Evaluating and Strengthening Iowa's Power Grid for High Wind/Solar Penetration Levels

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Evaluating and Strengthening Iowa's Power Grid for High Wind/Solar Penetration Levels

Project Report #1
MISO and SPP Planning Processes

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Executive Summary

This document was developed for the "Evaluating and Strengthening Iowa's Power Grid for High Wind/Solar Penetration Levels" project funded by the Iowa Economic Development Authority. The overall project objective, consistent with the Iowa Utilities Board's (IUB's) objectives in Docket No. INU-2021-000, is to apply expansion planning analysis for the state of Iowa, exploring the challenges and opportunities of Iowa's grid in the forthcoming years. This report responds to a particular project objective (Task G2), by characterizing MISO and SPP planning processes. It provides an overview of the MISO and SPP planning activities, aiming to enhance understanding regarding their planning methods and processes. This report examines and summarizes their planning analysis procedures and models, and the integration between their main planning activities. Their interregional collaboration, intra-regional cost allocation methods, and resilience evaluation strategies are also described. The information presented in this report is derived from publicly available manuals, studies, reports, and surveys addressed by MISO and SPP planning coordinators.

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1. Introduction

Iowa is progressing toward becoming one of the most decarbonized electric grid infrastructures in the United States. Wind turbines contribute nearly 60% of the state's electricity generation, and utilities are actively working on integrating new technologies that support the state grid challenges over the next decades. The Midcontinent Independent System Operator (MISO) and the Southwest Power Pool (SPP), with nine states overlapping in both RTO regions, including Iowa, are pivotal players in the operation and planning of the actively changing Iowa infrastructure. Their functions include evaluating regional needs, establishing local resource adequacy requirements, and analyzing the impact of new interconnections through technical studies. Moreover, the lengthy MISO-SPP seam spanning from Canada to Texas requires interregional cooperation to identify expansion opportunities representing mutual benefits for both regions, including the common states along the seam.

In order to understand the potential impacts of future regional and interregional projects on Iowa, it is essential to begin by characterizing the MISO and SPP long-term planning processes and identifying their unique and common features. Then, this will allow us to efficiently monitor the diverse planning activities involving the state and contribute by developing strategies to improve those processes, especially supporting Iowa's needs. This document has been developed through an extensive review of public reports, studies, presentations, and tariffs. In addition, the authors have engaged with MISO and SPP planners to gather relevant information.

The report is organized as follows. Chapter 2 introduces long-term regional planning and provides overviews of how MISO and SPP carry out their planning process, including models and tools. Chapter 3 explains the integration of internal organization functions, such as the generation interconnection queue and capacity procurement, into the long-term planning process. Chapter 4 describes the SPP and MISO interregional collaboration. Chapter 5 reviews how public policies are considered and the main role of stakeholders in developing project recommendations. Chapter 6 covers the different cost allocation strategies for recommended upgrades and expansions. Chapter 7 presents the resilience evaluation strategies implemented by the RTOs. Finally, Chapter 8 discusses the main findings and conclusions.

2. Overview of the MISO and SPP Planning Processes

This chapter aims to support the understanding of the planning processes employed by MISO and SPP by describing particular features and comparing how the different processes developed for expansion planning are conceived. This chapter introduces a general review of typical power system planning processes. Then, a summary of each RTO planning process is presented, covering the following areas:

(i) Planning models, tools, and studies
(ii) Integration of central RTO planning functions such as generation interconnection queue, capacity procurement, and interregional planning into the expansion planning processes
(iii) Incorporation of stakeholder feedback and public policy into the planning process
(iv) Cost allocation methods
(v) Resilience evaluation strategies

2.1. Introduction to bulk power system planning

In collaboration with a diverse stakeholder group, ISO/RTOs conduct long-term planning processes to identify the needs across all utilities within their footprint through technical and economic studies, exploring multiple future system scenarios. Figure 1 shows a general high-level flow diagram characterizing most of the ISO/RTO planning processes. The process generally starts with gathering data about existing facilities, loads, local plans, and retirements. In parallel, load forecasting, federal and state energy goals, and stakeholder feedback are used to develop future scenarios and studies' scopes. Data from the generation interconnection process, capacity procurement, and neighboring ISO/RTOs are also used to create different models that will help analyze multiple future conditions and identify potential system violations. Reliability assessments represent an essential pillar for the long-term planning process. Projects that could alleviate congestion and reduce costs are identified through economic analyses. Planning coordinators also strengthen the plan by addressing particular needs, such as environmental or policy issues.

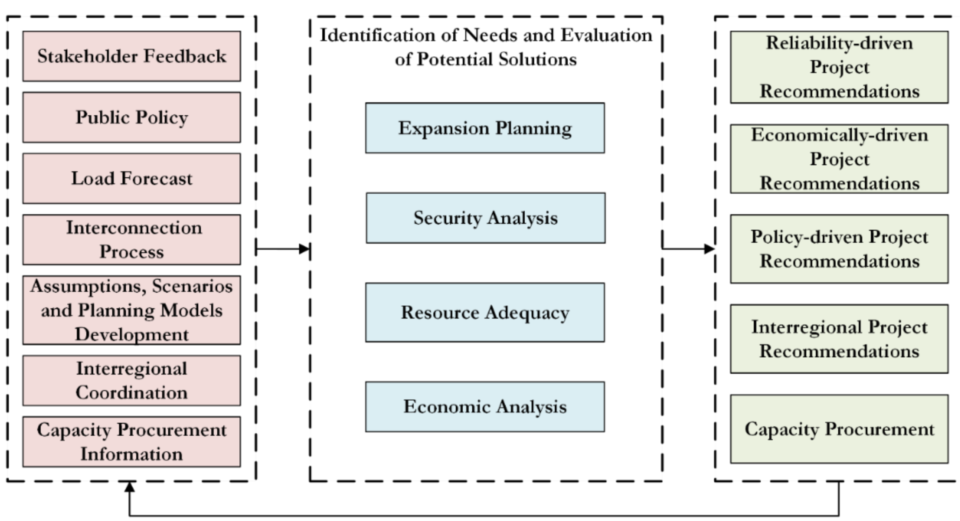

Figure 1. Typical high-level ISO/RTO planning process diagram.

Once the reliability, economic, and policy needs are identified through technical studies, the ISO/RTOs develop corrective action plans in collaboration with participating transmission organizations (TO) and other market participants to address those needs. The planning process encompasses different timeframes, focusing on short-term and long-term planning. Typically, long-term planning spans over 10 years and serves as an overarching guide for mid- and short-term planning, which covers fewer than 10 years.

2.2. Overview of the MISO planning process

MISO is an independent, not-for-profit, member-based organization responsible for the reliable operation and planning of the electrical grid and the energy market in 15 U.S. states (including most of Iowa) and part of Canada. The MISO planning process consists of annual studies to assess the system needs ensuring a reliable and cost-effective operation while supporting energy policies and meeting the Federal Energy Regulatory Commission (FERC) requirements. MISO collaborates with stakeholders to identify upgrades, additions, and expansions to alleviate the transmission issues identified in reliability and economic studies. This process, known as the MISO Transmission Expansion Plan (MTEP), results in the approval of the transmission projects to address reliability and congestion issues for 5 and 20 years [1]. The overall planning process also includes the Long-Range Transmission Planning (LRTP) process, launched periodically to prepare the grid for significant future changes [2]. LRTP considers one of the multiple scenarios developed in MTEP (usually the one which incorporates known and projected generation and load presented by member plans) to identify large-scale transmission investments that consider challenges anticipated for the next 20 years and beyond [2]. New projects and recommendations defined during the LRTP, called "Tranches," are included in the MTEP and approved by the MISO board of directors.

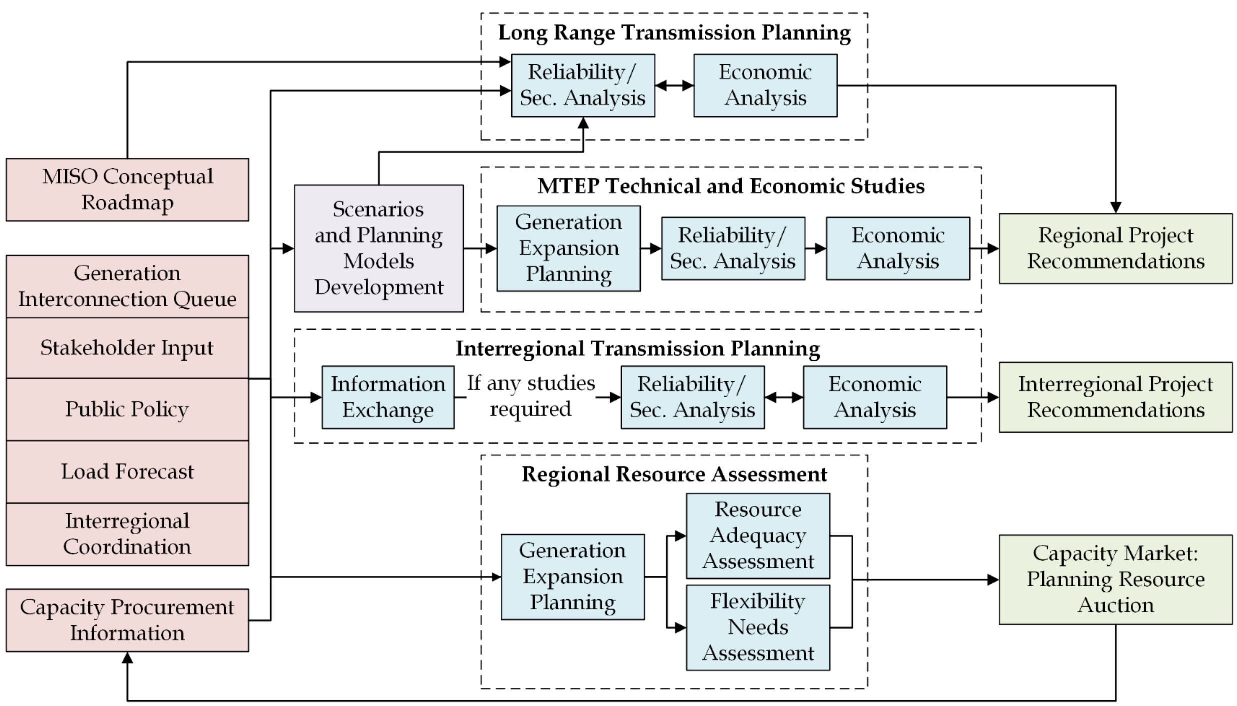

Figure 2. MISO planning process high-level diagram.

The MISO's planning process is founded on transmission system models. Based on the transmission models, they develop reliability (power flow and dynamics) and economic models to support the core planning functions needed to fulfill the MISO's Tariff requirement and North American Electric Reliability Corporation (NERC) standards [3]. MISO develops the planning models in collaboration with transmission owners, providers, customers, and other stakeholders. These models also include most of the Eastern Interconnection (the Tier 1 and most Tier 2 neighbors are accounted for) using the data available through the information exchange and coordination arrangement with the neighboring RTOs and regions [4].

Uncertainty is addressed by developing four "future" scenarios for evaluation in the MISO MTEP. MISO uses futures to represent a variety of potential outcomes over the following 20 years. Futures are developed over 18 months, taking into account stakeholder feedback, policy assessment, and market and industry trends [1]. These future scenarios include assumptions about load growth, electrification, utility and state goals, retirements, DERs adoption, and other significant factors.

Although future scenarios are developed considering a 20-year planning horizon, different timeframes are used depending on the study performed [5]. For instance, power flow studies are carried out for summer, fall, winter, and spring of the current year; 2-year out summer peak and light load; 5-year out summer peak, shoulder, and light load; and 10-year out summer peak load. Dynamic security assessments are performed using the 5-year out summer peak, shoulder and light load, and 10-year out summer peak power-flow cases. Lastly, economics analysis utilizes current-year, 5-year, and 10-year-out summer topology [3].

On the other hand, MISO models distributed energy resources (DERs) as potential load modifiers using different penetration levels for each Future deployed. These resources are grouped into three subcategories: demand resources (DR), energy efficiency, and distributed generation. The potential technical capacity from each category is simulated and determined for each Future using the Electric Generation Expansion Analysis System (EGEAS) tool [5]. MISO also refers to lower voltage levels in its Transmission Planning Business Practice Manual, stating that "any sub-BES, lower-voltage transmission may also be modeled as needed to provide additional transmission detail and perform the planning functions described elsewhere in this BPM" [4].

MISO has studied the potential implementation of emerging technologies (small modular reactors, Hydrogen, Load-Duration Energy Storage, and Carbon Capture, Utilization, and Storage) within the MISO footprint to consider them for future planning studies. To understand the impact of integrating future technologies, MISO assessed a Future Tech Proxy unit combing parameters and features of multiple technologies (avoiding any biases for a particular technology) as part of the 2022 Regional Resources Assessment. This future technology-sensitive analysis aims to determine the breakeven cost point when selecting a proxy unit along the planning horizon [6].

2.3. Overview of the SPP planning process

SPP is a nonprofit RTO that oversees the bulk power system and wholesale power market in portions of 14 U.S. states and a small part of Iowa. The SPP planning process encompasses various components, including the Integrated Transmission Planning (ITP) process, interconnection requests analyses, resource adequacy studies, interregional coordination, and generation retirement studies [7]. The SPP ITP focuses on identifying improvements for reliability, public policy, and economic needs over a 10- and 20-year planning horizon, aligning with NERC standards and the SPP tariff [7]. The annual 10-year assessment prioritizes 100 kV and higher facilities, while the 20-year assessment, mandated every five years or as directed by the SPP board of directors, targets 345 kV and above facilities [8][7]. Stakeholders are invited to participate through their insights, comments, and proposed solutions to the system needs in both assessments [7]. Moreover, two additional reports are valuable planning resources for SPP and its members. On one hand, the "SPP transmission expansion plan" report is a comprehensive record of the project portfolio resulting from the RTO's planning processes. It tracks the progress of all SPP transmission projects approved by the SPP Board of Directors or through a service agreement filed with FERC under the tariff [9]. On the other hand, SPP published the "Grid of the Future" report in April 2023, which aims to identify emerging trends and offer recommendations concerning the grid operation's potential challenges in the forthcoming 10-15 years [10].

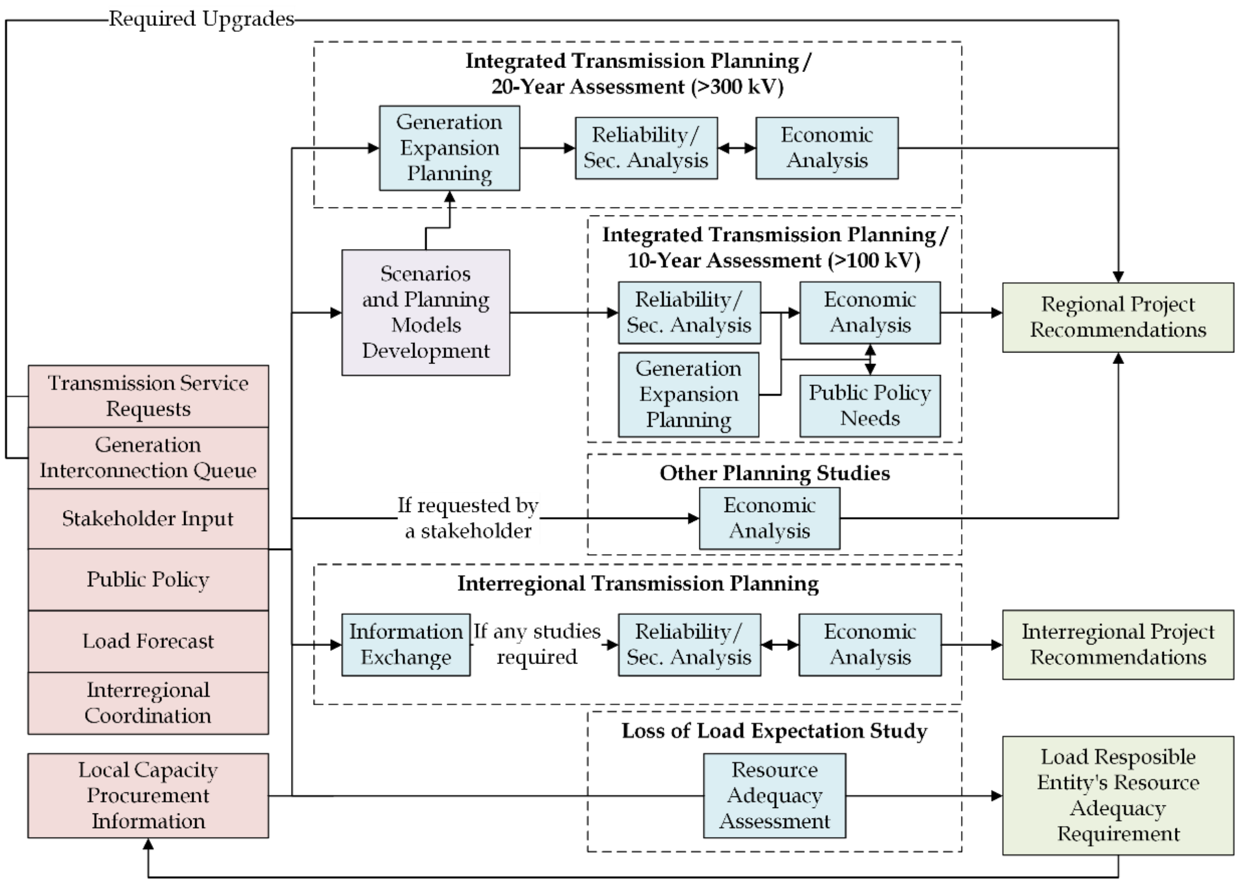

Figure 3. SPP planning process high-level diagram.

Three model sets are developed for the holistic planning assessment. The base reliability model, evaluated for multiple cases during the 2nd, 5th, and 10th planning year, includes existing and planned generation resources, retirements, transmission system topology, and load forecast. This model aims to perform steady-state and stability/short-circuit assessments satisfying the NERC standard TPL-001 [8]. The transmission topology (69 kV and above) is modeled based on information provided by SPP TO; generation resources (existing, new, and planned retired generation) data are provided by SPP Generator Owners (GO). On the other hand, TO and other stakeholders submit load forecasts representing the aggregated bus load totals within the SPP footprint. Similarly, data to model the external grid is obtained from the MMWG, including the first-tier planned upgrades, which are obtained in coordination with the appropriate external entities [8].

The second and third models for the ITP assessment cycle are the market economic and market power flow model. The market economic model is an hourly security-constrained unit commitment (SCUC) and economic dispatch (SCED) using a DC transmission representation. Conversely, the market power flow is a one-hour snapshot of a market economic model that aims to study reactive power flows on the system that the economic modeling tools are unable to study. The topology used for both the economic and power flow model followed the same guidelines used for the reliability model and are based on the summer-peak base reliability model for the 2nd, 5th, and 10th planning years [11].

Reliability models are evaluated for several stressed conditions using load forecast, assumed long-term firm transmission service-usage levels, and anticipated generation output levels. Contrary, economic models address uncertainty by developing multiple futures considering economic, environmental, regulatory, policy, and technological changes [8]. First-tier areas are modeled using the latest MTEP model available for the market economic model [12].

In the 10-year and 20-year ITP assessments, SPP develops a resource expansion plan through economic analysis (production cost models), performing SCUC and SCED for multiple scenarios and constraints. The top constraints producing the highest annual congestion costs will be identified as the system needs. Adjusted production cost and benefit-to-cost ratio are the metrics used to calculate and compare benefits among the project proposal window in which SPP stakeholders submit potential solutions to the identified system needs [8]. All solutions are also ranked, in terms of reliability, by using the cost per loading relief and cost per voltage relief metrics. Among other factors, reliability metrics, economic metrics, and public policy benefits are considered for the final portfolio consolidation [8].

2.4. Comparison of SPP and MISO analysis procedures and models for planning

Table 1 summarizes the main modeling techniques and inputs used in planning studies carried out by ISO/RTOs, including assumptions for DERs modeling and methodologies to address long-term uncertainty, among others. The table also includes information about the different studies and tools used by ISO/RTOs to accomplish reliability, economic, environmental, and policy goals.

Table 1. Comparison of the MISO and SPP modeling assumption and methods for planning.

Feature	MISO	SPP
Planning models	Reliability model and economic model	Reliability model, economic model, and market-informed reliability model
External Model	Model of tier 1 and most tier 2 neighbors	External transmission topology is modeled, including the tier 1 planned upgrades
Uncertainty	Scenario-based approach	Scenario-based approach

DERs and new technologies	Demand resources, energy efficiency, and DERs are modeled as load modifiers	DERs, EVs, and demand resources are integrated into the load forecast
Planning horizon	- Steady-State: years 2,5,10 - Dynamic: years 5,10 - Economic: years 5,10 - Expansion: 20 years	- Steady-State: years 2,5,10 Dynamic: years 2,10 - Economic: years 2-5,10 - Expansion: 10 and 20 years
Reliability (security) studies and tools	TARA for deliverability studies and power transfer limits to support RA evaluation [13]. PSS/E for case development and steady-state analysis [13]. POM for multiple element contingency analysis and evaluation of optimal power flow mitigation strategies [13]. TSAT for transient stability assessment [13]. VSAT for power transfer limits to support resource adequacy (RA) evaluation [13].	PSS/E for steady-state, dynamic, short-circuit, and contingency analyses [8][14]. POM for multiple element contingency analysis and stability analysis [15]. TSAT for stability analysis [15].
Economic model and tool	MISO creates economic models in PROMOD, representing each of the evaluated years without the "futures" generation or transmission improvements and a set of economic models with "futures" generation and proposed LRTP transmission projects. Evaluation of economic benefits compares the production cost savings associated with the Futures resource expansion and transmission reinforcements needed to reliably support it versus the production costs without generation that can not be reliably supported [16][4].	Production cost simulations are performed using PROMOD for two different planning horizons. 20-years: results will inform stakeholders of potential investments and is considered for short-term studies [11]. The 10-year assessment is developed to produce a cost-effective analysis that evaluates multiple alternatives proposed by stakeholders resulting in the most economical portfolio [8]. The production cost models also include operational and spinning reserves to account for capacity that might be required in case of unit failure [17].
Expansion model and tool	Generation expansion planning (GEP) analysis is used in MTEP to perform a 20-year Regional Resource Forecasting identifying the least-cost portfolio (type, size, and installation date of new resources) for each Future. Since the new resources' specific point of connection is not given by the expansion planning tool, the production cost model is used for the resource siting process. The results of this process are considered to develop and study the implementation of potential projects [5]. GEP is also used in the Regional Resource Assessment [6].	GEP is performed as a complement to determine resource needs required to solve economic studies (Market Economic Model) for a 10- and 20-year planning horizon [8].

Resource Adequacy model and tool	A Regional Resource Assessment (RRA) is performed to assist MISO stakeholders in effectively fulfilling their roles and responsibilities in RA. However, each LSE is responsible for the RA Assumptions of one of the futures developed in MTEP (the one which incorporates known and projected generation and load presented by member plans) that are used to perform the RRA. Additionally, the expansion planning model results for the Future considered in the RRA are used to complement the known and planned capacity additions for a 20-year planning horizon [6]. MISO uses SERVM to perform RA assessments.	SPP performs a probabilistic RA analysis every two years to determine the SPP Planning Reserve Margin (PRM) required to maintain a LOLE of 0.1 day/year. The study's findings provide valuable information for stakeholders of SPP and state commissions involved in making policy decisions regarding resource adequacy, particularly those related to modifications in the SPP PRM. However, each Load Responsible Entity is responsible for procuring sufficient capacity for their predicted summer season's peak demand [18]. SPP uses SERVM to perform RA assessments.

3. Integration of planning functions

Complementary to the expansion planning, ISO/RTOs establish mechanisms to ensure sufficient resources, manage the generation interconnection process (GIP), and consider interregional transmission. ISO/RTOs conduct RA assessments to calculate capacity requirements, which are used as the basis of procurement activities to minimize loss-of-load risk. On the other hand, the generation interconnection process, which includes technical analyses to evaluate the impact of interconnection requests on the system, is developed using different approaches. It can have an independent course, run parallel to long-term planning cycles using data from reliability studies as input, or it can be a component fully integrated into the planning process. Regardless of the approach, the generation interconnection queue (GIQ) is critical in expansion plans to identify new resource tendencies and associated upgrades needed to incorporate future resources. The following subsections describe how the GIQ and capacity procurement activities are integrated into the long-term regional planning process by MISO and SPP.

3.1. Integration of processes within the MISO long-term planning

Integration of GIQ within the planning process

In order to develop a Regional Resource Forecasting and model the generation for each one of the Futures analyzed during the MTEP, MISO initially requires information from the MISO GIQ to identify the short-term capacity additions. However, to maintain the load-to-resource balance and achieve the Planning Reserve Margin target for a 20-year study period, a resource expansion tool is utilized to cover periods beyond the five-year timeframe usually identified in the GIQ [4][19].

Integration of capacity procurement within the planning process

The Regional Resource Assessment, annually developed by MISO, conducts a probabilistic RA assessment to identify the annual LOLE index, Planning Reserve Margin Unforced Capacity, zonal per-unit Local Reliability Requirements, Zonal Import Ability, Zonal Export Ability, Capacity Import Limits and Capacity Export Limits. RRA results are used as inputs to the MISO Planning Resource Auction, which is a voluntary annual capacity auction to support the fulfillment of RA by market participants [4]. On the other hand, similarly to the use of GIQ information, if more generation is required to be modeled and serve future load growth, available market resources will be modeled and dispatched to satisfy electricity demands [20].

3.2. Integration of processes within the SPP long-term planning

Integration of GIQ within the planning process

In general, existing and in-service generation resources and planned resources with a Generation Interconnection Agreement (GIA) are considered for the generation model in reliability planning studies [8]. However, if more generation is needed to solve the model, GIQ information is used on the condition that the Transmission Working Group approves the inclusion. Similarly, economic studies consider GIQ information for generation modeling [8]. Besides, system upgrades resulting from generator interconnection and transmission services requests are identified in the ITP assessment so that a cost-effective transmission portfolio could be developed considering those upgrades in conjunction with reliability, operation, public policy, and economic needs [8].

Integration of capacity procurement within the planning process

SPP does not currently have a capacity market. The Load Responsibilities Entities have the responsibility for resource adequacy in the SPP Balancing Authority Area. Nevertheless, the SPP Supply Adequacy Working Group determines the local capacity requirements to meet demand needs in the SPP region [8]. SPP performs a probabilistic RA analysis every two years to determine the SPP Planning Reserve Margin (PRM) required to maintain a LOLE of 0.1 day/year. The study's findings provide valuable information for stakeholders of SPP and state commissions involved in making policy decisions regarding resource adequacy, particularly those related to modifications in the SPP PRM. Similarly, through the resource expansion planning process, SPP will determine the most optimal combination of new conventional and renewable generation to be added to the SPP region in all future scenarios [8].

4. Interregional Collaboration: MISO-SPP Joint Operating Agreement

In addition to establishing specific requirements to promote effective regional transmission planning processes, FERC Order No. 1000 emphasized the importance of enhanced coordination among neighboring regions [21]. This coordination involves developing information-sharing mechanisms and identifying and evaluating potential interregional transmission facilities that address the needs of the neighboring transmission planning regions. These collaborations support and supplement individual regional transmission plans by optimizing existing and planned resources and managing specific transmission needs more efficiently than separate and local regional planning [21].

SPP and MISO are neighboring RTOs with nine states in common. Table 2 shows the number of tie-lines by voltage level along the MISO-SPP seam (2018) [22]. In 2004, MISO and SPP filed a joint operation agreement (JOA) as a requirement by FERC for the SPP RTO status. This MISO-SPP JOA obligates the parties to share real-time and day-ahead operating and planning data to enhance reliability and market coordination. The JOA encompasses standard provisions regarding outage coordination, operation of emergency procedures, and reciprocal coordination of flowgates, among others. The JOA also establishes a framework for interregional transmission planning coordination between the parties. Figure 4 shows the diagram of the MISO-SPP interregional collaboration described in the JOA [23]. Article IX of the JOA outlines the rules for this coordination, agreeing on forming a Joint Planning Committee (JPC) comprised of representatives from both parties [23]. This committee serves as the decision-making body for interregional planning and is guided by the Interregional Planning Stakeholder Advisory Committee (IPSAC) and other stakeholder groups.

Table 2. Interconnections along the SPP-MISO seam (2018) [22].

Voltage level (kV)	Number of tie-lines
69	78
115	28
138	4
161	24
230	20
345	14
500	3
Total	**171**

To support this planning coordination, each party annually provides data and information such as power flow models, system stability models, production cost models, assumptions, relevant futures, and contingency lists. Reliability and congestion analyses are performed to evaluate the potential transmission needs along the seams between the two regions. Transmission issues are reviewed annually to determine the need for a Coordinated System Plan study. In the event of such a study, the

JPC collaboratively defines the study's scope, involving considerations like transmission issues to be evaluated, model descriptions, analysis types, timeline, and deliverables.

Interregional solutions may be proposed and evaluated during the Coordinated System Plan (CSP) study. The JPC asks for third-party input and reviews potential transmission solutions with the IPSAC. If a proposed interregional project is deemed beneficial to both regions by meeting regional criteria, it undergoes approval by the JPC and subsequent inclusion in regional transmission plans and presentation to each party's respective board of directors for final approval and implementation.

Conversely, the current JOA does not provide a cost-sharing mechanism to facilitate the development of large-scale infrastructure needed to interconnect anticipated levels of new generation (mostly renewable) near the seam. For that reason, SPP and MISO began a collaborative effort in 2020 called the "Joint Targeted Interconnection Queue (JTIQ) study" [24]. The JTIQ study focuses on two key objectives. First, it aimed to identify transmission solutions (focused on backbone projects rather than point-of-interconnection upgrades) to overcome constraints hindering generation interconnection at the SPP-MISO seam. Second, it aimed to align interconnection processes between the two RTOs to reduce delays caused by the coordination of affected system studies.

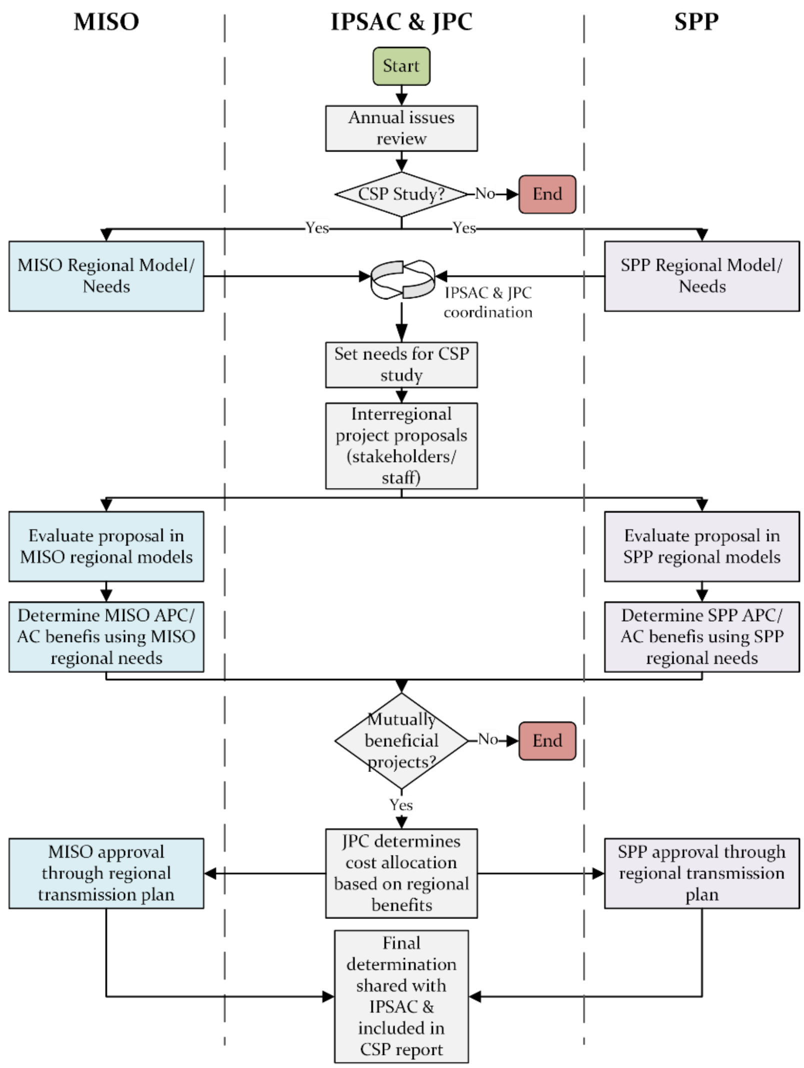

Figure 4. Diagram of the interregional transmission collaboration (taken from [23]).

In 2022, the JTIQ study evaluated several projects, resulting in the identification of seven technically feasible projects that offer improved reliability and economic benefits. An update from the MISO-SPP JTIQ in March 2023 outlines a proposed cost allocation methodology, indicating that the expenses associated with the JTIQ transmission projects will be divided between generators (90%) and load (10%)[25]. The 10% share pertaining to load will be allocated between SPP and MISO load in proportion to the Adjusted Production Cost (APC) benefits, while the entirety of operation and maintenance (O&M), administrative and general (A&G), and similar costs will be assumed by the load. The parties will keep refining the cost allocation plan with input from stakeholders. Once the methodology is complete and approved by FERC, the JTIQ portfolio will be reviewed by each RTO's board of directors for the implementation phase [24].

5. Incorporation of Public Policy and Stakeholder Collaboration

As a result of risks posed by climate change, stricter regulations have been implemented with regard to power system operations to reduce greenhouse gas emissions. These regulations ensure that power system planning considers environmental impacts and actively seeks sustainable solutions. These solutions mainly focus on transitioning from fossil fuel-dependent systems to electric grids that maximize the use of renewable energy. For this reason, it is critical to establish a close collaboration between policymakers and ISO/RTOs in order to ensure an orderly transition to the new-generation power systems. This chapter describes how that interplay is developed to incorporate policy-driven needs into the long-term planning processes. Additionally, stakeholder collaboration is a cornerstone to providing input and feedback that allows ISO/RTOs staff to conduct technical and economic studies that generate reliable and meaningful recommendations. Specifics of each ISO/RTO are provided in the following subsections. The main stakeholders' functions and principal characteristics of the engagement process are presented in Subsection 5.3.

5.1. Public policy within the MISO planning process

"State policies are included in the development of future scenarios that inform long-term transmission planning. MISO Futures development is a collaborative stakeholder assessment of the resource plans and goals of member utilities and states to meet the future energy requirements under a range of economic, policy, and technologic possibilities over a 20-year period. These Futures scenarios are then used to establish the requirements for transmission expansion needed to ensure continued reliability and economical delivery of energy."[1]

5.2. Public policy within the SPP planning process

Reliability, economic, and operation needs assessments are completed concurrently with the public policy needs assessment. If the economic simulations reveal conditions on the system that prevent a utility from fulfilling its legal or regulatory obligations as established by the renewable policy review and/or future particular public policy assumptions mentioned in the study's scope, then there is a need driven by public policy. If any policy needs are identified, then potential solutions are evaluated, and whether or not a public policy need is met determines how well a given solution is rated. Finally, during the portfolio development, projects that reduce the identified public policy need will be included for further consideration [8].

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[1] Direct textual contribution from MISO planning engineer.

5.3. Comparison of MISO and SPP stakeholder collaboration within the planning process

Table 3 shows whom each ISO/RTO considers being stakeholders for planning purposes, what the stakeholders' role is within long-term planning, and how often and where stakeholders meet.

Table 3. Comparison of ISO/RTO stakeholder collaboration.

ISO /RTO	Main Stakeholders	Functions	Meeting Logistics
MISO	Load-serving entities, transmission and generation owners, market participants, state-level regulatory personnel, and environmental and consumer groups [16].	Their roles mainly include providing assumptions for the development of the scenarios, responding to data requests, keeping the system's data accurate, examining models, and offering suggestions on needs and potential solutions [16].	Monthly PAC meetings and subregional planning sessions are scheduled throughout the MTEP timeline [16].
SPP	Market participants, transmission customers, transmission owners, neighboring first-tier entities, and state regulatory agencies. [26].	Stakeholders are organized into multiple working groups according to their technical expertise and interest to advise and guide the SPP ITP. Stakeholders also provide planning-related including modeling data, load and energy forecasts, potential public-policy drivers, market design inputs, and other relevant information [27]. SPP stakeholders can also submit solutions to the system violations identified in the planning process through a 30-day window called the Detailed Project Proposal process [8].	SPP develops a project schedule while determining the scope of each ITP study, identifying responsible parties for data exchanges, review and approvals, and the duration and time of each task [8].

6. Cost allocation

The Federal Energy Regulatory Commission (FERC) is the regulatory authority of MISO and SPP. The FERC Order No. 1000 provides the basic "principles" of cost allocation for new transmission projects [21]. These principles establish the following [21]:

1. Transmission facility costs must be fairly allocated to those within the planning region who benefit from them based on estimated benefits.
2. Transmission facility costs must not be allocated involuntarily to those who do not benefit from them, either currently or in expected future scenarios.
3. The benefit-to-cost threshold used to determine which facilities qualify for cost allocation in the regional transmission plan must not be set too high to exclude facilities with significant positive net benefits. The threshold should not exceed 1.25.
4. Transmission facility costs must not be allocated to a region outside of the facility's location unless the other region agrees to assume responsibility for paying a portion of those costs.
5. The cost allocation process determining benefits and identifying beneficiaries must be transparent.
6. Different cost allocation methods may be used by a transmission planning region for different types of projects.

Adhering to these principles, transmission providers can collaborate with stakeholders to determine suitable cost-allocation methods for further regional and interregional transmission facilities. This chapter outlines how each RTO implements the cost allocation process for new facilities recommended in their long-term plans to meet future demands.

6.1. Cost allocation considerations within the MISO planning process

The process to allocate project costs and the allocation granularity level in the MISO region varies depending on the type of project. The GIP costs are mainly paid for by the interconnecting customer [16]. "The cost of Market Efficiency Projects are allocated to the Transmission Pricing Zones with a net positive present value of annual benefits as determined by the analysis of adjusted production costs. For Interregional Market Efficiency Projects, costs are allocated to Cost Allocation Zones with a positive present value of annual benefits determined by the production cost analysis. For Multi-Value Projects, the cost is allocated to the subregion or footprint based on evaluation of total benefits for the portfolio and includes analysis of multiple metrics such as production cost savings, avoided capital costs, and mitigation of reliability risks."[2]

"Reliability benefits are largely not monetized except in the case of Multi-Value Projects where avoided-risk of load loss is evaluated as one of a number of benefit metrics. However, in the Multi-Value Project benefits analysis, reliability issues are captured and quantified to demonstrate the value of improved reliability that is spread to beneficiaries. Benefits of public policy are limited to a decarbonization metric which is derived from emissions data provided by the economic analysis and monetized using a value of carbon derived from state and federal assessments."[10]

On the other hand, "the cost of Regional/Interregional projects are not currently allocated to interconnection customers. MISO and SPP have been coordinating on the Joint Targeted

[2] Direct textual contribution from MISO planning engineer.

Interconnection Queue (JTIQ) Study to develop an interregional-based approach to addressing generation interconnection upgrades that would be cost-shared by interconnection customers in both regions. Finally, projects identified through regional planning studies may not be rejected (by participants) on the basis of cost allocation, but stakeholders may offer alternatives that provide better performance or value."[10]

6.2. Cost allocation considerations within the SPP planning process

The Southwest Power Pool (SPP) follows Attachment J to the SPP Tariff for the allocation of costs related to new or upgraded transmission facilities. [28]. SPP adopts three cost allocation strategies for new transmission projects. Sponsored projects involve the project owner constructing and receiving credit for utilizing transmission lines. Generator Interconnection Network Upgrades are directly assigned to the interconnection customer, who is responsible for the entire cost and can earn revenue credits for their contribution [28]. The principal methodology used by SPP is the Highway/Byway approach, which applies to Base Plan Upgrades (BPU). BPUs encompass approved reliability and economic projects, including priority Extra High Voltage projects and those resulting from the ISO's expansion planning process (ITP). Under Highway, projects with a voltage above 300 kV have their costs allocated regionally, while under Byway, projects with a voltage below 300 kV have zonal cost allocation [28]. For projects below 100 kV, costs are allocated based on zones, and for projects between 100 kV and 300 kV, 33% of the costs are allocated regionally and 67% zonally, with the specific zonal allocation determined by the SPP pricing zones [28].

7. Resilience evaluation strategies

In the electricity sector, ensuring resilience has become a dominant concern considering the changing weather patterns and extreme events happening more often. As pivotal players in planning the future grid, MISO and SPP have been proactively formulating strategies to address and enhance their system's resilience. This chapter examines the distinctive approaches adopted by MISO and SPP to evaluate and strengthen the resilience of their operations, providing insights into their respective initiatives, challenges, and accomplishments.

7.1. Resilience evaluation strategies implemented by MISO

MISO is working on various fronts to address resilience issues that the system operation could face in the short and long term. On one hand, RA planning in the MISO region aimed to secure enough capacity to meet peak demand during hot summer hours [29]. However, this approach has shifted due to various factors, including the retirement of conventional resources, more frequent and severe weather events, and growing reliance on weather-dependent resources. For that reason, MISO proposed a shift from a summer-focused resource adequacy approach to a seasonal basis that considers the diverse conditions throughout the year [29][4]. Its goal is to ensure resources are available when needed most by aligning resource availability with high-risk periods in each season. MISO has been establishing resource adequacy requirements on a seasonal basis since the fall of 2022 [4].

On the other hand, in 2021, MISO released a technical report called "MISO's Renewable Integration Impact Study (RIIA)", exploring the challenges and risks of the Eastern Interconnection bulk power system (with a focus on the MISO footprint) that could arise from the increased penetration of wind and solar to the grid and the retirement of conventional generators [30]. The study covered three focus areas: resource adequacy, energy adequacy, and operating reliability. RA, power flow, dynamic, and production cost models were used to analyze different scenarios of penetration levels. The RIIA stated that with over 30% renewable penetration, the system could experience major problems related to stability, flexibility, and transmission capacity [30]. Although the RIIA performed multiple analyses relevant to the study objectives, it did not examine the resilience of the MISO electricity system in response to the increased integration of wind and solar power. The final RIIA conclusion is that planning, market, and operation changes are required to support the integration of more renewable resources beyond one-third of the region's electricity supply [30].

Finally, as part of the Reliability Imperative initiatives, MISO, its members, and states are collaboratively addressing a range of challenges arising from fleet changes, the electrification of adjacent industries, fuel assurance, and the increasingly frequent and intense occurrences of extreme weather events such as winter storms and hurricanes [29]. Currently, MISO is also modifying its planning criteria to assess and enhance the system's resiliency [29].

7.2. Resilience evaluation strategies implemented by SPP

SPP has not performed any resilience study yet, but they are actively moving in that direction. SPP's research department collaborates with members, consultants, universities, DOE laboratories, research institutions, and other system operators to prepare for extreme weather events and other potential high-risk conditions [31]. Their joint efforts focus on integrating new technologies safely and reliably into the grid, harnessing their capabilities to enhance grid reliability and operations. SPP is involved in research initiatives with organizations like the Electric Power Research Institute (EPRI), the Power Systems Engineering Research Center (PSERC), the Institute of Electrical and Electronics Engineers (IEEE), and the Research Center on GRid-connected Advanced Power Electronic Systems (GRAPES) [31].

SPP is also enhancing efforts to coordinate with neighboring balancing authorities (BAs) for interregional resource adequacy, optimizing the utilization of surplus energy from different areas [10]. These improvements aim to lower costs, increase resource adequacy, and bolster grid resilience while accounting for transmission capabilities and possible uncertainties during extreme weather and climate scenarios. The Grid of the Future Assessment includes other resiliency considerations for future studies, including developing rules and regulations for incorporating microgrids into the operation and planning of transmission and resource adequacy to enhance grid resiliency during severe weather events [10].

8. Findings and Conclusions

ISO/RTOs have a crucial role in reliably operating the grid, implementing competitive markets with open access to the transmission system, and conducting planning analyses that identify and address future system needs. Understanding their planning process is essential for the research community and state agencies to be able to contribute by developing strategies that improve those processes. This report provides an overview of the main planning activities carried out by MISO and SPP, updating and broadening the aspects covered by previous reports [32][33][34].

Stakeholder collaboration is a critical factor for MISO and SPP planning processes. Load-serving entities, transmission and generation owners, market participants, and state-level regulatory personnel are the shared stakeholders among the RTOs. Stakeholders provide essential data for planning modeling and analyses. They play a key role in offering relevant feedback along the planning cycles, supporting the development of studies' scope and assumptions, and contributing to solutions' development. The Multiregional Modeling Working Group is a valuable data source for BPS reliability modeling in the Eastern Interconnection. By leveraging stakeholder engagement, RTOs can enhance the accuracy and effectiveness of their planning analyses. This collaboration promotes a comprehensive understanding of the challenges and needs of the grid, aiding in formulating informed planning strategies.

For most RTO/ISOs in the USA, interregional transmission planning represents an independent process, primarily exchanging regional plans and information and addressing specific issues. To a lesser extent, interregional collaborations assess interregional projects to alleviate mutual needs. While passive cooperation is predominant in interregional planning, the MISO-SPP JOA is a notable exception. Studies from academia and national labs consistently highlight the significant benefits associated with projects not identified in traditional intra-regional planning processes, underscoring the importance of further research and collaboration [35].

Reliability, economic, and public policy analyses form the foundation of RTOs' long-term planning processes. These studies serve as the basis for evaluating the BPS under different future scenarios, guiding both long-term and near-term planning efforts. Analyses are usually run sequentially or independently using tools developed to address specific studies. However, changes in the grid operation require innovative and accurate computational tools to explore future scenarios and determine transformations needed to satisfy diverse types of needs under different contexts.

Resource adequacy (RA) studies are critical in capacity and reserve procurement for ISO/RTOs. Efforts are underway to improve RA methodologies, including the consideration of accrediting the reliability provided by renewable resources. Given the increasing variability resulting from the intermittency of renewable resources, it is important to develop innovative production cost tools that can account for highly granular timeframes (less than one hour). These tools ensure fair compensation for ancillary services, supporting the effective integration of renewable energy into the grid.

Climate change and extreme weather events' escalating severity and frequency represent an alarming threat to the power system's resiliency. Increased integration of weather-dependent resources needs more substantial operational and planning adjustments, as demonstrated in [36]. Identifying events and conditions that impose high risk on the grid is imperative. Furthermore, creating comprehensive resiliency metrics is crucial for evaluating and comparing various mitigation strategies that can ensure the secure operation of the grid during high-risk situations. While MISO and SPP have yet to conduct resiliency-focused studies, they are proactively advancing in this direction. They are working on incorporating probabilistic approaches into their planning processes, considering more extreme transmission contingencies and additional extreme weather scenarios or sensitivities. They are also exploring multiple strategies to improve reliability, flexibility, and resilience, including integrating multiple technologies, developing a regulatory framework for microgrids, installing battery storage, and more active interregional collaboration.

Expansion planning (EP) tools are an alternative and beneficial approach to studying existing power grids under future scenarios and identifying the most economically attractive generation and transmission designs over decades [37]. MISO and SPP integrate generation EP tools within their long-term planning processes, as presented in Subsection 2.4. Generation and transmission expansion planning tools complement reliability and economic studies, providing valuable insights into its scenario development and supporting decision-making. Although these tools are increasingly used, further advancement is still needed to incorporate all investment options and the services they could provide [37].

Finally, MISO and SPP implement the scenario-based method to consider diverse future conditions in the technical and economic analyses. This is also a consistent trend among most ISO/RTOs in the USA. Traditional deterministic approaches do not account for uncertain conditions and demand significant time due to the need for separate analysis of each individual scenario, thereby highlighting the need to transition from deterministic to stochastic approaches that address long-term uncertainty. This transition involves identifying flexible investment portfolios that could adapt to several future scenarios, including weather scenarios that could impose a risk on grid resiliency. Stochastic programming methods, including the ISU's Adaptive Coordinated Expansion Planning (ACEP) tool, is able to handle uncertainty by finding a flexible core portfolio that most effectively transitions to the other scenarios and identifying adaptations needed from that core trajectory to each deployed scenario. This tool, which will be used for this work, will identify the least-cost approaches to providing energy while maintaining high levels of reliability and resilience.

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