Purpose Statement

This paper evaluates a Short-Term Reserve product intended to align MISO’s markets with specific reliability obligations to meet short-term capacity reserve (STCR) needs for local, regional, and system-wide flexibility.

Executive Summary

Changes to MISO’s Energy and Ancillary Services markets to address STCR needs will further strengthen MISO’s vision for reliable and economically efficient markets. Today STCR needs are addressed with significant out-of-market costs. MISO incurred about $35 million in Revenue Sufficiency Guarantee (RSG) payments for Regional Dispatch Transfer (RDT) and load pocket STCR needs in 2017 and much more in some previous years. MISO is exploring the introduction of a new Short-Term Reserve product that will align with STCR needs and allow the market to meet these needs more efficiently.

There are three key anticipated improvements associated with the proposed changes accompanying the introduction of the Short-Term Reserve product.

- Increased efficiency in the MISO commitment process related to load pocket, RDT, and, when needed, system-wide reliability needs
- Improved transparency of the costs associated with satisfying STCR needs through Short-Term Reserve prices
- Enhanced reliability by aligning operational needs and market models to ensure the market dispatch provides the required 30-minute response in the needed locations

Consistent with MISO’s market vision and the MISO Independent Market Monitor’s (IMM’s) recommendations, MISO recommends moving forward with the Conceptual Design phase of the Short-Term Capacity Reserve project. This phase will address core design questions and complexities associated with a new Short-Term Reserve product including detailed interaction with other ancillary services, scarcity pricing and demand curves, modeling of STCR needs related to voltage issues, and identification of local causes for commitments to support cost-causation in settlements. The Short-Term Reserve product will have features patterned after other types of reserves including co-optimization with energy and other ancillary services, product offers from participants, location-based requirements (local area and/or system-wide requirements), and eligibility for supply by both online and offline resources.
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1. Introduction

This paper evaluates a Short-Term Reserve product intended to align MISO’s markets with specific reliability obligations to meet short-term capacity reserve (STCR) needs. The evaluation examines (1) operational needs which are not efficiently modeled in MISO’s current market, (2) the inconsistency of the current approach for addressing STCR needs with the principles of MISO’s market vision, and (3) the efficacy of a Short-Term Reserve product to better address STCR needs relative to existing practice and other potential approaches. The goal of this evaluation is to recommend whether the STCR project should advance to the Conceptual Design phase where further investigation and development of a Short-Term Reserve product solution will be pursued.

MISO, as the system operator, has an obligation to operate the Bulk Electric System (BES) within defined North American Electric Reliability Corporation (NERC) reliability criteria. Many of these criteria are met by resource flexibility, often provided through defined reserve products, to respond to imbalances in power system supply and demand or to maintain the resiliency of the transmission network. Current ancillary service products provide capacity that can produce energy within different time periods to satisfy specific system needs and reliability requirements, but the current products are not applicable to all system needs.

The Short-Term Reserve product examined in this evaluation addresses STCR needs, which are not explicitly addressed by MISO’s current suite of ancillary service products and are addressed by out-of-market commitments that may be inefficient, may result in significant RSG payments, may not adequately address the STCR reliability needs, and do not provide price transparency. The new product will provide the market increased flexibility to meet STCR needs through qualifying resources with longer 30-minute ramp times and address reliability needs through market mechanisms that will enable improved economic efficiency, provide explicit price signals, and support cost-causation principles where costs are allocated to the beneficiaries.

1.1 STCR Reliability Needs

STCR needs discussed in this evaluation represent the flexibility of generating resources to change their energy output within 30-minutes to meet operational requirements. MISO’s current STCR needs can be categorized into load pocket, regional, or system-wide based on the locational requirement driving the need.

1.1.1 Load Pocket STCR Needs

Load pockets are local areas with limited availability of flexible resources which are also constrained by transmission capacity and/or voltage issues that limit import from surrounding areas. Due to the import limitations and lack of flexible resources, MISO must augment its normal practices and secure these local areas for the loss of two system elements, either generation or transmission. This ensures availability of sufficient flexibility to prevent extended overloads of transmission facilities, which may result in load shed to avoid violating reliability criteria in the event of a contingency.
1.1.2 Regional or RDT STCR Needs
MISO’s RDT obligation limits energy transfers between the North/Central and South regions. Under a settlement agreement between MISO, Southwest Power Pool (SPP) and the joint parties, MISO’s inter-regional dispatch flows can exceed the contractual limits, or RDT limits, following a contingency, but must be restored within 30 minutes. Although violating these obligations is not a physical operating limit of the system, MISO must ensure sufficient flexibility is available to ensure post-reserve deployment inter-regional dispatch flows respect RDT limits.

1.1.3 System-wide STCR Needs
In addition to local needs, MISO also expects that future changes in the mix of generation and their operating characteristics may fail to deliver sufficient 30-minute flexibility without intentional definition and clearing of a discrete 30-minute capacity requirement. Although a 2013 MISO study concluded that the available 30-minute response of MISO resources was sufficient to meet MISO-wide STCR needs, the resource portfolio in MISO’s footprint continues to evolve. Higher penetrations of wind and solar are expected to increase MISO’s needs for flexibility, and relative changes in fuel prices can decrease the amount of unloaded flexible resources that have historically been available to respond to STCR needs.

1.2 MISO’s Current Approach to STCR Needs is Not Market-Based
The Midwest portion of the MISO footprint generally has adequate resources to address STCR needs, including significant offline quick-start capacity. The MISO South region often has limited offline quick-start capacity. To supply the needed 30-minute capacity in the South region, MISO manually commits longer lead generators available in MISO South locations when issues are identified in reliability assessment processes. These manual, out-of-market commitments do not provide efficient and transparent market results reflecting the reliability needs of the BES.

This evaluation identifies and explores three issues with MISO’s current approach for addressing STCR needs.

- Inefficiencies due to sequential analysis of STCR needs and energy and ancillary service products across the Reliability Assessment Commitment processes, and lack of STCR models in the Day-Ahead market and real-time commitment process.
- High RSG payments (about $35 million in 2017 and much more in some previous years) due to manual commitments for STCR needs and lack of transparent market signals regarding the cost to address STCR needs.

1 The joint parties include Southern Company, Tennessee Valley Authority (TVA), Associated Electric Cooperative (AECL), Louisville Gas and Electric (LG&E), Kentucky Utilities Company (KU) and PowerSouth Energy Cooperative.
2 MISO study on Short-Term Capacity Shortage, March 7, 2013.
3 For the purposes of this evaluation, quick-start capacity will be considered resources that can be started, synchronized and inject energy within 30 minutes. Quick-start capacity does not necessarily refer to the more restrictive, Tariff defined Quick Start Resource, A Generation Resource or Demand Response Resource-Type II that can be started, synchronized and inject Energy within the Contingency Reserve Deployment Period.
Insufficient coverage of STCR reliability needs in real time even with sufficient capacity commitment because MISO's dispatch engine is not required to ensure availability of 30-minute ramp.

1.3 Proposed Short-Term Reserve Product

Adding a Short-Term Reserve product to the MISO’s markets and co-optimizing Short-Term Reserves with energy and other ancillary services is expected to improve market dispatch and commitments. Key attributes of the proposed Short-Term Reserve product include the following.

- Online and offline capacity eligibility
- 30-minute ramp response time
- Co-optimization with energy and ancillary services products
- Location based requirements

MISO expects the inclusion of models for STCR needs and the Short-Term Reserve product in MISO’s commitment and dispatch engines will lead to more efficient results than the current sequential analysis approach. Introducing a product that explicitly establishes STCR requirements in MISO’s markets will also provide local market prices that better reflect the value of STCR needs in the market dispatch, adequately address STCR reliability needs, and provide more transparency to the market.

MISO assessed three options, Short-Term Reserve product, expanded use of Contingency Reserves, and enforcement of additional energy dispatch constraints, and concluded the Short-Term Reserve product is better suited for reliably addressing MISO’s STCR needs in an efficient and transparent manner.

1.4 MISO Market Roadmap

Development of a Short-Term Reserve product has been given a high priority by MISO and stakeholders in the MISO Market Roadmap. The Short-Term Reserve product furthers MISO’s market vision to foster wholesale electricity markets that deliver reliable and economically efficient outcomes. This evaluation demonstrates that the Short-Term Reserve product is consistent with the guiding principles of MISO’s market vision.

1.5 Independent Market Monitor Recommendations

MISO’s Independent Market Monitor (IMM) identified issues with large RSG payments associated with load pocket and RDT STCR needs. The IMM recommended the addition of a 30-Minute Reserve product to help address these needs in a more efficient manner. This Short-Term Reserve product evaluation recognizes the IMM’s concerns and recommendations.

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- [MISO Market Roadmap](https://www.misoenergy.org/markets-and-operations-market-roadmap)
Load pocket needs addressed by IMM Recommendation 2014-2\(^5\)

“We recommend that MISO create a local 30-minute reserve product in these areas so that these requirements can be priced and procured through MISO’s markets (rather than through out-of-market commitments that result in uplift). This would be beneficial because it would provide market signals to build fast-starting units or other resources that can satisfy the VLR needs at a much lower cost (because they can satisfy the requirements while offline).”

RDT needs addressed by IMM Recommendation 2016-4\(^6\)

“We believe the 30-minute reserve product recommended in 2014-2 could be expanded to reflect these regional capacity needs. This would likely alter the resource commitments in the day-ahead market to satisfy these needs at overall lower costs. It will also price these requirements, including allowing the markets to price shortages when the regional resources are insufficient to satisfy the full reserve requirement.”

2. Short Term Capacity Reserve Needs

Reserves are utilized to respond to imbalances between generation and load. They are important for system reliability since they provide the flexibility to respond to unexpected changes in system conditions. Reliability needs addressed by reserves can be differentiated based on required response time and the nature of operating issue addressed. Differentiation based on these criteria is shown in Table 2.0.1 for current MISO market ancillary service products, including operating reserve and ramp products.

<table>
<thead>
<tr>
<th>ANCILLARY SERVICE PRODUCT</th>
<th>OPERATING ISSUE ADDRESSED</th>
<th>TIME HORIZON</th>
<th>REQUIREMENT SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulating Reserves</td>
<td>Continuous imbalance due to normal generation/load variation</td>
<td>Seconds</td>
<td>NERC BAL-001-2</td>
</tr>
<tr>
<td>Contingency (Spin and Supplemental) Reserves</td>
<td>Disturbance triggered by a contingency that meets the Disturbance Control Standard (DCS) threshold</td>
<td>10 min.</td>
<td>NERC BAL-002-2(i)</td>
</tr>
<tr>
<td>Ramp Products</td>
<td>Uncertainty due to normal energy supply and demand variation</td>
<td>10 min. after target dispatch interval</td>
<td>Good Utility Practice</td>
</tr>
</tbody>
</table>

Table 2.0-1: Current MISO Ancillary Service Products

MISO’s needs for flexibility extend beyond those addressed by existing ancillary service products. They also include STCR needs, which represent the flexibility of generating resources to change their energy output within

30 minutes to meet operational requirements. MISO’s STCR needs have three categories – Load Pocket, RDT, and System-Wide – and they are described in the following subsections.

2.1 Load Pocket STCR Needs

MISO’s load pocket STCR needs result from limited flexibility in load pockets to ensure sufficient local capacity is available to ramp, following disturbances, to avoid violation of reliability criteria. Load pockets are local areas with limited availability of quick-start capacity and limited import capabilities due to constrained transmission capacity and/or voltage issues.

Under normal operating conditions, MISO secures the BES for the loss of a single system element, known as a contingency (N-1 contingency). MISO will utilize emergency ratings of transmission equipment to make necessary system changes (e.g. generation changes, reconfiguration, load shed, etc.) to ensure transition to a new stable operating state following a contingency. These emergency ratings are only available for short a period of time (generally 30 minutes) and flows must be returned within normal ratings prior to the time limit to prevent equipment damage or failure. MISO must ensure that the BES can withstand a new contingency within 30 minutes.

In load pockets, MISO must consider the limited amount of resources available to respond to the first contingency and still keep the system secure for the second within 30 minutes – for example, loss of a generator followed by the loss of a transmission element (G-1/N-1). Following the first contingency in a load pocket, import constraints could exceed their limits and can only be restored by either ramping up other generation or shedding load. If available generation isn’t able to replace the lost generator within 30 minutes, then the system may not be able to withstand the loss of another system element. Without sufficient quick start resources to replace the lost generator, longer lead resources are committed and held in reserve. With the longer lead resource already online prior to the first generator contingency, its available capacity is only limited by its ramp rate. This commitment ensures availability of sufficient local capacity to avoid extended overloads of system elements, the need for load shed, and the potential violation of NERC standards.

2.2 Regional Directional Transfer STCR Need

The RDT need results from the negotiated contractual energy flow limit between the North/Central and the Southern portions of the MISO footprint. The contractual limit, although not physical, is intended to limit the impact of MISO’s energy flows on neighboring systems. Energy flows are limited to 3,000 MW in the north-to-south direction and 2,500 MW in the south-to-north direction. If exceeded, MISO has a maximum of 30 minutes to return transfers within limits per the agreement.

MISO utilizes RDT constraints, also known as Sub-Regional Power Balance Constraints in the Tariff, in the market dispatch and commitment engines to economically commit and re-dispatch generation to effectively manage RDT flows. To ensure timely restoration of RDT transfers to the contractual limits, following a generator loss in the South region, MISO must ensure that sufficient flexible generation is available to ramp up in the region.
Although MISO may deploy existing Contingency Reserve (CR) products for the loss of a generator in the South region if the contingency meets the DCS threshold, exceedances of the RDT limit due to non-DCS disturbances are more appropriately addressed by a Short-Term Reserve product. MISO’s generation to load must be balanced within 15 minutes following a DCS event, but MISO has 30 minutes to restore RDT flows to within limits.

2.3 System-Wide STCR Needs

System-wide STCR needs are non-location specific requirements for addressing imbalances in load and generation triggered by non-DCS related events such as a generator loss below the DCS threshold, large unexpected changes to Net Scheduled Interchange (NSI), and significant drops in intermittent resources. MISO addresses DCS events by deploying CR but does not typically deploy CR for non-DCS events. System-wide Short-Term Reserve can address such non-DCS-related imbalances.

Historically, coal units have been dispatched as baseload units and flexible gas generators have been offline or economically dispatched down from their maximum such that they are available to meet the system-wide STCR needs. Relative changes in fuel prices have made flexible gas-fired resources relatively more economic and, as such, they have been increasingly committed and dispatched ahead of less-flexible resources. If flexible resources are online and generating near maximum capacity with less-flexible resources offline and unavailable to respond quickly, the ability to respond to STCR needs may fall relative to levels MISO has historically observed on its system.

In 2013, MISO evaluated available response to address system-wide STCR needs. The study concluded that the system has sufficient response and there would be limited benefit of introducing a new Short-Term Reserve product to respond to the system-wide need. MISO’s generation resource portfolio continues to evolve, and MISO expects continued expansion of intermittent renewable energy. Registered wind generation in the MISO footprint has increased from approximately 1 GW in 2005 to nearly 17 GW in 2017. Solar generation, although currently small, is estimated to increase to approximately 11 GW in 2032. More intermittent renewable generation, due to their low marginal cost and the inherent variability, is expected to increase the system-wide STCR need.

3. Issues with MISO’s Current Approach to Address STCR Needs

MISO frequently addresses STCR needs by committing additional resources in the required locations. Where the capability exists, MISO commits offline quick-start resources after an STCR event to address a resulting STCR need. Where available 30-minute capacity is not sufficient to address STCR needs, MISO pre-positions the

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6 MISO study on Short-Term Capacity Shortage, March 7, 2013.
7 MISO Planning Year 2018-2019 Wind Capacity Credit Report, page 8, [https://tinyurl.com/y7epufhn](https://tinyurl.com/y7epufhn)
8 MISO MTEP18 Futures, page 70, [https://tinyurl.com/y9h2jwz2](https://tinyurl.com/y9h2jwz2)
system for STCR events by pre-committing longer lead units (units with lead-time exceeding the needed response time).

Commitment of offline quick-start resources is only typically available as an option for the system-wide STCR need since offline quick-start resources are more available in the North/Central portion of the MISO footprint. MISO usually pre-commits longer lead units to address RDT and load pocket needs since sufficient offline quick-start resources are often unavailable in these areas. As shown in Figure 3.0-1, historical data corroborates operational experience that the MISO South Region often has limited offline quick-start resources.

Three issues have been identified with MISO’s current approach for pre-committing longer-lead units to address load pocket and RDT STCR needs and are explored in the following subsections.

- Commitment inefficiencies for STCR needs
- RSG and inadequate market transparency surrounding needs
- Insufficient coverage of STCR needs in dispatch

### 3.1 Commitment Inefficiencies for STCR Needs

Figure 3.1-1 is a high-level representation of the current MISO process for committing resources for STCR needs. As shown in the figure, MISO assesses the sufficiency of projected available resources relative to load pockets and RDT needs beginning with the Multi-Day Reliability Assessment Commitment (MDRAC) process. MDRAC results are fed into the DA market as inputs. Load pockets in MDRAC are analyzed using a special purpose load pocket tool and the results are supplied to the DA market as must-run resources, which must be committed in the

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9 Capacity reflects offered Economic Maximum. Data includes all offline resources without adjustment for operating characteristics except outages and non-participating status. Lead Time includes Hot Start Up and Notification Time.

10 Some of the issues apply to quick-start commitments as well. However, their effects are not as pronounced since quick-start units have lead times that allow their commitment only when an STCR event occurs.
DA market commitment schedule. MDRAC commitments for RDT needs are made available for selection based on economics in the DA market, but MDRAC’s RDT commitments are not required to be online in the DA market.

Following the DA market, MISO updates its load pocket and RDT sufficiency assessments in the Next-Day RAC (NDRAC) process and continues to refine the reliability assessment through Real-Time Operations. If insufficient capacity margin for an STCR need is projected in any of the reliability assessments, MISO commits resources if the available resource’s lead-time exceeds the start-up time available for action following the next assessment. If there is sufficient lead-time, MISO will often wait for the results of the next assessment with updated input data before committing the resource.

**Figure 3.1-1: Current MISO Commitment Process**

For the most efficient commitment of resources, STCR needs and other operational requirements should be simultaneously co-optimized using resource market offers. Table 3.1-1 describes (1) the current modeling and commitment analysis of load pocket and RDT STCR needs in each stage of the MISO commitment process and (2) the following three types of issues (noted by number in square brackets in Table 3.1-1) that introduce inefficiencies in the set of MISO-committed resources.

1. STCR needs are not modeled in market-based analyses – In the DA SCUC, IRAC and LAC processes, STCR needs are not modeled. STCR needs must be modeled to enable efficient commitments for STCR needs in these commitment processes.

2. Sequential analysis of commitment requirements may lead to inefficient resource selection – The market-based SCUC algorithm simultaneously co-optimizes a broad pool of resources for a comprehensive set of requirements to determine the most efficient set of resources to meet the requirements. When STCR needs for load pockets and RDT are analyzed outside the SCUC algorithm, the resulting commitment may be inefficient. For example, if additional commitments are needed for STCR in a load pocket after other resources were committed by SCUC outside the load pocket to meet system-wide obligations, some of the commitments outside the load pocket may no longer be necessary. The sequential nature of the analysis does not provide a good opportunity to evaluate all requirements together to enable identification...
of the most efficient set of commitments. The MDRAC, DA SCUC, and NDRAC processes do not analyze STCR needs simultaneously with other system requirements.

3. Reduced flexibility for the DA market since load pocket commitments are made prior and become must-run in the DA market – most load pocket commitments are made in MDRAC, even when their lead times may not require it. The manual MDRAC commitment allows identification of the associated costs for local allocation to those entities which benefit. Load pocket commitments are generally fed forward into the DA market as must-run commitments giving the DA SCUC reduced flexibility to find the most efficient set of commitments to meet the combination of both load pocket constraints and all other system requirements.

<table>
<thead>
<tr>
<th>MDRAC</th>
<th>DA SCUC</th>
<th>NDRAC</th>
<th>IRAC</th>
<th>LAC</th>
<th>MANUAL RT COMMITMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Pocket STCR needs</td>
<td>STCR needs modeled</td>
<td>STCR needs not modeled [1]</td>
<td>STCR needs modeled</td>
<td>STCR needs not modeled [1]</td>
<td>STCR needs not modeled [1]</td>
</tr>
<tr>
<td>RDT STCR needs</td>
<td>STCR needs modeled</td>
<td>STCR needs not modeled [1]</td>
<td>MDRAC committed resources are made available to DA SCUC, but may not be DA committed since STCR needs not modeled [2]</td>
<td>STCR needs not modeled [1]</td>
<td>STCR needs not modeled [1]</td>
</tr>
<tr>
<td>RDT Analysis</td>
<td>Sequential system-wide and RDT analysis [2]</td>
<td>STCR needs not modeled [1]</td>
<td>MDRAC committed resources are made available to DA SCUC, but may not be DA committed since STCR needs not modeled [2]</td>
<td>STCR needs not modeled [1]</td>
<td>STCR needs not modeled [1]</td>
</tr>
</tbody>
</table>

[1] STCR needs are not modeled in the market-based analysis.
[2] Sequential analysis of commitment requirements may lead to inefficient resource selection.
[3] Commitments are made prior to the Day-Ahead market and become must-run in the Day-Ahead.

Table 3.1-1: Current Load Pocket and RDT STCR Needs in MISO Commitment Processes

The inefficiencies summarized in Table 3.1-1 provide opportunities for improvement of the commitment process and for reducing the MISO production cost.

3.2 RSG and Inadequate Market Transparency

MISO incurs significant RSG payments for commitments made to manage RDT and load pockets. In 2017, MISO incurred more than $20 million in load pocket-related Day-Ahead RSG payments\(^{11}\) and about $15 million in RDT-related Real-Time RSG payments\(^{12}\) (see Figures 3.2-1 and 3.2-2.). RSG payments related to these STCR needs are driven significantly by the fixed costs of commitments made to pre-position the system. For RDT needs,

\(^{11}\) Over 90% of all load-pocket-related RSG payments are from the Day-Ahead market.
\(^{12}\) Over 98% of all RDT-related RSG payments are from the Real-Time market.
related RSG payments have been on an increasing trend. Load pocket RSG payments declined from 2014 through 2016 due to improvements in commitment processes, decline in gas prices, and addition of transmission capability. However, Day-Ahead load pocket RSG payments increased slightly from 2016 to 2017 and accounted for a larger share of total Day-Ahead RSG payments. Inefficiencies in the commitment process, as identified in Section 3.1, contribute to the high RSG payments, which may be improved by efficiency enhancements.

![Graph showing historical Day-Ahead RSG incurred to manage Load Pocket STCR Needs]

Figure 3.2-1: Historical Day-Ahead RSG incurred to manage Load Pocket STCR Needs

![Graph showing historical Real-Time RSG incurred to manage Regional Dispatch Transfer STCR Needs]

Figure 3.2-2: Historical Real-Time RSG incurred to manage Regional Dispatch Transfers STCR Needs
Commitment of offline quick-start resources to address STCR needs, which requires starts only after the first generator or transmission element trips, is normally a relatively more efficient solution than commitment of long lead resources which run all of the time. While the South region and load pockets typically lack sufficient quick-start capability to meet their STCR needs, actions taken to address STCR needs that are not modeled in the market lack the transparency of price signals to incent development of desirable quick-start capability in these locations.

3.3 Insufficient Coverage of STCR Need in Dispatch

For a resource to adequately respond to an STCR need, it must have capacity available, be in an effective location, and its available capacity must be rampable within 30 minutes. Two of the three requirements, available capacity and commitment in the appropriate location, are ensured by MISO’s pre-commitment of longer-lead resources. However, MISO’s market dispatch may not maintain the availability of the needed 30-minute ramp since there is no explicit constraint modelled in the engines to enforce such a requirement.

When ramp is insufficient, relative to STCR needs in a dispatch interval, it is not apparent to system operators and the market. An IMM analysis of 2016 indicates that despite the commitments made to address load pocket STCR needs in the South region, the AMITE South load pocket lacked the required ramp capability nearly 20 percent of the time and 12 percent of the time in WOTAB

4. Proposed Solution Concept

MISO proposes the addition of a Short-Term Reserve product in the market commitment and dispatch processes to improve reliability, market efficiency, and price transparency for system-wide, RDT, and load pocket STCR needs. There are two main aspects of the overall solution approach.

- Introduce a Short-Term Reserve product to model and procure the applicable STCR needs and to provide market clearing prices
- Incorporate the new Short-Term Reserve product in enhanced MISO commitment processes for improved commitment efficiencies

Section 4 explores Short-Term Reserve product design and proposed enhancements to the MISO commitment process.

4.1 Short-Term Reserve Product

The proposed Short-Term Reserve product would be cleared and settled in the Day-Ahead and Real-Time markets and be included in market studies for commitment, dispatch and pricing. Key features of the product are listed below.

• Online and offline capacity eligibility and offers
• 30-minute ramp response time
• Co-optimization with energy and ancillary service products
• Location-based requirements

4.1.1 Online and Offline Capacity Eligibility
Both online and offline resources may participate in providing the Short-Term Reserve product. Online resources will participate with their committed capacity, ramp rates, and other operating parameters. Offline resources will provide STCR response up to the output level they can achieve from the offline status in 30 minutes. It is anticipated that the use of online capacity for energy, regulation, and contingency reserves will be exclusive of cleared Short-Term Reserves to ensure the needed capacity is available for each service even if all services are needed at the same time. Similarly, the use of offline capacity for contingency reserves will be exclusive of cleared Short-Term Reserves.

Offline resources, which can start and ramp up their energy output within the 30-minute time window, offer an attractive economic method to meet STCR needs since commitment costs for offline resources are only incurred when there is an STCR event.

4.1.2 Short-Term Reserve Offers
It is anticipated that participants will offer a price associated with providing Short-Term Reserves, similar to the availability offers for spinning and supplemental reserve products. Generally, when the Short-Term Reserve clearing price is above a resource’s Short-Term Reserve offer plus the opportunity cost associated with other products, the offer will clear. When the Short-Term Reserve clearing price is below the resource’s Short-Term Reserve offer plus the opportunity cost associated with other products, the offer will not clear. Similar to offline supplemental reserves, participants will indicate their capability to provide Short-Term Reserves from an offline status and the power output that can be reached within 30 minutes.

4.1.3 30-Minute Ramp Response Time
Each online resource’s cleared Short-Term Reserves will be limited by its capacity-constrained 30-minute ramp response or its available capacity not used by other products.

4.1.4 Co-optimization with Energy and Ancillary Service Products
For the most efficient market clearing solution, cleared Short-Term Reserves will be simultaneously co-optimized with energy and other ancillary service products in MISO’s security constrained unit commitment (SCUC) and security constrained economic dispatch (SCED) applications for commitment, dispatch, and pricing.

The interaction of the new product with energy and other ancillary services must be carefully modeled. Assumptions about energy associated with regulation deployment, CR deployment and ramp product use within the 30-minute STCR need time period will impact the Short-Term Reserve product and energy dispatch to ensure STCR needs are met. The product design rules will include assumptions about the shared use of an individual resource’s available ramp rate and capacity to mirror anticipated operational conditions and provide a reliable and
economic solution. The complexities of the market clearing rules for integrating the Short-Term Reserve product with energy and other products will be explored in the Conceptual Design phase.

4.1.5 Location-Based Requirements in Market Clearing and Pricing

System-wide STCR needs do not require capacity in a specific location. System-wide response to events can generally be provided at any location in the system. RDT and load pocket constraints require STCR response within a defined region to accommodate contractual and reliability needs, respectively. Zonal STCR requirements or reserve procurement constraints (similar to those used for contingency reserve deployments) will be used to ensure that cleared Short-Term Reserves can ramp up within 30 minutes to satisfy regional or load pocket load subject to post-contingency import constraints.

It is anticipated that the market dispatch and pricing will incorporate the locational STCR needs for RDT and load pockets to economically clear Short-Term Reserves along with energy and the existing ancillary services. By clearing Short-Term Reserves explicitly, the system will be re-dispatched as needed to satisfy STCR needs, reducing the instances in which sufficient capacity is committed, but the resources are not positioned to provide the needed response should an STCR event occur.

Load pocket and RDT Short-Term Reserve prices will reflect the marginal offer cost and opportunity cost associated with dispatching to procure the needed Short-Term Reserves. If the requirements cannot be met, scarcity pricing will result based on a Short-Term Reserve demand curve. The visibility of these Short-Term Reserve prices will improve the transparency of the costs to meet STCR needs.

4.2 Commitment Process Changes

Including Short-Term Reserve requirements in the commitment analysis will provide a more robust commitment process that will enable improved efficiency in determining commitment schedules consistent with RDT and load pocket STCR needs. Key impacts of the new commitment process anticipated in conjunction with the addition of the Short-Term Reserve product are listed below.

- Short-Term Reserve requirements will enable accounting for STCR needs for load pockets and RDT in all SCUC analyses.
- SCUC will be able to select the most efficient set of commitments based on concurrent consideration of load pocket and RDT STCR requirements with other system requirements. Separate sequential analysis tools may still be supported as a reliability backstop, but most commitments for load pockets and RDT will be expected to be identified by SCUC results.
- Enhanced functionality will be added to identify which commitments are primarily for load pockets or RDT to support cost- causation allocation in settlement. MISO initial investigations have resulted in a successful prototype. Programmatic identification of commitment reasons will reduce the need for operator identification via commitments prior to the DA market and will increase the flexibility to identify the most efficient commitments to meet all requirements.
These changes to the MISO commitment process are summarized in Figure 4.2-1 and described for individual assessments in Table 4.2-1.

### Figure 4.2-1: Enhanced MISO Commitment Process

<table>
<thead>
<tr>
<th></th>
<th>MDRAC</th>
<th>DA SCUC</th>
<th>NDRAC</th>
<th>IRAC</th>
<th>LAC</th>
<th>MANUAL RT COMMITMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Pocket</td>
<td>STCR needs modeled</td>
<td>STCR needs modeled</td>
<td>STCR needs modeled</td>
<td>STCR needs modeled</td>
<td>STCR needs modeled</td>
<td>STCR needs considered</td>
</tr>
<tr>
<td>STCR needs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analysis</td>
<td>STCR needs modeled</td>
<td>STCR needs modeled</td>
<td>STCR needs modeled</td>
<td>STCR needs modeled</td>
<td>STCR needs modeled</td>
<td>STCR needs modeled</td>
</tr>
<tr>
<td>Load Pocket</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Operator manually commits for Load Pocket need</td>
</tr>
<tr>
<td>Analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Pocket</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RDT STCR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STCR needs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Needs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RDT Analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Operator manually commits for RDT need</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Changes from current practice indicated in blue

### Table 4.2-1: Enhanced Load Pocket and RDT STCR Needs in MISO Commitment Assessments
4.3 Additional Complexities

The introduction of a new Short-Term Reserve product and modification of the MISO commitment processes will have some complications that necessitate further investigation. This section describes some of the anticipated challenges associated with the proposed changes.

4.3.1 Managing Voltage Constraints

The Short-Term Reserve product is designed to represent STCR needs with requirements specified as a continuous function of market dispatch. A requirement example could be an import limit into a defined region. Some MISO local STCR needs represent local voltage requirements. These voltage requirements may be met by the reactive power capabilities of certain needed combinations of online resources under the anticipated system operating conditions. In these areas, the key requirements are determined by offline studies and represented as look-up tables of the viable resource combination options satisfying the forecasted system conditions. Even after the introduction of the Short-Term Reserve product, these studies will still be required to identify the combinations of generators which satisfy various potential operating conditions. These fundamental requirements are not easily represented by the local area import constraints used to define the local Short-Term Reserve product requirements. Although the reliability requirements will continue to be met by committing the appropriate units, approximate STCR import-type constraints are proposed to provide STCR price incentives similar to other STCR constraints.

4.3.2 Local Cost-Causation

With certain STCR needs occurring in local areas, the costs associated with committing generators in a specific area should be allocated to that area. To enable this cost allocation consistent with cost-causation, resources committed for local area needs should be identified. When the commitment for STCR needs is integrated for simultaneous analysis with other market needs, all system needs are analyzed concurrently within the SCUC commitment decision. Identification of a single cause for unit commitment can be challenging. Although MISO’s preliminary investigations into logic to identify such commitments is promising, additional analysis or methods may be needed to robustly identify commitments associated with STCR needs.

4.3.3 Incentives to Build and Impact on RSG

Due to the longer lead times of resources currently available in the constrained areas, MISO’s current approach to fulfill STCR needs is often to commit additional resources to carry the needed capacity online. Over time, the resource mix in an area can change. As new resources are introduced, the ability to fulfill the reliability need through a less-expensive option is desired. For example, the use of offline resources that can start within 30 minutes would allow the STCR needs to be met by offline resources that only need to be started in the infrequent instances where the first contingency has occurred.

Short-Term Reserve product prices will ideally provide efficient and transparent economic incentives for new investment (new market-registered equipment and/or enhancement to existing equipment) which can meet the STCR needs more cost effectively than current practices.
Achieving prices that reflect the full costs of committing resources to provide online reserve necessitated by the current resource mix can be a challenge with Short-Term Reserve prices reflecting the incremental dispatch cost. Although the constraints can be used to help ensure the most effective resources are committed, the proposed Short-Term Reserve prices would incorporate the re-dispatch costs needed to meet STCR requirements, but they would not include the commitment costs, such as start-up and minimum-load costs, required to commit and run those units. As a result, the resulting Short-Term Reserve price signals may under-represent the total system costs of meeting STCR needs.

This challenge with pricing commitment costs is not unique to STCR needs, but the following issues are important when considering the Short-Term Reserve product.

- Where the current “out-of-market” costs of STCR needs have been identified as large, STCR needs are largely met out-of-market resource commitments.
- Most of the time when the needed resources are committed, the economics of the market will naturally provide the needed Short-Term Reserve capability with no re-dispatch costs. The IMM identified that in today’s market, where STCR needs are not modeled in the dispatch, the additional commitments address the STCR needs in the load pockets more than 80 percent of the time with no re-dispatch costs incurred for STCR needs.
- With this historical record, it may be anticipated that much of the time Short-Term Reserve prices would be small. This may limit both the incentives for new investment to enable change in the current operating practice and changes in STCR-related RSG payments.
- When the needed capacity is available from the market commitments, but re-dispatch is required to position the resources to enable the potentially needed response, Short-Term Reserve prices would represent the re-dispatch cost and may be more substantial. The magnitude of Short-Term Reserve prices will depend on the relative costs of the resources re-dispatched to provide the needed capabilities and submitted Short-Term Reserve offers.
- If there is a situation in which the STCR needs cannot be met through re-dispatch of the system, there could be a shortage of Short-Term Reserve capability which would result in scarcity pricing and a substantial market incentive.

### 4.3.4 Integration with Existing Reserves
Existing Regulating and Contingency Reserves are deployed to manage the near-term Balancing Authority Area power balance and to restore system balance following DCS events, respectively. The ramp product provides standby ramp capability to enable the real-time dispatch to respond to unanticipated conditions. MISO’s location-based design for these ancillary service products include assumptions about which services are deployed when another is called on to change energy production. For example, during a DCS event, regulation may already be ramped up in response to the event when spinning and supplemental reserve are deployed. Similar consideration of the interaction of reserve deployments in real time operating conditions will need to be considered in the detailed design of the Short-Term Reserve product.
Design assumptions about the interaction of the Short-Term Reserve, energy, and other ancillary service products, such as their coincident impact on load pocket and RDT limits, will be explored further in the Conceptual Design phase.

4.3.5 Local Market Power
With STCR needs occurring in local areas, there is the potential for one or more market participants to exert local market power. With the purpose of addressing these local needs with a product, the Short-Term Reserve offers in these areas will need to be monitored for abuses of market power and processes for mitigating non-competitive behavior.

5. Short-Term Reserve Product Examples
The illustrative system in Figure 5.0.1 and Table 5.0.1 is used to demonstrate the use of the Short-Term Reserve product to meet locational STCR needs similar to a load pocket or RDT need\(^{14}\). Market dispatch examples demonstrate co-optimized dispatch of Short-Term Reserve offers for online and offline resources to meet STCR needs and transparently price Short-Term Reserves in three scenarios.

- Example I: Status quo – current approach for addressing STCR needs, which involves commitment of generator capacity without ensuring market dispatch positions resources for the needed response or providing prices reflective of STCR needs
- Example II: Short-Term Reserve product – use of a Short-Term Reserve product to meet STCR needs, to provide Short-Term Reserve marginal clearing prices, and to reduce RSG payments under the same system conditions as the status-quo example
- Example III: Short-Term Reserve product with new entry – use of the Short-Term Reserve product to take advantage of a newly introduced resource with offline Short-Term Reserve capability

\(^{14}\) Although labeled “Load Pocket” in the example system, the import constraint in this example can also be used to illustrate RDT STCR needs.
The illustrative system (Figure 5.0-1) is comprised of four generating resources, two of which are located within the load pocket constrained by an import capability of 126 MW. To recover to the import limit within 30 minutes following the loss of the load pocket’s largest generator, R3, the load pocket must be able to ramp up the remaining resource, R4, to restore load pocket imports at or below 126 MW. In Section 5.3, a fifth generator, R5, providing quick-start capability is introduced in the load pocket. The market offers for the four generators are shown in Table 5.0-1.

For the inclusion of start-up cost in the calculation of RSG in this single interval (1 hour) example, start-up cost is allocated over 18 hours for all resources, i.e., allocated hourly start-up cost equals offered start-up cost divided by 18 hours.

To explore the behavior of the new Short-Term Reserve product, a market clearing simulation tool including a basic definition of the Short-Term Reserve product was constructed for the small system example. The inputs and formulation options representing each example scenario were adjusted to produce the reported market clearing solutions.
5.1 Example I: Status Quo Dispatch

System-wide CR Requirement 50 MW

The current MISO market dispatch does not explicitly identify or attempt to satisfy STCR needs despite commitments to pre-position the system. The results of this example (see Figure 5.1-1) illustrates that the response to the loss of R3 is insufficient to restore imports within limits despite the commitment of R4. The example’s market clearing solution is described below and in Tables 5.1-1, 5.1-2, and 5.1-3:

- R1 (outside the load pocket) is the marginal unit and sets the LMP for the entire system.
- R2 (outside the load pocket) is dispatched at its minimum due to its high energy cost.
- R3 (within the load pocket) is dispatched at its maximum due to its low energy cost.
- R4 (within the load pocket) is dispatched at its minimum due to its high energy cost.
- R1 clears the maximum CR possible, limited by its 10-minute ramp.
- R2 clears the remaining CR requirement and sets the CR marginal clearing price.

<table>
<thead>
<tr>
<th>UNIT</th>
<th>ENERGY LMP ($/MWh)</th>
<th>CLEARED ENERGY (MW)</th>
<th>ENERGY CHANGE FROM EX. I (MW)</th>
<th>RSG ($)</th>
<th>RSG CHANGE FROM EX. I ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>24.76</td>
<td>634</td>
<td>--</td>
<td>5,549</td>
<td>--</td>
</tr>
<tr>
<td>R2</td>
<td>24.76</td>
<td>50</td>
<td>--</td>
<td>3,085</td>
<td>--</td>
</tr>
<tr>
<td>R3</td>
<td>24.76</td>
<td>300</td>
<td>--</td>
<td>1,782</td>
<td>--</td>
</tr>
<tr>
<td>R4</td>
<td>24.76</td>
<td>16</td>
<td>--</td>
<td>463</td>
<td>--</td>
</tr>
</tbody>
</table>

Table 5.1-1: Status Quo Example’s Unit Energy and RSG Results
Table 5.1-2: Status Quo Example’s Unit Ancillary Services Results

<table>
<thead>
<tr>
<th>UNIT</th>
<th>CR MCP ($/MWH)</th>
<th>CLEARED CR (MW)</th>
<th>CR CHANGE FROM EX. I (MW)</th>
<th>SHORT-TERM RESERVE MCP ($/MWH)</th>
<th>CLEARED SHORT-TERM RESERVE (MW)</th>
<th>SHORT-TERM RESERVE CHANGE FROM EX. I (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>2.71</td>
<td>30</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>R2</td>
<td>2.71</td>
<td>20</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>R3</td>
<td>--</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>R4</td>
<td>--</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Table 5.1-3: Status Quo Example’s System Production Cost and RSG Results

<table>
<thead>
<tr>
<th>EXAMPLE TOTAL</th>
<th>$/MWH</th>
<th>CHANGE FROM EX.1 ($/MWH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy/CR Production Cost</td>
<td>$23,970 / hour</td>
<td>--</td>
</tr>
<tr>
<td>Total RSG</td>
<td>$10,879 / hour</td>
<td>--</td>
</tr>
</tbody>
</table>

The load pocket dispatch result in this example does not have sufficient ramp to recover to the required 126 MW import limit within 30 minutes following the loss of R3. Without R3, the 170 MW load pocket demand may be served by up to 126 MW of load pocket imports, requiring R4 output at least 44 MW after 30 minutes (170 MW load – 126 MW import = 44 MW load pocket generation). With an initial dispatch of 16 MW from the market dispatch, R4 can ramp a maximum of 15 MW in 30 minutes (0.5 MW/min ramp rate) to an output of 31 MW. The load pocket import would be 139 MW after 30 minutes, above the required 126 MW. Figure 5.1-2 depicts the import and R4 responses during the 30 minutes following the loss of R3 with this example’s dispatch assuming no change in the load.

Figure 5.1-2: Status Quo Example’s Import and R4 Response to R3 Trip
5.2 Example II: New Short-Term Reserve Product

System-wide CR Requirement 50 MW

<table>
<thead>
<tr>
<th>Non-Load Pocket</th>
<th>Load Pocket</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMP</td>
<td>LMP</td>
</tr>
<tr>
<td>$24.76/MWh</td>
<td>$27.68/MWh</td>
</tr>
<tr>
<td>CRMCP</td>
<td>CR</td>
</tr>
<tr>
<td>$2.71/MWh</td>
<td>not cleared</td>
</tr>
<tr>
<td>STCR</td>
<td>STMCP</td>
</tr>
<tr>
<td>not cleared</td>
<td>$2.92/MWh</td>
</tr>
<tr>
<td>Other RSG</td>
<td>Ld Pkt RSG</td>
</tr>
<tr>
<td>$8634</td>
<td>$1312</td>
</tr>
</tbody>
</table>

Results:
- LMPs split
- Reduced RSG
- Reliability needs met

Figure 5.2-1: Short-Term Reserve Product Dispatch Solution

The Short-Term Reserve product is introduced in this example to model the load pocket’s STCR need. The dispatch results shown in Figure 5.2-1 provide the needed capability in the load pocket to successfully restore the import flow to its limit in 30 minutes following the loss of R3. This summary and Tables 5.2-1, 5.2-2, and 5.2-3 describe the market clearing result with the Short-Term Reserve product and its differences with the status quo in Example I:

- R1 is dispatched down to 621 MW to maintain power balance with dispatch changes for R4.
- R4 energy dispatch increases to 29 MW to enable it to ramp up to 44 MW (29 MW + 0.5 MW/minute * 30 minutes) meeting the STCR need for the load pocket.
- LMPs are different inside and outside the load pocket with R4 setting the energy price in the load pocket as it is the marginal resource to maintain energy balance and STCR needs associated with an incremental energy need within the load pocket.
- The Short-Term Reserve marginal clearing price (MCP) in the load pocket reflects the value to obtain an incremental MW to support 30-minute recovery to the import limit. Since R3’s capacity is fully loaded and R4 has already cleared its ramp limited amount of Short-Term Reserve, the most cost-efficient solution to an incremental Short-Term Reserve need in the load pocket is to re-dispatch between R4 and R1: load pocket Short-Term Reserve MCP = $2.92/MWh = R4 energy increase at $27.68/MWh – R1 energy reduction at $24.76/MWh.
• Co-optimization clears the Short-Term Reserve product and adjusts the energy dispatch to provide the needed 30-minute energy output in the needed location within the load pocket.

• To re-dispatch the system to meet the STCR needs, the production cost increases compared to the status quo by $71/hour.

• The total RSG goes down as the LMP goes up in the load pocket and R4 receives Short-Term Reserve revenue.

<table>
<thead>
<tr>
<th>UNIT</th>
<th>ENERGY LMP ($/MWH)</th>
<th>CLEARED ENERGY (MW)</th>
<th>ENERGY CHANGE FROM EX. I (MW)</th>
<th>RSG ($)</th>
<th>RSG CHANGE FROM EX. I ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
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<td>-13</td>
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<td>0</td>
</tr>
<tr>
<td>R2</td>
<td>24.76</td>
<td>50</td>
<td>0</td>
<td>3,085</td>
<td>0</td>
</tr>
<tr>
<td>R3</td>
<td>27.68</td>
<td>300</td>
<td>0</td>
<td>906</td>
<td>-876</td>
</tr>
<tr>
<td>R4</td>
<td>27.68</td>
<td>29</td>
<td>+13</td>
<td>406</td>
<td>-57</td>
</tr>
</tbody>
</table>

Table 5.2-1: Short-Term Reserve Product Example’s Unit Energy and RSG Results

<table>
<thead>
<tr>
<th>UNIT</th>
<th>CR MCP ($/MWH)</th>
<th>CLEARED CR (MW)</th>
<th>CR CHANGE FROM EX. I (MW)</th>
<th>SHORT-TERM RESERVE MCP ($/MWH)</th>
<th>CLEARED SHORT-TERM RESERVE (MW)</th>
<th>SHORT-TERM RESERVE CHANGE FROM EX. I (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>2.71</td>
<td>30</td>
<td>0</td>
<td>--</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>R2</td>
<td>2.71</td>
<td>20</td>
<td>0</td>
<td>--</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>R3</td>
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<td>0</td>
<td>0</td>
<td>--</td>
<td>0</td>
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<tr>
<td>R4</td>
<td>--</td>
<td>0</td>
<td>0</td>
<td>2.92</td>
<td>15</td>
<td>+15</td>
</tr>
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</table>

Table 5.2-2: Short-Term Reserve Product Example’s Unit Ancillary Services Results

<table>
<thead>
<tr>
<th>EXAMPLE TOTAL</th>
<th>$/MWH</th>
<th>CHANGE FROM EX. I ($/MWH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy/Reserve Production Cost</td>
<td>$24,040/hour</td>
<td>$71/hour</td>
</tr>
<tr>
<td>Total RSG</td>
<td>$9,946/hour</td>
<td>-$933/hour</td>
</tr>
</tbody>
</table>

Table 5.2-3: Short-Term Reserve Product Example’s System Production Cost and RSG Results

Figure 5.2-2 shows that the increased R4 dispatch to support STCR needs enable the import to be restored to its limit following the loss of R3.
5.3 Example III: Short-Term Reserve Product and New Resource with Offline Capability

The third example demonstrates the potential savings associated with offline Short-Term Reserve capability. Although such quick-start capability is currently not frequently available in some MISO regions, the Short-Term Reserve product may help incent new participation of quick-start resources. In this example, a new resource R5 is introduced in the load pocket. R5 can provide the Short-Term Reserve product when it is offline since it can ramp from an offline status to its maximum of 55 MW within 30 minutes. In this example, R4 is offline since R5 removes the need for its commitment.

The modified system containing R5 for this example is shown in Figure 5.3-1. The resource offer data including R5 which additionally offers 55 MW of offline Short-Term Reserve capability is shown in Table 5.3-1. The dispatch results are shown in Figure 5.3-2.
Short Term Capacity Reserve - Evaluation

<table>
<thead>
<tr>
<th>UNIT</th>
<th>MAX MW</th>
<th>MIN MW</th>
<th>START-UP ($)</th>
<th>ENERGY ($/MWH)</th>
<th>CR ($/MWH)</th>
<th>SHORT-TERM RESERVE ($/MWH)</th>
<th>RAMP RATE (MW/MIN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>674</td>
<td>196</td>
<td>100,000</td>
<td>24.76</td>
<td>2.48</td>
<td>1.73</td>
<td>3.0</td>
</tr>
<tr>
<td>R2</td>
<td>240</td>
<td>50</td>
<td>45,000</td>
<td>36.47</td>
<td>2.71</td>
<td>7.96</td>
<td>4.1</td>
</tr>
<tr>
<td>R3</td>
<td>300</td>
<td>80</td>
<td>60,000</td>
<td>19.59</td>
<td>2.79</td>
<td>2.04</td>
<td>2.7</td>
</tr>
<tr>
<td>R4</td>
<td>49</td>
<td>16</td>
<td>7,500</td>
<td>27.68</td>
<td>2.93</td>
<td>2.18</td>
<td>0.5</td>
</tr>
<tr>
<td>R5</td>
<td>55</td>
<td>22</td>
<td>18,500</td>
<td>38.73</td>
<td>2.54</td>
<td>1.79</td>
<td>2.5</td>
</tr>
</tbody>
</table>

System-wide CR Requirement 50 MW

- **R4** is offline and now clears no products.
- **R5** is offline and clears offline Short-Term Reserve to provide the needed response capability.
- The load pocket energy LMP is $26.78/MWh. Incremental energy in the load pocket requires incremental Short-Term Reserve clearing on R5 and additional energy dispatched from R1, which shifts CR between R1 and R2 due to R1’s capacity constraint: $26.78/MWh = $1.79/MWh R5 Short-Term Reserve + $24.76/MWh R1 energy - $2.48/MWh R1 CR + $2.71/MWh R2 CR.

Table 5.3-1: Offer Data for 5-Unit Test System

Figure 5.3-2: Offline Short-Term Reserve Product Dispatch Solution

The following summary and Tables 5.3-2, 5.3-3, and 5.3-4 describe the market clearing result with the Short-Term Reserve product.

- R4 is offline and now clears no products.
- R5 is offline and clears offline Short-Term Reserves to provide the needed response capability.
• Outside the load pocket, the energy LMP is $24.99/MWh where incremental energy comes from R1 but also requires a shift in CR clearing between R1 and R2.

<table>
<thead>
<tr>
<th>UNIT</th>
<th>ENERGY LMP ($/MWH)</th>
<th>CLEARED ENERGY (MW)</th>
<th>ENERGY CHANGE FROM EX. I (MW)</th>
<th>RSG ($)</th>
<th>RSG CHANGE FROM EX. I ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>24.99</td>
<td>650</td>
<td>+16</td>
<td>5,401</td>
<td>-148</td>
</tr>
<tr>
<td>R2</td>
<td>24.99</td>
<td>50</td>
<td>0</td>
<td>3,074</td>
<td>-11</td>
</tr>
<tr>
<td>R3</td>
<td>27.78</td>
<td>300</td>
<td>0</td>
<td>1,176</td>
<td>-606</td>
</tr>
<tr>
<td>R4</td>
<td>--</td>
<td>0</td>
<td>-16</td>
<td>0</td>
<td>-463</td>
</tr>
<tr>
<td>R5</td>
<td>--</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.3-2: Offline Short-Term Reserve Product Example’s Unit Energy and RSG Results

<table>
<thead>
<tr>
<th>UNIT</th>
<th>CR MCP ($/MWH)</th>
<th>CLEARED CR (MW)</th>
<th>CR CHANGE FROM EX. I (MW)</th>
<th>SHORT-TERM RESERVE MCP ($/MWH)</th>
<th>CLEARED SHORT-TERM RESERVE (MW)</th>
<th>SHORT-TERM RESERVE CHANGE FROM EX. I (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>2.71</td>
<td>24</td>
<td>-6</td>
<td>--</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>R2</td>
<td>2.71</td>
<td>26</td>
<td>+6</td>
<td>--</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>R3</td>
<td>--</td>
<td>0</td>
<td>0</td>
<td>--</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>R4</td>
<td>--</td>
<td>0</td>
<td>0</td>
<td>--</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>R5</td>
<td>--</td>
<td>0</td>
<td>0</td>
<td>1.79</td>
<td>44</td>
<td>+44</td>
</tr>
</tbody>
</table>

Table 5.3-3: Offline Short-Term Reserve Product Example’s Unit Ancillary Services Results

<table>
<thead>
<tr>
<th>EXAMPLE TOTAL</th>
<th>$/MWH</th>
<th>CHANGE FROM EX.1 ($/MWH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy/Reserve Production Cost</td>
<td>$24,003 / hour</td>
<td>$33 / hour</td>
</tr>
<tr>
<td>Total RSG</td>
<td>$9,651 / hour</td>
<td>-$1,228 / hour</td>
</tr>
</tbody>
</table>

Table 5.3-4: Offline Short-Term Reserve Product Example’s System Production Cost and RSG Results

Figure 5.3-3 shows the R5 response to the loss of R3 and the associated import behavior. The import is able to be reduced to its limit within the required 30 minutes.
6. Alternatives Not Selected

Table 6.0-1 below shows three market-based options MISO considered for potentially addressing STCR needs. MISO assessed these three options against the following factors to identify the most effective to reliably address STCR needs in an economically efficient and transparent manner.

- Reliability – effectiveness of an option to ensure rampable capacity is available in the appropriate location to adequately address STCR needs
- Transparency – provision of explicit price signals reflective of the cost of addressing STCR needs
- Efficiency – alignment of needed reliability response time requirements with resource characteristics (e.g., lead time/ramp capability, online/offline) to allow broad participation of all capable resources

<table>
<thead>
<tr>
<th>NO.</th>
<th>POTENTIAL SOLUTION</th>
<th>ADDRESSES RELIABILITY NEED?</th>
<th>PROVIDES EXPLICIT STCR PRICE SIGNAL?</th>
<th>EFFICIENT FOR 30-MIN NEED?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Short-Term Reserve Product</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>Expand use of 10-Minute Contingency Reserve</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>Enforce N-1/G-1 Constraints in Market</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 6.0-1: Options for Addressing STCR Needs

As shown in Table 6.0-1, the three options can adequately address MISO’s STCR reliability needs. However, only the Short-Term Reserve product provides a distinct price signal that explicitly reflects the costs to address STCR needs and to incent entry of resources with the needed capabilities. In addition, only the Short-Term
Reserve product properly aligns the 30-minute response time with the required resource characteristics, therefore allowing for a broader resource pool and full resource ramp capability to participate.

The same illustrative four-unit test system used to demonstrate MISO’s current approach for addressing STCR needs and the Short-Term Reserve product (option 1) in Section 5 are used in the following sections to illustrate the expanded use of CR (option 2) and enforcement of N-1/G-1 constraints (option 3) to address STCR needs.

6.1 Example IV: Expand Use of Contingency Reserve (Option 2)

This example illustrates expansion of the existing CR product to address STCR needs. With this approach, two changes from the status quo are made to the market clearing model.

- The CR needed for the local issue is cleared in addition to the original CR requirement associated with DCS events. The total amount of CR cleared increases.
- The additional CR cleared in the load pocket is modeled as contributing toward the restoration of the load pocket import.

The results are depicted in Figure 6.1-1 below.

**Figure 6.1-1: Expand Use of Contingency Reserve Dispatch Solution**

In this scenario, 5 MW of CR is cleared on R4 in addition to the 50 MW total cleared on R1 and R2 for a total of 55 MW of cleared CR. The cleared CR is greater than the 50 MW needed for DSC events. The following summary and Tables 6.1-1, 6.1-2, and 6.1-3 describe the clearing results.
- The unloaded R4 capacity used to meet the post-contingent import maximum is limited by the CR response time and the R4 ramp rate to 5 MW = 0.5 MW/min * 10 minutes.
- To ensure R4 can achieve the needed output of 44 MW, R4’s energy dispatch is increased to 39 MW = 44 MW – 5 MW capacity cleared as CR.
- LMPs separate with R4 setting the energy price in the load pocket and R1 setting the energy price outside the load pocket.
- The CR MCP in the load pocket reflects the complex relationship between CR used for DCS response and additional CR used for STCR needs and incorporates both incremental total CR requirement and incremental capability to recover to the import limit within 30 minutes.
- Since R3’s capacity is fully loaded and R4 has already cleared its ramp-limited amount of CR, the most cost-efficient dispatch is to clear incremental CR on R2, the marginal CR resource with an incremental offer cost of $2.71/MWh.
- Re-dispatch of energy between R4 and R1 provides incremental capability for the 30-minute load pocket import constraint with a cost of $2.92/MWh = R4 energy increase at $27.68/MWh – R1 energy reduction at $24.76/MWh.
- The total CR clearing price in the load pocket is the $5.63/MWh.

<table>
<thead>
<tr>
<th>UNIT</th>
<th>ENERGY LMP ($/MWH)</th>
<th>CLEARED ENERGY (MW)</th>
<th>ENERGY CHANGE FROM EX. I (MW)</th>
<th>RSG ($)</th>
<th>RSG CHANGE FROM EX. I ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>24.76</td>
<td>611</td>
<td>-23</td>
<td>5,549</td>
<td>0</td>
</tr>
<tr>
<td>R2</td>
<td>24.76</td>
<td>50</td>
<td>0</td>
<td>3,085</td>
<td>0</td>
</tr>
<tr>
<td>R3</td>
<td>27.68</td>
<td>300</td>
<td>0</td>
<td>906</td>
<td>-876</td>
</tr>
<tr>
<td>R4</td>
<td>27.68</td>
<td>39</td>
<td>+23</td>
<td>403</td>
<td>-60</td>
</tr>
</tbody>
</table>

Table 6.1-1: Expand Use of CR Example’s Unit Energy and RSG Results

<table>
<thead>
<tr>
<th>UNIT</th>
<th>CR MCP ($/MWH)</th>
<th>CLEARED CR (MW)</th>
<th>CR CHANGE FROM EX. I (MW)</th>
<th>SHORT-TERM RESERVE MCP ($/MWH)</th>
<th>CLEARED SHORT-TERM RESERVE (MW)</th>
<th>SHORT-TERM RESERVE CHANGE FROM EX. I (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>2.71</td>
<td>30</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>R2</td>
<td>2.71</td>
<td>20</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>R3</td>
<td>--</td>
<td>0</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>R4</td>
<td>5.63</td>
<td>5</td>
<td>+5</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Table 6.1-2: Expand Use of CR Example’s Unit Ancillary Services Results

<table>
<thead>
<tr>
<th>EXAMPLE TOTAL</th>
<th>$/MWH</th>
<th>CHANGE FROM EX.1 ($/MWH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy/CR Production Cost</td>
<td>$24,052 / hour</td>
<td>$82 / hour</td>
</tr>
<tr>
<td>Total RSG</td>
<td>$9,943 / hour</td>
<td>-$936 / hour</td>
</tr>
</tbody>
</table>

Table 6.1-3: Expand Use of CR Example’s System Production Cost and RSG Results
Figure 6.1-2 shows that with R4’s energy dispatch increased above the status quo and the Short-Term Reserve examples, import can be restored to its limit in well under 30 minutes.

![Figure 6.1-2: Expand Use of CR Example's Import and R4 Response to R3 Trip](image)

Although this scenario meets the STCR need, using additional CR with a 10-minute ramp rate constrains the use of unloaded available ramp capacity for the STCR need to as little as one-third of what is available. The result is that more uneconomic energy from R4 must be used; a condition which would exist all the time, not just when there is a disturbance in the load pocket. The misalignment of the STCR need and 10-minute response creates a less efficient solution.

There are other issues to consider with this approach. For example, the CR deployed for STCR requirements (local, sub-regional, or system-wide) would need to be deployed in a separate manner from existing CR to ensure that the location of the CR MWs deployed for the load pocket constraint will satisfy the reliability requirements and that these deployments do not degrade the CR needed to respond to DCS events. Additionally, the frequency of deployments for STCR needs would be different from the frequency for 10-minute needs which may cause a preference for being operationally considered for one use or the other.

### 6.2 Example V: Enforce N-1/G-1 Constraint (Option 3)

This scenario is similar to the status quo with an additional transmission constraint representing the N-1/G-1 operating constraint: G-1 is the loss of R3 and N-1 is represented by the 126 MW load pocket import limit. With this approach, energy is re-dispatched to a greater degree such that no ramp time is required to restore the import limit following the loss of R3. The dispatch solution for this scenario is shown in Figure 6-2.1.
System-wide CR Requirement 50 MW

**Non-Load Pocket**
- LMP $24.76/MWh
- CRMCP $2.71/MWh
- Other RSG $8634

**Load Pocket**
- LMP $27.68/MWh
- CR not cleared
- Ld Pkt RSG $1323

**Results:**
- LMP split
- Reduced RSG
- Inefficient energy
- Reliability needs met

![Diagram of N-1/G-1 Constraint Dispatch Solution](image)

In this scenario, the 44 MW energy output needed 30 minutes after the potential loss of R3 is supplied all the time (not just when R3 trips) by the R4 energy dispatch. No unloaded available capacity from R4 is considered in the solution.

The following summary and Tables 6.2-1, 6.2-2, and 6.2-3 describe the clearing results.

- No unloaded R4 capacity is used to meet the post-contingent import maximum, so R4 is dispatched up to 44 MW in the base dispatch.
- LMPs separate with R4 setting the energy price in the load pocket and R1 setting the energy price outside the load pocket.

<table>
<thead>
<tr>
<th>UNIT</th>
<th>ENERGY LMP ($/MWh)</th>
<th>CLEARED ENERGY (MW)</th>
<th>ENERGY CHANGE FROM EX. I (MW)</th>
<th>RSG ($)</th>
<th>RSG CHANGE FROM EX. I ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>24.76</td>
<td>606</td>
<td>-28</td>
<td>5,549</td>
<td>0</td>
</tr>
<tr>
<td>R2</td>
<td>24.76</td>
<td>50</td>
<td>0</td>
<td>3,085</td>
<td>0</td>
</tr>
<tr>
<td>R3</td>
<td>27.68</td>
<td>300</td>
<td>0</td>
<td>906</td>
<td>-876</td>
</tr>
<tr>
<td>R4</td>
<td>27.68</td>
<td>44</td>
<td>+28</td>
<td>417</td>
<td>-46</td>
</tr>
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</table>

Table 6.2-1: N-1/G-1 Constraint Example’s Unit Energy and RSG Results
### Table 6.2-2: N-1/G-1 Constraint Example’s Unit Ancillary Services Results

<table>
<thead>
<tr>
<th>UNIT</th>
<th>CR MCP ($/MWH)</th>
<th>CLEARED CR (MW)</th>
<th>CR CHANGE FROM EX. I (MW)</th>
<th>SHORT-TERM RESERVE MCP ($/MWH)</th>
<th>CLEARED SHORT-TERM RESERVE (MW)</th>
<th>SHORT-TERM RESERVE CHANGE FROM EX. I (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>2.71</td>
<td>30</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>R2</td>
<td>2.71</td>
<td>20</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>R3</td>
<td>--</td>
<td>0</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>R4</td>
<td>--</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

### Table 6.2-3: N-1/G-1 Constraint Example’s System Production Cost and RSG Results

<table>
<thead>
<tr>
<th>EXAMPLE TOTAL</th>
<th>$/MWH</th>
<th>CHANGE FROM EX.1 ($/MWH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy/CR Production Cost</td>
<td>$24,052 / hour</td>
<td>$82 / hour</td>
</tr>
<tr>
<td>Total RSG</td>
<td>$9,957 / hour</td>
<td>-$922 / hour</td>
</tr>
</tbody>
</table>

Figure 6.6-2 shows that with R4’s energy dispatch increased above the status quo and Short-Term Reserve examples. The import would stay within its limit immediately following the loss of R3.

**Figure 6.2-2: N-1/G-1 Constraint Example’s Import and R4 Response to R3 Trip**

Although this scenario meets the STCR need, the use of the high-cost R4 for energy and reduced use of lower-cost R1 for energy makes the solution more expensive than necessary. This approach misaligns the 30-minute need with the exclusion of available unloaded capacity and creates a less efficient solution.
7. Conclusion and Next Steps

The addition of a Short-Term Reserve product to MISO’s Energy and Ancillary Services markets will further strengthen MISO’s vision for reliable and economically efficient markets. The reliability needs examined are most often addressed today but with significant out-of-market costs including RSG payments for RDT and load pocket STCR needs of about $35 million in 2017 and much more in some previous years. The Short-Term Reserve product aligns with MISO’s STCR needs and will allow the market to meet these needs more efficiently.

Three key anticipated improvements associated with the proposed changes accompanying the introduction of the Short-Term Reserve product are listed below.

- Increased efficiency in the MISO commitment process related to load pocket, RDT, and, when needed, system-wide reliability needs
- Improved transparency of the costs associated with satisfying STCR needs through Short-Term Reserve prices
- Enhanced reliability by aligning operational needs and market models to ensure the market dispatch provides the required 30-minute response in the needed locations

Consistent with MISO’s market vision and the MISO IMM’s recommendations, MISO recommends moving forward with the Conceptual Design phase of the Short-Term Capacity Reserve project. The proposed Short-Term Reserve product will be co-optimized with energy and other ancillary services and will have features patterned after other types of reserve including product offers from participants, location-based requirements (local area and/or system-wide requirements), and eligibility for supply by both online and offline resources.

While this document has demonstrated the impact of a Short-Term Reserve product in small-system examples, several complexities associated with a new Short-Term Reserve product have yet to be resolved such as detailed interaction with other ancillary services, scarcity pricing and demand curves, modeling of STCR needs related to voltage issues, identification of local causes for commitments to support cost-causation in settlements, and detailed business rules. MISO plans to address these and other issues in the Conceptual Design phase and looks forward to working with stakeholders to develop an effective Short-Term Reserve product.