



Integrating RTO and Utility Processes in Planning and Cost Allocation

Final Project Report

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Power Systems Engineering Research Center
*Empowering Minds to Engineer
the Future Electric Energy System*



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Executive Summary

Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs) are crucial in ensuring a secure operation, a fair, competitive market, and strategic planning for large-scale power systems. The current grid planning processes employed by ISOs/RTOs face challenges due to the complexity of integrating renewable resources, ensuring resource adequacy, and managing cost allocation. Traditional planning methods, often deterministic in nature, are insufficient for managing the long-term uncertainties and the evolving dynamics of modern power systems. Effective transmission planning requires coordinated intraregional and interregional collaboration, supported by advanced computational tools, to effectively assess future scenarios and identify the most cost-effective investments that satisfy future grid needs. This project is motivated by the need to develop forward-looking, flexible, and robust planning frameworks that anticipate diverse future scenarios, enhance grid reliability and efficiency, and ensure equitable cost allocation. It seeks to mature expansion planning and reliability-related tools while identifying ways to facilitate coordination and integration of central ISO/RTO planning functions, including cost allocation.

The project began with thoroughly examining current planning methodologies used by leading ISO/RTOs, identifying key practices, tools, and strategies in grid planning through an extensive review of public reports, studies, and tariffs, and engaging with planners within PSERC member organizations. This process helped characterize ISO/RTO planning processes, identify planning needs, and determine ways to address those needs with new planning tools. This examination culminated in the report “ISO/RTO Long-term Planning Processes.” Key findings revealed the need for better integration and coordination among primary ISO/RTO planning functions, the potential for interregional transmission projects, and the lack of established guidelines for long-term planning that align with regulatory requirements. These findings highlight the necessity for a framework that integrates essential planning functions while promoting interregional coordination. The proposed framework enhances the integration of key planning functions. It fosters the creation of flexible portfolios, considering both cost-effectiveness and reliability in the face of high uncertainty. This approach will benefit ISO/RTOs by enabling exploration across a full spectrum of investment portfolios under a broader set of performance attributes, including energy cost, reliability, and adaptability.

A prevailing trend among ISO/RTOs is employing scenario-based methods to consider diverse future conditions in their planning processes. To address the limitations of traditional deterministic approaches, this project emphasizes the adoption of stochastic methods that account for long-term uncertainties. This shift is crucial as traditional methods often fail to consider uncertain conditions adequately and require extensive time to analyze each scenario separately. Moving towards stochastic approaches allows for identifying flexible investment portfolios capable of adapting to multiple future scenarios. Advanced tools like the Adaptive Coordinated Expansion Planning (ACEP) optimizer, developed by ISU, exemplify this transition. ACEP employs stochastic programming methods to find a core investment portfolio that can flexibly adapt across various projected scenarios. This approach ensures robust planning and strategic adaptation in the face of evolving conditions within the power system landscape.

Ensuring a reliable power supply amidst the growing integration of variable renewable energy sources and the retirement of conventional thermal resources also presents significant challenges

in power system planning. A key achievement of this project is the development of a software system that coordinates long-term expansion planning with reliability evaluations. The integration of ACEP with GE-MARS, a probabilistic resource adequacy tool, was developed by implementing an iterative loop that optimizes investment portfolios while meeting reliability requirements. By subjecting future portfolios to a range of realistic scenarios, we refined the ACEP formulation to improve accuracy and account for unreliability costs. Testing this application using a reduced model of the Eastern Interconnection demonstrated its effectiveness in balancing investment robustness, resource adequacy, and system adaptability. The integration of ACEP with a resource adequacy assessment is designed to streamline the decision-making process in power system management by incorporating advanced simulation and optimization techniques.

A major challenge in the development of regional and interregional transmission infrastructure is determining who will pay for projects selected in the planning process. The basic legal principle guiding cost allocation in U.S. systems is “beneficiary pays,” the idea that those who benefit from a project (or group of projects) should pay. While this principle is simple conceptually, the complexity of power systems and uncertainty inherent to long-term planning make the identification of beneficiaries a difficult task. In the final part of the project, we investigated the translation of planning model outputs into estimates of the benefits that will be seen by different market participants. Addressing the implications of uncertainty and risk in transmission expansion decisions is crucial for fair and mutually agreeable cost allocation. We analyzed the challenges posed by significant uncertainties in transmission investments, focusing on the divergence between ex ante cost allocation decisions and ex post benefits realization. This work provides valuable insights into cost allocation discussions and the equity and efficiency implications of transmission expansion.

The project “Integrating RTO and Utility Processes in Planning and Cost Allocation” represents a meaningful step towards modernizing grid planning methodologies. By integrating advanced planning tools, supporting the integration of main planning activities, and addressing cost allocation challenges, our research provides a useful contribution to power system planning effectiveness. The proposed approaches and tools will equip ISO/RTOs with the capabilities to navigate the complexities of modern power systems, ensuring a reliable, cost-effective, and sustainable energy future.

Project Publications:

- [1] G. Cuello-Polo, J. McCalley, J. Mays, H. Shu. (2023). ISO/RTO Long-term Planning Processes. A Report for the Power Systems Engineering Research Center. Ames, IA. Available: <https://home.engineering.iastate.edu/~jdm/psercm43.pdf>
- [2] S. Risanger and J. Mays. Congestion risk, transmission rights, and investment equilibria in electricity markets. *The Energy Journal* 45(1), 173–200 (2024). doi: 10.5547/01956574.45.1.sris
- [3] G. Cuello-Polo, and J. McCalley, “Enhancing Grid Development through Integration of ISO/RTO Planning Functions,” IEEE PES GM, 2024.

Student Theses:

- [1] G. Cuello-Polo, “Enhancing ISO/RTO Planning Strategies for Robust Transmission Infrastructure,” Ph.D. dissertation, Iowa State University, Dec 2025 (Expected).

- [2] H. Shu, “Electricity Market Design: Contractual Forms, Transmission Cost Allocation, and Short-term Pricing Strategies,” Ph.D. dissertation, Cornell University, June 2025 (Expected).