

Business Requirements Specification

Commitment Costs Phase 3

Document Version: 1.9

Date Created: 12/21/2016

Revision History

Date	Version	Description
12/21/2016	1.1	Create Document
4/7/2017	1.5	<p>Move data process for input to Opportunity cost optimization model from ECIC to OCC: BRQ5214, BRQ5215 BRQ5216 BRQ5217 BRQ5218 BRQ5219 BRQ5220 BRQ5221 BRQ5222</p> <p>Change Opportunity cost related requirements start with OCC_</p> <p>BRQ5430 Change OCC 15 minute interval to hourly interval optimization. Hourly LMP will be the average of 15 minute LMP</p> <p>Update BRQ5660, ED will use Market based value, not designed value. Remove BRQ5680</p> <p>Add BRQ5631 for DEB opportunity cost.</p> <p>Simplify the MF validation for market-based value:</p> <p>Add BRQ5161, BRQ5162, BRQ5163, update BRQ5160, Remove BRQ5165, BRQ5170, BRQ5171, BRQ5172, BRQ5173, BRQ5174, BRQ5175, BRQ5180</p> <p>BRQ5465 remove bullet 4, update bullet 5</p> <p>Add BRQ5721 Retain "Short term Use-Limit Reached" outage card</p>
7/13/2017	1.8	Major version update
8/18/2017	1.9	- Section 3.1.5 (description of MF resource characteristics):



		<ul style="list-style-type: none"> ○ Added clarifications to remove operating reserve and regulation RRs from daily bids. ○ Stroke through Flex RA automatic validation requirements as it will be moved to another forthcoming project. - Section 4.1 (BPM): <ul style="list-style-type: none"> ○ Stroke through Flex RA automatic validation as it will be moved to another forthcoming project. - Section 5 (Business Requirements): <ul style="list-style-type: none"> ○ Summary of 5.10 (CIRA): Stroke through Flex RA automatic validation as it will be moved to another forthcoming project. - Section 5.2 (MF): <ul style="list-style-type: none"> ○ OCC-BRQ5105: Split it into 2 BRQs (OCC-BRQ5103, OCC-BRQ5105). ○ OCC-BRQ5105, OCC-BRQ5115: For consistency, changed annual to fixed-annual and rolling-12 to rolling-annual. ○ OCC-BRQ5117, OCC-BRQ5118, OCC-BRQ5119: Added reference to examples on applicability dates in Appendix-10. ○ OCC-BRQ5119: Corrected dates examples and applicability of backward rolling limit. ○ OCC-BRQ5140: Updated reference to Appenix-4 numerical example of SUC and TC bid cap calculations for MSG resources. ○ OCC-BRQ5155: Corrected MSG configurations to MSG resources. ○ CCE3-BRQ5191: Removed reference to orphan BRQ. ○ CCE3-BRQ5195: Renamed Hub as ICE Hub. Removed Hub Name field. ○ CCE3-BRQ5197: Removed. ○ CCE3-BRQ5199: Renamed Hub as ICE Hub. Changed fuel region to hub mapping to resource's ICE hub attribute. ○ OCC-BRQ5457: Replaced 'N' with 'J' so it does not get confused with end month of rolling-annual use limit plan. - Section 5.3 (ECIC): <ul style="list-style-type: none"> ○ OCC-BRQ5210: Refined Opportunity Cost Methodology Type population mechanism.
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- OCC-BRQ5212: Added new BRQ to store ICE hub's contract type.
- OCC-BRQ5214: Modified to use on-peak for retail price for the entire month. Added notes that ECIC shall prepare historical power prices for ICE hubs for first-time deployment or new ICE hubs and send it to OCC.
- OCC-BRQ5228: Added new BRQ for fallback mechanism.
- OCC-BRQ 5250: Added a reference to Appendix-6 for a numerical example of opportunity cost calculations for non-MSG resources, and Appendix-7 for MSG resources.
- OCC-BRQ 5255: Corrected typo to remove "adder" from formula. Added a reference to Appendix-7 for a numerical example of opportunity cost calculations for MSG resources.
- OCC-BRQ5257: For consistency, changed annual to fixed-annual and rolling-12 to rolling-annual.
- OCC-BRQ5225: Modified for ECIC to initialize, edit and publish daily OC adders that are used in the market with market type in case a use-limit plan changes intra-monthly.
- OCC-BRQ5452: Removed OCS and included any pre-processing or post processing calculations.
- Section 5.4 (MQS):
 - OCC-BRQ5310: Changed to daily granularity calculation of usage metrics.
 - OCC-BRQ5312: Changed daily usage metrics calculations to be performed at T+7.
 - OCC-BRQ5313, OCC-BRQ5350: Removed.
 - OCC-BRQ5314: Changed broadcast to daily values.
 - OCC-BRQ5315: Changed GUI display to daily values.
 - OCC-BRQ5316, OCC-BRQ5318, OCC-BRQ5319: Changed calculations formula from month to day. Added more details on the calculations.
 - OCC-BRQ5320: Moved to section 5.6 (OCC)
 - OCC-BRQ5340, OCC-BRQ5342: Changed broadcast to daily values.
 - OCC-BRQ5355: Removed PCA, OCC from impacted systems.
- Section 5.6 (OCC):



- OCC-BRQ5401: New BRQ due to MQS calculation of daily values: Consume daily scheduled starts (implied, including MSG transition), run-hour and energy output.
 - OCC-BRQ5402: New BRQ due to MQS calculation of daily values: Aggregation of daily values into monthly
 - OCC-BRQ5403: New BRQ due to MQS calculation of daily values: Furnish GUI to display monthly values.
 - OCC-BRQ5404: New BRQ due to MQS calculation of daily values: First time deployment 12-past month aggregation.
 - OCC-BRQ5405: New BRQ due to MQS calculation of daily values: Publish monthly scheduled starts (implied, including MSG transition), run-hour and energy output
 - OCC-BRQ5320: Moved from section 5.4 (MQS)
 - OCC-BRQ5405: New BRQ due to MQS calculation of daily values: User adjustment of monthly usage metrics.
 - OCC-BRQ5406: New BRQ due to MQS calculation of daily values: Furnish GUI for manual publishing
 - OCC-BRQ5407: New BRQ due to MQS calculation of daily values: System shall allow users to view the status of the running process(s)
 - OCC-BRQ5410, OCC-BRQ5411, OCC-BRQ5415, OCC-BRQ5216, OCC-BRQ5445, OCC-BRQ5450, OCC-BRQ5457: Modify acronym convention for clarity and consistency.
 - OCC-BRQ5216: Removed Trading Hub to Hub mapping. Changed fuel region to hub mapping to resource's ICE hub attribute. Removed RDTCostTC since it is not used. Changed GHG cost to GHG price. Added a note that for first time deployment or for new ICE hubs, ECIC shall consume historical power prices for ICE hubs for past 12 months from ECIC.
 - OCC-BRQ5445: Clarified some verbiage, and clarified annual to fixed or rolling. Change rounding to lower integer instead of nearest integer. Added more details on the note about modeling.
 - OCC-BRQ5450, OCC-BRQ5457: Clarified some verbiage for clarity and consistency.
 - OCC-BRQ5457: Added more details and clarifications on the formulation.
- Section 5.7 (CMRI):
- OCC-BRQ5510: Added a notes that the OC adders include future monthly OC adders as well as daily OC adders and



market type to identify which values are used by the market. Added Market Type to the report.

- o OCC-BRQ5521: remove "initial as well as recalculated".

- Section 5.8 (SIBR, DAM, RTM):

- o OCC-BRQ5630, OCC-BRQ5632: Added reference to Appendix-4 for a numerical example of SUC and TC bid cap calculations for MSG resources.
- o OCC-BRQ5636: Added new BRQ for fallback mechanism.
- o CCE3-BRQ5670: Added operating reserve and regulation to the removed RRs from daily bid.

- Section 5.10 (CIRA):

- o CCE3-BRQ5860, CCE3-BRQ5870: Stroke through Flex RA automatic validation requirements as it will be moved to another forthcoming project.

- Section 6 (Appendix-1: Acronym Definition):

- o Updated.

- Section 7 (Appendix-2: Technical Appendix):

- o Added more details and clarifications on the formulation.
- o Corrected some formulations
- o Added more details on the modeling.
- o Modify acronym convention for clarity and consistency.
- o Clarified some verbiage for clarity and consistency.
- o Updated Example-1 to Example-7 to be consistent with the requirements.
- o Added Example-8 for Updating OC for Rolling Annual Start Limitation (only).

- Section 9 (Appendix-4: Examples for Calculations of MSG SUC and TC Bid Caps):

- o Updated example to be consistent with the requirements.

- Section 11 (Appendix-6: Opportunity Cost Numerical Example for Non-MSG Resource):

- o Created.

- Section 12 (Appendix-7: Opportunity Cost Numerical Example for MSG Resource):

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		<ul style="list-style-type: none"> ○ Created. - Section 13 (Appendix-8: Actual (Scheduled) Usage Numerical Example for Non-MSG Resource: <ul style="list-style-type: none"> ○ Created. - Section 14 (Appendix-9: Actual (Scheduled) Usage Numerical Example for MSG Resource: <ul style="list-style-type: none"> ○ Created. - Section 15 (Appendix-10: Examples for Use-Plan Applicability and Opportunity Cost Model Run Dates: <ul style="list-style-type: none"> ○ Created.
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Disclaimer

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1. Introduction

1.1 Purpose

The purpose of this document is to capture and record a description of what the Users and Business Stakeholders of the **Commitment Cost Enhancements Phase 3** project wish to obtain by providing high-level business requirements. This document establishes the basis for the agreement between the initiators and implementers of the project. The information in this document serves as input to determining the scope of projects and to all Business Process Modeling and System Requirements Specifications efforts.

This initiative is a continuation of the Commitment Cost Enhancements Phase 2 initiative and will entail developing a methodology for calculating use-limited resource opportunity costs and creating opportunity cost adders for bidding into the ISO market using the proxy cost option. After implementing these changes, the ISO will still keep registered cost option for a period of time (configurable) until the ISO evaluates the effectiveness of the newly-implemented opportunity cost model. The ISO will decide when to retire the registered cost option upon this evaluation, or decide to keep it indefinitely.

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2. Intellectual Property Ownership

Intellectual property covers a broad array of information and materials, including written works, computer programs, software, business manuals, processes, symbols, logos, and other work products. Determining ownership of intellectual property is very important in preserving rights of the California ISO and helps to avoid intellectual property infringement issues. In considering the business requirements or service requirements to be performed, the business owner of the project must determine intellectual property Ownership.

2.1 Guidelines

Intellectual property ownership must be considered by all applicable stakeholders before the services are performed. The level of analysis is two-fold. One, the business owner must determine if the intellectual property necessary to perform the services is owned by the California ISO or whether it must be obtained from a third party. Once it has been determined that the California ISO has secured the proper intellectual property rights to perform the services (i.e., the intellectual property is owned by the California ISO or we have licensed it from a third party), then the second step in the analysis is to consider whether new intellectual property will be created as a result of the business requirements or service requirements to be performed and how that intellectual property will be owned and protected by the California ISO. In order to assist the business owner in the analysis previously described, refer to the California Intellectual Property Policy available at <http://www.caiso.com/rules/Pages/LegalPoliciesNotices/Default.aspx>, which provides a brief tutorial on what Intellectual Property is and how the California ISO can go about protecting its intellectual property. Please contact the Legal Department if you have any questions regarding intellectual property.

2.2 Checklist

Yes,

The California ISO assumes the ownership of

- Design of CCE3;
- Related Business Practice Manual;
- Software codes to implement the Opportunity Cost Calculator.

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3. Details of Business Need/Problem

3.1 Description

3.1.1 Use-limited registration process

Use limited resource is defined as the resource with limited starts, run-hours, or energy output and the market will use limited opportunity cost to adjust commitment cost bid caps and default energy bids (DEBs).

For a resource to be considered use-limited and be eligible for an opportunity cost, it must first register as a use-limited resource.

- 1) **Supporting documentation:** For each resource applying for use-limited status, the market participant will submit to the ISO copies of original documentation stating the resources' limitations or restrictions on start, run-hours, energy output, or other limitations, that cannot be optimized within the ISO optimization horizon, as imposed by regulatory agencies, legislation, or providing evidence of design limitations and in the case of translated limitations, the methodology used.
- 2) **Documentation review:** ISO will verify and validate that 1) the resource meets the definition of use-limited and is eligible for an opportunity cost, and 2) the limitations identified in the use plan are supported by the documentation provided or that the methodology used to translate limitations into starts, run hours, or energy output is reasonable and results in identified limitations.
- 3) **Maintaining opportunity costs and use-limited status:** All resources seeking use limited status will need to register in an initial process. In subsequent years following the first registration process, if nothing has changed from the supporting documentation previously submitted and reviewed by the ISO, scheduling coordinators can submit an affidavit in lieu of re-submitting all supporting documentation already on file and reviewed by the ISO. SC needs to submit the ULPDT every year for the following years (due date is in October), even if there's no change from previous year.
- 4) **Use-limited registration of new resources:** Scheduling coordinators seeking use-limited status for existing or new resources for the first time must complete the registration process and provide all required documentation and allow sufficient time for the ISO to review documentation and complete the process to calculate an opportunity cost prior to the first applicability date of the limitation.

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3.1.2 Evaluating submitted limitations/Opportunity Cost Calculation

The ISO will evaluate each submission on a case-by-case basis to determine whether the submission meets the first two criteria (refer to section 3.1.3 below) of the use limited definition to be eligible for inclusion in opportunity cost calculation model. Opportunity cost adders will be added to the bid cap for commitment costs (start-up costs, transition costs, and/or minimum load costs), after applying the current 125% bid cap, or added to the resource's Default Energy Bid (DEB) (cost-based only).

- 1) **Modeled Limitation:** For each resource, the ISO will use this method to model opportunity cost utilizing the unit's commitment model over future time period (e.g. annual, month) based on projected resource-specific LMPs. Inputs for the model include:
 - a. Use plan limitations
 - b. Unit characteristics
 - c. Commitment cost and Variable Energy Cost (VEC) estimates
 - d. Historical implied heat rate
 - e. Natural gas future prices
 - f. Greenhouse gas prices
 - g. Gas transportation costs (including Cap-and Trade Credit)
 - h. Retail rate for electric auxiliary energy (used in calculations of future EPI)
 - i. Future power price conversion factor
 - j. Net benefits test result

The output of this calculation will be separate resource specific opportunity costs adders for start-up cost, minimum load cost, transition cost, and variable energy cost, as appropriate. They can be reflected in commitment cost bid caps or resource's DEB (cost-based only).

- 2) **Negotiated Limitation:** Limitations that the ISO determines cannot be modeled will be eligible to request a negotiated opportunity cost. The scheduling coordinator will provide the opportunity cost(s) and documentation of the modeling methodology for calculating the opportunity cost(s) and proposed frequency of updates for the calendar year. The resource will then use negotiated opportunity cost adders as approved by the ISO based on the submitted methodology. Example of resources expected to use negotiated opportunity cost are: resources with environmental permits (e.g., Delta Dispatch), as well as hydro-electric generating resources.

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3.1.3 Use-limited definition

In response to FERC rejection of the revised definition of use-limited as proposed under Commitment Cost Enhancements Phase 2 (CCE2), the ISO added clarity to the definition of use-limited resource. The ISO is narrowing the definition of “use-limited” to just include resources that have an opportunity cost to starts, run-hours, or energy output due to limitations on them that come from external regulatory bodies, legislation, court or due to design or programmatic (demand response) restrictions that cannot be optimized per their limitations because of the ISO’s commitment horizon; and that have an opportunity cost for its use. This change now excludes resources that merely can’t bid in all hours because they might not be available such as VERs.

The ISO is also adding clarity on the revised definition as follows:

- 1) Will clearly identify the limitations as limits on starts, run-hours, and/or energy output that originate from restrictions imposed by external regulatory bodies, legislation, or courts, or due to the design of the resource where programmatic restrictions under demand response programs apply.
- 2) Will include a non–exhaustive list of specific examples which, to the ISO’s understanding, captures the majority of restrictions.
- 3) Will clarify that these cannot be contractual limitations, economic decision based, or due to fuel intermittency. However, the ISO is providing a three year limited exception for long-term contractual limitations on starts, run-hours, or output that were individually reviewed and approved through a comprehensive regulatory process as a new build that evaluated cost implications on ratepayers, after January 1, 2021 they will no longer qualify.
- 4) Will clarify that a use-limitation will be considered under the definition only if the applicability of the limitation is longer than the resource’s appropriate commitment process in the ISO market.
- 5) Will clarify that there must be an opportunity cost associated with the registered use limitations.

In accordance with the new definition, the ISO will no longer support a default use limit definition once the opportunity cost adders are effective. At that time, the ISO will eliminate default use-limited designation including any technology specific consideration of resources during the use-limited registration process.

After implementing opportunity cost model, the ISO will still keep registered cost option for a period of time (configurable) until the ISO evaluates the effectiveness of the newly-implemented opportunity cost model. The ISO will decide when to retire the registered cost option upon this evaluation, or keep it indefinitely.

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3.1.4 Nature of Work attribute for Outage Cards

When use-limited resource adequacy and flexible resource adequacy resources reach their limitations, scheduling coordinators must submit an outage card indicating the resource has reached the limitation, and is no longer available for the remainder of the limitation horizon. Four “Use-Limited Reached” “nature of work” attributes for generation Outage card have been created by RSI and were implemented for RA resources under that project: Annual, Monthly, Other and Short-term.

RSI provided substitution and RAIM exemption for use-limited resources that have reached the limitation and submitted a “Use-Limited Reached” outage card during their use-limited horizon for all four categories.

- 1) Makes changes to “Use-Limited Reached” regarding RAIM Treatment. Retire Annual/monthly/other.
 - RA resources will be exempt from RAIM for the remainder of the month if submitting any of the four “Use-Limited Reached” outage cards
 - Annual and Other Use-Limited Reached nature of works will have a substitution requirement beginning the first day of the following month and will be exposed to RAIM.
 - Monthly and Short-term Use-limited Reached nature of works will continue to be exempt from the substitution requirement and therefore exempt from RAIM.

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3.1.5 Master File resource characteristics

ISO will clarify that the responsibility for registering accurate design capability values, where programmatic limitations for demand response resources are considered design limitations, belongs to the Generator Owner.

The ISO will support a subset of resource characteristics as market-based values Market Characteristics in addition to the existing resource characteristics (Design-Capability Characteristics) representing the extreme design values. So there are two sets of Master File values for the subset of characteristics that the market characteristics were deemed appropriate.

- a. Keep all the **existing** resource characteristics – Design-Capability Characteristics
- ~~b. Validate that Master File Design-Capability Characteristics support RA obligation.~~
- c. Minimum requirements for these design-capability characteristics will include:
 - o **Maximum Daily Starts (MDS)** will validate that the design-capability MDS registered values be, at a minimum, ‘Q’ (configurable, currently defaulted to 2) starts per day except when the design-capability value for MDS is (less than ‘Q’) starts per day or under a limited exception for resources nearing end of their life cycle.
 - o **Maximum Daily MSG Transitions (MDMT)** will validate that the design-capability MDMT registered values be, at a minimum, ‘R’ (configurable, currently defaulted to 2) transitions per day except when the design-capability value for MDMT is (less than ‘R’) transitions per day or under a limited exception for resources nearing end of their life cycle.
- d. **Ramp Rates (RR)**. ~~The design-capability RR should support the RA obligation for that resource. The ISO would monitor the submitted Resource Data Template (RDT) design-capability RR and contact Scheduling Coordinator (SC) for revisions if applicable, where the RR value would not support its RA showing.~~ Add an additional field for a subset of resource characteristics – Market Characteristics
- e. These will be used in the ISO market for normal operations to reflect a balance between technical capabilities and economic trade-offs. These values may be different than the first design-capability set and will be referred to as “market-based” characteristics:
 1. **Maximum Daily Starts (MDS)** may warrant being more restrictive than the design-capability values. The ISO will validate that the market-based MDS values be greater than the minimum of ‘Q’ starts and less than the design-capability MDS unless an exception was provided to the design-capability MDS for less than ‘Q’ then both values may be less than ‘Q’.
 2. **Maximum Daily MSG Transitions (MDMT)** may warrant being more restrictive than the design capability of the resources. The ISO will validate that the market-based MDMT values be greater than the minimum of ‘R’ transitions and less than the design-capability MDMT unless an exception was provided to the design-capability MDMT for less than ‘R’ then both values may be less than ‘R’.
 3. **Ramp Rates (RR)**. The ISO proposes to remove the capability to specify operational RR in daily energy bids, and proposes to allow resources to have a market-based RR to reflect the preferred operational RR of the resource under normal system conditions, ~~which must at least support the resource’s RA showing value.~~ Also, ISO proposes to remove the capability to specify operating reserve and regulation RRs in daily bids, and proposes to allow resources to have a market-based RRs for operating reserve and regulation.
- ~~f. Changes to Master File Market Characteristics that would affect RA obligation.~~

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~~For resource adequacy (RA) resources, changes to Master File market characteristics may no longer support the RA obligation for that resource. The ISO would monitor the submitted Resource Data Template (RDT) with such changes and contact Scheduling Coordinator (SC) for revisions if applicable, where the changes are made after a resource has received an RA designation.~~

Note: Automation of validation of market-based ramp rate and flex RA capacity will be part of another forthcoming project.

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4. Business Process Impacts

4.1 Business Practice Manual (BPM)

BPM	Description of Impact(s)
Market Instruments	YES Opportunity cost adder that affects bid caps.
Outage Management	YES Nature of Work attribute for Outage card.
Reliability Requirement	YES Validation of RA plan based on Resources characteristics and MF. RAAIM exemption rule for use-limited nature of work attributes in Generation Outage card Note: Automation of validation of market-based ramp rate and flex RA capacity will be part of another forthcoming project.
Market Operations	YES ED needs to use the right MF values. Market will use the market-based values. Adding Opportunity cost calculation and negotiation as a new separate section. This section may be added in Market Instruments, which to be further determined.

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5. Business Requirements

The sections below describe the Business Processes and the associated Business Requirements involved in the project. These may represent high level functional, non-functional, reporting, and/or infrastructure requirements. These business requirements directly relate to the high level scope items determined for the project.

The System Impact:

Section 5.2: Master File: Set use-limited resource types and limits; Set market-based values

For Use-limited resource Opportunity cost:

1. Submit Use-Limited Plan Data Template (ULPDT) follow similar process as the RDT upload and approval process
2. Notify and Allow market participant to download ULPDT
3. Specify Use-limited type, granularity, applicability start and end time, use limits for the resource in ULPDT
4. Register use-limited MSG resource at resource level and configuration level in ULPDT and Identify number of implied starts per MSG configurations configuration in RDT.
5. MF shall send use-limit resources flags and limits to the ECIC and Opportunity Cost Calculator for processing input data and calculate the opportunity cost.
6. After implementing opportunity cost model, the ISO will still keep registered cost option for a period of time (configurable) until the ISO evaluates the effectiveness of the newly-implemented opportunity cost model. The ISO will decide when to retire the registered cost option upon this evaluation, or keep it indefinitely.

For Market-based values:

1. New Market-Based Characteristics, Max daily Starts (MDS), Max Daily Transitions (MDMT) and Ramp Rate (RR) (operational, operating reserve, and regulation) in RDT and MF. Default Market-Based value equal to design-capability values. The market-based values must be within the range of designed value, Reject the RDT if the market value is out of range of designed value.
2. Apply validation rule for market-based MDS values at least 'Q' (configurable, currently defaulted to 2) starts or market-based MDMT values at least 'R' (configurable, currently defaulted to 2) transitions unless exception granted, reject the RDT if the resource failed validation.
3. Validate market ramp rate (RR) (operational, operating reserve, and regulation).
4. .Transfer market-based values for MDS, MDMT, and RR (operational, operating reserve, and regulation) and design-capability values for all other attributes to the market

Section 5.3: ECIC: Process use limited resource input values for and Receive opportunity cost adders from Opportunity Cost Calculator

For Use-limited resource Opportunity cost

1. Set Flag for use-limited resource. Define resource opportunity cost methodology type flags for calculated or negotiated: calculated opportunity cost, and negotiated opportunity cost
2. Receive the opportunity cost per applicable use limitation for Starts (implied, including MSG transitions), run-hours and energy output from Opportunity Cost Calculator.

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3. Calculate Opportunity Cost Adders for SUC, TC, MLC and VEC using opportunity cost per applicable use limitation received from OCC.
4. Allow user to input the negotiated opportunity cost adder values for SUC, TC, MLC and VEC for the resources defined use negotiated opportunity cost in MF and for other use-limited resources follow the applicable process
5. Publish the opportunity cost adders for SUC, TC, MLC, and VEC to the market and downstream systems.
6. Calculate and publish the DEB that includes VEC opportunity cost adder for the energy output-use-limited resources.
7. Allow user Pre-schedule and on-demand runs the calculation and publish opportunity cost adders.

Section 5.4: MQS: publish the scheduled start up, run hour and energy output for the use limited resource

For Use-limited resource Opportunity cost (section 5.4)

1. Estimate resource scheduled starts (implied, including MSG transitions), run-hour and energy output based on real-time market scheduled values
2. Allow for user adjustment of actual (scheduled) starts, run-hour and energy output, run-hour, and energy output (UI- manually input corrected value)
3. publish resource actual (scheduled) starts (implied, including MSG transitions), run-hours and energy output to Opportunity Cost Calculator, CMRI

Section 5.5: Settlements: publish the Net Benefit Test for the use limited resource

1. Publish Net Benefit Test (NBT) for PDR resources
2. Track starts, run-hours, and energy output limitation types for rolling-annual and fixed-annual. This is only used for RAIM exemption rules.

Section 5.6: Opportunity Cost Calculator (OCC): calculates and publishes opportunity cost for start (implied, including MSG transitions), run-hours and energy output limitation types:

For Use-limited resource Opportunity cost

1. Receive MF defined use-limited resources for each opportunity cost limitation type and limits
2. Receive all the historical data for processing the input data.
3. Prepare input data to be used in optimization the Opportunity cost Calculator,
4. Receive from MQS for use-limited resource actual (scheduled) starts (implied, including MSG transitions), run-hour and energy output
5. The Opportunity Cost Calculator shall be able to run opportunity cost calculation models on-demand at any time for a specific user-entered set of resources.
6. The Opportunity Cost Calculator shall be capable of performing model runs for each resource to solve for resource's optimal dispatch (MWh_t) that maximizes profit π .
7. The Opportunity Cost Calculator shall distinguish between opportunity costs modeled for each limitation type.

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8. Calculate Opportunity cost as the difference profit (objective function value) of base case and (limit-Y) case.
9. Run one constraint with (limit-Y), hold other constraint limits at it base case value. (Y is configurable, can be defaulted to 1)
10. MSG use limit resource modeling Opportunity cost for biddable SUC, TC, and MLC.
11. Calculate opportunity cost for a rolling-annual limitation by the rolling limitation in the upcoming 12-month period and the rolling limitation from M-11 to M reduced by actual usage (based on real-time market schedule data) from M-11 to M-1 for that limitation type.
12. Build flexibility in Opportunity Cost input data to the optimization in OCC.
13. Publish resource opportunity cost per applicable limitation (starts (implied, including MSG transitions), run-hour and energy output).
14. Build a production user and a study user, Data store for the save case for production user and study user.

Section 5.7: CMRI: Publish opportunity cost for use-limited resource Opportunity Cost Adders

1. Display opportunity cost adders for each resource (SUC, TC, MLC, VEC)
2. Display Actual (Scheduled) use of Starts (implied, including MSG transitions), Ran-hour, energy output

Section 5.8: SIBR:

For Use-limited resource Opportunity cost

1. Receive Opportunity Cost (OC) adders (SUC, TC, and MLC).
2. Calculate Commitment Cost cap for SUC, TC, and MLC.
3. SIBR continues to validate that bids that are passed to IFM/RTM market are under the commitment cost bid caps that include the opportunity cost adders.
4. Pass SUC, TC, MLC and DEB bids to market IFM/RTM.

For Market-based values

1. Receive both designed and market-based RR (operational, operating reserve, and regulation)
2. Pass both designed and market-based RR (operational, operating reserve, and regulation) to IFM/RTM
3. Remove daily bid RR

Section 5.8: IFM/RTM:

For Market-based values

- Use Master File defined market-based MDS, MDMT and RR (operational, operating reserve, and regulation) in IFM/RTM
- Use market-based MDS, MDMT and RR (operational, operating reserve, and regulation) in all market applications ED Tool, MED, and IOOC

For Use-limited resource Opportunity cost

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- Send FERC commitment bid cap opportunity cost and resource characteristics market-based values (FODD)

Section 5.9: WebOMS: Allow use-limited access to the four “Use-Limited Reached” nature of works

For Outage card

1. Receive MF defined resource with use-limited flags
2. Allow Resource with use-limited flags to submit outage card associated with “Use-Limit Reached” Nature of Work Attributes that include: Annual, Monthly, Other, or Short-term.

Section 5.10: CIRA: Changes to substitution rules and their associated RAIM exemption rules

For outage card and RAIM exemption

1. Receive outage card with attribute “Annual Use-Limit Reached”, “Monthly Use-Limited Reached”, “Other Use-Limited Reached”, or “Short-term Use-Limited Reached” for the use limited resources.
2. Apply substitution requirement to the annual and other use-limited reached nature of works where:
 - a. Apply the RAIM exempt rule for the resource for the remainder of month for the outage card start date of the effective period
 - b. RAIM exempt rule is no longer apply starting the first day of the following month. The substitution (Y) is required.
3. Continue to exempt monthly and short-term use-limited reached nature of works (existing)
4. Publish the RAIM exempt MW for the resource to the downstream system with the period of the remainder of month. Using existing functionality, RAIM will receive the exempt MW apply the settlement rule.
- ~~5. Validate that market-based ramp rate (RR) supports the flexible RA MW showing.~~

Note: Automation of validation of market-based ramp rate and flex RA capacity will be part of another forthcoming project.

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5.1 Business Process: General

5.1.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
CCE3-BRQ5005	There shall be mechanism to activate all new functionalities in this BRS based on configurable date except for MF and retirement of registered cost.	Core	ECIC CIRA WebOMS CMRI SIBR IFM/RTM OCC MQS MQS Archive

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5.2 Business Process: < Manage Use-limited Resource Registration, Market-Based Values in Master File >

5.2.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
OCC-BRQ5103	<p>Establish a process to register use-limited resources :</p> <ul style="list-style-type: none"> ○ All resources that need to be registered as Use-limited and further need to update the limit plan Data must follow the Use Limitation Registration & Use Limit Plan Data Update Process, detailed in the business process diagram. <p>Note: Demand response resources (PDR/RDRR) can be registered as use-limited in MF and fill out ULPDT (existing process).</p>	Core (BPM revisions needed)	MF process
OCC-BRQ5105	<p>Business Rule for eligibility of use-limited resource to have opportunity cost</p> <p>Resources that have an opportunity cost on starts, run hours, or energy output due to limitations on starts, run-hours, or energy output that come from external regulatory bodies, legislation, court or due to design or programmatic (demand response) restrictions that cannot be optimized per their limitations because of the ISO's commitment horizon.</p> <p>Specifically, the three following conditions must be met:</p> <ul style="list-style-type: none"> • Limited by restrictions set forth by regulatory bodies, legislation, court, or due to design or demand response programmatic limitations (limits cannot be contractually negotiated limits except for long-term contractual limitations signed as of January 1, 2015 on starts, run-hours, or output that were individually reviewed and approved through a comprehensive regulatory process as a new build that evaluated cost implications on ratepayers for a three-year transition period after the effective date of activation of CCE3), • Cannot be optimized per their limitations because of the resource-specific commitment horizon (e.g. monthly/fixed-annual/rolling-annual for long starts or monthly/fixed-annual/rolling-annual/daily for medium, short or fast units). 	Core (BPM revisions needed)	MF process



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> • Eligible for opportunity cost if it is run during less profitable hours since it will forego potential profits if that use had been reserved and used in a more profitable hour and to greater system benefit. (Note: value may be zero if the limitation is not binding within a specific model run but the resource will still have use limit status. Specifically, resources that do not have controllable fuel source [wind, solar, geothermal, run of river] are not eligible for opportunity cost). <p>Examples include but are not limited to the following resource types:</p> <ul style="list-style-type: none"> • Gas-fired with environmental restrictions, including MSG • Gas –fired with design limitations, including MSG • Hydro-Large storage with environmental condition • Hydro-small storage/small conduit • Hydro-run of the river with downstream water flow needs • QF with capacity limitation • PDR with use limit (ex: 25events/year as start-up limits. 150 hours/year as run hour limits) • Resources with daily limitations that meet the three criteria (listed above) shall be eligible for use-limit status. <p>Resources that are not eligible include:</p> <ul style="list-style-type: none"> ○ Resources that only have limitations which are not accepted by ISO’s revised definition such as purely contractual (except for limited three year exception on long term contracts approved through regulatory process), based on economic decisions such as staffing requirements, or purely due to fuel intermittency (e.g. wind and solar) ○ Resources that have limitations which do not exceed the resource’s appropriate ISO market unit commitment process timeline (e.g. over 24 hours for long start or extremely long start units, over 4.5 hours for medium, short, or fast units). 		

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> ○ Resources that are unable to reflect opportunity costs in their bids, due to their bidding requirements by the ISO. RDRR, RMR, CHP cannot have opportunity costs and are required to bid at or near the energy bid cap and they are not mitigated. ○ Resources that require the ISO market to dispatch them when their bids are not eligible, due to the current ISO market rules (i.e. RMR resources). 		
OCC-BRQ51 15	<p>Submit Use-Limited Plan Data Template (ULPDT) for initial approval of use-limit status</p> <p>SC shall have the ability to submit a Use Limited Plan Data Template (ULPDT) to begin the use-limitation registration process (can be done anytime throughout the year). MSG resource shall submit resource level and configuration level use limited type and value including supporting documentation. MSG resources can enter resource level limitations under the same categories as any other resource.</p> <p>SC's seeking use-limit status must submit necessary information in sufficient time for the ISO to confirm its use-limit status prior to January 1, 2018 otherwise they may need to wait until the following year to complete the process. (business process)</p> <p>Proxy demand response or Reliability Demand Response Resources must complete use-limit registration process to gain access to the four use-limit reached outage cards regardless of whether or not they expect to have opportunity costs.</p> <p>ISO retiring requirement to provide historical information, specifically to show attainable MWhs for each 24-hour period during the preceding year, for support. ISO eliminating the five business day response time and the guidelines for approvals based on technology type.</p> <p>The following information should be included in the ULPDT and submitted:</p> <ul style="list-style-type: none"> • Scheduling Coordinator ID, • Res ID • Configuration ID • Applicability (start and end time) 	Core (Existing Functionality)	MF, ULPDT

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> • Use limit type: Start (implied, including MSG transitions)/Run-hours/Energy Output/Other • Applicability Granularity: Daily/Monthly/Fixed-Annually/Rolling-Annual/Other • Limitation Value <p>SCs seeking use-limit status for a resource(s) based on restrictions imposed by external regulatory bodies, legislation, or courts should submit original documentation stating limitations or restrictions shall provide the following supporting documentation, for example:</p> <ul style="list-style-type: none"> • Air Permit that expressly states a limitation on starts, run hours, or output. • Translation methodology for translating “other” types of limitations than starts, run hours, or output as needed including the “other” type as stated in original documentation, limitation type that the “other” is being translated into (e.g. run hours), and translation formula <p>Long-term contractual limitations on starts, run-hours, or output that were individually reviewed and approved through a comprehensive regulatory process as a new build that evaluated cost implications on ratepayers effective as of January 1, 2015 (temporary eligibility to end January 1, 2021)</p> <p>SCs seeking use-limit status for a resource(s) based on design limitations shall provide the following supporting documentation, for example:</p> <ul style="list-style-type: none"> • Detailed explanation to why the design of the resource limits the resource in such a way to qualify for an opportunity cost • Original Equipment Manufacturer (OEM) recommendations or bulletins • Operating Manuals with guidelines for design-intended operating parameters and limits or restrictions to operations • Manufacturer warranty specifications 		

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> California Public Utilities Commission approved demand response tariffs, programs, or contracts (e.g. Summer Discount Program or Aggregator Managed Program) Energy Resource Recovery Account (ERRA) filing summary <p>Note: Demand response programmatic limitations are design limitation. "other" limitation type does not have clear corresponding units, i.e. "other" per "other" and "other" per month comparison to starts per year. Refer to Appendix-3 for a snapshot of ULPDT template</p> <p>As noted above, "other" granularity is needed for the entry of any use limitations that are not clearly a function of only one of the following: starts, run-hours, or energy output. In these cases, either the "other" limitations are translated (through negotiation) into one of the three supportable limitation types with an accompanied methodology for that translation or a negotiated opportunity cost is the only available option. Other limitations are not passed to Settlements for RAAIM</p> <p>Resources should enter fixed-annual limitations with the effective start and end dates: January-December, February-January, ... That will allow the ISO to calculate opportunity costs correctly. Note: MF will not enforce this.</p> <p>Resources with a rolling-12-month (rolling-annual) limitation can submit applicability start and end dates that reflect the rolling limitation is applicable.</p>		
OCC-BRQ51 17	<p>Rules for Use-Limit Plan Applicability for Monthly Granularity</p> <ul style="list-style-type: none"> The applicability shall cover at least one calendar month per plan. The applicability shall cover multiple integer of 1 calendar month per plan (e.g. 1, 2, 3, ... months). Applicability start time shall be always at the first day of month Applicability end time shall be always at the last day of month. 	Core	MF ULPDT UI

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> • Plan limitation shall be applicable to every calendar month within the applicability start and end time. • If any existing ULPDT, violates this rule, ISO shall reject it, and SC shall resubmit it again to comply with this rule. • Example 1: <ul style="list-style-type: none"> ○ Applicability start time: 6/1/2017 ○ Applicability end time: 6/30/2017 ○ Use limit is applicable on entire month of June, 2017 • Example 2: <ul style="list-style-type: none"> ○ Applicability start time: 7/1/2017 ○ Applicability end time: 8/31/2017 ○ Use limit is applicable on entire two months of (7/1/2017-7/31/2017 and 8/1/2017-8/31/2017) <p>Note: Refer to Appendix-10 for examples on applicability dates.</p> <p>Implementation Note: OCC may breakdown this monthly use-limited plans to multiple monthly plans, each one covering one calendar month applicability period.</p>		
OCC-BRQ51 18	<p>Rules for Use-Limit Plan Applicability for Fixed-Annual Granularity</p> <ul style="list-style-type: none"> • The applicability shall cover at least 12 calendar month per plan. • The applicability shall cover multiple integer of 12 calendar month per plan (e.g. 12, 24, 36, ... months). • Applicability start time shall be always at the first day of month • Applicability end time shall be always at the last day of month. • Plan limitation shall be applicable to every 12 calendar month within the applicability start and end time. 	Core	MF ULPDT UI OCC

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> • If any existing ULPDT, violates this rule, ISO shall reject it, and SC shall resubmit it again to comply with this rule. • Example 1: <ul style="list-style-type: none"> ○ Applicability start time: 7/1/2017 ○ Applicability end time: 6/30/2018 ○ Use limit is applicable on entire 12 month • Example 2: <ul style="list-style-type: none"> ○ Applicability start time: 8/1/2017 ○ Applicability end time: 7/31/2019 ○ Use limit is applicable on entire 12-month applicability (8/1/2017-7/31/2018 and 8/1/2018-7/31/2019) <p>Note: Refer to Appendix-10 for examples on applicability dates.</p> <p>Implementation Note: OCC may breakdown this fixed-annual use-limited plans to multiple fixed-annual plans, each one covering 12 calendar month applicability period.</p>		
OCC-BRQ51 19	<p>Rules for Use-Limit Plan Applicability for Rolling-Annual Granularity</p> <ul style="list-style-type: none"> • The applicability shall cover any length of calendar months per plan that is ≥ 12 month. • Applicability start time shall be always at the first day of month. It indicates when the limit starts rolling. Looking-backward roll-limit shall go M-11 month (where M is the analysis month) but shall not look beyond this start date. • Applicability end time shall be always at the last day of month. It indicates when the limit ends rolling. Looking-forward roll-limit shall go M+11 month (where M is the analysis month) but shall not look beyond the applicability end date. The last applicable analysis month shall be the month encompassing the end date minus 11 month. 	Core	MF ULPDT UI OCC

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	<ul style="list-style-type: none"> • If any existing ULPDT, violates this rule, ISO shall reject it, and SC shall resubmit it again to comply with this rule. • Example 1: <ul style="list-style-type: none"> ○ Applicability start time: 1/1/2017 ○ Applicability end time: 12/31/2018 ○ For analysis month of Jan, 2017: <ul style="list-style-type: none"> ▪ No backward-rolling limit is applicable since it cannot go 12 month in the past. ▪ Forward rolling limit will start 1/1/2017 and stop at 12/31/2017. ○ For analysis month of February, 2017: <ul style="list-style-type: none"> ▪ No backward-rolling limit is applicable since it cannot go 12 month in the past. ▪ Forward rolling limit will start 2/1/2017 and stop at 1/31/2018. ○ For analysis month of January, 2018: <ul style="list-style-type: none"> ▪ Backward-rolling limit will start at 2/1/2017 and end 1/31/2018. ▪ Forward-rolling limit will start 1/1/2018 and stop at 12/31/2018. ○ For analysis month of February, 2018: <ul style="list-style-type: none"> ▪ No backward-rolling limit is applicable since no forward-rolling limit is applicable. ▪ No Forward-rolling limit is applicable since it cannot go 12 month in the future. <p>Note: Refer to Appendix-10 for examples on applicability dates.</p>		
OCC- BRQ51 10	Receive Use-Limited Plan Data Template (ULPDT) System shall define and store resource use-limited characteristics and values based on submitted use-limit plan data template (ULPDT) for resource level (existing process) and MSG configuration level (new process)	Core	MF ULPDT UI

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	<ul style="list-style-type: none"> • All submitted use-plans via Use Limited Plan Data Template (ULPDT) shall follow the RDT upload and approval process, including: • Backend validation (i.e. not all rules are validated via the UI) and Validation Report • Compare Report • Batch approval UI and client-side script • Batch reject UI and client-side script <ul style="list-style-type: none"> ○ Status screen shall include the ULPDT “batch” for UI upload, where the participant can confirm the ULPDT has loaded and passed validation. <p>The ULPDT does not need an API.</p>		
OCC-BRQ5125	<p>Timing for submitting ULPDT shall follow existing timeline that is described in Market Instruments BPM.</p> <p>Note: Hydro resources today are able to submit updated use-plans, intra-monthly. This shall still to be retained with submitting use-plans through the ULPDT.</p>	Core, if not implemented in RSI (Existing Process)	MF ULPDT
OCC-BRQ5145	<p>System notify and allow download ULPDT for SC submitting ULPDT:</p> <ul style="list-style-type: none"> • System shall automatically notify market participants when the processing status of a resource’s submitted use-limited plan is updated • Market participants shall be able to download the approved plans for a range of months. <ol style="list-style-type: none"> a) Modifications shall be made to the new ULPDT report and report query (to accept and filter on a date range) and the associated requestor changes (to display and process the date range input parameters). b) ULPDT security requirements shall stay the same as RDT <p>Notes: The requestor components for the date range input are available from the baseline code. One existing Master File report</p>	Core	MF ULPDT UI

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	("Resources with Approved Changes Becoming Effective") uses a date range filters.		
OCC-BRQ51 40	<p>Identify Number of Implied Starts in RDT for use in calculating SUC and TC opportunity cost adders (Start limitation type):</p> <ul style="list-style-type: none"> • GRDT shall be modified to add a new field for MSG resource for use-limited resources to identify the number of implied starts: <ul style="list-style-type: none"> ○ This field shall be per configuration (for all configurations). This field is required only for all use-limited MSG resources. For MSG plant level, this field shall be null. • For each MSG transition, MF shall derive the number of implied starts as follows: <ul style="list-style-type: none"> ○ Max (0, [Number of Implied starts of To Configuration - Number of Implied starts of From Configuration]) ○ Note: For existing use-limited MSG resources records, where the number of implied starts on configuration level is null, the number of implied starts per transition shall stay null until the former fields are populated by SC. Null records shall not be converted to 0. • For non-use-limited resources, the number of implied starts field shall not be required and there shall be no validation rules for it. • For non-MSG resources, number of implied starts field shall not be in the GRDT. MF shall default it this field to 1 for use by internal ISO downstream applications. <p>Notes:</p> <ul style="list-style-type: none"> • Number of implied starts is the number of starts of physical units within an ISO modeled use-limited MSG configuration. It should be the same resolution level, on which the MSG configuration will submit the use-limit limitation of number of starts. The start has to contribute to the use-limitation number of starts to in order to be counted as a start. 	Core	MF RDT integration



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> • The ISO market is modeled on MSG configuration start level, where use-limit constraints are submitted and modeled on implied start level. • The number of implied starts for an MSG configuration shall be measured from the MSG resource being entirely off to being started directly to that configuration. • The number of implied starts shall be submitted for every configuration of MSG resources that are registered as use-limited resource. • The supporting documentation that are provided during the use-limit registration process shall also support the number of implied starts. <p>Implementation Notes for Number of Implied Starts Data (Configuration Level):</p> <ul style="list-style-type: none"> • Initialization Update Rule: <ul style="list-style-type: none"> ○ No change to existing data • New Data Rule: <ul style="list-style-type: none"> ○ Validation Rule: <ul style="list-style-type: none"> ▪ All configurations for use-limited MSG resources shall have a provided value. <p>Implementation Notes for Number of Implied Starts Data (MSG Transition):</p> <ul style="list-style-type: none"> • Initialization Update Rule: <ul style="list-style-type: none"> ○ No change to existing data • New Data Rule: <ul style="list-style-type: none"> ○ For each use-limited MSG resources, the value for Number of Implied Starts shall be calculated by MF as : 		



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	<ul style="list-style-type: none"> ▪ Max (0, [Number of Implied starts of To Configuration - Number of Implied starts of From Configuration]) ○ If Number of Implied starts of From- and To-Configurations are null, this value shall be null. MF will not convert null to 0. ○ This value will be calculated at materialized view level. <p>Note: Refer to Appendix-4 for a numerical example of SUC and TC bid cap calculations for MSG resources.</p>		
OCC-BRQ5150	<p>Resource use-limited eligible flag:</p> <p>Use-limited resource flag shall be equal to 'Y' if the resource is use-limited. (existing process)</p>	Core (Existing Functionality)	MF
OCC-BRQ5155	<p>System shall publish use-limit plan data :</p> <p>Publish the defined resource with use-limited eligible flag to the downstream systems (existing flag)</p> <ul style="list-style-type: none"> • Res ID • Effective dates (start and end) • Use-limited resource flag <p>Publish the resource use-limited values based on submitted ULPDT for resource level and MSG configuration level</p> <ul style="list-style-type: none"> • Plan ID (use-limit plan ID) • Res ID • Config ID • Applicability (start and end time) • Use limit type: Start (includes MSG transitions)/Run-hours/Energy Output/Other • Granularity: Daily/Monthly/Fixed-Annually/Rolling-Annual/Other 	Core	MF Integration



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> Use Limitation Value (MaxSTRT (implied for MSG resources, including MSG transitions), MaxHRS, MaxMWH). 		
OCC-BRQ5156	<p>Require resources seeking use-limit status to complete use-limited registration process to register their programmatic limitations to gain access to the use-limit reached outage cards.</p>	Core	MF
CCE3-BRQ5160	<p>Set New Market-Based Characteristics in master file through submitted RDT. In MF: The following new (market-based) values for Market resource Characteristics shall be added to MF, in addition to the existing “design-capability” characteristics:</p> <ul style="list-style-type: none"> Market-based Max Daily Starts (MDS) Market-based Max Daily MSG Transitions (MDMT) Market-based Ramp Rate (RR) (operational, operating reserve, and regulation), market-based ramp rate for each ramp rate segment of a resource or MSG configuration ramp rate. In RDT: These new values shall be added as above new attributes to MF (RDT). <p>Default market-based values shall be equal to design-capability in MF, and shall be replaced by the resource submitted valid market-based values.</p> <p>Implementation Notes for Market-Based MDS Data:</p> <ul style="list-style-type: none"> Initialization Update Rule: <ul style="list-style-type: none"> If no value exists for design MDS, Then: <ul style="list-style-type: none"> No value shall be set for market-based MDS Else: <ul style="list-style-type: none"> The value for market-based MDS shall be set as design MDS End If New Data Rule: 	Core	MF RDT Integration



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> ○ If market-based MDS value is submitted, Then: <ul style="list-style-type: none"> ▪ The value for market-based MDS shall be set as the submitted value ○ Else: <ul style="list-style-type: none"> ▪ The value for market-based MDS shall be defaulted to design MDS ○ End If <p>Implementation Notes for Market-Based MDMT Data:</p> <ul style="list-style-type: none"> • Initialization Update Rule: <ul style="list-style-type: none"> ○ The value for market-based MDMT shall be set as design MDMT • New Data Rule: <ul style="list-style-type: none"> ○ If market-based MDMT value is submitted, Then: <ul style="list-style-type: none"> ▪ The value for market-based MDMT shall be set as the submitted value ○ Else: <ul style="list-style-type: none"> ▪ The value for market-based MDMT shall be defaulted to design MDMT ○ End If <p>Implementation Notes for Market-Based RR (Operational, Operating Reserve, and Regulation) (Resource and Configuration) Data:</p> <ul style="list-style-type: none"> • Initialization Update Rule: <ul style="list-style-type: none"> ○ If Segment Type = 'RAMP', Then: <ul style="list-style-type: none"> ▪ The value for market-based RR (Operational, Operating Reserve, and Regulation) shall be set as the 		

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	<p>design RR (Operational, Operating Reserve, and Regulation, respectively) (Max RR).</p> <ul style="list-style-type: none"> ○ Else: <ul style="list-style-type: none"> ▪ The value for market-based RR (Operational, Operating Reserve, and Regulation) (shall be NULL ○ End If ● New Data Rule: <ul style="list-style-type: none"> ○ If market-based RR (Operational, Operating Reserve, and Regulation) value is submitted, Then: <ul style="list-style-type: none"> ▪ The value for market-based RR (Operational, Operating Reserve, and Regulation) shall be set as the submitted value ○ Else: <ul style="list-style-type: none"> ▪ The value for market-based RR (Operational, Operating Reserve, and Regulation) shall be defaulted to design RR ○ End If 		
CCE3-BRQ5181	<p>New Minimum Requirement for Design-Capability of Maximum Daily Starts (MDS) or Maximum Daily MSG Transition (MDMT)</p> <p>Generally, the design value for MDS must be greater than or equal 'Q' (configurable, currently defaulted to 2) starts per day; and the design value for MDMT must be greater than or equal 'R' (configurable, currently defaulted to 2) transitions per day.</p> <p>ISO shall allow design values to be registered at (less than 'Q') starts per day or (less than 'R') transitions through an exception request process on a case-by-case basis and subject to ISO discretion.</p>	Core	MF



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
CCE3-BRQ5182	<p>Design-Capability Maximum Daily Starts (MDS) or Maximum Daily MSG Transitions (MDMT) Exception Request:</p> <p>SC shall have the ability to submit a request to change the design-capability MDS to (less than 'Q') starts per day or MDMT MDS to (less than 'R') transitions per day. The ISO will support limited exceptions to its minimum requirement of 'Q' starts per day for MDS or 'R' transitions per day for MDMT, these are:</p> <ul style="list-style-type: none"> • Supportable design limitations showing resource can only start (less than 'Q') times per day. • Supportable design limitations showing resource can only transition (less than 'R') times per day. <p>Notes:</p> <ul style="list-style-type: none"> • Supportable programmatic limitations for PDR/RDRR resources that show it can only starts (less than 'Q') times per day or transitions (less than 'R') times per day. Supportable justification for only (less than 'Q') starts per day or (less than 'R') transitions per day based on resource nearing the end of its life cycle (note: at ISO discretion) <p>SC shall provide the following supporting documentation, for example:</p> <ul style="list-style-type: none"> • Detailed explanation of the design limitations or PDR/RDRR programmatic limitations which restrict the resource to only (less than 'Q') starts per day or (less than 'R') transitions per day. • Detailed explanation of the mechanical justification for why the resource cannot start 'Q' times or more per day, or transition 'R' times or more per day including the vintage of the resource. 	Core	MF
CCE3-BRQ5183	<p>Design-Capability Maximum Daily Starts (MDS) or Maximum Daily MSG Transitions (MDMT) Exception Request Approval/Rejection</p> <p>MCI shall manually validate the following.</p> <ul style="list-style-type: none"> • Validate that the request is resource appropriate through reviewing supporting documentation: <ul style="list-style-type: none"> ○ ISO shall approve request if design or programmatic documentation shows sufficient 	Core	MF



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<p>reason for restricting MDS to (less than 'Q') times per day or MDMT to (less than 'R') times per day.</p> <ul style="list-style-type: none"> ○ ISO shall approve request if mechanical documentation and explanation shows sufficient reason for restricting MDS to (less than 'Q') times per day or MDMT to (less than 'R') times per day for resources nearing the end of their life cycle ○ ISO shall reject exception request if after review of documentation provided it finds the explanations insufficient to show reason to restrict MDS to (less than 'Q') times per day or MDMT to (less than 'R') times per day. ● ISO shall leverage existing ISO tariff alternative dispute provisions for a review of an ISO denial of an exception request. 		
CCE3-BRQ5161	<p>Reject RDT if the resource (RA/Non-RA) Market-based Max Daily Starts (MDS) violates validation rules:</p> <ul style="list-style-type: none"> ● If design value >= 'Q' then market-based MDS can be between 'Q' and its design value ('Q' <= market-based MDS <= Design Value) ● If ISO approved a design value exception request for (less than 'Q') starts per day (i.e. validated design value < 'Q') then the market-based MDS shall be less than 'Q' (i.e. ('Q'-1) <= market-based MDS <= validated Design Value) ● If ISO approved a design value exception request then the resource is identified as an exception, set flag design MDS Exception Flag = 'Y' (default = 'N'). ● Design value for MDS can be less than 'Q' only if design MDS Exception Flag is 'Y'; else reject the RDT <p>Note:</p> <ul style="list-style-type: none"> ● For RA resources, 'Q' and 'R' are the minimum starts or transitions per day requirements, respectively, for the flexible RA category the resource is providing. 	Core	MF RDT



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<p>Market based MDS >= minimum start per day requirement for the flexible RA category the resource is providing ('Q' [configurable, currently defaulted to 2])</p> <p>Implementation Notes for Design MDS Exception Flag:</p> <ul style="list-style-type: none"> • Initialization Update Rule: <ul style="list-style-type: none"> ○ If no value exists for design MDS, Then: <ul style="list-style-type: none"> ▪ No value shall be added to design MDS Exception Flag ○ Else: <ul style="list-style-type: none"> ▪ Design MDS Exception Flag = 'N' ▪ If design MDS < 'Q' Then <ul style="list-style-type: none"> - Set Design MDS = 'Q' ▪ End If ○ End If • New Data Rule: <ul style="list-style-type: none"> ○ Design MDS Exception Flag shall be set manually by MCI. It shall carry over from the previous version. 		
CCE3-BRQ5162	<p>Reject RDT if the resource (RA/Non-RA) market-based Max Daily Transitions (MDMT) violates validation rules:</p> <ul style="list-style-type: none"> • If Design value >= 'R' then market-based MDMT can be between 'R' and design-value (i.e. 'R' <= market-based MDMT <= Design Value) • If ISO approved a design value exception request for one transition per day (i.e. validated design value < 'R') then the market-based MDMT shall be less than 'R' (i.e. ('R'-1) =<market-based MDMT <= validated Design Value) • If ISO approved a design value exception request then the resource is identified as exception, set Design MDMT Exception Flag = 'Y' (default = 'N') 	Core	MF RDT



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> Design value for MDMT) can be less than 'R' only if Design MDMT Exception Flag is 'Y'; else reject the RDT <p>Implementation Notes for Design MDMT Exception Flag:</p> <ul style="list-style-type: none"> Initialization Update Rule: <ul style="list-style-type: none"> Design MDMT Exception Flag = 'N' If design MDMT < 'R' Then <ul style="list-style-type: none"> Set MDMT = 'R' End If New Data Rule: <ul style="list-style-type: none"> Design MDMT Exception Flag shall be set manually by MCI. It shall carry over from the previous version. 		
CCE3-BRQ5163	<p>Reject RDT if the resource (RA/Non-RA) Market-based Ramp Rate (RR) (Operational, Operating Reserve, and Regulation) violates validation rules (at both resource and configuration level):</p> <ul style="list-style-type: none"> The design and market-based Operational RR curves must cover the entire operating range (Pmin to Pmax) and they must have the same operating segment breakpoints. For each operational ramp rate corresponding segment : Market-based Operational Ramp Rates <= Design Operational Ramp Rate For each market-based operating reserve ramp rate segment : Market-based Operating Reserve Ramp Rates <= Max (over all segments) of market-based Operational Ramp Rates For each market-based regulation ramp rate segment : Market-based Regulation Ramp Rates <= Max (over all segments) market-based Operational Ramp Rates 	Core	MF RDT

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	<ul style="list-style-type: none"> For each design operating reserve ramp rate segment : Design Operating Reserve Ramp Rates <= Max (over all segments) of design Operational Ramp Rates For each design regulation ramp rate segment : Design Regulation Ramp Rates <= Max (over all segments) design Operational Ramp Rates <p>Note: These validation rules shall apply to the "best" value of these ramp rates.</p>		
CCE3-BRQ5164	Worst Ramp Rates (for Operational, Operating Reserve, and Regulation) shall be nulled out upon submittal (via RDT and/or bulk loader). Existing data shall not be modified.	Core	MF
CCE3-BRQ5185	<p>System shall send market-based values for MDS, MDMT, and RR (Operational, Operating Reserve, and Regulation) and designed-capability values for all other resource characteristics to the market:</p> <ul style="list-style-type: none"> System shall accept RDT If validation passed, System shall store the market-based values System shall transfer market-based value to the market for MDS, MDMT, and RR (Operational, Operating Reserve, and Regulation) resource characteristics. System shall transfer designed-capability value to the market for all other resource characteristics.as usual 	Core	MF, RDT, transfer Script
CCE3-BRQ5190	<ul style="list-style-type: none"> After implementing opportunity cost model, the ISO will still keep registered cost option for a period of time (configurable) until the ISO evaluates the effectiveness of the newly-implemented opportunity cost model. The ISO will decide when to retire the registered cost option upon this evaluation, or keep it indefinitely. There shall be a configurable effective date to allow the ISO to retire registered cost option at that effective date. When the registered cost retirement effective date is reached, the registered cost validations shall be retired. 	Core	MF



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> When the registered cost retirement effective date is reached, MCI publishing of monthly GPI as PDF in caiso.com website shall be retired. 		
CCE3-BRQ5191	Develop a business process to support the Design-Capability Maximum Daily Starts (MDS) or Maximum Daily MSG Transitions (MDMT) Exception Request and ISO approval or rejection of that request.	Core	MF
CCE3-BRQ5193	<p>Add specific technology type exemptions for generated bid insertion to existing exemptions for MOO</p> <p>MF shall continue to exempt resources with a use-limited status from generated bid insertion based on the use-limited eligible flag (in MF).</p> <p>MF shall add an exemption from generated bid insertion based on technology type. The following technology types shall be exempt from generating bids:</p> <ul style="list-style-type: none"> Hydroelectric Generating Units (Hydro) Proxy Demand Resources (PDR) Reliability Demand Response Resources (RDRR) Participating Load, including Pumping Load 	Core	MF (business process only)
CCE3-BRQ5195	<ul style="list-style-type: none"> System shall define new ICE Hubs ID's and post it in Market Instruments BPM. This shall include: <ul style="list-style-type: none"> ICE Hub ID Effective time MVQA shall provide the ICE hub names (only the ones relevant to ISO or EIM Areas) and maintain it for modifications going forward. 	Core BPM	MF
CCE3-BRQ5199	<ul style="list-style-type: none"> System shall define new resource attribute for ICE Hubs. Multiple resources can be linked to one ICE hub. Each resource must be associated with only one ICE hub. This shall include: 	Core	MF

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	<ul style="list-style-type: none"> ○ Resource ID ○ ICE Hub ID ○ Effective Time ● Existing as well as new Resource's SC shall specify the corresponding ICE hub that is associated with that resource in RDT (required field). 		

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5.3 Business Process: < Manage Use-Limited Resource Input Values, and Opportunity Cost Adders in ECIC >

5.3.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
OCC-BRQ5210	<p>Populate Opportunity Cost Methodology Type</p> <ol style="list-style-type: none"> 1. System shall provide a way to characterize opportunity cost methodology for use-limit resources: <ul style="list-style-type: none"> ○ Calculated: Standard modeled opportunity cost methodology modeling, or ○ Negotiated: negotiated opportunity cost methodology modeling 2. This characterization shall be on resource level (Configuration level for MSG resources). 3. ECIC shall default opportunity cost methodology for all use-limit resources to “Calculated” except when the resource has a valid negotiated adder defined in ECIC. 4. MVQA users shall have the capability in ECIC to manually flag resources on resource level (configuration level for MSG resources) that are eligible to receive the negotiated adders with applicable start and end date/time. The Opportunity Cost Methodology Type shall stay at negotiated until SC submits a request to MVQA to change it or MVQA changes it based on its business process. 5. If a resource does not have a calculated opportunity cost, default adders of zero 	Core	ECIC



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<p>shall be used until a negotiated value is available. Based on initial review of the submitted documents, if ISO determines the resource warrants establishing a non-zero OC value, the ISO may propose a temporary OC value during the negotiation phase if a methodology/OC value is not finalized.</p>		
OCC-BRQ5210	<p>ECIC shall store contract types (peak/off-peak) for each ICE hub.</p> <p>Note: This needed for extraction of ICE hubs' future as well as historical power prices.</p>	Core	ECIC
OCC-BRQ5214	<p>ECIC System shall provide input data to OCC:</p> <ul style="list-style-type: none"> • (ECIC) Future natural gas price & transportation cost, ($NatGasF_{m,l}$, $GasT_{m-1,l}$ [including Base Gas Transportation Cost, Gas Transportation Shrinkage Allowance, Cap and Trade Credits and Miscellaneous Costs]) for month m. • (ECIC) Historical natural gas, the monthly average of daily natural gas price from the previous year's period ($NatGas_{m-12,l}$) • (ECIC) Daily gas price index of the previous year ($GPI_{t,y-1,l}$) • (ECIC) GHG price ($GHGas_{m-1}$) for the previous month, average greenhouse gas allowance price from prior month • (ECIC) GHG price ($GHGas_{t,y-1}$) for the previous year, average greenhouse gas allowance price from prior year. • (ECIC) GHG price ($GHGas_{m-12}$) for the monthly average greenhouse gas allowance price from the previous year's period, $m-12$ 	core	ECIC integration OCC

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	<ul style="list-style-type: none"> • (ECIC) Future electric region (e) level $EPI_{m,e}$: <ol style="list-style-type: none"> a. For wholesale electric region, $EPI_{m,e} = (\text{NatGasTotalF}_{m,l} * 10)$ where $\text{NatGasTotalF}_{m,l} = \text{NatGasF}_{m,l} + \text{GasT}_{m-1,l}$ [including Cap and Trade Credits and Miscellaneous Costs]. b. For retail electric region, $EPI_{m,e}$ = retail rate (On-Peak value shall be used) • (ECIC) Power future price ($PPF_{hub,m,tou}$) at ICE hub h for the analysis month m and tou. • (ECIC) Power historical price ($PP_{hub,m-12,tou}$) at ICE hub “hub” from the same month the previous year $m-12$ and tou. Note: For first time deployment or for new ICE hubs, ECIC shall prepare this input for past 12 months and send it to OCC. <p>Note: Refer to OCC-BRQ5216</p>		
OCC-BRQ5223	<p>Receive the opportunity cost adders optimized results from Opportunity Cost Calculator</p> <ul style="list-style-type: none"> • Receive from Opportunity Cost Calculator published opportunity cost for applicable limitation type by resource. • For MSG resources, ECIC shall receive limitation OC's on configuration level and plant level, separately. This shall apply to Start (implied, including MSG transitions), Run-Hours, and Energy Output use-limitation types. 	Core	OCC integration ECIC



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
OCC-BRQ 5250	<ul style="list-style-type: none"> For MSG resources, ECIC shall superimpose plant limitation OC's to configuration limitation OC's. <ul style="list-style-type: none"> Configuration use-limitation OC (new) = Configuration use-limitation OC (received from OCC) + Plant use-limitation OC (received from OCC) This shall apply to Start (implied, including MSG transition), Run-Hours, and Energy Output OC use-limitation types. ECIC shall then use configuration limitation OC's to calculate OC adders. <p>Note: Refer to Appendix-6 for a numerical example of opportunity cost calculations for non-MSG resources, and Appendix-7 for MSG resources.</p>	Core	OCC integration ECIC
OCC-BRQ 5255	<p>System shall calculate the SUC OC adder by multiplying the start limitation implied OC (output from OCC) by the number of implied start/transition per resource for non-MSG resources or per configuration for MSG resources.</p> <ul style="list-style-type: none"> SUC OC adder = Start (implied) use-limitation OC * Number of implied starts per resource (configuration for MSG resources) TC OC adder (MSG resources) 	Core	OCC integration ECIC



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<p>=</p> <p>Start (implied) use-limitation OC of To-configuration of the transition</p> <p>*</p> <p>Number of implied starts per transition</p> <p>Note: Refer to Appendix-7 for a numerical example of opportunity cost calculations for MSG resources.</p>		
OCC-BRQ 5256	<p>ECIC shall store all calculated Resource and MSG configuration Opportunity Cost Adders by calendar month granularity. This shall be performed so that latest resource (or MSG configuration) OC adder for a specific calendar month overwrites previously calculated data.</p> <p>For example, if OC adder for resource "A" is calculated on yearly granularity as XX (from February 1, 2018 to January 31, 2019, ECIC shall store resource "A" OC adder of XX for February 2018, March 2018, April 2018,, December 2018, January 2019.</p>	Core	ECIC
OCC-BRQ5257	<p>ISO shall identify resources likely to need negotiated opportunity cost adders based on use limited registration</p> <ul style="list-style-type: none"> • ISO shall review approved limitations and identify those that cannot be modeled. Such limitations could include: <ul style="list-style-type: none"> ○ Certain hydro resources ○ Complex limitations cannot be translated into starts, run hours, 	(Clarifications)	(Business Process Only)



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> ○ or output limitations (i.e. “other” limit type) ○ MSG configuration level limitations cannot be modeled at this time (i.e. “other” limit type) ○ Complex limitations cannot be translated into either fixed-annual, monthly, rolling-annual, or nested (annual/monthly) applicability time horizon (i.e. “other” applicability time horizon) ● ISO shall notify SC that it has identified its use limited resource will likely not be suitable for its calculated process and initiate an opportunity cost negotiation process. 		
OCC-BRQ5230	<p>SC may request a negotiated opportunity cost adders for SUC, TC, MLC and VEC</p> <ul style="list-style-type: none"> ● SC may submit request to ISO to negotiate the opportunity cost adder for any approved use limitations in its Masterfile RDT. The ISO shall only accommodate OC negotiations that can be reflected in start-up cost (SUC) bids, minimum load cost (MLC) bids, transition cost (TC) bids, or default energy bids (DEBs). ● For use-limited MSG resources, negotiated OC adders for SUC, MLC bid caps, and negotiated DEB (NDEB) shall be per MSG configuration level. Negotiated OC adders for TC bid cap shall be per MSG transition. ● SC must provide sufficient justification for entering into a negotiation process, this could include: <ul style="list-style-type: none"> ○ Significant factor not accounted for in the model that cannot be 	Core	integration ECIC



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<p>reasonably modeled, and significantly impacts the calculated opportunity cost adders</p> <ul style="list-style-type: none"> ○ Resource adequacy resource is at risk of not being available for the entirety of its RA showing despite its commitment cost bids reflecting the calculated opportunity cost adders. ● Once a negotiation process is entered, SC shall submit to the ISO documentation, including but not limited to: <ul style="list-style-type: none"> ○ Opportunity cost adder (\$/start, \$/transition, \$/hour, \$/MWH) ○ Documentation describing methodology used to determine submitted opportunity cost adder values ○ Processes used to arrive to submitted opportunity cost adder values (i.e. formulas, simulation models, historical analysis) ○ Proposed frequency of updates within the calendar year, only updates to values not the approved methodology. ● ISO shall review submitted opportunity cost adder values and supporting documentation to ensure: <ul style="list-style-type: none"> ○ Methodology or process to derive opportunity cost adder only includes approved use limitations through Use Limited Resource registration process ○ Methodology or process uses reasonable approach to 		

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<p style="text-align: center;">opportunity cost adders for use limitation management</p> <ul style="list-style-type: none"> • ISO shall validate submitted negotiated opportunity cost adder values and work with SC to reach an approved methodology and negotiated opportunity cost adder values. • If ISO and SC cannot reach mutual agreement through the negotiation process prior to the applicability start date of the use limitation, ISO may propose a temporary value that it finds reasonable while the negotiation process continues. SC may accept or reject proposed temporary value. • If no agreement can be reached, SC may file at FERC for rate approval (existing). 		
OCC-BRQ5232	<p>Allow SC to request updates to its negotiated opportunity cost values</p> <ul style="list-style-type: none"> • Subject to the negotiated agreement for the frequency of updates • SC may request update to the opportunity cost adder values • SC shall provide sufficient explanation to the ISO at the time the updated value is requested, including but not limited to: <ul style="list-style-type: none"> ○ New value ○ Explanation of why the cost output changed ○ Identify the change of the input variables or original assumptions from approved methodology to warrant a change in negotiated opportunity cost adder values 	Core	(Business Process Only)



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
OCC-BRQ5234	<p>ISO ability to initiate renegotiation of negotiated values</p> <ul style="list-style-type: none"> ISO may open a negotiation process to renegotiate either its negotiated opportunity cost adder values or its negotiated Default Energy Bids (NDEBs), based on reviewing and proposing modifications to existing negotiated values For example, NDEBs that are opportunity cost adders may no longer be appropriate or may need to be adjusted given new opportunity cost methodology. SC shall be required to participate in a renegotiation if initiated by the ISO and shall be required to provide supporting information and cost justification, as required. 	Core	(Business Process Only)
OCC-BRQ5224	<p>Allow user to input the negotiated opportunity cost adders for applicable limitation types.</p> <ul style="list-style-type: none"> Allow user choose resource based on the MF defined use negotiated opportunity cost methodology type. Allow user to input opportunity cost adders for SUC, TC, MLC and VEC for the resources (or MSG configurations, transitions). Allow user to overwrite the previous stored opportunity cost adders, include optimized (calculated) results System shall flag user-overridden OC adder records and display the original calculated/negotiated values as well as the user-overridden values. 	Core	ECIC



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
OCC-BRQ5225	<p>Publish the resource opportunity cost adders for SUC, TC, MLC and VEC to the market and downstream systems</p> <ul style="list-style-type: none"> - Res ID (same as plant ID for MSG resources) - Config ID (MSG resources) - From-Config ID (MSG transitions) - To-Config ID (MSG transitions) - Applicability (start and end time) - Market Type (Used for Daily OC adders only) - Opportunity Cost Methodology Type (Calculated/Negotiated) - Opportunity Cost Adder Used (Y/N) - Opportunity Cost Adders Types: <ul style="list-style-type: none"> o SUC o TC o MLC o VEC - Opportunity Cost (\$/start, \$/transition, \$/hour, \$/MWH) <p>Notes:</p> <ul style="list-style-type: none"> - For use-limited MSG resources, there shall be SUC opportunity cost adder for each startable configuration as well as TC opportunity cost adder for each transition. - The OC adders shall be per resource for non-MSG resources. 	Core	ECIC Integration SIBR CMRI



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> - The OC adders shall be per configuration only (no plant-level) for MSG resources. - In addition to future monthly OC adders, ECIC shall publish daily OC adders to identify the OC adders that are used in the market. ECIC shall initialize the daily OC adders from monthly OC adders, but MVQA users may edit the daily values in case a use-limit plan changes intra-monthly. 		
OCC-BRQ5226	<p>Calculate and publish the DEB that include VEC opportunity cost for the use-limited resources</p> <p>System shall publish the final DEB that include the VEC opportunity cost using existing payload.</p> <p>The calculations shall follow the following formula:</p> <p>If $OC_{VEC} \neq \text{null}$ then</p> $DEB_{\text{variable cost}} = DEB_{\text{existing}} + OC_{VEC}$ <p>Else</p> $DEB_{\text{variable cost}} = DEB_{\text{existing}}$ <p>End If</p> <p>OC_{VEC} can be from negotiated inputs or calculated values</p> <p>Notes:</p> <ul style="list-style-type: none"> - VEC Opportunity cost adder for eligible energy output limitations shall be incorporated in the resource's DEB where the DEB will include a VEC opportunity cost adder on top of the 110% scalar. - It shall apply only to cost-based DEB's. 	core	ECIC Integration

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
OCC- BRQ5228	Fallback Mechanism In the event that ECIC does not receive opportunity costs for applicable limitation for the use-limited resources, the opportunity cost adders shall fallback to the most recently calculated or negotiated Opportunity Cost adders, only if the use-limit resource plan is active for the applicable use-limitation type at the fallback date. The fallback values shall be used for the trade date being processed, and shall also be sent to downstream systems.	core	- ECIC - Integration

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5.4 Business Process: < Manage Scheduled Starts, Run-Hours and Energy Output in MQS

5.4.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
OCC-BRQ5310	On daily granularity, system shall automatically calculate resource scheduled starts (implied, including MSG transitions), run-hours and energy output of each Use-Limited resources (for each configuration and transition for MSG resources) based on real-time schedule data.	Core	- MQS - MQS Archive
OCC-BRQ5312	Calculations shall be performed automatically every day as part of T+x MQS calculations workflow (where x=7) to calculate the scheduled metrics for trade day T. For example, on January 8, metrics of January 1 trade day shall be calculated. Note: The purpose of T+x calculations delay is capture important post-market corrections into usage metrics calculations.	Core	- MQS - MQS Archive
OCC-BRQ5314	First time deployment shall calculate and broadcast the scheduled metrics for all days within 12 past individual calendar months.	Core	- MQS - MQS Archive - Integration
OCC-BRQ5315	System shall furnish a GUI to display all calculated outputs for daily scheduled starts (implied. Including MSG transitions), run hours, and energy output.	Core	- MQS - MQS Archive
OCC-BRQ5316	<ul style="list-style-type: none"> System shall calculate scheduled starts (implied, including MSG transitions) as the summation over the applicable day of the number of implied starts, including MSG transitions to To-Configuration on the following resource levels: 	Core	- MQS - MQS Archive



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> ○ Resource (Non-MSG, MSG Plant level) ○ MSG configuration ● Calculations of number of actual (scheduled) implied starts shall utilize RT unit commitment data that has all correction up to date. ● The MF number of implied starts per non-MSG resource or MSG configuration or Transition shall be the value that is effective at the calculation time. ● For non-MSG resources: <ul style="list-style-type: none"> ○ For every day, the number of scheduled implied starts = Number of scheduled resource-level starts * number of implied starts per resource. ○ Any unit commitment status change from OFF to non-OFF shall be counted as one resource start. ● For MSG resources: <ul style="list-style-type: none"> ○ On MSG configuration-level: At any given time, the Number of scheduled implied starts = (Number of scheduled configuration direct starts * number of implied starts per configuration) + (Number of scheduled transition starts of To-Config * number of implied starts per transition to To-Config) ○ Any unit commitment status change from MSG Plant OFF to configuration non-OFF shall be counted as one configuration start. ○ Any unit commitment status change from another configuration "F" non-OFF 		



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<p>to that configuration "T" non-OFF shall be counted as one F-T transition.</p> <ul style="list-style-type: none"> ○ Number of actual (scheduled) starts on MSG plant shall be calculated as the summation of all configuration number of actual (scheduled) implied starts at any given time. <p>Notes:</p> <ul style="list-style-type: none"> • Exceptional dispatches that force a start-up or transition shall be accounted for in calculations of starts (implied, including MSG transitions). • Refer to Appendix-8 for a numerical example of actual (scheduled) usage calculations for non-MSG resources, and Appendix-9 for MSG resources. 		
OCC-BRQ5318	<ul style="list-style-type: none"> • System shall calculate scheduled run-hours as the summation over the applicable day of the online commitment time in hours unit on the following resource levels: <ul style="list-style-type: none"> ○ Resource (Non-MSG, MSG Plant level) ○ MSG configuration • Calculations of actual (scheduled) run-hours shall utilize RT unit commitment data that has all correction up to date. • For non-MSG resources or MSG configurations, any non-OFF unit commitment status shall be counted as ON time for the run-hours. • MSG plant run-hours shall be calculated as the summation of all configuration run-hours at any given time. • Calculation and use of run hours shall be in full precision without any numerical rounding. 	Core	<ul style="list-style-type: none"> - MQS - MQS Archive



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<p>Note:</p> <ul style="list-style-type: none"> Refer to Appendix-8 for a numerical example of actual (scheduled) usage calculations for non-MSG resources, and Appendix-9 for MSG resources. 		
OCC-BRQ5319	<ul style="list-style-type: none"> System shall calculate scheduled energy output MWH as the summation over the applicable day of the 5-minute Total Expected Energy (TEE) on the following resource levels: <ul style="list-style-type: none"> Resource (Non-MSG, MSG Plant level) MSG configuration MSG plant MWH shall be calculated as the summation of all configuration MWH at any given time. <p>Notes:</p> <ul style="list-style-type: none"> For MSG resources, configuration-level MWH shall only be assigned to RT configuration. Refer to Appendix-8 for a numerical example of actual (scheduled) usage calculations for non-MSG resources, and Appendix-9 for MSG resources. 	Core	<ul style="list-style-type: none"> - MQS - MQS Archive
OCC-BRQ5332	System shall maintain versioning of calculated outputs for scheduled starts (implied, including MSG transitions), run hours, and energy output for each individual modification of the calculation.	Core	<ul style="list-style-type: none"> - MQS - MQS Archive
OCC-BRQ5340	<p>Broadcast daily scheduled starts (implied, including MSG transition), run-hour and energy output</p> <p>System shall automatically broadcast an up-to-date tracking of daily scheduled (Starts (implied, including MSG transitions), Run-hours, and</p>	Core	<ul style="list-style-type: none"> - MQS - Integration

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	Energy Outputs) of each Use-Limited resources. <ul style="list-style-type: none"> • Resource ID • Config ID (MSG resources) • Applicability (start and end time) • Actual (Scheduled) starts (implied, including transition) (ActSTRT) • Actual (Scheduled) Run-hours (ActHRS) • Actual (Scheduled) Energy Output (ActMWH) 		
OCC-BRQ5342	System shall furnish a GUI to allow users to manually publish the outputs of the calculation for daily scheduled starts (implied, including MSG transitions), run hours, and energy output on demand, for a user-entered past trade dates (from list of days that have their daily outputs been calculated).	Core	- MQS - MQS Archive - Integration
OCC-BRQ5355	System shall allow users to view the status of the running process(s) (calculation or publishing) and via UI consistent with all other core processes.	Core	- MQS - MQS Archive

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5.5 Business Process: < Publish Data Sets to Support Opportunity Cost Calculations (Settlement) >

5.5.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
OCC-BRQ5341	System shall publish Net Benefit Test (NBT) Value for PDR: <ul style="list-style-type: none"> • Effective time • TOU (On Peak/Off Peak) • NBT 	Core	Settlement Integration OCC
CCE3-BRQ5342	System shall track starts, run-hours, and energy output limitation types for rolling-annual and fixed-annual. <p>Notes:</p> <ul style="list-style-type: none"> • This is only used for RAAIM exemption rules. • Tracking of limitation types for monthly limitation is existing functionality. 	Core	Settlement

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5.6 Business Process: < Manage Opportunity Cost Calculation Process in Opportunity Cost Calculator (OCC)>

5.6.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
OCC-BRQ5401	<p>Consume daily scheduled starts (implied, including MSG transition), run-hour and energy output</p> <p>System shall automatically consume daily scheduled (Starts (implied, including MSG transitions), Run-hours, and Energy Outputs) of each Use-Limited resources.</p> <ul style="list-style-type: none"> • Resource ID • Config ID (MSG resources) • Applicability (start and end time) • Actual (Scheduled) starts (implied, including transition) (ActSTRT) • Actual (Scheduled) Run-hours (ActHRS) • Actual (Scheduled) Energy Output (ActMWH) 	Core	<ul style="list-style-type: none"> - OCC - Integration
OCC-BRQ5402	<p>For each calendar month, system shall automatically aggregate daily values into monthly values for resource scheduled starts (implied, including MSG transitions), run-hours and energy output.</p> <p>Note:</p> <p>The monthly metric data of last month “m-1” will be ready at the xth day of month current month ‘m’, where x=7. OCC tool can only run starting from (x+1)th day of the month.</p>	Core	<ul style="list-style-type: none"> - OCC
OCC-BRQ5403	<p>System shall furnish a GUI to display all calculated outputs for monthly scheduled starts (implied. Including MSG transitions), run hours, and energy output.</p>	Core	<ul style="list-style-type: none"> - OCC
OCC-BRQ5404	<p>First time deployment shall consume and calculate the scheduled metrics for 12 past individual calendar months.</p>	Core	<ul style="list-style-type: none"> - MQS - MQS Archive - OCC - Integration



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
OCC-BRQ5405	<p>Publish monthly scheduled starts (implied, including MSG transition), run-hour and energy output</p> <p>System shall automatically publish an up-to-date tracking of monthly scheduled (Starts (implied, including MSG transitions), Run-hours, and Energy Outputs) of each Use-Limited resources.</p> <ul style="list-style-type: none"> Resource ID Config ID (MSG resources) Applicability (start and end time) Actual (Scheduled) starts (implied, including transition) (ActSTRT) Actual (Scheduled) Run-hours (ActHRS) Actual (Scheduled) Energy Output (ActMWH) 	Core	<ul style="list-style-type: none"> OCC Integration
OCC-BRQ5320	<p>System shall allow user to adjust the scheduled starts (including MSG transitions), run-hours and energy output, add an incremental positive or negative value.</p> <ul style="list-style-type: none"> System shall allow analyst to upload adjustment values for the effective period. The system shall accept and store the resource adjustment for starts (including MSG transitions), run-hour, and energy output. 	Core	- OCC
OCC-BRQ5406	<p>System shall furnish a GUI to allow users to manually publish the outputs of the calculation for monthly scheduled starts (implied, including MSG transitions), run hours, and energy output on demand, for a user-entered past calendar trade month (from list of months that have their outputs been calculated).</p>	Core	<ul style="list-style-type: none"> OCC Integration
OCC-BRQ5407	<p>System shall allow users to view the status of the running process(s) (calculation or publishing) and via UI consistent with all other core processes.</p>	Core	- OCC
OCC-BRQ5410	<p>System shall receive MF resource characteristics and published use-limited resource flags, use limit types and limits defined at CCE3-BRQ5155:</p>	Core	MF Integration



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> • Use Limitation <ul style="list-style-type: none"> ○ $MaxSTRT_{k(w)}$ (implied for MSG resources, including MSG transitions) ○ $MaxHRS_{k(w)}$ ○ $MaxMWH_{k(w)}$ • Resource Characteristics <ul style="list-style-type: none"> ○ Number of Implied Starts per non-MSG Resources or MSG configuration ○ Number of Implied Starts per MSG transition 		OCC
OCC-BRQ5411	<p>System shall calculate Opportunity Cost for each of the 3 limitation types (MaxSTRT, MaxHRS, MaxMWH), irrespective of the OC methodology type (calculated/negotiated flag).</p> <p>Notes:</p> <ul style="list-style-type: none"> • If a resource enabled “Other” limitation type only, OCC shall not calculate Opportunity Cost for this resources. • If a resource enabled at least one of these limitation types ($MaxSTRT_{k(w)}$, $MaxHRS_{k(w)}$, $MaxMWH_{k(w)}$), irrespective of “Other” limitation type, OCC shall calculate Opportunity Cost for this resource for the enabled limitation type except for “Other”. 	Core	OCC
OCC-BRQ5415	<p>System shall receive use-limited resource scheduled implied starts, run-hour and energy output (by configurations) by calendar months for prior months:</p> <ul style="list-style-type: none"> • $ActSTRT_{k(w)}$ • $ActHRS_{k(w)}$ • $ActMWH_{k(w)}$ 	Core	MQS MQS Archive Integration OCC
OCC-BRQ5215	<p>Receive MF defined use-limited resources for each opportunity cost limitation type</p>	Core	MF Integration OCC

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	<ol style="list-style-type: none"> 1. System shall receive from MF use-limited resource flags and limits defined in OCC-BRQ5155 2. System shall be able to filter and display those resources by limitation type 3. System shall receive from MF resource characteristics needed to calculate VEC and SUC MLC. Note: refer to items in OCC-BRQ5216 and Appendix-2 (Section 7.7) 		
OCC-BRQ5216	<p>System shall receive all required data for monthly proxy cost calculation (VEC, MLC, SUC, TC) in same way as per existing functionality as in SIBR.</p> <p>This shall include, but is not limited to:</p> <ul style="list-style-type: none"> • (MF) Startup Cost ($RDTCostSU_{g,k}$) • (MF) Minimum Load Cost ($RDTCostML_k$) • (MF) Average cost curve ($AvgCostF_{g,k}$) • (MF) Minimum operating level ($Pmin_{k(w)}$) • (MF) Segment heat rate and segment megawatts, ($SegMW_{g,k}, HR_{g,k}$) both the heat rate operating level and the heat rate for each level. • (ECIC) Future natural gas price & transportation cost, ($NatGasF_{m,l}, GasT_{m-1,l}$) for month m and region l (including Base Gas Transportation Cost, Gas Transportation Shrinkage Allowance, Cap and Trade Credits and Miscellaneous Costs) • (ECIC) <i>Historical natural gas ($NatGas_{m-12,l}$), the monthly average of daily natural gas price from the previous year's period</i> • (ECIC) Daily gas price index of the previous year per fuel region l ($GPI_{d-1y,l}$) • (MF) Emission Rate of resource ($EmRate_k$) • (MF) Greenhouse gas obligation flag (Y/null) • (ECIC) GHG price for the previous month, average greenhouse gas allowance price from prior month ($GHGas_{m-1}$) 	Core	MF, PCA, ECIC Integration OCC



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> • (ECIC) GHG price for the previous year, daily greenhouse gas allowance price from previous year's period ($GHGas_{d-1y}$) • (ECIC) GHG price ($GHGas_{m-12}$) for the monthly average greenhouse gas allowance price from the previous year's period, $m-12$ • (MF) O&M adder, ($O\&M_k$) • (MF) Start-up fuel, ($SUFuel_{g,k}$) • (MF) Startup Time ($SUT_{g,k}$) • (MF) Resource's auxiliary energy for start-ups ($AUX_{g,k}$) • (ECIC) Future electric region $EPI_{m,e}$ • (MF) Resource to fuel region (l) mapping • (MF) Resource to electric region (e) mapping • (MF) Resource's ICE Hub Attribute • (MF) Startup MMA ($SU_MMA_{g,k}$) • (MF) Minimum Load MMA (ML_MMA_k) • (PCA) Previous year 15-minute LMP, ($LMP_{i,f-1y}$) • (ECIC) Power future price ($PPF_{hub,m,tou}$) at ICE hub "hub" for the analysis month m and tou. • (ECIC) Power historical price ($PP_{hub,m-12,tou}$) at ICE hub "hub" from the same month the previous year $m-12$ and tou. Note: For first time deployment or for new ICE hubs, OCC shall consume this input for past 12 months. • (Settlement) PDR Net Benefits test input value ($NBT_{m,k}$). Allow OCC user to override this value. • (MF) Maximum operating level ($Pmax_{k(w)}$) • (MF) Minimum Up Time ($MUT_{k(w)}$) • (MF) Minimum Down Time ($MDT_{k(w)}$) • (MF) Maximum Daily Starts ($MDS_{k(w)}$) 		

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	Note: Refer to Appendix-2 (Section 7.7) for the full list of data		
OCC-BRQ5240	System shall receive required data for calculating projected resource-specific LMPs as listed in Appendix-2 (Section 7.7)	Core	PCA, MQS MQS Archive ECIC Integration OCC
OCC-BRQ5245	ISO shall identify compatible nodes to the resource-specific nodes of new resources to provide the historical data (prior 12 month). The new resource's resource-specific cost calculations projected resource-based LMPs shall be based on historical information at the compatible node. The system shall maintain node to resource association override table and editable UI.	Core	MF Integration OCC
OCC-BRQ5219	Calculate hourly implied marginal heat rate ($ImpHR_{k,h-1y}$) based on previous year 15 minute LMP at resource 'k', daily gas prices <ul style="list-style-type: none"> • Calculating an <u>implied marginal heat rate</u> $ImpHR_{k,f-1y}$ at each use-limited resource 'k' based on FMM real-time energy prices $LMP_{k,f-1y}$ (using $LMP_{i,f-1y}$) and daily gas price index $GPI_{d-1y,l}$ and greenhouse gas costs where applicable from the same time period the previous year (d-1y) • Calculates hourly $ImpHR_{k,h-1y}$ as the simple average of the four relevant 15-minutes $ImpHR_{k,f-1y}$ 	Core	OCC
OCC-BRQ5220	Calculate implied heat rate of future power prices and an implied heat rate of historical power prices. The <u>implied heat rate based on future power prices</u> ($ImpHRF_{hub,m,tou}$) shall be calculated for the future power price at ICE hub "hub" for the analysis month <i>m</i> and Time Of Use (<i>tou</i>) (peak or off peak) and Natural	core	OCC

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	<p>Gas futures price for month 'm' and GHG price for "m-1". where applicable based on GHG flag or GHG price of zero.</p> <p>The <u>implied heat rate of historical power prices</u> ($ImpHR_{hub,m-12,tou}$) is based on average monthly power price at ICE hub "hub" from the same month of the previous year "m-12", and Time Of Use (tou) (peak or off peak) and the monthly average of daily natural gas price from the region 'l' of resource 'k' of the previous year's period, "m-12" and the monthly average greenhouse gas allowance price from the previous year's period, "m-12", where applicable based on GHG flag or GHG price of zero.</p>		
OCC-BRQ5221	<p>Calculate price conversion factor:</p> <p>Calculating a <u>power price conversion factor</u> based on the ratio of an implied heat rate of future power prices ($ImpHR_{hub,m,tou}$) and an implied heat rate of historical power prices ($ImpHR_{hub,m-12,tou}$)</p>	core	OCC
OCC-BRQ5222	<p>Estimate average hourly LMP ($LMP_{k,h}$) for each resource 'k' based on future gas price ($NATGas_{m,l}$), gas transportation price ($GasT_{m-1,l}$) and GHG price ($GHGas_{m-1}$) to the hourly implied heat rate scaled by the price conversion factor, and pass LMP to the Opportunity cost Calculator</p> <ol style="list-style-type: none"> 1. Calculating the hourly implied marginal heat rate $ImpHR_{k,h-1y}$ as CCE3-BRQ5219 2. Calculating a power price conversion factor as CCE3-BRQ5221 3. Scaling the implied heat rate from (1) by the power price conversion factor from (2). 4. <u>Estimating the hourly real-time energy prices</u> by applying the natural gas future prices, gas transportation costs, and greenhouse gas costs where applicable based on GHG flag or zero GHG price to the scaled implied heat rates from (3). <p>Pass the estimated hourly LMP ($LMP_{k,h}$) for each resource 'k' to the opportunity cost Calculator.</p>	core	OCC integration



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OCC-BRQ5420	<p>Retrieve input data from OCC.</p> <p>Including:</p> <ol style="list-style-type: none"> 1) Monthly $VEC_{m,k}$ of each use limited resource (or MSG configuration), based on proxy cost methodology for gas and non-gas units. (Note: Refer to OCC-BRQ5216) 2) Monthly $TC_{m,p}$ of each use limited resource MSG resource, based on proxy cost methodology for gas and non-gas units. (Note: Refer to OCC-BRQ5216) 3) Monthly $SUC_{m,g,k}$, $MLC_{m,k}$ of each use limited resource (or MSG configuration), based on proxy cost methodology for gas and non-gas units. (Note: Refer to OCC-BRQ5216) 4) Estimated hourly $LMP_{k,h}$ of the resources in OCC-BRQ5222 	Core	OCC
OCC-BRQ5425	<p>On-demand and scheduled run Opportunity Cost Calculator</p> <ul style="list-style-type: none"> • The Opportunity Cost Calculator shall be able to run opportunity cost calculation models at pre-scheduled time for all the use-limited resources or a specific user-entered a set of resources • The Opportunity Cost Calculator shall be able to run opportunity cost calculation models on demand at any time for all or a specific user-entered single or a set of resources <p>The OCC shall be able to accept and model new resources as specified by Master File.</p>	Core	OCC
OCC-BRQ5430	<p>Opportunity Cost Optimization Model:</p> <p>The OCC shall be capable of performing model runs for each resource to solve for resource's optimal dispatch (MWh_h) that maximizes resource's profit – (revenue-cost) subject to applicable resource's constraints and limitations. Detailed formula for <u>the objective function is in Technical Appendix-2</u> at end of this document.</p>	Core	OCC

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OCC-BRQ5431	The initial condition of use limited resources in the Opportunity cost optimization model shall be off line and cold start.	Core	OCC
OCC-BRQ5432	System shall allow user to control the OCC horizon start time: <ul style="list-style-type: none"> • OCC horizon start time default is the first day of the next coming month. • OCC shall allow user to specify the horizon start time. 	Core	OCC
OCC-BRQ5440	OCC shall distinguish opportunity costs modeled for each limitation type: <ul style="list-style-type: none"> • SUC Opportunity cost adder modeled based on start limitation is applicable to SUC bid cap. • TC Opportunity cost adder modeled based on start limitation is applicable to TC bid cap for MSG resources. • MLC Opportunity cost adder modeled based on run-hours limitation is applicable to MLC bid cap. • VEC Opportunity cost adder modeled based on energy output limitation is applicable to DEB (cost-based only) bid cap. 	Core	OCC
OCC-BRQ5445	Run base case including all applicable limitation types. Apply the Reserve Margin (configurable) to the use-limitation limits <ul style="list-style-type: none"> • The opportunity cost model shall include three type of limitation: Starts (implied, including MSG transitions), run-hours and energy output. • The opportunity cost model shall include four types of applicability time horizons: Fixed-annual (12 months limitation or balance of the applicability year), rolling-annual (rolling-backward rolling-forward 12 months limitation with two rolling time horizons: M-11 to M and M to M+11, where M is the last and first month of the rolling time 	Core	OCC



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<p>horizon), monthly, and nested (monthly and annual (fixed or rolling)).</p> <ul style="list-style-type: none"> System shall allow Reserve Margin $x_{k(w),v}\%$ [of the plan limit minus actual (scheduled) uses] to vary for each resource for each limitation type. System shall default Reserve Margin to: <ul style="list-style-type: none"> 90% for start limit type 100% for run-hours limit type 100% for energy output limit type System shall allow user to set/edit the Reserve Margin $x_{k(w),v}\%$ for each resource for each limit type. For start and run-hours limitation types, system shall round limitation value, after multiplying by reserve margin, to lower (floor) integer. <p>Notes:</p> <ul style="list-style-type: none"> For monthly (only) applicability [M] that runs the OC model during M-1 month to update the OC for [M], the simulation period is [M] and no need for buffer month. <p>Note: Refer to Example-A1 in Appendix-10 and Example-1 (with dates) in Technical Appendix-2 (Section 7.5.1).</p> <ul style="list-style-type: none"> For the fixed-annual (only) applicability [M,M+11]: <ul style="list-style-type: none"> First run of the OC model shall be on M-1 month to update the OC for [M, M+11], the simulation period is [M, M+11] and no need for buffer month. <p>Note: Refer to Example-B1 in Appendix-10 and Example-1 (with dates) in Technical Appendix-2 (Section 7.5.1).</p> <ul style="list-style-type: none"> Subsequent runs of the OC model shall be on "M+m" month to revise the OC for [M+m+1, M+11], the simulation period is [M+m, M+11] where "M+m" is the buffer 		



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<p>month; actuals from [M, M+m-1] are used to reduce the remaining-annual limit of the limitation enforced in the simulation, and where (0 ≤ m ≤ 10).</p> <p>Note: Refer to Example-B2, B3, B4, B5 in Appendix-10 and Example-2 (with dates) in Technical Appendix-2 (Section 7.5.2).</p> <ul style="list-style-type: none"> • For the rolling-annual (only) applicability [C,N]: <ul style="list-style-type: none"> ○ First run of the model shall be on M-1 where M=C to update the OC for [M, M+11], and the simulation period is [M, M+11] that reflect the forward-rolling 12-month use-limit. No buffer month is needed. No backward-rolling constraint is enforced. Note: This run is similar to fixed-annual first run. (Refer to Example-C1 in Appendix-10 and Example-7 (with dates) in Technical Appendix-2 (Section 7.5.7)) ○ Subsequent runs of the model shall be on M, where (C≤M≤C+10) to update the OC for [M+1, M+11], and the simulation period is [M, M+11] that reflect the forward-rolling 12-month use-limit. Buffer month is M. No backward-rolling constraint is enforced since there is less than 12-month backward until 'C'. (Refer to Example-C2, C3 in Appendix-10) ○ Subsequent runs of the model shall be on M, where (C+11≤M≤N-11) to update the OC for [M+1, M+11], and the simulation period is [M, M+11] that reflect the forward-rolling 12-month use-limit. Buffer month is M. Backward-rolling constraint is enforced by subtracting actuals from [M-11, M-1] from the rolling limit that was applied in the backward-rolling window [M-11, M], to reflect it on the monthly use-limitation for [M]. (Refer to Example-C4, C5, C6 in Appendix-10 and Example-8 (with dates) in Technical Appendix-2 (Section 7.5.8)) 		



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> ○ No runs of the model shall be on M, and no OC's are updated when $(M \geq N - 10)$ since there is less than 12-month forward until 'N'. (Refer to Example-C7 in Appendix-10) <p>Note: Existence of more than use-limit plan that have applicability overlap (for example, fixed-annual on start and monthly on run-hours) shall dictate use of the longer applicability period and may dictate use of buffer month. Refer to Examples in Technical Appendix-2 (Section 7.5).</p> <p>Base Case (B-Run) Scenarios Based on Applicability Time Horizon:</p> <ul style="list-style-type: none"> ● Fixed-Annual: <ul style="list-style-type: none"> ○ Run model with reserve margin $x_{k(w),v}\%$ (of the plan limits minus actual (scheduled) uses counted during applicability time horizon for each limit type) ○ When modeling for opportunity cost of a given limit type; if the other limit types include fixed-annual, rolling-annual, or nested applicability then these shall include adjustment for actual uses of limit (based on real-time market schedule data). ○ Outputs single value for fixed-annual profits. ● Monthly: <ul style="list-style-type: none"> ○ Run model with reserve margin $x_{k(w),v}\%$ (of the plan limits). Note: no actual (scheduled) values adjustments since limits are reset every month) ○ When modeling for opportunity cost of a given limit type; if the other limit types include fixed-annual, rolling-annual, or nested applicability then these will include adjustment for actual uses of limit (based on real-time market schedule data). ○ Outputs up to 12 values which can differ by month and shall be valid for corresponding month, i.e. monthly profits. 		



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	<ul style="list-style-type: none"> • Rolling-Annual: <ul style="list-style-type: none"> ○ For M-11 to M rolling limitation, prior months M-11 to M-1 actual (scheduled) limits shall be calculated and rolled into the monthly limitation for the upcoming month M. ○ Run model with reserve margin $x_{k(w),v}\%$ (of plan limits minus actual (scheduled) uses) for the upcoming 12 month period (M to M+11) treating it same way as a fixed-annual limit. ○ When modeling for opportunity cost of a given limit type; if the other limit types include fixed-annual, rolling-annual, or nested applicability then these will include adjustment for actual uses of limit (based on real-time market schedule data). ○ Outputs single value for rolling profits. • Nested limitations (monthly and annually): <ul style="list-style-type: none"> ○ Run model with reserve margin $x_{k(w),v}\%$ (of annual and monthly limit minus actual (scheduled) uses (based on real-time market schedule data) counted during applicability time horizon). ○ When modeling for opportunity cost of a given limit type; if the other limit types include fixed-annual, rolling-annual, or nested applicability then these shall include adjustment for actual uses of limit (based on real-time market schedule data). ○ Outputs up to 12 values of nested profits which can differ by month and shall be valid for corresponding month, i.e. monthly profits. 		
OCC-BRQ5450	<p>“Limit-Y” (L-Run) Scenarios Based on Applicability Time Horizon:</p> <p>Run “Limits-Y” case scenarios for the test limit type, hold other limit types at their base case limit values. Calculate Opportunity cost for applicable use limitation as the positive difference of profits (objective function value) between base case (B-run) and (limit-Y) case (L-run), where $Y_{k(w),v}$ is configurable (can be defaulted to 1)</p>	Core	OCC



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<p>Scenarios:</p> <ul style="list-style-type: none"> • Fixed-Annual: <ul style="list-style-type: none"> ○ Run model with reserve margin $x_{k(w),v}\%$ (of plan limit minus actual (scheduled) uses, counted during applicability time horizon for limit type) minus $Y_{k(w),v}$. ○ When modeling for opportunity cost of a given use limit type: If the other limit types include fixed-annual, rolling-annual, or nested applicability then these shall include adjustment for actual uses of limit (based on real-time market schedule data). ○ Calculate the difference of estimated profit (objective function value) between base case with $x_{k(w),v}\%$ of (limit-actual) and "Limit-Y" case with [$x_{k(w),v}\%$ of (limit-actual)]-$Y_{k(w),v}$, divided by $Y_{k(w),v}$. ○ Outputs single value for opportunity cost for balance of the applicable fixed-annual horizon. • Monthly: <ul style="list-style-type: none"> ○ Run model with reserve margin $x_{k(w),v}\%$ (of plan limit) minus $Y_{k(w),v}$ enforced for each month. Note: no actual adjustments since limits reset every month. ○ When modeling for opportunity cost of a given limit type: If the other limit types include fixed-annual, rolling-annual, or nested applicability then these shall include adjustment for actual uses of limit (based on real-time market schedule data). ○ Calculate the difference of estimated profit (objective function value) between base case with $x_{k(w),v}\%$ of (limit-actual) and "Limit-Y" case with [$x_{k(w),v}\%$ of (limit- 		



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<p>actual)]-$Y_{k(w),v}$, divided by $Y_{k(w),v}$ for each month.</p> <ul style="list-style-type: none"> ○ Outputs up to 12 monthly opportunity cost values which can differ by month and shall be valid for corresponding month. ● Rolling-Annual: <ul style="list-style-type: none"> ○ For M-11 to M rolling limitation, prior months M-11 to M-1 actual (scheduled) limits shall be calculated and rolled into the monthly limitation for the upcoming month M. ○ Run model with reserve margin $x_{k(w),v}\%$ (of plan limits minus actual uses) minus $Y_{k(w),v}$ for the upcoming 12 month period (M to M+11) treating it same way as a fixed-annual limit. ○ When modeling for opportunity cost of a given limit type: If the other limit types include fixed-annual, rolling-annual, or nested applicability then these shall include adjustment for actual uses of limit (based on real-time market schedule data). ○ Calculate the difference of estimated profit (objective function value) between base case with $x_{k(w),v}\%$ of (limit-actual) and "Limit-Y" case with [$x_{k(w),v}\%$ of (limit-actual)]-$Y_{k(w),v}$, divided by $Y_{k(w),v}$. ○ Outputs single value for opportunity cost in upcoming rolling period (12 months [M,M+11] for first run, and 11 months [M+1,M+11] for subsequent runs). ● For nested annual and monthly applicability time horizons on the same limit type: <ul style="list-style-type: none"> ○ If both annual and monthly limits apply, run "Limit-Y" for annual and "Limit-Y" for each month and hold all other months at base case; 		

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	<ul style="list-style-type: none"> ○ When modeling for opportunity cost of a given limit type: If the other limit types include fixed-annual, rolling-annual, or nested applicability then these shall include adjustment for actual uses of limit (based on real-time market schedule data). ○ Calculate the difference of estimated profit (objective function value) between base case and “Limit-Y” case for each “Limit-Y” case, divided by $Y_{k(w),v}$ (e.g. difference between base case and “Limit-Y” case for first month, divided by $Y_{k(w),v}$ is opportunity cost adder for first month; difference between base case and “Limit-Y” case for last month, divided by $Y_{k(w),v}$ is opportunity cost adder for last month). ○ Outputs up to 12 opportunity cost values, a value for each month within the balance of the applicable nested limitation. <ul style="list-style-type: none"> ● The calculation shall not apply to limitations of less than a month in duration (not daily). <p>Note: Refer to Appendix-2 (Section 7.5) examples</p>		
OCC-BRQ5452	<p>OCC Miscellaneous Modeling Requirements:</p> <ul style="list-style-type: none"> ● For nested applicability, the L-run will reduce the limit for both the monthly use-limitation and the corresponding annual limitation. ● For fixed-annual limitation, system shall not assume January-December calendar year, it shall rather use 12 fixed months depending on the applicability (start and end dates) that is defined in ULPDT. ● For rolling-annual limitations, the time horizon would be 12 calendar months and there will be a monthly limitation for the first month as 	Core	OCC

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	<p>initial condition to not violate prior rolling periods.</p> <ul style="list-style-type: none"> • For a partial year, annual limitations shall be reduced by actuals (scheduled) metrics for the previous months of the year. The current month shall be used as a buffer, thus the OC for monthly limitations in the current month shall not be published. • System shall provide a workflow for OCC execution including any pre-processing or post processing calculations. • System shall provide batch functionality and cascaded GUI for resource list, limitation types and applicability by resource, with check boxes so that the user can select which resources and limitations are active (default will be all). System shall alert user on missing data and skipped calculations. • For nested applicability (yearly and monthly) and monthly applicability, system shall derive the OC as the positive difference of the profit between the B-run and L-run. • For limitations on MSG configurations, the OC shall still be calculated as the positive difference of the profit between the B-run and L-run (for the relevant configuration limitation) runs, where all limitations for all configurations and the MSG plant are enforced in the B-run. 		
OCC- BRQ5455	<p>MSG use limit resource modeling Opportunity cost for biddable SUC, MLC and TC</p> <ul style="list-style-type: none"> a) The limit shall be set up at plant level and configuration level for start (implied, including MSG transitions), run-hours, and energy output; b) The opportunity cost for applicable limitation shall be calculated separately for plant, and for configuration level. 	Core	OCC

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	c) The opportunity cost for applicable limitation shall be calculated separately for each configuration.		
OCC-BRQ5457	<ul style="list-style-type: none"> ○ The B-run shall run for all current use-limitation constraints enforced. System shall calculate the total resource profit as $P_{w(w),B}(D_{k(w),v})$, where: <ul style="list-style-type: none"> ▪ $D_{k(w),v} = x_{k(w),v}\% * (J_{k(w),v} - A_{k(w),v})$ ▪ For start and run-hours limitation types, system shall round limitation value $D_{k(w),v}$ to lower (floor) integer. ▪ k: non-MSG resource (or MSG configuration) ▪ w: Plant ▪ v: Use limitation ▪ J: Plan limit ▪ A: Actual (scheduled) usage <p>Notes on formula's notation:</p> <ul style="list-style-type: none"> ▪ For non-MSG resources $w \neq k$: <ul style="list-style-type: none"> ▪ Calculate $P_{w,B}(D_{k,v}) \equiv P_{k,B}(D_{k,v})$ ▪ $D_{k,v} = x_{k,v}\% * (J_{k,v} - A_{k,v})$ ▪ For MSG resources, total resource profit $P_{w,B}(D_{k(w),v})$ shall always be calculated on plant level (w) for limitations on configuration level (k) or plant level (w). ▪ For limitation on configuration level: <ul style="list-style-type: none"> ▪ Calculate $P_{w,B}(D_{k,v})$ ▪ $D_{k,v} = x_{k,v}\% * (J_{k,v} - A_{k,v})$ ▪ For limitation on MSG plant level: 	Core	OCC



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> ▪ Calculate $P_{w,B}(D_{w,v})$ ▪ $D_{w,v} = x_{w,v} \% * (J_{w,v} - A_{w,v})$ ○ The L-run shall run for all current use-limitation constraints enforced except for the use-limit constraint (or constraints for nested limitation) under evaluation, where it shall be reduced by $Y_{k(w),v}$. System shall calculate the total resource profit as $P_{w(w),L}(Z_{k(w),v})$, where: <ul style="list-style-type: none"> ▪ $Z_{k(w),v} = \text{Max} \{ 0, (D_{k(w),v} - Y_{k(w),v}) \}$. ▪ For start and run-hours limitation types, system shall round limitation value $Z_{k(w),v}$ to lower (floor) integer. <p>Notes on formula's notation:</p> <ul style="list-style-type: none"> ▪ For non-MSG resources $w \equiv k$: <ul style="list-style-type: none"> ▪ Calculate $P_{w,L}(Z_{k,v}) \equiv P_{k,L}(Z_{k,v})$ ▪ $Z_{k,v} = \text{Max} \{ 0, (D_{k,v} - Y_{k,v}) \}$ ▪ For MSG resources, total resource profit $P_{w,L}(Z_{k(w),v})$ shall always be calculated on plant level (w) for limitations on configuration level (k) or plant level (w). ▪ For limitation on configuration level: <ul style="list-style-type: none"> ▪ Calculate $P_{w,L}(Z_{k,v})$ ▪ $Z_{k,v} = \text{Max} \{ 0, (D_{k,v} - Y_{k,v}) \}$ ▪ For limitation on MSG plant level: <ul style="list-style-type: none"> ▪ Calculate $P_{w,L}(Z_{w,v})$ ▪ $Z_{w,v} = \text{Max} \{ 0, (D_{w,v} - Y_{w,v}) \}$ 		



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> ○ The Use-Limitation OC per limitation type and resource (or configuration) shall be calculated as: <ul style="list-style-type: none"> ▪ $OC_{k(w),v} = \text{Max} \{ 0, ([P_{w(w),B}(D_{k(w),v}) - P_{w(w),L}(Z_{k(w),v})] / Y_{k(w),v}) \}$ <p>Notes on formula's notation:</p> <ul style="list-style-type: none"> ○ For non-MSG resources $w=k$: <ul style="list-style-type: none"> ▪ $OC_{k,v} = \text{Max} \{ 0, ([P_{k,B}(D_{k,v}) - P_{k,L}(Z_{k,v})] / Y_{k,v}) \}$ ○ For MSG resources and limitation on configuration level: <ul style="list-style-type: none"> ▪ $OC_{k,v} = \text{Max} \{ 0, ([P_{w,B}(D_{k,v}) - P_{w,L}(Z_{k,v})] / Y_{k,v}) \}$ ○ For MSG resources and limitation on MSG plant level: <ul style="list-style-type: none"> ▪ $OC_{w,v} = \text{Max} \{ 0, ([P_{w,B}(D_{w,v}) - P_{w,L}(Z_{w,v})] / Y_{w,v}) \}$ ○ For non-MSG use-limit resources, system shall store $Y_{k,v}$ values per limitation type on individual resource level (k). ○ For MSG use-limit resources, system shall store $Y_{k(w),v}$ values per limitation type on individual configuration level (k) and plant level (w). ○ For Start use-limitation type, $Y_{k(w),v}$ shall correspond to implied starts. 		



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> ○ System shall allow users to choose default value of $Y_{k(w),v}$: <ul style="list-style-type: none"> ▪ OPTION 1: $Y_{k(w),v} = 1$ for all resources and MSG configurations and limitation types (option 1). ▪ OPTION 2: For Start limitation type: <ul style="list-style-type: none"> ▪ For non-MSG resources, $Y_{k,v}$ = number of implied starts per resource. Note: MF will populated number of implied starts per non-MSG resource to 1. ▪ For MSG configurations, $Y_{k,v}$ = number of implied starts per configuration. ▪ For MSG plants, $Y_{w,v}$ = Maximum number of implied starts across all configurations. ▪ OPTION 2: For Run-Hours Limitation type: <ul style="list-style-type: none"> ▪ For non-MSG resources, MSG configurations, MSG plants, $Y_{k(w),v} = \text{Max}\{ 1 , [S\% * \text{MaxHRS}_k]\}$. Where “S” is a global configurable user-enterable parameter set by the user and is defaulted to 0.1%. ▪ OPTION 2: For Energy Output MWH Limitation type: <ul style="list-style-type: none"> ▪ For non-MSG resources, MSG configurations, MSG plants, $Y_{k(w),v} = [U\% *$ 		

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	<p style="text-align: center;">MaxMWH_k] Where “U” is a global configurable user-enterable parameter set by the user and is defaulted to 0.1%.</p> <ul style="list-style-type: none"> ○ System shall allow the user to override the default values of $Y_{k(w),v}$ on individual resource and configuration level and limitation types’ basis. ○ The examples in the Technical Appendix-2 is assuming $Y_{k(w),v} = 1$ for all resources and limitation types. 		
OCC-BRQ5465	<p>Build flexibility in Opportunity Cost Calculator, allow user to input limit, model spec, input data</p> <ul style="list-style-type: none"> • System shall allow user to filter and display on resource use-limit types, date range • System shall allow user to input the use limits for starts (implied, including MSG transitions), run-hours and energy output • System shall allow user to manually update the input data from OCC: <ul style="list-style-type: none"> a. Monthly Variable Energy Costs ($VEC_{m,k}$), b. Monthly Commitment cost of start –up ($SUC_{m,g,k}$), transition cost ($TC_{m,p}$) and min load ($MLC_{m,k}$) • Estimated hourly LMP of future months for each resource- • System shall be capable of running the opportunity cost optimization model with user specified input data. • The model results, are obtained by calculating the difference of base case and “limit-Y” case. The opportunity cost for each limitation type is for start (per implied start, including MSG transitions), run-hours, and energy output. 	Core	OCC



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
OCC-BRQ5475	<p>OCC shall publish opportunity costs for each limitation per applicability per resource (per plant and per configuration for MSG resources) to downstream system.</p> <ul style="list-style-type: none"> • Res ID (same as Plant ID for MSG resources) • Config ID (for MSG resources) • Applicability (start time and end time) • Limitation type (start (implied, including MSG transitions)/run-hours/energy) • Opportunity cost <p>Notes:</p> <ul style="list-style-type: none"> • The start limitation OC shall be per implied starts for MSG as well as non-MSG resources. • If an MSG resource has a use limitation on plant level, there shall be an OC calculated and published on the plant level for that limitation type. • If an MSG resource has a use limitation on a specific configuration, there shall be an OC calculated and published on that configuration for that limitation type. 	Core	OCC, Integration ECIC,
OCC-BRQ5480	<p>Store the data of Opportunity Cost Calculator of each model run case:</p> <ol style="list-style-type: none"> 1. Input data 2. Model 3. Results the opportunity cost adders 	Core	OCC EDR
OCC-BRQ5485	<ul style="list-style-type: none"> • OCC shall allow a production user and a study user. • Save case shall store the data for both production user and study user. 	Core	OCC EDR

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5.7 Business Process: < Report Opportunity Cost in CMRI >

5.7.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
OCC-BRQ5510	<p>System shall consume and display opportunity costs adder results for each resource from ECIC.</p> <ul style="list-style-type: none"> • Receive resource opportunity cost adders for SUC, TC, MLC and VEC monthly with applicable start time and end time. Note: The OC adders include future monthly OC adders as well as daily OC adders and market type to identify which values are used by the market. • Display resource opportunity cost (O.C): <ul style="list-style-type: none"> ○ Resource Id ○ Config ID ○ From Config id (MSG Only) ○ To Config id (MSG Only) ○ Applicable Start time ○ Applicable End time ○ Market Type (Used for Daily OC adders only) ○ OC Methodology Type Negotiated/Calculated ○ OC Adder Type (SUC, TC, MLC,VEC) ○ OC Adder (\$/start,\$/Transition\$/hour,\$/MWh,) 	Core	integration CMRI
OCC-BRQ5520	<p>System shall allow SCs to access and download their corresponding resource opportunity costs adders.</p>	Core	CMRI UI/API Integration MP
OCC-BRQ5521	<p>System shall consume and display actuals (scheduled) starts (including MSG transitions), run-hours and energy output for use-limited each resource. Allow SC to access and download them.</p>	Core	CMRI UI/API

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> • Resource ID • Config ID (MSG Only) • Applicability (start time and end time) • (Scheduled) start (ActSTRT) • (Scheduled) Run-hours (ActHRS) • (Scheduled) Energy Output (ActMWH) 		Integration MP
OCC-BRQ5522	System shall allow SC to access and download scheduled starts (implied, including MSG transitions), run-hours and energy output for use-limited each resource.	Core	CMRI UI/API Integration MP

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5.8 Business Process: < Day-Ahead Market and Real Time Market: SIBR, DAM and RTM >

5.8.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
OCC-BRQ5610	<p>SIBR shall receive opportunity cost adders for SUC, TC, MLC and VEC for each use limited resources</p> <p>Receive the opportunity cost adders from the upstream system (ECIC)</p> <ol style="list-style-type: none"> 1. Resource ID (same as plant ID for MSG resources) 2. Config ID (MSG resources) 3. From Config ID (MSG transitions) 4. To Config ID (MSG transitions) 5. Applicability (start and end date/time) 6. Opportunity Cost Methodology Type (Calculated/Negotiated) 7. Opportunity Cost Adders Types: <ol style="list-style-type: none"> a. SUC b. TC c. MLC d. VEC 8. Opportunity Cost (\$/start, \$/transition, \$/hour, \$/MWH) 	Core	Integration SIBR
OCC-BRQ5620	<p>System shall allow resources under the proxy cost option regardless of technology type including those exempted from energy mitigation (participating load and PDR resources) to submit commitment costs bid, subject to bid cap</p> <ol style="list-style-type: none"> 9. All resources under the proxy cost option including those exempted from energy mitigation (participating load and PDR) 	Core (Existing Functionality)	SIBR

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<p>submitted commitment cost are subject to a bid cap on SUC, TC, and MLC.</p> <p>10. Participating load and PDR energy bid, subject to bid cap, currently \$1000/MWh and are exempt from energy mitigation.</p> <p>11. If participating load resource or PDR is defined as use-limited resource, system shall receive the opportunity cost adder from the upstream system. Opportunity cost SUC adder, TC adder, and/or MLC adder shall be added to the commitment cost bid caps.</p>		
OCC- BRQ5630	<p>System shall add the opportunity cost adder to each resource's current commitment cost bid caps to determine new commitment cost bid caps,</p> <p>SIBR shall add opportunity cost adders to the current bid cap for SUC, TC, MLC to determine new commitment cost bid caps as follows:</p> <ul style="list-style-type: none"> • Opportunity cost SUC adder is applicable to SUC bid cap, • Opportunity cost TC adder is applicable to TC bid cap for identified MSG resources and transitions. • Opportunity cost MLC adder is applicable to MLC bid cap. <p>Notes:</p> <ul style="list-style-type: none"> ○ Opportunity cost adder shall be added to the current bid caps for SUC, TC, and/or MLC to determine new maximum allowable levels (bid cap). Bid cap going forward shall have its maximum allowable level set by the sum of the 125% of proxy cost and opportunity cost adder where applicable. 	Core	SIBR Integration

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> ○ Refer to Appendix-4 for a numerical example of SUC and TC bid cap calculations for MSG resources. <p>Note: Refer to OCC-BRQ5632</p>		
OCC-BRQ5631	<p>System shall add the opportunity cost VEC adder to each resource's SIBR-generated (inserted) energy bid curve to cover Resource Adequacy (RA) range:</p> <ul style="list-style-type: none"> • Opportunity cost VEC adder for energy output shall be added to every segment of SIBR-generated (inserted) bid curve to cover the RA range where applicable. • Use existing rule to extend submitted bid to cover the RA range. Opportunity cost of VEC shall not be added. <p>Note: Refer to OCC-BRQ5226</p>	Core	SIBR
OCC-BRQ5632	<p>Calculate and publish the Maximum Allowable SUC/TC/MLC Levels that include opportunity cost for the use-limited resources</p> <p>System shall publish the final Maximum Allowable SUC/TC/MLC Levels that include the opportunity cost using existing payload.</p> <p>The calculations shall follow the following formula:</p> <p>If $OC_{SUC/TC/MLC} \neq \text{null}$ then</p> <p style="padding-left: 40px;">Maximum Allowable SUC/TC/MLC = (125% * Proxy_{existing}) + $OC_{SUC/TC/MLC}$</p> <p>Else</p> <p style="padding-left: 40px;">Maximum Allowable SUC/TC/MLC = 125% * Proxy_{existing}</p> <p>End If</p>	core	SIBR Integration



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<p>OC_{SUC/TC/MLC} can be from negotiated inputs or calculated values can be from negotiated inputs or calculated values</p> <p>Note: Refer to Appendix-4 for a numerical example of SUC and TC bid cap calculations for MSG resources.</p>		
OCC-BRQ5636	<p>Fallback Mechanism</p> <p>In the event that SIBR does not receive opportunity costs adders for the use-limited resources, the opportunity cost adders shall fallback to the most recently calculated or negotiated Opportunity Cost adders for that resource, only if the use-limit resource plan is active for the applicable use-limitation type at the fallback trade date.</p>	core	- SIBR
CCE3-BRQ5640	<p>IFM/RTM, SIBR and BSAP shall receive the market-based values of MDS, MDMT and RR (Operational, Operating Reserve, and Regulation) from MF.</p> <ul style="list-style-type: none"> IFM/RTM receive design-capability characteristics from all other resource characteristics from MF <p>SIBR shall no longer consume “technical (design-capability)” RR value for validating the daily RR bid since the daily RR bid functionality is being removed.. Note: Refer to CCE3-BRQ5670 for more details</p>	Core	IFM/RTM/ED Tool/MED/IOOC SIBR BSAP Integration
CCE3-BRQ5650	Use Market MDS,MDMT, RR (Operational, Operating Reserve, and Regulation) in IFM/RTM economic commitment and dispatch	Core	IFM/RTM/ED Tool/MED/IOOC
CCE3-BRQ5670	<p>Remove operational, operating reserve, regulation daily bid RRs</p> <p>Ramp rates (RRs) shall no longer be a component of the daily energy bids, while the ISO</p>	Core	SIBR WebOMS

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	shall continue to allow resources to have a market-based RR (operational, operating reserve, regulation) through the additional market-based RR field in MF.		
CCE3-BRQ5682	Include opportunity costs adders and resource characteristics market-based values in the data set sent to FERC. Note: Continue to send entire set of design characteristics including those with the new market based fields (MDS, MDMT, RR (Operational, Operating Reserve, and Regulation)) to FERC.	Core	FODD

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5.9 Business Process: < Manage Use-Limited Reached Outage in WebOMS >

5.9.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
CCE3-BRQ5710	System shall receive MF-defined resource with use-limited flags CCE3-BRQ5155	Core	MF Integration WebOMS
CCE3-BRQ5720	<p>System shall allow eligible resource to submit outage card with any of the four “Use-Limit Reached” Nature of Work Attributes (Annual, Monthly, Other, Short-term)</p> <p>System shall validate eligible resources include:</p> <ul style="list-style-type: none"> • Use-limited resource 	Core (Existing Functionality)	WebOMS
CCE3-BRQ5721	<p>Clarify appropriate uses of the “Use-Limit Reached” outage cards</p> <p>Eligible reasons for “Short term Use-Limit Reached” include:</p> <ul style="list-style-type: none"> • Use limited resource safety net primarily limited to cases where opportunity cost has been ineffective and the resource is at risk of prematurely reaching its limitation with the use of the opportunity cost adder in its bids • PDR, RDRR Fatigue breaks <p>Validation is not required for fatigue breaks, and unforeseen issues in OMS</p> <p>Note:</p> <p>The eligible reasons for the annual, monthly, or other nature of works remain the same as existing reasons which includes:</p> <ul style="list-style-type: none"> • Annual use-limit reached to be used when a use-limited resource with an annual limitation has reached the annual limitation specified in the use plan data 	Core (Clarifications provided for BPM changes only)	WebOMS



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<p>template. This attribute applies only to use limit resources or to proxy demand response or reliability demand response resources.</p> <ul style="list-style-type: none"> Monthly use-limit reached to be used when a use-limited resource with a monthly limitation has reached the monthly limitation specified in the use plan data template. This attribute applies only to use limit resources or to proxy demand response or reliability demand response resources. Other use-limit reached to be used if unit with a limitation other than annual/monthly reaches its other type of use limitation specified in the use plan data template. These limitations are expected to have an applicable time horizon greater than a month. This attribute applies only to use limit resources or to proxy demand response or reliability demand response resources. 		
CCE3-BRQ5730	<p>System shall publish the submitted outage card with all relevant attributes with effective period to the downstream systems:</p> <ul style="list-style-type: none"> Effective time Res ID <p>Nature of work attribute depending on the nature of work submitted either "Annual Use-Limit Reached", "Monthly Use-Limit Reached", "Other Use-Limit Reached", or "Short-term Use Limit Reached"</p>	Core (Existing Functionality)	WebOMS Integration CIRA
CCE3-BRQ5740	WebOMS shall activate existing validation of monthly nature of work attribute to make sure outage will end at end of the month	Core	WebOMS

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5.10 Business Process: < Manage RAIM Exempt in CIRA >

5.10.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
CCE3-BRQ5810	System shall receive outage card with one of four use-limit reached attributes of nature of work.	Core (Existing Functionality)	OMS Integration CIRA
CCE3-BRQ5820	System shall apply the RAIM exempt rule for the resource for the remainder of month for the annual or other use-limit reached outage card start date of the effective period Notes: <ul style="list-style-type: none"> • System shall continue to apply the RAIM exempt rule for the resource for the remainder of month for the monthly as well as short-term use-limit outage card start date of the effective period • RAIM exemption rules shall not be applied if a resource submits a use-limited reached outage card that has not actually reached its limitation. For example, if a resource submits an annual use-limited reached card, it should only be exempt for the remainder of the month, if it actually reached its limitation. <p>System shall publish the RAIM exempt MW for the resource to the downstream system with the period of the remainder of month.</p> <p>If any RA resource submits either an annual or other use limit reached outage for 3/15 to 4/15 and the resource is RA for March and April then resource will be exempt from RAIM for the month of March and resource will no longer exempt for the month of April. The exempt MW calculation needs to reflect this for this outage ID.</p>	Core (Clarifications, providing example)	CIRA Integration

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	<p>System shall set the flag indicating the exempt MW applies to RAAIM use limitation rules (ULCURTFLAG = true)</p> <p>Note:</p> <p>Before January 1. 2018, RAAIM exempt rule is applicable for the outage effective time, not limited in the remainder of month.</p> <p>Given the implementation effective date of January 1. 2018, the ISO should have provided the entirety of the transition period and shall apply RAAIM exempt rule as described.</p>		
CCE3-BRQ5830	<p>RAAIM exempt rule is no longer applied upon starting the first day of the following month for annual or other use-limit reached outage cards. (Existing RA rule apply).</p> <p>System shall publish the RAAIM exempt MW for the resource to the downstream system starting the first day of the following month.</p> <p>System shall set the flag indicating the exempt MW not applies to RAAIM use limitation rules (ULCURTFLAG = false)</p>	Core	CIRA Integration
CCE3-BRQ5835	<p>RAAIM exemption during transition to Tariff Effective Date</p> <p>System shall consider any outage period prior to the tariff effective date to be considered as the RAAIM Exempt period under the revised RAAIM exemption rule. In this case, the portion of the outage period that extends into the post-tariff effective date shall be considered non-RAAIM exempt (applies only to Annual and Other use limited Nature of Work categories).</p> <p>For example, if the tariff effective date was 4/1 (a sample date), an “Other” use-limited outage with a start date of 3/29 that extends until 4/9 will be RAAIM exempt from 3/29 to 3/31 (up to remainder of the first month). The same outage will not be RAAIM exempt for its period from 4/1 to 4/9.</p>	Core	CIRA



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
CCE3-BRQ5860	<p>Note: Automation of validation of market-based ramp rate and flex RA capacity will be part of another forthcoming project.</p> <ul style="list-style-type: none"> ● System shall automatically validate and display that any registration of MF market-based ramp rates (operational) shall not make a resource unable to provide the flexible RA capacity as defined in RA plans, flex CPM and flex substitution: <ul style="list-style-type: none"> ○ Market based ramp rates shall be high enough for the resource to still provide flexible RA capacity that has been shown for. <p>Note: Refer to Appendix 5 for Resource Adequacy Table for Base Ramping Qualification.</p>	Core	<ul style="list-style-type: none"> -CIRA -Integration -MF
CCE3-BRQ5870	<ul style="list-style-type: none"> ● System shall automatically validate and display that any registration of MF market-based MDS or MDMT shall meet minimum starts or transitions per day requirements for the flexible RA category the resource is providing: <ul style="list-style-type: none"> ○ Market based MDS \geq minimum start per day requirement for the flexible RA category the resource is providing ('Q' [configurable, currently defaulted to 2]) ○ Market based MDMT \geq minimum transitions per day requirement for the flexible RA category the resource is providing ('R' [configurable, currently defaulted to 2]) 	Core	<ul style="list-style-type: none"> -CIRA -Integration -MF

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6. Appendix-1: Acronym Definition

Acronym	Definition
A	Actual Usage
ActHRS	Actual Run-Hours
ActMWH	Actual Output
ActDirectSTRT	Actual number of Direct Startups (from OFF state only, not including transitions) (within a specified time horizon).
ActSTRT	Actual number of Startups (implied, including MSG transitions) (within a specified time horizon).
ActTRANSITION	Actual number of MSG Transitions (within a specified time horizon).
AGR	Aggregate Generating Resource
API	Application Program Interface
AUX	Auxiliary Energy
AvgCostF	RDT Submitted Cost
AvgHR	Fuel-equivalent Average Heat rate for the non-gas fired resource or MSG configuration with GHG compliance.
b	Number of MSG configurations for MSG resources; 1 for non-MSG resources
B	Base case model run
B2B	Business-to-Business
BA	Business Analyst
BA	Balancing Authority
BAA	Balancing Authority Area
BOG	Board Of Governors
BPM	Business Process Manual

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Acronym	Definition
BRS	Business Requirement Specifications
BSAP	Base Schedule Aggregation Portal
BTU	British Thermal Unit
c	Number of MSG transitions for MSG resources; 0 for non-MSG resources.
C	Start month of rolling-annual use-limit plan applicability
CAISO	California Independent System Operator
CCE2	Commitment Cost Enhancement Phase 2
CCE3	Commitment Cost Enhancement Phase 3
CHP	Combined Heat & Power
CIP	Critical Infrastructure Protection
CIRA	California ISO Interface for Resource Adequacy
CMRI	Customer Market Results Interface
CONFIG	Configuration
d	A subscript to denote a calendar day.
D	Adjusted use limit that is used in Base B-run
DA	Day-Ahead
DB	Data Base
DDS	Design & Development Specifications
DEB	Default Energy Bid
DF	Dispatchability Flag
DMM	Department of Market Monitoring

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Acronym	Definition
DUIT	Detailed Unit Information Calculator. It is an in-house developed Calculator that is used by Operations.
e	A subscript to denote an electric region.
ECIC	Energy Costs & Index Calculator
ED	Exceptional Dispatch
EDR	Enterprise Data Repository
EFC	Effective Flexible Capacity
EIM	Energy Imbalance Market
EMM	Enterprise Modeling Management
EMMS	Enterprise Modeling Management System
EmRate	Green House Gas Emissions Rate (per MMBtu of natural gas)
EMS	Energy Management System
EPI	Electricity Price Index
ERRA	Energy Resource Recovery Account
ESP	Electronic Security Perimeter
e-Terra	Settlements Application System
f	A subscript to denote a fifteen minutes.
FERC	Federal Energy Regulatory Commission
FIT	Fully Integrated Transactions
FMM	Fifteen Minute Market
FODD	FERC Outgoing Data Depository
g	A subscript to denote a segment

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Acronym	Definition
GasT	Gas Transportation Cost
GHG	Green House Gas
GHGas	Green House Gas Allowance Price (if resource is subject to greenhouse gas costs)
GMC	Grid Management Cost
GPI	Gas Price Index
GRDT	Generator Resource Data Template
GUI	Graphical User Interface
h	A subscript to denote an hour
H	Hour
HR	Heat Rate
i	A subscript to denote a pnode.
ICE	InterContinental Exchange
ID	Identification
IFM	Integrated Forward market
ImpHR	Implied Heat Rate on resource
ImpHRF	Implied Heat Rate based on ICE hub's Future Power Price
ImpHRH	Implied Heat Rate based on ICE hub's Historical Average Power Price
IOOC	Integrated Optimal Outage Coordination
IS	Information Security
ISO	California Independent System Operator
IT	Information Technology

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Acronym	Definition
ITPD	Information Technology Product Development
ITPM	Information Technology Product Management
J	Use Plan Limitation
k	A subscript to denote a non-MSG resource or MSG configuration
KWh	Kilo Watt Hour
l	A subscript to denote a fuel region.
L	Limit-Y model run
LMP	Local Marginal Price
m	A subscript to denote a calendar month.
M	Month
MaxHRS	Maximum Run-Hours (within a specified time horizon)
MaxMWH	Maximum Energy Output (within a specified time horizon)
MaxSTRT	Maximum number of Startups, implied including MSG transitions (within a specified time horizon)
MCI	Model & Contract Implementation
MDS	Maximum Daily Startups
MDT	Minimum Down Time
MDMT	Maximum Daily MSG Transitions
MED	Manual Economic Dispatch
MF	Master File
ML_GMC	GMC Adder at Pmin
ML_MMA	Major Maintenance Adder at Pmin

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Acronym	Definition
ML	Minimum Load (same as Pmin)
MLC	Minimum Load Cost
MLF	Minimum Load Fuel
MMA	Major Maintenance Adder
MBTU	Million British Thermal Unit (same as MMBTU)
MMBTU	Million British Thermal Unit (same as MBTU)
MOO	Must-Offer Obligation
MOT	Minimum On Time (same as MUT)
MP	Market Participant
MQRI	Market Quality and Renewable Integration
MQS	Market Quality System
MSG	Multi-Stage Generator
MUT	Minimum Up Time (same as MOT)
MVQ	Market Validation Quality
MVQA	Market Validation Quality & Analysis
MWh	Optimal dispatch of the resource in Mega Watt Hour
n	Number of hours in the analysis time horizon.
N	End month of rolling-annual use-limit plan applicability
N/A	Not Applicable
NatGas	Natural Gas Historical Price
NatGasF	Natural Gas Futures Price

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Acronym	Definition
NatGasTotalF	Total Natural Gas Futures Price (including Gas Transportation, Cap and Trade credits and miscellaneous costs).
NBT	Net Benefit Test
NDEB	Negotiated Default Energy Bid
NQC	Net Qualifying Capacity
O&M	Operating & Maintenance Adder
OC	Opportunity Cost
OCC	Opportunity Cost Calculator
OEM	Original Equipment Manufacturer
OES	Operations Engineering Services
OMS	Outage Management System
Online	Optimal commitment (0/1) flag to indicate if resource or MSG configuration is online (1) (active) or offline (0)
PCA	Price Correction Application
PDR	Proxy Demand Response
π	Objective Function Profit
p	A subscript to denote an MSG transition
P	Objective Function Profit
Pmax	Maximum Generation (Load) MW Level
Pmin	Minimum Generation (Load) MW Level (same as ML)
PminHR	Resource Heat Rate at Pmin
PP	ICE hub's Historical Average Power Price

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Acronym	Definition
PPConv	ICE hub's Conversion Factor based on Future Power Prices
PPF	ICE hub's Future Power Price
PSTD	Power Systems Technology Development
PSTO	Power Systems Technology Operations
Q	Minimum MF Registered MDS per day (Configurable)
QF	Qualified Facility
QRB	Quality Review Board
r	Resource
R	Minimum MF Registered MDMT per day (Configurable)
RA	Resource Adequacy
RAAIM	Resource Adequacy Availability Incentive Mechanism
RDRR	Reliability Demand Response Resources
RDT	Resource Data Template
RDTCostML	RDT Average Fuel cost at Pmin
RDTCostSU	RDT Start-Up Fuel or Fuel Equivalent Cost
RDTCostT	RDT Transition Fuel or Fuel Equivalent Cost
RES	Resource
RMR	Reliability Must-Run
RMT	Regulatory-Must-Take
RR	Ramp Rate
RRavg	Average Ramp Rate

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Acronym	Definition
RSI	Reliability Services initiative
RT	Real-Time
RTM	Real-Time Market
RTN	Real-Time Market
RUC	Residual Unit Commitment
S%	Global configurable user-enterable parameter that is used to calculate default 'Y' for max run hours that is used in "Limit-Y" L-run
SADS	System And Design Specifications
SC	Scheduling Coordinator
SCUC	Security Constrained Unit Commitment
SegMW	MW in Heat Rate Segment
SIBR	Scheduling Infrastructure Business Rules
SME	Subject Matter Expert
SRS	System Requirement Specifications
Starting	0/1 flag to indicate if resource or active MSG configuration for an optimal segment is starting (1); otherwise (0).
STUC	Short-Term Unit Commitment
SU	Start Up
SU_GMC	GMC Adder for Start Ups
SU_MMA	Major Maintenance Adder for Start Ups
SUC	Start Up Cost
SUF	Start Up Fuel

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Acronym	Definition
SUfuel	Start-Up Fuel
SUT	Start Up Time
T	Operating Day
T-1	Operating Day minus 1 calendar day
T+x	Operating Day plus x calendar days
T+7	Operating Day plus 7 calendar days
TBD	To Be Determined
TC	Transition Cost
TEE	Total Expected Energy
TOU (tou)	Time Of Use
Transitioning	0/1 flag to indicate if active MSG transition has occurred (1); otherwise (0).
S%	Global configurable user-enterable parameter that is used to calculate default 'Y' for max MWH that is used in "Limit-Y" L-run
UI	User Interface
ULPDT	Use Limited Plan Data Template
v	A subscript to denote a use-limitation
VEC	Variable Energy Cost
VER	Variable Energy Resource
w	A subscript to denote an MSG Plant and is equivalent to 'k' for non-MSG resources
WebOMS	Web-based Outage Management System
X%	Reserve Margin in %
Y	Configurable decrement of base limit under-analysis in the "Limit-Y" (L) run.

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Acronym	Definition
Z	Adjusted use limit that is used in "Limit-Y" L-run.

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7. Appendix-2: [Technical Appendix](#)

7.1 Introduction

This technical appendix documents the proposed design and methodology for determining opportunity cost (OC) adders for use-limited resources. The ISO is proposing to include OC adders to the commitment cost bid caps and/or the resource's Default Energy Bid (DEB) to enable a more optimal and efficient use of these resources given the limitations that are not considered by the current market optimization.

Commitment Cost Enhancements Phase 3¹ initiative developed a revised definition of use-limited to align use-limited status with resources needing an opportunity cost in commitment costs and DEBs to be optimally committed due to restrictions which extend beyond the ISO's market optimization.

The ISO issued a draft final proposal on February 17, 2016, which was approved by the Board of Governors at the March 25th Board of Governor's Meeting. This technical appendix is intended to provide transparency to the proposed methodology and calculation of opportunity costs. These formulas were initially provided in the straw and revised straw proposals, but were removed from the draft final as the ISO committed to providing a technical appendix with more detail.

The technical appendix is organized as follows:

- Section 7.2 provides a high level description of what constitutes an opportunity cost, the proposed methodology, and how it will facilitate a more optimal and efficient use of use-limited resources.
- Section 7.3 describes the model inputs and formulation of inputs.
- Section 7.4 provides the formulation of the resource-specific opportunity cost model.
- Section 7.5 provides examples of how the opportunity cost model will determine opportunity costs for sample resources with various combinations of limitations.
- Section 7.6 provides the various permutations on cost estimate formulas for non-gas fired resources with and without greenhouse gas compliance obligations.
- Section 7.7 provides more detailed information on the data sources necessary for the cost estimate calculations.

¹ Refer to the Draft Final Proposal posted at:

<http://www.caiso.com/informed/Pages/StakeholderProcesses/CommitmentCostEnhancementsPhase3.aspx>

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7.2 Overview of Opportunity Cost

Use-limited resources have start and run limitations due to environmental or other operational restrictions. These restrictions extend beyond a one-day period and therefore cannot be explicitly recognized in the ISO market commitment decision. For example, an environmental restriction may limit a resource’s run time over a single month to only 200 hours. However, the ISO’s day-ahead market only considers a single day.

The ISO’s optimization does not currently take into account that dispatching a resource in the current day may restrict its ability to run later in the month. When a resource runs in lower-priced hours, it incurs an opportunity cost to the extent it is not available in higher priced hours. Including opportunity costs in commitment costs and DEBs, however, can allow the ISO market to optimally commit these resources by considering the limitations that extend beyond a single day, such as over a month or a year.

Commitment Cost Enhancements Phase 3 proposed a methodology to determine resource-specific opportunity costs for limitations of use-limited resources. If the resource and limitations lend itself to be modeled, the opportunity cost will be determined by modelling the market commitment of these resources based on projected locational marginal prices. The ISO will update these opportunity costs monthly throughout the year to reflect each resource’s actual commitment by the market. Sections 7.3 through 7.5 below go into more detail of the opportunity cost model. Resources and limitations that cannot be modeled utilizing the method below can receive a negotiated opportunity cost.

The end result enables use-limited resources to reflect the opportunity costs in daily commitment costs bids and DEBs. This increases market efficiency by increasing consistent participation of use-limited resources and allowing the market to determine the most optimal commitment and use of use-limited resources.

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7.3 Opportunity Cost Model Inputs

This section discusses resource characteristics and market inputs used in the optimization model.

7.3.1 Resource Characteristics and Constraints

The ISO will use the following Master File characteristics in the resource-specific opportunity cost model. The most recent values will be used in the model. The labels provided in parentheses will be the notation of that variable used throughout the technical appendix.

- (1. Minimum operating level ($P_{min_{k(w)}}$)
- (2. Maximum operating level ($P_{max_{k(w)}}$)
- (3. Minimum Up Time ($MUT_{k(w)}$)
- (4. Minimum Down Time ($MDT_{k(w)}$)
- (5. Maximum Daily Starts ($MDS_{k(w)}$)

Where:

- k denotes MSG configuration (or non-MSG resource)
- w denotes MSG plant (or non-MSG resource)

The ISO will rely on limitations identified on the use-limit plan data template (ULPDT) to determine the resource's use-limitation(s). The limitation(s) will be in terms of maximum starts (implied for MSG resources, including MSG transitions) ($MaxSTRT_{k(w)}$), run-hours ($MaxHRS_{k(w)}$), and/or output ($MaxMWH_{k(w)}$). When the opportunity cost is updated as a resource is part way through the limitation horizon, the limitation used in the model will be based on the remaining available limitation.

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7.3.2 Estimated Costs

The model will use estimated variable energy, minimum load, start-up, and transition costs of the resource. The commitment cost estimates will be based on the proxy cost formulas as described in the Market Instruments Business Practice Manual² with adjustments necessary to forecast the costs over the modeled time horizon. The variable energy cost calculation will be a megawatt weighted cost based on the Default Energy Bid (DEB) formulation, or equivalent, as described in Attachment D of the Market Instruments BPM.

The following formulas are for gas-fired resources. The permutations of the formulas for non-gas fired resources can be found in Section 7.6.

Variable Energy Cost

The model will use an estimated Variable Energy Cost ($VEC_{m,k}$) for each month in the model for the entire output range of the resource. The monthly VEC will be based on the resource-specific megawatt weighted average heat rate, monthly forward natural gas prices, and the most recent natural gas transportation costs, greenhouse gas costs, and O&M Adder.

Note: For MSG resources, the monthly VEC will be on configuration level 'k'.

The monthly VEC (\$/MWh) will be determined as follows:

$$(1) VEC_{m,k} = \sum_g (\text{SegMW}_{g,k} * (\text{HR}_{g,k} / 1,000 * (\text{NatGasF}_{m,l} + \text{GasT}_{m-1,l} + \text{GHGas}_{m-1} * \text{EmRate}_k) + \text{O\&M}_k)) / \sum_g (\text{SegMW}_{g,k})$$

Where:

$VEC_{m,k}$	is the estimated monthly Variable Energy Cost for the resource or MSG configuration 'k' (\$/MWh)
$\text{SegMW}_{g,k}$	is the megawatts in heat rate segment 'g' for the resource or MSG configuration 'k' (MW)
$\text{HR}_{g,k}$	is the heat rate for segment 'g' for the resource or MSG configuration 'k' (BTU/KWh)
$\text{NatGasF}_{m,l}$	is the Natural Gas futures price for month 'm' for fuel region 'l' (\$/MMBTU)
$\text{GasT}_{m-1,l}$	is the most recent gas transportation cost for fuel region 'l' (including Base Gas Transportation Cost, Gas Transportation Shrinkage Allowance, Cap and Trade Credits and Miscellaneous Costs) (\$/MMBTU)
GHGas_{m-1}	is the most recent greenhouse gas price, if resource is subject to greenhouse gas costs (\$/metric ton CO ₂ e)
EmRate_k	is the resource specific greenhouse gas emissions rate per MMBtu of natural gas for resource or MSG configuration 'k' (metric ton CO ₂ e/MMBTU)
O\&M_k	is the operating and maintenance adder for the resource or MSG configuration 'k' (\$/MWh)

Commitment costs

² Refer to Attachment G.2 for proxy cost formulas at <https://bpmcm.caiso.com/Pages/BPMDetails.aspx?BPM=Market Instruments>

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For commitment costs, the ISO will calculate monthly proxy start-up, Transition and minimum load costs using the proxy cost formulations, adjusted for monthly forward natural gas prices, as shown below.

Note: For MSG resources, the monthly SUC and MLC will be on configuration level; and monthly TC will be on transition level.

$$(2a) \text{ SUC}_{m,g,k} = [\text{SUFuel}_{g,k} * (\text{NatGasF}_{m,l} + \text{GasT}_{m-1,l})] + (\text{AUX}_{g,k} * \text{EPI}_{m,e}) + (\text{SUFuel}_{g,k} * \text{GHGas}_{m-1} * \text{EmRate}_k) + \text{SU_MMA}_{g,k} + \text{SU_GMC}_{g,k}^3$$

Where:

- $\text{SUC}_{m,g,k}$ is the estimated monthly start-up cost for the resource or MSG configuration 'k' for segment 'g' (\$/start)
- $\text{SUFuel}_{g,k}$ is the most recent start-up fuel value in Master File for the resource or MSG configuration 'k' for segment 'g' (MMBTU/start)
- $\text{NatGasF}_{m,l}$ is the Natural Gas futures price for month 'm' for fuel region 'l' (\$/MMBTU)
- $\text{GasT}_{m-1,l}$ is the most recent gas transportation cost for fuel region l (including Base Gas Transportation Cost, Gas Transportation Shrinkage Allowance, Cap and Trade Credits and Miscellaneous Costs) (\$/MMBTU)
- $\text{AUX}_{g,k}$ is the most recent Auxiliary Energy value in Master File for the resource or MSG configuration 'k' for segment 'g' (MWH/start)
- $\text{EPI}_{m,e}$ is Future Electricity Price Index for month 'm' for electric region 'e' (\$/MWh)
- GHGas_{m-1} is the most recent greenhouse gas price, if resource is subject to greenhouse gas costs (\$/metric ton CO₂e)
- EmRate_k is the resource specific greenhouse gas emissions rate per MMBtu of natural gas for resource or MSG configuration 'k' (metric ton CO₂e/MMBTU)
- $\text{SU_MMA}_{g,k}$ is the most recent Major Maintenance Adder for starts for the resource or MSG configuration 'k' for segment 'g' (\$/start)
- $\text{SU_GMC}_{g,k}$ is the GMC adder for starts⁴ for the resource or MSG configuration 'k' for segment 'g' (\$/start)

$$(2b) \text{ TC}_{m,p} = \text{Max} (0 , [\text{SUC}_{m,g,\text{ToConfig}} - \text{SUC}_{m,g,\text{FromConfig}}])$$

Where:

- $\text{TC}_{m,p}$ is the estimated monthly transition cost for transition 'p' (of the MSG plant 'w') (\$/transition)
- $\text{SUC}_{m,g,\text{ToConfig}}$ is the estimated monthly direct start-up cost (of the highest cost segment) for the MSG resource "To" configuration of transition 'p' (of MSG plant 'w') (\$/start)

³ $\text{SU_GMC}_{g,k}$ is determined by $\text{PMIN}_k * \text{Start up time}_{g,k}$ in minutes / 60 mins per hour* (GMC adder/2)

⁴ $\text{SU_GMC}_{g,k}$ is determined by $\text{Pmink} * (\text{STARTUP_RAMP_TIME}_{g,k} / 60\text{min}) * \frac{\text{GMC}}{2}$

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$SUC_{m,g,FromConfig}$ is the estimated monthly direct start-up cost (of the highest cost segment) for the MSG resource “From” configuration of transition ‘p’ (of MSG plant ‘w’) (\$/start)

$$(3) MLC_{m,k} = (PminHR_k * Pmin_k * (NatGasF_{m,l} + GasT_{m-1,l})) / 1000 + (GHGas_{m-1} * EmRate_k * PminHR_k * Pmin_k) / 1000 + (O\&M_k * Pmin_k) + ML_MMA_k + ML_GMC_k$$

Where:

- $MLC_{m,k}$ is the estimated monthly minimum load cost for the resource or MSG configuration ‘k’ (\$/h)
- $PminHR_k$ is the most recent heat rate at minimum operating point of the resource or MSG configuration ‘k’ in Master File (BTU/KWh)
- $NatGasF_{m,l}$ is the Natural Gas futures price for month ‘m’ for fuel region ‘l’ (\$/MMBTU)
- $GasT_{m-1,l}$ is the most recent gas transportation cost for fuel region ‘l’ (including Base Gas Transportation Cost, Gas Transportation Shrinkage Allowance, Cap and Trade Credits and Miscellaneous Costs) (\$/MMBTU)
- $GHGas_{m-1}$ is the most recent greenhouse gas price, if resource is subject to greenhouse gas costs (\$/metric ton CO₂e)
- $EmRate_k$ is the resource specific greenhouse gas emissions rate per MMBtu of natural gas for resource or MSG configuration ‘k’ (metric ton CO₂e/MMBTU)
- $O\&M_k$ is the operating and maintenance adder for the resource or MSG configuration ‘k’ (\$/MWh)
- ML_MMA_k is the most recent Major Maintenance Adder for minimum operating point for the resource or MSG configuration ‘k’ (\$/h)
- ML_GMC_k is the GMC adder for minimum operating point⁵ for the resource or MSG configuration ‘k’ (\$/h)
- $Pmin_k$ is the minimum operating point for the resource or MSG configuration ‘k’ (MW)

⁵ ML_GMC_k is determined by $Pmin_k * GMC$ adder

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7.3.3 Estimated LMPs

The opportunity cost model will determine the optimal commitment of the resource using the above described resource characteristics, constraints, and estimated costs. The model will also use estimated fifteen minute locational marginal prices (LMPs). The ISO will estimate real-time prices by:

- (A) **Equation (4a):** Calculating a 15-minute implied marginal heat rate at each use-limited resource 'k' ($ImpHR_{k,f-1y}$) based on fifteen minute real-time energy prices ($LMP_{k,f-1y}$, using $LMP_{i,f-1y}$ at pnode 'i') from the same time period the previous year (f-1y).
- (B) **Equation (4b):** Calculating an hourly implied marginal heat rate at each use-limited resource 'k' ($ImpHR_{k,h-1y}$) for the same time period the previous year (h-1y) as the simple average of the resource specific four 15-minute (f-1y) implied heat rate ($ImpHR_{k,f-1y}$) corresponding to (h-1y) hour.
- (C) **Equation (5):** Calculating a power price conversion factor ($PPConv_{hub,m}$) based on the ratio of an implied heat rate of future power prices ($ImpHRF_{hub,m,tou}$) and an implied heat rate of historical power prices ($ImpHRH_{hub,m-12,tou}$).
- (D) **Equation (6):** Scaling the implied heat rate from (B) by the power price conversion factor from (C).
- (E) **Equation (6):** Estimating the hourly real-time energy prices ($LMP_{k,h}$) by applying the natural gas future prices, gas transportation costs, and greenhouse gas costs to the scaled implied heat rates from (D).

Each step is described in more detail below.

Each interval's and location's LMP is assumed to reflect the heat rate of a marginal unit, and that heat rate can be inferred from the prices of gas and emissions allowances at that time and place. This procedure will allow the implied heat rate to inherently capture real-time price volatility, which will then be used to forecast future prices.

A set of resource-specific 15 minute implied heat rates, $ImpHR_{k,f-1y}$ will be determined as follows:

$$(4a) \text{ Im } pHR_{k,f-1y} = \frac{LMP_{k,f-1y}}{GPI_{d-1y,l} + (GHGas_{d-1y} * EmRate)}$$

Where:

- $LMP_{i,f-1y}$ is the fifteen minute real time energy price at pnode 'i' from the previous year's period (f,y-1).
- $LMP_{k,f-1y}$ is the fifteen minute real time energy price at resource 'k' from the previous year's period (f,y-1).

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- $GHGas_{d-1y}$ is the daily greenhouse gas allowance price from the previous year's period, (d, y-1).
 $EmRate$ is the greenhouse gas content of natural gas, which is $.0531148mtCO_2e/MMBtu^6$
 $GPI_{d-1y,l}$ is the daily gas price index fuel region 'l' (of resource 'k') of the previous year's period, (d,y-1)

A set of resource-specific hourly implied heat rates, $ImpHR_{k,h-1y}$ will be calculated as the simple average of the resource-specific corresponding four 15-minute implied heat rate:

$$(4b) \text{Im } pHR_{k,h-1y} = \frac{\sum_{f=1}^4 \text{Im } pHR_{k,f-1y}}{4}$$

The power price conversion factor will adjust the historical implied heat rate for any anticipated changes in wholesale energy prices that are not reflected in natural gas future prices.

The power price conversion factor will be generated as follows:

$$(5) PPC_{conv_{hub,m}} = \frac{ImpHRF_{hub,m,tou}}{ImpHRH_{hub,m-12,tou}}$$

Where:

$ImpHRF_{hub,m,tou}$ is the implied heat rate based on the future power price at ICE hub "hub" (of resource 'k') for the analysis month 'm' and Time Of Use (tou) (peak or off peak), calculated as:

$$(5.1) ImpHRF_{hub,m,tou} = \frac{PPF_{hub,m,tou}}{NatGasF_{m,l} + (GHGas_{m-1} * EmRate)}$$

Where:

$PPF_{hub,m,tou}$ is the future power price at ICE hub "hub" (of resource 'k'), for the analysis month 'm' and interval time of use "tou".

$NatGasF_{m,l}$ is the Natural Gas futures price for month 'm' for fuel region 'l' (of resource 'k')

$GHGas_{m-1}$ is the average greenhouse gas allowance price from the previous month, "m-1"

⁶ Per EPA

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EmRate is the greenhouse gas emissions rate per MMBtu of natural gas, which is *.0531148mtCO₂e/MMBtu*

And where:

ImpHRH_{hub,m-12,tou} is the implied heat rate based on average monthly power price at ICE hub “hub” (of resource ‘k’) from the same month the previous year (*m-12*), and time of use (peak or off peak) (*tou*), calculated as:

$$(5.2) ImpHRH_{hub,m-12,tou} = \frac{PP_{hub,m-12,tou}}{NatGas_{m-12,l} + (GHGas_{m-12} * EmRate)}$$

Where:

PP_{hub,m-12,tou} is the monthly average power price at ICE hub “hub” (of resource ‘k’) from the previous time period “*m-12*”, and interval time of use “*tou*”.

NatGas_{m-12,l} is the monthly average of daily natural gas price from the region ‘*l*’ (of resource ‘*k*’) of the previous year’s period “*m-12*”

GHGas_{m-12} is the monthly average greenhouse gas allowance price from the previous year’s period “*m-12*”.

EmRate is the greenhouse gas content of natural gas, which is *.0531148mtCO₂e/MMBtu*

The estimated resource-specific hourly real time energy prices will be generated as follows:

$$(6) LMP_{k,h} = ImpHR_{k,h-1y} * PPConv_{hub,m,tou} * (NatGasF_{m,l} + GasT_{m-1,l} + (GHGas_{m-1} * EmRate))$$

Where:

LMP_{k,h} is the forecasted hourly real time price at resource ‘*k*’ for hour ‘*h*’

ImpHR_{k,h-1y} is the calculated hourly implied heat rate at resource ‘*k*’ from the previous year’s period (*h,y-1*)

NatGasF_{m,l} is the Natural Gas futures price for month ‘*m*’ for fuel region ‘*l*’ (of resource ‘*k*’)

GasT_{m-1,l} is the average gas transportation cost for region ‘*l*’ (of resource ‘*k*’) from the previous month “*m-1*”

GHGas_{m-1} is the average greenhouse gas allowance price from the previous month “*m-1*”.

EmRate is the greenhouse gas content of natural gas, which is *.0531148mtCO₂e/MMBtu*

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$PPConv_{hub,m,tou}$ is the conversion factor based on future power prices at a given ICE hub “hub” (of resource ‘k’) for the analysis interval ‘m’ and time of use “tou”

The end result is a set of resource-specific estimated hourly real-time energy prices. These estimated prices will be used in the opportunity cost model, along with the estimated resource costs and characteristics to estimate the dispatch of the resource over the modeled time period.

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7.3.4 Comparison of Estimated and Actual Market LMPs (Deleted from BRS)

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7.4 Opportunity Cost Model Formulation

The opportunity cost methodology estimates the foregone profits of the last start, run-hour, and/or MWh assuming the resource is committed when most valued. The objective function of the opportunity cost model will be to maximize total profits given the estimated LMPs, estimated costs, resource characteristics, and constraints. Below is the mathematical formulation of the profit maximizing objective function based on hourly real-time intervals.

$$(7) \text{ Max } \pi_w = \sum_{h=1}^n \left\{ \sum_{k=1}^b \left(\langle \text{Online}_{h,k} * [(LMP_{k,h} * MWh_{h,k}) - (VEC_{m,k} * (MWh_{h,k} - Pmin_k)) - MLC_{m,k}] \rangle - \langle \text{Starting}_{h,k} * SUC_{m,g,k} \rangle - \sum_{p=1}^c \langle \text{Transitioning}_{h,p} * TC_{m,p} \rangle \right) \right\}$$

Where:

- h denotes hours within the analysis time horizon
- n is the number of hours in the analysis time horizon
- w denotes plant for MSG resources and is equivalent to 'k' for non-MSG resources
- k denotes non-MSG resource or MSG configuration
- b is the number of MSG configurations for MSG resources; 1 for non-MSG resources.
- p denotes MSG transition
- c is the number of MSG transitions for MSG resources; 0 for non-MSG resources.

Online_{h,k} is the optimal commitment (0/1) flag to indicate if resource or MSG configuration 'k' is online (1) (active) or offline (0) at hour 'h'.

Starting_{h,k} is the 0/1 flag to indicate if resource or active MSG configuration 'k' and optimal segment 'g' is starting (1) at hour h; otherwise (0).

Transitioning_{h,p} is the 0/1 flag to indicate if active MSG transition 'p' has occurred at hour h (1); otherwise (0).

LMP_{k,h} is the estimated hourly LMP, for hour 'h', at resource or MSG configuration 'k'

MWh_{h,k} is the optimal dispatch of the resource or MSG configuration 'k' during hour 'h'⁷

VEC_{m,k} is the estimated variable energy cost for month 'm' and resource or MSG configuration 'k', as determine by equation 1, 1.1, or 1.2

MLC_{m,k} is the estimated minimum load cost for month 'm' and resource or MSG configuration 'k', as determined by equation 3, 3.1, or 3.2

⁷ The model uses a single variable energy cost estimate, therefore the MWh value will either be 0, minimum operating point, or maximum operating point.

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$SUC_{m,g,k}$ is the estimated start-up cost for month ‘m’ and resource or MSG configuration ‘k’ for the optimal start segment ‘g’, as determined by equation 2a, 2.1a, or 2.2a

$TC_{m,p}$ is the estimated transition cost for month ‘m’ and MSG resource for transition ‘p’ (of MSG plant ‘w’) as determined by equation 2b, 2.1b, or 2.2b

Subject to:

(7.1) $MWh_h \geq P_{min_{k(w)}}$ if committed

(7.2) $MWh_h \leq P_{max_{k(w)}}$ if committed

(7.3) Count (‘h’, where MWh_h is between $P_{min_{k(w)}}$ and $P_{max_{k(w)}}$ during consecutive intervals) $\geq MUT_{k(w)}$

(7.4) Count (‘h’, where MWh_h is zero during consecutive intervals) $\geq MDT_{k(w)}$

(7.5) $SUM(Startups_{k(w)}) \leq x_{k(w),v} \% * (MaxSTRT_{k(w)} - ActSTRT_{k(w)})$ over the limitation horizon, if resource has a limitation on starts and where $ActSTRT_{k(w)}$ is actual incurred starts during the limitation horizon, and model run is estimating opportunity cost for limitation on starts. ($x_{k(w),v} \%$ is the reserve margin, configurable, currently defaulted to 90% for starts limitation and 100% for run-hours and energy output limitations).

(7.6) Count (‘h’, where ‘h’ is between $P_{min_{k(w)}}$ and $P_{max_{k(w)}}$ and ‘h’ is within the limitation horizon) $\leq x_{k(w),v} \% * (MaxHRS_{k(w)} - ActHRS_{k(w)})$, if resource has a limitation on run-hours and where $ActHRS_{k(w)}$ is actual incurred run-hours during the limitation horizon, and model run is estimating opportunity cost for limitation on run-hours.

(7.7) $SUM(MWh_h) \leq x_{k(w),v} \% * (MaxMWH_{k(w)} - ActMWH_{k(w)})$, if resource has a limitation on output and where $ActMWH_{k(w)}$ is actual output during the limitation horizon, and model run is estimating opportunity cost for limitation on output.

Note: The last three constraints represent the limitations for which an opportunity cost needs to be calculated. A resource may have one, two, or all three limitation types. A resource may have more than one limitation type with different applicability horizons (annual and monthly start limitations).

The solution to the objective function is the estimated profits of the resource over the modeled horizon. This estimated profits will then be used to determine the opportunity cost for each limitation type, starts (implied, including MSG transitions), run-hours, and energy output by reducing the limitation by $Y_{k(w),v}$ and re-running the model. The non-negative difference in the two objective functions, divided by $Y_{k(w),v}$, is the opportunity cost for that limitation type for that resource.

The next section provides illustrative examples on how the model will be used to determine the initial opportunity cost, and how the opportunity cost will be updated as the year progresses.

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7.5 Examples of Opportunity Cost Model

The following examples are intended to better illustrate how the model will be utilized to determine opportunity costs for various limitations, and combinations thereof. It also serves to provide clarity as to how the limitations will be set and run in each model.

Example-1 through Example-4 below illustrate how the model will determine the opportunity cost for fixed-annual and monthly limitations, as well as updating the opportunity costs as the year progresses.

Note, that if a resource only has a fixed-annual limitation, **Example-1 and Example-2** will still apply without the monthly limitation in the model. If a resource only has a monthly limitation, **Example-3 and Example-4** will still apply without the fixed-annual limitation.

Example-5 and Example-6 illustrate how the model will determine the opportunity cost for nested limitations. Nested limitations refer to limitations of the same type, e.g., start, but over different time horizons, e.g., fixed-annual and monthly.

Example-7 and Example-8 illustrate how the model will determine the opportunity cost for a rolling-annual limitation.

Note:

Also, refer to Appendix-6 for a numerical example of opportunity cost calculations for non-MSG resources, and Appendix-7 for MSG resources.

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7.5.1 Example-1: Calculating the Opportunity Cost for Fixed-Annual Start Limitation (Overlapping with Monthly Run-Hours Limitation)

For each limitation type (starts, run hours or output) that has fixed-annual limitation (under analysis) (still can have monthly limitation for another limitation type), system shall perform two model runs one month before the applicability start month, for resources with “fixed-annual limitation”.

For example:

- For fixed-annual plan applicability from March 1, 2018-February 28, 2019, initial model run shall be run on any day within February 2018.
- The model run analysis time horizon shall cover March 1, 2018 – February 28, 2019 (12 months).

System shall calculate the opportunity cost **for each limitation type** for the following fixed 12 months (March 2018-February 2019 for the above example) as the difference between Model_Run_1 and Model_Run_2, divided by $Y_{k,v}$, where:

- Model_Run_1 (base B-run) would reflect
 - a) Fixed-annual limitation for that limitation type under analysis
 - b) Any fixed-annual limitation and monthly limitations for all calendar months for other limitation types
- Model_Run_2 (L-run) would reflect
 - a) $Y_{k,v}$ less fixed-annual limitation for that limitation type under analysis
 - b) Any fixed-annual limitation and monthly limitations for all calendar months for other limitation types

Notes:

- There will be two model runs that covers the fixed-annual applicability under analysis where opportunity cost needs to be modeled (March 2018-February 2019 for the above example).
- Modeled opportunity cost for fixed-annual limitation is applicable to each month of the following fixed 12 months (March 2018-February 2019 for the above example).
- No need to add a buffer month if initial model run of fixed-annual limitation is the only one under analysis, but other use plan types/granularities may require use of a buffer month.

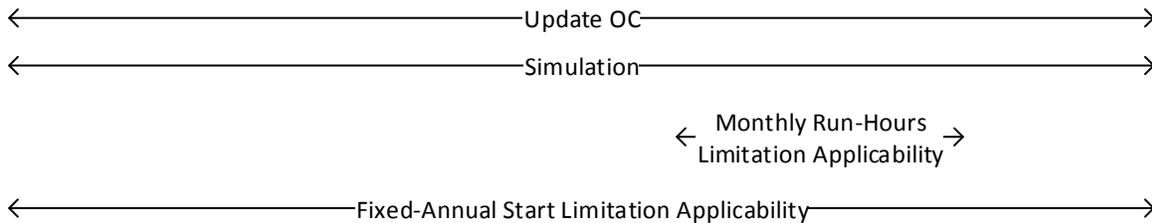
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Model
Run

M-1 M

M+11

Feb 2018	Mar 2018	Apr 2018	May 2018	Jun 2018	Jul 2018	Aug 2018	Sep 2018	Oct 2018	Nov 2018	Dec 2018	Jan 2019	Feb 2019
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Input Data:

- Resource Type: Non-MSG resource
- Analysis: Initial calculation of fixed-annual start limitation
- 300 starts per fixed-annual use limit plan applicability (March 1, 2018 through February 28, 2019).
- 400 run hours per month use limit plan applicability (October 1, 2018 through December 31, 2018).
- Analysis time horizon March 1, 2018 through February 28, 2019. No buffer month is needed.
- Running model on any day on February 2018.
- For Start limitation:
 - $x_{k,v} = 90\%$
 - number of implied start per resources = 1
 - $Y_{k,v} =$ number of implied start per resources = 1
- For Run-Hours limitation:
 - $x_{k,v} = 100\%$

Base Model run (B-run):

- Set the fixed-annual maximum starts ($MaxSTRT_k$) to ≤ 270 (270 = 90% of 300 starts, applicable from March 1, 2018 through February 28, 2019)
- Set the maximum run hours ($MaxHRS_k$) for each month to ≤ 400 hours (100% of 400 hours, applicable to each month from October, 2018 through December, 2018).

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- Run the model as described in Section 7.4, optimizing March 1, 2018 through February 28, 2019.
- The resulting fixed-annual estimated profits is defined as “Base run fixed-annual profits”.

Model Run 2 (L-run):

- Reduce the fixed-annual maximum starts by one ($MaxSTRT_k$) to ≤ 269 ($269 = 90\%$ of 300 starts, minus one start, applicable from March 1, 2018 through February 28, 2019),
- Keep the maximum run hours ($MaxHRS_k$) for each month at ≤ 400 hours (100% of 400 hours, applicable to each month from October, 2018 through December, 2018).
- Re-run the model, optimizing March 1, 2018 through February 28, 2019.
- The resulting fixed-annual estimated profits is defined as “Model run 2 fixed-annual profits”.

Opportunity Cost per Applicable Use Limitation:

- The opportunity cost, due to the applicable fixed-annual start limitation is:
 - $OC_{k,v} = \text{Max} \{ 0, (\text{Base run fixed-annual profits} - \text{Model run 2 fixed-annual profits}) \} / Y_{k,v}$

Opportunity Cost Adder:

- The opportunity cost adder for SUC is:
 - $OC_{k,SUC} = OC_{k,v} * \text{number of implied starts per resource}$
- The opportunity costs is valid for every month from March, 2018 through February, 2019 (same value for every month), or until next model run updates this value.
- It will increase the start-up cost bid cap by the opportunity cost adder.

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7.5.2 Example-2: Updating the Opportunity Cost for Fixed-Annual Start Limitation (Overlapping with Monthly Run-Hours Limitation) from Example-1

For each limitation type (starts, run hours or output) that only has fixed-annual limitation (under analysis) (still can have monthly limitation for another limitation type), system shall perform two model runs on each calendar month within the fixed-annual plan applicability time horizon, excluding the last month, for the remaining calendar year succeeding the month on which the model is run.

For example:

- For fixed-annual plan applicability from March 1, 2018-February 28, 2019, update model run shall be run on any day within each of these months (March 2018, April 2018, ..., until January 2019).
- For September 2018 model run, analysis time horizon shall start September 1, 2018 – February 28, 2019. The first month (September 2018) is added as a buffer month to generate the usage metrics for this month since the actuals for this month is not ready yet. However, no opportunity cost shall be calculated for buffer month (September 2018).

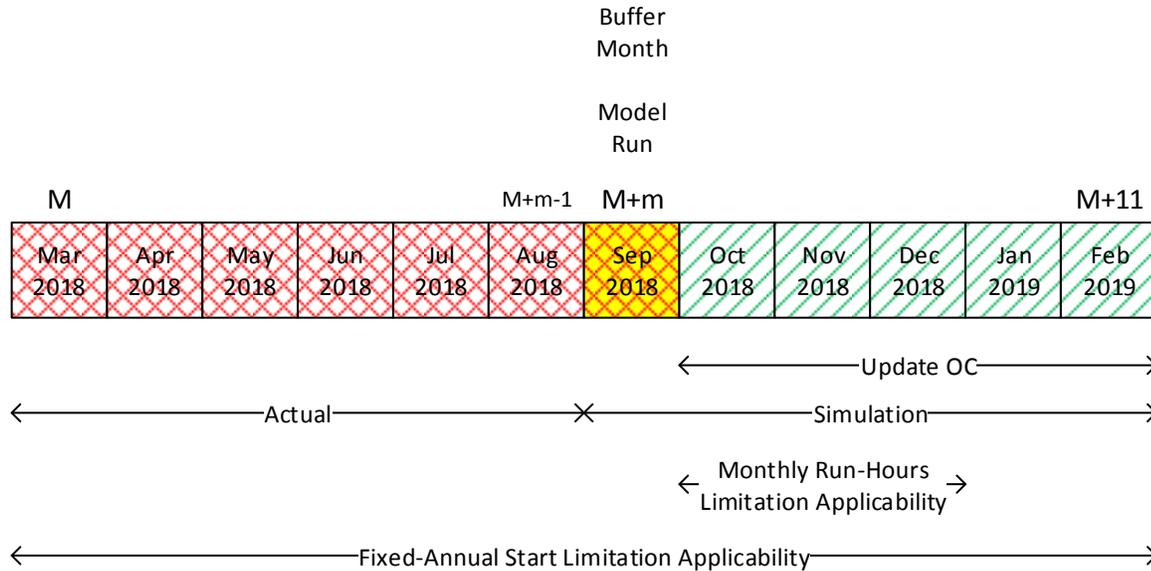
System shall calculate the opportunity cost **for each limitation type** for the remaining calendar months of the plan applicability (October 2018-February 2019 for the above example) as the difference between Model_Run_1 and Model_Run_2, divided by $Y_{k,v}$, where:

- Model_Run_1 (base B-run) would reflect
 - Remaining-annual limitation for that limitation type under analysis
 - Any fixed-annual limitation and monthly limitations for the remaining calendar months for other limitation types
- Model_Run_2 (L-run) would reflect
 - $Y_{k,v}$ less remaining-annual limitation for that limitation type under analysis
 - Any fixed-annual limitation and monthly limitations for the remaining calendar months for other limitation types

Notes:

- There will be two model runs that covers the remaining-annual applicability under analysis where opportunity cost needs to be modeled and add a buffer month (September 2018-February 2019 for the above example).
- Modeled opportunity cost is applicable to each remaining month that succeeds the month on which the calculation is done up to the last month of applicability fixed 12 months (October 1, 2018 – February 28, 2019 for the above example).
- No opportunity cost will be calculated for buffer month (September 2018 in the above example).

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Input Data:

- Resource Type: Non-MSG resource
- Analysis: Update remaining-annual start imitation
- 300 starts per fixed-annual use limit plan applicability (March 1, 2018 through February 28, 2019).
- 250 actual starts from March 1, 2018 until August 31, 2018
- 50 (300-250) starts per remaining annual use limit plan applicability (September 1, 2018 through February 28, 2019).
- 400 run hours per month use limit plan applicability (October 1, 2018 through December 31, 2019).
- Analysis time horizon September 1, 2018 – February 28, 2019. The first month (September 2018) is added as a buffer month. However, no opportunity cost shall be calculated for buffer month (September 2018).
- Running model on any day on September 2018.
- For Start limitation:
 - $x_{k,v} = 90\%$
 - number of implied start per resources = 1
 - $Y_{k,v} =$ number of implied start per resources = 1
- For Run-Hours limitation:

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- $x_{k,v} = 100\%$

Base Model run (B-run):

- Set the annual maximum starts ($MaxSTRT_k$) to ≤ 45 (45 = 90% of 50 remaining starts, applicable from September 1, 2018 through February 28, 2019)
- Set the maximum run hours for each month ($MaxHRS_k$) to ≤ 400 hours (100% of 400 hours, applicable to each month from October, 2018 through December, 2018).
- Run the model as described in Section 7.4, optimizing September 1, 2018 through February 28, 2019 (September, 2018 is buffer month).
- The resulting remaining-annual estimated profits is defined as “Base run remaining-annual profits updated”.

Model Run 2 (L-run):

- Reduce the annual maximum starts ($MaxSTRT_k$) to ≤ 44 (44 = 90% of 50 starts, minus one start, applicable from September 1, 2018 through February 28, 2019),
- Keep the maximum run hours ($MaxHRS_k$) for each month at ≤ 400 hours (100% of 400 hours, applicable to each month from October, 2018 through December, 2018).
- Re-run the model, optimizing September 1, 2018 through February 28, 2019 (September, 2018 is buffer month).
- The resulting annual estimated profits is defined as “Model run 2 remaining-annual profits updated”.

Opportunity Cost per Applicable Use Limitation:

- The updated opportunity cost, due to the applicable remaining-annual limitation on starts is:
 - $OC_{k,v} = \text{Max} \{ 0, (\text{Base run remaining-annual profits updated} - \text{Model run 2 remaining-annual profits updated}) \} / Y_{k,v}$

Opportunity Cost Adder:

- The opportunity cost adder for SUC is:
 - $OC_{k,SUC} = OC_{k,v} * \text{number of implied starts per resource}$
- The opportunity cost is valid for October 2018 through Feb 2019 (same value for every month), or until the next model run updates this value.
- The updated opportunity cost will supersede previously calculated opportunity cost adder for the same month due to the same limitation type.
- It will increase the start-up cost bid cap by the opportunity cost adder.

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7.5.3 Example-3: Calculating the Opportunity Cost for Monthly Run-Hours Limitation (Overlapping with Fixed-Annual Start Limitation)

For each limitation type (starts, run hours or output) that has monthly limitation (under analysis) and fixed-annual limitation for another limitation type, system shall perform two model runs one month before the applicability start month of the “monthly limitation”. The model run analysis time horizon shall cover the fixed or remaining-annual plan applicability and a buffer month, if applicable.

For example:

- For monthly plan applicability for October, 2018 through December, 2018 on one limitation type (under analysis) and, fixed-annual plan of (March 1, 2018 – February 28, 2019) for another limitation type, initial model run shall be on any day within September, 2018.
- For September 2018 model run, the model run analysis time horizon shall cover the remaining-annual plan applicability (September 1, 2018 – February 28, 2019). The first month (September 2018) is added as a buffer month to generate the usage metrics for this month for the remaining-annual plan applicability since the actuals for this month is not ready yet (Same as in Example-2). However, no opportunity cost shall be calculated for buffer month (September 2018).

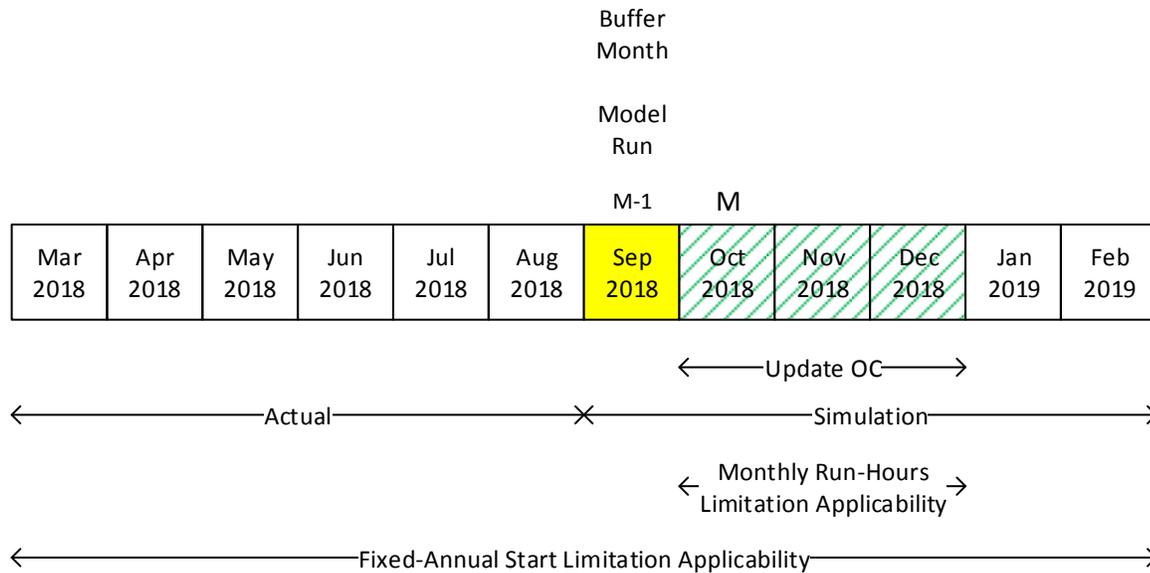
System shall calculate the opportunity cost for plan applicability calendar months (October 2018 through December, 2018 for the above example) **for each limitation type** as the difference between Model_Run_1 and Model_Run_2, divided by $Y_{k,v}$, where:

- Model_Run_1 (base B-run) would reflect
 - a) Monthly limitation for that month for that limitation type under analysis
 - b) Any fixed-annual limitation and monthly limitations for that month for other limitation types
- Model_Run_2 (L-run) would reflect
 - a) $Y_{k,v}$ less monthly limitation for that month for that limitation type under analysis
 - b) Any fixed-annual limitation and monthly limitations for that month for other limitation types

Notes:

- There will be two model runs that covers the remaining-annual applicability and add a buffer month (September 2018-February 2019 for the above example).

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Input Data:

- Resource Type: Non-MSG resource
- Analysis: Update calculation of monthly run-hours limitation
- 300 starts per fixed-annual use limit plan applicability (March 1, 2018 through February 28, 2019).
- 250 actual starts from March 1, 2018 until August 31, 2018
- 50 (300-250) starts per remaining-annual use limit plan applicability (September 1, 2018 through February 28, 2019).
- 400 run hours per month use limit plan applicability (October 1, 2018 through December 31, 2018).
- Because the run-hour limitation is a monthly limitation, there is no adjustment needed based on the actual run-hours of the resource.
- Analysis time horizon September 1, 2018 through February 28, 2019. The first month (September 2018) is added as a buffer month to accommodate a fixed annual use limit plan applicability that also spans this time horizon.
- Running model on any day on September 2018.
- For Start limitation:
 - $x_{k,v} = 90\%$
- For Run-Hours limitation:
 - $x_{k,v} = 100\%$

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- $Y_{k,v} = 1$ hour

Base Model run (B-run):

- Set the maximum monthly run-hours ($MaxHRS_k$) to ≤ 400 hours per month (400 = 100% of 400 run-hours, applicable to each month from October, 2018 through December, 2018)
- Set the maximum starts ($MaxSTRT_k$) to ≤ 45 (45 = 90% of 50 remaining starts, applicable from September 1, 2018 through February 28, 2019).
- Run the model as described in Section 7.4, optimizing September 1, 2018 through February 28, 2019 (September, 2018 is buffer month need for fixed-annual limitation).
- The resulting monthly estimated profits are defined as “Base run October 2018 monthly profits”, “Base run November 2018 monthly profits”, “Base run December 2018 monthly profits”

Model Run 2 (L-run):

- Reduce the monthly maximum run-hours ($MaxHRS_k$) to ≤ 399 per month (399 = 100% of 400 run-hours, minus one run-hour, applicable to every month from October 2018 through December 2018),
- Keep the maximum starts ($MaxSTRT_k$) at ≤ 45 starts (45 = 90% of 50 remaining starts, applicable from September 1, 2018 through February 28, 2019).
- Re-run the model, optimizing September 1, 2018 through February 28, 2019 (September, 2018 is buffer month need for fixed-annual limitation).
- The resulting monthly estimated profits are defined as “Model run 2 October 2018 monthly profits”, “Model run 2 November 2018 monthly profits”, “Model run 2 December 2018 monthly profits”.

Opportunity Cost per Applicable Use Limitation:

- The opportunity costs, due to the applicable monthly limitation on run-hours, for each month are:
 - **October 2018:**
 - $OC_{k,v} = \text{Max}\{ 0, (\text{Base run October 2018 monthly profits} - \text{Model run 2 October 2018 monthly profits}) / Y_{k,v}$
 - **November 2018:**
 - $OC_{k,v} = \text{Max}\{ 0, (\text{Base run November 2018 monthly profits} - \text{Model run 2 November 2018 monthly profits}) / Y_{k,v}$
 - **December 2018:**
 - $OC_{k,v} = \text{Max}\{ 0, (\text{Base run December 2018 monthly profits} - \text{Model run 2 December 2018 monthly profits}) / Y_{k,v}$

Opportunity Cost Adder:

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- The opportunity cost adder for MLC is:
 - $OC_{k,MLC} = OC_{k,v}$
- The opportunity cost valid for each month can differ and will be valid for the corresponding month until next model run updates the value.
- These updated opportunity costs will supersede all previously calculated opportunity costs for the same month due to the same limitation type.
- The minimum load cost bid cap will be increased by the opportunity cost adder.

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7.5.4 Example-4: Updating the Opportunity Cost for Monthly Run-Hours Limitation (Overlapping with Fixed-Annual Start Limitation) in Example-3

For each limitation type (starts, run hours or output) that has monthly limitation (under analysis) and fixed-annual limitation for another limitation type, system shall perform two model runs on each calendar month within the monthly plan applicability time horizon, excluding the last month. The model run analysis time horizon shall cover the fixed or remaining-annual plan applicability and a buffer month, if applicable.

For example:

- For monthly plan applicability for October, 2018 through December, 2018 on one limitation type (under analysis) and, fixed-annual plan of (March 1, 2018 – February 28, 2019) for another limitation type, update model run shall be on any day within each of these months (October 2018, November 2018).
- For October 2018 model run, the model run analysis time horizon shall cover the remaining-annual plan applicability (October 1, 2018 – February 28, 2019). The first month (October 2018) is added as a buffer month to generate the usage metrics for this month for the remaining-annual plan applicability since the actuals for this month is not ready yet (Same as in Example-2). However, no opportunity cost shall be calculated for buffer month (October 2018).

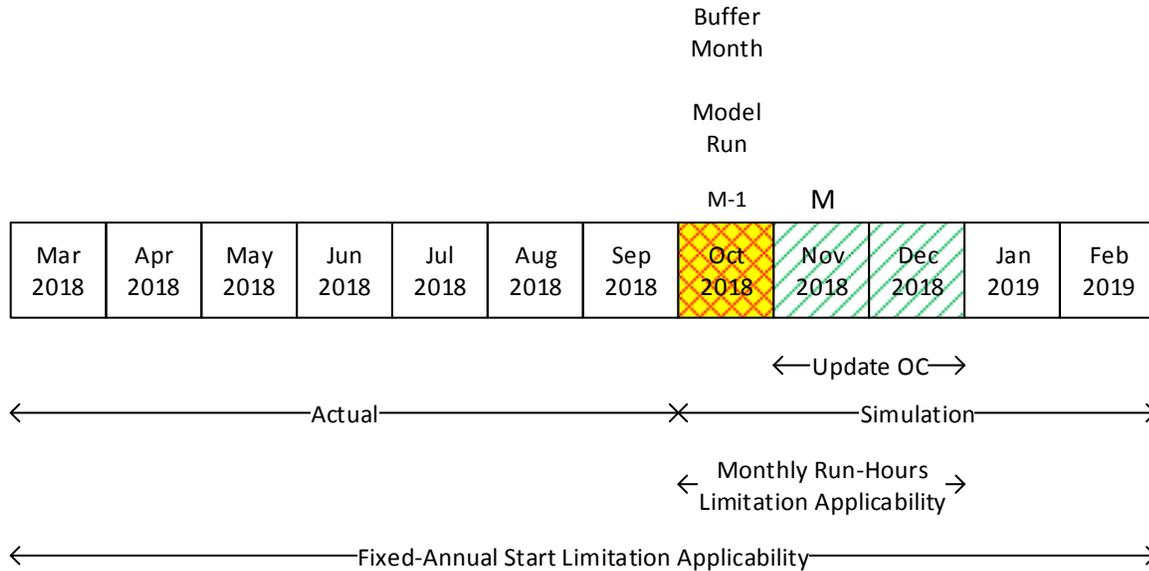
System shall calculate the opportunity cost for each the remaining calendar months of the monthly plan applicability (November 2018 through December, 2018 for the above example) **for each limitation type** as the difference between Model_Run_1 and Model_Run_2, divided by $Y_{k,v}$, where:

- Model_Run_1 (base B-run) would reflect
 - a) Monthly limitation for that month for that limitation type
 - b) Any fixed-annual limitation and monthly limitations for that month for other limitation types
- Model_Run_2 (L-run) would reflect
 - a) $Y_{k,v}$ less monthly limitation for that month for that limitation type
 - b) Any fixed-annual limitation and monthly limitations for that month for other limitation types

Notes:

- There will be two model runs that covers the remaining-annual applicability and add a buffer month (October 2018-February 2019 for the above example).

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Input Data:

- Resource Type: Non-MSG resource
- Analysis: Update calculation of monthly run-hours limitation
- 300 starts per fixed-annual use limit plan applicability (March 1, 2018 through February 28, 2019).
- 260 actual starts from March 1, 2018 until September 30, 2018
- 40 (300-260) starts per remaining-annual use limit plan applicability (October 1, 2018 through February 28, 2019).
- 400 run hours per month use limit plan applicability (October 1, 2018 through December 31, 2018).
- Because the run-hour limitation is a monthly limitation, there is no adjustment needed based on the actual run-hours of the resource.
- Analysis time horizon October 1, 2018 through February 28, 2019. The first month (October 2018) is added as a buffer month to accommodate a fixed annual use limit plan applicability that also spans this time horizon.
- Running model on any day on October 2018.
- For Start limitation:
 - $x_{k,v} = 90\%$
- For Run-Hours limitation:
 - $x_{k,v} = 100\%$

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- $Y_{k,v} = 1$ hour

Base Model run (B-run):

- Set the maximum monthly run-hours ($MaxHRS_k$) to ≤ 400 hours per month (400 = 100% of 400 run-hours, applicable to each month from October, 2018 through December, 2018)
- Set the maximum starts ($MaxSTRT_k$) to ≤ 36 (36 = 90% of 40 remaining starts, applicable from October 1, 2018 through February 28, 2019).
- Run the model as described in Section 7.4, optimizing October 1, 2018 through February 28, 2019 (October, 2018 is buffer month need for fixed-annual limitation).
- The resulting monthly estimated profits are defined as “Base run November 2018 monthly profits”, “Base run December 2018 monthly profits”

Model Run 2 (L-run):

- Reduce the monthly maximum run-hours ($MaxHRS_k$) to ≤ 399 per month (399 = 100% of 400 run-hours, minus one run-hour, applicable to every month from November 2018 through December 2018),
- Keep the monthly maximum run-hours ($MaxHRS_k$) to ≤ 400 per month (399 = 100% of 400 run-hours, applicable to October 2018),
- Keep the maximum starts ($MaxSTRT_k$) at ≤ 36 starts (36 = 90% of 40 remaining starts, applicable from October 1, 2018 through February 28, 2019).
- Re-run the model, optimizing October 1, 2018 through February 28, 2019 (October, 2018 is buffer month need for fixed-annual limitation).
- The resulting monthly estimated profits are defined as “Model run 2 November 2018 monthly profits”, “Model run 2 December 2018 monthly profits”.

Opportunity Cost per Applicable Use Limitation:

- The opportunity costs, due to the applicable monthly limitation on run-hours, for each month are:
 - **November 2018:**
 - $OC_{k,v} = \text{Max}\{ 0, (\text{Base run November 2018 monthly profits} - \text{Model run 2 November 2018 monthly profits}) / Y_{k,v}$
 - **December 2018:**
 - $OC_{k,v} = \text{Max}\{ 0, (\text{Base run December 2018 monthly profits} - \text{Model run 2 December 2018 monthly profits}) / Y_{k,v}$

Opportunity Cost Adder:

- The opportunity cost adder for MLC is:

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○ $OC_{k,MLC} = OC_{k,v}$

- The opportunity cost valid for each month can differ and will be valid for the corresponding month until next model run updates the value.
- These updated opportunity costs will supersede all previously calculated opportunity costs for the same month due to the same limitation type.
- The minimum load cost bid cap will be increased by the opportunity cost adder.

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7.5.5 Example-5: Calculating the Opportunity Cost for the Nested Fixed-Annual and Monthly Start Limitation (Overlapping with Monthly Run-Hours Limitation)

For each limitation type (starts, run hours or output) that has both annual (fixed or rolling) and monthly limitations for same limitation type (nested-limitation), system shall perform two model runs one month before the fixed-annual applicability start month.

For example:

- For fixed-annual plan applicability on Starts from March 1, 2018-February 28, 2019, and monthly plan applicability for October, 2018 through December 2018 on run-hours, initial model run shall be run on any day within February 2018.
- The model run analysis time horizon shall cover March 1, 2018 – February 28, 2019 (12 months).

System shall calculate the opportunity cost **for each limitation type** for the following fixed 12 months (March 2018-February 2019 for the above example) as the difference between Model_Run_1 and Model_Run_2, divided by $Y_{k,v}$, where:

- Model_Run_1 (base B-run) would reflect
 - a) Fixed-annual limitation and monthly limitation for that calendar month for that limitation type under analysis
 - b) Monthly limitations for the other calendar months for that limitation type under analysis
 - c) Any fixed-annual limitation and monthly limitations for all calendar months for other limitation types
- Model_Run_2 (L-run) would reflect
 - a) $Y_{k,v}$ less fixed-annual limitation and $Y_{k,v}$ less monthly limitation for that calendar month for that limitation type under analysis
 - b) Monthly limitations for the other calendar months for that limitation type under analysis
 - c) Any fixed-annual limitation and monthly limitations for all calendar months for other limitation types

Notes:

- There will be two model runs for each month of the following fixed 12 months (March 2018-February 2019 for the above example) where opportunity cost needs to be modeled.
- The nested limitation is for months of October 2018 through December, 2018.
- No need to add a buffer month if initial model run of nested fixed-annual and monthly limitations are the only one under analysis.

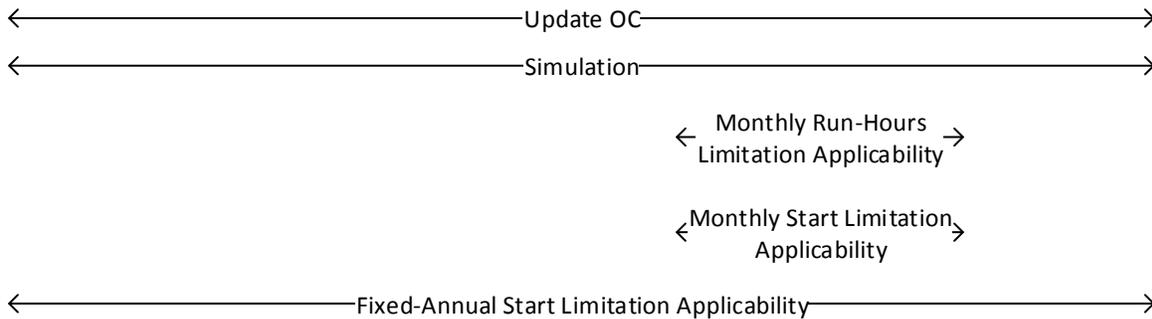
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Model
Run

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Feb 2018	Mar 2018	Apr 2018	May 2018	Jun 2018	Jul 2018	Aug 2018	Sep 2018	Oct 2018	Nov 2018	Dec 2018	Jan 2019	Feb 2019
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Input Data:

- Resource Type: Non-MSG resource
- Analysis: Initial calculation of nested fixed-annual and monthly start limitation
- 300 starts per fixed-annual use limit plan applicability (March 1, 2018 through February 28, 2019).
- 30 starts per month use limit plan applicability (October 1, 2018 through December 31, 2018):
 - The annual and monthly limitations on starts are considered to be nested for October 1, 2018 through December 31, 2018.
 - A resource is considered to have a nested limitation when there are limits of the same type (start, run-hour, or output) with two different horizons (annual and monthly).
- 400 run hours per month use limit plan applicability (October 1, 2018 through December 31, 2018).
- Analysis time horizon March 1, 2018 through February 28, 2019 (since a fixed-annual use limit plan applicability that span this time horizon exists).
- Running model on any day on February 2018.
- For Start limitation:
 - $X_{k,v} = 90\%$
 - number of implied start per resources = 1
 - $Y_{k,v} =$ number of implied start per resources = 1

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- For Run-Hours limitation:
 - $x_{k,v} = 100\%$

Base Model run (B-run):

- The opportunity cost model will be able to determine the opportunity cost for the nested limitations simultaneously as follows.
- Set the monthly maximum run hours (MaxHRS_k) to ≤ 400 hours (400 = 100% of 400 run-hours, applicable to each month from October 2018 through December 2018).
- Set the annual maximum starts ($\text{MaxSTRT}_{\text{annual},k}$) to ≤ 270 (270 = 90% of 300 starts per year, applicable from March 1, 2018 through February 28, 2019).
- Set the monthly maximum starts ($\text{MaxSTRT}_{\text{monthly},k}$) to ≤ 27 (27 = 90% of 30 starts, applicable to each month from October 2018 through December 2018),
- Run the model as described in Section 7.4, optimizing March 1, 2018 through February 28, 2019.
- The resulting annual estimated profits is defined as “Base run nested fixed-annual profits”.

Model Run 2 (L-run):

- Keep the maximum monthly run-hour (MaxHRS_k) at ≤ 400 hours (400 = 100% of 400 run-hours, applicable to each month from October 2018 through December 2018).
- Reduce the annual maximum starts ($\text{MaxSTRT}_{\text{annual},k}$) to ≤ 269 (269 = 90% of 300, minus one start, applicable from March 1, 2018 through February 28, 2019).
- **For Opportunity Cost of October 2018 (nested):**
 - Reduce the monthly maximum start ($\text{MaxSTRT}_{\text{monthly},k}$) to ≤ 26 (26 = 90% of 30 starts, minus one start, applicable to October 2018).
 - Keep the monthly maximum starts ($\text{MaxSTRT}_{\text{monthly},k}$) at ≤ 27 (27 = 90% of 30 starts, applicable to each month from November 2018 through December 2018).
 - Re-run the model, optimizing March 1, 2018 through February 28, 2019.
 - The resulting fixed-annual estimated profits is defined as “Model run 2 October 2018 nested fixed-annual profits”.
- **For Opportunity Cost of November 2018 (nested):**
 - Reduce the monthly maximum start ($\text{MaxSTRT}_{\text{monthly},k}$) to ≤ 26 (26 = 90% of 30 starts, minus one start, applicable to November 2018).
 - Keep the monthly maximum starts ($\text{MaxSTRT}_{\text{monthly},k}$) at ≤ 27 (27 = 90% of 30 starts, applicable to October 2018 and December 2018).

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- The resulting annual estimated profits is defined as “Model run 2 November 2018 nested fixed-annual profits”.
- **For Opportunity Cost of December 2018 (nested):**
 - Reduce the monthly maximum start ($\text{MaxSTRT}_{\text{monthly},k}$) to ≤ 26 (26 = 90% of 30 starts, minus one start, applicable to December 2018).
 - Keep the monthly maximum starts ($\text{MaxSTRT}_{\text{monthly},k}$) at ≤ 27 (27 = 90% of 30 starts, applicable to October 2018 through November 2018).
 - The resulting annual estimated profits is defined as “Model run 2 December 2018 nested fixed-annual profits”.
- **For Opportunity Cost of March 2018 through September 2018; and January 2019 through February 2019 (non-nested):**
 - Keep the monthly maximum starts ($\text{MaxSTRT}_{\text{monthly},k}$) at ≤ 27 (27 = 90% of 30 starts, applicable to each month from October 2018 through December 2018).
 - Re-run the model, optimizing March 1, 2018 through February 28, 2019.
 - The resulting fixed-annual estimated profits is defined as “Model run 2 non-nested fixed-annual profits”.

Opportunity Cost per Applicable Use Limitation:

- The opportunity costs, due to the applicable nested and non-nested start limitations, for each month are:
 - **March 2018-September 2018 (non-nested):**
 - $\text{OC}_{k,v} = \text{Max}\{ 0, (\text{Base run nested fixed-annual profits} - \text{Model run 2 non-nested fixed-annual profits}) / Y_{k,v}$
 - **October 2018 (nested):**
 - $\text{OC}_{k,v} = \text{Max}\{ 0, (\text{Base run nested fixed-annual profits} - \text{Model run 2 October 2018 nested fixed-annual profits}) / Y_{k,v}$
 - **November 2018 (nested):**
 - $\text{OC}_{k,v} = \text{Max}\{ 0, (\text{Base run nested fixed-annual profits} - \text{Model run 2 November 2018 nested fixed-annual profits}) / Y_{k,v}$
 - **December 2018 (nested):**
 - $\text{OC}_{k,v} = \text{Max}\{ 0, (\text{Base run nested fixed-annual profits} - \text{Model run 2 December 2018 nested fixed-annual profits}) / Y_{k,v}$
 - **January 2019-February 2019 (non-nested):**

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- $OC_{k,v} = \text{Max}\{ 0, (\text{Base run nested fixed-annual profits} - \text{Model run 2 non-nested fixed-annual profits}) / Y_{k,v}$

Opportunity Cost Adder:

- The opportunity cost adder for SUC is:
 - $OC_{k,SUC} = OC_{k,v} * \text{number of implied starts per resource}$
- The opportunity cost valid for each month can differ and will be valid for the corresponding month until next model run updates the value.
- It will increase the start-up cost bid cap by the opportunity cost adder.

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7.5.6 Example-6: Updating the Opportunity Cost for the Nested Fixed-Annual and Monthly Start Limitation (Overlapping with Monthly Run-Hours Limitation)

For each limitation type (starts, run hours or output) that has both annual (fixed or rolling) and monthly limitations for same limitation type (nested-limitation), system shall perform two model runs on each calendar month within the fixed-annual plan applicability time horizon, excluding the last month, for the remaining calendar year succeeding the month on which the model is run.

For example:

- For fixed-annual plan applicability on Starts from March 1, 2018-February 28, 2019, and monthly plan applicability for October, 2018 through December, 2018 on run-hours, update model run shall be run on any day within each of these months (March 2018, April 2018, ..., until January 2019).
- For September 2018 model run, analysis time horizon shall start September 1, 2018 – February 28, 2019. The first month (September 2018) is added as a buffer month to generate the usage metrics for this month since the actuals for this month is not ready yet. However, no opportunity cost shall be calculated for buffer month (September 2018).

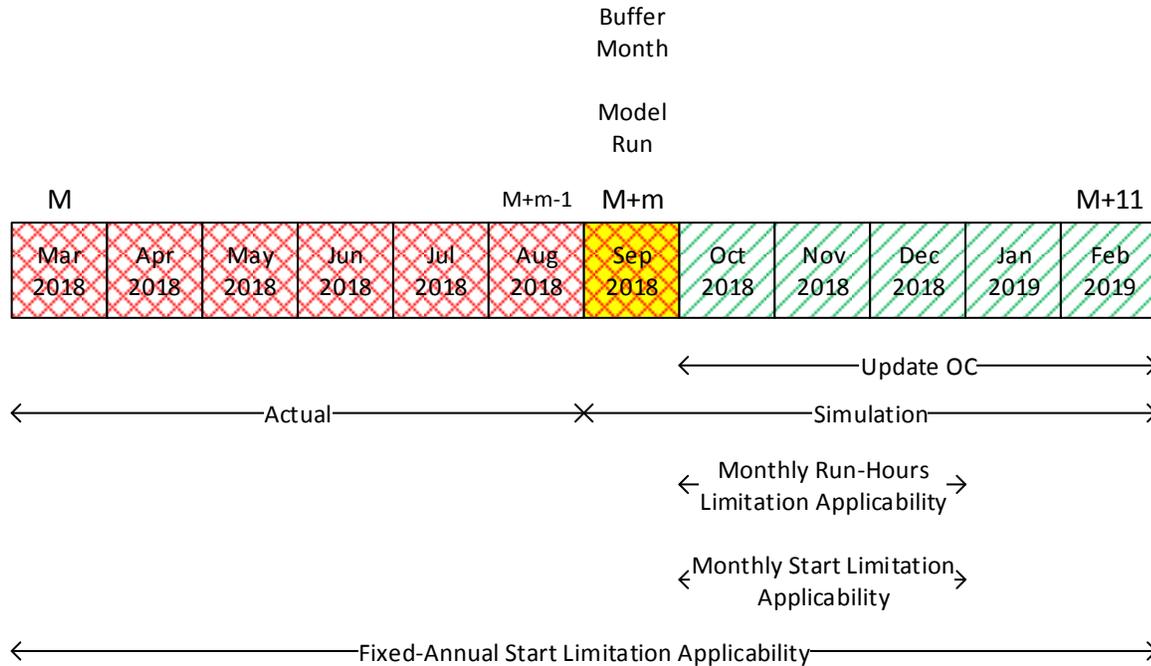
System shall calculate the opportunity cost **for each limitation type** for each remaining calendar month of the plan applicability (October 2018-February 2019 for the above example) as the difference between Model_Run_1 and Model_Run_2, divided by $Y_{k,v}$, where:

- Model_Run_1 (base B-run) would reflect
 - a) Remaining-annual limitation and monthly limitation for that calendar month for that limitation type under analysis
 - b) Monthly limitation for the other remaining calendar months for that limitation type under analysis
 - c) Any fixed-annual limitation and monthly limitations for all remaining calendar months for other limitation types
- Model_Run_2 (L-run) would reflect
 - a) $Y_{k,v}$ less remaining-annual limitation and $Y_{k,v}$ less monthly limitation for that calendar month for that limitation type under analysis
 - b) Monthly limitation for the other remaining calendar months for that limitation type under analysis
 - c) Any fixed-annual limitation and monthly limitations for all remaining calendar months for other limitation types

Notes:

- There will be two model runs for each month of the remaining-annual applicability under analysis where opportunity cost needs to be modeled and add a buffer month (September 2018-February 2019 for the above example).
- The nested limitation is for months of October 2018 through December 2018.
- No opportunity cost will be calculated for buffer month (September 2018 in the above example).

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Input Data:

- Resource Type: Non-MSG resource
- Analysis: Update calculation of nested fixed-annual and monthly start limitation
- 300 starts per fixed-annual use limit plan applicability (March 1, 2018 through February 28, 2019).
- 250 actual starts from March 1, 2018 until August 31, 2018
- 50 (300-250) starts per remaining annual use limit plan applicability (September 1, 2018 through February 28, 2019).
- 30 starts per month use limit plan applicability (October 1, 2018 through December 31, 2018):
 - The annual and monthly limitations on starts are considered to be nested for October 1, 2018 through December 31, 2018.
 - A resource is considered to have a nested limitation when there are limits of the same type (start, run-hour, or output) with two different horizons (annual and monthly).
- 400 run hours per month use limit plan applicability (October 1, 2018 through December 31, 2018).

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- Analysis time horizon September 1, 2018 through February 28, 2019. The first month (September 2018) is added as a buffer month. However, no opportunity cost shall be calculated for buffer month (September 2018).
- Running model on any day on September 2018.
- For Start limitation:
 - $x_{k,v} = 90\%$
 - number of implied start per resources = 1
 - $Y_{k,v} =$ number of implied start per resources = 1
- For Run-Hours limitation:
 - $x_{k,v} = 100\%$

Base Model run (B-run):

- The opportunity cost model will be able to determine the opportunity cost for the nested limitations simultaneously as follows.
- Set the monthly maximum run hours ($MaxHRS_k$) to ≤ 400 hours (100% of 400 hours, applicable to each month from October, 2018 through December, 2018).
- Set the annual maximum starts ($MaxSTRT_{annual,k}$) to ≤ 45 (45 = 90% of 50 remaining annual starts, applicable from September 1, 2018 through February 28, 2019),
- Set the monthly maximum starts ($MaxSTRT_{monthly,k}$) to ≤ 27 (27 = 90% of 30 monthly starts, applicable to each month from October, 2018 through December, 2018).
- Run the model as described in Section 7.4, optimizing September 1, 2018 through February 28, 2019 (September, 2018 is buffer month).
- The resulting remaining-annual estimated profits is defined as “Base run nested remaining-annual profits”.

Model Run 2 (L-run):

- Keep the maximum monthly run-hour ($MaxHRS_k$) at ≤ 400 hours (100% of 400 hours, applicable to each month from October, 2018 through December, 2018).
- Reduce the annual maximum starts ($MaxSTRT_{annual,k}$) to ≤ 44 (44 = 90% of 50, minus one start, applicable from September 1, 2018 through February 28, 2019).
- **For Opportunity Cost of October 2018 (nested):**
 - Reduce the monthly maximum start ($MaxSTRT_{monthly,k}$) to ≤ 26 (26 = 90% of 30 starts, minus one start, applicable to each month from October, 2018).
 - Keep the monthly maximum starts ($MaxSTRT_{monthly,k}$) at ≤ 27 (27 = 90% of 30 starts, , applicable to each month from November, 2018 through December, 2018).

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- Re-run the model, optimizing September 1, 2018 through February 28, 2019 (September, 2018 is buffer month)
- The resulting annual estimated profits is defined as “Model run 2 October 2018 nested remaining-annual profits”.
- **For Opportunity Cost of November 2018 (nested):**
 - Reduce the monthly maximum start ($\text{MaxSTRT}_{m,k}$) to ≤ 26 (26 = 90% of 30 starts, minus one start, applicable to November 2018).
 - Keep the monthly maximum starts ($\text{MaxSTRT}_{\text{monthly},k}$) at ≤ 27 (27 = 90% of 30 starts, applicable to October 2018 and December 2018).
 - Re-run the model, optimizing September 1, 2018 through February 28, 2019 (September, 2018 is buffer month)
 - The resulting annual estimated profits is defined as “Model run 2 November 2018 nested remaining-annual profits”.
 - **For Opportunity Cost of December 2018 (nested):**
 - Reduce the monthly maximum start ($\text{MaxSTRT}_{\text{monthly},k}$) to ≤ 26 (26 = 90% of 30 starts, minus one start, applicable to December 2018).
 - Keep the monthly maximum starts ($\text{MaxSTRT}_{\text{monthly},k}$) at ≤ 27 (27 = 90% of 30 starts, applicable to October 2018 through November 2018).
 - The resulting annual estimated profits is defined as “Model run 2 December 2018 nested remaining-annual profits”.
 - **For Opportunity Cost of January 2019 through February 2019 (non-nested):**
 - Keep the monthly maximum starts ($\text{MaxSTRT}_{\text{monthly},k}$) at ≤ 27 (27 = 90% of 30 starts, applicable to each month from October 2018 through December 2018).
 - Re-run the model, optimizing September 1, 2018 through February 28, 2019.
 - The resulting fixed-annual estimated profits is defined as “Model run 2 non-nested remaining-annual profits”.

Opportunity Cost per Applicable Use Limitation:

- The opportunity costs, due to the applicable nested and non-nested start limitations, for each month are:
 - **October 2018 (nested):**
 - $\text{OC}_{k,v} = \text{Max}\{ 0, (\text{Base run nested remaining-annual profits} - \text{Model run 2 October 2018 nested remaining-annual profits}) / Y_{k,v}$
 - **November 2018 (nested):**

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7.5.7 Example-7: Calculating the Opportunity Cost for a Rolling-Annual Start Limitation (Only)

For each limitation type (starts, run hours or output), that has rolling-annual limitations with rolling-annual applicability [C,N], system shall perform two model runs one month (M-1) before the start month (M=C), for the forward 12-month rolling period (M to M+11) that succeeds the month on which the model is run (M-1).

Note: This initial model run is same as the run of fixed-annual limitation.

Theoretically, the opportunity cost for the current twelve month period is affected by the opportunity cost of an indefinite number of rolling twelve month periods.

To reasonably estimate the opportunity cost for the current twelve month period, the opportunity cost model will include this constraint:

- The forward-rolling constraint from M to M+11 where M is the upcoming rolling month. This constraint is applicable only if $M < N - 10$.
- The backward-rolling constraint is not applicable since there is no 12 month period from start of rolling plan 'C' until month 'M'. (This constraint is applicable only if $M \geq C + 11$)

For example:

- For rolling-annual plan applicability on Starts from March 1, 2017-February 28, 2020:
 - For M=March 2017 rolling month:
 - Model run on (M-1: February 2017)
 - Update opportunity costs of forward rolling 12 months (M to M+11: March 2017 through February 2018).
 - Actual usage data are: Not applicable since no backward-rolling limit is applicable.
 - Analysis time horizon shall be (M to M+11: March 1, 2017 – February 28, 2018). This is same as forward-rolling use-limit window.
 - No need for a buffer month
 - No backward-rolling limit is enforced

System shall calculate the opportunity cost **for each limitation type** for each calendar month of the forward 12-month rolling period (M to M+11), as the difference between Model_Run_1 and Model_Run_2, divided by $Y_{k,v}$, except if $M \geq N - 10$, there will not be forward rolling applicability to enforce, and hence no opportunity cost to update, where:

- Model_Run_1 (base B-run) would reflect
 - a) The annual-rolling limitation in the forward-rolling 12-month period (from M to M+11) for that rolling limitation type under analysis (forward-rolling limitation for month M). This constraint is applicable only if $M \leq N - 11$
 - b) No backward-rolling limit is enforced.
 - c) Any other limitation types

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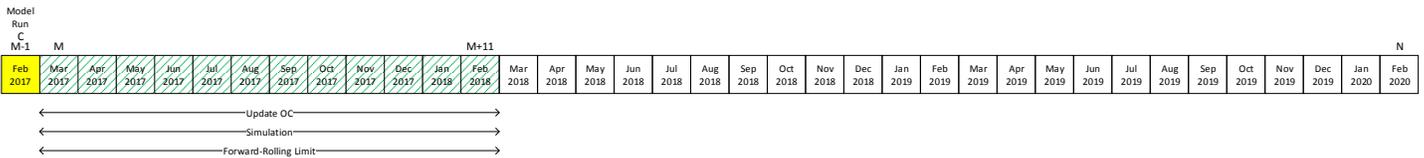
- Model_Run_2 (L-run) would reflect
 - a) The annual-rolling limitation in the forward-rolling 12-month period (from M to M+11) with $Y_{k,v}$ less rolling limitation for that limitation type under analysis (forward-rolling limitation for month M). This constraint is applicable only if $M \leq N-11$
 - b) No backward-rolling limit is enforced.
 - c) Any other limitation types

Notes:

- There will be two model runs for rolling month (M) that covers M to M+11 analysis time horizon, where opportunity cost needs to be modeled (M to M+11), and no buffer month.

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7.5.7.1 For rolling month M: March 2017 (first run):



Input Data:

- Resource Type: Non-MSG resource
- Analysis: Model initial calculation of rolling-annual start imitation
- 300 starts per rolling-annual use limit plan applicability (rolling-annual within March 1, 2017-February 28, 2020):
 - This constraint applies forward to (M to M+11: March 2017 through February 2018) and no backward-rolling constraint is enforced.
- Actual starts:
 - N/A, since no backward-rolling limit is applied.
- Remaining starts:
 - N/A, since no backward-rolling limit is applied.
- Analysis time horizon (M to M+11):
 - Analysis time horizon is March 2017 through February 2018).
- Running model on any day on M-1:
 - Running model on February 2017
- For Start limitation:
 - $x_{k,v} = 90\%$
 - number of implied start per resources = 1
 - $Y_{k,v} =$ number of implied start per resources = 1

Base Model run (B-run):

- Set the maximum starts for forward-rolling ($MaxSTRT_{annual,k}$) to ≤ 270 starts (270 = 90% of 300 starts, applicable to continuous period from M to M+11: March 2017 through February 2018).
- Run the model as described in Section 7.4, optimizing M to M+11: March 2017 through February 2018.

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- The resulting annual estimated profits is defined as “Base run rolling-annual March 2017 (first run) profits”.

Model Run 2 (L-run):

- Reduce the maximum starts for forward-rolling ($MaxSTRT_{annual,k}$) to ≤ 269 (269 = 90% of 300 starts, minus one start, applicable to continuous period from M to M+11: March 2017 through February 2018).
- Re-run the model, optimizing M-1 to M+11: March 2017 through February 2018.
- The resulting annual estimated profits is defined as “Model run 2 rolling-annual March 2017 (first run) profits”.

Opportunity Cost per Applicable Use Limitation:

- The opportunity cost, due to the applicable rolling-annual start limitations, for each month of the rolling 12-month period of M to M+11 (March 2017 through February 2018) is:
 - $OC_{k,v} = \text{Max}\{ 0, (\text{Base run rolling-annual March 2017 (first run) profits} - \text{Model run 2 rolling-annual March 2017 (first run) profits}) / Y_{k,v}$

Opportunity Cost Adder:

- The opportunity cost adder for SUC is:
 - $OC_{k,SUC} = OC_{k,v} * \text{number of implied starts per resource}$
- This opportunity cost adder is valid for each month of the rolling 12-month period of M to M+11 (March 2017 through February 2018) (same value for every month) until the next model run updates the opportunity cost adder due to the rolling limitation.
- These updated opportunity costs will supersede all previously calculated opportunity cost adders for the same month due to the same limitation type.
- It will increase the start-up cost bid cap by the opportunity cost adder.
- The next model run for rolling month M: March 2017 (second run) will update opportunity costs from M+1 to M+11 (April 2017 through February 2018).

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7.5.8 Example-8: Updating the Opportunity Cost for a Rolling-Annual Start Limitation (Only)

For each limitation type (starts, run hours or output), that has rolling-annual limitations with rolling-annual applicability [C,N], system shall perform two model runs on each calendar month (M) within the rolling-annual plan applicability time horizon (excluding the last plan calendar months that do not have 12 months forward rolling (M to M+11) until end time of the rolling plan applicability (i.e. excluding $M \geq N-10$)), for the forward 12-month rolling period (M to M+11) that encompasses the month on which the model is run (M).

Theoretically, the opportunity cost for the current twelve month period is affected by the opportunity cost of an indefinite number of rolling twelve month periods.

To reasonably estimate the opportunity cost for the current twelve month period, the opportunity cost model will include these constraints:

- The forward-rolling constraint from M to M+11 where M is the upcoming rolling month. This constraint is applicable only if $M \leq N-11$.
- The backward-rolling constraint from M-11 to M. The usage data from M-11 to M-1 will be lumped sum and subtracted from the backward rolling constraint, so the adjusted backward rolling constraint will be reflected on the monthly constraint of the upcoming rolling month (M). This constraint is applicable only if $M \geq C+11$.

If backward-rolling constraint is applicable, system shall have the data of actual usage from M-11 to M-1. Month M is the rolling month, the month of the model run, and is also the buffer month. The backward rolling constraint is defined as the actual usage from M-11 to M.

For example:

- For rolling-annual plan applicability on Starts from March 1, 2017-February 28, 2020:
 - **For M=March 2017 rolling month (second run):**
 - Model run on (M: March 2017)
 - Update opportunity costs of forward rolling 11 months ([M+1,M+11]: April 2017 through February 2018).
 - Actual usage data are [M-11, M-1]: Not applicable since no backward-rolling limit is applicable.
 - Analysis time horizon shall be [M,M+11]: March 1, 2017 – February 28, 2018. This is same as forward-rolling use-limit window.
 - M: March 2017 is the buffer month to generate the usage metrics for this month since the actuals for this month is not ready yet.
 - However, no opportunity cost shall be calculated for buffer month (M: March 2017) in this model run.
 - **For M=April 2017 rolling month (middle run):**
 - Model run on (M: April 2017)

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- Update opportunity costs of forward rolling 11 months ([M+1,M+11]: May 2017 through March 2018).
- Actual usage data are [M-11, M-1]: Not applicable since no backward-rolling limit is applicable.
- Analysis time horizon shall be [M,M+11]: April 1, 2017 – March 31, 2018. This is same as forward-rolling use-limit window.
- M: April 2017 is the buffer month to generate the usage metrics for this month since the actuals for this month is not ready yet.
- However, no opportunity cost shall be calculated for buffer month (M: April 2017) in this model run.
- **For M=March 2018 rolling month (middle run):**
 - Model run on (M: March 2018)
 - Update opportunity costs of forward rolling 11 months ([M+1,M+11]: April 2018 through February 2019).
 - Actual usage data are [M-11, M-1]: April 2017 through February 2018.
 - Analysis time horizon shall be [M,M+11]: March 1, 2018 – February 28, 2019. This is same as forward-rolling use-limit window.
 - M: March 2018 is the buffer month to generate the usage metrics for this month since the actuals for this month is not ready yet.
 - However, no opportunity cost shall be calculated for buffer month (M: March 2018) in this model run.
- **For M=February 2019 rolling month (middle run):**
 - Model run on (M: February 2019)
 - Update opportunity costs of forward rolling 11 months ([M+1,M+11]: Macrh 2019 through March 2020).
 - Actual usage data are [M-11, M-1]: March 2018 through January 2019.
 - Analysis time horizon shall be [M,M+11]: February 1, 2019 – January 31, 2020. This is same as forward-rolling use-limit window.
 - M: February 2019 is the buffer month to generate the usage metrics for this month since the actuals for this month is not ready yet.
 - However, no opportunity cost shall be calculated for buffer month (M: February 2019) in this model run.
- **For M=March 2019 rolling month (last run):**
 - Model run on (M: March 2019)

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- Update opportunity costs of forward rolling 11 months ([M+1,M+11]: April 2019 through February 2020).
- Actual usage data are [M-11, M-1]: April 2018 through February 2019.
- Analysis time horizon shall be [M,M+11]: March 1, 2019 – February 29, 2020. This is same as forward-rolling use-limit window.
- M: March 2019 is the buffer month to generate the usage metrics for this month since the actuals for this month is not ready yet.
- However, no opportunity cost shall be calculated for buffer month (M: March 2019) in this model run.

System shall calculate the opportunity cost **for each limitation type** for each calendar month of the forward 11-month rolling period (M+1 to M+11), as the difference between Model_Run_1 and Model_Run_2, divided by $Y_{k,v}$, except if $M \geq N-10$, there will not be forward rolling applicability to enforce, and hence no opportunity cost to update, where:

- Model_Run_1 (base B-run) would reflect
 - a) The annual-rolling limitation in the forward-rolling 12-month period (from M to M+11) for that rolling limitation type under analysis (forward-rolling limitation for month M). This constraint is applicable only if $M \leq N-11$
 - b) The annual-rolling limitation in the backward-rolling 12-month period from M-11 to M reduced by actual usage from M-11 to M-1 for that limitation type under analysis (backward-rolling limitation for month M); and will be modeled as monthly limitation of rolling month M. This constraint is applicable only if $M \geq C+11$.
 - c) Any other limitation types
- Model_Run_2 (L-run) would reflect
 - a) The annual-rolling limitation in the forward-rolling 12-month period (from M to M+11) with $Y_{k,v}$ less rolling limitation for that limitation type under analysis (forward-rolling limitation for month M), This constraint is applicable only if $M \leq N-11$.
 - b) The annual-rolling limitation in the backward-rolling 12-month period from M-11 to M reduced by actual usage from M-11 to M-1 with $Y_{k,v}$ less rolling limitation for that limitation type under analysis (backward-rolling limitation for month M); and will be modeled as monthly limitation of rolling month M. This constraint is applicable only if $M \geq C+11$.
 - c) Any other limitation types

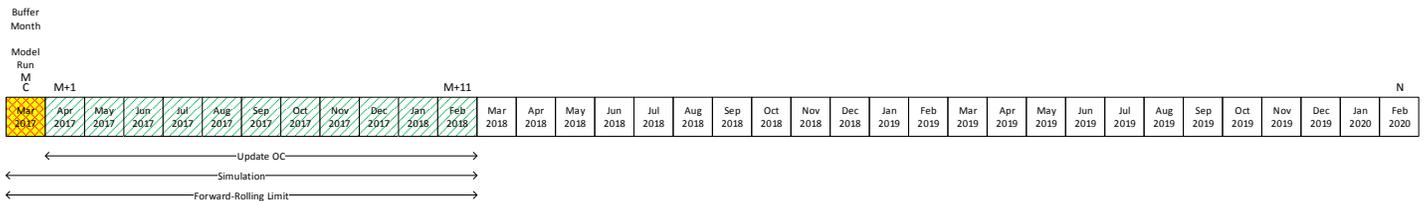
Notes:

- There will be two model runs for each rolling month (M) of the rolling-annual plan applicability (excluding the last plan calendar months that do not have 12 months forward rolling (M to M+11) until end time of the rolling plan applicability, (i.e. excluding $M \geq N-10$)) that covers M to M+11 analysis time horizon, where opportunity cost needs to be modeled (M+1 to M+11), and M is the buffer month.
- No opportunity cost will be calculated for buffer month M.

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7.5.8.1 For rolling month M: March 2017 (second run):



Input Data:

- Resource Type: Non-MSG resource
- Analysis: Model and update rolling-annual start imitation
- 300 starts per rolling-annual use limit plan applicability (rolling-annual within March 1, 2017-February 28, 2020):
 - This constraint applies forward to (M to M+11: March 2017 through February 2018) and no backward-rolling constraint is enforced.
- Actual starts (M-11 to M-1):
 - N/A, since no backward-rolling limit is applied.
- Remaining starts (M):
 - N/A, since no backward-rolling limit is applied.
- Analysis time horizon (M to M+11), the first month (M) is the buffer month. However, no opportunity cost shall be calculated for buffer month:
 - Analysis time horizon is March 2017 through February 2018).
- Running model on any day on M:
 - Running model on March 2017
- For Start limitation:
 - $x_{k,v} = 90\%$
 - number of implied start per resources = 1
 - $Y_{k,v} =$ number of implied start per resources = 1

Base Model run (B-run):

- Set the maximum starts for forward-rolling ($MaxSTRT_{annual,k}$) to ≤ 270 starts (270 = 90% of 300 starts, applicable to continuous period from M to M+11: March 2017 through February 2018).
- Run the model as described in Section 7.4, optimizing M to M+11: March 2017 through February 2018.

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- The resulting annual estimated profits is defined as “Base run rolling-annual March 2017 (second run) profits”.

Model Run 2 (L-run):

- Reduce the maximum starts for forward-rolling ($MaxSTRT_{annual,k}$) to ≤ 269 (269 = 90% of 300 starts, minus one start, applicable to continuous period from M to M+11: March 2017 through February 2018).
- Re-run the model, optimizing M to M+11: March 2017 through February 2018.
- The resulting annual estimated profits is defined as “Model run 2 rolling-annual March 2017 (second run) profits”.

Opportunity Cost per Applicable Use Limitation:

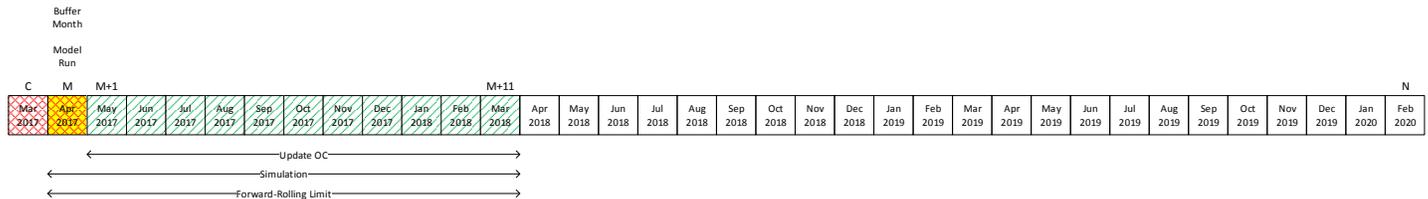
- The opportunity cost, due to the applicable rolling-annual start limitations, for each month of the rolling 11-month period of M+1 to M+11 (April 2017 through February 2018) is:
 - $OC_{k,v} = \text{Max}\{ 0, (\text{Base run rolling-annual March 2017 (second run) profits} - \text{Model run 2 rolling-annual March 2017 (second run) profits}) / Y_{k,v}$

Opportunity Cost Adder:

- The opportunity cost adder for SUC is:
 - $OC_{k,SUC} = OC_{k,v} * \text{number of implied starts per resource}$
- This opportunity cost adder is valid for each month of the rolling 11-month period of M+1 to M+11 (April 2017 through February 2018) until the next model run updates the opportunity cost adder due to the rolling limitation.
- These updated opportunity costs will supersede all previously calculated opportunity cost adders for the same month due to the same limitation type.
- It will increase the start-up cost bid cap by the opportunity cost adder.
- The next model run for rolling month M: April 2017 will update opportunity costs from M+1 to M+11 (May 2017 through March 2018).

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7.5.8.2 For rolling month M: April 2017 (middle run):



Input Data:

- Resource Type: Non-MSG resource
- Analysis: Model and update rolling-annual start imitation
- 300 starts per rolling-annual use limit plan applicability (rolling-annual within March 1, 2017-February 28, 2020):
 - This constraint applies forward to (M to M+11: April 2017 through March 2018) and no backward-rolling constraint is enforced.
- Actual starts (M-11 to M-1):
 - N/A, since no backward-rolling limit is applied.
- Remaining starts (M):
 - N/A, since no backward-rolling limit is applied.
- Analysis time horizon (M to M+11), the first month (M) is the buffer month. However, no opportunity cost shall be calculated for buffer month:
 - Analysis time horizon is April 2017 through March 2018).
- Running model on any day on M:
 - Running model on April 2017
- For Start limitation:
 - $x_{k,v} = 90\%$
 - number of implied start per resources = 1
 - $Y_{k,v} =$ number of implied start per resources = 1

Base Model run (B-run):

- Set the maximum starts for forward-rolling ($MaxSTRT_{annual,k}$) to ≤ 270 starts (270 = 90% of 300 starts, applicable to continuous period from M to M+11: April 2017 through March 2018).
- Run the model as described in Section 7.4, optimizing M to M+11: April 2017 through March 2018.

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- The resulting annual estimated profits is defined as “Base run rolling-annual April 2017 profits”.

Model Run 2 (L-run):

- Reduce the maximum starts for forward-rolling ($MaxSTRT_{annual,k}$) to ≤ 269 (269 = 90% of 300 starts, minus one start, applicable to continuous period from M to M+11: April 2017 through March 2018).
- Re-run the model, optimizing M to M+11: April 2017 through March 2018.
- The resulting annual estimated profits is defined as “Model run 2 rolling-annual April 2017 profits”.

Opportunity Cost per Applicable Use Limitation:

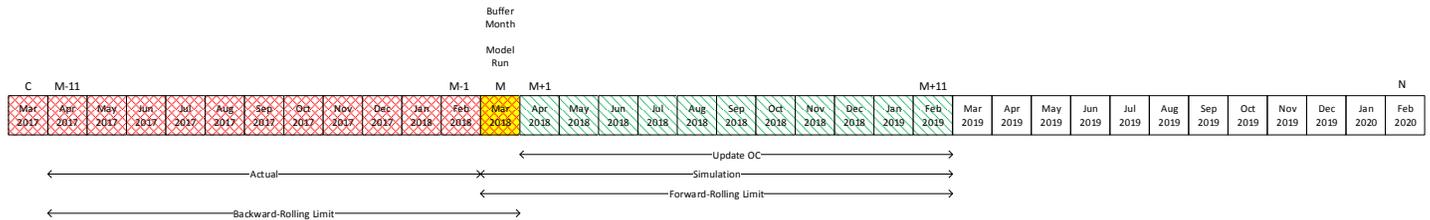
- The opportunity cost, due to the applicable rolling-annual start limitations, for each month of the rolling 11-month period of M+1 to M+11 (May 2017 through March 2018) is:
 - $OC_{k,v} = \text{Max}\{ 0, (\text{Base run rolling-annual April 2017 profits} - \text{Model run 2 rolling-annual April 2017 profits}) / Y_{k,v}$

Opportunity Cost Adder:

- The opportunity cost adder for SUC is:
 - $OC_{k,SUC} = OC_{k,v} * \text{number of implied starts per resource}$
- This opportunity cost adder is valid for each month of the rolling 11-month period of M+1 to M+11 (May 2017 through March 2018) until the next model run updates the opportunity cost adder due to the rolling limitation.
- These updated opportunity costs will supersede all previously calculated opportunity cost adders for the same month due to the same limitation type.
- It will increase the start-up cost bid cap by the opportunity cost adder.
- The next model run for rolling month M: May 2017 will update opportunity costs from M+1 to M+11 (June 2017 through April 2018).

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7.5.8.3 For rolling month M: March 2018 (middle run):



Input Data:

- Resource Type: Non-MSG resource
- Analysis: Model and update rolling-annual start imitation
- 300 starts per rolling-annual use limit plan applicability (rolling-annual within March 1, 2017-February 28, 2020):
 - This constraint applies forward to (M to M+11: March 2018 through February 2019) and backward to (M-11 to M: April 2017 through March 2018).
- Actual starts (M-11 to M-1):
 - Actual starts = 280 for April 2017 through February 2018).
- Remaining starts (M):
 - Remaining starts = 20 (300-280) for March 2018).
- Analysis time horizon (M to M+11), the first month (M) is the buffer month. However, no opportunity cost shall be calculated for buffer month:
 - Analysis time horizon is March 2018 through February 2019).
- Running model on any day on M:
 - Running model on March 2018
- For Start limitation:
 - $x_{k,v} = 90\%$
 - number of implied start per resources = 1
 - $Y_{k,v} =$ number of implied start per resources = 1

Base Model run (B-run):

- Set the maximum starts due to backward-rolling constraint ($MaxSTRT_{monthly,k}$) to ≤ 18 (18 = 90% of 20 remaining starts, applicable to month M: March 2018)
- Set the maximum starts for forward-rolling ($MaxSTRT_{annual,k}$) to ≤ 270 starts (270 = 90% of 300 starts, applicable to continuous period from M to M+11: March 2018 through February 2019).

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- Run the model as described in Section 7.4, optimizing M to M+11: March 2018 through February 2019.
- The resulting annual estimated profits is defined as “Base run rolling-annual March 2018 profits”.

Model Run 2 (L-run):

- Reduce the maximum starts due to backward-rolling constraint ($MaxSTRT_{monthly,k}$) to ≤ 17 (17 = 90% of 20 remaining starts, minus one start, applicable to month M: March 2018)
- Reduce the maximum starts for forward-rolling ($MaxSTRT_{annual,k}$) to ≤ 269 (269 = 90% of 300 starts, minus one start, applicable to continuous period from M to M+11: March 2018 through February 2019).
- Re-run the model, optimizing M to M+11: March 2018 through February 2019.
- The resulting annual estimated profits is defined as “Model run 2 rolling-annual March 2018 profits”.

Opportunity Cost per Applicable Use Limitation:

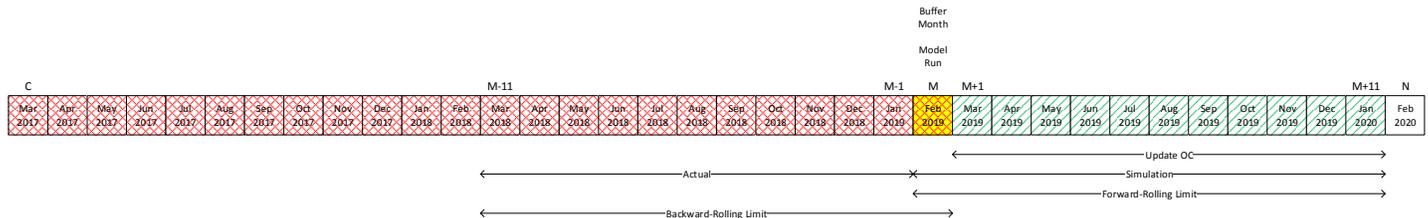
- The opportunity cost, due to the applicable rolling-annual start limitations, for each month of the rolling 11-month period of M+1 to M+11 (April 2018 through February 2019) is:
 - $OC_{k,v} = \text{Max}\{ 0, (\text{Base run rolling-annual March 2018 profits} - \text{Model run 2 rolling-annual March 2018 profits}) / Y_{k,v}$

Opportunity Cost Adder:

- The opportunity cost adder for SUC is:
 - $OC_{k,SUC} = OC_{k,v} * \text{number of implied starts per resource}$
- This opportunity cost adder is valid for each month of the rolling 11-month period of M+1 to M+11 (April 2018 through February 2019) until the next model run updates the opportunity cost adder due to the rolling limitation.
- These updated opportunity costs will supersede all previously calculated opportunity cost adders for the same month due to the same limitation type.
- It will increase the start-up cost bid cap by the opportunity cost adder.
- The next model run for rolling month M: April 2018 will update opportunity costs from M+1 to M+11 (May 2018 through March 2019).

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7.5.8.4 For rolling month M: February 2019 (middle run):



Input Data:

- Resource Type: Non-MSG resource
- Analysis: Model and update rolling-annual start imitation
- 300 starts per rolling-annual use limit plan applicability (rolling-annual within March 1, 2017-February 28, 2020):
 - This constraint applies forward to (M to M+11: February 2019 through January 2020) and backward to (M-11 to M: March 2018 through February 2019).
- Actual starts (M-11 to M-1):
 - Actual starts = 280 for March 2018 through January 2019).
- Remaining starts (M):
 - Remaining starts = 20 (300-280) for February 2019).
- Analysis time horizon (M to M+11), the first month (M) is the buffer month. However, no opportunity cost shall be calculated for buffer month:
 - Analysis time horizon is February 2019 through January 2020).
- Running model on any day on M:
 - Running model on February 2019
- For Start limitation:
 - $x_{k,v} = 90\%$
 - number of implied start per resources = 1
 - $Y_{k,v} =$ number of implied start per resources = 1

Base Model run (B-run):

- Set the maximum starts due to backward-rolling constraint ($MaxSTRT_{monthly,k}$) to ≤ 18 (18 = 90% of 20 remaining starts, applicable to month M: February 2019)
- Set the maximum starts for forward-rolling ($MaxSTRT_{annual,k}$) to ≤ 270 starts (270 = 90% of 300 starts, applicable to continuous period from M to M+11: February 2019 through January 2020).

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- Run the model as described in Section 7.4, optimizing M to M+11: February 2019 through January 2020.
- The resulting annual estimated profits is defined as “Base run rolling-annual February 2019 profits”.

Model Run 2 (L-run):

- Reduce the maximum starts due to backward-rolling constraint ($MaxSTRT_{monthly,k}$) to ≤ 17 (17 = 90% of 20 remaining starts, minus one start, applicable to month M: February 2019)
- Reduce the maximum starts for forward-rolling ($MaxSTRT_{annual,k}$) to ≤ 269 (269 = 90% of 300 starts, minus one start, applicable to continuous period from M to M+11: February 2019 through January 2020).
- Re-run the model, optimizing M to M+11: February 2019 through January 2020.
- The resulting annual estimated profits is defined as “Model run 2 rolling-annual February 2019 profits”.

Opportunity Cost per Applicable Use Limitation:

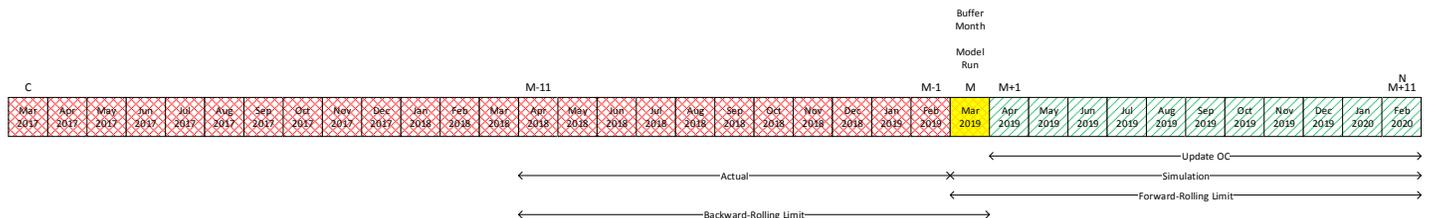
- The opportunity cost, due to the applicable rolling-annual start limitations, for each month of the rolling 11-month period of M+1 to M+11 (March 2019 through January 2020) is:
 - $OC_{k,v} = \text{Max}\{ 0, (\text{Base run rolling-annual February 2019 profits} - \text{Model run 2 rolling-annual February 2019 profits}) / Y_{k,v}$

Opportunity Cost Adder:

- The opportunity cost adder for SUC is:
 - $OC_{k,SUC} = OC_{k,v} * \text{number of implied starts per resource}$
- This opportunity cost adder is valid for each month of the rolling 11-month period of M+1 to M+11 (March 2019 through January 2020) until the next model run updates the opportunity cost adder due to the rolling limitation.
- These updated opportunity costs will supersede all previously calculated opportunity cost adders for the same month due to the same limitation type.
- It will increase the start-up cost bid cap by the opportunity cost adder.
- The next model run for rolling month M: March 2019 will update opportunity costs from M+1 to M+11 (April 2019 through February 2020).

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7.5.8.5 For rolling month M: March 2019 (last run):



Input Data:

- Resource Type: Non-MSG resource
- Analysis: Model and update rolling-annual start imitation
- 300 starts per rolling-annual use limit plan applicability (rolling-annual within March 1, 2017-February 28, 2020):
 - This constraint applies forward to (M to M+11: March 2019 through February 2020) and backward to (M-11 to M: April 2018 through March 2019).
- Actual starts (M-11 to M-1):
 - Actual starts = 280 for April 2018 through February 2019).
- Remaining starts (M):
 - Remaining starts = 20 (300-280) for March 2019).
- Analysis time horizon (M to M+11), the first month (M) is the buffer month. However, no opportunity cost shall be calculated for buffer month:
 - Analysis time horizon is March 2019 through February 2020).
- Running model on any day on M:
 - Running model on March 2019
- For Start limitation:
 - $x_{k,v} = 90\%$
 - number of implied start per resources = 1
 - $Y_{k,v} =$ number of implied start per resources = 1

Base Model run (B-run):

- Set the maximum starts due to backward-rolling constraint ($MaxSTRT_{monthly,k}$) to ≤ 18 (18 = 90% of 20 remaining starts, applicable to month M: March 2019)
- Set the maximum starts for forward-rolling ($MaxSTRT_{annual,k}$) to ≤ 270 starts (270 = 90% of 300 starts, applicable to continuous period from M to M+11: March 2019 through February 2020).

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- Run the model as described in Section 7.4, optimizing M to M+11: March 2019 through February 2020.
- The resulting annual estimated profits is defined as “Base run rolling-annual March 2019 profits”.

Model Run 2 (L-run):

- Reduce the maximum starts due to backward-rolling constraint ($MaxSTRT_{monthly,k}$) to ≤ 17 (17 = 90% of 20 remaining starts, minus one start, applicable to month M: March 2019)
- Reduce the maximum starts for forward-rolling ($MaxSTRT_{annual,k}$) to ≤ 269 (269 = 90% of 300 starts, minus one start, applicable to continuous period from M to M+11: March 2019 through February 2020).
- Re-run the model, optimizing M to M+11: March 2019 through February 2020.
- The resulting annual estimated profits is defined as “Model run 2 rolling-annual March 2019 profits”.

Opportunity Cost per Applicable Use Limitation:

- The opportunity cost, due to the applicable rolling-annual start limitations, for each month of the rolling 11-month period of M+1 to M+11 (April 2019 through February 2020) is:
 - $OC_{k,v} = \text{Max}\{ 0, (\text{Base run rolling-annual March 2019 profits} - \text{Model run 2 rolling-annual March 2019 profits}) \} / Y_{k,v}$

Opportunity Cost Adder:

- The opportunity cost adder for SUC is:
 - $OC_{k,SUC} = OC_{k,v} * \text{number of implied starts per resource}$
- This opportunity cost adder is valid for each month of the rolling 11-month period of M+1 to M+11 (April 2019 through February 2020) (same value for every month) until the next model run updates the opportunity cost adder due to the rolling limitation.
- These updated opportunity costs will supersede all previously calculated opportunity cost adders for the same month due to the same limitation type.
- It will increase the start-up cost bid cap by the opportunity cost adder.
- This is the last model run for this rolling-annual applicability plan. There will not be any further updates to the opportunity costs from M+1 to M+11 (April 2019 through February 2020) due to this rolling plan applicability.

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7.6 Permutations of Cost Estimate Calculations for Non-Gas Fired Resources

As noted above, the cost estimate formulas in Section 7.7.3.2 were for gas-fired resources based on the proxy cost formulation of those costs for gas-fired resources. Attachment G of the Market Instruments Business Practice Manual specifies how proxy costs are calculated for non-gas fired resources. To be consistent with those calculations, the cost estimates for non-gas fired resources used in the opportunity cost model will also be based on those calculations.

Below are the cost estimate formulas for variable energy cost, minimum load cost, and start-up costs, for non-gas fired resources without a Greenhouse gas compliance and for non-gas fired resources with a greenhouse gas complies. These formulas will be used to estimate the resource specific costs for the opportunity cost model.

7.6.1 Non-Gas Fired Resource without a GHG Compliance Obligation

Note: For MSG resources, the monthly VEC, SUC and MLC will be on configuration level; and monthly TC will be on transition level.

Variable Energy Cost

$$(1.1) VEC_{m,k} = \text{Max}\{ NBT_{m,k}, (\sum_g [\text{SegMW}_{g,k} * (\text{AvgCostF}_{g,k} + O\&M_k)] / \sum_g \text{SegMW}_{g,k}) \}$$

Where:

- $VEC_{m,k}$ is the estimated Variable Energy Cost for month 'm' for resource or MSG configuration 'k' (\$/MWH)
- $\text{SegMW}_{g,k}$ is the megawatts in cost curve segment 'g' for resource or MSG configuration 'k' (MW)
- $O\&M_k$ is the Operations and Maintenance adder for the resource or MSG configuration 'k' (\$/MWH)
- $\text{AvgCostF}_{g,k}$ is the RDT submitted cost corresponding to the cost curve segment 'g' for resource or MSG configuration 'k' (\$/MWH)
- $NBT_{m,k}$ is the most recent Net Benefits Test value if the resource 'k' is a PDR resource, otherwise 0 (\$/MWH)

Start-Up Costs

$$(2.1a) SUC_{m,g,k} = \text{RDTCostSU}_{g,k} + \text{SU_MMA}_{g,k} + \text{SU_GMC}_{g,k}$$

Where:

- $SUC_{m,g,k}$ is the estimated start-up cost for month 'm' for segment 'g' for resource or MSG configuration 'k' (\$/start)
- $\text{RDTCostSU}_{g,k}$ is the most recent Master File start-up fuel or fuel equivalent cost for segment 'g' for resource or MSG configuration 'k' (\$/start)

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SU_MMA_{g,k} is the most recent Major Maintenance Adder for starts for segment ‘g’ for resource or MSG configuration ‘k’ (\$/start)

SU_GMC_{g,k} is the GMC adder for starts⁸ for segment ‘g’ for resource or MSG configuration ‘k’ (\$/start)

Transition Costs

$$(2.1b) TC_{m,p} = \text{Max} (0 , [SUC_{m,g,ToConfig} - SUC_{m,g,FromConfig}])$$

Where:

TC_{m,p} is the estimated monthly transition cost for transition ‘p’ (of the MSG plant ‘w’) (\$/transition)

SUC_{m,g,ToConfig} is the estimated monthly direct start-up cost (of the highest cost segment) for the MSG resource “To” configuration of transition ‘p’ (of MSG plant ‘w’) (\$/start)

SUC_{m,g,FromConfig} is the estimated monthly direct start-up cost (of the highest cost segment) for the MSG resource “From” configuration of transition ‘p’ (of MSG plant ‘w’) (\$/start)

Minimum Load Costs

$$(3.1) MLC_{m,k} = RDTCostML_k + (O\&M_k * Pmin_k) + ML_MMA_k + ML_GMC_k$$

Where:

MLC_{m,k} is the estimated monthly minimum load cost for the resource or MSG configuration ‘k’ (\$/h)

RDTCostML_k is the average fuel cost at minimum load per the most recent Master File costs⁹ for the resource or MSG configuration ‘k’ (\$/h)

O&M_k is the operating and maintenance adder for the resource or MSG configuration ‘k’ (\$/MWh)

ML_MMA_k is the most recent Major Maintenance Adder for minimum operating point, if costs approved by the ISO for the resource or MSG configuration ‘k’ (\$/h)

ML_GMC_k is the GMC adder for minimum operating point¹⁰ for the resource or MSG configuration ‘k’ (\$/h)

Pmin_k is the minimum operating point for the resource or MSG configuration ‘k’ (MW)

⁸SU_GMC_{g,k} is determined by $Pmin_k * (STARTUP_RAMP_TIME_{g,k}/60min) * \frac{GMC}{2}$

⁹ Average fuel cost at minimum load for non-gas fired resources is the product of minimum load and the submitted Heat average cost in Master File corresponding to minimum load divided by 1,000.

¹⁰ ML_GMC_k is determined by Pmin_k*GMC adder

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7.6.2 Non-Gas Fired Resource with a GHG Compliance Obligation¹¹

For non-gas fired resources to have greenhouse gas compliance costs explicitly included in the proxy cost calculations below, they have to have submitted sufficient data for the ISO to conduct the calculations.

Note: For MSG resources, the monthly VEC, SUC and MLC will be on configuration level; and monthly TC will be on transition level.

Variable Energy Cost

$$(1.2) \quad VEC_{m,k} = \text{Max} \left\{ \text{NBT}_{m,k}, \left(\sum_g [\text{SegMW}_{g,k} * (\text{AvgCostF}_{g,k} + \text{O\&M}_k + ([\text{AVgHR}_k/1000] * \text{GHGas}_{m-1} * \text{EmRate}_k)) \right] / \sum_g \text{SegMW}_{g,k} \right\}$$

Where:

$VEC_{m,k}$ is the estimated Variable Energy Cost for month 'm' (\$/MWH)

$\text{SegMW}_{g,k}$ is the megawatts in cost curve segment 'g' for the resource or MSG configuration 'k' (MW)

$\text{AvgCostF}_{g,k}$ is the RDT submitted cost corresponding to the cost curve segment 'g' for the resource or MSG configuration 'k' (\$/MWh)

GHGas_{m-1} is the most recent greenhouse gas price, if resource is subject to greenhouse gas costs (\$/metric ton CO₂e)

EmRate_k is the resource specific greenhouse gas emissions rate per MMBtu of natural gas for resource or MSG configuration 'k' (metric ton CO₂e/MMBTU)

O\&M_k is the operating and maintenance adder for the resource for the resource or MSG configuration 'k' (\$/MWh)

$\text{NBT}_{m,k}$ is the most recent Net Benefits Test value if the resource 'k' is a PDR resource, otherwise 0 (\$/MWh)

AvgHR_k is the average Heat rate for the resource or MSG configuration 'k'. This is needed to convert BTU to MWH. (BTU/KWh)

Start-Up Costs

$$(2.2a) \quad \text{SUC}_{m,g,k} = \text{RDTCostSU}_{g,k} + \text{SU_MMA}_{g,k} + \text{SU_GMC}_{g,k} + (\text{SUFuel}_{g,k} * \text{GHGas}_{m-1} * \text{EmRate}_k)^{12}$$

Where:

¹¹ For GHG costs to be included for non-gas fired resources, the GHG compliance flag in Master File has to be set to 'Y' and all necessary data has been submitted by the SC via RDT.

¹² $\text{SU_GMC}_{g,k}$ is determined by $\text{PMIN}_k * \text{Start up time}_{g,k}$ in minutes / 60 mins per hour * (GMC adder/2)

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$SUC_{m,g,k}$ is the estimated monthly start-up cost for the resource for segment 'g' for the resource or MSG configuration 'k' (\$/start)

$RDTCostSU_{g,k}$ is the most recent Master File start-up fuel or fuel equivalent cost for segment 'g' for the resource or MSG configuration 'k' (\$/start)

$SU_{fuel,g,k}$ is the most recent start-up fuel value in Master File for segment 'g' for the resource or MSG configuration 'k' (MMBTU/start)

$GHGas_{m-1}$ is the most recent greenhouse gas price, if resource is subject to greenhouse gas costs (\$/metric ton CO_{2e})

$EmRate_k$ is the resource specific greenhouse gas emissions rate per MMBtu of natural gas for resource or MSG configuration 'k' (metric ton CO_{2e}/MMBTU)

$SU_MMA_{g,k}$ is the most recent Major Maintenance Adder for starts for segment 'g' for the resource or MSG configuration 'k' (\$/start)

$SU_GMC_{g,k}$ is the GMC adder for starts¹³ for segment 'g' for the resource or MSG configuration 'k' (\$/start)

Transition Costs

$$(2.2b) TC_{m,p} = \text{Max} (0 , [SUC_{m,g,ToConfig} - SUC_{m,g,FromConfig}])$$

Where:

$TC_{m,p}$ is the estimated monthly transition cost for transition 'p' (of the MSG plant 'w') (\$/transition)

$SUC_{m,g,ToConfig}$ is the estimated monthly direct start-up cost (of the highest cost segment) for the MSG resource "To" configuration of transition 'p' (of MSG plant 'w') (\$/start)

$SUC_{m,g,FromConfig}$ is the estimated monthly direct start-up cost (of the highest cost segment) for the MSG resource "From" configuration of transition 'p' (of MSG plant 'w') (\$/start)

Minimum Load Costs

$$(3.2) MLC_{m,k} = RDTCostML_k + (O\&M_k * Pmin_k) + ML_MMA_k + ML_GMC_k + [(GHGas_{m-1} * EmRate_k * PminHR_k * Pmin_k) / 1000]$$

Where:

$MLC_{m,k}$ is the estimated monthly minimum load cost for the resource or MSG configuration 'k' (\$/h)

¹³ $SU_GMC_{g,k}$ is determined by $Pmin * (STARTUP_RAMP_TIME_{g,k} / 60min) * \frac{GMC}{2}$

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- $RDTCostML_k$ is the average fuel cost at minimum load per the most recent Master File costs¹⁴ for the resource or MSG configuration 'k' (\$/h)
- $O\&M_k$ is the operating and maintenance adder for the resource or MSG configuration 'k' (\$/MWh)
- ML_MMA_k is the most recent Major Maintenance Adder for minimum operating point, if costs approved by the ISO for the resource or MSG configuration 'k' (\$/h)
- ML_GMC_k is the GMC adder for minimum operating point¹⁵ for the resource or MSG configuration 'k' (\$/h)
- $GHGas_{m-1}$ is the most recent greenhouse gas price, if resource is subject to greenhouse gas costs (\$/metric ton CO_{2e})
- $EmRate_k$ is the resource specific greenhouse gas emissions rate per MMBtu of natural gas for resource or MSG configuration 'k' (metric ton CO_{2e}/MMBTU)
- $PminHR_k$ is the most recent heat rate at minimum operating point of the resource in Master File for the resource or MSG configuration 'k' (BTU/KWh)
- $Pmin_k$ is the minimum operating point for the resource or MSG configuration 'k' (MW)

¹⁴ Average fuel cost at minimum load for non-gas fired resources is the product of minimum load and the submitted Heat average cost in Master File corresponding to minimum load divided by 1,000.

¹⁵ ML_GMC_k is determined by $Pmin_k * GMC$ adder

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7.7 Input Data Sources

Below is a table providing more information on the input data necessary for the ISO to calculate the cost estimates used in the opportunity cost model.

Input variable name	Description of variable	Data source	Comments/Examples	Equations using this variable ¹⁶
SegMW _{g,k}	Megawatts for each heat rate operating segment 'g' for gas fired resource or MSG configuration 'k', or the cost curve segment 'g' for non-gas fired resource or MSG configuration 'k'.	Master File		1, 1.1, and 1.2
HR _{g,k}	Heat rate for operating range segment 'g' for resource or MSG configuration 'k'	Master File		1, 1.1, and 1.2,
NatGasF _{m,l}	Natural gas futures price for month 'm' and in fuel region 'l'	Index Price	Resources in PGE2 fuel region will use the PG&E Citygate prices. Resources in SCE1, SCE2, SDGE1, and SDGE2 will use SoCal city gas prices. All others will use the minimum of PG&E and SoCal citygate prices.	1 ,2a, 3, 5.1, and 6

¹⁶ The numbers in this column corresponds to the number labels next to each equation throughout the technical appendix.

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Input variable name	Description of variable	Data source	Comments/Examples	Equations using this variable ¹⁶
			Based on using the average of several days' future prices.	
GasT _{m-1,l}	Most recent month's gas transportation cost for fuel region 'l' (including Base Gas Transportation Cost, Gas Transportation Shrinkage Allowance, Cap and Trade Credits and Miscellaneous Costs)	Index price	Resources will use the gas transportation costs based on territory rates as stated in Appendix C of the Market Instruments BPM.	1, 2a, 3, and 6
GHGas _{m-1}	Average of most recent month's daily greenhouse gas allowance prices	Index price	Consistent with formulation in G.1.3 of Market Instruments BPM	1, 1.2, 2a, 2.2a, 3, 3.2, 5.1, and 6
EmRate _k	Greenhouse gas emissions rate of resource or MSG configuration 'k'	Master File	If resource k is not subject to greenhouse gas compliance obligations, then zero.	1, 1.2, 2a, 2.2a, 3, and 3.2
O&M _k ¹⁷	Operations and Maintenance adder for	Administrative Fee	Refer to Market Instruments BPM for default O&M values.	1, 1.1, 1.2, 3, 3.1, and 3.2

¹⁷ Refer to Exhibit 4.2 in Market Instruments BPM for default O&M adders by technology type at [https://bpmcm.caiso.com/Pages/BPMDetails.aspx?BPM=Market Instruments](https://bpmcm.caiso.com/Pages/BPMDetails.aspx?BPM=Market%20Instruments)

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Input variable name	Description of variable	Data source	Comments/Examples	Equations using this variable ¹⁶
	resource or MSG configuration 'k'			
$NBT_{m,k}$	Net Benefits test value for resource or MSG configuration 'k'	CASIO calculated value	Calculated monthly for PDR resources	1.1, 1.2
$EPI_{m,e}$	Energy price index for future month 'm' and electric region 'e'	Index price	<p>To forecast all resource's EPI, for each electric region and each month m:</p> <ul style="list-style-type: none"> For wholesale electric region, $EPI_{m,e} = (\text{NatGasTotalF}_{m,l} * 10)$ where $\text{NatGasTotalF}_{m,l} = \text{NatGasF}_{m,l} + \text{GasT}_{m-1,l}$ [including Cap and Trade Credits and Miscellaneous Costs]. For retail electric region, $EPI_{m,e} = \text{retail rate}$ 	2a
$SUFuel_{g,k}$	Resource's Start-up fuel for segment 'g' for resource or MSG configuration 'k'	Master File		1
$AUX_{g,k}$	Resource's auxiliary energy for start-ups for segment 'g' for resource or MSG configuration 'k'	Master File		2a and 2.2
$SU_MMA_{g,k}$	Major maintenance	Master File	As approved by the ISO, otherwise zero	2a, 2.1a, and 2.2a



Input variable name	Description of variable	Data source	Comments/Examples	Equations using this variable ¹⁶
	adder for starts for segment 'g' for resource or MSG configuration 'k'			
SU_GMC _{g,k}	Grid management charge applied to the start-up costs for segment 'g' for resource or MSG configuration 'k'	Determined based on Master File values and Administrative fee	PMin*Startup ramp time/60*GMC adder/2 where GMC adder represents Market Services Charge and System Operations Charge.	2a, 2.1a, and 2.2a
ML_GMC _k	Grid management charge applied to the minimum load costs for resource or MSG configuration 'k'	Determined based on Master File values and Administrative fee	PMin*GMC adder where GMC adder represents Market Services Charge, System Operations Charge, and Bid Segment Fee.	3, 3.1, and 3.2
PMinHR _k	Heat rate at the minimum operating point for resource or MSG configuration 'k'	Master File		3 and 3.2
ML_MMA _k	Major maintenance adder for minimum load for resource or MSG configuration 'k'	Master File	As approved by the ISO, otherwise zero	3, 3.1, and 3.2

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Input variable name	Description of variable	Data source	Comments/Examples	Equations using this variable ¹⁶
$LMP_{i,f-1y}$	15 minute energy LMP at resource's pnode 'i', from same time period of the previous year	Market data	For example, when forecasting June 2016 15 minute energy LMPs, use June 2015 15 minute energy LMPs	4a
$GHGas_{d-1y}$	Previous year's daily greenhouse gas allowance prices	Index price	For example, when forecasting June 2016 energy LMPs, use the June 2015 daily greenhouse gas allowance price.	4a
EmRate	Standard greenhouse gas emissions rate	As provided, and updated, by EPA	Currently .0531148mtCO ₂ e/mmBTU. Same value for all resources as natural gas resources are assumed to be on the margin.	4a, 5.1, 5.2, and 6
$GPI_{d-1y,l}$	Daily gas price index for fuel region 'l' from the previous year	Index price	For example, when forecasting June 2016, use the June 2015 daily gas price of indices. These values contain the gas transportation costs.	4a
$PPF_{hub,m,tou}$	Future power price of ICE hub "hub", month 'm', and by time of use "tou"		Based on same indices used to determine the EPI as stated in Appendix M of the Market Instruments BPM. NP15 prices for resources in PGE1 and PGE2 fuel regions. SP15 prices for all other regions.	5.1

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Input variable name	Description of variable	Data source	Comments/Examples	Equations using this variable ¹⁶
PP _{hub,m-12,tou}	Monthly average power price of ICE hub “hub”, month ‘m’, and time of use “tou”.		<p>For example, when forecasting June 2016 prices, take the average daily power price of June 2015 from ICE hub “hub” by time of use.</p> <p>NP15 prices for resources in PGE1 and PGE2 fuel regions. SP15 prices for all other regions.</p>	5.2
NatGas _{m-12,l}	Monthly average natural gas price from the previous year of region ‘l’, month ‘m’, and time of use “tou”.		<p>For example, when forecasting June 2016 prices, take the average daily natural gas price of June 2015 from region ‘l’ by time of use.</p> <p>Resources in PGE2 fuel region will use the PG&E Citygate prices. Resources in SCE1, SCE2, SDGE1, and SDGE2 will use SoCal city gas prices. All others will use the minimum of PG&E and SoCal citygate prices.</p>	5.2
GHGas _{m-12}	Average of daily greenhouse gas allowance price from the same month ‘m’ of last year	Index Price	<p>For example, when forecasting June 2016, take the average of daily greenhouse gas allowance prices from June 2015.</p>	5.2
RDTCostSU _{g,k}	Most recent fuel equivalent start-up cost for non-gas fired resources for	Master File		2.1a and 2.2a

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Input variable name	Description of variable	Data source	Comments/Examples	Equations using this variable ¹⁶
	segment 'g' for resource or MSG configuration 'k'.			
RDTCostML _k	Most recent fuel equivalent minimum load cost for non-gas fired resource or MSG configuration 'k'.	Master File		3.1 and 3.2
AvgCostF _{g,k}	Most recent fuel or fuel equivalent cost curve segment for non-gas fired resources for segment 'g' for resource or MSG configuration 'k'.	Master File		1.1 and 1.2
AvgHR _k	Fuel-equivalent Average Heat rate for the non-gas fired resource or MSG configuration 'k' with GHG compliance. This is needed to convert BTU to MWH.			1.2
MaxSTR _{k(w)}	Acceptable limitation on starts for the non-MSG resource or	Use-limitation plan data template		7.5



Input variable name	Description of variable	Data source	Comments/Examples	Equations using this variable ¹⁶
	MSG configuration 'k' or MSG plant 'w'			
MaxHRS _{k(w)}	Acceptable limitation on run-hours for the non-MSG resource or MSG configuration 'k' or MSG plant 'w'	Use-limitation plan data template		7.6
MaxMWH _{k(w)}	Acceptable limitation on output for the non-MSG resource or MSG configuration 'k' or MSG plant 'w'	Use-limitation plan data template		7.7
ActSTRT _{k(w)}	Actual starts incurred during the corresponding limitation horizon for the non-MSG resource or MSG configuration 'k' or MSG plant 'w'.	Settlement and market data	If an SC experiences a start not captured by settlement or market data, e.g., failed starts or testing, that start will be incorporated into the ActSTRT value if communicated to the ISO.	7.5
ActHRS _{k(w)}	Actual run hours incurred during the corresponding	Settlement and market data		7.6

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Input variable name	Description of variable	Data source	Comments/Examples	Equations using this variable ¹⁶
	limitation horizon for the non-MSG resource or MSG configuration 'k' or MSG plant 'w'.			
ActMWH _{k(w)}	Actual output during the corresponding limitation horizon for the non-MSG resource or MSG configuration 'k' or MSG plant 'w'.	Settlement and market data		7.7

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8. Appendix-3: ULPDT Template

	A	B	C	D	E	F	G	H	I	J	K	L
1	SC ID	Resource ID	Use Limit Type	Granularity	Effective Start Date	Effective End Date	Limitation Number	Minimum Capacity Level	Maximum Capacity Level	Documentation Name		
2	SC_ID	RES_ID	USE_LIMIT_TYPE	GRANULARITY	PLAN_STRT_DT_TM	PLAN_END_DT_TM	LIMITATION	MIN_USE_LIMIT	MAX_USE_LIMIT	DOC_NAME		
3	<i>SCID</i>	<i>Existing, active resource provisioned to the SC uploading the ULPDT</i>	<i>START, RUNHOURS, ENERGY, OTHER</i>	<i>DAILY, MONTHLY, ANNUALLY, OTHER</i>	<i>Date this use limitation becomes effective (MM/DD/YYYY)</i>	<i>Date this use limitation expires. This date must be provided. (MM/DD/YYYY)</i>	<i>The number or amount of the limitation for the granularity period (e.g. number of starts for the year)</i>	<i>Minimum capacity level for which the limitation applies (optional)</i>	<i>Maximum capacity level for which the limitation applies (optional)</i>	<i>Documentation name, page number, CIDI Ticket #</i>		
4												
5												
6												
7												
8												
9												
10												

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9. Appendix-4: Examples for Calculations of MSG SUC and TC Bid Caps

No opportunity cost				Start-up opportunity cost - with transitions					
Configuration start-up cost and bid caps				Configuration start-up cost and bid caps					
Config IDs	Configuration	Start-up Cost (SUC)	cost bid cap (Pre-CCE3) SUC x 125%	Config IDs	Config number	Start-up Cost (SUC)	Start-up cost bid cap (Pre-CCE3) SUC x 125%	Opp Cost	Start-up cost bid cap (Post-CCE3)
UnitA_1	1 - Startable	\$645	\$806	UnitA_1	1 - Startable	\$645	\$806	\$100	\$906
UnitA_2	2 - NOT startable	\$1,320	\$1,650	UnitA_2	2 - NOT startable	\$1,320	\$1,650	\$50	\$1,700
UnitA_3	3 - Startable	\$2,145	\$2,681	UnitA_3	3 - Startable	\$2,145	\$2,681	\$150	\$2,831
UnitA_4	4 - NOT startable	\$3,020	\$3,775	UnitA_4	4 - NOT startable	\$3,020	\$3,775	\$75	\$3,850
Transition costs				Transition costs					
"From" Configuration	"To" configuration				"From" Configuration	"To" configuration			
	UnitA_1	UnitA_2	UnitA_3	UnitA_4		UnitA_1	UnitA_2	UnitA_3	UnitA_4
UnitA_1		\$675	\$1,500	\$2,375	UnitA_1		\$675	\$1,500	\$2,375
UnitA_2			\$825	n/a	UnitA_2			\$825	n/a
UnitA_3				\$875	UnitA_3				\$875
UnitA_4					UnitA_4				
Transition cost bid caps (pre-CCE3: no opportunity cost)				Transition opportunity costs					
"From" Configuration	"To" configuration				"From" Configuration	"To" configuration			
	UnitA_1	UnitA_2	UnitA_3	UnitA_4		UnitA_1	UnitA_2	UnitA_3	UnitA_4
UnitA_1		\$844	\$1,875	\$2,969	UnitA_1		\$50	\$150	\$75
UnitA_2			\$1,031	n/a	UnitA_2			\$150	n/a
UnitA_3				\$1,094	UnitA_3				\$75
UnitA_4					UnitA_4				
Transition cost bid caps (pre-CCE3: without opportunity cost)				Transition cost bid caps (Post-CCE3: with opportunity cost)					
"From" Configuration	"To" configuration				"From" Configuration	"To" configuration			
	UnitA_1	UnitA_2	UnitA_3	UnitA_4		UnitA_1	UnitA_2	UnitA_3	UnitA_4
UnitA_1		\$844	\$1,875	\$2,969	UnitA_1		\$894	\$2,025	\$3,044
UnitA_2			\$1,031	n/a	UnitA_2			\$1,181	n/a
UnitA_3				\$1,094	UnitA_3				\$1,169
UnitA_4					UnitA_4				

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10. Appendix-5: Resource Adequacy Table for Base Ramping Qualification

	Base Ramping ^[1]	Peak Ramping ^[2]	Super-Peak Ramping ^[3]
Capable of DAM and RTM Economic Bidding	5:00 a.m. – 10 p.m.	Five hour block determined seasonally ^[4]	Five hour block determined seasonally ^[5]
Energy Requirement	Minimum 6 hours at EFC	Minimum 3 hours at EFC	Minimum 3 hours at EFC
Daily Availability	7 days per week, all days per month	7 days per week, all days per month	All non-holiday weekdays per month
Daily Start-Up Capability	The resource must be able to provide the minimum of (i) two Start-Ups per day for every day of the month or sixty Start-Ups per month, or (ii) the number of Start-Ups allowed by its operational limits, including minimum up and minimum down time	At least one start per day	At least one start per day
Other Limitations	No monthly or annual limitations on number of starts or energy limits that translate to less than the daily requirements	No monthly or annual limitations on number of starts or energy limits that translate to less than the daily requirements	Must be capable of responding to at least 5 dispatches per month during the five-hour period of the must offer obligation

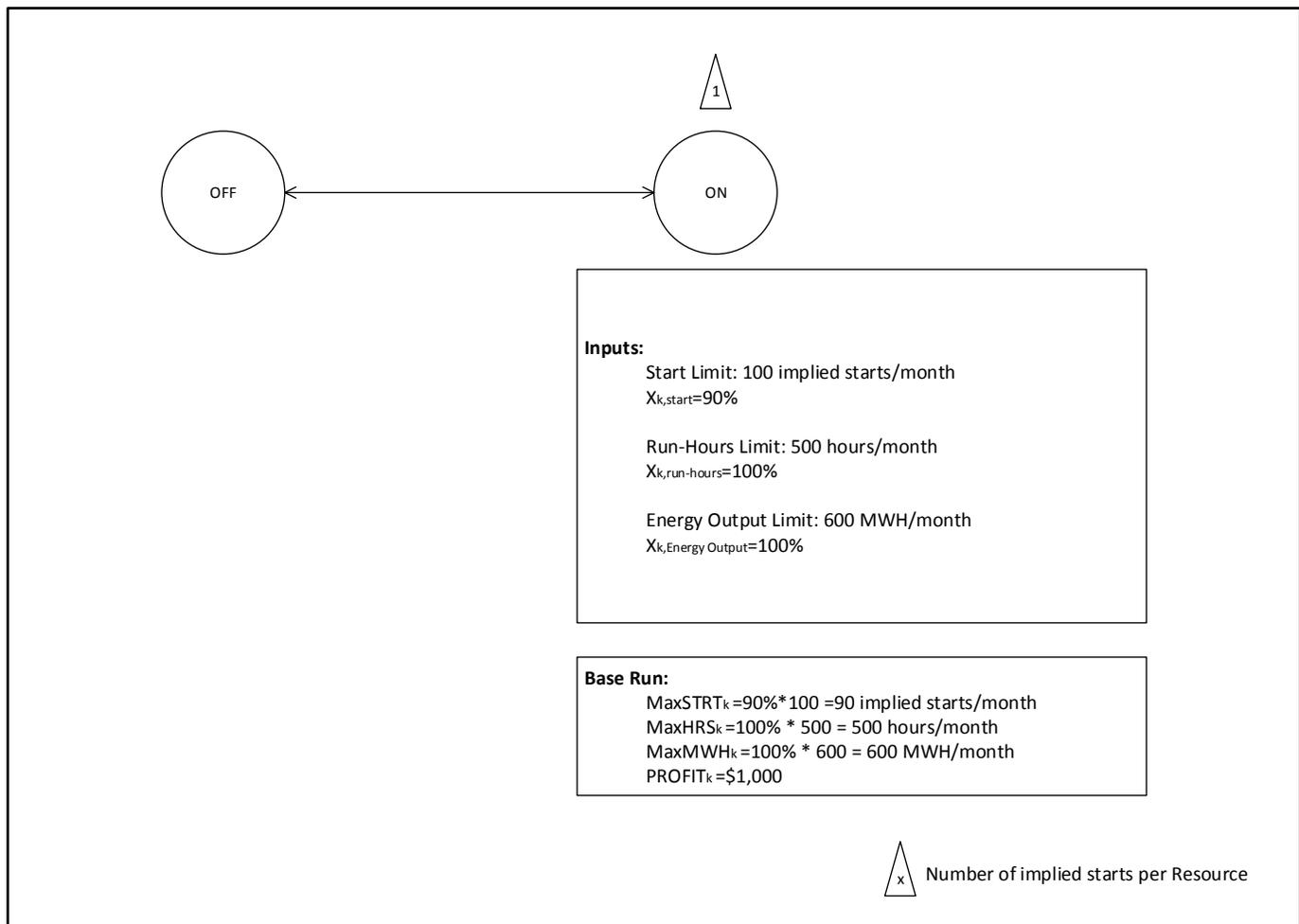
^[1] For a complete list of Base Ramping qualifications, please refer to ISO Tariff Section 40.10.3.2

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11. Appendix-6: Opportunity Cost Numerical Example for Non-MSG Resource

Note: In this example, all use-limitations are assumed to be of same granularity (for example: monthly).

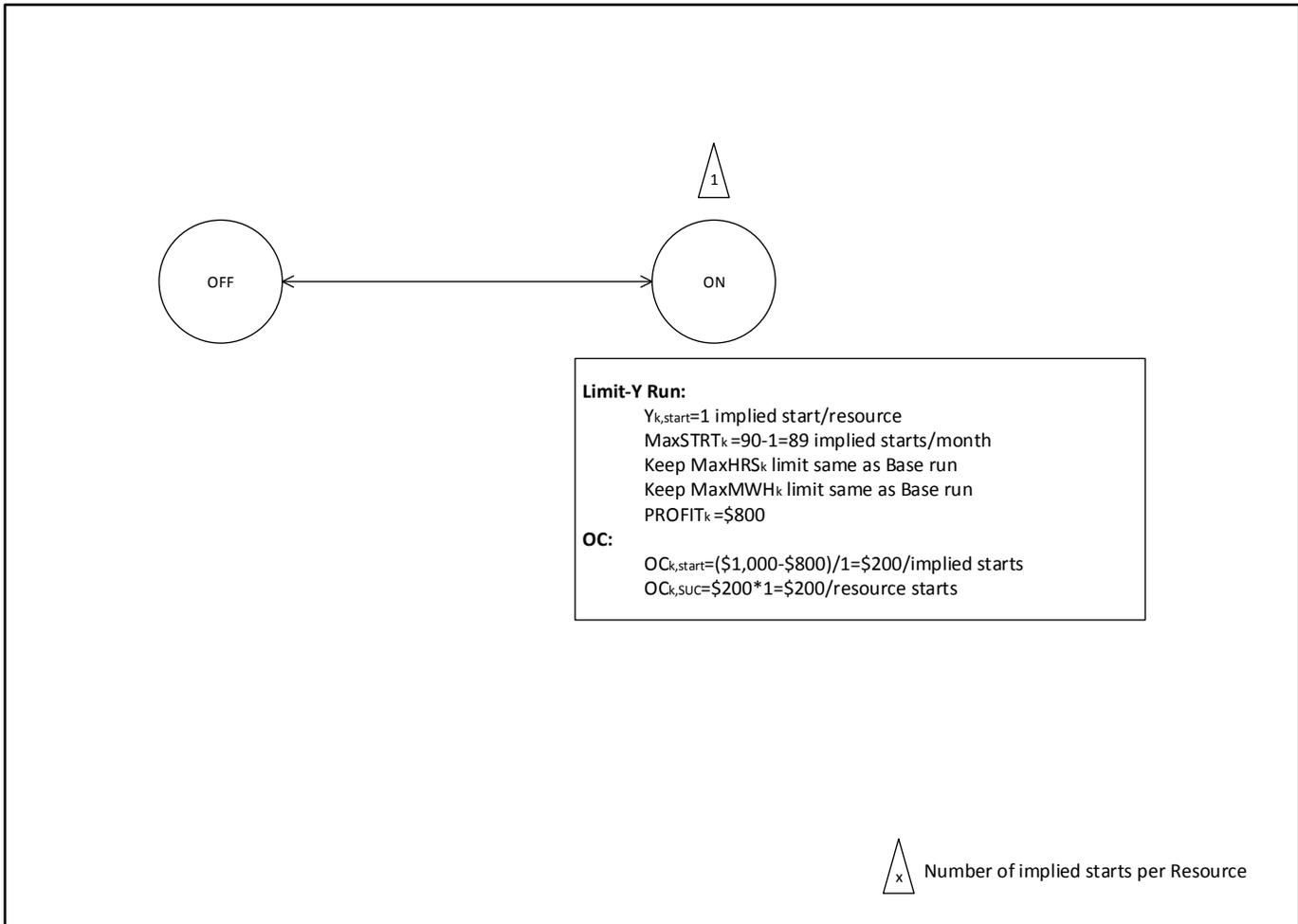
11.1 Base Case (B-Run):



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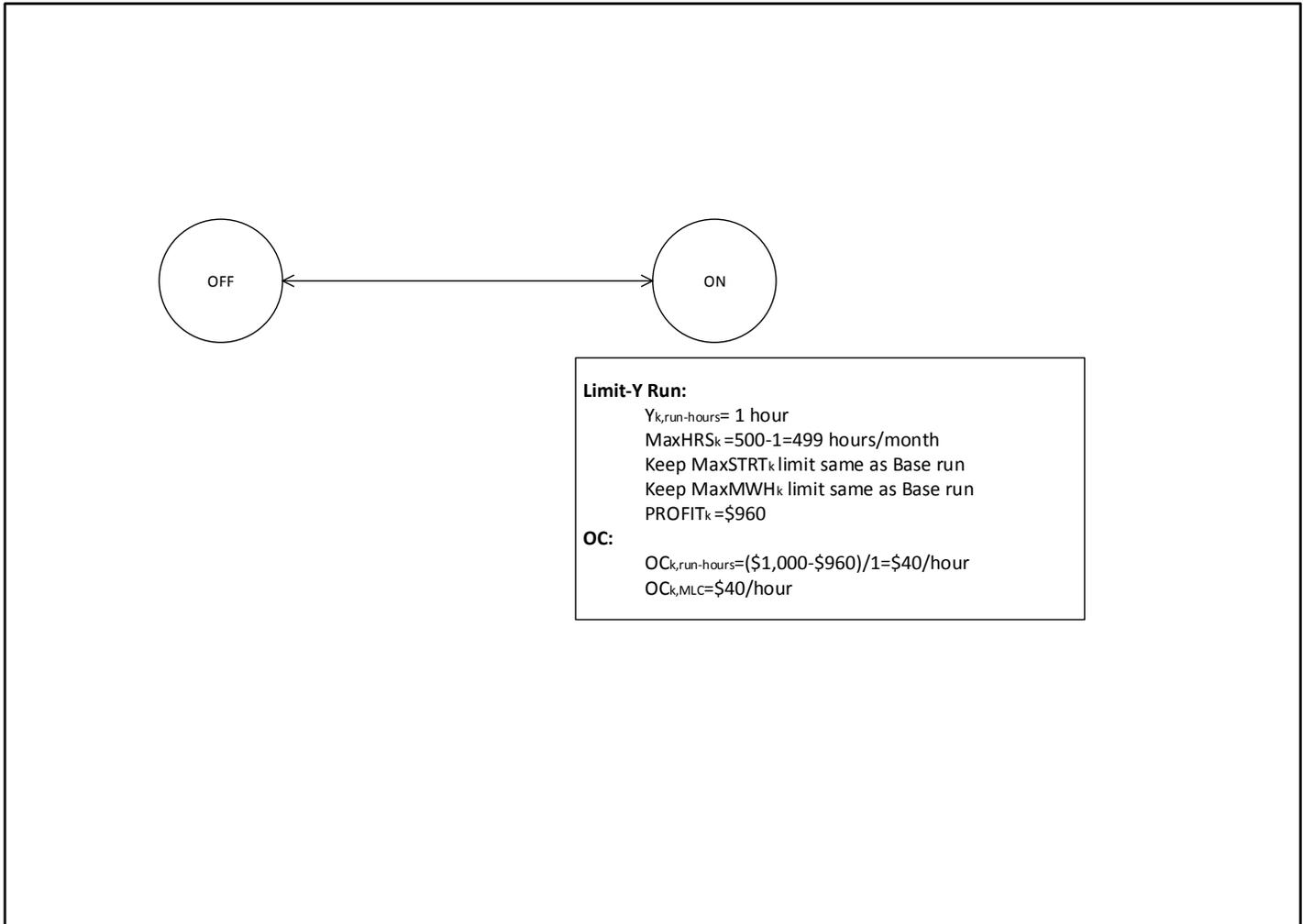
11.2 Limit-Y (L) Run (with Option-1: All Y=1)

11.2.1 Limit-Y (L-Run) for Start Limitation:



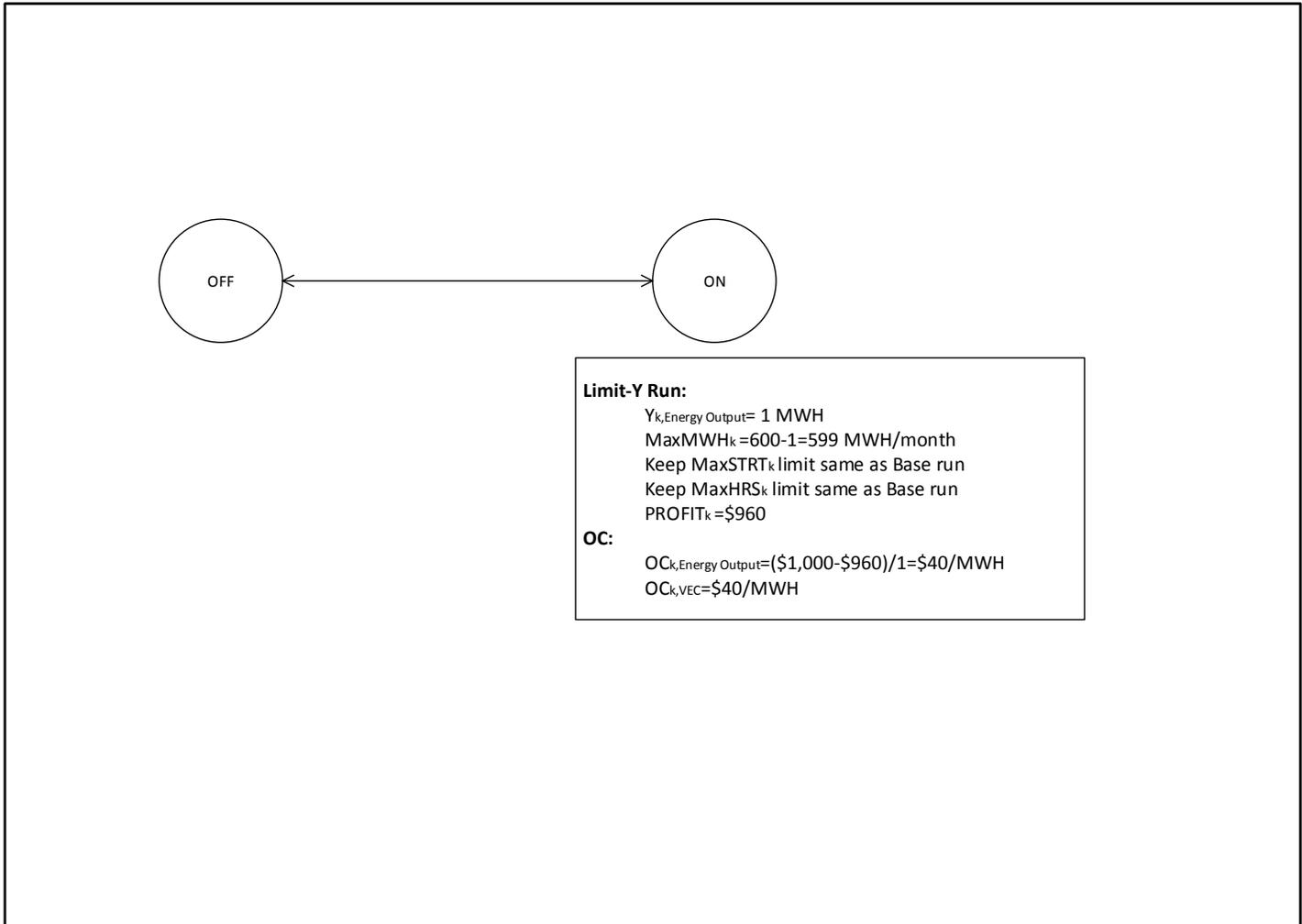
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11.2.2 Limit-Y (L-Run) for Run-Hours Limitation:



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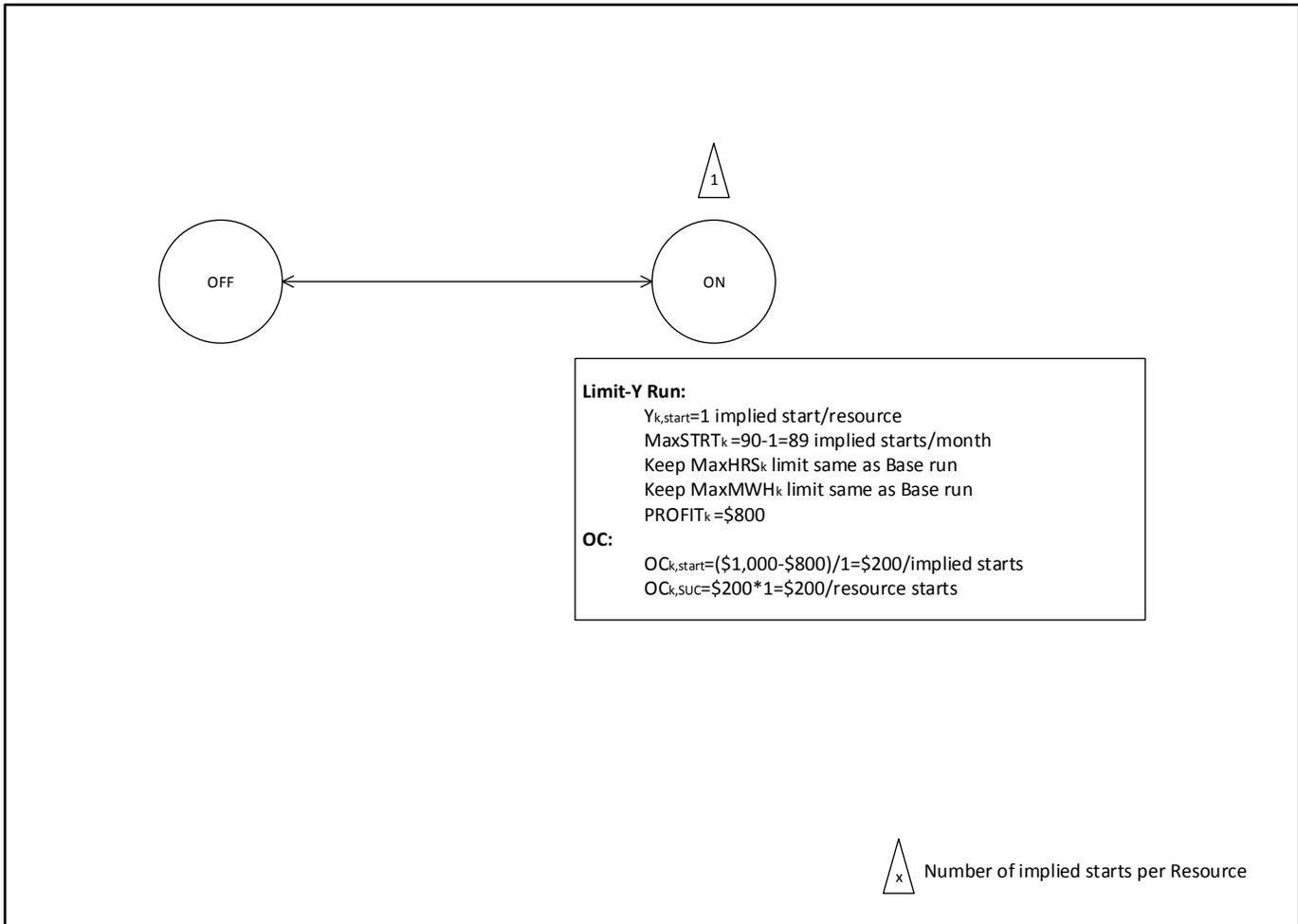
11.2.3 Limit-Y (L-Run) for Energy Output Limitation:



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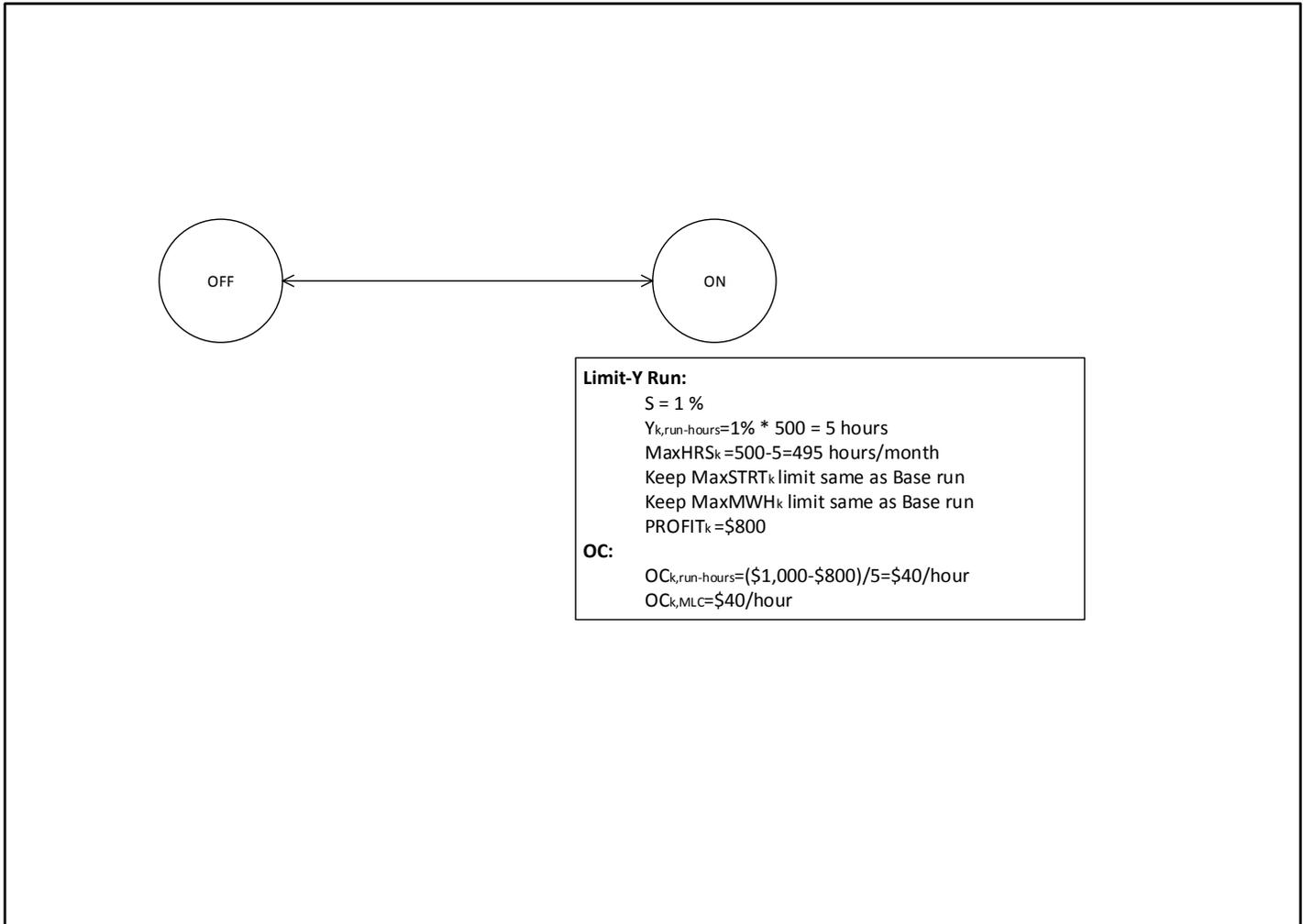
11.3 Limit-Y (L) Run (with Option-2: S=1%, U=1%)

11.3.1 Limit-Y (L-Run) for Start Limitation:



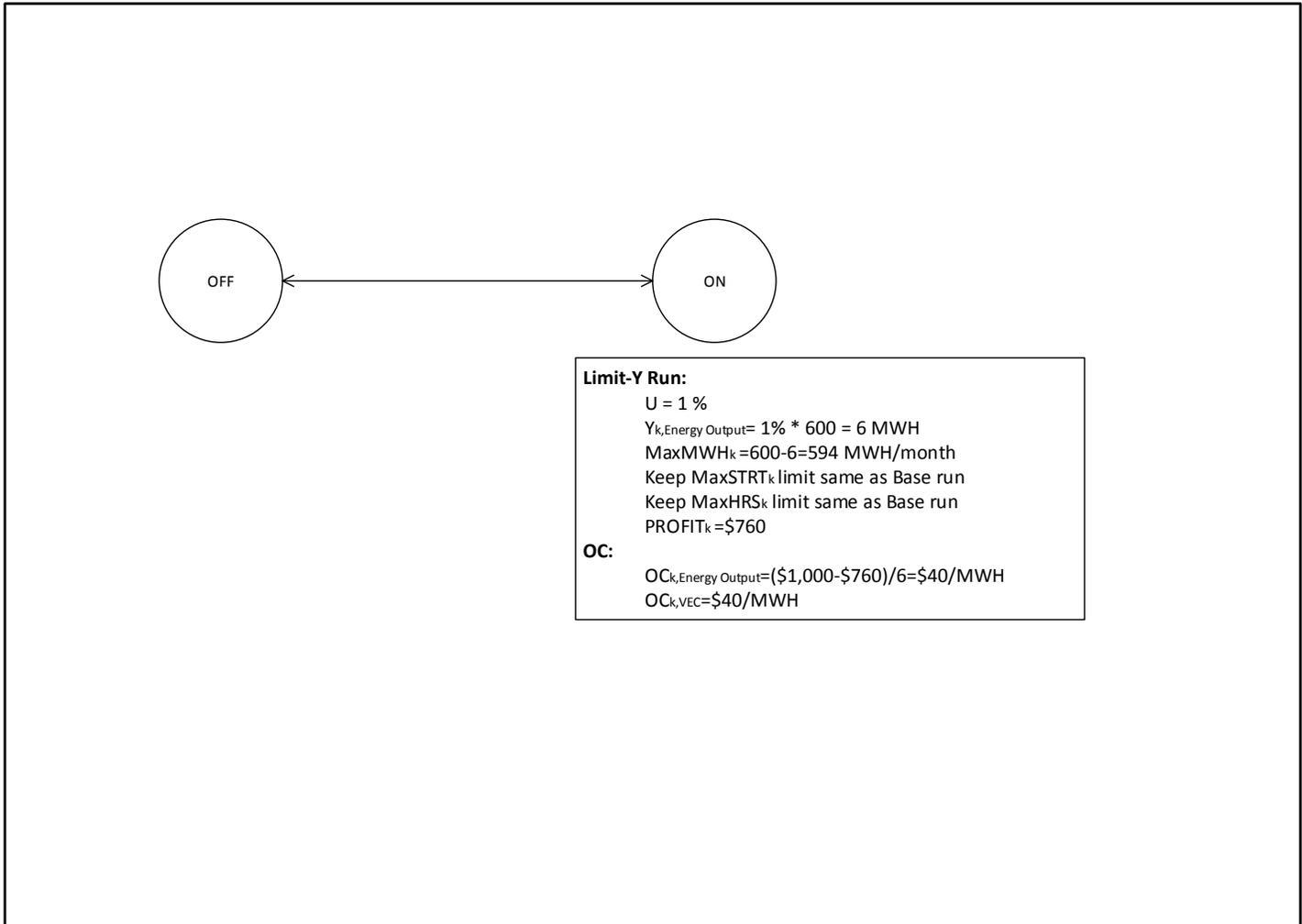
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11.3.2 Limit-Y (L-Run) for Run-Hours Limitation:



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11.3.3 Limit-Y (L-Run) for Energy Output Limitation:



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12. Appendix-7: Opportunity Cost Numerical Example for MSG Resource

Note: In this example, all use-limitations are assumed to be of same granularity (for example: monthly).



12.1 Base Case (B-Run):

Plant

Inputs:

- Start Limit: 900 implied starts/month
- Number of implied starts per Plant = 1 implied start
- $X_{w,start}=90\%$
- Run-Hours Limit: 900 hours/month
- $X_{w,run-hours}=100\%$
- Energy Output Limit: 900 MWH/month
- $X_{w,Energy-Output}=100\%$

Base Run Constraints for this Plant:

- $MaxSTRT_w=90\% * 900 = 810$ implied starts/month
- $MaxHRs_w=100\% * 900 = 900$ hours/month
- $MaxMWH_w=100\% * 900 = 900$ MWH/month

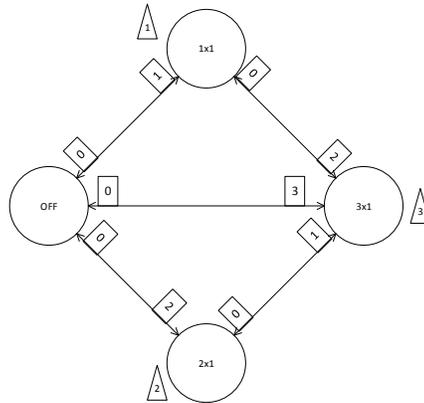
1x1

Inputs:

- Start Limit: 100 implied starts/month
- $X_{u,start}=90\%$
- Run-Hours Limit: 500 hours/month
- $X_{u,run-hours}=100\%$
- Energy Output Limit: 500 MWH/month
- $X_{u,Energy-Output}=100\%$

Base Run Constraints for this Configuration:

- $MaxSTRT_k=90\% * 100 = 90$ implied start/month
- $MaxHRs_k=100\% * 500 = 500$ hours/month
- $MaxMWH_k=100\% * 500 = 500$ MWH/month



3x1

Inputs:

- Start Limit: 300 implied starts/month
- $X_{u,start}=90\%$
- Run-Hours Limit: 300 hours/month
- $X_{u,run-hours}=100\%$
- Energy Output Limit: 300 MWH/month
- $X_{u,Energy-Output}=100\%$

Base Run Constraints for this Configuration:

- $MaxSTRT_k=90\% * 300 = 270$ implied start/month
- $MaxHRs_k=100\% * 300 = 300$ hours/month
- $MaxMWH_k=100\% * 300 = 300$ MWH/month

2x1

Inputs:

- Start Limit: 200 implied starts/month
- $X_{u,start}=90\%$
- Run-Hours Limit: 400 hours/month
- $X_{u,run-hours}=100\%$
- Energy Output Limit: 400 MW/month
- $X_{u,Energy-Output}=100\%$

Base Run Constraints for this Configuration:

- $MaxSTRT_k=90\% * 200 = 180$ implied start/month
- $MaxHRs_k=100\% * 400 = 400$ hours/month
- $MaxMWH_k=100\% * 400 = 400$ MWH/month



Base Run for Entire Plant & All Configurations

Base Run (for entire plant):

- Use $MaxSTRT_{(w)}$ limits of plant and all configs
- Use $MaxHRs_{(w)}$ limits of plant and all configs
- Use $MaxMWH_{(w)}$ limits of plant and all configs
- Run model
- $PROFIT_w=\$3,000$ (entire plant)

Note: there is only one Base run and profit for the entire plant

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12.2 Limit-Y (L) Runs (with Option-1: All Y=1):

12.2.1 Limit-Y (L-Runs) for Start Limitations:

Plant

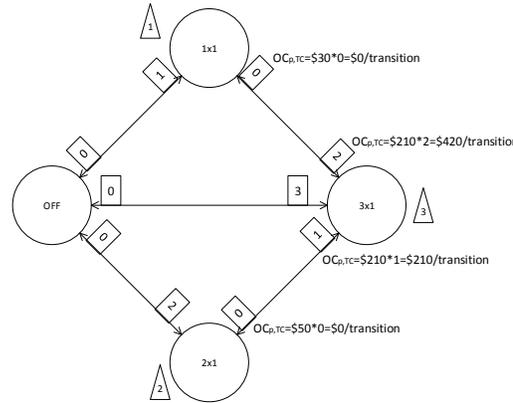
Limit-Y Run:
 $Y_{w,start} = 1$ implied start
 $MaxSTR_{Tw} = 810-1=809$ implied starts/month
 Keep $MaxSTR_{k(w)}$ limits of all configs same as Base
 Keep $MaxHR_{k(w)}$ limits of plant and all configs same as Base
 Keep $MaxMWH_{k(w)}$ limits of plant and all configs same as Base
 Run model
 $PROFIT_w = \$2990$ (entire plant)

OC:
 $OC_{w,start} = (\$3,000-\$2990)/1 = \$10$ /implied start

1x1

Limit-Y Run:
 $Y_{w,start} = 1$ implied start
 $MaxSTR_{Tw} = 90-1=89$ implied starts/month
 Keep $MaxSTR_{k(w)}$ limits of plant and other configs same as Base
 Keep $MaxHR_{k(w)}$ limits of plant and all configs same as Base
 Keep $MaxMWH_{k(w)}$ limits of plant and all configs same as Base
 Run model
 $PROFIT_w = \$2980$ (entire plant)

OC:
 $OC_{k,start} = (\$3,000-\$2980)/1 = \$20$ /implied start
 $OC_{(new)k,start} = \$20+\$10 = \$30$ /implied start
 $OC_{k,suc} = \$30*1 = \30 /config start



3x1

Limit-Y Run:
 $Y_{w,start} = 1$ implied start
 $MaxSTR_{Tw} = 270-1=269$ implied starts/month
 Keep $MaxSTR_{k(w)}$ limits of plant and other configs same as Base
 Keep $MaxHR_{k(w)}$ limits of plant and all configs same as Base
 Keep $MaxMWH_{k(w)}$ limits of plant and all configs same as Base
 Run model
 $PROFIT_w = \$2800$ (entire plant)

OC:
 $OC_{k,start} = (\$3,000-\$2800)/1 = \$200$ /implied start
 $OC_{(new)k,start} = \$200+\$10 = \$210$ /implied start
 $OC_{k,suc} = \$210*3 = \630 /config start

2x1

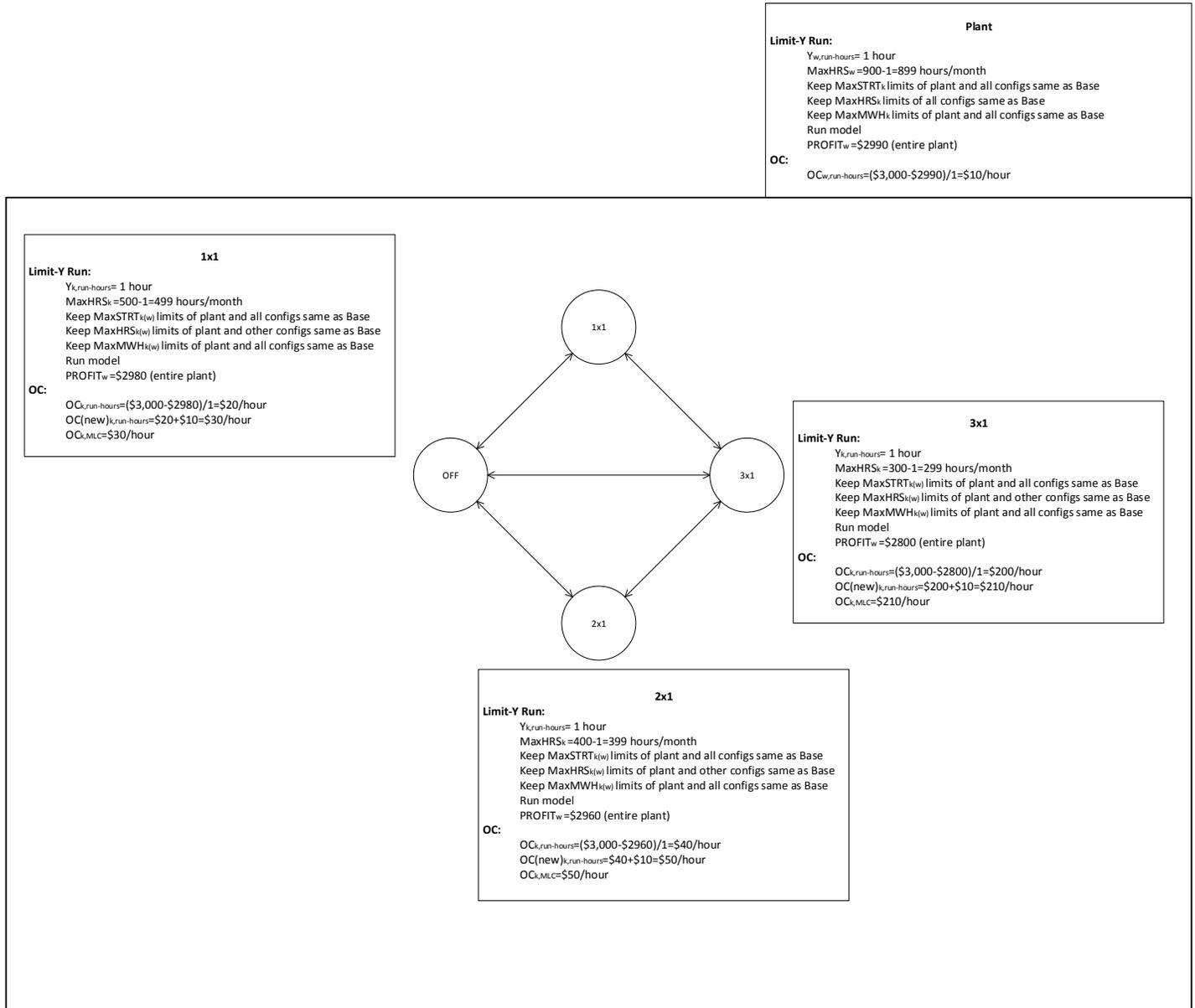
Limit-Y Run:
 $Y_{w,start} = 1$ implied start
 $MaxSTR_{Tw} = 180-1=179$ implied starts/month
 Keep $MaxSTR_{k(w)}$ limits of plant and other configs same as Base
 Keep $MaxHR_{k(w)}$ limits of plant and all configs same as Base
 Keep $MaxMWH_{k(w)}$ limits of plant and all configs same as Base
 Run model
 $PROFIT_w = \$2960$ (entire plant)

OC:
 $OC_{k,start} = (\$3,000-\$2960)/1 = \$40$ /implied start
 $OC_{(new)k,start} = \$40+\$10 = \$50$ /implied start
 $OC_{k,suc} = \$50*2 = \100 /config start

 Number of implied starts per configuration
 Number of implied starts per transition

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12.2.2 Limit-Y (L-Runs) for Run-Hours Limitations:



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12.2.3 Limit-Y (L-Runs) for Energy Output Limitations:

Plant

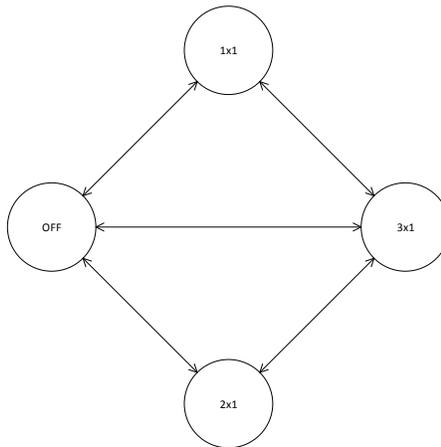
Limit-Y Run:
 $Y_{k,Energy-Output} = 1 \text{ MWH}$
 $MaxMWH_k = 900-1 = 899 \text{ MWH/month}$
 Keep $MaxSTRT_{k(w)}$ limits of plant and all configs same as Base
 Keep $MaxHRS_{k(w)}$ limits of plant and all configs same as Base
 Keep $MaxMWH_{k(w)}$ limits all configs same as Base
 $PROFIT_w = \$2990$ (entire plant)

OC:
 $OC_{w,Energy-Output} = (\$3,000 - \$2990) / 1 = \$10/\text{hour}$

1x1

Limit-Y Run:
 $Y_{k,Energy-Output} = 1 \text{ MWH}$
 $MaxMWH_k = 500-1 = 499 \text{ MWH/month}$
 Keep $MaxSTRT_{k(w)}$ limits of plant and all configs same as Base
 Keep $MaxHRS_{k(w)}$ limits of plant and all configs same as Base
 Keep $MaxMWH_{k(w)}$ limits of plant and other configs same as Base
 $PROFIT_w = \$2980$ (entire plant)

OC:
 $OC_{k,Energy-Output} = (\$3,000 - \$2980) / 1 = \$20/\text{MWH}$
 $OC(new)_{k,Energy-Output} = \$20 + \$10 = \$30/\text{MWH}$
 $OC_{k,VEC} = \$30/\text{MWH}$



3x1

Limit-Y Run:
 $Y_{k,Energy-Output} = 1 \text{ MWH}$
 $MaxMWH_k = 300-1 = 299 \text{ MWH/month}$
 Keep $MaxSTRT_{k(w)}$ limits of plant and all configs same as Base
 Keep $MaxHRS_{k(w)}$ limits of plant and all configs same as Base
 Keep $MaxMWH_{k(w)}$ limits of plant and other configs same as Base
 $PROFIT_w = \$2800$ (entire plant)

OC:
 $OC_{k,Energy-Output} = (\$3,000 - \$2800) / 1 = \$200/\text{MWH}$
 $OC(new)_{k,Energy-Output} = \$200 + \$10 = \$210/\text{MWH}$
 $OC_{k,VEC} = \$210/\text{MWH}$

2x1

Limit-Y Run:
 $Y_{k,Energy-Output} = 1 \text{ MWH}$
 $MaxMWH_k = 400-1 = 399 \text{ MWH/month}$
 Keep $MaxSTRT_{k(w)}$ limits of plant and all configs same as Base
 Keep $MaxHRS_{k(w)}$ limits of plant and all configs same as Base
 Keep $MaxMWH_{k(w)}$ limits of plant and other configs same as

Base
 $PROFIT_w = \$2960$ (entire plant)

OC:
 $OC_{k,Energy-Output} = (\$3,000 - \$2960) / 1 = \$40/\text{MWH}$
 $OC(new)_{k,Energy-Output} = \$40 + \$10 = \$50/\text{MWH}$
 $OC_{k,VEC} = \$50/\text{MWH}$

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12.3 Limit-Y (L) Runs (with Option-2: S=1%, U=1%):

12.3.1 Limit-Y (L-Runs) for Start Limitations:

Plant

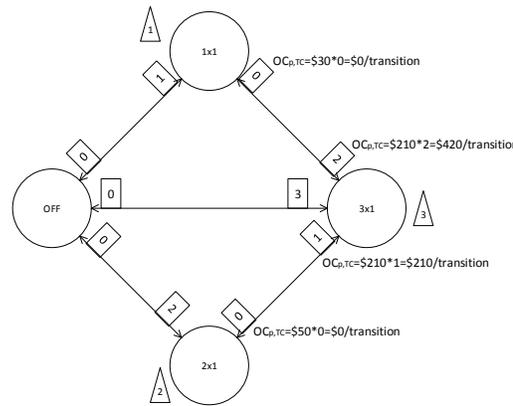
Limit-Y Run:
 Number of implied starts per Plant = Max (1,2,3)=3 implied start
 $Y_{k,start} = 3$ implied starts
 $MaxSTRTx = 810-3=807$ implied starts/month
 Keep $MaxSTRTx_{(kw)}$ limits of all configs same as Base
 Keep $MaxHRSk_{(kw)}$ limits of plant and all configs same as Base
 Keep $MaxMWHk_{(kw)}$ limits of plant and all configs same as Base
 Run model
 $PROFIT_w = \$2970$ (entire plant)

OC:
 $OC_{k,start} = (\$3,000-\$2970)/3 = \$10/\text{implied start}$

1x1

Limit-Y Run:
 $Y_{k,start} = 1$ implied start
 $MaxSTRTx = 90-1=89$ implied starts/month
 Keep $MaxSTRTx_{(kw)}$ limits of plant and other configs same as Base
 Keep $MaxHRSk_{(kw)}$ limits of plant and all configs same as Base
 Keep $MaxMWHk_{(kw)}$ limits of plant and all configs same as Base
 Run model
 $PROFIT_w = \$2980$ (entire plant)

OC:
 $OC_{k,start} = (\$3,000-\$2980)/1 = \$20/\text{implied start}$
 $OC(new)_{k,start} = \$20 + \$10 = \$30/\text{implied start}$
 $OC_{k,suc} = \$30 * 1 = \$30/\text{config start}$



3x1

Limit-Y Run:
 $Y_{k,start} = 3$ implied start
 $MaxSTRTx = 270-3=267$ implied starts/month
 Keep $MaxSTRTx_{(kw)}$ limits of plant and other configs same as Base
 Keep $MaxHRSk_{(kw)}$ limits of plant and all configs same as Base
 Keep $MaxMWHk_{(kw)}$ limits of plant and all configs same as Base
 Run model
 $PROFIT_w = \$2400$ (entire plant)

OC:
 $OC_{k,start} = (\$3,000-\$2400)/3 = \$200/\text{implied start}$
 $OC(new)_{k,start} = \$200 + \$10 = \$210/\text{implied start}$
 $OC_{k,suc} = \$210 * 3 = \$630/\text{config start}$

2x1

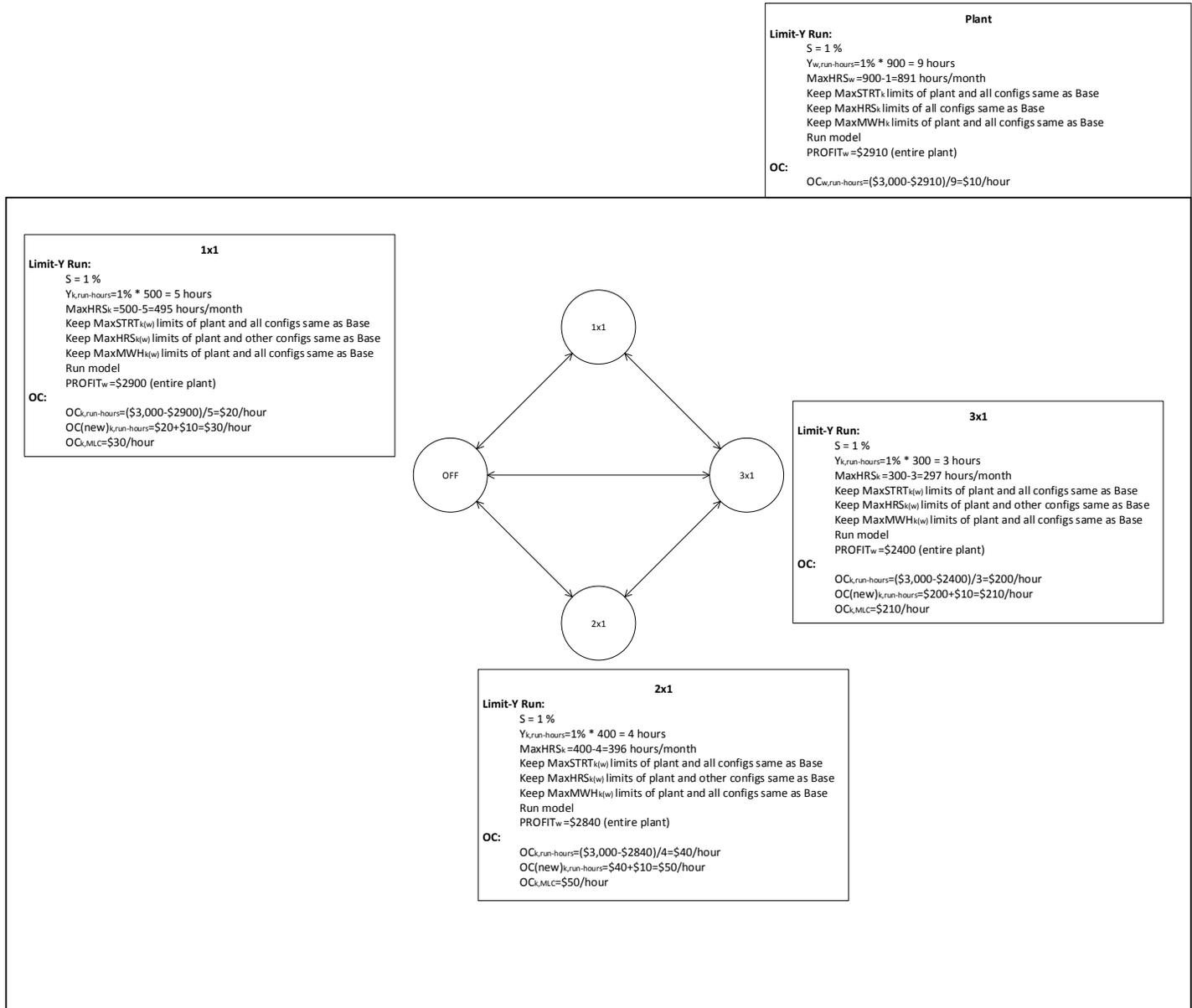
Limit-Y Run:
 $Y_{k,start} = 2$ implied start
 $MaxSTRTx = 180-2=178$ implied starts/month
 Keep $MaxSTRTx_{(kw)}$ limits of plant and other configs same as Base
 Keep $MaxHRSk_{(kw)}$ limits of plant and all configs same as Base
 Keep $MaxMWHk_{(kw)}$ limits of plant and all configs same as Base
 Run model
 $PROFIT_w = \$2920$ (entire plant)

OC:
 $OC_{k,start} = (\$3,000-\$2920)/2 = \$40/\text{implied start}$
 $OC(new)_{k,start} = \$40 + \$10 = \$50/\text{implied start}$
 $OC_{k,suc} = \$50 * 2 = \$100/\text{config start}$

 Number of implied starts per configuration
 Number of implied starts per transition

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12.3.2 Limit-Y (L-Runs) for Run-Hours Limitations:



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12.3.3 Limit-Y (L-Runs) for Energy Output Limitations:

Plant

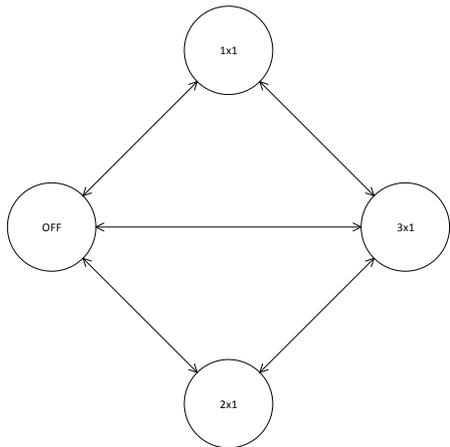
Limit-Y Run:
 U = 1 %
 $Y_{k,Energy-Output} = 1\% * 900 = 9 \text{ MWH}$
 $MaxMWH_k = 900 - 9 = 891 \text{ MWH/month}$
 Keep MaxSTRT_k limits of plant and all configs same as Base
 Keep MaxHRS_k limits of plant and all configs same as Base
 Keep MaxMWH_k limits all configs same as Base
 PROFIT_w = \$2910 (entire plant)

OC:
 $OC_{k,Energy-Output} = (\$3,000 - \$2910) / 9 = \$10/\text{hour}$

1x1

Limit-Y Run:
 U = 1 %
 $Y_{k,Energy-Output} = 1\% * 500 = 5 \text{ MWH}$
 $MaxMWH_k = 500 - 5 = 495 \text{ MWH/month}$
 Keep MaxSTRT_{k(w)} limits of plant and all configs same as Base
 Keep MaxHRS_{k(w)} limits of plant and all configs same as Base
 Keep MaxMWH_{k(w)} limits of plant and other configs same as Base
 PROFIT_w = \$2900 (entire plant)

OC:
 $OC_{k,Energy-Output} = (\$3,000 - \$2900) / 5 = \$20/\text{MWH}$
 $OC(\text{new})_{k,Energy-Output} = \$20 + \$10 = \$30/\text{MWH}$
 $OC_{k,VEC} = \$30/\text{MWH}$



3x1

Limit-Y Run:
 U = 1 %
 $Y_{k,Energy-Output} = 1\% * 300 = 3 \text{ MWH}$
 $MaxMWH_k = 300 - 3 = 297 \text{ MWH/month}$
 Keep MaxSTRT_{k(w)} limits of plant and all configs same as Base
 Keep MaxHRS_{k(w)} limits of plant and all configs same as Base
 Keep MaxMWH_{k(w)} limits of plant and other configs same as Base
 PROFIT_w = \$2400 (entire plant)

OC:
 $OC_{k,Energy-Output} = (\$3,000 - \$2400) / 3 = \$200/\text{MWH}$
 $OC(\text{new})_{k,Energy-Output} = \$200 + \$10 = \$210/\text{MWH}$
 $OC_{k,VEC} = \$210/\text{MWH}$

2x1

Limit-Y Run:
 U = 1 %
 $Y_{k,Energy-Output} = 1\% * 400 = 4 \text{ MWH}$
 $MaxMWH_k = 400 - 4 = 396 \text{ MWH/month}$
 Keep MaxSTRT_{k(w)} limits of plant and all configs same as Base
 Keep MaxHRS_{k(w)} limits of plant and all configs same as Base
 Keep MaxMWH_{k(w)} limits of plant and other configs same as

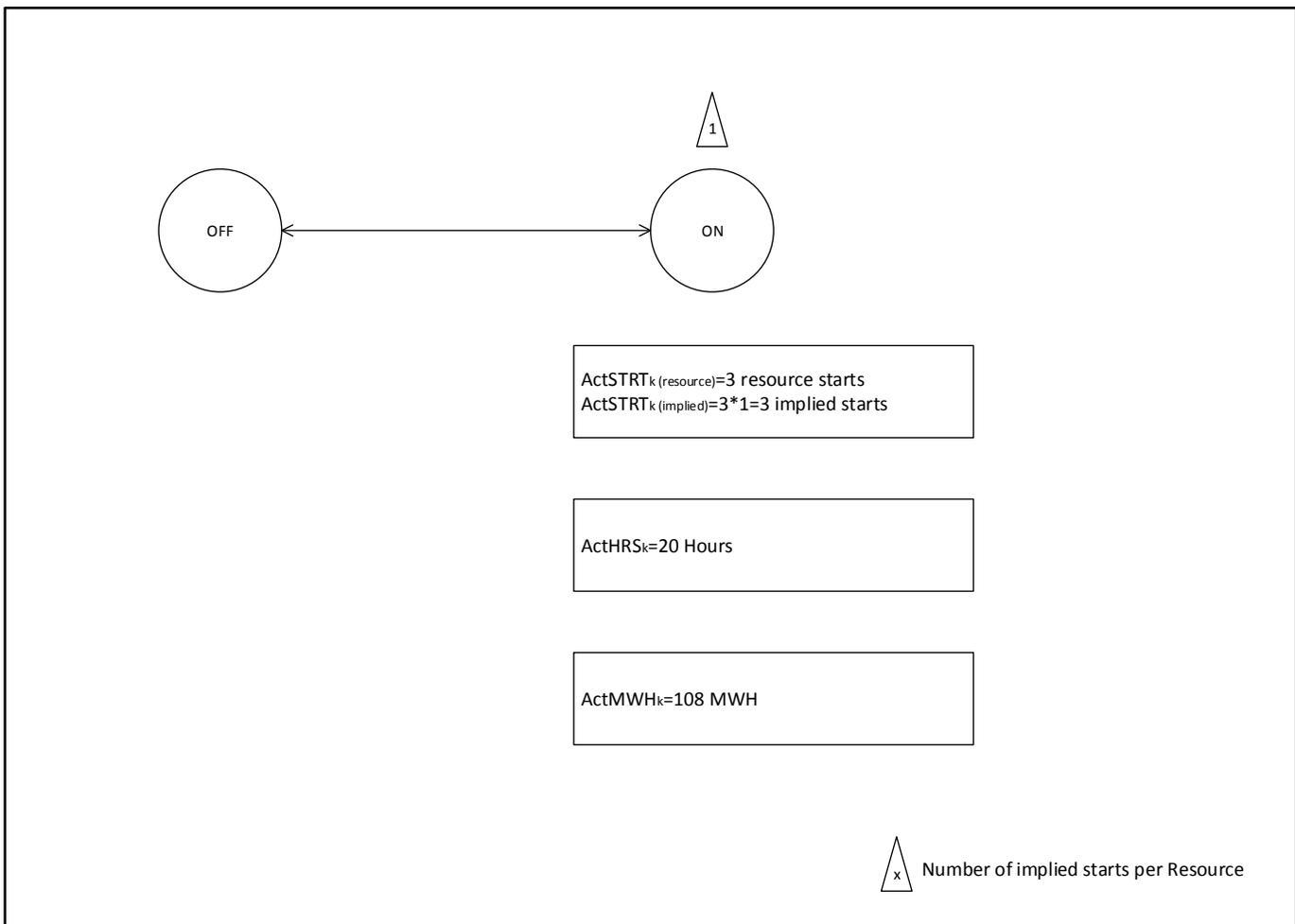
Base
 PROFIT_w = \$2840 (entire plant)

OC:
 $OC_{k,Energy-Output} = (\$3,000 - \$2840) / 4 = \$40/\text{MWH}$
 $OC(\text{new})_{k,Energy-Output} = \$40 + \$10 = \$50/\text{MWH}$
 $OC_{k,VEC} = \$50/\text{MWH}$

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13. Appendix-8: Actual (Scheduled) Usage Numerical Example for Non-MSG Resource

Note: In this example, all usage are daily values (calculated by MQS). OCC will aggregate daily values to produce monthly values by summing daily values within each calendar month.



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13.1 Accruing Example for ActSTRT, ActHRS

Note: In this example, all usage are daily values (calculated by MQS). OCC will aggregate daily values to produce monthly values by summing daily values within each calendar month.

Date/Time	RT Commitment Status	No. of Startups	Run Hours
05/18/2017 00:00	OFF		
05/18/2017 01:15	ON	1	5
05/18/2017 06:15	OFF		
05/18/2017 08:00	ON	1	14.25
05/18/2017 22:15	OFF		
05/18/2017 23:00	ON	1	0.75
05/18/2017 23:45	OFF		
Accrued No		3	20

No. of Implied Starts per resource	ActSTRT _{resource}	ActSTRT _{implied}
A	B	$C=A*B$
1	3	3

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13.2 Accruing Example for ActMWH

For 1 hour of data:

Date/Time	Total Expected Energy (TEE)
5/18/2017 0:00	0
5/18/2017 0:05	0
5/18/2017 0:10	0
5/18/2017 0:15	0.1
5/18/2017 0:20	0.2
5/18/2017 0:25	0.3
5/18/2017 0:30	0.7
5/18/2017 0:35	0.8
5/18/2017 0:40	0.9
5/18/2017 0:45	0.6
5/18/2017 0:50	0.5
5/18/2017 0:55	0.4
Accrued ActMWH	4.5

In this example, assuming the above pattern repeats for every hour during that day:

Date/Time	Total Expected Energy (TEE)
Accrued ActMWH	108

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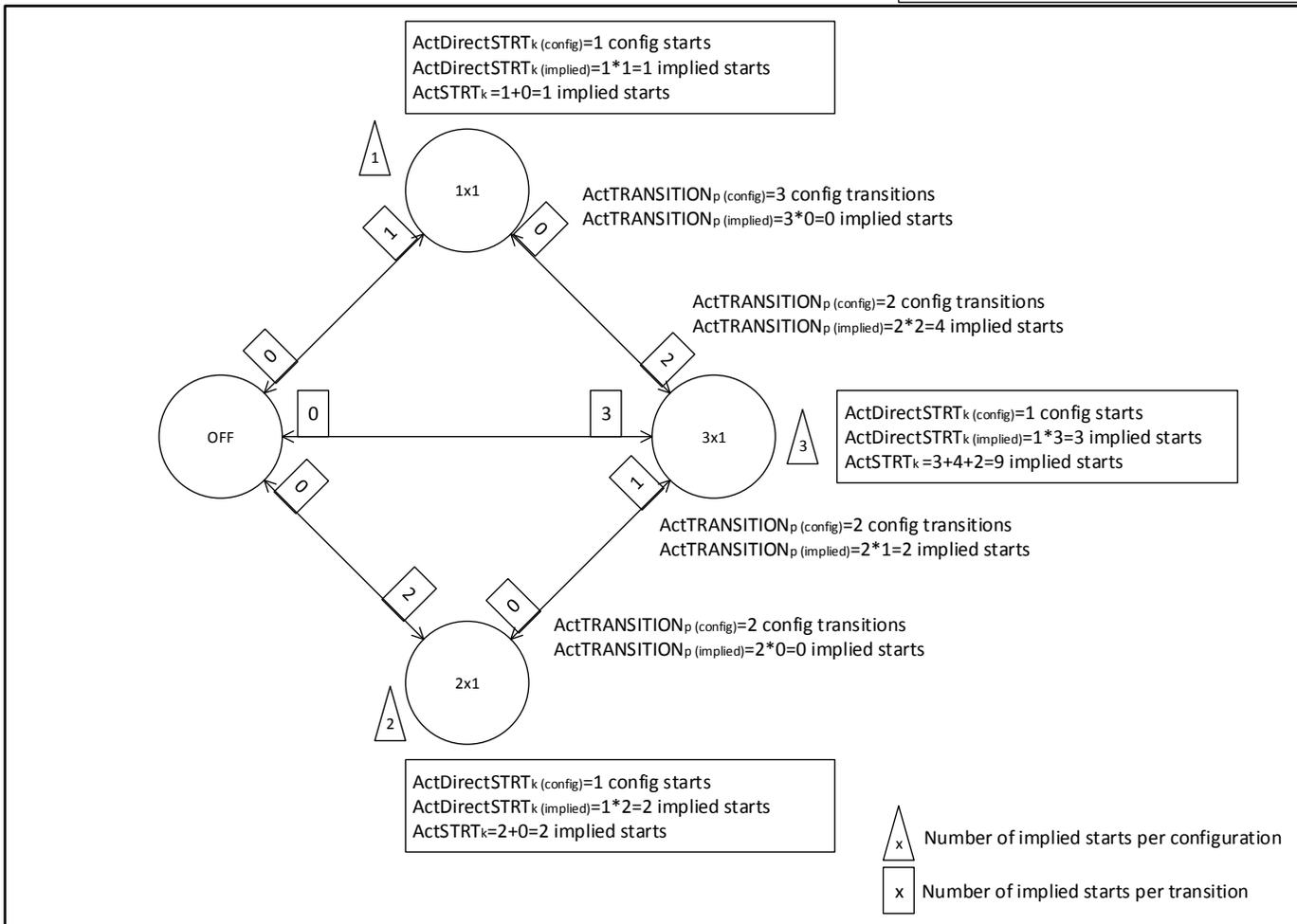


14. Appendix-9: Actual (Scheduled) Usage Numerical Example for MSG Resource

14.1 Actual (Scheduled) Usage for Implied Starts (ActSTRT)

Note: In this example, all usage are daily values (calculated by MQS). OCC will aggregate daily values to produce monthly values by summing daily values within each calendar month.

$ActSTRT_w = (1+2+9) = 12$ implied starts





Date/Time	RT Active Configuration	No. of Direct Startups (Config)			No. of Transitions (Config)			
		1X1	2X1	3X1	1X1-3X1	3X1-1X1	2X1-3X1	3X1-2X1
05/18/2017 00:00	OFF							
05/18/2017 01:15	1X1	1						
05/18/2017 03:00	3X1				1			
05/18/2017 05:30	2X1							1
05/18/2017 06:15	OFF							
05/18/2017 08:00	2X1		1					
05/18/2017 10:30	3X1						1	
05/18/2017 13:00	1X1					1		
05/18/2017 14:15	3X1				1			
05/18/2017 16:45	2X1							1
05/18/2017 18:00	3X1						1	
05/18/2017 21:30	1X1					1		
05/18/2017 22:15	OFF							
05/18/2017 23:00	3X1			1				
05/18/2017 23:15	1X1					1		
05/18/2017 23:45	OFF							
Accrued No		1	1	1	2	3	2	2



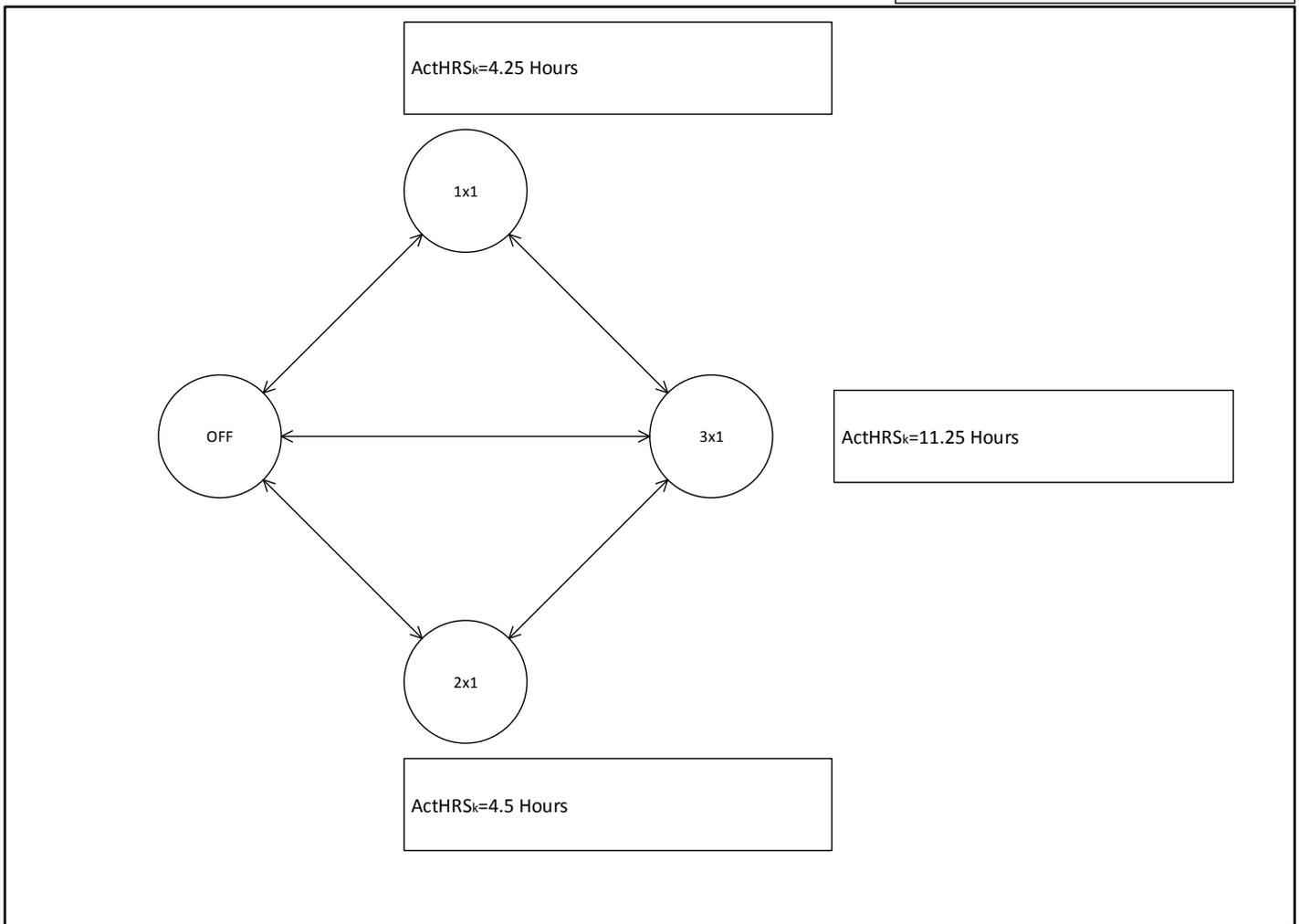
From Config	To Config	No. of Implied Starts per config or transition	ActDirectSTRT _{config}	ActTRANSITION _{config}	ActDirectSTRT _{implied}	ActTRANSITION _{implied}	ActSTRT _{implied}
		A	B	C	D = A*B	E=A*C	F=D+E
OFF	1X1	1	1		1		1
3X1		0		3		0	
OFF	2X1	2	1		2		2
3X1		0		2		0	
OFF	3X1	3	1		3		9
1X1		2		2		4	
2X1		1		2		2	
Plant							12

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14.2 Actual (Scheduled) Usage for Run-Hours (ActHRS)

Note: In this example, all usage are daily values (calculated by MQS). OCC will aggregate daily values to produce monthly values by summing daily values within each calendar month.

$$\text{ActHRS}_w = (4.25 + 4.5 + 11.25) = 20 \text{ Hours}$$



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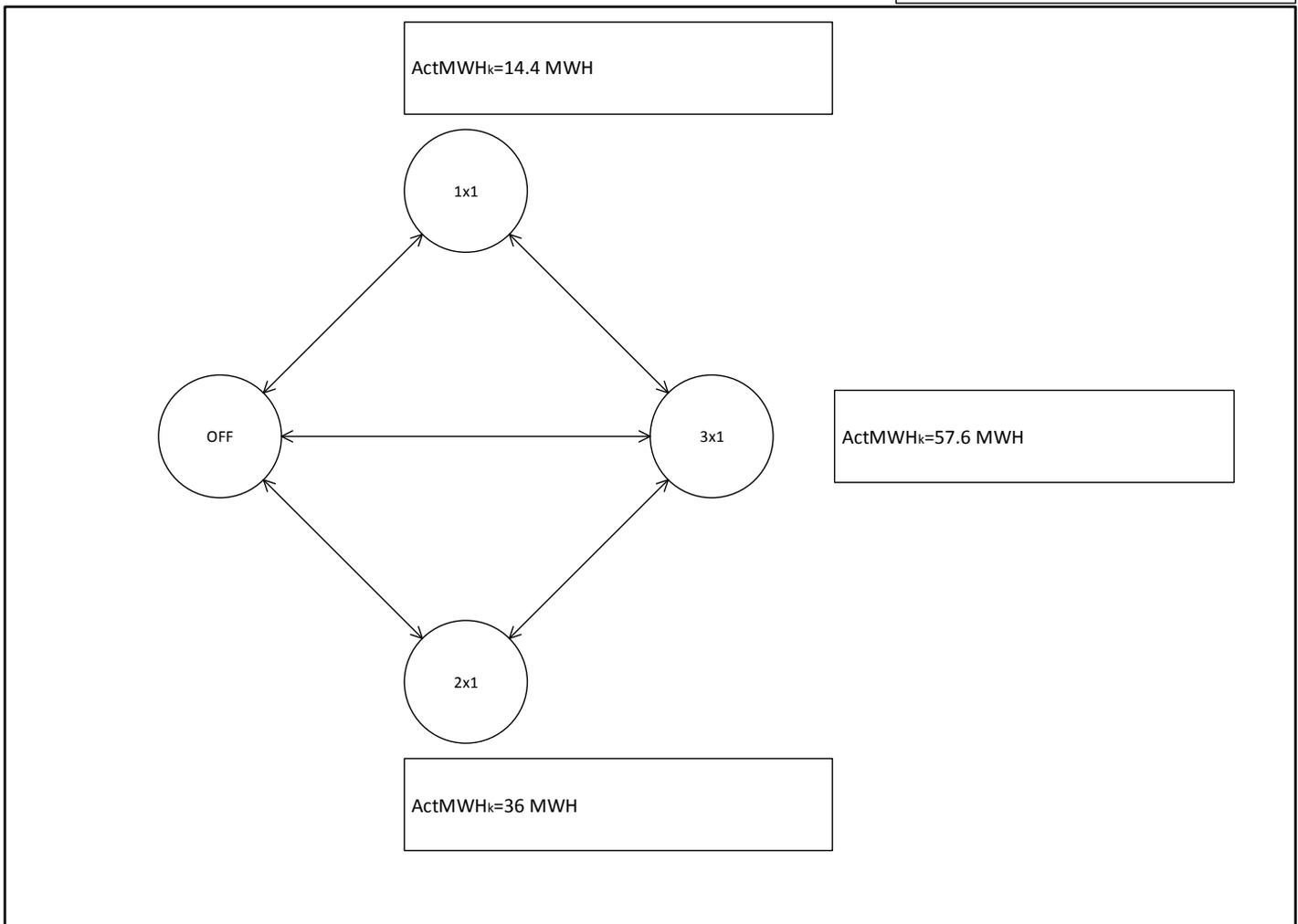
Date/Time	RT Active Configuration	Run Hours			
		1X1	2X1	3X1	Plant
05/18/2017 00:00	OFF				
05/18/2017 01:15	1X1	1.75			1.75
05/18/2017 03:00	3X1			2.5	2.5
05/18/2017 05:30	2X1		0.75		0.75
05/18/2017 06:15	OFF				
05/18/2017 08:00	2X1		2.5		2.5
05/18/2017 10:30	3X1			2.5	2.5
05/18/2017 13:00	1X1	1.25			1.25
05/18/2017 14:15	3X1			2.5	2.5
05/18/2017 16:45	2X1		1.25		1.25
05/18/2017 18:00	3X1			3.5	3.5
05/18/2017 21:30	1X1	0.75			0.75
05/18/2017 22:15	OFF				
05/18/2017 23:00	3X1			0.25	0.25
05/18/2017 23:15	1X1	0.5			0.5
05/18/2017 23:45	OFF				
Accrued ActHRS		4.25	4.5	11.25	20

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14.3 Actual (Scheduled) Usage for Energy Output (ActMWH)

Note: In this example, all usage are daily values (calculated by MQS). OCC will aggregate daily values to produce monthly values by summing daily values within each calendar month.

$$\text{ActMWH}_w = (14.4 + 36 + 57.6) = 108 \text{ MWH}$$



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For 1 hour of data:

Date/Time	RT Active Configuration	Total Expected Energy (TEE)			
		1X1	2X1	3X1	Plant
5/18/2017 0:00	OFF				0
5/18/2017 0:05	OFF				0
5/18/2017 0:10	OFF				0
5/18/2017 0:15	1X1	0.1			0.1
5/18/2017 0:20	1X1	0.2			0.2
5/18/2017 0:25	1X1	0.3			0.3
5/18/2017 0:30	3X1			0.7	0.7
5/18/2017 0:35	3X1			0.8	0.8
5/18/2017 0:40	3X1			0.9	0.9
5/18/2017 0:45	2X1		0.6		0.6
5/18/2017 0:50	2X1		0.5		0.5
5/18/2017 0:55	2X1		0.4		0.4
Accrued ActMWH		0.6	1.5	2.4	4.5

In this example, assuming the above pattern repeats for every hour during that day:

Date/Time	Total Expected Energy (TEE)			
	1X1	2X1	3X1	Plant
Accrued ActMWH	14.4	36	57.6	108

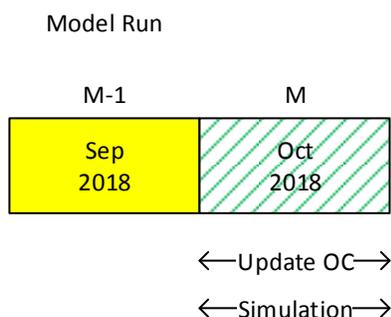
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15. Appendix-10: Examples for Use-Plan Applicability and Opportunity Cost Model Run Dates

15.1 Monthly (Only) Use-Limit Plan Applicability

15.1.1 Example-A1:



- Monthly Plan Applicability:
 - [M]: October 2018.
- Run the model on:
 - Any day within M-1: September 2018.
- Simulation (Analysis) Time horizon:
 - [M]: October 1, 2018 through October 30, 2018.
- Update OC for:
 - [M]: October 2018.
- Buffer month:
 - Not needed

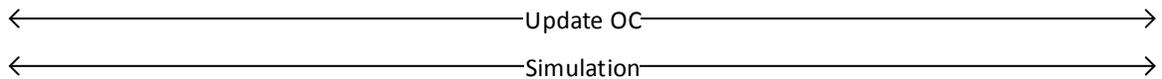
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15.2 Fixed-Annual (Only) Use-Limit Plan Applicability

15.2.1 Example-B1 (First Run):

Model
Run

M-1	M												M+11
Feb 2018	Mar 2018	Apr 2018	May 2018	Jun 2018	Jul 2018	Aug 2018	Sep 2018	Oct 2018	Nov 2018	Dec 2018	Jan 2019	Feb 2019	



- Fixed-annual Plan Applicability:
 - [M,M+11]: March 2018 through February 2019.
- Run the model on:
 - Any day within M-1: February 2018.
- Simulation (Analysis) Time horizon:
 - [M,M+11]: March 1, 2018 through February 28, 2019.
- Use Actuals from:
 - N/A
- Update OC for:
 - [M,M+11]: March 2018 through February 2019.
- Buffer month:
 - Not needed

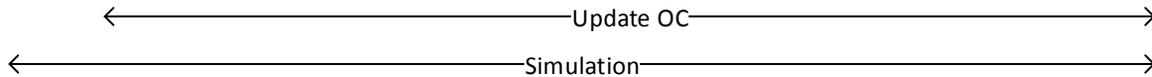
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15.2.2 Example-B2 (m=0):

Buffer
Month

Model
Run
M+m
M

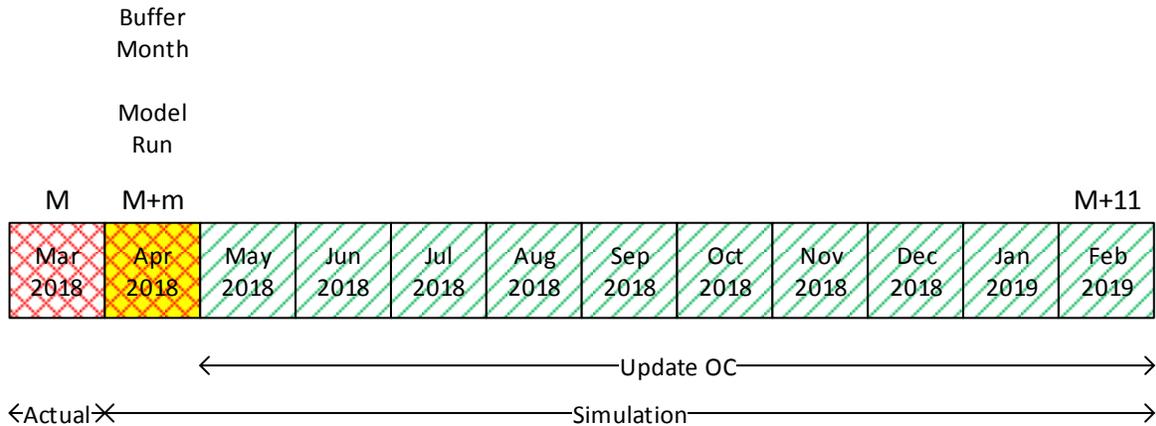
M+11



- Revise Fixed-annual Plan Applicability:
 - [M,M+11]: March 2018 through February 2019.
- Run the model on:
 - Any day within M+m: March 2018.
- Simulation (Analysis) Time horizon:
 - [M+m,M+11]: March 1, 2018 through February 28, 2019.
- Use Actuals from:
 - N/A
- Update OC for:
 - [M+m+1,M+11]: April 2018 through February 2019.
- Buffer month:
 - M+m: March 2018.

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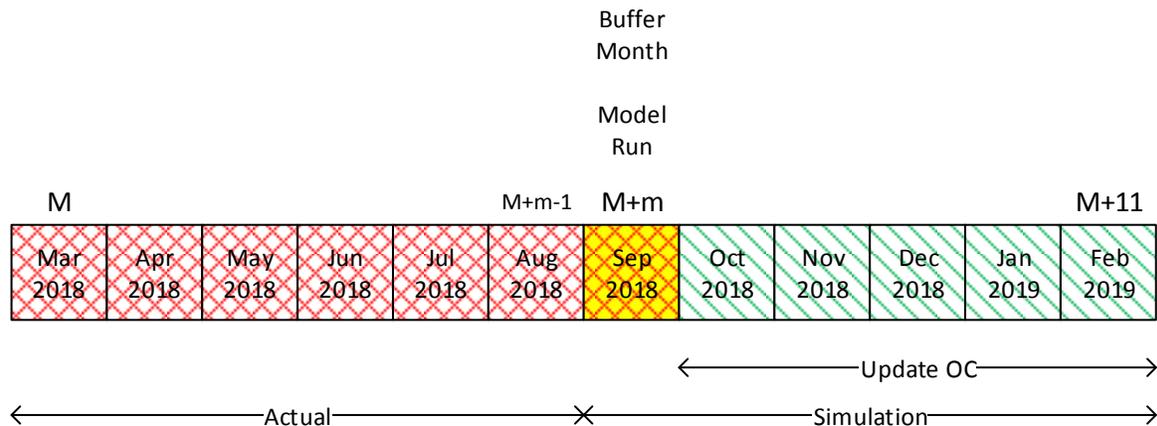
15.2.3 Example-B3 (m=1):



- Revise Fixed-annual Plan Applicability:
 - [M,M+11]: March 2018 through February 2019.
- Run the model on:
 - Any day within M+m: April 2018.
- Simulation (Analysis) Time horizon:
 - [M+m,M+11]: April 1, 2018 through February 28, 2019.
- Use Actuals from:
 - [M, M+m-1]: March 2018 are used to reduce the remaining-annual limit.
- Update OC for:
 - [M+m+1,M+11]: May 2018 through February 2019.
- Buffer month:
 - M+m: April 2018.

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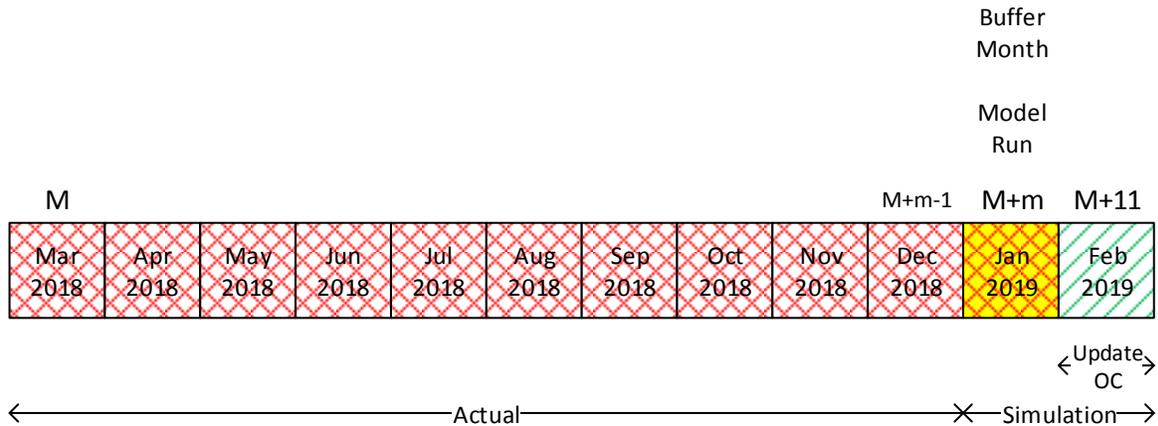
15.2.4 Example-B4 (m=6):



- Revise Fixed-annual Plan Applicability:
 - [M,M+11]: March 2018 through February 2019.
- Run the model on:
 - Any day within M+m: September 2018.
- Simulation (Analysis) Time horizon:
 - [M+m,M+11]: September 1, 2018 through February 28, 2019.
- Use Actuals from:
 - [M, M+m-1]: March 2018 through August 2018 are used to reduce the remaining-annual limit.
- Update OC for:
 - [M+m+1,M+11]: October 2018 through February 2019.
- Buffer month:
 - M+m: September 2018.

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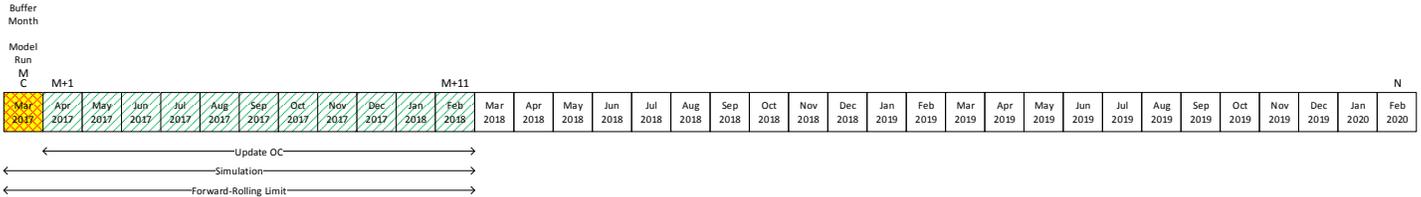
15.2.5 Example-B5 (Last Run: m=10):



- Revise Fixed-annual Plan Applicability:
 - [M,M+11]: March 2018 through February 2019.
- Run the model on:
 - Any day within M+m: January 2019.
- Simulation (Analysis) Time horizon:
 - [M+m,M+11]: January 1, 2019 through February 28, 2019.
- Use Actuals from:
 - [M, M+m-1]: March 2018 through December 2018 are used to reduce the remaining-annual limit.
- Update OC for:
 - [M+m+1,M+11]: February 2019.
- Buffer month:
 - M+m: January 2019.

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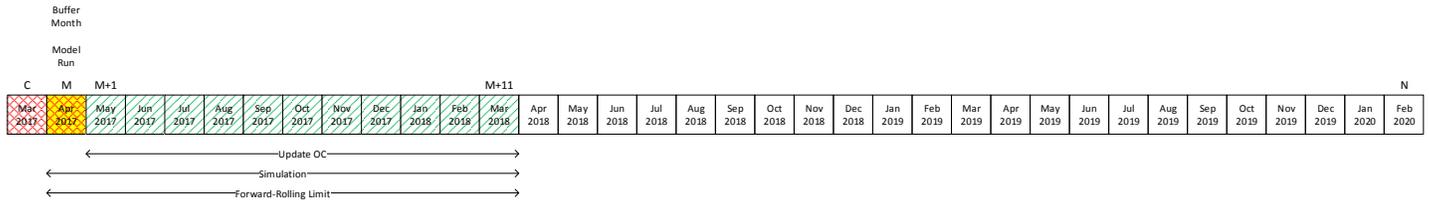
15.3.2 Example-C2 (M=March 2017 – Second Run):



- Rolling-annual Plan Applicability:
 - [C,N]: March 1, 2017-February 28, 2020.
- Run the model on:
 - Any day within M: March 2017.
- Simulation (Analysis) Time horizon:
 - [M,M+11]: March 1, 2017 through February 28, 2018. This is same as forward-rolling use-limit window.
- Use Actuals from:
 - N/A, since no backward-rolling limit is applied.
- Update OC for:
 - [M+1,M+11]: April 2017 through February 2018.
- Buffer month:
 - M: March 2017.

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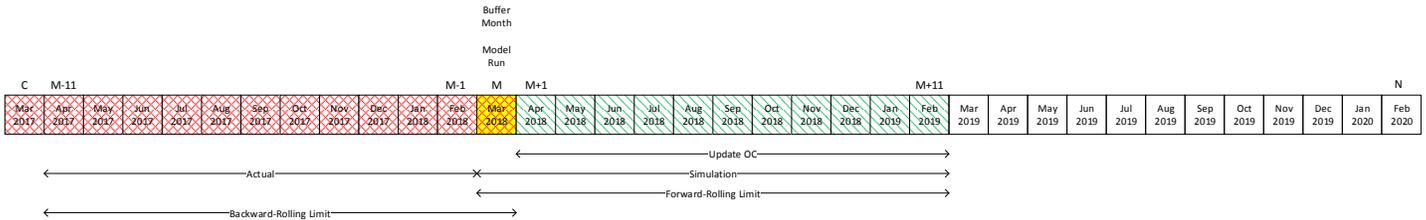
15.3.3 Example-C3 (M=April 2017 – Middle Run):



- Rolling-annual Plan Applicability:
 - [C,N]: March 1, 2017-February 28, 2020.
- Run the model on:
 - Any day within M: April 2017.
- Simulation (Analysis) Time horizon:
 - [M,M+11]: April 1, 2017 through March 31, 2018. This is same as forward-rolling use-limit window.
- Use Actuals from:
 - N/A, since no backward-rolling limit is applied.
- Update OC for:
 - [M+1,M+11]: May 2017 through March 2018.
- Buffer month:
 - M: April 2017.

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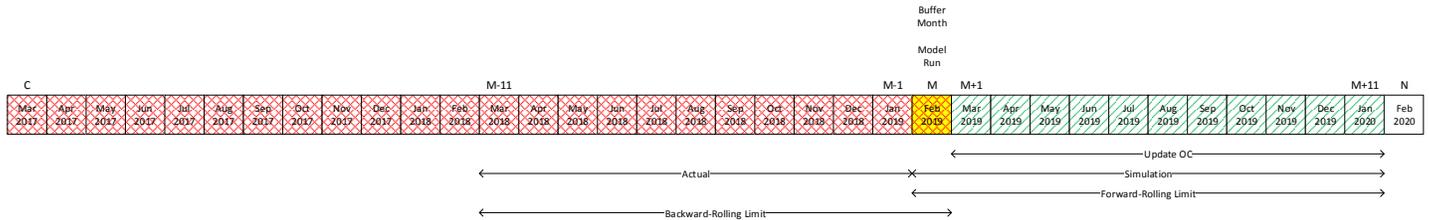
15.3.4 Example-C4 (M=March 2018 – Middle Run):



- Rolling-annual Plan Applicability:
 - [C,N]: March 1, 2017-February 28, 2020.
- Run the model on:
 - Any day within M: March 2018.
- Simulation (Analysis) Time horizon:
 - [M,M+11]: March 1, 2018 through February 28, 2019. This is same as forward-rolling use-limit window.
- Use Actuals from:
 - [M-11, M-1]: April 2017 through February 2018 will be subtracted from 12-month rolling limit and applied in monthly limit for M: March 2018.
- Update OC for:
 - [M+1,M+11]: April 2018 through February 2019.
- Buffer month:
 - M: March 2018.

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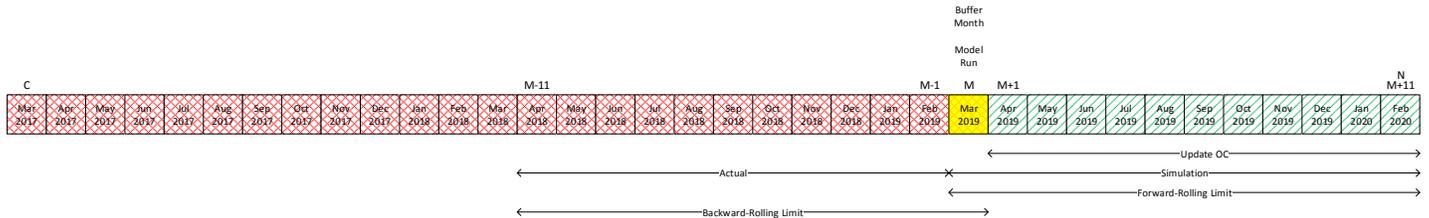
15.3.5 Example-C5 (M=February 2019 – Middle Run):



- Rolling-annual Plan Applicability:
 - [C,N]: March 1, 2017-February 28, 2020.
- Run the model on:
 - Any day within M: February 2019.
- Simulation (Analysis) Time horizon:
 - [M,M+11]: February 1, 2019 through January 31, 2020. This is same as forward-rolling use-limit window.
- Use Actuals from:
 - [M-11, M-1]: March 2018 through January 2019 will be subtracted from 12-month rolling limit and applied in monthly limit for M: February 2019.
- Update OC for:
 - [M+1,M+11]: March 2019 through January 2020.
- Buffer month:
 - M: February 2019.

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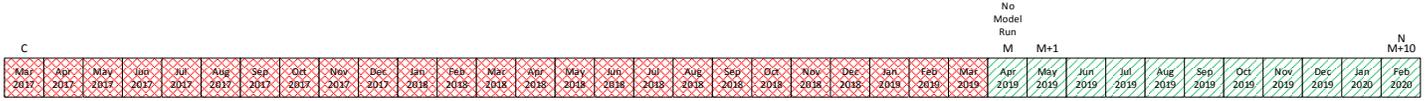
15.3.6 Example-C6 (M=March 2019 – Last Run):



- Rolling-annual Plan Applicability:
 - [C,N]: March 1, 2017-February 28, 2020.
- Run the model on:
 - Any day within M: March 2019.
- Simulation (Analysis) Time horizon:
 - [M,M+11]: March 1, 2019 through February 29, 2020. This is same as forward-rolling use-limit window.
- Use Actuals from:
 - [M-11, M-1]: April 2018 through February 2019 will be subtracted from 12-month rolling limit and applied in monthly limit for M: March 2019.
- Update OC for:
 - [M+1,M+11]: April 2019 through February 2020.
- Buffer month:
 - M: March 2019.

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15.3.7 Example-C7 (Skip M=April 2019 and later):



- Rolling-annual Plan Applicability:
 - [C,N]: March 1, 2017-February 28, 2020.
- Run the model on:
 - No runs since there is less than 12-month forward until February 28, 2020
- Simulation (Analysis) Time horizon:
 - N/A
- Use Actuals from:
 - N/A
- Update OC for:
 - No updates. Use previously calculated OCs.
- Buffer month:
 - N/A