incorporating economic indicators and considering different scenarios.
- **Challenges of Renewable Energy Integration:**
  - Discussed the challenges posed by the increasing penetration of renewable energy sources, such as intermittency, variability, and the need for enhanced grid flexibility.
  - Highlighting the importance of accurate forecasting of renewable energy generation and the need for grid infrastructure upgrades to accommodate the increased levels of renewable energy integration.
- **Role of Transmission Planning:**
  - Emphasized the crucial role of transmission planning in ensuring reliable and efficient power delivery, including the need for timely grid upgrades and the development of robust transmission corridors.
  - Highlighting the need for coordinated planning between generation and transmission sectors to ensure adequate grid capacity to accommodate future demand and renewable energy integration.
- **Data Quality and Availability:**
  - Stressed the importance of accurate and timely data on demand, generation, and grid conditions for effective resource adequacy planning and operations.
  - Highlighting the need for improved data sharing and collaboration among stakeholders to ensure data accuracy and accessibility.
- **Importance of Flexibility:**
  - Emphasized the need for increased grid flexibility to accommodate the variability of renewable energy sources and importance of integrating flexible resources such as energy storage, demand response, and advanced grid technologies to enhance grid stability and reliability.
- **Need for Robust Frameworks:**
  - Discussed the need for robust and adaptable resource adequacy frameworks that can effectively address the challenges of a rapidly changing grid.
  - Emphasizing the need to move beyond traditional metrics and consider alternative approaches that better account for the uncertainties associated with renewable energy integration.
- **Stakeholder Collaboration:**
  - Highlighted the importance of effective collaboration among stakeholders, including generators, transmission and distribution companies, regulators, and researchers, to ensure a coordinated and effective approach to resource adequacy planning.

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- **Continuous Learning and Adaptation:**
    - Emphasized the need for continuous learning and adaptation to address the evolving challenges of resource adequacy planning, including the development of new technologies, the refinement of existing methodologies, and the continuous improvement of grid operations.

4 Workshop Agenda

The workshop agenda of Karnataka workshop is as follows:

Time (h)	Session	Speaker
10:00 – 10:30	***Registration***	
10:30 – 11:00	**Inaugural Session**	
	Welcome Address	Sh. Balawant Joshi, MD, Idam Infra
	Overview RA Framework	Sh. Jitendra Meena, Director (IRP), CEA
	Inaugural Address	Sh. P. Ravi Kumar IAS, Chairman, KERC
	Vote of Thanks	Sh. Ajit Pandit, Director, Idam Infra
11:00 – 11:15	***Tea Break***	
11:15 – 13:00	**Technical Session 1: RA Rules and Regulations, Session Chair: Sh. P. Ravi Kumar IAS, Chairman, KERC**	
	National RA Framework and Model RA Regulations & State experiences	Sh. Ajit Pandit, Director, Idam Infra
	Overview of KERC RA Regulations	Sh. Pradeep Kumar, EE, KERC
	Demand Forecasting Techniques and Tools	Dr. Chandrasekhar Reddy Atla, Deputy GM, PRDC
	Capacity Crediting Mechanism	Sh. Girija, Asst. Director (IRP), CEA
	Q&A	
13:00 – 14:00	***Lunch Break***	
14:00 – 16:00	**Technical Session 2: Generation RA Planning for Karnataka Session Chair: Sh. Balawant Joshi, MD, Idam Infra**	
	Multiple Approaches and Scenarios for RA Planning in Karnataka	Dr. K Balaraman, ED, Idam Infra
	Resource Adequacy Plan – Discom Perspective	Sh. Girish, EE, HESCOM
	Emerging Issues in RA Framework	Sh. Ashwin Gambhir, Fellow, Prayas
	Review of Various RA Tools	Sh. Aniket Ghosh, AFRY
	Q&A	
16:00 – 16:15	***Tea Break***	
16:15 – 17:45	**Technical Session 3: Transmission RA Planning and Operational Challenges Session Chair: Sh. Srinivasappa, Director (Technical), KERC**	
	Short-term RA and Operational Challenges	Sh. Shashank Jewalikar, ED, Maharashtra SLDC
	Overview of Transmission Adequacy	Sh. D. Chethan, SEE (Planning), KPTCL
	Operational Challenges with RA	Sh. Malleshappa, CEE, SLDC
	Implementation Challenges with RA	Sh. Daljit Singh, CSEP
	Q&A	
17:45 – 18:00	**Closing Remarks**	Sh. Balawant Joshi, MD, Idam Infra

5 Workshop Participants

5.1 Speakers

Sr. No.	Name	Designation	Organisation
1	Sh. Aniket Ghosh	Principal	AFRY
2	Sh. Girija	Assistant Director	CEA
3	Sh. Jitendra Meena	Director (IRP)	CEA
4	Daljit Singh		CSEP
5	Sri Girish V	Executive Engineer	HESCOM
6	Dr. K. Balaraman	Executive Director	Idam Infra
7	Sh. Ajit Pandit	Director	Idam Infra
8	Sh. Balawant Joshi	Managing Director	Idam Infra
9	Sh. P. Ravi Kumar	Chairman	KERC
10	Sh. Pradeep Kumar	Executive Engineer	KERC
11	Sh. Sri Srinivasappa	Director (Technical)	KERC
12	Sh. D. Chethan	Senior Executive Engineer	KPTCL
13	Sh. Shashank Jewalikar	Executive Director	MSLDC
14	Sh. Ashwin Gambhir	Fellow	Prayas
15	Dr. Chandrasekhar Reddy Atla	Deputy General Manager	PRDC
16	Malleshappa B V	Chief Executive Engineer	SLDC

5.2 Participants

S. No.	Name	Organization
1	M. D Kartian	BESCOM
2	Rajashekarappa D C	BESCOM
3	Seema	BESCOM
4	Bhuvaneshwari.B.S	CESC
5	K.M.Swarooparani	CESC
6	Nagaraj.M	CESC
7	Prathibha B. A	CESC
8	Harikrishna K.V	CSTEP
9	Sairam Thandra	CSTEP
10	Teja V	CSTEP
11	Rangarajan	Execs
12	Hanamant. D	GESCOM
13	Kishor Nayak	GESCOM
14	Seeta Darshankar	GESCOM
15	Aravindakshan Ramanan	GIZ
16	Smt Vijayalakshmi	HESCOM
17	Smt Jayapradha B N	HESCOM
18	Sri A L Desai	HESCOM
19	Sri Nagraj Hombale	HESCOM

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20	Divya Soodh	IPPAI
21	Jayasankar B	KERC
22	Sheshadri H.S	KERC
23	Uma H M	KERC
24	Sandhana T. Erumal	KERC
25	Chinmayi Mohan	KPMG
26	Arunkumar Vijayan	KPMG
27	Gayatri Kulkari	KPTCL
28	Arati B Avanti	KPTCL
29	Akhila S	KPTCL
30	Sushma G. C	KPTCL
31	Prakruthi G B	KPTCL
32	Sathishchandra	KPTCl
33	J. Wilfred	KPTCL
34	Hema K S	KPTCL
35	Arina Kumari C R	MESCOM
36	Haridasa P	MESCOM
37	H.S Deepak	MESCOM
38	R. Jithendra tuma	MESCOM
39	Shantha Kumar	MESCOM
40	Jayaprakash	MSEZL
41	Ramanujam	MSEZL
42	LOKHANDE SNEHAL PRABHAKAR	PCKL
43	Prthvi R	PRDC
44	Vikram G.S	PRDC
45	Latha B N	SLDC
46	Shashirekha	SLDC
47	Shyla HP	SLDC
48	Neeraj Kuldeep	Sustainable Energy for All
49	Dr.Varun Jyothiprakash	WRI India
50	Sandhya S	WRI India
51	Umesh Kumar Sharma Ramamoorthi	WRI India