Developing a Market Vision for MISO

Supporting a Reliable and Efficient Electricity System in the Midcontinent

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FOUNDATIONAL REPORT

PREPARED FOR

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Executive Summary

The Midcontinent Independent System Operator's (MISO's) current Market Vision and Roadmap process presents a special opportunity to improve its wholesale markets. The Market Vision will define market development objectives and principles, and identify Focus Areas for development that will most improve the market. After MISO and stakeholders finalize the Market Vision this January, they will spend six months developing a Roadmap that prioritizes, sequences, and plans for the execution of initiatives over the next five years (subject to future updates).

In this report, we provide a foundation for the Market Vision and Roadmap process. We start by defining "well-functioning markets" generally and then identifying electricity-specific factors (*e.g.*, network externalities and difficulties balancing supply and demand absent significant storage) that would prevent electricity markets from functioning well absent a centralized coordinator such as MISO. More specifically, we delineate the essential responsibilities of MISO from those of regulators and market participants, leading to a list of "Core Services" that MISO needs to provide to support well-functioning markets. These Core Services include: Scheduling and Dispatch, Energy and Ancillary Service Price Formation, Energy and Ancillary Service Market Administration, Administration of Complex Hedging Products, Market Transparency, Market Monitoring and Mitigation, Resource Adequacy, Transmission Planning, and Public Policy Support.

We also developed Principles for *how* MISO should aim to provide these Core Services and enhance the market design, and these Principles align closely with the ones MISO is proposing as part of its Vision. The ones we articulated are to: (1) strive for highest efficiency, defined as minimizing the operational and investment cost to serve load; (2) align market requirements with reliability requirements; (3) provide transparent market prices reflective of marginal system cost; allocate out-of-market costs based on cost causation; (4) disseminate non-proprietary information on market and system conditions to enable market participants to operate, plan, and transact more cost-effectively; and (5) ensure that wholesale markets are competitive, through market monitoring and enabling non-discriminatory market participation. These Principles are largely consistent with MISO's current approach to administering and enhancing its markets, although they have not previously been officially codified.

Perhaps most importantly for informing the specifics of the Roadmap, our discussions with stakeholders, MISO staff, and the Independent Market Monitor (IMM) identified types of initiatives that offer the greatest opportunities for improving MISO's electricity market. These coalesced into the following seven "Focus Areas:"

1. Enhance Unit Commitment and Economic Dispatch Processes
2. Maximize Economic Utilization of Existing and Planned Transmission Infrastructure
3. Improve Efficiency of Prices under All Operating Conditions
4. Facilitate Efficient Transactions across Seams with Neighboring Regions
5. Streamline Market Administrative Processes to Reduce Transaction Costs

6. Maximize Availability of Non-Confidential and Non-Competitive Market Information
7. Support Efficient Development of Resources Consistent with Long-term Reliability and/or Public Policy Objectives

If adopted as part of the Market Vision, these Focus Areas will represent a commitment among MISO and stakeholders to make substantial progress in enhancing the market design over the coming two to five years.

We review each potential Focus Area by describing the types of initiatives it could encompass, providing initial indicators of the value of such initiatives, and suggesting next steps for pursing them in the Roadmap. As described, we find that the Transmission Utilization, Seams Management, and Resource Development Support areas have enormous potential value, each offering on the order of $100 million per year in system cost savings (as rough, order-of-magnitude estimates). The next steps for these three Focus Areas would involve refining the initiatives and benefit-cost estimates, as well as coordinating with other entities on objectives, feasibility, and process. The four other Focus Areas are worth pursuing because they may: have more value than initial indicators suggest; have high benefit-cost ratios; include initiatives that effectively serve the Market Vision; or are already underway.

Finally, we offer process suggestions for developing the Roadmap over the next six months into an actionable plan. These suggestions start with organizing sub-teams to address each Area, and considering combining the Focus Areas on administrative processes and market transparency. Each sub-team would establish criteria to identify specific initiatives to consider, conduct benefit-cost analysis, refine initiatives to maximize value, and then prioritize and sequence the best initiatives. Ultimately, MISO would then finally consolidate all areas and initiatives together into a coherent Roadmap that recognizes interdependencies among areas and the limited resources that MISO can devote to implementation. MISO and stakeholders would then execute the Roadmap over the next five years, while also updating the Roadmap periodically as needs change and more information becomes available.

I. Introduction

The Midcontinent Independent System Operator (MISO) administers a very active wholesale electricity market that has produced great economic efficiencies while maintaining reliability. For example, MISO's "Value Proposition" estimates that its centralized wholesale markets and system operations provide the region with $1.9 to $2.4 billion per year in economic benefits.[1] Further, the Independent Market Monitor (IMM) assesses that the market has "generally performed competitively."[2]

However, as in all regional transmission operators (RTOs), there are many opportunities for improving MISO's market design. Accordingly, MISO, its IMM, and its stakeholders have identified a large number of market enhancement initiatives that are currently at various stages of evaluation, conceptual development, or implementation. However, some proposed initiatives have not yet been pursued, for example, because of a lack of stakeholder consensus, lack of staff and stakeholder time, or interactions with inter-related design elements. MISO has endeavored to evaluate and implement the most valuable of these market design enhancements and subjected most major initiatives to a rigorous cost-benefit analysis, but prioritizing among these many potential initiatives has been a somewhat *ad hoc* process.

Recognizing a need to more systematically evaluate and prioritize among its market enhancement efforts, MISO leadership realized that it would benefit from establishing a coherent Market Vision and Roadmap. The Market Vision will clearly lay out the organizational objectives and market design principles, while the Roadmap will provide a 3- to 5-year plan for implementing that Market Vision. These guiding documents will be used to support a more systematic annual stakeholder process for setting priorities, weighing alternative proposals, and focusing efforts on the market enhancements likely to generate the most value to the region. Over the past several months, we have worked with MISO and its stakeholder community toward developing its Market Vision. This Foundational Report is one input into that process.

A. Purpose of this Foundational Report

In this Foundational Report we aim to support MISO and stakeholders in their visioning process by offering guiding principles for market development and identifying the most fruitful focus areas for enhancing the market design. We do so by: (1) providing a theoretical economic basis to ground the discussion of what constitutes a well-functioning electric market; (2) articulating MISO's role in supporting an economically efficient and reliable electric system; (3) gathering and compiling stakeholder input into an organized list of Focus Areas for market enhancements over the coming years; (4) conducting a high-level evaluation to scale the potential benefits if

[1] See MISO (2013a).

[2] See Potomac Economics (2013).

MISO and stakeholders were to adopt each Focus Area; (5) suggesting possible next steps for making progress in each potential Focus Area; and (6) suggesting a process for prioritizing initiatives in developing a multi-year roadmap for enhancing the market design.

This report incorporates the material from presentations we delivered to stakeholders—and input they provided back to us—in April, June, September, and December.[3] However, while we have incorporated a substantial body of input from stakeholders and MISO, this report represents the authors' independent views that may not be entirely consistent with MISO or stakeholder positions.

B. MISO's Market Visioning Process

Over the past months, we have worked with MISO to facilitate stakeholder discussions aimed at providing a foundation for the market vision, developing market design principles, and identifying Focus Areas for market enhancement. One important product from that process is a draft of MISO's formal Market Vision statement that defines three components:

- A *Vision Statement* defining the objectives of MISO's Market;
- *Principles* that will guide how MISO pursues market development initiatives to better serve its Vision; and
- *Focus Areas* within which MISO and stakeholders will commit to making substantial market design improvements over the coming two to five years.

The current version of MISO's Market Vision as of the date of this report is consistent with the foundational concepts that we lay out in this report. The draft Market Visions document is reproduced in Figure 1.

The Market Vision diagram also makes reference to MISO's forthcoming "Roadmap" that will establish an implementation plan for enhancing MISO's market design over the next two to five years. MISO and stakeholders will develop the first Roadmap between January and June of 2014. Thereafter, they will execute the Roadmap and update it periodically based on progress, regulatory requirements, and changing market conditions.

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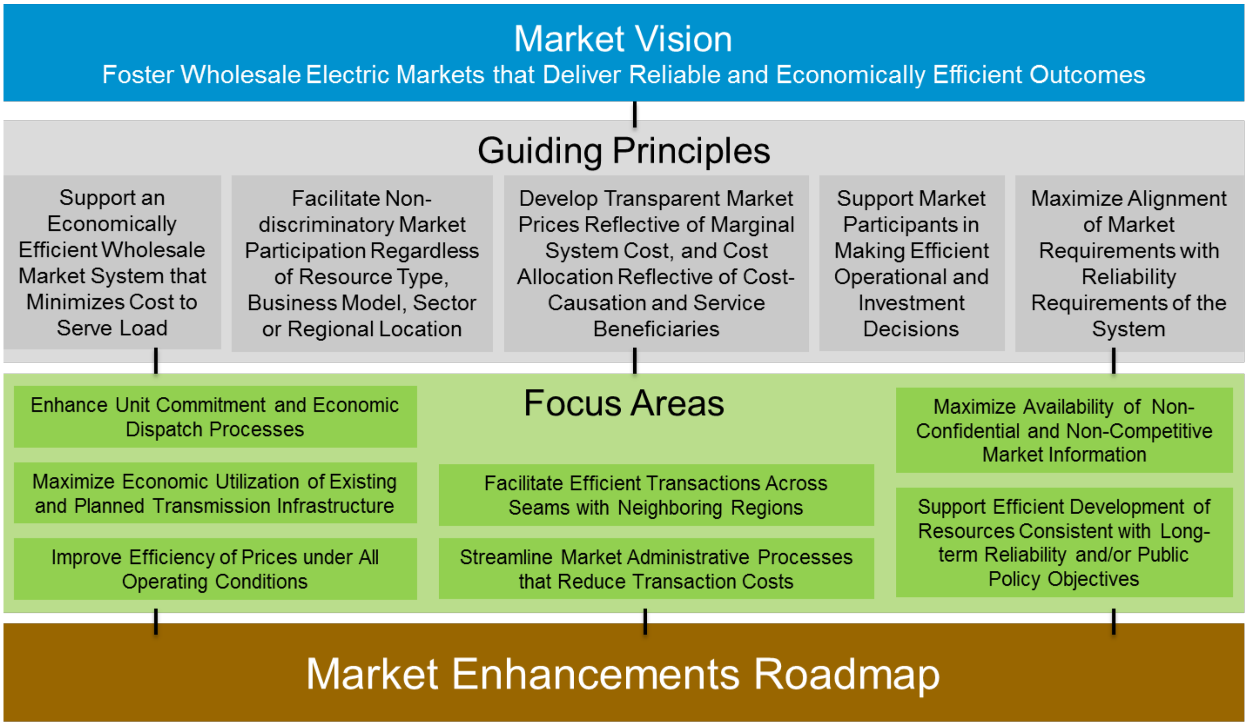
[3] *The Brattle Group* presented to stakeholders on June 5, September 6, and December 3, 2013. See Newell and Spees (2013a), (2013b), and (2013c).

Figure 1
Summary of MISO's Draft Market Vision



Sources and Notes: MISO's Final Proposed Draft Market Vision as of January 7, 2014.

MISO's Market Visioning process was initiated partly out of the corporate strategic planning process. This effort supports the organization's Strategic Plan and will ultimately enable market design enhancements that substantially contribute to the organization's Value Proposition.[4]

[4] Specifically, the Market Vision contributes to Strategic Element 4: Enhance Products and Performance in the Strategic Plan, see MISO (2013b). See MISO (2013a) for the current MISO Value Proposition.

II. Foundations: What Constitutes a Well-Functioning Market?

As the first step in our Market Visioning process, we conducted a stakeholder workshop to review the economic foundations of a well-functioning market and stimulate a discussion about the institutions and rules necessary to support an efficient electric market in the Midcontinent. In this section, we review these fundamental economic concepts and examine how they can be used to further enhance the MISO market design.

A. "Perfectly" and "Workably" Efficient Markets

In order to illustrate the theoretical ideal as a starting point, this section outlines the characteristics and preconditions necessary to establish *perfectly* efficient markets. While this ideal is not achievable in reality, it does provide some guidance as to how MISO can further improve its imperfect, but workably efficient, markets.

1. Theoretical Preconditions for Perfectly Efficient Markets

Economic theory asserts that, under certain preconditions, unconstrained markets will produce maximally efficient outcomes with the greatest societal benefits. Markets achieve *allocative efficiency* such that no further improvements to one market participant's welfare are possible without making someone else worse off. However, markets fully achieve this theoretical ideal only under a number of preconditions:[5]

- **All entities are price-takers**. If buyers or sellers have the ability to profitably move prices away from competitive levels, they are said to have market power. The exercise of supplier market power typically results in a reduction of the quantity sold relative to competitive levels, such that additional "gains from trade" could be realized. Market power is usually avoided when there are high numbers of both buyers and sellers in the market, meaning both demand and supply are diffuse.
- **Profit-maximizing motive.** Buyers and sellers are generally assumed to do as well as they can for themselves. Violations of this condition could again result in unrealized gains from trade.
- **Symmetric information**. The characteristics of all commodities should be observable to all market participants. If this condition does not hold, the market for that commodity will break down.
- **Costless transactions**. The classic model assumes that transactions occur without frictions, whether due to search and information costs, bargaining costs, or policing and

[5] See, for example, Stiglitz (1988) or Stiglitz (1991).

enforcement costs. The presence of such transaction costs means that some beneficial exchanges would not occur.

- **No externalities**. Externalities occur when the well-being of a market participant is directly affected by the actions of another (pollution is the classic example). The existence of, and the inability of markets to address these externalities, often means that the market outcome is suboptimal in some sense.

These preconditions represent a high standard for efficiency that may be unattainable in any real-world market, but nevertheless inform the conditions that will enhance efficiency. For example, while MISO cannot completely eliminate information asymmetries, transactions costs, externalities, or other sources of market imperfections, it has many opportunities to reduce the magnitude and influence of these imperfections.

2. Characteristics of "Workably-Efficient" Markets

In practice, markets do not operate according to the perfect efficiency envisioned in classical microeconomics because the specified preconditions are not possible to achieve in real-world circumstances.[6] Instead, real-world markets must operate within the context of inefficiencies and challenges that force deviations from the theoretical ideal. Sometimes these challenges are so substantial that the market is not able to function at all, resulting in a "market failure" as described further in Section II.B.

More commonly, these challenges introduce some inefficiencies, but are not substantial enough to prevent the market from achieving a reasonably efficient outcome. For our purposes, we classify a market as well-functioning if it meets a more attainable standard of being "workably efficient." Commodity markets that do achieve a high degree of efficiency often have some of the following characteristics in common, with electric markets matching these characteristics to varying degrees:

- **"Workable competition."** While there is no widely-accepted definition of "workable competition," the term usually implies a market with several producers and consumers each of whom has at most a limited ability to influence the market price. Workably competitive markets also exhibit few barriers to entry and exit. Some types of electric markets require a substantial amount of monitoring and mitigation to achieve a workably competitive environment, since inelastic demand, localized transmission constraints, and long-lead times for entry and exit can create recurring conditions where individual entities have structural market power.[7]

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6 Mas-Colell, *et al.* (1995).

7 The term "workable competition" is due to Clark (1940).

- **Well-defined, standardized products.** Efficient exchange can be hampered by poorly defined or non-standardized products that make it more costly to exchange goods.[8] In contrast, some examples of well-defined standard products that enable efficient trading include on-peak energy futures at trading hubs, state-level renewable energy credits (RECs), and MISO's planning resource credits (PRCs) reflecting a unit of capacity. Prior to MISO defining PRCs, capacity in MISO's footprint was not standardized and as such each transaction required a complex contract to define the quantity of capacity procured at what times and locations, availability requirements, and penalty provisions for non-delivery.
- **Low transactions costs, typically facilitated by a liquid, centralized exchange.** Decentralized bilateral markets can have high transactions costs, where inquiring about prices from each potential counterparty is a time-consuming negotiation process, and each potential counterparty has unique counterparty risks that must be evaluated. A centralized exchange or auction can eliminate these problems by making bid, ask, or clearing prices easily accessible and by establishing credit requirements that eliminate counterparty risks. Such transparent prices also support a healthy bilateral market and effective regulatory oversight by providing clear reference points for appropriate bilateral contract prices.
- **Information transparency**. Prices most accurately reflect underlying fundamentals if all transacting parties have access to accurate and up-to-date information about market conditions. If only one party is aware of this information, they may capture excess profits at the expense of others, as in high-profile cases of insider trading. In electricity, some information is highly transparent including information about day-ahead prices and weather forecasts. MISO and other RTOs play a major role in providing transparent pricing and other system information. However, not all important information will be incorporated into parties' trades if it is inaccessible, difficult, or time-consuming to interpret. For example, generator outages, transmission outages, and interconnection process updates are all big drivers of market prices, but have varying amounts of information transparency and ease of use.
- **Risks can be assigned to the entities most able to manage risks**. All markets exist in the context of risks that increase the cost of doing business and must be borne by one party or another. Some market-wide risks can be absorbed by customers or managed by financial market participants, for example the uncertainties in weather and fuel prices. However, risks that can be managed physically are most appropriately assigned to the entities capable of managing them. For example, the owner of a generation asset may be the most

[8] For example, the USDA has specified standards for corn, including the minimum weight per bushel and limits on the number of heat-damaged kernels, broken corn, and foreign materials. See USDA (1996) at http://www.gipsa.usda.gov/fgis/standards/810corn.pdf. Note that standardized products are not always a necessary feature of workably efficient markets, and are much more difficult to implement in non-commoditized markets, such as differentiated consumer products.

appropriate entity to assign outage risks for that asset, which would create appropriate incentives to evaluate and invest in cost-effective measures to prevent or minimize outage risks.

Electricity wholesale markets encompass a large range of sub-markets from long-term bilaterals, to over-the-counter energy futures at liquid trading hubs, to centralized real-time markets with very localized nodal pricing, to hedging instruments such as financial transmission rights (FTRs). These many markets exhibit varying degrees of the "workably efficient" preconditions described above, and in most cases require substantial supporting infrastructure to achieve most of the above characteristics and function at a workably efficient level. At the same time, other products and services in the electricity industry, such as transmission planning and voltage support, are provided on a non-market basis, as creating conditions for a workably efficient market for those products and services has not been possible.

3. Institutions Required to Support Well-Functioning Markets

Efficient markets have at their core large numbers of willing buyers and sellers engaging in many mutually beneficial transactions. For the purposes of our discussion, however, it is important to recognize that such efficient markets generally do not exist in a vacuum neither in the electricity industry nor even in technically simpler contexts.

Efficient markets rely on a set of institutions that enable them to function. For example, even a very simple transaction requires the rule of law, well-established property rights, and currency. More complex transactions require legal institutions to enforce contracts, banking infrastructure, and electronic trading platforms that enable the transfer of goods with a minimum of transactions costs. More complex markets such as those in the electricity industry rely on an even greater number of supporting institutions to function. As a market administrator, MISO is the primary entity responsible for creating and supporting the institutions that enable an efficient electric industry in the Midcontinent.

Along with regulators, these institutions can play a critical role resolving market failures or challenges that would otherwise inhibit well-functioning markets, as discussed below.

B. Classical Market Failures

There are several reasons that a workably efficient market may fail to materialize for a particular product. Inefficient, poorly functioning, or even non-existent markets are the consequence of a market failure. Table 1 summarizes and provides examples of several classic market failures, including externalities, public goods, common goods, failures of competition, and failures of information. The existence of such market failures will reduce the societal value created by a particular market, for example by reducing the quantity of goods exchanged. In some cases market failures can lead to "incomplete markets" where the good cannot be exchanged at all, though the private value of that good would exceed the private costs to create it.[9]

Table 1
Classic Market Failures

Market Failure	Description	Examples
Externalities	*Externalities* occur when one market participant imposes costs or benefits on others but does not compensate or get compensated accordingly.	Environmental Impacts Network Effects
Public Goods	*Public Goods* are goods or services that are "non-rival" (zero marginal cost to additional individuals enjoying the good) and "non-excludable" (producers cannot exclude non-payers from enjoying the good). They will be underprovided by the market because producers cannot capture and will not consider the full benefits of the good.	National Defense Free Broadcast TV Operational Grid Reliability
Common Goods	*Common Goods* are "rival" (one individual's use of the good reduces the availability to others) and "non-excludable." Subject to "Tragedy of the Commons," the good is underprovided due to non-excludability (as with public goods) and has the additional problem of being rapidly depleted by self-interested consumption.	Grazing Commons
Failure of Competition	*Failure of Competition* can occur when there is structural supplier or buyer market power and barriers to entry, and the severity depends on the relevant geographic scope and product substitutability and time required for entry.	Computer Operating System Monopoly Used to Exclude Software Competitors
Information Failures	*Information Failures* may occur when consumers lack sufficient information to judge value, classically regarding safety, medical care, nutritional information, *etc.* Some commodity markets have addressed this challenge by defining standardized products.	Consumer Health Care Costs
Incomplete Markets	*Incomplete Markets* occur when private markets fail to provide a commodity whose private benefits would exceed the private costs.	Some Types of Insurance or Loans Thin Trading in Some OTC Markets

Sources and Notes:
Adapted from Stiglitz (1988).

When market failures exist, it is often possible to correct or mitigate the failure by creating an appropriate institution or regulation. However, there is no one-size-fits-all correction to each

9 Note that the lack of an active market in a particular product or service does not necessarily indicate a market failure if the cost of producing that good exceeds the value it provides to customers.

type of market failure, and interventions will only be successful if carefully designed to address the problem within a particular context. Doing this correctly requires identifying the root cause of the market failure. For example, an "incomplete market" can be caused by any number of underlying challenges such as undefined or unenforced property rights, high transactions costs, or regulatory uncertainty. The appropriate corrective intervention depends on the nature of the particular challenge. In the electricity industry, addressing market failures has required a complex set of regulatory institutions and technical infrastructure to be developed, which is still an ongoing process as discussed in the rest of this report.

C. Why Electricity Markets are Challenging

Electricity is one of the most challenging commodity markets, primarily because of two unique sets of physical characteristics: (1) the very limited availability of storage, combined with highly variable but inelastic demand and generators' operational constraints make it exceptionally difficult to balance supply and demand and maintain grid stability in real-time; and (2) network externalities are rife when using a common transmission system that is subject to Kirchhoff's laws, thermal limits, voltage limits, and stability issues.

These unique challenges interact with some of the more common problems, including susceptibility to exercise of market power, barriers to rapid entry, natural monopolies, and common good attributes of reliability. Finally, the industry's history, organizational complexity, and public policy importance, create further challenges. We describe here how these factors make it challenging to create and support workably efficient electric markets.

1. Demand-Side Challenges

Unlike other markets, demand for electricity has historically behaved inelastically on a short-term basis, not responding to changing real-time or day-ahead prices and market conditions. This lack of response is caused by a lack of information and exposure at the retail level to prevailing wholesale prices. Dynamic pricing is rare for all but the largest customers, and introducing dynamic pricing to others would require expensive metering infrastructure and usage management. However, the increasing penetration of smart meters, dynamic pricing, and wholesale demand response participation is slightly easing these challenges over time.

The consequence of inelastic demand is that customers over-consume when wholesale spot prices are high and under-consume when spot prices are low. This means that the electric system must have a complex and extensive set of ancillary services to help balance fluctuations in supply and demand almost entirely on the supply side. This is problematic in shortage conditions that would naturally be solved in most markets by prices rising high enough to reduce demand sufficiently. In electric energy markets, the lack of demand elasticity means high prices do not curtail demand and so uneconomic rationing, or involuntary load shedding, is the only way to bring supply and demand into balance.

2. Very Limited Storage

One of electricity's most unique and important challenges is the lack of storage for electric energy. Whereas most other industries may be able to store days' or months' worth of product inventory at modest cost, electric systems have few storage facilities due to their high cost. In MISO, for example, there are two large pumped storage facilities, equivalent to a few percent of the system's energy requirements and able to output for only a few consecutive hours. The lack of storage makes it challenging to absorb temporary supply-demand imbalances and maintain the stability of the grid. Thus, supply must be actively managed to match demand in real-time, a difficult feat given demand's variability and inelasticity, and given the operational realities of supply such as startup times, limited ramp rates, and sudden outages.

3. Transmission-Related Challenges

The electric markets rely on a reliable, well-functioning transmission network to operate, making them unique among industries in a number of ways that pose market challenges. Some of these issues are similar to challenges faced in other network industries, including the natural monopoly characteristics and network externalities. However, the electric transmission system is singular in its technical complexity, constraints related to underlying physical laws, and the public good nature of transmission security. These challenges include:

- **Natural monopoly nature of transmission and distribution.** Regulators have long recognized that the transmission and distribution (T&D) portion of the industry is a natural monopoly. Once an incumbent has built a T&D network, the marginal cost to the incumbent of serving another customer is insignificant compared to the marginal cost of a hypothetical new entrant serving that customer. It would therefore be inefficient to have several different, private sets of "wires" connecting generation to the eventual end-users. This gives rise to both horizontal and vertical market power, necessitating regulatory oversight to facilitate an efficient level of transmission investment, protect against the exercise of market power, and enable at least some limited opportunities for merchant transmission investors.
- **Vertical and horizontal market power.** With horizontal market power, an unregulated transmission owner would be able to extract all of the value between the buyer and seller by negotiating the seller down to cost and negotiating the buyer up to their willingness to pay. With vertical market power, transmission owners could enhance their generation profits by limiting other potential suppliers' access to the system. This is similar to the situation in the natural gas industry. The Federal Energy Regulatory Commission (FERC) has developed several important policies to prevent such exercise of market power, including enforcing open access to the transmission system and enforcing functional unbundling of generation and transmission affiliates.
- **Network externalities.** Market participants may have open access to the transmission system, but their usage of it must be centrally managed to avoid overloading facilities. Flow cannot be privately controlled and contracted because energy flows along the multiple paths of least resistance according to Kirchhoff's Laws. A grid operator is needed

to prevent users from overloading transmission facilities individually and in aggregate. Moreover, individuals' usage, even if managed, imposes costs on other users since one user's use of scarce capacity can limit another's (and counterflows expand the amount of capacity available to others)—thereby introducing congestion costs (or benefits) that impact others on the system, which is the very definition of an externality. The existence (and resolution) of network externalities is a primary reason for the use of centralized dispatch and locational marginal pricing (LMP), which MISO already administers but that can be further improved to better account for these externalities, as discussed in Section IV.

- **Public good nature of operational grid reliability.** Operational grid reliability and transmission security are a public good: they are non-rival because reliability is a pooled service to the entire grid, and one user benefitting from grid reliability does not prevent others from also benefiting; they are non-excludable because the entire grid will experience the same level of operational reliability, *e.g.* voltage support cannot be provided only to those individuals that have paid for it. As with other public goods, the non-excludable nature of grid security makes it susceptible to free-rider problems. Therefore, without supporting regulatory infrastructure and institutions, the market would not have any means of compensating suppliers for providing these services, and the services would be underprovided.
- **Technical complexity.** Finally, the electricity infrastructure is a physically enormous and technically complex machine on a scale unique to the electric industry. Reliably operating such a machine depends on a complex set of technical, operational, and market-making functions, all of which complicate market price formation challenges. For example, this complexity tends to limit the usefulness of traditional over-the-counter (OTC) market-makers for real-time products; and nuanced technical decisions (*e.g.*, in manual adjustments to an economic dispatch) can have unanticipated large market consequences.

Other network industries also face a host of issues related to the physical nature of the supporting network, and have similarly needed to develop a range of regulatory and technical measures to enable markets to operate. However, other network industries are generally less challenging to manage than electricity due to controllability of flows and/or storage, as described in Section II.D.

4. Supply-Side Challenges

Two important supply-side challenges, neither of which is unique to electricity are: (1) *barriers to entry* of new generation resources, caused by long lead times, high capital costs, and regulatory hurdles[10]; and (2) *common good* issues that limit incentives to invest.[11]

First, minimizing barriers to new entry is an important component of a workably efficient and competitive market. If substantial barriers to entry prevent new suppliers from coming online, existing generators will develop structural market power that, if unchecked, would raise prices to levels above long-run marginal cost. New entrants mitigate against the sustained exercise of market power because they would enter the market during times of high prices, therefore reducing prices back to sustainable levels and increasing the competitiveness of the market. Electric power generation has a number of substantial, but not insurmountable, barriers to entry that reduce the effectiveness of relying on new suppliers to mitigate against the exercise of market power, including: (a) long lead times, (b) high capital costs, and (c) complex and sometimes uncertain series of regulatory and interconnection processes. The importance of these barriers should not be overstated however, since there are several types of incremental supply that do not face all of these barriers, including demand response, energy efficiency, imports, and uprates.

A second set of challenges relate to the *common good* attributes of resource adequacy, which is the ability to ensure a sufficient aggregate quantity of generation resources during times of peak demand. Current industry practice, retail power rates, and technology infrastructure are such that resource adequacy is largely *non-excludable*, in that any customer connected to the grid can consume scarce supplies during shortage events. A customer or load-serving entity (LSE) that fails to procure or build sufficient capacity to meet their own peak demand will not be subjected to greater levels of involuntary load shedding during shortage events, and might not even have to pay prices commensurate with the very high opportunity cost of power in those circumstances. This naturally leads buyers to free ride off of others' reserves while underproviding themselves, leading to a sub-optimal level of resource adequacy in aggregate. One solution could be to change technology and practices: have a grid operator ration scarce supplies according to the amount of reserves each buyer secured privately, while facilitating efficient wholesale and retail prices fully reflective of scarcity. MISO and other RTOs have made progress in scarcity pricing, but not at a level that fully reflects the value of reliability implied by the high one-outage-in-ten-years standard policymakers believe is necessary. Nor do they yet have the technical means to

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10 Similarly, the industry-specific nature of the assets (and thus large sunk costs) discourage exit in times of supply surplus.

11 Specifically, in the electric industry, the common good nature of resource adequacy is subject to the "tragedy of the commons" in the absence of an enforced resource adequacy standard. While not identical, the telecommunications and road industries faces similar common good issues that disincentivize private investment in infrastructure.

target load shedding according to the amount of reserves each buyer secured. Hence, resource adequacy would still be under-provided. This leads to the continued need for resource adequacy standards that require load-serving entities to build or buy sufficient capacity to meet their own summer peak demand plus a specified reserve margin.

5. Regulatory Challenges

Finally, because the electric industry is susceptible to many types of market imperfections for the reasons outlined above and because of its role in underpinning the rest of our economy, it is also a highly regulated industry with a long history and complex regulatory structure. Power is vital to all aspects of the economy, evoking strong reactions from public officials, customers, and businesses in cases of retail price increases and substantial outages.

Local, state, and federal legislative bodies have intervened to address many challenges over the past century. There is a long regulatory history that began with the regulated monopoly model to address the natural monopoly nature of the industry, followed by a many-decade series of efforts to introduce competition into different aspects of the industry, including retail competition, wholesale competition, and open access to transmission. The result is great regulatory complexity, with many governing bodies with different mandates and jurisdictions. Further, many of the institutions and processes that are still in place today were developed in an earlier time when the industry faced different economic and technical challenges, and likely would be designed differently if reimagined with access to modern technology and institutions. Finally, the territorial differences created by differing institutional histories can also lead to seams inefficiencies between utilities and RTOs.

D. Comparison to Other Industries

The combination of challenges faced by the electric industry makes it a difficult sector to oversee, regulate, and enable workably efficient markets. Given the scale of the challenges, the wholesale power markets in MISO are already remarkably well-functioning.

Nonetheless, it is instructive to consider other industries, particularly network industries, that face similar challenges. It is important to note, however, that none of these markets is very similar to electric power in totality.

Some of these similarities and important differences with other industries are summarized in Table 2, where we compare the electric industry to tradable commodities as well as to other network industries, including natural gas, airlines, telecommunications, and roads. Interestingly, in addition to many of the challenges in electric power related to its nature as a network industry, it also has a number of advantages due to the commoditized nature of the product. Like other commodity industries, power can be sufficiently well-defined to be traded on a liquid exchange.

Table 2
Comparison of Power to Other Industries

Industries	Similarities	Differences
Metals and Other Tradable Commodities	• Standardized product exchanges foster liquidity, enable hedging • Many industries capital intensive limiting entry and exit (can extend duration of boom-bust cycles)	• Much easier because of storage • Generally absent of many network effects; common goods, public goods problems
Natural Gas	• Natural monopoly from owning the pipes requires functional separation • Many of the same regulatory institutions (FERC, states, local), • Similar siting challenges for pipes and transmission	• Much easier because of storage (line pack, seasonal underground) and because flows are controllable
Airlines	• No storage (*i.e.,* can't save a seat for later flights) • High stakes of safety-related reliability that far exceed electric industry • Capital intensive industry, economics driven by capacity factor and volatile fuel prices • Air traffic control has safety and scheduling responsibilities similar to RTO	• Elastic demand • Congestion alleviated through non-price rationing (*i.e.,* flight delays) • More tolerance for imperfect service and low reliability (excluding safety, see left)
Telecommunication	• Many uses demand instant transmission (similar to real-time supply and demand balance) • Service quality requires excess "capacity" similar to reserve margin or resource adequacy (but inadequate supply tolerated much more frequently than 1-in-10)	• Some ability to ration consumption at the user-specific level (if users exceed data or download limits) • Traditionally a natural monopoly on wires to house (same as electric) but no longer true, in part because of newer modes of data transmission (cable, cell network, *etc.*)

III. MISO's Role in Supporting a Well-Functioning Electricity Market

As explained above, markets cannot exist in a vacuum. Instead, they rely on a bedrock of institutions that enable them to function and facilitate the efficient exchange and allocation of goods. MISO is the primary institution responsible for structuring and administering wholesale power markets by providing the legal, technical, and other services required to support a well-functioning electricity market. These services cover a large scope and involve great technical complexity in light of the challenges and potential market failures outlined in Section II above.

In this section, we describe MISO's role in supporting a well-functioning market by: (a) explaining how MISO's role differs from the roles of other entities, such as states and market participants; and (b) outlining the core services that MISO must provide to fulfill that role, which are generally the same services that MISO is already providing. Finally, to guide how to improve MISO's services to better achieve its Market Vision, we then outline principles for *how* to provide these services. These principles should guide future initiatives, particularly in the Focus Areas for Improvement outlined in the Section IV.

A. What Other Entities Can Do Best

Before defining the scope of MISO's role in supporting a well-functioning market, it is important to recognize that some challenges can be effectively addressed by others. Table 3 lists the primary responsibilities of policy makers, individual buyers and sellers, and brokers and OTC Markets, all of whom play an important role in participating in or overseeing well-functioning markets. MISO's role complements theirs, providing core services that only a centralized coordinating entity can provide through its technical capabilities, legal authority, and neutrality with respect to financial interests. However, MISO's role stops short of: (a) making policy decisions, which are under the purview of state and federal policy makers; and (b) making operating or investment decisions, which in the context of a well-functioning market can be better made by individual market participants acting in their own self-interest.

Delineating MISO's role from that of independent brokers and third-party exchanges is somewhat more nuanced, since they all perform market-making and/or administration functions. MISO's special role is to provide market administration services that facilitate the trade of valuable products that are not feasible for third parties to provide or administer. For example, although over-the-counter (OTC) markets can effectively administer relatively simple product markets such as renewable energy credits (RECs) and energy futures, they cannot administer markets such as virtual trades and financial transmission rights (FTRs) that would be prohibitively costly to administer, would require access to confidential information, or are inextricably entwined in other complex functions such as unit commitment and economic dispatch.

While the functions of other entities described below do not directly involve MISO, the platform of services that MISO provides is often essential to facilitate their success. Policy makers such as state commissions and the FERC rely on MISO to support the efficient and effective implementation of their policies in many cases, for example by considering state renewable portfolio standards (RPS) in transmission planning; or, more directly, by responding to and implementing FERC orders.

Market participants rely heavily on MISO to coordinate the grid, define products, and calculate prices. Even OTC markets and brokers who perform market-making services for derivative products rely on MISO's physical markets in terms of product definition and setting the settlement price in the physical spot market.

Table 3
Roles and Responsibilities of Other Entities

Entities	Functions
Policy Makers ***(States and FERC)***	• Setting policy objectives • Administering retail markets and ratemaking • Overseeing integrated resource planning • Statutory responsibility for resource adequacy
Individual Buyers and Sellers ***(Utilities, Merchant Generation, and Competitive Retailers)***	• Identifying lowest-cost supply options • Potentially reflecting end-user preferences • Asset management • Managing supply portfolio and financial risks
Brokers and OTC Markets	• Standardized, high-volume products (RECs, on-peak strips at trading hubs) • Some types of individualized hedges

B. Core MISO Services to Support a Well-Functioning Wholesale Market

The preceding discussion regarding market challenges and roles leads to a set of core services that MISO needs to provide to support a well-functioning wholesale market. Table 4 summarizes the MISO core services that resolve challenges that other entities cannot effectively address and that would otherwise prevent a well-functioning market from materializing.

Table 4
Core MISO Services Required for a Well-Functioning Electric Market

Core Service	Why is MISO Needed?
Scheduling and Dispatch	• Transmission security is a *public good* that private markets would not provide. • Centralized scheduling and dispatch provides large cost savings relative to uncoordinated unit commitment and economic dispatch. • A multitude of inter-area seams inefficiencies, reliability concerns, and loop flow problems would prevail without the coordinated scheduling function of an RTO, causing *externalities* from network effects.
Energy and A/S Price Formation	• It is possible to calculate efficient LMPs only with full system view. • Transparency of energy prices enables market participants to make cost-effective tradeoffs that minimize system-wide production costs. • Ancillary services prices signal private entities to provide least-cost solutions to operational needs.
Market Administration *(e.g. define products, ensure credit, settlements)*	• Administering some aspects of electricity market, especially for nodal and real-time or near-real-time transactions, involves massive complexity, transaction-intensive processes, and interactions with centrally-dispatched physical operations. • Administration by MISO reduces transactions and overhead costs for stakeholders while also enabling consistency with physical operations and reliability requirements.
Complex Hedging Products *(e.g. FTRs, virtuals)*	• Detailed system models and information requirements would be infeasible for brokers or OTC markets, and derivatives of nodal prices would naturally be illiquid. • Due to network effects, a centralized coordinator is needed to ensure simultaneous feasibility.
Market Transparency *(e.g. data, studies)*	• MISO has access to data and information that no other entity has. • Data and studies provide information necessary for investment and operational efficiency.
Monitoring and Mitigation	• In an industry as susceptible to (often temporary and localized) structural market power, market monitoring and mitigation is essential. • Effective monitoring and mitigation depends on transparency in costs, offers, imports/exports that is unavailable in bilateral markets.
Resource Adequacy	• Resource adequacy is a *common good* (non-excludable, rival) with free-rider incentives. • System-wide assessments enable load and supply diversity benefits, reducing total cost. • Transparency can help regulators and other stakeholders make more informed decisions.
Transmission Planning	• To date, no region has developed any mechanisms for relying on merchant transmission investments other than special cases, therefore nearly all transmission projects must be selected through centralized planning by an RTO or other entity. • MISO can achieve large cost savings relative to uncoordinated planning due to its system-wide view of topology, load, supply, and state policies.
Public Policy Support	• MISO can provide technical information that states and FERC need for developing policy. • MISO can address a variety of technical system challenges, *e.g.*, regarding renewables integration.

C. Principles for Improving MISO's Core Services

The following principles reflect our view of the most important guidelines for improving MISO's services, as informed by stakeholder input and our foundational study of well-functioning markets. These principles are consistent with the Principles MISO and stakeholders developed in their Vision Development Process.[12] Slight differences in wording reflect stakeholder preferences but are not substantively material.

- *Principle 1: Strive for highest efficiency, defined as minimizing the operational and investment cost to serve load.* This definition corresponds to the goal of maximizing social welfare, as a perfectly functioning market will do under ideal conditions. This Principal is essentially the same as the Principle in MISO's proposed Market Vision statement to "Support an Economically Efficient Wholesale Market System that Minimizes Cost to Serve Load."
- *Principle 2: Align market requirements with reliability requirements.* This principle recognizes that market planners and operators need to undertake actions to maintain reliability standards, and that these actions can interfere with markets if they are accomplished through out-of-market actions and side-payments. To the extent that reliability requirements can be internalized in the market, providers of reliability services can compete and minimize system costs. This principle was articulated by the independent market monitor (IMM) in discussions about developing MISO's Market Vision. It is essentially the same as MISO's Principle in its proposed Market Vision statement to "Maximize Alignment of Market Requirements with Reliability Requirements of the System."
- *Principle 3: Provide transparent market prices reflective of marginal system cost; allocate out-of-market costs based on cost causation.* A fundamental tenet of well-functioning markets is that prices are transparent and reflective of actual costs. This allows market participants to make efficient decisions to produce or consume depending on whether their costs are above or below the market benchmark. Relatedly, to the extent that costs are incurred outside of markets, they should be allocated based on cost causality so that market participants can economically reduce the activities that drive costs. MISO has included this Principal in its proposed Market Vision statement.
- *Principle 4: Disseminate non-proprietary information on market and system conditions to enable market participants to operate, plan, and transact more cost-effectively.* One of the characteristics of well-functioning markets is that market participants have good and symmetric information. In electric systems, there is much useful information about the system that complements price information, such as congestion patterns, transmission outage schedules, interconnection queue updates, and generation retirement plans. Many of these data are readily available through MISO, but others may be unavailable or may

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12 See MISO (2013c).

require time-consuming data gathering to acquire. Availing all market participants of such information allows them to economically meet system needs without a select few being able to exploit asymmetric information. This Principal is similar to the combination of MISO's proposed Principal, "Support Market Participants in Making Efficient Operational and Investment Decisions" and its Focus Area regarding information (see below). We included the information concept at the principal level because we view information availability as essential to well-functioning markets.

- *Principle 5: Ensure that wholesale markets are competitive through market monitoring and enabling non-discriminatory market participation.* Achieving least-cost competitive outcomes depends on maximizing competition by enabling all resource types to participate in the market. It also requires market monitoring to prevent market power abuse, especially because electricity becomes structurally uncompetitive, for example, when transmission constraints bind or barriers to entry prevent new supply from readily entering the market. This Principal is similar to the one in MISO's proposed Market Vision to "Facilitate Non-discriminatory Market Participation Regardless of Resource Type, Business Model, Sector or Regional Location," but it also acknowledges the importance of market monitoring.

IV. Focus Areas for Improvement in MISO's Markets

We describe here seven Focus Areas for improvement that we identified based on input from stakeholders through a series of Market Vision workshops. The Focus Areas also reflect our review of existing initiatives, IMM recommendations, concepts being pursued in other ISOs, and discussions with MISO staff. Our review of these potential Focus Areas incorporates stakeholder input on a draft set of Focus Areas, and we have adopted MISO's revised set of Focus Areas in this study:

1. Enhance Unit Commitment and Economic Dispatch Processes
2. Maximize Economic Utilization of Existing and Planned Transmission Infrastructure
3. Improve Efficiency of Prices under All Operating Conditions
4. Facilitate Efficient Transactions across Seams with Neighboring Regions
5. Streamline Market Administrative Processes to Reduce Transaction Costs
6. Maximize Availability of Non-Confidential and Non-Competitive Market Information
7. Support Efficient Development of Resources Consistent with Long-term Reliability and/or Public Policy Objectives

Once MISO and stakeholders agree on these or a somewhat revised final set of Focus Areas, they will represent a commitment to make substantial progress in the Market Design over the coming two to five years. These distinct Focus Areas will also be the basis for developing a work plan to pursue these improvements as MISO develops its Roadmap as discussed further in Section V. However, these Focus Areas will not preclude important initiatives that lie outside of the seven areas, especially as market, system, and regulatory needs change.

Below, we outline for each Focus Area: (1) why it is important; (2) the scope of initiatives or concepts to consider pursuing; (3) indicators of value and how MISO could further quantify costs and benefits of specific initiatives where relevant; and (4) our recommendations regarding the next steps for making progress if MISO and stakeholders adopt each Focus Area.

Based on our initial review of value indicators, we find that the Transmission, Seams, and Resource Development Focus Areas are likely to have the highest potential benefits and as such warrant the most attention in the Roadmap. Although the other Focus Areas appear to have somewhat lower potential benefits, we believe that most or all of them may be valuable to adopt as priorities for market enhancement because they are important to stakeholders, or they may have higher benefits than our initial indicators suggest and encompass initiatives with high benefit-cost ratios, or they may be relatively easy to implement. Ultimately, MISO and stakeholders will make the most progress if the Focus Areas include initiatives with the highest potential value, while being sufficiently well-defined and limited in scope such that significant progress will be achievable over the coming two- to five-year Roadmap horizon.

A. Enhance Unit Commitment and Economic Dispatch Processes

Through its Security Constrained Unit Commitment (SCUC) and Security Constrained Economic Dispatch (SCED), MISO minimizes dispatch costs subject to transmission and operational constraints. However, there are a number of opportunities for incremental improvements that are underway or that stakeholders and the IMM have proposed. We list this set of initiatives here to provide an indication of scope, not to rigidly define or limit the options that MISO and stakeholders might consider. Initiatives shown in leading capital letters refer to existing initiatives, with the development status of each existing initiative indicated in parentheses.

- **Enabling more efficient participation of resources with special characteristics.** Stakeholders frequently identified the need to recognize the ability of a combined-cycle plant to operate in different modes. There are also existing initiatives to enhance participation of other types of resources. Existing initiatives or proposals in these areas include:
  - *Combined-Cycle Generation Offer Configurations* to solicit mutually-exclusive offers for each plant to optimize, for example, the number of combustion and steam turbines operating (evaluation).
  - *Demand Response Resource (DRR)* Enhancements with various changes to offer structures further enabling DRRs to provide operating reserves (various stages).
  - *Long-Term Stored Energy Resource Enhancement* so pump-storage can provide operating flex and ramping (evaluation).
  - *External Asynchronous Resource* (EAR) Purchasing from the market so EARs can utilize full import and export capability and provide ancillary services (software design).
  - *Block Schedules* and *Block Load Commitment* to make physical exports and dispatchable load eligible for make-whole payments (evaluation).
  - Re-order emergency procedures to utilize demand response efficiently, per IMM recommendations.
- **Enhancing ramping needs and capabilities**. MISO frequently experiences very large ramping needs, and ramping constraints are responsible for many of MISO's extremes in real-time price volatility.[13] Moreover, these conditions are likely to increase as the penetration of intermittent renewable resources increases and as interchange schedules (with neighboring systems) become allowed to change at 15-minute intervals.[14] Recognizing these concerns, MISO has articulated the need to define ramping needs

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[13] See p. 28, Potomac Economics (2013).

[14] See MISO (2013d).

differently, and to procure ramp capability differently. Existing, proposed, and recommended initiatives include:

- *Ramp Capability Enhancement* to define and procure a ramp product to meet unanticipated needs (conceptual design).
- *Look-ahead Dispatch* across multiple intervals to anticipate ramp constraints (evaluation).
- *Bi-directional Ramp Rate Model* in the day-ahead market and the Reliability Assessment Commitment (RAC) (evaluation).
- *Load Offset Parameter Enhancements* to better manage ramp capability (evaluation).
- *Emergency Ramp Rate* to take advantage of flexibility (software design).
- Consider 15-minute day-ahead market, per IMM recommendation.

- **Other ancillary service market (ASM) initiatives.**
  - *Short-Term Capacity Reserves* to procure generation with 30- or 60-minute startup times to more efficiently respond to sudden forced generator outage or reduction in wind generation or imports (evaluation).
  - *Reserve Procurement Enhancement Phase II* incorporating nodal reserve deployment variables into co-optimized SCED (evaluation).
- **Other commitment and dispatch-related initiatives.**
  - *Stochastic Unit Commitment* to better account for uncertainty (evaluation).
  - Consider further than 24–36 hour look-ahead commitment to better evaluate the commitment of slow-start coal.
  - Identify and remedy units not following dispatch, per IMM recommendation.
  - *Look-ahead Commitment Phase II* to add simultaneous feasibility test to discover new transmission constraints (evaluation).
  - *Voltage Profile and Reactive Power Scheduling with Optimal Power Flow (OPF*) to manage voltage profiles and VAR schedules (evaluation).

This set of opportunities represents a large proportion of all of MISO's potential initiatives and reflects a substantial amount of staff and stakeholder work if they were all to be adopted. However, it is important to recognize that several of these initiatives are alternative solutions to the same problem and so would need to be evaluated in terms of which initiatives are the most cost-beneficial of each subset to pursue.

As an indicator of the potential value in this Focus Area, we note that the maximum benefits from further enhancing SCUC and SCED is likely to be a fraction of the $200 million per year MISO conservatively estimates it has already achieved from centralized unit commitment and dispatch.[15] The improvements listed above will generally affect a smaller subset of units or time intervals, or the relatively small ancillary service markets. Another value indicator is that for an individual initiative MISO estimated $4 to 5 million in annual benefits from introducing up-ramp and down-ramp products.[16] Further, improvements to unit commitment and dispatch may help reduce MISO's revenue sufficiency guarantee (RSG) charges, which were $53 million in 2012.[17] More precise benefit-cost estimates may be possible when evaluating specific initiatives. Overall, it seems that the scale of potential benefits from improving SCUC and SCED in the footprint could be on the order of tens of millions of dollars per year over the next two to five years.

Making substantial progress in this Focus Area will also require a careful examination of timing and sequencing. Because many of the individual initiatives would require changes to the same software, implementation needs to be carefully sequenced and grouped. Finally, many of the proposed enhancements could increase the computational intensity of SCUC and SCED, which may necessitate upgrading MISO's computational power and related information technology.

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15 See categories 2, 3, and 4, and MISO's Value Proposition MISO (2013). MISO's savings estimate is likely to be conservative because it does not fully account for outages and extreme conditions that would tend to increase the value of centralized unit commitment and dispatch.

16 See MISO (2013d).

17 Note that some amount of the RSG charges is unavoidable since it is not possible to determine a set of prices that is always consistent with optimal commitment and dispatch; however, lower RSG charges generally indicate improved pricing and improved efficiency.

Table 5

Recommended Next Steps for Unit Commitment and Economic Dispatch
1. Develop an exhaustive list of potential SCED and SCUC initiatives. 2. Categorize initiatives according to the underlying problem they solve so that alternative solutions to the same or closely-related problems can be grouped together. 3. Categorize initiatives as "major" or "minor," with major initiatives involving more cost or implementation complexity and risk. Major initiatives may need to be individually sequenced (while multiple minor initiatives can be rolled out at once). 4. Estimate potential benefits by conducting simulation analyses of historical market data. Due to the large number of initiatives under consideration, this study may need to rely on simplified analyses that provide an order of magnitude rather than a highly precise estimate. 5. Estimate the potential costs for each initiative, again focusing on the order of magnitude rather than great accuracy. Most costs may be estimated roughly using analogy to recent initiatives of a similar magnitude and scope. 6. Based on a report of these costs, benefits, and sequencing alternatives, develop a plan for pursuing the greatest net benefits achievable over the next two to five years by: (a) selecting the best solution to each underlying problem; and (b) sequencing major initiatives in order of their greatest net benefits.

B. Maximize Economic Utilization of Existing and Planned Transmission Infrastructure

One of MISO's most important functions is to minimize the cost of serving load subject to transmission constraints, as optimized in SCUC and SCED. However, some stakeholders have explained that many transmission constraints could be safely relaxed to increase the utilization of the transmission system and provide substantially more economic value. With several cutting-edge transmission management techniques, it is possible to reduce congestion costs with little or no incremental investment in the physical transmission infrastructure. Three of the most promising approaches that are under review or implementation in other RTOs include: (1) topology control algorithms; (2) dynamic and adaptive transmission ratings; and (3) utilizing advanced transmission technologies.

- **Topology Control Algorithms (TCAs)** can minimize the cost of protecting transmission facilities by opening circuits when doing so is more economic than re-dispatching generation. This opportunity arises when there are system redundancies in which only a few facilities limit the desired transfers, leaving other transmission paths underutilized. For example, if there are lower voltage lines in parallel with higher voltage lines, it is usually the case that the lower voltage facilities limit flows and prevent higher utilization of the higher voltage facilities. In these cases, opening the lower voltage branches, will reduce overall congestion and production costs. Topology control is effective for relieving both pre and post-contingency constraints. If the constraint to be relieved is a post-contingency constraint, topology changes may be implemented either pre- or post-contingency (*i.e.*, preventively or correctively), depending on the system operator criteria. Although system operators already open circuits for reliability reasons, such as through operating guides or special protection schemes, we are aware of only one system operator changing topology for economic reasons.[18] New algorithms and computational power make it possible to systematically identify breakers that would be beneficial to open or close to optimize power flow and reduce total costs.[19]

- **Dynamic and Adaptive Transmission Ratings** involve safely adjusting transmission facility limits based on actual system and ambient conditions, rather than based on static limits that conservatively assume worst- or near-worst-case conditions.
  - *Adaptive Post-Contingency Line Ratings* revise contingency ratings implemented in SCED so they are consistent with system conditions. Whereas current post-contingency limits are typically set such that the line would not overheat after a static, pre-specified number of hours at the limit (*e.g.*, 4 hours), actual system conditions may allow faster re-dispatch to unload the line back to its normal continuous rating should the contingency occur. If, for example, a line could be unloaded in 15 minutes after a contingency, it could safely transmit more power for those 15 minutes than it could for 2 hours, before the thermal reservoir of the line reached its critical sagging temperature. The increase in the limit can be very significant, often exceeding 20% of the static limit.[20] With higher post-contingency limits, the system can accommodated more flow, including under pre-contingency conditions. For example, ISO-NE found an average increase of 11.7% in the capacity of binding real-time constraints.[21] And yet raising the post-contingency limit does not cause significant wear-and-tear on the lines, since their pre-contingency flows would still be below their normal ratings. Higher loadings would occur only very rarely and briefly, after a contingency occurs.
  - *Dynamic Transmission Ratings* involve adjusting limits based on ambient conditions, most importantly temperature and wind speed, which affect how

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18 See PJM (2014).

19 For example, DOE ARPA-E is funding the development of such tools in a project with PJM, Boston University, and members of The Brattle Group. Project: Transmission Topology Control for Infrastructure Resilience to the Integration of Renewable Generation, Award number DE-AR0000223, Program: GENI - Green Electricity Network Integration, http://arpa-e.energy.gov/.

20 The estimate is provided for illustration purposes only, and is based on the ratio (short-term emergency limits)/(long-term emergency limits) for a wide collection of branches with different such limits using data included in the MMWG power flows.

21 See Maslennikov (2012).

quickly a line heats to its sagging point. Knowing the limit specific to each ambient condition can enable dynamic limits that allow more flow under most conditions and less flow (with greater reliability) under extreme conditions. Dynamic ratings relieve both normal and post-contingency limits and are especially useful in wind-rich areas, where usually the thermal ratings of overhead lines would increase under high wind output conditions due to the additional cooling brought by wind. The application of dynamic ratings is fully enabled by sensor deployment, although new sensors are usually not a requisite for more basic applications. As a reference point, the use of dynamic ratings by Oncor (in ERCOT) led to average increased transmission ratings of 6–14% in 345 kV facilities.[22] During some high-temperature hours, the dynamic ratings were lower than the used static ratings, as apparently the real-time temperature was above the based temperature of 104°F. Using dynamic ratings under such extreme conditions increases system reliability.

- **Utilizing Advanced Technologies**. Several types of transmission devices are controllable and could be "dispatched" to help minimize the cost to serve load. These devices include High-Voltage Direct Current (HVDC) lines, Phase Angle Regulators (PARs), Variable Frequency Transformers (VFT), and Flexible Alternating Current Transmission Solutions (FACTS). Taking full advantage of these devices entails the active management of existing flow-control facilities (to the extent possible) in coordination with SCED and SCUC decisions to enable the most economically efficient dispatch. Planning and placement of new facilities in strategic locations can further the benefits of these special equipment technologies. New equipment includes the deployment and use of phasor measurement units (PMU), which allow a more precise determination of non-thermal transfer limits (voltage or stability-driven limits), valuable in areas prone to such limitations.

The value of this Focus Area is likely one of the greatest among all areas. One indicator that the value is likely to be very large comes from the current ARPA-E Topology Control Algorithms project with PJM, which estimates that TCA could have eliminated more than half of all real-time market congestion in 2010, reducing production costs by over $100 million per year. Another indicator is that MISO evaluated savings from eliminating all constraints to be worth about $180 million in 2028 and 86% of congestion cost was contingencies, which could be substantially reduced by adaptive and dynamic ratings.

The cost of these opportunities will depend partly on how difficult it is to gather data on system and ambient conditions. MISO already has the system data it would need to calculate re-dispatch times for establishing adaptive ratings, including the operating status and ramp rates of generators. Measuring ambient conditions precisely and locationally may require new devices,

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22 See Oncor (2013).

although less precise measurement may be possible using existing weather stations (using such data would necessitate more conservative calculations to account for error).

Pursuing this innovative Focus Area could be motivated by further assessment, including: reviewing other regions' experience and studies; characterizing where and why congestion occurs in MISO; conducting MISO-specific benefit-cost analyses; and considering the development of trials. Once the value of specific opportunities are demonstrated, MISO will have to work with Transmission Owners (TOs) to establish if and how MISO would be allowed to adjust or propose adjustments to line ratings, transmission topology, and flow-control equipment settings, given that these are the responsibility of the TOs. TOs will clearly need to be assured that new techniques would not degrade their facilities and that reliability would not be compromised.

Table 6

Recommended Next Steps for Efficient Transmission Utilization
1. Similar to Focus Area 1 above, create a detailed list of possible initiatives beginning with the options we describe here and adding others identified by stakeholders, the IMM, or MISO staff. The list of initiatives should be informed by an understanding of where and why congestion occurs on the MISO system, and by a review of other regions' experience and studies. 2. Conduct a benefit-cost analysis of each of the possible initiatives and use the results to prioritize and sequence these initiatives, considering interdependencies and relative value compared to other Focus Areas if relevant. 3. For promising initiatives, explore feasibility with transmission owners (TOs); considering the already-defined roles and responsibilities of MISO vs. TOs. 4. Develop a plan for pursuing feasible initiatives with the greatest net benefits achievable over the next two to five years. For this cutting-edge focus area, the plan might include developing small-scale trials to test the mechanics and ensure reliability is not compromised.

C. Improve Efficiency of Prices Under all Operating Conditions

This Visioning process rightly defined as one of its core Principles, "Provide transparent market prices reflective of marginal system cost; any out-of-market costs should be allocated based on cost causation." MISO has made great progress in this through its LMP pricing and scarcity pricing reforms following FERC Order 719, and its eLMP initiative, among other initiatives. It is worth noting that improvements in pricing efficiency can only be taken to a certain point, as it is not possible to develop a set of perfectly efficient prices that are totally consistent with perfectly optimized unit commitment and economic dispatch at all times.[23]

Nevertheless, stakeholders, MISO, and the IMM have identified several areas for improvement, including:

- Refine *scarcity pricing*, including: (a) revising SCED to EDR/LMR/BTMG and emergency imports to set prices when deployed, and imposing scarcity price floors during emergencies; (b) developing administrative estimates of the marginal system costs imposed by out-of-market actions such as enduring reserves shortages or implementing voltage reductions; and (c) revising the order of emergency procedures according to their marginal system costs.
- Enhance *eLMP*, for example, by extending to multiple intervals and expand eligible resources.
- Improve *make-whole payments*: cost allocation refinements, change PVMWP eligibility, 5-min settlement, eliminate make whole for contingency reserve deployments, all per IMM recommendations.
- *Improve interface pricing* with respect to PARs and the definition of external interfaces; eliminate excess payments and charges to physical transactions that affect external constraints.
- Price supplemental reserves more accurately by accounting for quick-start units while starting, per the IMM's recommendation.
- Introduce a virtual spread product, which the IMM recommended and MISO is already evaluating.

We have not quantified the value of these initiatives, but some will likely vary with market conditions. In particular, the most valuable initiatives will be those that either result in small improvements across the vast majority of hours (*i.e.*, underlying issues that drive RSG charges) or else those that result in large improvements in a small number of emergency or scarcity hours. For example, scarcity pricing becomes more important as reserve margins tighten. If, for instance, there were 10 scarcity hours per year with 1,000 MW of emergency actions each time, and if pricing enhancements enabled a more efficient dispatch with a $1,000/MWh production cost improvement (*e.g.*, getting the right dispatch of PRD vs. depleting operating reserves), the annual benefit would be $10 million. MISO and stakeholders would have to evaluate specific initiatives in more detail to estimate the benefits.

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23 This is because of the discontinuous nature of the optimization problem after considering commitment costs and multi-period intervals. Although some pricing approaches, like convex hull pricing, perform better than others, no approach can produce perfect results under all circumstances. For example, see Gribik, *et al.* (2007).

Special considerations for pursuing this focus area include interactions with the Commitment and Dispatch Focus Area. Both may involve upgrades to the same set of software.

Table 7

Recommended Next Steps for Price Efficiency
1. Lay the groundwork for identifying promising initiatives by: a. Conducting a review of RSG charges, categorizing these charges according to the underlying causes, and identifying initiatives that would address these causes; b. Documenting options for better-integrating demand response into day-ahead and real-time price-setting; and c. Reviewing MISO's emergency procedures and scarcity pricing provisions to determine if emergency procedures are implemented in order of ascending cost, and relatedly evaluating how well MISO's administrative pricing mechanisms during shortage conditions reflect those marginal system costs. 2. Informed by the information in step 1, develop a comprehensive list of potential initiatives. 3. Evaluate the benefits and costs of each potential initiative, again focusing on the order of magnitude rather than great accuracy, as in Focus Area 1. 4. Based on a report of these costs, benefits, and sequencing alternatives, develop a plan for pursuing the greatest net benefits achievable over the next two to five years.

D. Facilitate Efficient Transactions across Seams with Neighboring Regions

Managing institutional seams that cut across an interconnected grid is inherently challenging. Without a unified unit commitment and dispatch, neighboring systems have to find ways to exchange information and facilitate efficient transactions as if the systems were unified, *i.e.*, enabling utilization of the lowest-cost resources while respecting transmission constraints and operational constraints. Although MISO has already made much progress in managing its seams, particularly with PJM, many stakeholders expressed strong views that there remains room for substantial improvement along all of its seams.

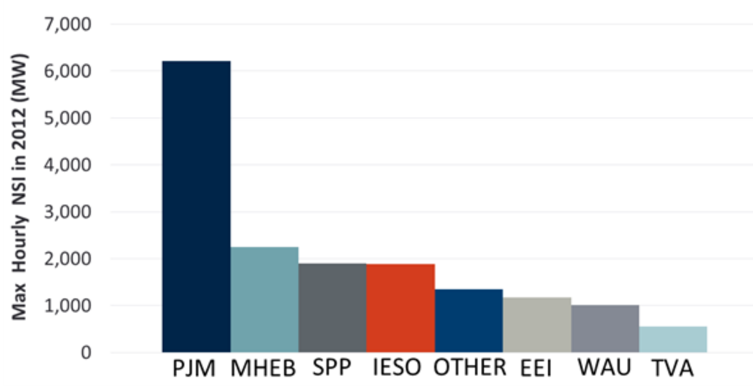
The name for this Focus Area seems to emphasize *scheduled* flows, but seams management also encompasses unscheduled flows or "loop flows." Indeed, stakeholders and the IMM identified a number of initiatives that address both types of flows, including:

- Optimize real-time interchange with PJM and facilitate the alignment of intra-hour schedules. (Some stakeholders even suggested ambitious initiatives for optimizing interchange, such as having PJM and MISO combine their commitment, dispatch, and pricing algorithms, but there are likely more practical ways to improve interchange.)

- Improve market-to-market congestion management with PJM, including by extending to the day-ahead market the kind of re-allocation of flowgate shares currently practiced in the real-time market-to-market congestion management process.
- Implement the market-to-market seams management practices developed for the MISO-PJM seam to the MISO-SPP seam.
- Explore opportunities to apply MISO-PJM best practices to other seams.
- Improve how TLR relief obligations are determined and how the constraints are modeled in the real-time market, per the IMM's recommendation.[24]
- Clearly define cross-border capacity transfer capabilities into and out of MISO, establish mechanisms for more efficiently allocating such capability, and clarify obligations for resources selling capacity across RTOs.
- Promote cross-border planning of economic transmission to improve economic efficiency (although transmission planning is outside the scope of "market development").

A MISO-PJM joint study estimated $28–128 million of annual savings from optimizing interchange between MISO and PJM.[25] If other MISO seams had similar savings potential per MW of ties, the total potential could be three times larger. Figure 2 below shows the maximum hourly net scheduled interchange on each seam in 2012 as an indicator of the amount of relative interchange potential. It is conceivable that the potential in non-PJM seams could be even larger per MW since coordination is currently less developed, although the actual potential will depend on many factors.

Figure 2
Maximum Hourly Net Scheduled Interchange in 2012, by Neighbor



Source: Maximum hourly Real-time Net Scheduled Interchange in 2012 from MISO Hourly Historical Real-time NSI report posted at: https://www.misoenergy.org/Library/Repository/Market%20Reports/2012_sr_hist_is.csv

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24 See Potomac Economics (2013).

25 See MISO (2013e).

The value from better managing loop flows may be similarly large. One indicator is the enormous difference between congestion revenue and congestion costs, which were $778 million (for day-ahead congestion revenue) and $1.30 billion respectively.[26] That difference indicates an enormous amount of costly loop flow on MISO's system that could be more efficiently managed through market-to-market mechanisms such as MISO and PJM's (part of the difference is simply PJM's entitlements on reciprocal coordinated flowgates located on the MISO system).

The key challenge in pursuing this rich Focus Area is that most improvement will require close coordination with seams partners who will have their own interests, priorities, market structures, and timelines. At the very least, progress will be slow in most cases. Where joint implementation is not feasible, MISO and stakeholders should identify beneficial unilateral measures.

Furthermore, full integration of software systems is not practical. MISO and stakeholders should work with seams partners to identify creative solutions that achieve most of the benefits.

Table 8

Recommended Next Steps for Seams Efficiency
1. Develop a list of potential initiatives, then present to the MISO Seams Management Working Group. 2. Assess the potential difficulty of engaging neighbors, recognizing the different stages of development of neighbors' markets and of institutions for addressing seams. 3. Where full joint implementation is not feasible, identify beneficial measures that require less coordination. 4. Analyze the costs and benefits of each feasible initiative. 5. Select initiatives for inclusion in the Roadmap.

E. Streamline Market Administrative Processes to Reduce Transaction Costs

Several stakeholders mentioned that some market processes are too complex and impose substantial staffing and overhead costs onto market participants. We have not heard many specifics, but one that several mentioned was registration processes, *e.g.*, when changing the names of commercial nodes, when retail choice load switches, when a load zone configuration changes, and when assets change ownership. Another area identified by multiple stakeholders is

[26] See p. 46, MISO (2012).

the generator interconnection process, although we did not hear what specifically could be improved.

Other "market processes" were identified in generic terms. This Focus Area is not likely to produce net benefits that are large in monetary terms. If MISO and stakeholders decide to evaluate specific process changes, they could estimate the number of person-hours that would be saved. It is possible that the benefits would be greater if they facilitate increased participation in MISO's markets.

A special consideration for pursuing this Focus Area is that stakeholders would have to identify improvement opportunities more specifically than they have in this Visioning process. If there are specific elements that MISO could improve at minimal cost, it may be well worth the stakeholder good will. Making progress in this Focus Area, as well as the following Focus Area on market transparency, may require a somewhat different overall approach compared to the other Focus Areas because: (a) there are likely to be a large number of small initiatives; (b) the initiatives may have small or difficult-to-quantify net benefits; (c) many of the initiatives would not be controversial but are likely to have idiosyncratic value to only a small number of market participants; and (d) the lower stakes of any one initiative might result in a lack of stakeholder interest and participation, and may not justify a large amount of general stakeholder time to review and pursue. In any case, it seems that the first step is to maintain a comprehensive list of requested initiatives, but we also propose three alternative (but not mutually-exclusive) approaches for prioritizing the pursuit of these possible initiatives given the unique nature of this Focus Area.

Table 9

Recommended Next Steps for Streamlining Market Processes
1. In combination with the Market Transparency Focus Area below, gather and maintain a detailed list of individual market participant requests for improving market processes, perhaps in a dedicated website location or through email-based communication that can be monitored by stakeholders without substantial in-person meeting time.
2. Consider introducing a voting or scoring mechanism designed to provide an indication of how important and valuable market participants consider each initiative, as well as to identify issues that have substantial disagreement and therefore should not be pursued without a broader stakeholder discussion.
3. Consider making an ***a priori*** decision regarding the total bandwidth of MISO staff time or vendor fees that is to be devoted to this Focus Area, and then developing a triage system for prioritizing initiatives within those budget and staffing constraints. For example, if two full-time employees are to be devoted, then initiatives would be ranked higher if performing better on stakeholder scores but ranked lower if they would incur higher person-months to implement.
4. Consider creating a path for pursuing initiatives that do not face general stakeholder opposition but that are idiosyncratically valuable to only one or a few stakeholders, for example, by having MISO estimate the cost of pursuing the initiative and moving forward only if one or several stakeholders are willing to independently fund the initiative. If there are many studies or initiatives that would be funded under this approach it may result in MISO expanding its staffing capabilities to support a greater level of services of this sort.

F. Maximize Availability of Non-Confidential and Non-Competitive Market Information

Stakeholders did not mention many specifics, but this Focus Area could include market data, system data, and studies addressing particular questions (some of which may overlap with the next Focus Area regarding informing efficient Resource Development). The goal would be to fulfill Principle 4 noted above, to "Provide non-proprietary information on market and system conditions that will enable market participants to operate, plan, and transact more cost-effectively."

Absent specific ideas at this time, it is difficult to assess the cost or benefits of better information. It is also unclear whether providing information is very costly, but if it is, MISO could attempt to estimate benefits. They may be able to assess relative value based on the size of the market affected and how much it is affected.

Table 10

Recommended Next Steps for Information Transparency
1. Combine this Focus Area with the administrative processes Focus Area above, and address both using the same approach to documenting and prioritizing possible initiatives.

G. SUPPORT EFFICIENT DEVELOPMENT OF RESOURCES CONSISTENT WITH LONG-TERM RELIABILITY AND/OR PUBLIC POLICY OBJECTIVES

We view this Focus Area as spanning at least two distinct areas, which we call: "Support Efficient Development of Renewable Resources," and "Inform and Support Efficient Decisions for Resource Adequacy." Each of these is described below.

1. Support Efficient Development of Renewable Resources

A large number of wind generation resources and supporting transmission infrastructure have been built in recent years and will continue to be built over the coming decade, representing billions of dollars in stakeholder investments. Introducing so much of this unconventional resource poses new kinds of challenges, from transmission planning to operations. Transmission planning is different from conventional generation partly because so much of the resource tends to co-locate where the good wind resources are; and because their intermittency prevents them from having the incentive to build enough transmission upgrades to gain capacity injection rights at their nameplate capacity. As such, wind generation faces much congestion, low LMPs, and curtailment risk. Sometimes the property rights around energy injection rights are unclear. These complications have implications for generation owners, contractual counterparties, and other grid users who are affected by the congestion.

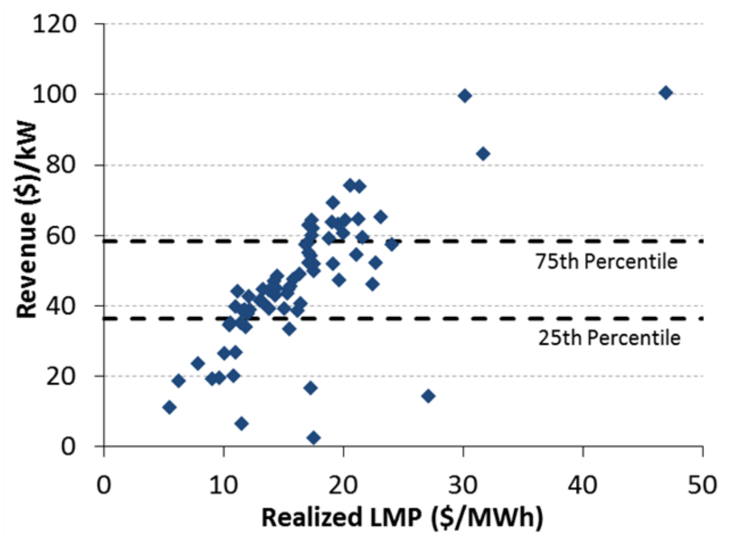
The objective of this Focus Area would be to enable MISO stakeholders to make informed investment and contracting decisions. Possible initiatives include:

- Providing more information on potential congestion and curtailments by location, accounting for effects of planned Multi-Value Transmission Projects.
- Further analyzing renewables' impacts on operating reserve needs, grid instability, voltage support.
- Developing ways to provide more clarity about property rights surrounding energy injection rights.

The diversity of existing plant performance suggests that this Focus Area could generate a very large amount of value. Figure 3 shows that existing plants' revenues per kW vary by more than a factor of four, and the primary driver is their location on their annual average LMP (the relationship to capacity factor turns out to be much weaker). This suggests that transmission is the largest factor differentiating projects.

Better information could help wind developers move to better locations with less congestion and curtailment risk. For example, if the next 3,000 MW developed is located at sites like the current 75th percentile instead of the 25th (a difference of more than $20/kW-year), the value created would exceed $60 million per year.

Figure 3
MISO Wind Plant Revenues vs. LMP



Sources and Notes:
Created from data provided by MISO.

Table 11

Recommended Next Steps for Renewables Development
1. Develop a list of initiatives to consider.
2. Analyze costs and benefits.
3. Consider including the highest-value initiatives in the Roadmap.

2. Inform and Support Efficient Decisions for Resource Adequacy

MISO and its regulators, members, and stakeholders face several challenges in the coming years relating to reliability, largely due to a large number of simultaneous retire, retrofit, and new build decisions being made in response to low gas prices, the EPA's Mercury and Air Toxics Standard (MATS), and other proposed environmental regulations. MISO's Module E aims to ensure resource adequacy at the footprint-wide and zonal levels.

However, Module E operates only on a year-by-year basis, so one concern is whether capacity needs will be signaled soon enough to accommodate the lead time for developing new resources. This is primarily a problem in retail choice states, such as Illinois, that are currently able to rely on system-wide supply excesses to meet load growth, but that will eventually need merchant investors to build power plants to meet their resource adequacy needs. Those independent power producers (IPPs) will only build new supply if they expect energy and capacity prices to be high enough to recover their capital investments. They would need to expect capacity prices at the net cost of new entry (CONE) over the life of a plant.

The current MISO Module E design is not likely to produce such prices, however, because: (a) the non-forward market combined with a vertical demand curve is likely to produce bi-modal prices near zero in most years (as has always been the case historically) and at the cap in the infrequent years where there is a supply shortage; (b) the price cap is set relatively low at Gross CONE, so prices would need to be at the cap most of the time in order to settle out at Net CONE on average and thereby attract merchant investments[27]; and (c) each year at the price cap would correspond to insufficient supply on a footprint-wide basis, with the required frequency price cap events resulting in an unacceptably low level of reliability on a system-wide basis that would likely lead to administrative intervention.

Planning processes and Integrated Resource Plans (IRPs) developed under regulatory oversight provide longer-term views, at least of their own systems. Utilities in traditionally-regulated states would be unlikely to run short of supply and are likely always to build sufficient supplies to meet their own resource adequacy needs. In other words, traditionally-regulated utilities, which represent the large majority of the footprint, are not facing the same type of resource adequacy challenge as retail choice states and therefore do not see a need to introduce any changes to Module E that would interfere with their existing planning processes. However, those traditionally-regulated utilities will not wish to indefinitely build excess capacity beyond their own needs, sufficient to meet the resource adequacy needs of neighboring retail choice states. Therefore, a lack of investment to meet the resource adequacy needs of retail choice states could ultimately result in lower reserve margins, lower reliability, and higher energy prices on a footprint-wide basis unless some revisions are made to Module E.

As a more immediate economic challenge for traditionally-regulated states, the longer-term views of individual planning entities can be inconsistent across the MISO footprint and there is no formal mechanism for coordinating current processes. This lack of coordination and relatively short-term price signals available through Module E may not adequately support efficient investment decisions for longer-term reliability needs. This may result in some plants being uneconomically retired in some parts of the footprint, while higher-cost plants are upgraded or newly built in other locations. Having a more transparent, forward-looking indicator of prices across the footprint would assist integrated utilities as well as state commissions in determining which incremental investments are the most cost-effective, and in which cases it may be more advantageous to procure some supplies bilaterally or through a centralized exchange.

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27 For example, if Net CONE were 75% of CONE and capacity prices were truly bi-modal at zero or the cap, prices would have to reach CONE three times as often as zero.

In light of these challenges, MISO and stakeholders have discussed various ideas to increase forward transparency, including their recently-completed survey of load-serving entities. The IMM has also recommended evaluating a sloped demand curve.[28]

One indicator of the value of this Focus sub-Area is the declining reserve margin and the possibility of shortages that could be mitigated by increased information and signals. Another indicator is that new capacity is expensive, so increased efficiency with better information can provide a lot of economic value. Even state PUCs and utilities could benefit from more transparent market information when making decisions to retire, retrofit, build, or contract for capacity. For example, if better transparency enabled more efficient decisions than uncoordinated IRP and reduced excess capacity by 1% on average over the long term, costs could be reduced by \$60 million per year (*i.e.*, 1% × about 100 GW × about \$60/kW-year Net Cost of New Entry).[29] Another example is if the next 3,000 MW of coal capacity facing retrofit vs. retire decisions could save \$30 million if better information led to a \$10/kW-year more economic decision.[30]

One special consideration for pursuing this Focus sub-Area is its controversy and the inherent challenge of reconciling fundamentally different regulatory and business models within one RTO market. Independent power producers have argued for a centralized forward capacity market with a demand curve, an approach that would be better-suited to accommodating the merchant investments necessary to sustain resource adequacy in a retail choice environment.

On the other hand, the majority of stakeholders and MISO states are in vertically integrated regions that rely on integrated regulated planning and so do not face the same merchant investment challenge. Many state commissions and utilities relying on traditional planning approaches are opposed to implementing changes to Module E that would interfere with their traditional approaches to investment and bilateral contracting decisions. Past discussions related to capacity markets in MISO have been so divisive that they impeded constructive progress and may have temporarily corroded the collaborative stakeholder culture.

We are hopeful that future discussions can be productive while serving both sets of interests. We believe MISO and stakeholders should consider a middle path, for example by creating a forward market that is mandatory only for retail choice loads and voluntary for all others. Doing

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28 See Potomac Economics (2013).

29 See MISO (2012).

30 A \$10/kW-year improvement is conceivable in a market where capacity value could vary from \$0 (recent prices) to \$80/kW-year (the Cost of New Entry), and retrofit costs could be tens of dollars per kW-year. For example, a 600 MW unit that needs ACI, DSI and ESP upgrade, total CapEx is about \$160/kW (\$40 for DSI, \$20 for ACI, and \$100 for ESP upgrade). This would be equivalent to \$24/kW-year at 15% capital charge rate. FOM adder from ACI and DSI would be small at about \$4/kW-year, so the total annual cost of CapEx and FOM would be about \$28/kW-year. ESP upgrade cost for "Level 3 upgrades" from EPA (2011); DSI and ACI costs from EEI (2011).

so would not impinge on traditional planning, and it could provide a stronger signal for new supply when needed to meet load that does not plan for its own reserves. This will be particularly important as MISO's reserve margin dwindles, and without it the system could fall short.[31] We advise considering this approach, and a few other middle-path options for partly mitigating the above concerns, if MISO and stakeholders are to make significant progress on resource adequacy over the next two to five years.

Table 12

Recommended Next Steps for Resource Adequacy
1. Through the Supply Adequacy Working Group (SAWG), MISO could initiate a dialogue around finding practical solutions to meeting the needs of both types of MISO members: those that rely on traditional planning and those that are more dependent on the market. The discussion should include new ideas that are not so polarizing, such as: a. To increase forward liquidity and price transparency, consider introducing a standardized zonal capacity product for forward planning years that would be voluntarily traded by market participants bilaterally, through an over-the-counter exchange, or in voluntary forward capacity auctions. b. To address the merchant investment challenge in retail choice states, consider implementing a forward auction for the mandatory procurement of capacity on behalf of retail choice loads, with the auction enabling purely voluntary participation for suppliers and utilities that conduct planning. 2. These discussions should produce a set of initiatives to be evaluated for inclusion in the Roadmap.

31 See MISO-OMS (2013), the results of a MISO-OMS survey of load serving entities on their resource adequacy outlooks.

V. Roadmap Process

After finalizing its Vision, MISO and stakeholders will create a Roadmap for market development, aiming to finalize the Roadmap in May or June of 2014. The Roadmap will be a coherent two- to five-year plan for implementing specific initiatives that most effectively serve MISO's Market Vision. In the years that follow, as market, system, and regulatory conditions change, the Roadmap will be revised as necessary (also informed by periodic review of the success and challenges with the Roadmap to date).

This section offers ideas for structuring the Roadmap development process over the next several months. We recommend organizing around Focus Areas, possibly combining areas with strong interdependencies, such as the Commitment and Dispatch Focus Area and the Pricing Focus Area. For each Area(s), MISO should consider designating a leader who can coordinate MISO resources and work with the appropriate stakeholder working group to introduce, evaluate, and prioritize initiatives within each Focus Area. Next, a single MISO-led team involving stakeholders could incorporate all Focus Areas' priorities into a coherent Roadmap. This second process would involve prioritization of all initiatives across all Focus Areas, recognizing interdependencies. Undoubtedly, both processes would face stakeholders' conflicting interests, and both would be constrained by MISO and stakeholders' limited time and resources.

A. Prioritization within Focus Areas

MISO and stakeholders may consider the following steps toward developing priorities within each Focus Area: (1) designating a MISO leader and appropriate stakeholder working group; (2) establishing criteria they will use to select initiatives; (3) identifying specific initiatives to consider; (4) conducting a high-level evaluation of each initiative against those criteria; (5) conducting more detailed benefit-cost analysis for the initiatives that appear to have large benefits but also substantial costs; (6) redesigning initiatives as needed to avoid unnecessary complexity while gaining most of the benefits; (7) producing a priority list for use in developing a Roadmap.

Table 13

Recommended Next Steps for Developing Priorities in Each Focus Area
1. Designate a leader and appropriate stakeholder working group to address each Area
2. Establish criteria to select initiatives
3. Identify specific initiatives to consider
4. Conduct high-level benefit-cost analyses
5. Conduct detailed benefit-cost analyses for large initiatives
6. Refine initiatives
7. Prioritize initiatives for Roadmap

When designating stakeholder groups to pursue each Focus Area, one consideration will be how to make use of pre-existing stakeholder working groups. Maintaining continuity of expertise and efforts will likely make the Roadmap process more successful. It will also be helpful to consider interdependencies among Focus Areas and perhaps assign a single sub-group to address those that are closely related. However, for the Focus Areas with more ambitious agendas, it may be necessary to agree at the outset on how much time members and MISO staff can spend over the next several months.

One of the first questions to address is the criteria for selecting and prioritizing initiatives. Perhaps criteria should be common to all Focus Areas. Criteria that would make sense and that are consistent with stakeholder input include prioritizing initiatives that:

- Fulfill legal or contractual obligations that are necessary for reliability;
- Achieve the greatest net benefits or otherwise serve the Vision in ways that are clearly valuable even if unquantifiable;
- Avoid excessive implementation complexity (see section below on seeking easier alternatives);
- Avoid stakeholder controversy if possible, although many times this is unavoidable; and
- Consider interdependencies of initiatives and design appropriate grouping and sequencing.

Next, each Focus Area team would have to define the set of initiatives to consider. This document provides a starting point based on stakeholder issues list, IMM recommendations, and FERC Orders, but MISO and stakeholders would need to comprehensively specify the initiatives to consider.

A high-level evaluation could score each initiative against the criteria listed above. Benefits can be assessed using high-level value indicators, similar to those presented in this report, saving detailed benefit-cost analysis for subsequent steps. Costs are always difficult to assess, but a realistic range might be estimated by benchmarking against past initiatives of similar substance and complexity. The other criteria can be assessed more qualitatively to complete an initial scoring matrix.

Smaller or less costly initiatives may require minimal further analysis for stakeholders to have sufficient information to proceed. Initiatives with substantial costs may warrant more detailed benefit-cost analysis and more exhaustive design refinement to capture most of the benefits with less cost, complexity, and controversy. For such major initiatives, MISO staff could conduct detailed benefit-cost analysis with stakeholder input. Some initiatives are amenable to evaluation using the tools MISO already employs for its evaluation of its Value Proposition and for transmission planning. Others will require creative analysis of data. Consistent with the Principles and MISO's past analyses, the primary benefit metric would be the initiative's impact on total system cost, including production costs, investment costs, and any other quantifiable benefits. Where benefits are not fully quantifiable, MISO may still be able to provide informative data or indicators. Regarding costs, MISO could further refine its estimates from the high-level benchmarking noted above; stakeholders could provide input into how initiatives would impact their own operating or investment costs.

Where either the high-level evaluation or the more detailed analysis indicate high benefits but potentially high costs, complexity, or controversy, the Focus Area team could attempt to redesign the initiative. It may be possible to identify smaller, easier ways to achieve the same ends or most of the benefits. For example, there may be much more practical ways to improve the MISO-PJM interchange than trying to merge both RTOs' commitment and dispatch software.

The final step for each sub-group would be to prioritize initiatives (within each Focus Area) according to the agreed-upon evaluation criteria. Prioritization will also have to consider sequencing and grouping due to interactions among initiatives; for example, where two initiatives involve modifying the same software.

Inevitably, tradeoffs will arise, with some initiatives having higher net benefits but greater complexity. And many initiatives will be controversial, some that strongly affect a minority of stakeholders. We heard from many stakeholders that in controversial situations, the greatest weight should be placed on the net benefits criterion, with MISO leading to "do the right thing" in service of the Vision. Others, however, said that differences should be resolved by majority vote. MISO and stakeholders will have to decide how to resolve such situations, whether in general or on a case-by-case basis.

Final prioritization should be presented in a document specifying not only a priority order but also the following information for each selected initiative: a description, benefit-cost information, timing, interactions, and metrics or methods for tracking progress in the future. Such a document will be invaluable in the next stage, translating Focus Area priorities into a coherent Roadmap.

B. TRANSLATING FOCUS AREA PRIORITIES INTO A COHERENT ROADMAP

MISO and stakeholders may consider the following steps toward translating the various Focus Areas' priorities into a coherent Roadmap: (1) determining the decision-making organization and leadership; (2) prioritizing, sequencing, and grouping initiatives among all Focus Areas; and (3) producing a Roadmap document. We expect that the most effective forum for developing the Roadmap would be the Market Subcommittee, with MISO leading the effort and incorporating stakeholder input.

The Roadmap must prioritize more comprehensively than within Focus Areas because of limited total resourcese within MISO and among stakeholder. After all, even if the Roadmap provides more coherence than market development efforts in the past, there is only so much that can practically be accomplished in two to five years. Priorities will ultimately be determined by MISO and stakeholder judgment, but should be informed by evaluation criteria similar to those used within Focus Areas. Top priority should be given to initiatives with the highest net benefits and that strongly serve the Vision, and that are easiest to accomplish. It will also be important to sequence and group initiatives where necessary to efficiently address interdependencies that may not have been identified within Focus Areas.

When controversy arises, MISO and stakeholders will face similar governance questions to those described in Section IV above. One important principle is that the controversy can impede progress, so perhaps the less controversial items should be addressed first. Another is that controversy is inevitable, and initiatives with very high net benefits should not be entirely avoided only because they are controversial. MISO and stakeholders will have to grapple with these issues, and of course we offer no silver bullet for resolving them other than the power of demonstrating net benefits and service toward the agreed-upon Vision.

The final Roadmap should be memorialized in a coherent document that both lays out a clear path, including: which initiatives to pursue, and when they would reach each development milestone. Development milestones could be defined by the same lifecycle stages MISO already uses to track its progress on initiatives. We understand that MISO aims to complete its document by May or June of 2014.

C. UPDATING THE ROADMAP OVER TIME

The Roadmap should build in future monitoring and redirection. Monitoring involves tracking how active initiatives are progressing, how costs are comparing to estimates, and, for those that are already completed, assessing the benefits using the types of metrics MISO already uses to assess its Value Proposition, as well as other indicators. Refinement may be needed annually, or more frequently if necessary given major developments to system conditions; for example as FERC Orders introduce a legal compliance obligations that must be integrated into the roadmap.

We expect that the same within-Focus Area and across-Focus Area organizational structures that will have developed the Roadmap can provide for future monitoring and refinement.

VI. List of Acronyms

1-in-10	One-Day-In-Ten-Years
ARPA-E	Advanced Research Projects Agency-Energy
ASM	Ancillary Services Markets
BTMG	Behind-the-Meter Generation
C&D	Commitment and Dispatch
CC	Combined-Cycle
CT	Combustion Turbine
CONE	Cost of New Entry
DA	Day Ahead
DRR	Demand Response Resource
EAR	External Asynchronous Resource
EDR	Emergency Demand Response
EEI	Electric Energy, Inc.
eLMP	Extended Locational Marginal Pricing
EPA	Environmental Protection Agency
FA	Focus Area
FACTS	Flexible AC Transmission System
FERC	Federal Energy Regulatory Commission
GW	Gigawatt
HVDC	High-Voltage DC Transmission
IESO	Independent Electricity System Operator
IMM	Independent Market Monitor
IRP	Integrated Resource Plan
LMP	Locational Marginal Pricing
LMR	Load Modifying Resource
M2M	Market-to-Market
MATS	Mercury and Air Toxics Standard
MHEB	Manitoba Hydro
MISO	Midcontinent Independent System Operator

MP	Market Participant
MVP	Multi-Value Projects
Net CONE	Net Cost of New Entry
NSI	Net Scheduled Interchange
OTC	Over the Counter
OPF	Optimal Power Flow
PAR	Phase Angle Regulator
PJM	PJM Interconnection
PRA	Planning Resource Auction
PS	Pumped Storage
PUC	Public Utility Commission
PVMWP	Price Volatility Make Whole Payment
RAC	Reliability Assessment Commitment
REC	Renewable Energy Certificate
RSG	Revenue Sufficiency Guarantee
RT	Real Time
RTO	Regional Transmission Organization
SCED	Security-Constrained Economic Dispatch
SCUC	Security Constrained Unit Commitment
SPP	Southwest Power Pool
TCA	Topology Control Algorithms
TLR	Transmission Loading Relief
TVA	Tennessee Valley Authority
VFT	Variable-Frequency Transformer
VAR	Volt-Amperes Reactive
WAU	Western Area Power Administration

VII. Bibliography

Clark, John M. (1940). "Toward a Concept of Workable Competition." *American Economic Review*. Retrieved from http://www.jstor.org/stable/1807048.

Edison Electric Institute (EEI). (2011) "Potential Impacts of Environmental Regulation on the US Generation Fleet." January 2011, pages 33, 34 and 36. Retrieved from http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2011IRP/EEIModelingReportFinal-28January2011.pdf

Environmental Protection Agency (EPA). (2011) "Documentation Supplement for EPA Base Case v.4.10_MATS – Updates for Final Mercury and Air Toxics Standards (MATS) Rule." December 2011. Page 46. Retrieved from http://www.epa.gov/airmarkets/progsregs/epa-ipm/docs/SuppDoc410MATS.pdf

Gribik, Paul R., William W. Hogan, and Susan L. Pope. (2007) "Market-Clearing Electricity Prices and Energy Uplift." December, 2007. Retrieved from http://www.hks.harvard.edu/fs/whogan/Gribik_Hogan_Pope_Price_Uplift_123107.pdf

Mas-Colell, Andreu, Michael D. Whinston, and Jerry R. Green. (1995) *Microeconomic Theory*.

Maslennikov, S. and K. Cheung. (2012) "Prototyping and Testing Adaptive Transmission Rates for Dispatch." FERC Conference on Increasing Market Efficiency through Improved Software. Docket AD10-12-003. June 25, 2012. Retrieved from http://www.ferc.gov/EventCalendar/Files/20120626080541-Monday_SessionA_Maslennikov.pdf

Midcontinent Independent System Operator (MISO). (2013a) "Value Proposition." March 2013. Retrieved from https://www.misoenergy.org/WhatWeDo/ValueProposition/Pages/ValueProposition.aspx.

MISO. (2013b) *2012-2016 Strategic Plan*. March 2013. Retrieved from https://www.misoenergy.org/Library/Repository/Communication%20Material/Corporate/MISO%20Strategic%20Plan/MISO%20Strategic%20Plan%202012_2016%20Web.pdf

MISO. (2013c) *MISO Market Vision Development*. June 2013. Retrieved from https://www.misoenergy.org/Library/Repository/Meeting%20Material/Stakeholder/Workshops%20and%20Special%20Meetings/2013/Market%20Vision%20Workshop/20130605%20Market%20Vision%20Workshop/20130605%20Market%20Vision%20Workshop%20Introduction.pdf

MISO. (2013d) *Ramp Capability Product Design for MISO Markets*. July 2013. Retrieved from https://www.misoenergy.org/Library/Repository/Communication%20Material/Key%20Presentations%20and%20Whitepapers/Ramp%20Product%20Conceptual%20Design%20Whitepaper.pdf

MISO. (2013e) *Quarterly Seams Report*. Updated June 27, 2013. Retrieved from https://www.misoenergy.org/Library/Repository/Report/Quarterly%20Seams%20Reports/2013/2013%20Q2%20Quarterly%20Seams%20Report.pdf

MISO. (2011) *Ramp Capability for Load Following in MISO Markets*. July 2011. Retrieved from https://www.misoenergy.org/Library/Repository/Communication%20Material/Key%20Presentations%20and%20Whitepapers/Ramp%20Capability%20for%20Load%20Following%20in%20MISO%20Markets%20White%20Paper.pdf

MISO-OMS. (2013) MISO-OMS Survey Results presented to the MISO Supply Adequacy Working Group. December 2013. Retrieved from https://www.misoenergy.org/Library/Repository/Meeting%20Material/Stakeholder/SAWG/2013/20131205/20131205%20SAWG%20Item%2003%20OMS%20MISO%20Survey%20Results.pdf

Oncor (2013). *Electric Delivery Smart Grid Program, Dynamic Line Rating* Final Report. August 1, 2013. Retrieved from http://www.smartgrid.gov/sites/default/files/FTR_Final_Oncor_DE-OE0000320.pdf

PJM Interconnection. (2014) "Switching Solutions." 2014. Retrieved from www.pjm.com/markets-and-operations/etools/oasis/system-information/switching-solutions.aspx

Potomac Economics. (2013) *2012 State of the Market Report for the MISO Electricity Markets*. June 2013. Retrieved from https://www.misoenergy.org/Library/Repository/Report/IMM/2012%20State%20of%20the%20Market%20Report.pdf

Stiglitz, Joseph E. (1988) *Economics of the Public Sector*. 1988.

Stiglitz, Joseph E. (1991) "The Invisible Hand and Modern Welfare Economics." National Bureau of Economic Research Working Paper No. 3641. Retrieved from http://www.nber.org/papers/w3641.pdf.

United States Department of Agriculture. (1996) "Subpart D–United States Standards for Corn." September 1998. Retrieved from http://www.gipsa.usda.gov/fgis/standards/810corn.pdf.

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