Business Requirements Specification

Energy Imbalance Market Year 1 Enhancements

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Table of Contents

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 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 Information Systems projects and to all Business Process Modeling and System Requirements Specifications efforts.

These requirements will serve as the initial set of business unit requirements for the appropriate software application/systems development effort. It is understood that additional requirements and systems analysis may produce "To Be" Business Process Models, System Requirements Specifications, and Use Cases to serve as the set of requirements documents used by the development teams to buy, modify, or build the necessary software and hardware systems. The Business Unit(s) involved in the project will have an opportunity to review and approve all requirements documentation produced.

1.2 References

All references represent external requirements documents or stakeholder requests developed and submitted by the Business Units.

1. Policy-related documents, including the Draft Final Proposal and stakeholder comments are located on the "Energy Imbalance Market" EIM year 1 enhancements phase 1 Stakeholder Initiatives web page at

http://www.caiso.com/informed/Pages/StakeholderProcesses/EnergyImbalanceMarketYear1Enhancements.aspx

2. Details of Business Need/Problem

2.1 Description

The following lists the currently planned items in EIM Year 1 Enhancement phase 1:

Settlement of Non-Participating Resources – to align the calculation of expected energy across the EIM area, including additional energy categories that apply to ISO resources who self-schedule in the RTM to EIM non-participating resources with change from base schedule of EIM non-participating resources.

Administrative pricing rules – the ISO is clarifying its administrative pricing rules in the event of a market disruption or suspension. Since there is not a day-ahead price for EIM Entities, use the open access transmission tariff-approved price used by the EIM entity.

GHG cost based bid adder – GHG MW bids as GHG flag and Cost based GHG bid adder follows the rules GHG compliance costs

Resource sufficiency evaluation applied to ISO BAA –to extend the flexible ramping test at T-40 to the ISO.

Use of ATC for EIM Transfers and Modification to EIM transfer Limit Constraint –enforce the EIM transfer limit at each intertie scheduling point. Use available transmission capacity (ATC) or contract right. Use EIM transfer cost to enable market to select most direct path.

Enhance capacity test to cover potential imports and exports not tagging to base schedules – mitigation measures to address imports/exports assumed at T-40 not tagging

Redesign of EIM administrative charge - align billing determinants with two ISO GMC real-time market rates: market services charge and system operations charge.

Flexible ramping constraints BAA combination – enforce a single system-wide constraint and individual BAA constraint for each BAA in the EIM footprint.

3. Business Process Impacts

3.1 High Level Business Process

3.1.1 Description

Impacted Business Processes:

Manage Markets & Grid (MMG)

- Manage Real Time Hourly Market
- Manage Real Time Interchange Scheduling
- Manage Real Time Operations - Maintain Balancing Area
- Manage Real Time Operations - Transmission & Electric System

Manage Operations Support & Settlements (MOS)

- Manage Market Billing & Settlements
- Manage Market Quality System (MQS)
- Perform Market Reporting

Support Business Services (SBS)

- Monitor Market

3.2 Justification

FERC compliance, commitments made during the stakeholder process are the major drivers for this project.

4. 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.

EIM Year 1 Enhancement phase 1 and associated system:

Settlement of Non-Participating Resources – (MQS, Settlement)

- Non-participating resources base schedule is equivalent to an ISO real-time market self-schedule
- Energy categories to reflect operational characteristics as IIE settled at RTD price:
    - Standard Ramping Energy: changes between hourly base schedules, 20 minute ramp between hours
    - Ramping Energy Deviation: differences from standard ramp and actual ramp
    - Derate Energy: changes in Pmin or Pmax
    - Optimal Energy: all remaining IIE with DOT=base schedule.
    - Residual Energy

Administrative pricing rules – (MF, MQS, Price correction)

- The ISO administrative pricing rule applies to EIM entities in the event of a market disruption or suspension.
- In one scenario, the ISO proposes to use the day-ahead price. Since there is not a day-ahead price for EIM Entities, a different administrative price sent by EIM entity must be used.

GHG cost based bid adder – (SIBR, RTM, RLC)

- On an hourly basis, submit the single MW quantity and single cost by resource that can receive GHG award MW quantity is independent of bid range

- The “flag” is equivalent to bidding 0 MW. If a SC does not submit a GHG MW bid, the default will be zero
- EIM GHG import limit into ISO from all EIM BAAs can be no greater than total MW of GHG bids
- Calculate a daily maximum GHG bid allowed by resource

    - On a daily basis,
        - use highest heat rate
        - use GHG emissions rate authorized by CARB
        - use GHG allowance price index
        - calculate Daily maximum GHG bids
        - plus 10% adder
    - Resource must submit a daily GHG Bid adder <= daily maximum GHG bid
        - If Bid Adder > daily maximum GHG bid, ISO will override with resource’s daily maximum GHG bid
        - GHG Bid adder must by greater than zero
    - If a MW is submitted, but no price, use daily maximum GHG bid as default

Add Base Schedule Import/Export Decline to Resource Sufficiency Evaluation– (BSAP, RTM, MQS, CMRI)

- Enhance capacity test to cover potential imports and exports not tagging to base schedule
    - Add incremental and decremental requirement of the hour in the month to the hourly load for capacity test.
    - effective 1st day of month for each hour
    - If base schedule plus highest bid range less than load forecast + import % due to not tagging, resource plan shall be deemed **Insufficient Supply**
    - If base schedule plus lowest bid range greater than load forecast - export % due to not tagging, resource plan shall be deemed **Excess Supply**

- **Separate monthly calculation for imports & exports**
    - No netting of imports and exports
    - Regardless of reason not tagged
    - Calculate prior 15th to 15th for each hour
    - For each hour, compare final base schedules with actual tagged value at T-20,
    - Configurable the time period and hours for the calculation
- Import histogram: (base schedule import-actual tagged import)/Base Schedule import
- Export histogram: (base schedule export-actual tagged export)/Base Schedule export
- Additional incremental requirement:
  *97.5th percentile of import histogram * gross import base schedule – 2.5th percentile of export histogram * gross export base schedule*
- Additional decremental requirement:
  *97.5th percentile of export histogram * gross export base schedule – 2.5th percentile of import histogram * gross import base schedule*

    - Notification to EIM Entity of increased bid range needed to pass test

Resource sufficiency evaluation applied to ISO BAA (RTM)

- Extend the flexible ramping test at T-40 to the ISO. In the event, the ISO fails the test, EIM transfers into the ISO will be restricted the same way as other EIM BAAs.

Use of ATC for EIM Transfers and Modification to EIM transfer Limit Constraint – (MF, RTM, Settlement)

- Need to enforce EIM transfer limit by each EIM internal intertie to correctly update the energy profile
- Modification to EIM transfer Limit Constraint

    - Enforce EIM transfer limits by individual intertie when ATC used for transfers
    - Supports use of contract rights for EIM transfers
    - Supports tagging of multiple dynamic schedules

EIM transfer cost - including a transfer cost is not to recover transmission revenues between EIM BAAs, but rather to ensure the most optimal path or paths for the EIM transfer are used. (MF, RTM)

- Direct paths will have higher priority over indirect paths.
- Paths that 5-minute scheduling is allowed on will have higher priority over paths that only 15-minute scheduling is allowed on.
- Paths with firm transmission will have higher priority over paths with non-firm transmission

- Paths that experience with less-frequent curtailments will have higher priority than paths with more-frequent curtailments

EIM administrative charge design – (Settlement)
- Market service rate ($0.0534 per MWh) of IIE
- System Operations rate ($0.1340 per MWh) of absolute difference between the meter and the base schedule
- During 6 month of exit, apply minimum charge ($0.1874 per MWh) of 5% load and exports plus 5% generation and imports

Flexible ramping constraints BAA combination – (MF)
- Define and enforce a single EIM system-wide constraint and individual BAA constraint for each EIM BAA.

4.1 Business Process: < Manage Energy Management System (EMS) and Manage Full Network Model (FNM) >

4.1.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
NVE_BRQ040	**Model multiple Dynamic Schedules on jointly owned external units in non-EIM BAA in FNM** For jointly owned units in external BAA with dynamic schedules, set up one system resource each for dynamic schedules at physical location of at external BAAs. MF will define dynamic schedule resource ID, map the System Resource (SR). Each Dynamic schedule shall have its telemetry.	Core	EMS/GDB/FNM, RTM
NVE_BRQ050	**Model external BAA share on jointly owned unit in EIM BAA in FNM** For jointly owned unit in EIM BAA, set up a system resource. MF will define export resource, map to the SR. The telemetry of export resources will represent the dynamic share of non-EIM.	Core	EMS/GDB/FNM, RTM

4.2 Business Process: < Manage Entity and Resource Maintenance Updates (Master File)>

4.2.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ020	**Administrative Energy pricing rule** Set default Administrative Energy Price for each EIM BAA submitted by EIM entity	Core	Master File
EIMY1_BRQ030	**Define Resource Eligibility, heat rate and emission rate for calculating cost based GHG bid adder for EIM participating resources** • Define resource eligibility as EIM participating resources, including EIM intertie participating resources • Define Incremental heat rate • Define GHG CO_2e emissions rate authorized by CARB	Core	Master File
EIMY1_BRQ060	**Setup for ISO Scheduling Points in EIM BAAs** ISO Scheduling Points within EIM Entity BAAs with shared intertie scheduling limit: • ISO gross import/export schedules are mirrored by export/import schedules at EIM System Resources to cancel out in the power flow	Core	Master File
EIMY1_BRQ072	**Maintain PSE:** • Access NAESB • Update the PSE list in MF with latest PSE in NAESB	Core	Master File

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ073	**Define BAA-specific default loss percentage** Define BAA-specific default loss penalty percentage. one value for one BAA, include ISO, EIM BAA and non EIM BAA. Send BAA-specific default loss penalty percentage definition to the market application system	Core	MF, IFM/RTM
EIMY1_BRQ076	**Define Intertie Scheduling Limit (ISL) and intertie mapping** • Define interties for all the interties • Define ISL for certain considered interties; not every intertie has an ISL. • define the map of ISL to intertie • The ISL and intertie mapping shall be available to downstream systems	Core	MF
EIMY1_BRQ077	**Define EIM transfer Resource (ETSR) transmission cost** • Register the transmission cost for ETSR; One value per ETSR • Pass the ETSR transmission cost to the Market	Core	MF
EIMY1_BRQ078	**Define mapping of ETSR pair** • ETSRs come in pairs so there should be a mapping from each ETSR to its mirror • Pass the ETSR pair mapping to the market	Core	MF

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
NVE_BRQ275	**Define EIM transfer resource ID (ETSR) convention :** EIM transfer: to avoid confusion Define import and export resource for modeling dynamic schedule of EIM transfers between each EIM BAA and the ISO BAA in real time EIM market. • Define two pairs of ETSR for each intertie between 2 BAAs with 4 resource IDs Example: for INTIE, define two pairs, 4 res IDs.: Pair: Res_id: BAA1_ INTIE _Export; BAA 1 Res_id: BAA2_ INTIE _Import; BAA 2 Pair Res_id: BAA1_ INTIE _Export; BAA 2 Res_id: BAA2_ INTIE _Import; BAA 1 • Define Static and dynamic ETSR • Clarify the sign convention, ensure the market can distinguish import/export regarding each BAA	Core	MF
NVE_BRQ300	**Define multiple dynamic schedules on the same underlying joint owned unit in non-EIM BAA:** 1. Define the Dynamic schedules resource ID for each BAA and link the Dynamic schedules with System Resource at underlying physical units. Map each Dynamic resource ID to an ISO intertie or an EIM BAA intertie: 2. Define jointly owned external BAA units with dynamic schedules	Core	MF,RTM
NVE_BRQ343	**Define Generation Only BAA** • Define BAA that include only generation resources, no load resources, same way as other BAA • Define Interties between Generation Only BAA and surrounding BAAs, same way as other BAA • Define Interchange resources ID if applicable	Core	MF

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
NVE_BRQ344	**Define SP and ITC independently, associate Pnode/APnode, SP or non SP, with ITC** • Define Scheduling Point (SP) • Define scheduling limit (ITC) • Associate both Scheduling Point underlying Pnode/Apnode and Pnode/Apnode that are not SP to the applicable ITC • Pass to Market the Association of Pnode/Apnode to ITC	Core	MF
NVE_BRQ440	**Ramping Requirements forecast for EIM BAA and EIM BAA group** Balance Area Ramping Requirements (BARR) Calculate Flexible Ramping upward and downward Requirement forecast (FRR) for • CAISO, • Each EIM BAAs • total EIM footprint The system shall broadcast Flexible Ramping Requirement resource forecast for CAISO, EIM BAAs, and total EIM footprint. The RTM shall display the Ramping Requirements forecast for EIM BAA	Core	BARR, integration, RTM, BSAP

4.3 Business Process: < Manage Default Energy Bids (RLC)>

4.3.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ080	**Calculate Default Daily Greenhouse gas bid adder Cap (GHG allowance cost) for eligible EIM participating resources:** The system shall apply similar calculation for EIM participating resource as for ISO resources: • Receive the resource eligibility, heat rate and emission rate, for EIM internal participating resources and, if an EIM entity allows economic participation in the FMM market by imports on EIM external interties, EIM import resources. • Receive greenhouse gas allowance price • Calculate daily greenhouse gas bid adder cap (a single value) as a per MWh incremental cost per segment of the incremental heat rate curve, which can be calculated as: Allowance cost per MWh = incremental CO2 emissions per MWh (mtCO2/MWh) * 1 allowance per mtCO2 * greenhouse gas allowance price (daily) Where, Incremental CO2 emissions per MWh (mtCO2/MWh) = unit's highest incremental heat rate (mmBTU/MWh) * CO_2e emission rate (default value for natural gas emission rate is 0.053165 mtCO2/mmBTU) • Add 10% adder: daily default GHG bid cost Cap= Allowance cost per MWh *110% • Publish the daily default GHG cost Cap for applicable resource • If the resource has no heat rate, set emission per MWH =0 • For MSG, get the resource highest heat rate of all the configurations. • The GHG bid cost cap is applicable EIM participating resource in RTM.	Core	RLC, Master File, integration

4.4 Business Process: < Manage Day Ahead Market and Real Time Market >

4.4.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ110	**GHG MW Bid Rule and constraint:** • On an hourly basis, system shall allow SC submit the GHG MW quantity by resource that can receive GHG award, for eligible EIMPR, include EIM intertie resources • GHG MW is independent of EIMPR bid range for energy. • GHG MW award shall be allowed to exceed EIMPR bid range. • GHG MW bid shall be limited by the resource Pmax • If a SC submit a GHG 0 MW bids, the resource shall not receive the GHG MW award • If a SC does not submit a GHG MW bid for an EIMPR, the default shall be zero. The resource shall not receive the GHG MW award. • Pass the clean GHG bids to market	Core	SIBR, integration

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ120	**System shall receive default GHG cost adder cap and submitted bid adder:** • Market shall receive the default daily GHG cost adder cap $/MWh for the EIM participating resources (EIMPR) • SC shall submit a single value **hourly** GHG Bid adder $/MWh for EIMPR • Hourly GHG Bid adder shall be less or equal to the default daily GHG Cost adder cap. If Bid Adder > default daily GHG Cost adder cap, ISO will override with resource's default GHG cost adder cap • GHG Bid adder must by greater than zero. • Energy bids plus GHG bids adder cannot exceed bids cap ($1000) • If a EIMPR submit MW, but no GHG bid adder submitted, use default daily GHG Cost adder cap for the resources GHG bid adder • Publish GHG bid MW and bid cost adder to the market	Core	RLC, SIBR, RTM, integration
EIMY1_BRQ121	**Model EIM resource GHG cost in the market optimization:** • No mitigation applies to GHG bid cost for EIMPR resource. • Include GHG bid cost for GHG award in optimization: • System shall enforce GHG import limit constraint: EIM GHG import limit into ISO from all EIM BAAs can be no greater than total MW of GHG bids at resource level • Publish GHG awards and Marginal cost	Core	RTM, integration

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ132	**Market system shall recognize ISL:** • Receive the ISL and ISL to intertie mapping from Master File • Receive the ISL limit from the ETCC • Enforce the ISL constraint based on schedule to Intertie mapping, include all the schedules specify that intertie. • Publish ISL ATC, • Publish ISL shadow price while ISL binding.	Core	MF, ETCC, RTM, integration

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ139	**Perform the capacity test for the EIM BAAs.** **Enhance capacity test to cover potential imports and exports not tagging to base schedules:** • Receive high (97.5th) and low (2.5th)percentile of import histogram and high (97.5th)and low (2.5th)percentile of export histogram for the hour of corresponding month for each EIM BAA For Upward Supply: • **A1**: Calculate extra upward capacity need : *97.5th percentile of import histogram * gross import base schedule – 2.5th percentile of export histogram * gross export base schedule* • **A2**: the sum of the highest quantity offers in the energy bid range from EIM Participating Resources --sum base schedules of EIM participating resources • **A3=** Total demand forecast by ISO for the associated EIM BAA –(Total base schedule of non-participating and Participating resources) + A1 • If **A2** is less than **A3**, an EIM Entity SC resource plan shall be deemed **Insufficient Supply** for the hour, therefore fail the **capacity upward sufficient test;** otherwise upward capacity test is success. For Downward Supply: • **B1**: Calculate extra downward capacity need *97.5th percentile of export histogram * gross export base schedule – 2.5th percentile of import histogram * gross import base schedule* • **B2**: sum of base schedules from participating resources - the sum of the lowest quantity offers in the energy bid range from EIM Participating Resources • **B3:** (Total of base schedules from non-participating and participating resources)- Total demand forecast by ISO for the associated EIM BAA +B1 • If B2 is less than **B3**, an EIM Entity SC resource plan shall be deemed **Excess Supply** therefore fail the capacity downward sufficient test; otherwise downward capacity test is success.	Core	MQS, integration, BSAP, RTM

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ140	**Perform the capacity test for the ISO.** **Enhance capacity test to cover potential imports and exports not tagging to base schedules:** • Receive 97.5th and 2.5th percentile of import histogram and 97.5th and 2.5th percentile of export histogram for the hour of corresponding month for ISO For Upward Supply: • **A1**: Calculate extra upward capacity need : *97.5th percentile of import histogram * gross import HASP schedule – 2.5th percentile of export histogram * gross export HASP schedule* *Use RUC schedule if HASP schedule not available* • **A2**: the sum of the highest quantity offers in the energy bid range –RUC schedule • **A3= -Total RUC schedule +Total demand forecast by ISO + A1** • If **A2** is less than **A3**, an EIM Entity SC resource plan shall be deemed **Insufficient Supply** for the hour, therefore fail the **capacity upward sufficient test;** otherwise upward capacity test is success. • For Downward Supply: • **B1**: Calculate extra downward capacity need *97.5th percentile of export histogram * gross export HASP schedule – 2.5th percentile of import histogram * gross import HASP schedule* *Use RUC schedule if HASP schedule not available* • **B2**: RUC schedule - the sum of the lowest quantity offers in the energy bid range • **B3:** Total RUC Schedule-Total demand forecast by ISO for ISO +B1 • If **B2** is less than B3, an EIM Entity SC resource plan shall be deemed **Excess Supply** therefore fail the capacity downward sufficient test; otherwise downward capacity test is success.	Core	MQS, integration, BSAP, RTM

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ141	**Test Flexible Ramping up requirement sufficiency for ISO, same as EIM BAA, using T-7.5' and energy bid and ramp up rate in RTM:** • If the ISO capacity test fails for **Insufficient Supply**, the flexible ramp up sufficiency test is considered failed and not performed; otherwise, perform the following test. • Receive Flexible Ramping up Requirement forecasts at 5 minute interval for the trading hour and look ahead 5 hours for the ISO, EIM BAAs and the total EIM footprint. Calculate the EIM diversity benefit (DB) factors. • Reduce the up requirement for each BAA in EIM based on DB pro rata. Reduce the up requirement for each BAA by net EIM transfer export at T-7.5". The reduction is limited by the available net import capacity. • Perform flexible ramping up requirement sufficiency test for ISO at same time of each of 3 submissions of EIM. • for each EIM BAA and ISO, set up separate flexible capacity up requirements; • test the BAA resource plan has sufficient bids in ramping up capacity to meet the EIM BAA or ISO the up requirement for every 15-minute RTUC; • The test is performed cumulatively for each 15 minute interval of the trading hour, 15 minute ramp up for the first interval, 30 minute ramp up for the second, 45 minute ramp up for the third and 60 minute ramp up for the fourth interval. • Use initial schedules at T-7.5' and resource energy bids and ramp up rates. • All resources with economic bids and are available for 15 minute RTUC commitment will be eligible to ensure the sufficient ramp up capacity in the EIM BAA or ISO. • If the total ramp up capacity is below the flexible ramping up requirement in any of four cumulative tests, up tests fail. If the total ramp up capacity meets the flexible ramping up requirement in all four cumulative tests, up tests passes • Broadcast the 3 flexible ramping up capacity sufficient test results to the EIM entity SC in RTM.	Core	BSAP, RTM, Integration

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ142	**In RTUC, enforce the Flexible ramping up capacity requirement constraints for the ISO BAA, each EIM BAA, and Total EIM footprint BAA group that include the BAAs pass the test:** • If EIM BAA or ISO fails the sufficient ramp up test at T-75', T-55', and T-40', constraint the EIM transfer at T-7.5' for the EIM BAA or ISO. Enforce the original Ramp requirement in the isolated EIM BAA or ISO. • If the EIM BAA or ISO passes the sufficient ramp up capacity test, the ramp up original requirement (no DB) shall be reduced by the available net import capacity, reduced by the loop flow through the BAAs that fails ramping up test. Enforce the ramp up constraint for each EIM BAA, the ISO BAA. • Enforce total requirement with DB for the EIM footprint; include all the BAAs in EIM footprint. Adjust DB and use Slack variables to ensure the failed BAA not use other BAA's resources for flexible ramping up requirement. • The system shall receive EIM footprint to BAA mapping, associate BAA with the corresponding resources that can provide the flexible ramping capacity for the EIM BAA or EIM footprint. • The flexible ramp up requirements for EIM footprint can be potentially lower than the sum of individual requirements of each BAA, reflecting the benefits of reduced uncertainty and volatility across the EIM footprint. • Available net import capacity is a variable in the market optimization. • *Broadcast the resource Flexible ramping awards.* • Publish the shadow prices of each flexible ramping constraint and associated BAA, ISO total EIM footprint.	Core	SIBR, BARR, RTM, Integration

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted

EIMY1_BRQ160	**Base schedules at EIM internal interties are deemed delivered:**
	• Market will not make schedule changes
	• Although no bids at this node, market will calculate LMP
	• Out of market deviations are settled at the relevant LMP
	  ○ If known prior to start of FMM, FMM LMP
	  ○ Otherwise, RTD LMP
	• This includes day-ahead transactions with the ISO that are in the EIM entity's base schedules
		Core	SIBR, BSAP, RTM, Settlement

EIMY1_BRQ170	**Scheduling at ISO Scheduling Points within EIM Entity BAAs with shared intertie scheduling limit** • ISO import/export schedules are constrained by applicable Intertie Transmission Corridor (ITC) limits and are not part of EIM Transfers • ISO gross import/export schedules are mirrored by export/import schedules at EIM System Resources to cancel out in the power flow	Core	SIBR, RTM,
EIMY1_BRQ193	**Get the ISL and intertie mapping from MF** • Get the ISL and intertie map from MF • Enforce applicable ISL limits on intertie schedules • Not enforce ISL constraint for the intertie that no ISL defined in the MF.	Core	MF, RTM,

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ194	**Not enforce Flexible ramping down constraints** We will not implement the down constraint in RTUC/RTD 1. Down constraint not enforced in RTUC/RTD 2. Therefore, no settlement of downward constraint	Core	RTM
NVE_BRQ510	**Model Base Schedule and dynamic schedule for the joint owned units in Non-EIM BAA with multiple Dynamic Schedules to serve multiple EIM BAAs:** • The market shall receive jointly owned units defined in the MF • Receive and calculate base schedule through load forecast and NSI of Non-EIM • Allocate base schedule to the underlying units • Model resource-specified dynamic schedule as applicable, associate telemetry with dynamic schedule The model is applicable for DAM and RTM.	Core	BSAP, DAM, RTM
NVE_BRQ520	**Model mirror resources:** Model multiple mirror resources for ISO SP at EIM BAA. Mirror resources should not be displayed on CISO BAA UI. Mirror resources shall be displayed on EIM BAA UI. EIM UI shall not display the tagged DAM schedule to the ISO.	Core	DAM, RTM, BAAOP

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
NVE_BRQ536	**Support Telemetry for Dynamic System resource:** The system shall apply telemetry to the corresponding dynamic system resources.	Core	DAM, RTM
NVE_BRQ660	**System shall have functionality to setup and enforce the limits by intertie of the EIM transfer between the ISO and EIM, and between EIM BAAs:** 1. The EIM entity SC shall be allowed to send EIM transfer limits by intertie. 2. Market shall enforce the limits of the NSI and EIM transfer by intertie limits in the market optimization. 3. The market shall publish the NSI limits of the NSI for each BAA and/or BAA group. 4. The market shall publish EIM transfer intertie through EIM transfer resource.	Core	RTM, integration
NVE_BRQ672	**Reserve AS capacity for EIM resources from up/bottom:** • The system shall allow EIM resource SC submit self provision ancillary service of the EIM participating resource into the BSAP/RTM to reserve the capacity for EIM BAA ancillary service and reliability dispatch. • The market system shall protect the participating resource ancillary service capacity not be dispatched to meet EIM footprint energy need. • Energy bid range shall reserve the AS capacity from up and bottom. • Protect AS capacity for the Regulation Up, Regulation Down, Spinning, Non-spinning.	Core	DAM, RTM, SIBR, BSAP
NVE_BRQ680	**Using BAA specific default loss percentage** • Estimating BAA loss using BAA specific default loss percentage • Apply BAA-specific loss penalty in the linearized power balance in the optimization.	Core	MF, DAM, RTM,

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
NVE_BRQ690	**Model EIM Energy transfer limit by interties between EIM BAAs, Using Available Transmission Capacity (ATC)** **Appendix A** 1. Receive Energy Transfer System Resources (ETSR), ETSR pair and transmission cost from MF 2. Include base schedule in the optimal Energy Transfer for each intertie or intertie group, therefore, the market shall enforce total intertie limit or the contract limit if it is applicable. This will address the EIM use ATC as the EIM transfer limit 3. Use previous ACPF solution as initial point for optimal NSI and to calculate EIM transfer 4. Include small cost term in the objective function to ensure robust solution. 5. Receive EIM BAA EIM transfer limit by intertie 6. Publish EIM transfer resource per intertie (ETSR) and ETSR limits 7. Publish total EIM transfer and limits for each BAA	Core	MF, RTM, BSAP, integration, BAAOP
NVE_BRQ696	**Support both Scheduling Point (SP) and Pnoe/APnode that are not a SP to associate with ITC** • Receive Pnode/Apnode association with ITC from MF • Enforce ITC constraint that includes the injection from SP and injection from Pnode/APnode that are not SP. • LMP for the Pnode/Ap node that are not SP shall include the congestion cost of the ITC, same as for SP LMP • Publish the LMP and energy, congestion and loss components	Core	MF, RTM, integration

4.5 Business Process: < Manage Expected Energy and Market Correction (MQS) >

4.5.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ210	**Administrative pricing rule** **The administrative pricing rule for ISO shall apply to the EIM BAA with one exception:** If ISO must use day-ahead price for ISO because the system run out the real time binding interval, then in each EIM BAA use the price the EIM entity establishes through its OATT for market suspension The system shall use EIM entity specified administrative pricing in MF.	Core	MF, MQS
EIMY1_BRQ220	**Receive GHG MW award:** Receive GHG MW award from RTM for each eligible resources Note: GHG MW is allowed to exceed the resource bid range.	Core	MQS

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted

EIMY1_BRQ239	**For EIM BAA, each hour of 24 hours in the corresponding month, calculate the histogram of percentage of the difference between import and export base schedule at T-40 and Tagged at T-20: See Example appendix 6.1**
	• Receive the T-20 tag as actual tagged schedule (could use RTPD binding interval in RTUC that reflect the T-20 tagged schedules)
	• Perform monthly calculation for imports & exports
	  ○ No netting of imports and exports
	  ○ Regardless of reason not tagged
	  ○ Calculate prior 15th to 15th, effective 1st day of month (configurable BRQ241)
	• Calculate histogram of deviation for each hour, use T-40 base schedule and T-20 actual tagged,
	  ○ Import histogram: *(base schedule import-actual tagged import)/base schedule import*
	  ○ Export histogram: *(base schedule export-actual tagged export)/base schedule export*
	• Notification period to EIM Entity of increased bid range needed to pass test
	• Minimum threshold of 1% Aligned with load scheduling accuracy, if 97.5th and 2.5th percentile % absolute value <1%, set as 0.
	• Publish 97.5th and 2.5th percentile (high %, low%) of import histogram and 97.5th and 2.5th percentile (high %,low%) of export histogram each hour of 24 hours for the applicable month each EIM BAA
		Core	RTM, BSAP, MQS, integration, CMRI

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted

EIMY1_BRQ240	**For ISO, each hour of 24 hours in the corresponding month, calculate the histogram of percentage of the difference between import and export HASP schedule at T-40 and Tagged at T-20:**
	• Receive the T-20 tag as actual tagged import (could use RTPD binding interval reflect T-20 tagging)
	• Perform monthly calculation for imports & exports
	  ○ No netting of imports and exports
	  ○ Regardless of reason not tagged
	  ○ Calculate prior 15th to 15th, effective 1st day of month (configurable BRQ241)
	• Calculate histogram of deviation for each hour, use HASP schedule of the hour and T-20 actual tagged,
	  ○ Import histogram: *(HASP schedule import-actual tagged import)/HASP schedule import*
	  ○ Export histogram: *(HASP schedule export-actual tagged export)/ HASP schedule export*
	• Notification period to ISO of increased bid range needed to pass test
	• Minimum threshold of 1% Aligned with load scheduling accuracy, if 97.5th and 2.5th percentile % absolute value <1%, set as 0.
	• Publish 97.5th and 2.5th percentile (high %, low%) of import histogram and 97.5th and 2.5th percentile (high %, low%) of export histogram each hour of 24 hours for the applicable month for ISO to the market
		Core	RTM, BSAP, MQS, integration, CMRI

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ241	**Setup configurable time period and hours for calculate histogram for deviation of the EIM BAA intertie schedule:** System shall: ○ Setup the time period of historical data for EIM BAA schedules and tags; default is prior month 15th to this month 15th ; ○ Setup the hours combining to calculate histogram, default is each hour stand alone ○ Setup effective date, default is next month 1st; System shall apply applicable time period and hourly data to calculate histogram System shall publish the applicable time period and hour configuration to the EIM entity	Core	MQS, integration, CMRI
EIMY1_BRQ251	**EIM Non-participating resource shall apply same rules as real time self-schedule resource, include BCR rule** • System shall apply the same rule include BCR for the self-schedule resource to EIM non-participating resource, include expected energy and auxiliary cost calculation. • Publish the eligible energy to the downstream systems.	Core	RTM, MQS, integration

4.6 Business Process: < Manage Market Validation and Quality, Price Corrections (PCT)>

4.6.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ310	**Administrative pricing rule** RTM Administrative pricing rule apply to the ISO also apply to the EIM entity, except If ISO must use day-ahead price for ISO, then in each EIM BAA use the price the EIM entity establishes through its OATT for market suspension. • Receive default EIM BAA administrative price • Set the administrative price for all the applicable resources • Send the price to the MQS • Settle the resources using applicable price.	Core	Price correction, MQS

4.7 Business Process: < Market Results Interface (CMRI), Open Access Same-Time System (OASIS) >

4.7.1 Business Requirements

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ410	**Publish hourly High (97.5th) and Low (2.5th)percentile of import histogram and 97.5th and 2.5th percentile of export histogram for the BAA EIM entity** Publish in CMRI for each EIM BAA and ISO for each hour (24 hours) for the applicable month: • 97.5th and 2.5th percentile of import histogram (high %, low %) • 97.5th and 2.5th percentile of export histogram (high%, low %) The EIM entity who get the base schedule test results shall see the high/low percentile %:	Core	CMRI, integration, MQS
EIMY1_BRQ420	**Providing access to a subset of the EIM entity level reports to a different user group** • Obtain agreement with EIM entity to allow the specified users to access a subset of reports at EIM tab • Support the certification to allow the specified users to access a subset of reports at EIM tab, include but not limited: 1) Flex Ramp Requirement, 2) Bid Range Capacity test 3) Balancing Test Result • EIM entity shall decide the user access right to the subset of reports.	Core	CMRI
EIMY1_BRQ434	**Publish Capacity and flexible ramping upwards test results for the EIM entity:** **The system shall receive and publish to EIM entity** • Both Flexible ramping upwards requirements sufficient test for each EIM BAA	Core	CMRI, BSAP, integration

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
NVE_BRQ721	**EIM transfer report (CMRI)** Receive EIM transfer resource per intertie results from market Publish EIM transfer results per intertie for the EIM transfer resource at resource report Publish the EIM transfer resource (ETSR) operating limits Retire EIM transfer results report	Core	RTM, Integration, CMRI

4.8 Business Process: < Manage Scheduling (e-Tagging)>

4.8.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ520	**EIM transfer system resource (ETSR) dynamic tag on each intertie:** System shall support ETSR dynamic tag on each intertie. Dynamic tag rule is applicable.	Core	ITS

4.9 Business Process: < Manage Billing and Settlements>

4.9.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ610	**Settlement of EIM Non-Participating Resources: Consistent treatment for both ISO real-time Self Schedule and EIM non-participating resources** • Self-schedule changes in FMM and RTD is optimal energy • Optimal energy is used in Bid Cost Recovery (BCR) calculations • Optimal energy because self-schedule changes for physical reasons is allowed and result in FMM instructed imbalance energy when known prior to start of FMM • No settlement changes, no tariff change.	Core	MQS, Settlement
EIMY1_BRQ620	**GHG MW award settlement** Receive GHG MW for each resource GHG MW award is allowed to exceed bid range. Receive marginal price GHG Settle GHG award as product of MW and marginal price	Core	MQS, RTM, integration, Settlement

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted

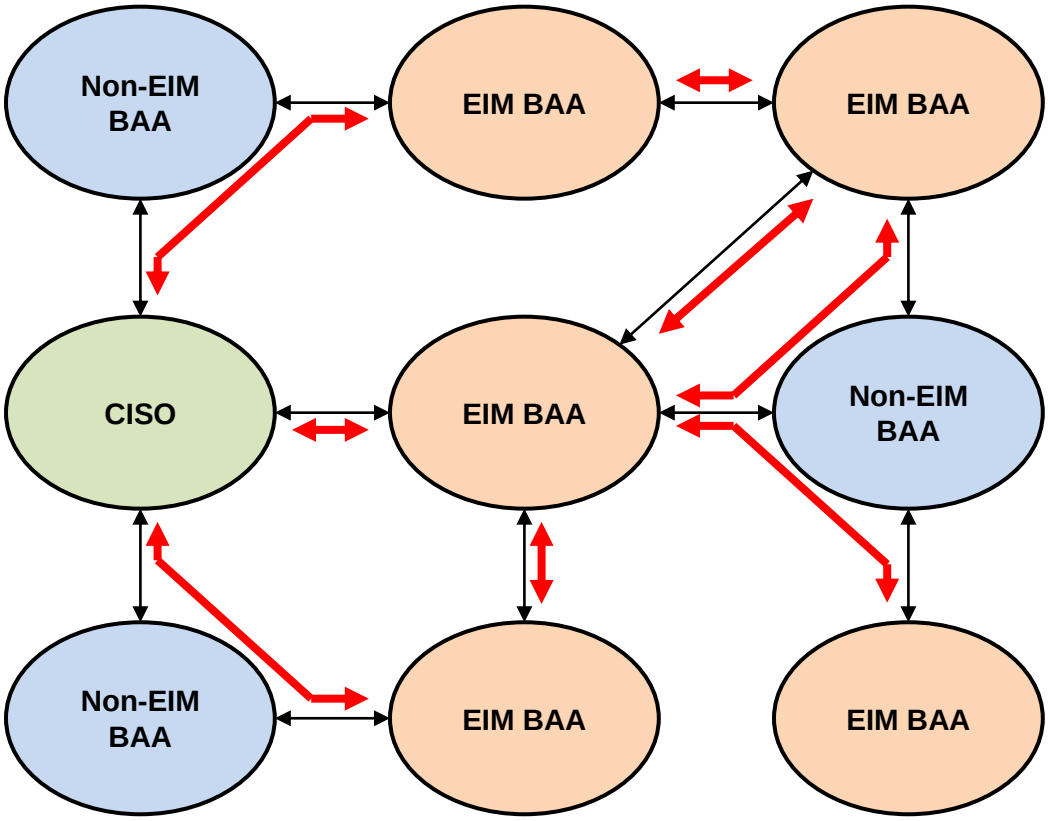
EIMY1_BRQ640	**Redesign of EIM administrative charge needed to align billing determinants with two ISO GMC real-time market rates: Market services rate and system operations rate**
	
	• The EIM market services rate and/or EIM system operations rate will be updated when the ISO grid management charge rates are updated. Start 1/1/2015, ISO Market service rate $0.0876, system operations rate $0.2978
	• The real-time market percentage is valid for three years and updated by a new cost of service study, start 1/1/2015, EIM % of ISO market service 61%, EIM % of ISO system operations 45%
	• To update the EIM administrative charges, the real-time market percentage determined in the cost of service study will be multiplied by the new ISO rates. Start 1/1/2015
	EIM market service rate =$0.0876*61%=$0.0534
	EIM system operation rate =$0.2978*45%=$0.1340
	EIM administrative charge total = $0.0534+$0.1340=$0.1874
	• The EIM charges will go to four decimal points, same as ISO rates, and not be rounded to the nearest cent.
	• Market services rate is $0.0534 per MWh of
	  ○ FMM IIE = Gross FMM Instructed Imbalance Energy excluding FMM Manual Dispatch Energy
	  ○ RTD IIE = Gross RTD Instructed Imbalance Energy excluding RTD Manual Dispatch Energy Standard Ramping Deviation, Ramping Energy Deviation, Residual Imbalance Energy, and Operational Adjustments.
	• System operations rate is $0.1340 per MWh of
	  ○ Gross real time energy flow which is the absolute difference between the meter and the base schedules.
		Core	Settlement

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
EIMY1_BRQ650	**Minimum charge only applies for the six month period if EIM entity exit EIM market as product of:** • EIM Administrative Charge $0.1874, and • Minimum charge of 5% load and exports plus 5% generation and imports	Core	Settlement
EIMY1_BRQ652	**Financial value of EIM transfer:** Use LMP of DGAP of EIM BAA to calculate EIM transfer value.	Core	RTM, integration Settlement

5. Appendix A: Energy Transfer Scheduling in EIM

5.1 Introduction

This technical paper describes the calculation of Energy Transfer schedules between Balancing Authority Areas (BAAs) in the Energy Imbalance Market (EIM) Area from the optimal EIM Transfer calculated for each BAA in the EIM Area by the Real-Time Unit Commitment (RTUC) and the Real-Time Dispatch (RTD) applications. The methodology in this document is general to account an arbitrary network configuration of EIM and non-EIM BAAs in the Full Network Model (FNM), such as the example shown below:



EIM BAAs may be interconnected with the CISO directly, through another EIM BAA, through a Non-EIM BAA, or a combination thereof. The EIM Entity for an EIM BAA may have made available transmission rights on a direct interconnection with the CISO, on a direct interconnection with another EIM BAA, or on an indirect interconnection with the CISO or another EIM BAA through one or more non-EIM BAAs. The red arrows in the example above illustrate such transmission rights. These transmission rights are essential to the EIM Transfers for each BAA in the EIM Area as they both allow and constrain the optimal exchange of imbalance energy among the BAAs in the EIM Area.

The EIM Transfer is an algebraic quantity (positive for export and negative for import) for the net energy exchange between a given BAA and the remaining BAAs in the EIM Area. The problem at hand is to determine the Energy Transfer schedules among the EIM BAAs and the CISO from the optimal EIM Transfers of the BAAs in the EIM Area using the available transmission rights without violating them. These Energy Transfer schedules can then be tagged to the relevant interties among the BAAs.

5.2 Energy Transfer System Resources

Although not necessary for implementation, it is convenient to define dedicated System Resources in each EIM BAA to anchor the Energy Transfer schedules from that BAA to other BAAs in the EIM Area for tracking, tagging, and settlement. These Energy Transfer System Resources (ETSRs) are defined as aggregate resources at the EIM BAA Default Generation Aggregation Point (DGAP), which is an aggregation of all supply resources in the BAA. Each ETSR is defined as either an import or an export resource, and it is associated with an EIM intertie with another EIM BAA, or a CISO intertie with the CISO. The associated intertie is one where the EIM Entity for the relevant EIM BAA has made transmission rights available for scheduling Energy Transfers from/to the other EIM BAA or the CISO.

At least two ETSRs must be defined in a BAA for each Energy Transfer schedule with another BAA in the EIM Area: one for import, and the other for export. An aggregate intertie may be used if there are multiple interties under the transmission rights that are made available. It may be necessary to define ETSRs for each intertie separately if the transmission rights are different for each one of them. It may also be necessary to define multiple ETSRs for each Transmission Service Provider (TSP) whose transmission rights are made available. Finally, it may be necessary to define different ETSRs for static 15min Energy Transfer schedules and dynamic 5min Energy Transfer schedules. The applicable transmission right limits can then be modeled as upper operating limits on the corresponding ETSRs.

For Energy Transfer schedules between BAAs in the EIM Area, the relevant ETSRs in these BAAs must be associated in import-export pairs since an Energy Transfer schedule between the BAAs is an import to one and an export to the other.

5.3 Notation

The following mathematical notation is used in this paper:

i	Node index.
j, k	BAA indexes; zero (0) is used for the CISO.
l	Intertie or Energy Transfer schedule index; in the latter case, it is the corresponding ETSR index (ETSR pair for Energy Transfers between BAAs in the EIM Area).
$\bar{}$	Accent denoting base schedule (RUC schedule for the ISO BAA).
$\hat{}$	Accent denoting gross tagged or forecasted interchange schedule between non-EIM BAAs.
$\sim$	Accent denoting initial values from the last AC Power Flow (ACPF) solution.
Δ	Denotes incremental values from the last ACPF solution.
$\forall$	For all…
$\in$	Member of…
$\wedge$	…and…
EIM	The set of CISO and all EIM BAAs.
BAA_j	The set of nodes in BAA j.
G_i	The generation at node i.
L_i	The load at node i.
$I_{j,k,l}$	The import schedule l into EIM BAA j from BAA k.
$E_{j,k,l}$	The export schedule l from EIM BAA j to BAA k.
D_j	The demand (load plus losses) forecast in BAA j.
$Loss_j$	The transmission loss in BAA j.
LPF_i	The loss penalty factor at node i.
$LPF_{j,k,l}$	The loss penalty factor at the Scheduling Point for intertie schedule l between BAA j in the EIM Area and non-EIM BAA k.
NSI_j	The Net Scheduled Interchange of BAA j; positive for export and negative for import.
T_j	The EIM Transfer of EIM BAA j; positive for export and negative for import.
$IT_{j,k,l}$	The import Energy Transfer schedule l of EIM BAA j from BAA k in the EIM Area.

$ET_{j,k,l}$ The export Energy Transfer schedule l of EIM BAA j to BAA k in the EIM Area.

$IT_{MAXj,k,l}$ The applicable limit of the import Energy Transfer schedule l of EIM BAA j from BAA k in the EIM Area.

$ET_{MAXj,k,l}$ The applicable limit of the export Energy Transfer schedule l of EIM BAA j to BAA k in the EIM Area.

$IT_{TRj,k,l}$ The transmission right for the import Energy Transfer schedule l of EIM BAA j from BAA k in the EIM Area.

$ET_{TRj,k,l}$ The transmission right of the export Energy Transfer schedule l of EIM BAA j to BAA k in the EIM Area.

$IT_{MAX15j,k,l}$ The static limit for the import Energy Transfer schedule l of EIM BAA j from BAA k in the EIM Area.

$ET_{MAX15j,k,l}$ The static limit of the export Energy Transfer schedule l of EIM BAA j to BAA k in the EIM Area.

$IT_{MAX5j,k,l}$ The dynamic incremental limit for the import Energy Transfer schedule l of EIM BAA j from BAA k in the EIM Area.

$ET_{MAX5j,k,l}$ The dynamic incremental limit of the export Energy Transfer schedule l of EIM BAA j to BAA k in the EIM Area.

$C_{j,k}$ The transmission cost of the Energy Transfer Schedules of EIM BAA j from/to BAA k in the EIM Area.

5.4 Mathematical Formulation

This section describes the relevant calculations and mathematical formulae.

5.4.1 Base Schedules

The base Energy Transfer schedules between EIM BAAs are submitted along with the generation and intertie base schedules ahead of the market run. The base Energy Transfer schedules between EIM BAAs and the CISO are the corresponding intertie schedules from the Residual Unit Commitment (RUC)[1] and need not be submitted since they are known:

$$\left.\begin{aligned}\overline{IT}_{j,0,l} &= \bar{E}_{0,j,l}\\ \overline{ET}_{j,0,l} &= \bar{I}_{0,j,l}\end{aligned}\right\} \ \forall j \in EIM \wedge j > 0$$

For accounting and validation purposes, base Energy Transfer schedules between EIM BAAs must be submitted for both BAAs and must be matching:

$$\overline{IT}_{j,k,l} = \overline{ET}_{k,j,l} \ \forall j,k \in EIM \wedge j \neq k \wedge j,k > 0$$

It is assumed that the base Energy Transfer schedules are feasible:

$$\left.\begin{aligned}0 \leq \overline{IT}_{j,k,l} &\leq IT_{MAXj,k,l}\\ 0 \leq \overline{ET}_{j,k,l} &\leq ET_{MAXj,k,l}\end{aligned}\right\} \ \forall j,k \in EIM \wedge j \neq k \wedge j > 0$$

For efficiency, there should not be both an import and an export base Energy Transfer schedule on a given intertie; at least one of them ought to be zero.

The base EIM Transfer for each EIM BAA is the net of all base Energy Transfer schedules:

[1] Currently, RUC intertie schedules are not part of the base EIM Transfer because no scheduling is allowed from EIM BAA Scheduling Hubs in the Day-Ahead Market, and intertie schedules from existing CISO Scheduling Points in EIM BAAs are not considered EIM transactions; hence the base Energy Transfer schedules with the CISO and the base EIM Transfer for the CISO are all zero.

$$\bar{T}_j = \sum_{\substack{k \in EIM \\ k \neq j}} \sum_{l} \left(\overline{ET}_{j,k,l} - \overline{IT}_{j,k,l} \right) \quad \forall j \in EIM \wedge j > 0$$

The base EIM Transfer for the CISO is simply the negative sum of the base EIM Transfers of all EIM BAAs:

$$\bar{T}_0 = - \sum_{\substack{j \in EIM \\ j > 0}} \bar{T}_j$$

The base NSI for each EIM BAA is the net of the EIM Transfer and the submitted base intertie schedules with non-EIM BAAs:

$$\overline{NSI}_j = \bar{T}_j + \sum_{k \notin EIM} \sum_{l} \left(\bar{E}_{j,k,l} - \bar{I}_{j,k,l} \right) \quad \forall j \in EIM \wedge j > 0$$

The base demand in each EIM BAA is derived to achieve power balance with the submitted base generation schedules and the base NSI:

$$\bar{D}_j = \sum_{i \in BAA_j} \bar{G}_i - \overline{NSI}_j \quad \forall j \in EIM \wedge j > 0$$

The base load in each EIM BAA is obtained initially by reducing the base demand with an assumed initial transmission loss and then distributing it to the load nodes in the BAA using Load Distribution Factors (LDFs); the base load is then adjusted to absorb the loss error by an ACPF using distributed load slack and Area Interchange Control (AIC) to maintain the base NSI:

$$\bar{D}_j = \sum_{i \in BAA_j} \bar{L}_i + \overline{Loss}_j \quad \forall j \in EIM \wedge j > 0$$

The base generation and load for the CISO are initialized at the RUC schedules; the CISO base load is also adjusted in the ACPF to account for generation and transmission outages occurred after RUC, and to absorb loss error as the CISO base NSI is maintained.

The base load for EIM BAAs is significant because it is used as a reference for imbalance energy settlement; however, the base load for the CISO is not important since for the CISO the reference for imbalance energy settlement is the day-ahead schedules from the Integrated Forward Market (IFM); nevertheless, it is used in the ACPF to balance the CISO, and the FNM overall, for calculating the power flows on EIM BAA transmission branches to identify any transmission limit violations for the feasibility test.

For the same reason, base schedules are also calculated for non-EIM BAAs to model unscheduled loop flow through the EIM Area. The approach for the non-EIM BAA base schedules is somewhat different because they are not submitted; instead, the demand forecast and the tagged or forecasted interchange schedules with other non-EIM BAAs are used to supplement the information available for the EIM BAAs and the CISO. Specifically, the base NSI for non-EIM BAAs is derived as follows:

$$\overline{NSI}_j = \sum_{\substack{k \notin EIM \\ k \neq j}} \sum_{l} \left(\hat{E}_{j,k,l} - \hat{I}_{j,k,l} \right) - \sum_{k \in EIM} \left(\bar{E}_{k,j,l} - \bar{I}_{k,j,l} \right) \quad \forall j \notin EIM$$

The base generation in each non-EIM BAA is derived as the sum of the demand forecast and the base NSI, and it is distributed to the generating resources in the BAA using Generation Distribution Factors (GDFs), renormalized for generation outages:

$$\sum_{i \in BAA_j} \bar{G}_i = \bar{D}_j + \overline{NSI}_j \quad \forall j \notin EIM$$

The base load in each non-EIM BAA is calculated similarly to the base load in EIM BAAs.

The base NSI for the CISO is simply the negative sum of the base NSIs of all BAAs in the FNM:

$$\overline{NSI}_0 = - \sum_{j > 0} \overline{NSI}_j$$

5.4.2 Optimal NSI and EIM Transfers

The optimal NSI for each BAA in the EIM Area, as calculated by RTUC and RTD, is the result of the optimal dispatch of resources within the BAA:

$$NSI_j = \sum_{i \in BAA_j} (G_i - L_i) - Loss_j \quad \forall j \in EIM \wedge j > 0$$

Linearizing from the previous ACPF solution:

$$\left.\begin{aligned} NSI_j &= \widetilde{NSI}_j + \Delta NSI_j \\ \widetilde{NSI}_j &= \sum_{i \in BAA_j} \left(\tilde{G}_i - \tilde{L}_i\right) - \widetilde{Loss}_j \\ \Delta NSI_j &= \sum_{i \in BAA_j} \frac{(\Delta G_i - \Delta L_i)}{LPF_i} \end{aligned}\right\} \forall j \in EIM$$

Where the optimal changes in generation and load are adjusted for marginal losses. Note that the load is not dispatched unless there is an outage or it is a dispatchable load, e.g., a hydro pump.

The optimal EIM Transfer for each EIM BAA is derived from the optimal NSI by subtracting the next export interchange with non-EIM BAAs:

$$T_j = NSI_j - \sum_{k \notin EIM} \sum_{l} \left(E_{j,k,l} - I_{j,k,l}\right) \quad \forall j \in EIM \wedge j > 0$$

Linearizing from the previous ACPF solution:

$$\left.\begin{aligned} T_j &= \tilde{T}_j + \Delta T_j \\ \tilde{T}_j &= \widetilde{NSI}_j - \sum_{k \notin EIM} \sum_{l} \left(\tilde{E}_{j,k,l} - \tilde{I}_{j,k,l}\right) \\ \Delta T_j &= \sum_{i \in BAA_j} \frac{(\Delta G_i - \Delta L_i)}{LPF_i} - \sum_{k \notin EIM} \sum_{l} \frac{\left(\Delta E_{j,k,l} - \Delta I_{j,k,l}\right)}{LPF_{j,k,l}} \end{aligned}\right\} \forall j \in EIM \wedge j > 0$$

Note that marginal loss contributions from network branches external to the EIM Area are ignored in the Loss Penalty Factors; consequently, the effect of intertie schedules between non-EIM BAAs and BAAs in the EIM Area on the EIM Area losses is the same as if the energy was generated or consumed at the EIM Area boundary.

The optimal EIM Transfer for the CISO is simply the negative sum of the optimal EIM Transfers of all EIM BAAs:

$$T_0 = -\sum_{\substack{j \in EIM \\ j>0}} T_j$$

The aggregate interchange dispatch at non-EIM BAA Scheduling Points/Hubs determines the NSI deviation (from the base NSI) of non-EIM BAAs and it is distributed to the generating resources of the relevant Generation Aggregation Point (GAP) using the applicable GDFs:

$$NSI_j - \overline{NSI}_j = -\sum_{k \in EIM} \sum_{l} \left(\Delta E_{k,j,l} - \Delta I_{k,j,l}\right) = \sum_{i \in BAA_j} (G_i - \bar{G}_i) \quad \forall j \notin EIM$$

The NSI is maintained for each BAA in the ACPF by adjusting the load using distributed load slack and AIC. Therefore, the NSI, EIM Transfer, and generation for EIM BAAs in the ACPF solution are always equal to the optimal solution in the last iteration.

5.4.3 Energy Transfer Schedules

The EIM Transfer for each EIM BAA is distributed optimally to the applicable Energy Transfer Schedules:

$$\sum_{\substack{k\in EIM\\ k\neq j}}\sum_{l}\left(ET_{j,k,l}-IT_{j,k,l}\right)=T_j\ \ \forall j\in EIM\wedge j>0$$

Where:

$$IT_{j,k,l}=ET_{k,j,l}\ \ \forall j,k\in EIM\wedge j\neq k\wedge j,k>0$$

Without violating the applicable transmission right limits:

$$\left.\begin{matrix}0\leq IT_{j,k,l}\leq IT_{MAXj,k,l}\\ 0\leq ET_{j,k,l}\leq ET_{MAXj,k,l}\end{matrix}\right\}\ \forall j,k\in EIM\wedge j\neq k\wedge j>0$$

For efficiency, there should not be both an import and an export Energy Transfer schedule on a given intertie; at least one of them should be zero.

It is assumed that the transmission limits are symmetric:

$$IT_{MAXj,k,l}=ET_{MAXk,j,l}\ \ \forall j,k\in EIM\wedge j\neq k\wedge j,k>0$$

To clarify, Energy Transfer schedules are variables in the market optimization calculated optimally subject to the above constraints. The base Energy Transfer schedule is included in the optimal Energy Transfer schedule; in other words, the optimal Energy Transfer schedule on any given intertie may completely back down a base Energy Transfer schedule and the energy transfer may reverse, resulting in efficient use of interconnecting transmission capacity.

The CISO is used as a reference, hence no constraints are formulated for the CISO Energy Transfer or Energy Transfer schedules from CISO ETSRs. Furthermore, to reduce the problem dimensionality, only the export ETSRs are included in the problem formulation; their import ETSR counterparts can be eliminated; the exception is the CISO export ETSRs, for which their import ETSR counterparts in EIM BAAs are used instead, for reasons explained in Energy transfer Tags.

5.4.4 Energy Transfer Schedule Limits

Normally, Energy Transfer schedules are dynamic and the same ETSRs and transmission limits are used in both RTUC and RTD. However, if some Energy Transfer schedules must be differentiated between RTUC and RTD, static ETSRs will be used for the 15min Energy Transfer schedules in RTUC and dynamic ETSRs will be used for the incremental 5min Energy Transfer schedules in RTD. In this case, the base Energy Transfer schedule is included in the 15min Energy Transfer schedule, and the transmission limit for the 5min Energy Transfer schedule is zero in RTUC and incremental (from the optimal 15min Energy Transfer schedule) in RTD. For a uniform treatment of all ETSRs to simplify implementation, the applicable Energy Transfer schedule limits in RTUC and RTD can be derived from the transmission right, static limit, and incremental dynamic limit, as follows:

$$\text{RTUC: }\left.\begin{matrix}IT_{MAXj,k,l}=\min\left(IT_{TRj,k,l},IT_{MAX15j,k,l}\right)\\ ET_{MAXj,k,l}=\min\left(ET_{TRj,k,l},ET_{MAX15j,k,l}\right)\end{matrix}\right\}\ \forall j,k\in EIM\wedge j\neq k\wedge j>0$$

$$\text{RTD: }\left.\begin{matrix}IT_{MAXj,k,l}=\min\left(IT_{TRj,k,l},IT_{j,k,l}+IT_{MAX5j,k,l}\right)\\ ET_{MAXj,k,l}=\min\left(ET_{TRj,k,l},ET_{j,k,l}+ET_{MAX5j,k,l}\right)\end{matrix}\right\}\ \forall j,k\in EIM\wedge j\neq k\wedge j>0$$

Where the Energy Transfer schedules used in the calculation of the applicable Energy Transfer schedule limit in RTD are the optimal 15min Energy Transfer schedules from RTUC. With these generic formulae, the static limit is what is made available from the

transmission right in RTUC, and the dynamic limit is additional transmission capacity that can be used in RTD. If there is no distinction between static and dynamic Energy Transfer scheduled, both static and dynamic limits should be equal to the transmission right to maximize transmission capacity use across RTUC and RTD.

5.4.5 Energy Transfer Tags

The optimal Energy Transfer schedules are assigned to the corresponding ETSRs and are tagged to the associated intertie using the corresponding ETSR identification. For static ETSRs, the tag is a static 15min tag that includes the base Energy Transfer. For dynamic ETSRs, the tag is a dynamic 5min tag; if there is no distinction between static and dynamic Energy Transfers on a given intertie, there is no static tag and the base Energy Transfer schedule is included in the dynamic 5min tag. Because the Energy transfer schedules between two BAAs are duplicated as import and export counterparts seen from each BAA, by convention only the export ETSRs will be tagged between the two BAAs. As an exception, because the CAISO as a Market Operator is not authorized to submit tags, both import and export ETSRs at EIM BAAs with CISO interties will be tagged.

5.4.6 Intertie Transmission Cost

The distribution of the Energy Transfer for a BAA over the various interties to adjacent BAAs in the EIM Area is not influenced by network impedance or transmission losses, and as such it does not represent actual power flows on these interties; it resembles the classical problem of transferring goods from supply centers to demand centers over a road network. The Energy Transfer schedule limits are scheduling limits and they resemble road throughput capacity. Physical intertie limits need to be enforced separately to constrain actual power flows on the interties, including loop flow contributions from base schedules in non-EIM BAAs.

In a problem like that, there is often not a unique solution, particularly if many intertie scheduling limits are not binding, i.e., there may be multiple ways to transfer the goods from the supply centers to the demand centers without violating any road constraints. To obtain a robust and efficient solution without circulating Energy Transfer schedules, a small nominal cost should be included in the objective function for each ETSR, as follows:

$$\min\left(\ldots+\sum_{\substack{j,k\in EIM\\ k\neq j\\ j>0}} C_{j,k}\sum_{l}\left(ET_{j,k,l}+IT_{j,k,l}\right)\right)$$

This cost resembles tolls paid on the roads connecting the supply and demand centers. Introducing this cost will also guarantee that Energy Transfer schedules between two BAAs in the EIM Area will always be unidirectional, i.e., either the export or the import will take value, but never both. This cost may ultimately reflect applicable wheeling or transmission access fees depending on agreed transmission pricing methods among the BAAs in the EIM Area.

5.4.7 Energy Transfer Economic Value

In calculating real-time neutrality by BAA, an economic value is required for the Energy Transfer, which must be considered to balance the BAA. Currently, the economic value is determined by pricing the EIM Transfer at the LMP of the metered end of the intertie used for tagging the relevant EIM Transfer schedule. With the introduction of multiple interties (multiple ETSRs) for a given BAA where the Energy Transfer can be optimally distributed based on the presented methodology, a more robust price would be the LMP of the DGAP of the BAA where the ETSR resides. This is a more appropriate price since the location of the ETSR is the DGAP of its BAA, which is deemed to be the source of the Energy Transfer anyway.

6. Appendix B:

6.1 Calculate Base Schedule Import/Export Decline Percentages

The histogram span from negative to positive because the tag can be over or under the schedule, although most frequencies would probably be on the under-tag area. You do not need to do any rounding, just count the samples to get the % over/under-scheduling at the 2.5 and 97.5 %-tiles of frequency:

Import histogram data: (base schedule imports – actual tagged imports) / base schedule imports

Export histogram data: (base schedule exports – actual tagged exports) / base schedule exports

These histograms are algebraic for ±% over/under-scheduling. Then the additional capacity test requirements can be derived as follows:

Additional incremental requirement = 97.5th %-tile of import histogram * gross import base schedule – 2.5th %-tile of export histogram * gross export base schedule

Additional decremental requirement = 97.5th %-tile of export histogram * gross export base schedule – 2.5th %-tile of import histogram * gross import base schedule

Example:

1000 samples for each histogram.

975 samples on import histogram have import under-scheduling less than 8.764%.

975 samples on export histogram have export over-scheduling greater than –2.357%.

Gross import base schedules: 2000MW

Gross export base schedules: 1000MW

Additional incremental capacity requirement: 2000 * 8.764% + 1000 * 2.357% = 175.28 + 23.57 = 198.85MW

6.2 EIM Resource BAA ID Convention

General rule: one resource one BAA ID

Resource Type	Rule	BAA ID
Generation resources	BAA ID based on the resource location	One BAA ID

EIM transfer Resources (ETSR)	BAA ID based on location Define two pair of ETSR resource IDs: Export of BAA1, import to BAA2. Export of BAA2, import to BAA1.	One BAA ID Export ETSR BAA ID at from BAA Import ETSR BAA ID at to BAA
Pseudo Tie Resource	Attaining BAA ID	One BAA ID
Intertie resources: - System Resources - Transactions - TG Dynamic Schedules - Mirror Resources	BAA ID based on the associated intertie from BAA ID	One BAA ID at intertie from BAA

General rule: Transmission, one to many BAA ID

Type	Rule	BAA ID
Interties	From/to BAA ID	One intertie has two BAA IDs
Entitlement	BAA ID of associated resources	One entitlement has multiple BAA IDs if the associated resources have multiple BAA IDs
ISL	From/To BAA ID of associated intertie	One ISL has two BAA IDs
ITC	BAA ID based on the BAA ID defined on MF	One ITC can have multiple BAA IDs if the associated schedules have multiple BAA IDs
Nomogram	BAA ID based on the BAA ID defined on MF	One ITC can have multiple BAA IDs if the associated resources have multiple BAA IDs
Transfer Limits	BAA id depend on the ETSR	One transfer limit can have two BAA IDs depend on the ETSR BAA ID.