Ramp Product Questions and Answers

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The following collection of questions and answers has been captured from the series of ramp capability product workshops (both internal and external). Also, Market Participants’ questions sent directly to MISO, and their answers, are included in this list.

Questions are categorized into the following sections:

1. Product Design
2. Requirements
3. Benefits
4. Cost/Benefit Analysis
5. Settlements
6. General

Where applicable, the references to MISO-posted presentations and documents are provided. These documents can be found on the following Webpage:

https://www.misoenergy.org/WhatWeDo/StrategicInitiatives/Pages/RampManagement.aspx

This document will be updated periodically and posted on the above Webpage.

Product Design

General

1) What is Ramp Scarcity?
   - It is a short-lived scarcity condition, when there is not enough ramp-able generation capacity in Real-Time, but there is enough total capacity on-line; so there is a need to sacrifice clearing one product, such as on-line contingency reserve, for shortage in the “up” direction and Regulation Service for shortage in the “down” direction.

2) Do the ramp products need to be implemented now?
   - Yes, because net load variability is increasing making system operations more challenging. By beginning now, we will get more flexibility out of our existing generation assets while being able to absorb the increased net load variability.

3) Will this be a new market or part of energy/AS market?
   - Ramp capability products are new products that will be integrated in the Day-Ahead and Real-Time Markets which currently clear energy, regulation, spinning reserve and supplemental reserve.
4) Will MISO enable availability offers for ramp?
   • No. MISO’s proposal is that ramp products will be cleared and priced using only opportunity costs associated with providing ramp, such as reduction in energy dispatch, to provide room to ramp “up” if needed.

5) Real-Time Operations uses “offsets” primarily for known errors. How does this new ramp product interact with “offsets”?
   • Using “offset values to correct forecasts” is one of the main purposes of the offset value. Another use of offset values is to pre-ramp units based on a projected ramp issue. The proposed ramp product can address this issue directly.

6) If payment is only opportunity cost, how MPs will change behavior since they will not be making any more money.
   • This statement is not entirely true. If a unit is not marginal, the cleared prices for “up” ramp capability and “down” ramp capability could be higher than its opportunity cost, leading to additional profit.
   • If a resource has an energy offer lower than the cleared energy price, it will receive an opportunity cost payment (at minimum).

7) If ramp capability products consider future intervals, do they require Look-Ahead-Dispatch?
   • Not necessarily. When solving for T1 (time period one), look at what is needed in T3 (time period three) (T3 = T1+10 minutes, for example)
   • The variation that needs to be covered for T3, from the T1 dispatch targets, defines the ramp needed for support at T1. However, the ramp capability products and the overall dispatch will be more efficient with a multi-interval dispatch.

8) Why would we need Look-Ahead-Dispatch if the ramp capability product is available?
   • Implementing LAD should provide additional benefits beyond the efficiency gain to be achieved with the ramp capability products. Both ramp products and LAD position resources to address future variability. Ramp products address variability (both expected and uncertain) for a defined time beyond the dispatch target. Although LAD does not address this uncertainty, it enables a more efficient dispatch by considering multiple intervals enabling economic tradeoffs and pre-ramping between different intervals.

9) We’re not sure how the commitment piece will work; could you please explain?
   • There are no changes to the process of close to real-time commitment. The change is that the analysis for real-time commitment will consider system-wide ramp products to recommend the most economic flexible resources for commitment which can provide the needed ramp capability in real-time dispatch.

10) Will the “headroom capacity” requirement be replaced by ramp requirements?
    • The headroom capacity requirements that are closely monitored and provisioned in Real-Time through the commitment process will be unchanged. The ramp products will assist in ensuring that the headroom provides adequate ramp capability.
    • Separately, the Day-Ahead commitment analysis currently incorporates constraints called “Market-Wide Ramp-Up Capacity Constraints” and “Market-Wide Ramp-Down Capacity Constraints.” These constraints, sometimes
referred to as “headroom” constraints, would be extended to make sure that this rampable capacity is considered both in the commitment and dispatch functions and on a system-wide basis.

11) What is the level of requirements in DA compare to the RT requirement?

- The Real-Time ramping requirements will not be known until Real-Time so the procurement of Ramp Capability products in the Day-Ahead Market will be based on estimates of Real-Time needs.

12) Confirm this is single interval dispatch, not savings from multi-interval dispatch included.

- Current design of the Ramp Capability products is based on single interval. However, it will also work with multi-interval dispatch.

13) Why not just use existing commitment and not introduce new products in dispatch?

- The idea is to enhance the dispatch to utilize the on-line units to create the required level of flexibility instead of committing new units. The new products allow for transparent pricing and dispatch when the flexibility is included in the dispatch constraints. In support of the dispatch function, the commitment function will also be modified to include the target requirements associated with the Ramp Capability products, which could lead to commitment of a different mix of resources to provide increased flexibility.

14) Confirm the following: Currently MISO often has to commit an additional unit to meet ramping requirements. With ramp products, MISO can avoid such commitments.

- This statement is correct. This avoided commitment may be achieved by enhanced dispatch of resources to provide additional flexibility and/or through the commitment of more flexible resources.

15) Examples in workshops (e.g., workshops 3, 4, and 5) presentations are associated with up-ramp when load is increasing. These examples involve higher deployment of some more expensive generators. Is there anything unusual about down ramp situations such as raising prices in down ramp situations?

- No anomalies were identified. Please refer to the down-ramp examples in those stakeholder workshops.

16) Other products we clear the Real-Time requirements in the Day-Ahead. Have we looked at doing that for ramp products?

- The idea is that the DA and RT requirements be as close as possible. Having a higher level of requirement in DA may add extra costs by getting more than is needed.

17) “Load charges are increased to compensate for ramp capability payments to resources”. What are the benefits to load (rate payers) from this Ramp Management mechanism?

- Improved reliability is the primary benefit. Reduced occurrence and magnitude of scarcity pricing is another benefit. Overall it is anticipated that there will a product cost savings, and there will be a significant load payment savings. Please refer to the examples and the cost / benefit analysis in workshops’ presentations.

18) Lastly, is this a pressing issue yet that needs to be addressed immediately? Or is this something that is anticipated to become an issue over the years, as older, dirtier units are retired or taken off line for retrofits? If ramp capability shortages are not yet a pressing issue, what’s the motivation for pursuing this mechanism at this time?
• Managing the ramp is the biggest challenge in MISO operations. The increasing penetration level of renewables is escalating the issue.

19) Why couldn’t MISO simply clear more regulation?

• Increasing regulation requirements to deal with the net load variability and uncertainty is a more expensive solution. Historically cleared prices in Day-Ahead and Real-Time for regulation are typically between $10/MWh to $20/MWh. The availability of regulation is limited in the MISO footprint. Increasing regulation requirements will increase the regulation clearing prices (and even cleared energy prices). The resulting higher price would be paid for all cleared regulation (not just the increased amount), increasing total cost of the base regulation requirement and relatively higher costs for the additional regulation. If is expected that URC and DRC would typically be less than regulation since regulation qualification is not required for the new ramp products. This was discussed in the technical workshop 4.

20) We would like to see full settlement example to understand the mechanics of URC and DRC as well as understand if there will be a new settlement charge type for billing purposes of URC and DRC. It is hard to understand how URC and DRC do not have a new offer parameter(s), yet it is cleared as a (separate) product. Slide 3 stated URC and DRC will be deployed as dispatched energy, yet slide 6 stated payments for URC and DRC will be a similar approach as AS products. For clarification purposes, do this mean URC and DRC will have LMP or MCP for the clearing price?

• Please refer to the end to end examples in technical workshop 5 (slides 10 to 25) for general examples of the settlements.
• URC and DRC will have MCP in DA and RT markets. You may look at it as a product with zero offer so that the cleared prices represent only the lost opportunity cost in DA and RT markets. The zero offer option is chosen for the following reason (which was presented in the technical workshop 3). Since UDS will dispatch units based on the target interval conditions, there is a possibility that units’ movements do not coincide with their cleared URC and DRC 10 minutes ago. Because (1) adding availability offer will widen this gap, (2) overall prices for URC and DRC would increase causing load to pay a premium, and (2) there is no direct link between availability offer and any additional operational cost encountered by providing the capability, the MISO current proposal is based on the zero offer for URC and DRC products. However, this option can be explored more.

21) How does this URC and DRC product fit into Look-Ahead-Dispatch when LAD is implemented?

• The current design can be fit into the single interval dispatch and multi interval dispatch. Same set of business / market rules are applicable. Problem formulations are very close to each other. Please refer to the materials for workshops 2, 3 and 4.

22) It has been stated that “Eligible resources (dispatchable resources including DIR) can clear for URC /DRC in Day Ahead Market” and “Self scheduling of ramp products is not allowed in Real Time or Day Ahead Markets”. If it is similar to A/S products, why would you not allow a MP to self-schedule? Conversely, are you going to allow a unit to submit as an offer parameter the option of being “Not Qualified” or “Not Participating” for URC/DRC? Please note that we have commented previously that having the option to choose if a unit is participating or not participating is very important, and should be incorporated into the design.

• Self-scheduling of URC / DRC appears to be in conflict with the design concept. The emphasis of this design is to utilize the on-line rampable capacity to fulfill the system need. Also deployment of these products lies within the dispatch function and is not a separate function or process. Economic dispatch will deploy part of URC/DRC
MWs cleared in previous intervals to fulfill current system need and also clear new URC/DRC MWs in anticipation of the need for the future intervals. If this capacity is self-scheduled then it will continue to be cleared for future dispatch intervals and can never be deployed for the current dispatch interval.

- Resource participation in the ramp capability products is voluntary. Resources can opt out from clearing ramp products by specifying their ramp product participation through a new attribute of Ramp Capability dispatch status. Ramp Capability dispatch status can be updated on the same timeline as other DA and RT offers and the acceptable status are ‘Economic’ or ‘Not Participating.’ Resources that are opted out will not be cleared for ramp capability during the dispatch process.

**Resources**

1) The ramp management enhancement tool could give a low cost generator with a high ramp rate a DA award below full load for ramp management. Does this mean that a 600 MW base load unit with a 5MW/minute ramp rate and a cost of $15/MW could get a DA award for 575 MWs (25 MW below maximum load for ramp management), even if the DA LMP was $28?

   - In this case, withholding per MW of ramp capability from this unit would incur an opportunity cost of $13 ($28 - $15). Since the demand curve price for the ramp capability product is $5, the demand curve would limit the ramp clearing and this unit would not be clearing ramp but get a full-load DA award of 600MW.
   - Nevertheless, this understanding is true if the ramp capability incur an opportunity cost of no more than $5, e.g., when the DA LMP is $18. In that case, the unit could get a DA award for 575 MW and for its cleared URC of 25 MW the unit will receive a payment at the MCP for URC of at least its opportunity cost of $3 ($18 - $15). As such, this unit will be at least indifferent in providing energy or the URC or can receive additional profit if this unit is not marginal and the cleared price for URC is higher than its opportunity cost.

2) Is participation in ramp capability voluntary?

   - Yes. Resource participation in the ramp products is voluntary. Resources can opt out from clearing ramp products by specifying their ramp product participation through a new attribute of Ramp Capability dispatch status.

3) Stored Energy Resources can only participate in Regulation. Will you allow them to participate in Ramp Up or Ramp Down?

   - The short-term storage resources (SER) will continue to provide the regulation since it is higher price product than the ramp products and resource can have more revenue by providing ramp. Another issue related to SER’s is that they cannot sustain for an extended period of time (e.g., 60 minutes) the deployed ramp needs.
   - For long term storage resources it is a different picture they can participate in ramp products and make revenue in providing ramp capability alongside energy and AS products. (Such provisions for long-term storage resources do not exist in current MISO markets.)

4) Can Demand Response participate in these products?

   - All online resources with a dispatchable range participate. (DRR-2)

5) Can offline resources participate?
• The current design of Ramp capability products is restricted to the on-line resources’ contributions.

6) No new offer elements?

• Yes. Just look at opportunity cost for these new products in current optimization.
• The option for considering availability offer for these products was studied. Since the deployment of these products are happening through the dispatch function and due to the changes in the system conditions we might move units differently than it was cleared 10 minutes ago. Such gap between the clearing process and the deployment is not sending the right price signal and the incentives.

7) Does the bi-directional ramp rate go away?

• This design is not imposing any restriction or change on the resource ramp rate. Since we have two distinct products for Up ramp and Down ramp we can work with bi-directional ramp rate as well as separate ramp up and ramp down rates.

8) Do resources have the option to participate?

• Yes. Resource participation in the ramp capability products is voluntary. Resources can specify their ramp product participation through a new attribute of Ramp Capability dispatch status. Ramp Capability dispatch status can be updated on the same timeline as other DA and RT offers and the acceptable status are ‘Economic’ or ‘Not Participating.’

9) It seems bidding & offering ramp capability is optional? What are the impacts for not offering or bidding any ramp capability once this mechanism has been implemented?

• Resource participation in the ramp capability products is voluntary. Resources can opt out from clearing ramp products by specifying their ramp product participation through a new attribute of Ramp Capability dispatch status. Ramp Capability dispatch status can be updated on the same timeline as other DA and RT offers and the acceptable status are ‘Economic’ or ‘Not Participating.’ Resources that are opted out will not be cleared for ramp capability during the dispatch process. If a resource chooses to participate, no availability offer is enabled at the initial implementation of the ramp products. As such, the prices will be determined based on opportunity costs. The proposed pricing mechanisms can be summarized as:
• Opportunity Cost Only in which the ramp capability clearing prices are determined only by the opportunity cost of a resource providing the capability (e.g., if a resource is dispatched down from otherwise economic energy production to provide ramping capability, it has experienced a lost opportunity cost). There will be demand curves to cap the cleared price of these products.

10) “Wear & tear costs can be compensated for, although maybe not at a 1:1 ratio.” Does that mean that resources that offer but don’t deliver may be funded for wear & tear that didn’t occur?

• Resources may be compensated for ramp capability even if their increased flexibility was not needed in a future dispatch. However, they did provide some value in that they were available if variation had occurred. In a competitive market, the wear and tear costs should be spread out over the times in which they would occur. For example, if the wear and tear were to occur “randomly” one time out of five, one might expect the offer to reflect 20% of the wear and tear costs in each of the five time intervals.
11) What are the differences between those who offer but don’t supply ramp & those who offer AND supply it? Where do they benefit over those who don’t actually supply it? And how will offers not cleared in the day-ahead, but actually called upon in real-time work? If you’re offer for up or down ramp capability is not cleared, are you still obligated to offer it in real-time? And how will that be compensated?

- Ramp capability provides the operational flexibility in the system level which may be needed to deal with uncertainties and expected variations in real-time dispatch. Whether subsequently dispatched for energy or not, the resource was available to serve the system reliability needs for energy in real time.
- Those who are selected to provide energy in a subsequent dispatch benefit by having the opportunity to produce an increased amount of energy.
- The Day-Ahead and Real-Time Markets are independent. A resource capable of providing ramp capability in the Day-Ahead Market but was not selected may participate in the Real-Time Market using its real-time Offer. Offering ramp capability is optional. (See earlier discussion on pricing options). There is no additional compensation for making this offer – by providing a ramp rate and a dispatchable range, the resource is already indicating that it is available for changing its output as system conditions warrant.

12) Does a generation resource need to offer same ramp rate offers in DA and RT markets?

- There is no need to change the current ramp rate offer in DA and RT.
- This could include a ramp rate curve in both DA and RT.
- The current design of URC and DRC can work with a wide variety of ramp rate models in DA and RT markets. Since there are not currently plans to change the existing ramp rate model, the design of URC and DRC are described relative to the current ramp rate model.
- Your suggestion for a ramp rate curve in both DA and RT is a valid one. However, a change in the format for specifying ramp rate is decoupled from the implementation of URC and DRC. If a change to the specification of ramp rate (e.g., a ramp rate curve) was agreed amongst the MISO stakeholders, the implementation of that change in the specification of the ramp rate could be implemented before, concurrently, or after the development of the URC and DRC products. Proposals for changes in the specification of ramp rates should be discussed in the MSC and other MISO forums.

**Pricing and Costs**

1) How will ramp product demand curves impact pricing?

- Ramp product demand curves are setting a price ceiling for providing adequate ramp capability for future needs which includes an uncertainty component. Higher ramp needs could increase the cleared prices. Consequently, without demand curves we might end up with paying much higher premium in redispached intervals compare to the savings in the intervals with ramp shortage. The tradeoff encapsulated by the demand curve is between the uncertainty of the ramp requirements in future intervals and the willingness to pay higher premium.

2) What are the units for pricing the ramp products?

- The ramp products are capacity products limited by the resource ramp rate(s). Pricing is in $ per MW of ramp product for an entire hour, $/MW /h, or just $/MWh.

3) How will ramp product prices compare with ancillary service products?
• Ramp products may not be binding much of the time and prices will be zero. When there is not surplus capacity, ramp prices come from the ramp opportunity cost and the ramp demand curves.
• Overall, it is anticipated that the ramp products will be much cheaper than regulation prices (addressing the need for increased system flexibility needs by increasing regulation requirements was considered but not adopted as a viable solution).

4) Will ramp products increase LMPs in intervals without scarcity?
• Yes. However, when there is enough in the system, the price is zero and no impact on dispatch or LMPs. As the system gets close to running out of rampable capacity, re-dispatch will ensure sufficient ramp capability and as a result the energy prices might change as well as the ancillary services and the ramp product could have a non-zero price.

5) How would the world look different for a specific unit?
• A specific unit that was subject to an out of merit dispatch will receive opportunity cost and the cleared price for the ramp products. Therefore, it does not have any economic incentive for not providing its available flexibility. This will ensure that in the future it will continue to offer its flexibility.

6) There will be 2 new MCPs?
• Yes. One for Up Ramp capability (URC) and one for Down Ramp capability (DRC) product.

7) Demand curve needs to be carefully designed; possibility of too high or too low may end up either making the constraint ineffective or leading to costly solution / price volatility
• Overall the statement is true. The main issue here is how the proposed demand curve is designed. It represents our willingness for higher prices in the unconstrained intervals to avoid or reduce the price spikes for the short-lived scarcity conditions. Since part of the up ramp and down ramp capability is based on the uncertainty down the road which could not be materialized, the tradeoff can be translated to: how much we want to pay now for a potential saving in a future interval which may have a ramp shortage.

8) Similar to DA headroom, adding these requirements will increase costs - similar to existing reserve products.
• Since we are trying to commit more flexible units and also we are pricing the ramp products there is a chance that the DA prices might increase slightly. However, the saving will be in avoidance of the short-lived ramp scarcity conditions and avoiding committing fast start up units close to RT to create the necessary rampable capacity. Overall, we can expect a production cost savings (including both DA and RT) depending on the selection of the requirement levels and the demand curve parameters.

9) $5/MWh demand curve. When shortage, LMP will be raised $5/MWh. Is this too small to maintain the requirement? If make larger, too big of an impact on price. Will it create value is move LMPs up by the amount of the demand curve?
• Answer: Don't pay high premium now for something that may change in the future. In addition, based on the study of historical cases, a demand curve price of $5/MWh strikes the balance between how much we want to pay now for a potential saving in a future interval and obtains most production cost savings.
• Answer: When there are not enough ramp products available at the demand curve price, less than the requested amount will be cleared. When this happens, the demand curve will participate in setting the price and will increase the LMP. With a low demand curve price, the impact on the LMP will not be large. If the use of the demand curve is infrequent (it is expected that often the ramp product prices will be zero) the total demand curve induced cost will be small and not impact the overall value.

• As an alternative, when the demand curve is used, the dispatch could be re-solved with the ramp product requirement reduced to the achievable level to eliminate the impact of the demand curve on pricing.

10) Reduce volatility: If the average energy price is predicted to increase, by how much?

• The cost / benefit analysis provides an insight for the production cost savings in MISO system. Some factors to consider but do not describe whether predicted increase or how much:

1) When comparing at a single snapshot of the system, with and without the ramp capability products, the system cost and prices could be higher during times of slower transition with ramp capability products and the cost and prices would be lower during volatile periods. The simulation results show that during the price spike periods there is a production cost savings and also during non-price spike periods, there might be a production cost saving due to pre-ramping and smoothing small jumps in the cleared prices.

2) A new product competing for capacity tends to increase prices since it adds constraints to the optimization,

3) Better positioning of resources will enable a more flexible response to ramping needs and reduce prices during short term events which would have otherwise stressed the system

4) If ramp capability is made a product, resources will have a new revenue stream to help meeting their long-run operating costs which may reduce the offered pricing for energy.

11) Estimating energy price changes is challenging due to the interaction of complex processes including the market strategy changes of the Market Participants. Will this be a new market on its own?

• Ramp capability is proposed to be a new product whose procurement will be added the existing Day-Ahead Market and Real-Time Market which currently clear energy, regulation, spinning reserve, and supplemental reserve. Ramp capability requirements would also be included in the RAC analysis to ensure that the committed capacity could support the ramping needs.

12) “Demand curve price for Ramp Capability shortage is $5/MWh”. Wouldn’t ramp be measured more in MW/h or MW/minute? Why does energy play a part in what seems more appropriately described in a change in power over a change in time, not power times time?

• The way the products are proposed, ramp capability is expressed in terms of MW ramp over a specified period of time such as 10 minutes. The demand curve price is expressed in terms of dollars per MW shortage for an hour or $/MW per hour, $/MW/h or equivalently $/MWh.

Clearing and Sharing
1) If resource output is modified for ramp capability will the resource look like it is not following dispatch?

- Not due to the provision of ramp capability. The dispatch instruction will recognize that the resource dispatch is modified to provide additional ramp capability.

2) How will it be determined what resources have been deployed for ramp product?

- There is no need to determine which resources have been deployed. Ramp capability products provide a flexible option for real-time dispatch. When needed the most cost-effective resources will be dispatched to provide energy.

3) Consider deliverability similar to reserve procurement constraints; currently the DA ramp constraints don’t work sometimes because of transmission constraints.

- The existing DA ramp capacity constraints are system wide. The new ramp product requirements are set system wide, too. However, we might be faced with the local transmission congestion issue similar to other reserves. The general solution for local deliverability of ancillary services (transmission constraint for post deployment of AS) or ramp products (transmission constraint for post deployment of ramp products) is adopted here.

4) 10 min product; how is it different than spinning reserve.

- This product is different than the spinning reserve due to its deployment. The deployment of the ramp products are embedded into the dispatch function in the real-time and no additional system is required as part of deployment strategy. When energy is dispatched for the next interval by the real-time dispatch function (RT-UDS), the ramp products are naturally deployed as energy as needed (and economic). Ramp products will be deployed very frequently and almost continuously vs. deployment of the spinning reserve which is very rare and in response to a specific event.

5) Congestion: What are the benefits associated with congestion?

- In general, these products will not remedy congestion issues. However, if the congestion has happened due to the shortage in the ramp in part of the system, URC / DRC might reduce the impact of the congestion. Please check the simulation results in cost / benefit analysis section.

6) Holding capacity for ramp capability may appear that resources are not following dispatch signals. How will this be accommodated?

- Ramp capability will be part of the market clearing function so resource dispatch instructions will align with need for resources to provide ramping. For example, if a resource’s dispatch may be reduced from otherwise economic energy production to provide ramp capability. The resource will be paid for its opportunity costs through the ramp capability product payments. The dispatch signals will reflect the withheld cleared ramp capability.

7) “No specific event signals deployment of ramp capability” Won’t this make it difficult to determine who actually dispatches their ramp capability vs. who just offers it?

- The value of the ramp capability products is in having the needed operational flexibility at the time of the next dispatch to respond to the variability and uncertainty that has occurred in real time. When ramp capability was
withheld in a previous dispatch, it is available to be deployed as energy in the current dispatch and communicated as dispatch instructions.

Ramp Sharing

1) Consider interaction with Regulation. You may not be adding all the ramp capability that is procured through this product due to ramp sharing.

- If such decision is taken for current market rules we can respect it in this design. You should consider the timing of such needs. This means that at the interval unit is moved behind its dispatch obligation due to its regulation deployment and stays in such position for the entire period that Up ramp or down ramp is enforced (in these examples another two intervals). This could be a rare scenario.
- The purpose of ramp products is to ensure that with the information we have at the time we determine the dispatch at t1 (e.g., at t1-10 minutes for a dispatch used from t1-5 to t1) that the resources have the ramp capability needed to ramp from the t1 solution to the range of anticipated variability between t1 and t1+ramp response time (e.g., 10 or 30 minutes). At the time of dispatch, the expected regulation at t1 is 0 MW. As time approaches t1, we may find that regulation has been deployed such that regulating resources are not at their t1 dispatch targets which impact the rampable range of the resource for time t1+ramp response time. This is expected; as system conditions change and we have more information about a specific point in time some of our planned flexibility may be consumed. We will be in a better position to respond to changes beyond t1 than we would had we not considered the variability beyond t1 in our dispatch.
- The purpose of regulation is to provide regulation capability during the dispatch interval t1-5 minutes to t1. Ramp capability is describing flexibility needed beyond t1. They do not directly interact through ramp sharing.

2) A/S share ramp rate between energy and A/S

- The ramp used for energy and ramp products apply for different time frames: energy ramp gets resources to the dispatch solution from current resource output and ramp products look at the ramp required beyond the dispatch solution. For a single-interval dispatch, the ramp used by energy and ramp products does not overlap. For multi-interval dispatch, one interval may interact with another, but since the ramp products cover all variations (expected and unexpected) in net load including the expected change in load, the ramp products and energy dispatch can re-use the same ramp rate.
- Based on the current market design the ramp rate can be shared between energy and Ancillary Services. The same concept is preserved in this design between ramp products and AS products however the time at which the ramp would apply should also be kept in mind.

Requirements:

1) How are future ramping needs determined?

- The proposal for the Day-Ahead Market and RAC is that ramping needs will be forecasted based on anticipated future operating conditions and historical real-time ramping needs.

2) Are you going to have same requirements at DA and RT markets for the same operating day, even considering the differences by the ramping periods, etc? For example, intra-hour variations where ramp related problems occur won’t be seen by the hourly DA Market intervals.
RT is based on RT operating conditions including known variability of the net load and the uncertainty associated with its components. It is anticipated that RT ramp product requirements will vary within an operating hour.

- DA is provisioned based on expected RT intra-hour operating conditions such as forecast (not bids and offers) and historical RT ramp requirements.
- The aim is that the DA requirement will be close to the hourly average of RT requirement which includes the intra-hour ramp needs.
- DA requirement will be a function of the time of the day and time of the year. It is possible that each hour will have its own distinct requirement for each product.
- The hourly variability of the net load does not include intra-hour variation. Statistically it is shown that the per minute value of 10 minute variation is 25% to 30% higher than the per minute variation of the hourly value. This increased level of intra-hour variability will be included in the DA requirements to reflect the expected RT ramp product requirements.

3) I would really like more explanation on how Ramp Capacity is going to be calculated for Day Ahead. Slide 16 states that “Day Ahead ramp capability requirements are estimated based on anticipated Real Time requirements, and they are “identified on system and / or zonal levels.” How are the Real Time requirements anticipated? What all goes into the anticipation formulation? Wind? Similar day forecast? Please elaborate.

- In Real Time, the URC / DRC requirement is calculated every five minutes as explained in the workshop presentation. The historical hourly values from previous similar days with approximately the same level of wind generation (as predicted for the next day) will be used. The requirement for the Real Time and Day Ahead will be at system level. No zonal requirement is needed.

4) How do we compare the 60% of load ramp headroom (e.g. 3000 MW for 5000 MW load ramp) with the 1800 MW up ramp requirement?

- The 60% of load ramp headroom corresponds to the allowable headroom monitored in real-time. This is not modified by the introduction of the ramp products. The expectation that the headroom monitoring will continue just has it has in the past.
- The 1800 MW (or other suitable value) up ramp requirement may impact which resources and/or which capacity on resources is used for energy and which counts for energy – the up ramp requirement will ensure that a portion of the reserved capacity is rampable. If the allowable headroom is 3000 MW, currently there is no constraint on how much of that capacity can be realized in a finite period of time (although slow ramping units may be excluded from the headroom total). Ramp product constraints will ensure an adequate portion of the headroom can ramp to meet requirements within the specified ramp time.

5) Scarcity can occur when headroom capacity is available, but ramp is not. With ramp capability modeled, it may be possible to reduce headroom over time.

- Ramp products will make sure that enough of the headroom capacity is rampable.
- Focus is on keeping the ramp in RT dispatch - impact on commitment of units is extra benefit (and potential extra savings) when included in commitment function.

6) How much ramp we need to reserve?

- Uncertainty + variability...the total 10-min number maximum is 1800 MW at 2.5 standard deviations during the morning ramp. When going down in the evening, it is similar. If the ramp response time is a longer time period,
the requirement would be larger. However, 2.5 standard deviation (99% of the anticipated scenarios) is expected to be the maximum variability that may need to be covered.

7) How do we consider the 5 minute wind forecast in DAM? The DA clearing process does not use the wind forecast.

- There is no need to consider 5 minute wind forecast in DAM. RAC process uses the hourly wind forecast. The DAM Up Ramp Capability and Down Ramp Capability requirements are defined based on the anticipated/historical needs in RT which covers the known net load variability plus the uncertainty associated with each component of the net load.

**Benefits**

1) Will ramp products reduce price volatility?

- Ramp products will make the system better positioned to handle net load volatility in operating conditions which will reduce price spikes and thus reduce price volatility. Ramp products are not expected to significantly reduce smaller variations in price as demonstrated in the following diagram.

![Price with Ramp Products vs Price without Ramp Products](image)

2) Are benefits during congestion or uncongested?

- This product will have system-wide requirements similar to other ancillary service post deployment constraints. Deliverability issues will be addressed by post deployment transmission constraints.

3) Is it better to say that this product will reduce the need to use real-time processes currently in place to deal with variability?

- This is accurate statement. It will provide a systematic approach within the market system commitment and dispatch and provide price signals. Inclusion of the ramp products will reduce the need for other real-time processes (such as the portion of the load offset that is to deal with ramp needs) as well as enhancing Market transparency of dealing with real-time ramping needs.
4) Anticipate savings also based on reduction in use of offset values
   - Same of previous question.

5) Explain the dampening effect in terms of price volatility as compared to LAD.
   - Since these products are going after those short-lived price spikes driven by ramp shortage, it is anticipated that it will damp the changes in the price profile. Multiple examples show this damping.
   - No such comparison vs. LAD has been performed yet.

6) In Hr3 RT dispatch in the combined DA and RT example, what committed G5?
   - The estimated ramp shortage by operator and manually committed close to RT or LAC function using the processes that currently exist today. There is no change proposed in basic steps to commit a resource in real-time.

7) There are no units in MISO that can start in 10 minutes; all commitments must be made at least 30 minutes ahead of time. Is the end-to-end example compatible with this aspect of MISO operations?
   - It is agreed that due to start up time and the notification time the commitment decisions should be done 20 to 30 minutes ahead of time. This does not change the picture. The point is that there is less needs for close to RT commitments.
   - Changes in all analysis functions from DA Market to RAC to RT.

8) Additional benefits in management of the UDS offset - operator has to approximate needs related to ramping today. This process will help.
   - Correct.

9) This is similar to look ahead dispatch which is known for price volatility. Why don't these ramp products cause volatility?
   - Volatility comes from deviations in expected system conditions. With a multi-interval dispatch, net load changes in the future intervals can impact current interval prices so current interval prices are subject to more volatility. Ramp solves for a range of feasible solutions where feasible dispatch is possible and is more similar to today’s ancillary services.

Cost / Benefit Analysis

1) In the study done by Scott Harvey, confirm that the redispatch was based on the original input data each interval - no actuals.
   - Confirmed.

2) Payouts (benefits) need to be high considering many intervals of added cost
   - Correct. Including the reduction in the shortage, the calculated benefit ratio for the example was over 75.
3) Is benefit the net over all 6 intervals?
   - Yes. Additional cost in intervals leading up to price spike is less than savings in the spike interval.
   - This example is showing savings from just redispatch, not avoided real-time commitments

4) Is ancillary cost included in Harvey example?
   - Yes

5) The Harvey analysis did not fully re-run SPD. How much confidence is there in the results?
   - Not running SPD is a concern. Only 3-4 units are marginal so the redispatch calculation is manageable.

6) Payoff is for 6 period analyses. Is an estimate for a whole day available?
   - No. Only looked at isolated time points; not looking at the whole day to estimate a typical day.
   - Harvey’s idea is to look at isolated time points in initial pass and looking for big savings ratio.
   - If you look at a day, you may see the same benefits.
   - The approach was to look at the times when there was savings and look at the ratio of the time when there are price spikes. Looking now for 60X savings during peaks to make up for non-spike times.
   - Additional benefits on operations, avoided commitments and avoided construction costs - these don’t show up in dispatch.

7) What is the Ratio of savings? Why is it 75?
   - benefit in price spike interval/ average production cost in 5 intervals prior to the price spike interval = 75
   - average of 5 intervals prior have additional cost (denominator) vs. savings in the intervals with benefits
   - 75 means comparison is on a one interval to one interval cost.
   - Ratio 5:1 - the cost savings would be wash over the duration of this example.

Questions from 6th workshop presentation for cost / benefit analysis:

8) I really appreciate the effort that went into the URC/DRC Simulation Analysis, but I may need a more in-depth explanation of the analysis and results. Some of the questions that I have include:

Please explain the Offer Cost Savings in greater detail... are you saying that this is the reduced cost from not having to commit additional generation due to a RT price spike, which may either (a) cause generation to dispatch higher on their cost curves, or (b) cause additional generation to be committed in the RAC process?

- Offer Cost Savings does not relate to avoided commitment cost but does relate to avoidance of dispatching generation higher on their cost curve during RT price spike. Production cost is simply driven from resources’ offer parameters for all products. If a resource has an offer of $20 for energy and $2 for spinning reserve and the cleared prices for energy and spinning reserve are $45 and $5, the production cost related to this resource is its dispatch MW multiplied by $20 and its spin allocation multiplied by $2 and the production cost for the system will be the sum of cleared MW for each product multiplied by its offer for each resource. During the price spike the same rule applies.
9) Similarly, please explain the Un-served Products Savings... it states on slide 56 that the value of un-served products is the “estimate value of reductions in ancillary service and ramp product deficits based on shortage prices”... so does this “cost” come in to play only when the demand curve is reached for ancillary services or energy?

- The short answer is “yes”. Suppose that there was a requirement of 900MW for spinning reserve. However, due to system conditions we end up clearing only 750 MW of spinning reserve. The rest of the 150MW of spinning reserve are the un-served portion of the spinning reserve. The demand curve for spinning reserve has been set to $98. Assume that the market clearing price for spinning reserve is $101. Now, by adding URC / DRC to the solution, we could have served 100 MW of this shortage and we will be short only by 50 MW for spinning reserve. Un-served product saving is related to the 100 MW of additional spinning reserve which could be served and the savings will be 101*100=$10,100. The same goes with other products such as regulation and supplemental.

10) On slide 60, for the July 6, 2012 URC/DRC Simulation analysis, please explain more about the URC/DRC binding periods, and please relate this to actual events of the day... for example, the simulation predicts the number of 5 minute intervals that would have bound for URC/DRC, but did that mean that on that day that we reached the demand curve for A/S for the same number of intervals?

- This is the peak date in 2012 with some specific issues such as DCS event. There were a number of price spike periods driven by a combination of ramp shortage and transmission constraint violation. The URC / DRC constraints were not only binding during the price spike periods but also during few intervals ahead of price spike interval (e.g., 2 to 3). Also, the URC / DRC constraints are binding in other periods outside the main price spike intervals. This is related to the fact that pre-positioning of the resources could assist in reducing (or eliminating) the smaller price jumps (e.g., above $10 price jumps and less than $100 price spikes associated with spinning reserve shortage). The number of binding conditions for this set of intervals is much higher than the intervals with price spikes. However, the simulation results illustrate that the production cost savings are higher during the price spike intervals with AS shortage compared to the production savings outside these intervals.

11) If I understand correctly, the analysis took the 4 sample days shown in the presentation (July 6, July 28, Sept. 15, and Oct. 14), and then designated each day of the year as one of these sample days for an annual analysis. Is this correct, or close to correct? If so, what was the distribution of each of these sample days? Out of 365 days in a year, how many were modeled as July 6, how many as July 28, and so on?

- This aggregation methodology is working as following: As explained in the previous question, the 288 intervals in each day have been divided into two parts: a) price spike periods (including Up and down spikes and 2 to 3 intervals prior to the start of each price spike; b) non price spike periods. For group of intervals in the first group are annualized by using two methods: I) using number of price spikes in these 4 days and the total number of price spikes during 2012 (slide 74); II) using number of intervals in each price spikes in these 4 days and the annual number reported in slide 74. For the non-price spike periods, we have averaged the 4 day results and then identified the annual savings (refer to slide 77). The total annual results is the sum of the two sets of savings (refer to slide 78). Please keep in mind since we have used two different methods for the price spike periods we end up with two values relatively close to each other and the final savings are presented as a range. (Overall, I suggest you to go back to slides 74 to 78).

12) On slide 79, please explain the relation between URC/DRC implementation and the reduction in CT commitments. It appears that a broad assumption is being used... Does the analysis predict there will be on average one to two less CT commitments per day, or is this just a rough guesstimate?
The DA to RT example (slides 33 to 45) could be used as a reference. URC /DRC implementation in DA and RT provided savings dominated by eliminating the need for committing the CT in RT as a result of a different commitment pattern in DA. In slide 45, we have presented the range of potential savings associated with avoiding a CT commitment assuming that it was committed only for one hour (very conservative assumption). Estimating that we could save at least one or 2 CTs per day, the production cost saving is approximated around $2M. WE did not simulate the entire DA process with MISO production data in this estimate.

13) I am a little surprised that the prediction of URC/DRC binding approximately 10% of the time... Based on previous discussions, it was my understanding that it was much lower than that (the number that sticks in my head was 2%). Please explain more how you came up with the value of 10%, and is this just a function of the assumptions made for the results presented today?

- Please refer to the previous answers. You are right that price spike periods are around 2% of the intervals in RT. However, the URC/DRC could be binding outside these price spike periods to reduce or eliminate smaller price jumps which do not contain any AS shortage.

14) Maybe it has been stated in previous workshops, but what is the cost that MISO is spending to design, implement, and place into production the URC/DRC Product?

- There are a number of functions within MISO DART system are impacted plus settlement and communication systems at minimum. The initial estimate for these changes is less than the production cost savings and the savings in un-served reserves in a single year. MISO is working with vendors to define the detailed implementation costs.

**Settlement**

1) Who is going to pay? Load or load plus exports?

- Same as other AS products load and exports will pay.
- There was discussion that Wind should pay for this, but this problem existed before wind too.
  - 10GW wind (before DIR) is less than 10% of variability
  - 5 GW wind, NSI was bigger impact on variability than wind.
  - Majority of variability is from load; however % uncertainty of load is lower.

2) If loads are charged for the ramp capability payments to generators, what are the benefits to the load?

- There is an expected production cost saving and offsetting savings from avoiding real-time CT commitment due to the ramp shortage, increased flexibility in operations, reducing the load payments during price spikes and improving reliability.

3) How is the settlement of imbalance between DA clearing and RT clearing handled?

- In today’s market design, we can have mismatch between AS requirements in RT and cleared DA AS products. We have settlement rules to deal with this.

4) “Revenues from Ramp Capability included in make whole payment calculation” Does this mean that it’s in addition to any make whole payment, or that it contributes toward any make whole payment owed?
• The intent of this statement is that the revenues from the ramp capability products would contribute toward reducing any owed make whole payment.

**General**

1) Run time increase with new products?
   • Yes, but small increment; should not be an issue

2) Release along with ELMP?
   • 2014/2015 is date for ELMP
   • Most likely will be sequenced just after ELMP.

3) Discussion with IMM?
   • Yes. IMM is behind it. IMM sees the value in dealing with the uncertainty.

**Acronyms**

AS Ancillary Service(s)
DA Day Ahead
DAM Day Ahead Market
DRC Down Ramp Capability
LMP Locational Marginal Price
MCP Market Clearing Price
RT Real Time (Real-Time)
RAC Reliability Assessment Commitment
URC Up Ramp Capability