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North American Electric Reliability Corporation Change Order #283

NAME: IDCWG
DATE: November 18, 2009
SUMMARY: Generation to Load Reporting Requirements
REVISION: 3.0

CHANGE REQUEST DETAIL:

ORIGINATION DATE: January 5, 2009.

SPONSOR: NERC IDCWG.

Revision 1.0:

Background and Purpose

The NERC ORS and RCWG have requested a business case be presented on the parallel flow visualization/mitigation SAR. The business case needs to include cost estimates and expected benefits of the SAR.

Revision 1.0 of this Change Order was written for the sole purpose of providing cost estimate of changing NERC IDC to support this SAR.

General Requirements

Under the parallel flow visualization/mitigation SAR, it is proposed that all RCs in the Eastern Interconnection would report their generation-to-load flows to the IDC for BAs within their RC Area. They would report generation-to-load flows only on flowgates where there was a significant impact (5% or greater) and the flowgate is likely to have TLR called.

Reported generation-to-load flows will replace the generation-to-load (NNL) impacts computed by the IDC using static data when TLR 5 is called. The generation-to-load flows will be reported on a directional basis and by priority bucket. NAESB will establish a methodology for assigning the generation-to-load flows into the appropriate priority bucket (either firm Priority 7 or the highest level of non-firm Priority 6).

When TLR is called to reduce loadings on a flowgate, the generation-to-load flows will be subject to curtailment on a proportional basis with tag impacts and market flows in the same priority bucket. The generation-to-load flows will be reported on a BA basis and the relief obligation will be assigned on a BA basis (the same as the NNL calculation does today during TLR 5). It is the responsibility of the BA to accomplish the relief obligation that is assigned to them. The RC for the BA is available to identify combinations of units that could be redispatched to accomplish the relief obligation.

Changes to TLR Process

With the implementation of the parallel flow visualization/mitigation SAR, the following changes will occur to the TLR process:

- The RCs will calculate generation-to-load flows for those generators within the reliability area of the RC and that are being used to serve load within the BA where the generator is located (does not involve a transaction that crosses a BA boundary). The generation-to-load flows will be accumulated on a BA basis, assigned to the appropriate priority buckets and then reported to the IDC. It is expected that the generation-to-load flows will be reported to the IDC at a

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minimum of once every 15 minutes. There will be an option where the RC can either make the impact calculation themselves or rely on a service provider to make the calculation for them.

- The four major changes to the IDC are:
 1. The IDC will be expanded to receive the generation-to-load flows from all RCs that have generators with significant impacts on a flowgate that is likely to have TLR called on it. The data submission will be in the same format as the market flows that are being reported by Midwest ISO, PJM and SPP (see below for format description). This should not be a significant change to the IDC since it currently receives this data from the three RTOs. This proposal only expands the current process to include other entities.
 2. The generation-to-load impact calculation made by the IDC using static data will be disabled (this is also called the NNL calculation). This removes the need for an RC experiencing congestion to go into the IDC and reset the status of generators prior to calling TLR 5 since we are no longer relying on the IDC to make the generation-to-load impact calculation. It also means that it is no longer critical to have hourly loads and net scheduled interchange in the SDX for use by the IDC in the generation-to-load impact calculation. (Please note that there is no current requirement that hourly loads and net scheduled interchange be reported to the SDX.)
 3. The existing user interfaces would be modified to show the impact of generation-to-load flows by BA on a flowgate experiencing congestion. Since tag impacts, market flows and generation-to-load flows will now be available on a near real-time basis, the actual real-time flow (either system intact flow or post contingent flow) will need to be reported to the IDC at the same frequency as the generation-to-load flows. Additionally, an unaccounted for usage will need to be calculated as the difference between the actual real-time flow and the summation of the tag impacts, market flows and generation-to-load flows. The unaccounted for usage will be available on the user interfaces along with the actual real-time flow, tag impacts, market flows and generation-to-load flows.
 4. An impact archive will be added to the IDC that will save tag impacts, market flows, generation-to-load flows, unaccounted for usage and real-time flows by flowgate. The archive will be available to make after-the-fact reviews of parallel flows on flowgates. Currently, the IDC archives raw tag data but not tag impacts. The response factors that were used to assign tag impacts to a flowgate may be kept on-line for a short period of time following a TLR event (need to confirm what this time period is). These response factors are only available for the times when the flowgate was in TLR and may not be available one week after the TLR has ended. Since this will be archiving all tag impacts, all market flows and all generation-to-load flows by specific tag, market and BA for all time periods (not just when TLR occurred), will need to discuss with OATI the amount of on-line storage that can be called-up immediately versus off-line storage that requires restoration from a backup medium. As a starting point for that discussion, would suggest the current calendar year (up to 12 months) and the previous calendar year (full 12 months) be available on-line and the previous 3 calendar years be available off-line.

Format Used to Report Generation-to-Load Flows

IDC is currently set up to receive the market flows from the Markets in an agreed upon format. The Generation to load flows can be reported to the IDC in the same format that the markets exchange with IDC.

The purpose Market Flow data exchange is to communicate Real-Time and Next Hour Generation to Load flow impacts on coordinated flowgates with the IDC. The values will be for current hour and next hour priorities 6, and 7 in either direction. Both constrained values and unconstrained values for 0% and 5% threshold will be exchanged and used by IDC for relief obligation in the event of TLR. There will be one set of data for each flowgate in each priority and is represented in MWs. The following format can be used to exchange the data with IDC:

CName,
FlowGateNumber
Priority
NormalCurrentMW
ReverseCurrentMW
NormalNHMW
ReverseNHMW
NormalCHUnconstrainedMW
ReverseCHUnconstrainedMW
NormalNHUnconstrainedMW
ReverseNHUnconstrainedMW
EffectiveDate

Where

CName - represents the BA that is reporting the Generation to Load flow
FlowGateNumber - Flowgate IDs assigned by NERC IDC
Priority - represent the priority level of Generation to load flow
NormalCurrentMW - Current hour generation to load impacts in the forward direction
ReverseCurrentMW - Current hour generation to load impacts in the reverse direction
NormalNHMW - Next hour generation to load impacts in the forward direction
ReverseNHMW - Next hour generation to load impacts in the reverse direction
NormalCHUnconstrainedMW -Unconstrained current hour generation to load impacts in the forward direction
ReverseCHUnconstrainedMW - Unconstrained current hour generation to load impacts in the reverse direction
NormalNHUnconstrainedMW - Unconstrained Next hour generation to load impacts in the forward direction
ReverseNHUnconstrainedMW - Unconstrained Next hour generation to load impacts in the reverse direction
EffectiveDate - The timing when the impacts will be effective

Revision 2.0:

The Revision 2.0 of this Change Order requests that OATI perform a technical and cost evaluation for providing the Generation-to-Load (GTL) calculator for all in Balancing Authority in the Eastern Interconnection in addition to the changes in the IDC as described in Revision 1.0. Details of the requested changes are as follows:

Background and Purpose

Currently, the PJM, Midwest ISO (MISO) and Southwest Power Pool (SPP) markets provide the IDC with their market dispatch contributions to the flow on a flowgate. These values are periodically calculated by the markets and provided to the IDC in near real-time, every five to fifteen minutes. Essentially, these values provide an accurate representation of the markets contribution to the flows on a flowgate in near real-time. The NERC IDC uses these values to determine the share of relief responsibility by the markets (PJM, MISO and SPP) towards the flow on a flowgate in TLR.

All other Markets and Balancing Authorities rely on the NERC IDC per-generation method for computing their Network and Native Load contributions and their share of relief obligation when a TLR level 5a or 5b is called for. These calculations rely on the BAs hourly load values provided to the IDC via the SDX and the static generation distribution of these load values among the generators in the BA, unless a generator is explicitly outage via the SDX. As such, the generation outputs calculated by the IDC may

be inaccurate and even include generators that out-of-service in the IDC base case but not outage in the SDX.

General Requirements

This Change Order is to request OATI to modify the NERC IDC as follows:

1. Calculate Generation-to-Load (GTL) contributions consistently and transparently for all Markets and Balancing Authorities (BA) in the Eastern Interconnection by expanding on the market flow calculation concepts used by PJM, MISO and SPP to all entities in the Eastern Interconnection. The following requirements describe the GTL reporting needs for every flowgate:
 - a. GTL calculations will be performed periodically, every 15 minutes for the current and next hours.
 - b. For each time period (current and next hour), the GTL will be calculated and reported directionally, in the normal (forward) and reverse directions.
 - c. For each time period and direction, the GTL will be reported in three different priority levels, comparable to OASIS products Firm (7-F), Network Non-Firm (6-NN) and Hourly Non-Firm (2-NH). The methodology for assigning GTL into appropriate priority buckets will be established by NAESB.
 - d. Constrained and unconstrained GTL will be calculated for each time period, direction and priority. Constrained GTL correspond to GTL actual values based on current and estimated next hour generation and load values. Unconstrained GTL corresponds to a “best estimate” forecast of GTL impacts when no flowgates are in TLR.
 - e. For each time period, direction and priority, the total and curtailable constrained and unconstrained GTLs will be calculated and reported. Total GTL includes all generators in a BA/market supplying the load of the BA/market. Curtailable GTL includes only a subset of generators whereby their Generation-to-Load Distribution Factor (GLDF) is greater than or equal to 5%.

Off-line studies will be performed by the RCs to determine the flowgates for which GTL impacts will be calculated by the IDC. These off-line studies are currently outside of the scope of the IDC. Nevertheless, the list of flowgates for which GTL impacts will be calculated will be provided via the Flowgate Management System (BoF) and/or update via the IDC user interface. Currently, PJM, MISO and SPP provide their list of coordinated flowgates via the BoF. The BoF will be expanded to enable all BAs and markets to provide this information. A BoF Change Order will be written, if appropriate, to document the necessary changes to the Flowgate Management System.

The IDC and GTL calculator will be able to model Control Zone Load (CZL) for every BA and market in the Eastern Interconnection. Currently, PJM, MISO and SPP model Control Zone Loads as partitions of their large footprint, either representing historical Balancing Authorities prior to consolidation (MISO and SPP) or geographical/electrical zones where generation and load generally move in concert (PJM). The primary purpose of CZLs is to partition large footprint BAs and markets with large volumes of non-tagged GTL.

The IDC will also be able to model load zones as a subset of load buses in a Control Zone Load area to improve the BA load model when appropriate. The Reliability Coordinators will report total current and next hour expected load in near real-time (every 15 minutes) for each load zone in a CZL for each BA and market under its purview. The total load in a load zone will be distributed among the load buses within the zone, and aggregated for the CZL. Load Shift Factors for each CZL will be determined based on actual load zone distribution, instead of static load values from the base case. The zonal loads will include losses.

The Reliability Coordinators will provide the IDC with current and next hour expected generation output for each generator in a CZL in its footprint in near real-time, every 15 minutes. Three generator output values will be provided to the GTL calculator for each time period (current and next hours) - the total generator output in priorities 2, 6 and 7. The total generator output is the sum of outputs in the three different priorities. The RC providing the generator output data must also provide generator output breakdown of jointly owned units.

The zonal loads and generation outputs will be provided either via the webSDX web service interface or via webData. OATI should provide cost estimates for both communication options and indicate the pros and cons of the two communication methods. If the IDCWG approves the communication via the webSDX, a webSDX Change Order will be provided to document changes to the webSDX system.

2. Modify the TLR calculations so that firm and non-firm GTL impact contributions are used in all TLR levels and by all markets and BAs similarly as to how market flows are used for PJM, MISO and SPP. When a TLR is called on a flowgate, the IDC will calculate GTL relief proportionally to interchange transaction tag impacts. The IDC will report to the Reliability Coordinators (RC) the GTL relief obligations for each BA/market in the RC footprint. It will be the responsibility of the RCs to notify the BAs under its purview of their relief obligations.
3. The markets and BAs will provide the IDC with the flowgate monitored element flows and, where applicable, the flowgate contingency element flows in near real-time (every 15 minutes). The IDC will calculate post-contingency flow by performing a Contingency Analysis on all OTDF flowgates.
4. Provide general flowgate monitoring and tracking displays to assist Reliability Coordinators in managing the total flow (or post-contingency flow) on the flowgates due to scheduled and unscheduled (loop flow) interchange transactions contributions and contributions from markets and BAs GTL contributions.
5. The IDC TLR and Whole Transaction List displays will be modified to show the GTL and tag impacts for every entity, together with the total flow (and post-contingency flow) on the flowgates. Unaccounted flows due to losses and/or voltage dependencies will be displayed as well.

Archival

An impact archival will be added to the IDC that will save tag impacts in the form of schedule and actual MW amounts and TDFs, generation-to-load flows, real-time flows, and unaccounted flows for every flowgate. The TDFs need to be saved for every flowgate and every calculation, not only the flowgates in TLR and the times the flowgates are in TLR, as it is currently done. The archived data must be available online for the current and previous year, for a sliding time from 12 to 24 months. Data must be available off-line and upon request for the previous three calendar years.

Revision 3.0:

In this Revision 3.0, a correction should be made whereby implementation of the Generation-to-Load in the TLR procedure will only take place upon approval by the NERC ORS.

EVALUATOR'S SECTION:

EVALUATOR'S NAME: Open Access Technology International, Inc.

DATE: November 18, 2009.

PROPOSED CHANGE DESCRIPTION: *For the purpose of this Change Order response, the term "GTL impact", or simply "GTL", will be used to signify market flows for PJM, Midwest ISO (MISO) and Southwest Power Pool (SPP), as well as Generation-to-Load impacts for all other Balancing Authorities in the Eastern Interconnection.*

The IDC currently receives market flows from PJM, Midwest ISO (MISO) and Southwest Power Pool (SPP) and process them in TLRs and other monitoring displays, such as the Whole Transaction List. These market flows are calculated by PJM, MISO and SPP and sent to IDC via webData.

Generation-to-Load Calculations:

In this Change Order, the IDC will be modified to calculate Generation-to-Load (GTL) impacts for all Balancing Authorities and markets in the Eastern Interconnection, including PJM, MISO and SPP.

The IDC will be modified to model two-level partitions of BA/market footprints.

- Control Zone Load (CZL) - a BA/market may be partitioned into multiple CZLs. A CZL is a first-level partition of a BA/market footprint for the purpose of calculating GTL impact. The total CZL load, including losses, must be provided by the BAs/markets.
- Load Zone - a Control Zone Load may be partitioned into multiple load zones. A load zone is a second-level partition of a CZL where loads behave similarly. A load zone represents a set of load buses that behave similarly, but different from loads in other load zones. Load zones may represent confirming, non-confirming, industrial, commercial, residential, rural (agricultural irrigation), or loads with specific seasonal behavior. Load zone loads will be determined as a proportion of the CZL load, with the proportionality factor provided by the BAs/markets.

The IDC GTL calculation for a BA/market will be performed for each Control Zone Load within a BA/market, and aggregated for all zones in the BA/market. The following describe the GTL calculations in detail:

- a. Determine the CZL GTL load value as the total load for the CZL (including losses) subtracted by the total CZL load supplied by tag imports:

$$\text{Load}_{\text{GTL-CZL}} = \text{Load}_{\text{CZL}} - \sum \text{TagImport}_{\text{CZL}}$$

Where:

$\text{Load}_{\text{GTL-CZL}}$ is the GTL load of a Control Zone Load

Load_{CZL} is the total load of a CZL (including losses)¹

$\sum \text{TagImport}_{\text{CZL}}$ is the sum of all tag imports into the BA/market, sinking at the CZL²

- b. Determine the total GTL load zone bus for each CZL, as a portion of the total GTL load of the CZL.

$$\text{Load}_{\text{GTL-LoadZone}} = (\text{Load}_{\text{GTL-CZL}} \times W_{\text{LoadZone}}) / \sum W_{\text{LoadZone}}$$

Where:

W_{LoadZone} is the load zone distribution weighting factor of an individual load zone at a CZL.

- c. Determine the bus loads as the proportional distribution of the total load zone among the buses in the load zone.

$$\text{Load}_{\text{GTL-LoadZone-Bus}} = (\text{Load}_{\text{GTL-LoadZone}} \times W_{\text{LoadZone-Bus}}) / \sum W_{\text{LoadZone-Bus}}$$

Where:

¹ A method for distributing the total BA load into the CZLs of a BA needs to be provided. Either the individual CZL loads are provided, or a form of weighted/proportional distribution is provided for each CZL, perhaps as a percentage of the total BA load.

² A method for identify the sink CZL of tag imports for BAs with multiple CZLs needs to be provided. This could be in form of mapping the sink point of a tag to a CZL, or some form of weighted/proportional distribution, or a combination of the two.

$Load_{GTL-LoadZone-Bus}$ is the individual bus load

$W_{LoadZone-Bus}$ is the bus weighting factor of an individual bus at a load zone

- d. Compute the LSF for each control zone:

$$LSF_{CZL} = (BSF_{Bus} \times Load_{GTL-LoadZone-Bus}) / \sum Load_{GTL-LoadZone-Bus}$$

Where

LSF_{CZL} is the LSF of a control zone

BSF_{Bus} is the incremental shift factor of a bus at a CZL on a flowgate, with respect to the swing bus

- e. Ideally, the GTL calculator should receive the MW output of each generator and for each CZL. However, there are many small generators in the footprint where data may not be provided. In order to circumvent this problem, OATI proposes to also receive from the BA/market the total generation output of each CZL. The unaccounted generation, calculated as the difference between the total CZL generation output and the sum of the individual generator outputs will be distributed among the in-service generators in the CZL for which the GTL calculator does not have information:

$$Gen_{Unaccounted-CZL} = Gen_{CZL} - \sum Gen_{Bus}$$

$$Gen_{Unaccounted-CZL-k} = Gen_{Unaccounted-CZL} \times Pmax_{CZL-k} / \sum_n Pmax_{CZL-n}$$

Where

Gen_{CZL} is the total generation output of the CZL

Gen_{Bus} is the bus generation output (measured or next-hour estimated) for a bus at a CZL

$Gen_{Unaccounted-CZL}$ is the total unaccounted generation of the CZL

$Pmax_{CZL-k}$ is the maximum MW output of generator k in CZL

$Gen_{Unaccounted-CZL-k}$ is the output of an unaccounted generator k in CZL

- f. Determine the GTL CZL generation value as the total generation for the CZL subtracted by the total CZL generation supporting tag exports:

$$Gen_{GTL-CZL} = Gen_{CZL} - \sum TagExport_{CZL}$$

Where:

$Gen_{GTL-CZL}$ is the GTL generation of a Control Zone Load

Gen_{CZL} is the total generation of a CZL

$\sum TagExport_{CZL}$ is the sum of all tag exports from the BA/market, sourcing at the CZL³

- g. Determine the GTL generation of each generator as the proportional distribution of the total GTL CZL generation among the generators in the CZL.

$$Gen_{GTL-CZL-Bus} = Gen_{Bus} \times Gen_{GTL-CZL} / Gen_{CZL}$$

Where:

$Gen_{GTL-CZL-Bus}$ is the GTL generator output of a generator

- h. Compare $Gen_{GTL-CZL}$ with $Load_{GTL-CZL}$:

³ A method for identify the source CZL of tag exports for BAs with multiple CZLs needs to be provided. This could be in form of mapping the source point of a tag to a CZL, or some form of weighted/proportional distribution, or a combination of the two.

- 1) When $Gen_{GTL-CZL} > Load_{GTL-CZL}$, then the CZL is self-sufficient and an exporting CZL to other CZLs at the BA/market; the GTL generation fully supplies the CZL load and exports to other CZLs at the BA/market. Set:

$$Gen_{GTL-CZL-native} = Load_{GTL-CZL}$$

$$Load_{GTL-CZL-native} = Load_{GTL-CZL}$$

$$Gen_{GTL-CZL-transfer} = Gen_{GTL-CZL} - Gen_{GTL-CZL-native}$$

$$Load_{GTL-CZL-transfer} = Load_{GTL-CZL} - Load_{GTL-CZL-native} = 0$$

$$Gen_{GTL-CZL-Bus-native} = Gen_{GTL-CZL-Bus} \times Gen_{GTL-CZL-native} / Gen_{GTL-CZL}$$

$$Load_{GTL-CZL-Bus-native} = Load_{GTL-LoadZone-Bus}$$

$$Gen_{GTL-CZL-Bus-transfer} = Gen_{GTL-CZL-Bus} - Gen_{GTL-CZL-Bus-native}$$

$$Load_{GTL-CZL-Bus-transfer} = 0$$

- 2) When $Gen_{GTL-CZL} = Load_{GTL-CZL}$, then the CZL is self-sufficient; all GTL generation at the CZL supplies GTL the CZL load with no spare capacity. Set:

$$Gen_{GTL-CZL-native} = Gen_{GTL-CZL}$$

$$Load_{GTL-CZL-native} = Load_{GTL-CZL}$$

$$Gen_{GTL-CZL-transfer} = Gen_{GTL-CZL} - Gen_{GTL-CZL-native} = 0$$

$$Load_{GTL-CZL-transfer} = Load_{GTL-CZL} - Load_{GTL-CZL-native} = 0$$

$$Gen_{GTL-CZL-Bus-native} = Gen_{GTL-CZL-Bus}$$

$$Load_{GTL-CZL-Bus-native} = Load_{GTL-LoadZone-Bus}$$

$$Gen_{GTL-CZL-Bus-transfer} = 0$$

$$Load_{GTL-CZL-Bus-transfer} = 0$$

- 3) When $Gen_{GTL-CZL} < Load_{GTL-CZL}$, then the CZL is short of generation; all GTL generation supplies the CZL load, and the CZL needs additional transfer support to meet its CZL load. Set:

$$Gen_{GTL-CZL-native} = Gen_{GTL-CZL}$$

$$Load_{GTL-CZL-native} = Gen_{GTL-CZL}$$

$$Gen_{GTL-CZL-transfer} = Gen_{GTL-CZL} - Gen_{GTL-CZL-native} = 0$$

$$Load_{GTL-CZL-transfer} = Load_{GTL-CZL} - Load_{GTL-CZL-native}$$

$$Gen_{GTL-CZL-Bus-native} = Gen_{GTL-CZL-Bus}$$

$$Load_{GTL-CZL-Bus-native} = Load_{GTL-LoadZone-Bus} \times Load_{GTL-CZL-native} / Load_{GTL-CZL}$$

$$Gen_{GTL-CZL-Bus-transfer} = 0$$

$$Load_{GTL-CZL-Bus-transfer} = Load_{GTL-LoadZone-Bus} - Load_{GTL-CZL-Bus-native}$$

- i. Compute the native GTL contributions on the flowgates as:

$$GTL_{Native-Impact} = \sum_{CZL} [\sum_{bus} Gen_{GTL-CZL-Bus-native} \times (GSF_{bus} - LSF_{CZL})]$$

Where:

$GTL_{Native-Impact}$ is the MW impact of a BA/market of each CZL in the BA/market supplying its own CZL load,

$Gen_{GTL-CZL-bus-native}$ is the MW output of a generator in a CZL supporting the load of the CZL, and GSF_{bus} is the Generator Shift Factor of the generator bus.

- j. Compute the BA/market LSF as:

$$LSF_{BA} = \sum (BSF_{Bus} \times Load_{GTL-CZL-Bus-transfer}) / \sum Load_{GTL-CZL-Bus-transfer}$$

- k. For every BA/market, compute the $Load_{GTL-BA-transfer}$ as the sum of $Load_{GTL-CZL-transfer}$, and $Gen_{GTL-BA-transfer}$ as the sum of $Gen_{GTL-CZL-transfer}$, for all CZLs in a BA/market:

$$Load_{GTL-BA-transfer} = \sum Load_{GTL-CZL-transfer}$$

$$Gen_{GTL-BA-transfer} = \sum Gen_{GTL-CZL-transfer}$$

These values correspond to the GTL generation and load of a BA/market that is served from CZLs other than the host CZL (intra-CZL transfers).

- l. Compare $Load_{GTL-BA-transfer}$ with $Gen_{GTL-BA-transfer}$:

- 1) When $Gen_{GTL-BA-transfer} > Load_{GTL-BA-transfer}$, the BA/market has positive inadvertent; that is, the BA/market generates more power than it consumes. The excess generation is exported to other BAs/markets as inadvertent. Since the total generation is greater than the total load, the $Gen_{GTL-CZL-transfer}$ of every exporting CZL in the BA must be scaled down so that the total scaled generation of the BA/market, $Gen_{Scaled-GTL-BA-transfer}$ equals the $Load_{GTL-BA-transfer}$.

$$Gen_{Scaled-GTL-BA-transfer} = Load_{GTL-BA-transfer}$$

$$\mu_{GTL-BA-transfer} = Gen_{Scaled-GTL-BA-transfer} / Gen_{GTL-BA-transfer}$$

$$Gen_{Scaled-GTL-CZL-transfer} = \mu_{GTL-BA-transfer} \times Gen_{GTL-CZL-transfer}$$

The remainder - the difference between $Gen_{GTL-BA-transfer}$ and $Gen_{Scaled-GTL-BA-transfer}$, is the export inadvertent. The scaled transfer CZL load equals the transfer CZL load ($Load_{Scaled-GTL-CZL-transfer} = Load_{GTL-CZL-transfer}$).

- 2) When $Gen_{GTL-BA-transfer} < Load_{GTL-BA-transfer}$, the BA/market has a negative inadvertent; that is, the BA/market generates less power than it consumes. The generation deficit is provided in the form of import inadvertent. Since the total generation is smaller than the total load, the $Load_{GTL-CZL-transfer}$ of every CZL in the BA/market must be scaled down so that the scaled load, $Load_{Scaled-GTL-BA-transfer}$ equals the $Gen_{GTL-BA-transfer}$. The remainder - the difference between $Load_{GTL-BA-transfer}$ and $Load_{Scaled-GTL-BA-transfer}$, is the import inadvertent. The scaled transfer CZL generation equals the transfer CZL generation ($Gen_{Scaled-GTL-CZL-transfer} = Gen_{GTL-CZL-transfer}$).
- 3) When $Gen_{GTL-BA-transfer} = Load_{GTL-BA-transfer}$, the generation meets the load and there is no inadvertent for the BA/market.

- m. Compute the transfer GTL contributions on the flowgates as:

$$GTL_{Transfer-Impact} = \sum Gen_{GTL-CZL-Bus-transfer} \times (GSF_{bus} - LSF_{BA})$$

Where:

$GTL_{Transfer-Impact}$ is the MW impact of a BA/market of the BA/market transfer interchange between CZLs,

$Gen_{GTL-CZL-Bus-transfer}$ is the transfer MW of every generator, and

LSF_{BA} is the LSF of the BA for the loads that are supplied from CZL transfers.

- n. The control zones with excess generation are considered exporting control zones within the BA/market, while the control zones with deficit generation are considered importing control zones within the BA/market.

The total GTL impact on a flowgate is calculated as the sum of the impact of CZLs generation supplying the CZLs load added to the impact of intra-BA/market transfers between CZLs in a BA/market.

$$GTL_{\text{Transfer-Impact}} = GTL_{\text{Native-Impact}} + GTL_{\text{Transfer-Impact}}$$

The following describes an example of GTL calculations for a Balancing Authority. Figure 1, below, depicts a sample footprint of a BA subdivided into three Control Zone Loads, CZL-A, CZL-B and CZL-C, where CZL-A is further partitioned into load zones A1, A2 and A3, while CZL-B and CZL-C represent load zones B and C, respectively.

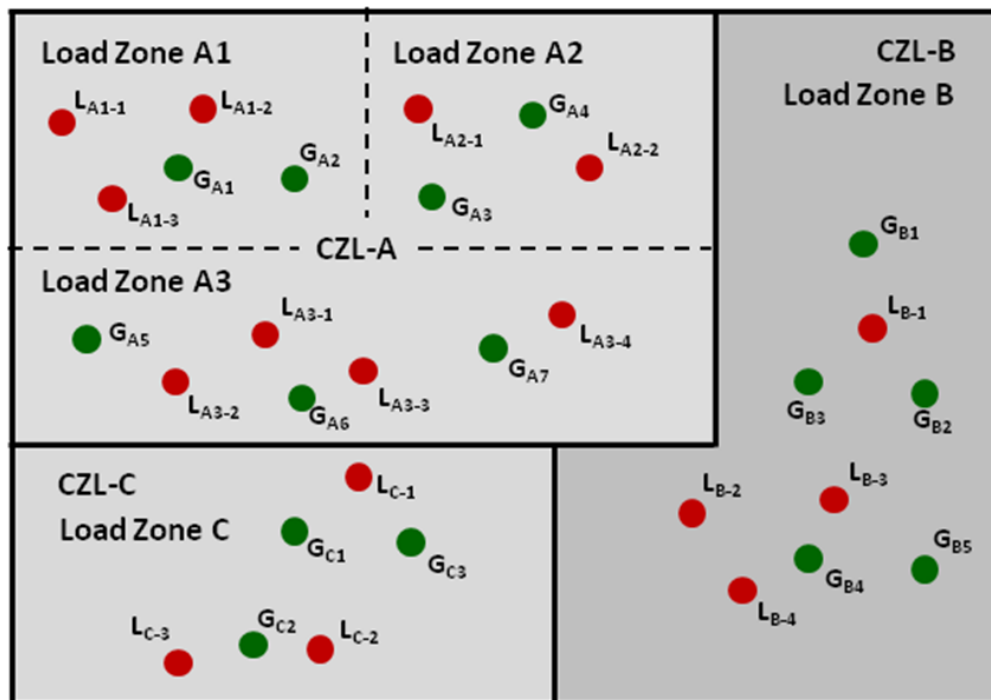


Figure 1. BA/market partitioned into three Control Zone Loads, with CZLs partitioned into load zones.

The GTL calculator receives the following CZL load information from the Balancing Authority:

- CZL-A load: 2,500 MW
- CZL-B load: 2,000 MW
- CZL-C load: 1,500 MW

In addition, the GTL calculator is notified that Load Zone A1 has 25% of CZL-A load, Load Zone A2 has 35% of CZL-A load, and Load Zone A3 has 40% of CZL-A load. As such, the load of the load zones are:

- Load Zone A1: 625 MW
- Load Zone A2: 875 MW
- Load Zone A3: 1,000 MW

Suppose also that there are 1,100 MW of imports into the BA, and that 250 MW can be associated to CZL-A, 400 MW is imported into CZL-B, and 150 MW is imported into CZL-C. Consequently, the

remaining 300 MW of import cannot be directly associated to any CZL and is proportionally distributed among the CZLs. The GTL load of the CZLs prior to the distribution of the unassigned 300 MW is:

- $GTL_{CZL-A} = 2,500 - 250 = 2,250$ MW
- $GTL_{CZL-B} = 2,000 - 400 = 1,600$ MW
- $GTL_{CZL-C} = 1,500 - 150 = 1,350$ MW

The distribution of the remaining 300 MW changes the GTL load of the CZLs as follows:

- $GTL_{CZL-A} = 2,250 - 300 \times 2,250 / (2,250 + 1,600 + 1,350) = 2,120$ MW
- $GTL_{CZL-B} = 1,600 - 300 \times 1,600 / (2,250 + 1,600 + 1,350) = 1,508$ MW
- $GTL_{CZL-C} = 1,350 - 300 \times 1,350 / (2,250 + 1,600 + 1,350) = 1,272$ MW

Suppose the base case loads and Bus Shift Factors as follows:

- CZL-A:
 - Load Zone A1:
 - $L_{A1-1} = 300$ $BSF_{A1-1} = 0.200$
 - $L_{A1-2} = 250$ $BSF_{A1-2} = 0.180$
 - $L_{A1-3} = 350$ $BSF_{A1-3} = 0.220$
 - Load Zone A2:
 - $L_{A2-1} = 400$ $BSF_{A2-1} = 0.150$
 - $L_{A2-2} = 200$ $BSF_{A2-2} = 0.120$
 - Load Zone A3:
 - $L_{A3-1} = 300$ $BSF_{A3-1} = 0.170$
 - $L_{A3-2} = 200$ $BSF_{A3-2} = 0.250$
 - $L_{A3-3} = 100$ $BSF_{A3-3} = 0.180$
 - $L_{A3-4} = 400$ $BSF_{A3-4} = 0.140$
- CZL-B (Load Zone B):
 - $L_{B-1} = 250$ $BSF_{B-1} = 0.080$
 - $L_{B-2} = 350$ $BSF_{B-2} = 0.050$
 - $L_{B-3} = 200$ $BSF_{B-3} = 0.020$
 - $L_{B-4} = 200$ $BSF_{B-4} = 0.110$
- CZL-C (Load Zone C):
 - $L_{C-1} = 150$ $BSF_{C-1} = 0.310$
 - $L_{C-2} = 50$ $BSF_{C-2} = 0.350$
 - $L_{C-3} = 200$ $BSF_{C-3} = 0.400$

The GTL load of each individual load is calculated as follows:

- CZL-A:
 - Load Zone A1:
 - $L_{GTL-A1-1} = 300 \times 2,120 \times 0.25 / (300 + 250 + 350) = 177$ MW
 - $L_{GTL-A1-2} = 250 \times 2,120 \times 0.25 / (300 + 250 + 350) = 147$ MW
 - $L_{GTL-A1-3} = 350 \times 2,120 \times 0.25 / (300 + 250 + 350) = 206$ MW
 - Load Zone A2:
 - $L_{GTL-A2-1} = 400 \times 2,120 \times 0.35 / (400 + 200) = 495$ MW
 - $L_{GTL-A2-2} = 200 \times 2,120 \times 0.35 / (400 + 200) = 247$ MW
 - Load Zone A3:
 - $L_{GTL-A3-1} = 300 \times 2,120 \times 0.40 / (300 + 200 + 100 + 400) = 254$ MW
 - $L_{GTL-A3-2} = 200 \times 2,120 \times 0.40 / (300 + 200 + 100 + 400) = 170$ MW
 - $L_{GTL-A3-3} = 100 \times 2,120 \times 0.40 / (300 + 200 + 100 + 400) = 85$ MW

- $L_{GTL-A3-4} = 400 \times 2,120 \times 0.40 / (300 + 200 + 100 + 400) = 339 \text{ MW}$
- CZL-B (Load Zone B):
 - $L_{GTL-B-1} = 250 \times 1,508 / (250 + 350 + 200 + 200) = 377 \text{ MW}$
 - $L_{GTL-B-2} = 350 \times 1,508 / (250 + 350 + 200 + 200) = 528 \text{ MW}$
 - $L_{GTL-B-3} = 200 \times 1,508 / (250 + 350 + 200 + 200) = 302 \text{ MW}$
 - $L_{GTL-B-4} = 200 \times 1,508 / (250 + 350 + 200 + 200) = 302 \text{ MW}$
- CZL-C (Load Zone C):
 - $L_{GTL-C-1} = 150 \times 1,272 / (150 + 50 + 200) = 477 \text{ MW}$
 - $L_{GTL-C-2} = 50 \times 1,272 / (150 + 50 + 200) = 159 \text{ MW}$
 - $L_{GTL-C-3} = 200 \times 1,272 / (150 + 50 + 200) = 636 \text{ MW}$

The LSF of each CZL is calculated as:

$$LSF_{CZL-A} = (\sum L_{GTL-A1-n} \times BSF_{A1-n} + \sum L_{GTL-A2-n} \times BSF_{A2-n} + \sum L_{GTL-31-n} \times BSF_{A3-n}) / (\sum L_{GTL-A1-n} + \sum L_{GTL-A1-n} + \sum L_{GTL-A1-n}) = 0.1882$$

$$LSF_{CZL-B} = (\sum L_{GTL-B-n} \times BSF_{B-n}) / \sum L_{GTL-B-n} = 0.0635$$

$$LSF_{CZL-C} = (\sum L_{GTL-C-n} \times BSF_{C-n}) / \sum L_{GTL-C-n} = 0.3600$$

Assume the generation output and GSFs as follows. The generation supports the native load of the BA and exports totaling 300 MW, of which 100 MW is known to be sourced at CZL-B.

- CZL-A:
 - $G_{A1} = 250 \text{ MW}$ $GSF_{A1} = 0.210$
 - $G_{A2} = 400 \text{ MW}$ $GSF_{A2} = 0.170$
 - $G_{A3} = 700 \text{ MW}$ $GSF_{A3} = 0.140$
 - $G_{A4} = 150 \text{ MW}$ $GSF_{A4} = 0.130$
 - $G_{A5} = 650 \text{ MW}$ $GSF_{A5} = 0.270$
 - $G_{A6} = 300 \text{ MW}$ $GSF_{A6} = 0.175$
 - $G_{A7} = 100 \text{ MW}$ $GSF_{A7} = 0.150$
 - $Total_{CZL-A} = 2,550 \text{ MW}$
- CZL-B:
 - $G_{B1} = 280 \text{ MW}$ $GSF_{B1} = 0.090$
 - $G_{B2} = 320 \text{ MW}$ $GSF_{B2} = 0.040$
 - $G_{B3} = 400 \text{ MW}$ $GSF_{B3} = 0.050$
 - $G_{B4} = 250 \text{ MW}$ $GSF_{B4} = 0.070$
 - $G_{B5} = 150 \text{ MW}$ $GSF_{B5} = 0.010$
 - $Total_{CZL-B} = 1,400 \text{ MW}$
- CZL-C:
 - $G_{C1} = 650 \text{ MW}$ $GSF_{C1} = 0.330$
 - $G_{C2} = 350 \text{ MW}$ $GSF_{C2} = 0.380$
 - $G_{C3} = \text{unaccounted}$ $GSF_{C3} = 0.340$
 - $Total_{CZL-C} = 1,250 \text{ MW}$

The generation of G_{C3} is not provided and is unaccounted for. The MW output of G_{C3} is calculated as the difference between the total CZL-C generation and total accounted generation in CZL-C:

$$G_{C3} = Total_{CZL-C} - G_{C1} - G_{C2} = 1,250 - 650 - 350 = 300 \text{ MW}$$

In order to determine the GTL generation of each CZL, the exports known to source at CZL-B must be subtracted from the generation at CZL-B:

- $G'_{B1} = G_{B1} - \text{Export}_{\text{CZL-B}} \times G_{B1} / (G_{B1} + G_{B2} + G_{B3} + G_{B4} + G_{B5}) = 280 - 100 \times 280 / (1,400) = 260 \text{ MW}$
- $G'_{B2} = G_{B2} - \text{Export}_{\text{CZL-B}} \times G_{B2} / (G_{B1} + G_{B2} + G_{B3} + G_{B4} + G_{B5}) = 320 - 100 \times 320 / (1,400) = 297 \text{ MW}$
- $G'_{B3} = G_{B3} - \text{Export}_{\text{CZL-B}} \times G_{B3} / (G_{B1} + G_{B2} + G_{B3} + G_{B4} + G_{B5}) = 400 - 100 \times 400 / (1,400) = 371 \text{ MW}$
- $G'_{B4} = G_{B4} - \text{Export}_{\text{CZL-B}} \times G_{B4} / (G_{B1} + G_{B2} + G_{B3} + G_{B4} + G_{B5}) = 250 - 100 \times 250 / (1,400) = 232 \text{ MW}$
- $G'_{B5} = G_{B5} - \text{Export}_{\text{CZL-B}} \times G_{B5} / (G_{B1} + G_{B2} + G_{B3} + G_{B4} + G_{B5}) = 150 - 100 \times 150 / (1,400) = 139 \text{ MW}$

The remaining exports (unassigned to any individual CZL) are proportionally subtracted from the generators, and the following GTL generation is computed:

$$G_{\text{GTL-A1}} = G_{A1} - \text{Export}_{\text{BA}} \times G_{A1} / (\Sigma G_{An} + \Sigma G'_{Bn} + \Sigma G_{Cn}) = 250 - 200 \times 250 / (2550 + 1300 + 1250) = 240 \text{ MW}$$

$$G_{\text{GTL-A2}} = G_{A2} - \text{Export}_{\text{BA}} \times G_{A2} / (\Sigma G_{An} + \Sigma G'_{Bn} + \Sigma G_{Cn}) = 400 - 200 \times 400 / (2550 + 1300 + 1250) = 384 \text{ MW}$$

$$G_{\text{GTL-A3}} = G_{A3} - \text{Export}_{\text{BA}} \times G_{A3} / (\Sigma G_{An} + \Sigma G'_{Bn} + \Sigma G_{Cn}) = 700 - 200 \times 700 / (2550 + 1300 + 1250) = 673 \text{ MW}$$

$$G_{\text{GTL-A4}} = G_{A4} - \text{Export}_{\text{BA}} \times G_{A4} / (\Sigma G_{An} + \Sigma G'_{Bn} + \Sigma G_{Cn}) = 150 - 200 \times 150 / (2550 + 1300 + 1250) = 144 \text{ MW}$$

$$G_{\text{GTL-A5}} = G_{A5} - \text{Export}_{\text{BA}} \times G_{A5} / (\Sigma G_{An} + \Sigma G'_{Bn} + \Sigma G_{Cn}) = 650 - 200 \times 650 / (2550 + 1300 + 1250) = 625 \text{ MW}$$

$$G_{\text{GTL-A6}} = G_{A6} - \text{Export}_{\text{BA}} \times G_{A6} / (\Sigma G_{An} + \Sigma G'_{Bn} + \Sigma G_{Cn}) = 300 - 200 \times 300 / (2550 + 1300 + 1250) = 288 \text{ MW}$$

$$G_{\text{GTL-A7}} = G_{A7} - \text{Export}_{\text{BA}} \times G_{A7} / (\Sigma G_{An} + \Sigma G'_{Bn} + \Sigma G_{Cn}) = 100 - 200 \times 100 / (2550 + 1300 + 1250) = 96 \text{ MW}$$

$$G_{\text{GTL-B1}} = G'_{B1} - \text{Export}_{\text{BA}} \times G'_{B1} / (\Sigma G_{An} + \Sigma G'_{Bn} + \Sigma G_{Cn}) = 260 - 200 \times 260 / (2550 + 1300 + 1250) = 250 \text{ MW}$$

$$G_{\text{GTL-B2}} = G'_{B2} - \text{Export}_{\text{BA}} \times G'_{B2} / (\Sigma G_{An} + \Sigma G'_{Bn} + \Sigma G_{Cn}) = 297 - 200 \times 297 / (2550 + 1300 + 1250) = 285 \text{ MW}$$

$$G_{\text{GTL-B3}} = G'_{B3} - \text{Export}_{\text{BA}} \times G'_{B3} / (\Sigma G_{An} + \Sigma G'_{Bn} + \Sigma G_{Cn}) = 371 - 200 \times 371 / (2550 + 1300 + 1250) = 356 \text{ MW}$$

$$G_{\text{GTL-B4}} = G'_{B4} - \text{Export}_{\text{BA}} \times G'_{B4} / (\Sigma G_{An} + \Sigma G'_{Bn} + \Sigma G_{Cn}) = 232 - 200 \times 232 / (2550 + 1300 + 1250) = 223 \text{ MW}$$

$$G_{\text{GTL-B5}} = G'_{B5} - \text{Export}_{\text{BA}} \times G'_{B5} / (\Sigma G_{An} + \Sigma G'_{Bn} + \Sigma G_{Cn}) = 139 - 200 \times 139 / (2550 + 1300 + 1250) = 134 \text{ MW}$$

$$G_{\text{GTL-C1}} = G_{C1} - \text{Export}_{\text{BA}} \times G_{C1} / (\Sigma G_{An} + \Sigma G'_{Bn} + \Sigma G_{Cn}) = 650 - 200 \times 650 / (2550 + 1300 + 1250) = 625 \text{ MW}$$

$$G_{\text{GTL-C2}} = G_{C2} - \text{Export}_{\text{BA}} \times G_{C2} / (\Sigma G_{An} + \Sigma G'_{Bn} + \Sigma G_{Cn}) = 350 - 200 \times 350 / (2550 + 1300 + 1250) = 336 \text{ MW}$$

$$G_{\text{GTL-C3}} = G_{C3} - \text{Export}_{\text{BA}} \times G_{C3} / (\Sigma G_{An} + \Sigma G'_{Bn} + \Sigma G_{Cn}) = 300 - 200 \times 300 / (2550 + 1300 + 1250) = 288 \text{ MW}$$

Calculate the $\text{Gen}_{\text{GTL-CZL}}$ and $\text{Load}_{\text{GTL-CZL}}$ for each CZL:

- $\text{Gen}_{\text{GTL-CZL-A}} = 2,450 \text{ MW}$ $\text{Load}_{\text{GTL-CZL-A}} = 2,120 \text{ MW}$
- $\text{Gen}_{\text{GTL-CZL-B}} = 1,248 \text{ MW}$ $\text{Load}_{\text{GTL-CZL-B}} = 1,509 \text{ MW}$
- $\text{Gen}_{\text{GTL-CZL-C}} = 1,249 \text{ MW}$ $\text{Load}_{\text{GTL-CZL-C}} = 1,272 \text{ MW}$
- **Total Gen = 4,947 MW** **Total Load = 4,901 MW**

Since the total generation is greater than the total load, scale down the total generation to meet the total load. The remaining difference is inadvertent generation (export from the BA):

- $\text{Gen}_{\text{Scaled-GTL-CZL-A}} = 2,450 \times 4,901 / 4,947 = 2,427 \text{ MW}$ $\text{Load}_{\text{GTL-CZL-A}} = 2,120 \text{ MW}$
- $\text{Gen}_{\text{Scaled-GTL-CZL-B}} = 1,248 \times 4,901 / 4,947 = 1,236 \text{ MW}$ $\text{Load}_{\text{GTL-CZL-B}} = 1,509 \text{ MW}$
- $\text{Gen}_{\text{Scaled-GTL-CZL-C}} = 1,249 \times 4,901 / 4,947 = 1,237 \text{ MW}$ $\text{Load}_{\text{GTL-CZL-C}} = 1,272 \text{ MW}$
- **Total Scaled Gen = 4,901 MW** **Total Load = 4,901 MW**
- **Inadvertent Export = 46 MW** **Inadvertent Import = 0 MW**

The generator outputs supporting GTL, excluding inadvertent, are also scaled down:

$$G_{\text{Scaled-GTL-A1}} = 240 \times 4,901 / 4,947 = 237.8 \text{ MW}$$

$$G_{\text{Scaled-GTL-A2}} = 384 \times 4,901 / 4,947 = 380.4 \text{ MW}$$

$$G_{\text{Scaled-GTL-A3}} = 673 \times 4,901 / 4,947 = 666.7 \text{ MW}$$

$$G_{\text{Scaled-GTL-A4}} = 144 \times 4,901 / 4,947 = 142.7 \text{ MW}$$

$$G_{\text{Scaled-GTL-A5}} = 625 \times 4,901 / 4,947 = 619.2 \text{ MW}$$

$$G_{\text{Scaled-GTL-A6}} = 288 \times 4,901 / 4,947 = 285.3 \text{ MW}$$

$$G_{\text{Scaled-GTL-A7}} = 96 \times 4,901 / 4,947 = 95.1 \text{ MW}$$

$$G_{\text{Scaled-GTL-B1}} = 250 \times 4,901 / 4,947 = 247.7 \text{ MW}$$

$$G_{\text{Scaled-GTL-B2}} = 285 \times 4,901 / 4,947 = 282.3 \text{ MW}$$

$$\begin{aligned}G_{\text{Scaled-GTL-B3}} &= 356 \times 4,901 / 4,947 = 352.7 \text{ MW} \\G_{\text{Scaled-GTL-B4}} &= 223 \times 4,901 / 4,947 = 220.9 \text{ MW} \\G_{\text{Scaled-GTL-B5}} &= 134 \times 4,901 / 4,947 = 132.8 \text{ MW} \\G_{\text{Scaled-GTL-C1}} &= 625 \times 4,901 / 4,947 = 619.2 \text{ MW} \\G_{\text{Scaled-GTL-C2}} &= 336 \times 4,901 / 4,947 = 335.8 \text{ MW} \\G_{\text{Scaled-GTL-C3}} &= 288 \times 4,901 / 4,947 = 285.3 \text{ MW}\end{aligned}$$

For each CZL, compute the native and transfer $\text{Gen}_{\text{GTL-CZL}}$, native and transfer $\text{Load}_{\text{GTL-CZL}}$, and also compute the native and transfer values for each individual generator and native and transfer loads for each individual load:

- CZL-A:
 - $\text{Gen}_{\text{GTL-CZL-A-native}} = 2,120 \text{ MW}$
 - $\text{Load}_{\text{GTL-CZL-A-native}} = 2,120 \text{ MW}$
 - $\text{Gen}_{\text{GTL-CZL-A-transfer}} = 2,427 - 2,120 = 307 \text{ MW}$
 - $\text{Load}_{\text{GTL-CZL-A-transfer}} = 0 \text{ MW}$
 - Generator A1:
 - $\text{Gen}_{\text{GTL-native-A1}} = 237.8 \times 2,120 / 2,427 = 207.7 \text{ MW}$
 - $\text{Gen}_{\text{GTL-transfer-A1}} = 237.8 \times 307 / 2,427 = 30.1 \text{ MW}$
 - Generator A2:
 - $\text{Gen}_{\text{GTL-native-A2}} = 380.4 \times 2,120 / 2,427 = 332.3 \text{ MW}$
 - $\text{Gen}_{\text{GTL-transfer-A2}} = 380.4 \times 307 / 2,427 = 48.1 \text{ MW}$
 - Generator A3:
 - $\text{Gen}_{\text{GTL-native-A3}} = 666.7 \times 2,120 / 2,427 = 582.4 \text{ MW}$
 - $\text{Gen}_{\text{GTL-transfer-A3}} = 666.7 \times 307 / 2,427 = 84.3 \text{ MW}$
 - Generator A4:
 - $\text{Gen}_{\text{GTL-native-A4}} = 142.7 \times 2,120 / 2,427 = 124.6 \text{ MW}$
 - $\text{Gen}_{\text{GTL-transfer-A4}} = 142.7 \times 307 / 2,427 = 18.1 \text{ MW}$
 - Generator A5:
 - $\text{Gen}_{\text{GTL-native-A5}} = 619.2 \times 2,120 / 2,427 = 540.9 \text{ MW}$
 - $\text{Gen}_{\text{GTL-transfer-A5}} = 619.2 \times 307 / 2,427 = 78.3 \text{ MW}$
 - Generator A6:
 - $\text{Gen}_{\text{GTL-native-A6}} = 285.3 \times 2,120 / 2,427 = 249.2 \text{ MW}$
 - $\text{Gen}_{\text{GTL-transfer-A6}} = 285.3 \times 307 / 2,427 = 36.1 \text{ MW}$
 - Generator A7:
 - $\text{Gen}_{\text{GTL-native-A7}} = 95.1 \times 2,120 / 2,427 = 83.1 \text{ MW}$
 - $\text{Gen}_{\text{GTL-transfer-A7}} = 95.1 \times 307 / 2,427 = 12.0 \text{ MW}$
 - Load A1-1:
 - $\text{Load}_{\text{GTL-native-A1-1}} = 177 \text{ MW}$
 - $\text{Load}_{\text{GTL-transfer-A1-1}} = 0 \text{ MW}$
 - Load A1-2:
 - $\text{Load}_{\text{GTL-native-A1-2}} = 147 \text{ MW}$
 - $\text{Load}_{\text{GTL-transfer-A1-2}} = 0 \text{ MW}$
 - Load A1-3:
 - $\text{Load}_{\text{GTL-native-A1-3}} = 206 \text{ MW}$
 - $\text{Load}_{\text{GTL-transfer-A1-3}} = 0 \text{ MW}$
 - Load A2-1:
 - $\text{Load}_{\text{GTL-native-A2-1}} = 495 \text{ MW}$
 - $\text{Load}_{\text{GTL-transfer-A2-1}} = 0 \text{ MW}$
 - Load A2-2:
 - $\text{Load}_{\text{GTL-native-A2-2}} = 247 \text{ MW}$
 - $\text{Load}_{\text{GTL-transfer-A2-2}} = 0 \text{ MW}$
 - Load A3-1:

- $\text{Load}_{\text{GTL-native-A3-1}} = 254 \text{ MW}$
 - $\text{Load}_{\text{GTL-transfer-A3-1}} = 0 \text{ MW}$
 - Load A3-2:
 - $\text{Load}_{\text{GTL-native-A3-2}} = 170 \text{ MW}$
 - $\text{Load}_{\text{GTL-transfer-A3-2}} = 0 \text{ MW}$
 - Load A3-3:
 - $\text{Load}_{\text{GTL-native-A3-3}} = 85 \text{ MW}$
 - $\text{Load}_{\text{GTL-transfer-A3-3}} = 0 \text{ MW}$
 - Load A3-4:
 - $\text{Load}_{\text{GTL-native-A3-4}} = 339 \text{ MW}$
 - $\text{Load}_{\text{GTL-transfer-A3-4}} = 0 \text{ MW}$
- CZL-B:
 - $\text{Gen}_{\text{GTL-CZL-B-native}} = 1,236 \text{ MW}$
 - $\text{Load}_{\text{GTL-CZL-B-native}} = 1,236 \text{ MW}$
 - $\text{Gen}_{\text{GTL-CZL-B-transfer}} = 0 \text{ MW}$
 - $\text{Load}_{\text{GTL-CZL-B-transfer}} = 1,509 - 1,236 = 273 \text{ MW}$
 - Generator B1:
 - $\text{Gen}_{\text{GTL-native-B1}} = 247.7 \text{ MW}$
 - $\text{Gen}_{\text{GTL-transfer-B1}} = 0 \text{ MW}$
 - Generator B2:
 - $\text{Gen}_{\text{GTL-native-B2}} = 282.3 \text{ MW}$
 - $\text{Gen}_{\text{GTL-transfer-B2}} = 0 \text{ MW}$
 - Generator B3:
 - $\text{Gen}_{\text{GTL-native-B3}} = 352.7 \text{ MW}$
 - $\text{Gen}_{\text{GTL-transfer-B3}} = 0 \text{ MW}$
 - Generator B4:
 - $\text{Gen}_{\text{GTL-native-B4}} = 220.9 \text{ MW}$
 - $\text{Gen}_{\text{GTL-transfer-B4}} = 0 \text{ MW}$
 - Generator B5:
 - $\text{Gen}_{\text{GTL-native-B5}} = 132.8 \text{ MW}$
 - $\text{Gen}_{\text{GTL-transfer-B5}} = 0 \text{ MW}$
 - Load B-1:
 - $\text{Load}_{\text{GTL-native-B-1}} = 377 \times 1,236 / 1,509 = 308.8 \text{ MW}$
 - $\text{Load}_{\text{GTL-transfer-B-1}} = 377 \times 273 / 1,509 = 68.2 \text{ MW}$
 - Load B-2:
 - $\text{Load}_{\text{GTL-native-B-2}} = 528 \times 1,236 / 1,509 = 432.5 \text{ MW}$
 - $\text{Load}_{\text{GTL-transfer-B-2}} = 528 \times 273 / 1,509 = 95.5 \text{ MW}$
 - Load B-3:
 - $\text{Load}_{\text{GTL-native-B-3}} = 302 \times 1,236 / 1,509 = 247.4 \text{ MW}$
 - $\text{Load}_{\text{GTL-transfer-B-3}} = 302 \times 273 / 1,509 = 54.6 \text{ MW}$
 - Load B-4:
 - $\text{Load}_{\text{GTL-native-B-4}} = 302 \times 1,236 / 1,509 = 247.4 \text{ MW}$
 - $\text{Load}_{\text{GTL-transfer-B-4}} = 302 \times 273 / 1,509 = 54.6 \text{ MW}$
- CZL-C:
 - $\text{Gen}_{\text{GTL-CZL-C-native}} = 1,237 \text{ MW}$
 - $\text{Load}_{\text{GTL-CZL-C-native}} = 1,237 \text{ MW}$
 - $\text{Gen}_{\text{GTL-CZL-C-transfer}} = 0 \text{ MW}$
 - $\text{Load}_{\text{GTL-CZL-C-transfer}} = 2,272 - 1,237 = 35 \text{ MW}$
 - Generator C1:
 - $\text{Gen}_{\text{GTL-native-C1}} = 619.2 \text{ MW}$
 - $\text{Gen}_{\text{GTL-transfer-C1}} = 0 \text{ MW}$
 - Generator C2:
 - $\text{Gen}_{\text{GTL-native-C2}} = 335.8 \text{ MW}$

- $Gen_{GTL-transfer-C2} = 0 \text{ MW}$
- Generator C3:
 - $Gen_{GTL-native-C3} = 285.3 \text{ MW}$
 - $Gen_{GTL-transfer-C3} = 0 \text{ MW}$
- Load C-1:
 - $Load_{GTL-native-C-1} = 477 \times 1,237 / 1,272 = 463.9 \text{ MW}$
 - $Load_{GTL-transfer-C-1} = 477 \times 35 / 1,272 = 13.1 \text{ MW}$
- Load C-2:
 - $Load_{GTL-native-C-2} = 159 \times 1,237 / 1,272 = 154.6 \text{ MW}$
 - $Load_{GTL-transfer-C-2} = 159 \times 35 / 1,272 = 4.4 \text{ MW}$
- Load C-3:
 - $Load_{GTL-native-C-3} = 636 \times 1,237 / 1,272 = 618.5 \text{ MW}$
 - $Load_{GTL-transfer-C-3} = 636 \times 35 / 1,272 = 17.5 \text{ MW}$

The native GTL contribution on the flowgate is calculated as:

$$\begin{aligned}
 GTL_{native-CZL-A-Impact} &= 207.7 \times (0.210 - 0.1882) + \\
 & 332.3 \times (0.170 - 0.1882) + \\
 & 582.4 \times (0.140 - 0.1882) + \\
 & 124.6 \times (0.130 - 0.1882) + \\
 & 540.9 \times (0.270 - 0.1882) + \\
 & 249.2 \times (0.175 - 0.1882) + \\
 & 83.1 \times (0.150 - 0.1882) = \\
 & = 0.94 \text{ MW}
 \end{aligned}$$

$$\begin{aligned}
 GTL_{native-CZL-B-Impact} &= 247.7 \times (0.090 - 0.0635) + \\
 & 282.3 \times (0.040 - 0.0635) + \\
 & 352.7 \times (0.050 - 0.0635) + \\
 & 220.9 \times (0.070 - 0.0635) + \\
 & 132.8 \times (0.010 - 0.0635) = \\
 & = -10.50 \text{ MW}
 \end{aligned}$$

$$\begin{aligned}
 GTL_{native-CZL-C-Impact} &= 619.2 \times (0.330 - 0.3600) + \\
 & 335.8 \times (0.380 - 0.3600) + \\
 & 285.3 \times (0.340 - 0.3600) = \\
 & = -17.57 \text{ MW}
 \end{aligned}$$

The LSF of the BA for the purpose of computing the transfer GTL is:

$$\begin{aligned}
 LSFBA &= (68.2 \times 0.08 + 95.5 \times 0.05 + 54.6 \times 0.02 + 54.6 \times 0.11 + 13.1 \times 0.31 + 4.4 \times 0.35 + 17.5 \times 0.40) / \\
 & (68.2 + 95.5 + 54.6 + 13.1 + 4.4 + 17.5) = \\
 & = 0.118
 \end{aligned}$$

The transfer GTL contribution on the flowgate is calculated as:

$$\begin{aligned}
 GTL_{Transfer-CZL-A-Impact} &= 30.1 \times (0.210 - 0.118) + \\
 & 48.1 \times (0.170 - 0.118) + \\
 & 84.3 \times (0.140 - 0.118) + \\
 & 18.1 \times (0.130 - 0.118) + \\
 & 78.3 \times (0.270 - 0.118) + \\
 & 36.1 \times (0.175 - 0.118) + \\
 & 12.0 \times (0.150 - 0.118) = \\
 & = 21.69 \text{ MW}
 \end{aligned}$$

$$GTL_{\text{Transfer-CZL-B-Impact}} = 0 \text{ MW}$$

$$GTL_{\text{Transfer-CZL-C-Impact}} = 0 \text{ MW}$$

The total GTL impact on the flowgate for the BA is the sum of the GTL_{native} impact for all CZLs in the BA added to the sum of the GTL_{Transfer} impact for all CZLs in the BA:

$$GTL_{\text{Impact}} = 0.94 - 10.50 - 17.57 + 21.69 = -5.44 \text{ MW}$$

The GTL_{Impact} above, corresponds to the total net GTL impact. This value needs to be broken down into forward and reverse directions, and also be calculated for 5% or higher impact:

- The forward direction GTL only includes the generators where their GTL impacts (native and transfer) are positive.
- The reverse direction GTL only includes the generator where their GTL impacts (native and transfer) are negative.
- The 5% or higher impact in the forward direction only includes the generators where their GTL impacts are positive (native and transfer) and GLDF is greater than 5%.
- The 5% or higher impact in the reverse direction only includes the generators where their GTL impacts are negative (native and transfer) and GLDF is less than 5%.

Other GTL points of consideration:

- In the example above, it has been assumed that generators' upper and lower MW limits are "unlimited" and zero, respectively. In reality, this is not the case. The generators lower and upper MW limits will be respected in GTL calculations. If a generator MW is calculated to be below its lower limit, the MW amount of the generator will be set to the lower limit, and the remaining difference will be proportionally distributed between the generators that are above the lower limit. Likewise, if a generator MW is calculated to be above its upper limit, the MW amount of the generator will be set to the upper limit, and the remaining difference will be proportionally distributed between the generators that are below the upper limit. The generator output transfer message will support the transfer of upper and lower limits. These limits will be used in lieu of generator limits in the IDC base case. However, the IDC base case limits (PMax and PMin) will be used when limits are not provided by the RCs.
- The GTL calculations for different priority levels (2, 6 and 7) is not clearly defined as of yet. It is assumed for the purpose of evaluating this Change Order that the generator outputs will be provided in priorities 2, 6 and 7. A decision on the method for calculating and determining GTL in different priorities will be discussed at NAESB. The evaluation of this Change Order may be modified pending the outcome of the NAESB standard definition.
- Jointly owned unit information has not been accounted in the Change Order. OATI proposes that the message that provides the generator output also provide the breakdown for multiple generator owners, including the generators upper and lower limits.
- BA internal flow controlled devices, such as phase shifters and DC lines, whereby non-tagged transactions are scheduled through the DC line need to be incorporated to the GTL calculation. OATI proposes to create CZLs at both ends of the controlling device with generation and load. The RCs/BAs will need to provide the scheduled and actual flow setting at the controlled devices. At the receiving end of the device (inverter, for a DC line), the flow will be added as load, while at the sending end of the device (converter, for a DC line), the flow will be added

as generation. To the extent that tags can be targeted to a controlling device, the schedule/actual amount of the tag will be subtracted from the schedule/actual flow of the controlling device, and the corresponding load and generation. The remaining controlling device flow (and generation and load) will be assigned as GTL, either as native or transfer GTL.

- Tagged dynamic schedules do not provide the actual value of the generation/load. OATI proposes to incorporate into the message interface the ability for RCs and BAs to provide actual and next-hour forecast value for dynamic schedules. These values, when available, will be used in the GTL calculations, instead of the tagged amount.
- Pump storage units can either be in generation or pumping mode. When in generation mode, the MW amount of the unit is positive and its amount is included in the total generation of the CZL. When in pump mode, the MW amount of the unit is negative and its amount is included in the total load of the CZL. In order to properly validate negative MW amounts from pump storage units, OATI needs to be able to know ahead of time the units that are pump storage capable.

TLR Calculations:

The IDC needs to be configured to process GTL impacts from all Balancing Authorities and Markets in the Eastern Interconnection. The current NNL calculations in TLR will be replaced by the usage of GTL impact. The modification of the TLR procedures and calculations to include GTL impact contributions and relief obligations will be implemented in the IDC following the NERC ORS approval. However, the IDC will maintain the NNL logic as a backstop for flowgates that could have NNL responsibility and are not flagged as GTL flowgates, or in the event of missing data. This will be performed the same way as the IDC currently processes market flow/NNL for PJM, MISO and SPP.

Additional Changes:

The following additional requests are made via this Change Order:

- *The IDC will receive real-time flows from the flowgate owners in near real-time.*

OATI proposes that near-real-time flow be sent to the IDC no more often than once every fifteen minutes for each flowgate. Flow values will be sent for each monitored and contingency element in a flowgate. The flowgate definition will be modified to indicate the RC that will provide the data for each monitored/contingency element. Multiple RCs may submit data for a given flowgate, but only one RC shall submit data for any given element. This is especially necessary in the event that a contingency element is located in a different RC footprint than the monitored element(s). This data needs to be propagated and maintained in the Book of Flowgates Database Management System, but the IDC flowgate editing displays also need to be modified accordingly.

OATI proposes to use the same data communication infrastructure mechanism used for providing the generator outputs, to provide flowgate flows.

The IDC will also compare the total measured flowgate flow with the total GTL and tag impact flow. The difference (unaccounted flow) can be attributed to many different things, such as, modeling inconsistencies, non-linearity of the GTL and tag impact flow calculations, inadvertent interchange, losses, etc. These unaccounted flows will be computed and displayed in the IDC user interface.

The IDC will also maintain the unaccounted flows over time and use this information to forecast future flows, up to two hours ahead in 15 minute intervals, using exponential smoothing techniques. The IDC will maintain profiles for different day types (days of the week), and are continuously updated as new flow measurements are received and impacts are calculated. The updated profiles and latest measurements are used to predict flows into the future. The technique has been successfully deployed on many OATI projects. The forecasted flowgate flows can be used by the Reliability Coordinators as an additional real-time tool for determining the need for requesting TLR, and/or the relief amount.

- *The IDC User Interface needs to be modified to display the GTL impacts, tag impacts and near-real-time flows. In addition, the IDC will compute and display the unaccounted flows as the difference between the near-real-time flows and the sum of all impacts (GTL and tag). Unaccounted flows are caused by modeling errors such as, network model, outages, inadvertent, losses, etc.*

OATI proposes to implement these displays in tabular and graphical form. The design of these displays will be done in conjunction with the IDCWG.

- *The IDC needs to archive the tag impacts and GTL impacts on all flowgates in support of audit trail and after-the-fact analysis online for a period of up to 24 months (current and previous year), and off-line for a period of 36 months.*

The storage requirements for storing this data can be quite significant, especially the archival of tag impacts on every flowgate for every 15 minute interval (same periodicity as GTL impacts and near-real-time flows will be available). Instead, OATI proposes the following alternative:

- Archive all GTL impacts for every flowgate and every BA/RTO, up to four snapshots per hour.
- Archive all actual flows (and limits, if available) for every flowgate, as reported by the Reliability Coordinator.
- Archive GTL and tag impact contributions, unaccounted flows, and flow estimates and standard deviation values, up to four snapshots per hour.
- For every flowgate, group tags into four categories according to their TDF impact:
 - Forward Impacting tags (FIT) with $TDF \geq +\text{threshold}\%$
 - Reverse Impacting tags (RIT) with $TDF \leq -\text{threshold}\%$
 - Forward Residual Impacting tags (FRIT) with $0 \leq TDF < +\text{threshold}\%$
 - Reverse Residual Impacting tags (RRIT) with $-\text{threshold}\% < TDF < 0$

All Forward Impacting and Reverse Impacting tags will be archived individually for every tag and flowgate. Archived data include the tags' TDF, MW (schedule and active), MW impact (schedule and active), and source and sink points.

All Residual Impacting tags (Forward and Reverse) are archived as an aggregate of all tags in each category; only the total impact of Forward Residual and Reverse Residual Impacting tags are archived. Archival will take place up to four snapshots per hour.

- In the event that the Residual Impacting tags need to be individually analyzed, OATI proposes to a) archive every tag individually, together with their source and sink points and MW (schedule and active), and b) archive the TDF matrices (flowgate, source/sink

point and TDF) for every calculation. The TDF matrices and tags enable the IDC user to query the archive system for detailed information on residual tags.