MISO Generation Deliverability Study Method

Introduction

This document serves the purpose of providing the methodology to determine whether or not a generator can be certified as deliverable under either the Midwest ISO's 1) Tariff Attachment X (Large Generator Interconnection Process for Network Resource Interconnection Service), or 2) Energy Market Tariff (EMT) Module E: Resource Adequacy Requirements. A generator that is certified deliverable (not bottled-up) could be designated by any Load Serving Entity (LSE) within the Midwest Energy Market footprint to satisfy its Resource Adequacy requirement as specified in EMT Module E. The generator deliverability study is a complement of Midwest ISO Load deliverability study performed in the Midwest ISO expansion planning process.

The way this is determined is by performing a "Generator Deliverability Study" (deliverability study). This study analyzes the ability of groups of generation in small pockets throughout the Midwest ISO footprint to operate at their maximum capability without being "bottled up" by transmission constraints. The test is performed in a 7-step process, which is outlined in detail in this document. The 7 steps can be grouped into 3 sections: Create a load flow model that is adequate for the study, perform the load flow analyses to find the potential "bottling" constraints (pre-screening), then post-process these results. The post-processing involves creating an "electrical circle" of generators around each potentially overloaded facility, such facilities determined during the second step, and using a reasonableness test to limit the amount of generators contributing to the flow on the overloaded element.

The generation deliverability study is one piece of Generation Interconnection Study and Transmission Expansion Planning Study process and will supplement rather than replace existing interconnection and planning studies. New generators applying for Network Resource Interconnection Service (NRIS) under the Midwest ISO Tariff Attachment X that pass the deliverability study qualify for deliverability certification. The deliverability study was also applied to existing generating resources, prior to the start of the Midwest Energy Market. The deliverability study should be performed during the Expansion Planning Study process to ensure that existing certified resources remain deliverable.

Study Method

Step 1: Setup a 'Deliverability Case'

Purpose of Step 1: Establish a "deliverability case" where MISO summer peak load and interchange are served by MISO NR resources and line flows are close to typical planning cases.

First of all, all wind farms' maximum output should be reduced to 20% in the model because only 20% of wind farm's maximum output can be counted for capacity purpose unless demonstrated otherwise.

The Deliverability Case is developed from a future 5 year out MTEP summer peak "contractual dispatch" case. A "merit order dispatch" is then performed/verified on each local area. Furthermore, fictitious generators are removed from the case and replaced with other NR generators within the same subregion. Higher queued NRIS projects or existing NR units that weren't dispatched to meet Midwest ISO load, loss and interchange are modeled at 0MW but available to be turned on. ER units not needed to meet Midwest ISO load, loss, and interchange requirements remain turned off in the study. This case remains relatively constant until the availability of the next-year MTEP case (Note: consideration will be given to redispatching the base case or turning on newly granted NRs if significant impacts are anticipated).

When testing the deliverability of a specific generator, this subject generator should be dispatched at its maximum output level in this specific Deliverability Case.

If there is any change in the network before the 5 year horizon that may impact the deliverability of the subject generator under study, sensitivity studies should be performed as determined by the Ad Hoc group discussion process.

In all cases, units external to MISO are dispatched the same way as in MMWG/MTEP case.

The Deliverability Case should include all "planned" transmission projects according to MISO Transmission Expansion Planning (MTEP) study at the time of the deliverability study. If a planned facility creates a constraint, it needs to coordinate with MTEP study, considering the queue order of generator and transmission projects. Deliverability model should be reviewed by transmission owners before the study and the study result (constraints) should also be reviewed by transmission owners.

Step 2: Use MUST to capture potential constraints that could bottle NR's

Purpose of Step 2: Use MUST algorithm to find potential facility thermal violations by looking at both pre-shift condition and worst dispatch condition. This step is a pre-screening process that obtains a list of potential facility overloads to be passed to the post-processing phase of the study (Step 3-4).

The following steps outline the input files used by MUST and the process to obtain the list of potential constraints for post-processing.

MUST input files:

Case file: The Deliverability Case file created from Step 1.

Sub file: Includes subsystems: MISO_EXP, MISO_IMP, and others that are needed to support the .mon and .con files.

MISO_EXP and MISO_IMP both contain all resources located in the MISO energy market footprint. By including all units in the exporting area, every unit's deliverability will be studied by MUST. By including all units in the importing area, MUST will, during the generator sensitivity study, dispatch the "most contributing units" against all MISO units so that MISO interchange with neighbors will be kept at the same level during this study.

Intuitively, it may appear problematic that there is overlap in the importing and exporting areas in this subsystem file. Practically, this is not a problem given the small ratio of the size of every single unit to the whole MISO system. The impact is negligible.

Mon file: This should include facilities in the affected areas of 69kV and above, non-thermal-limited MISO flowgates, and MISO external flowgates unless determined otherwise in the study process.

Con file: Use the expansion planning study contingency file (corresponding to the base case used to create the Deliverability Case) that has been reviewed by the Model Building Group and Expansion Planning Group. Besides specific contingency files, MUST automatic N-1 contingencies of monitored elements in effective area will also be used. NERC category C & D contingencies are removed from the contingency file in this deliverability study.

Exc file: Use the exclude file from expansion planning study that corresponds to the contingency file. It may also exclude other branches/contingencies as appropriate according to Transmission Owner's input. In addition, the deliverability study also excludes, for processing purpose only, some N-0 overloaded branches from being monitored for all contingencies. For these branches, N-0 issues should be fixed first and we can then check whether any contingency would overload this branch, otherwise MUST would report the same overloaded branch for every contingency and thus causes large unnecessary processing burden.

MUST options:

Because some of overload problems may show up in an AC power flow analysis but not in DC power flow, we set the branch rating multiplier in MUST at 98% (loading over 98% branch rating will be reported). Note that because the opposite is also true, sometimes, Step 6 is performed at the proper time. MUST option "convert branch rating to estimated MW rating" should be chosen to convert apparent power line ratings to real power rating. For the generator sensitivity portion of the analysis, a zero percent cutoff is used for option "PTDF/OTDF" to make sure all potential overload violations show up. This cutoff is not used to determine the actual constraints, but is merely a "trick" used to get MUST to report the constraints we want to analyze further.

MUST run:

Use MUST to perform two runs to find potential constraints:

1. "Pre-shift thermal violations". Without any transfer specified, use MUST to show both N-0 and contingency violations in the Deliverability Case obtained in step 1. Use the MUST function "DC contingency analysis => analysis by monitored elements => all violations list => branches".

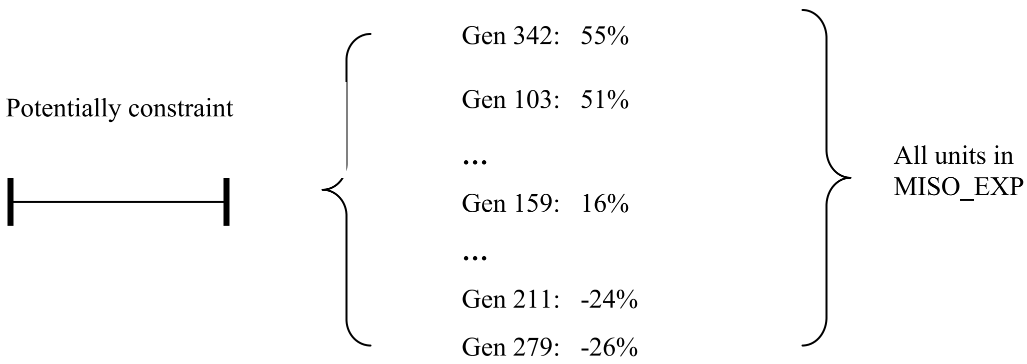
2. "Generator Sensitivity" (algorithm that determines "worst dispatch" thermal violations). Use MUST "generator sensitivity" function to test transfer from MISO_EXP (MISO Export) to MISO_IMP (MISO Import) for up to 8000 MW (By using MISO as the exporting area, every MISO unit's deliverability will be considered. By using MISO as the importing area, MISO interchange will be kept as the same level during the worst dispatch, as described in step 2. Through a trial and error method, MISO determined that at this time 8000MW transfer cap is sufficient to reveal all credible overloads caused by worst dispatch. This parameter will be reviewed periodically and revised if appropriate.). For each combination of monitored facility and contingency, MUST algorithm calculates sensitivity information (OTDF/PTDF) for each generator's contribution on this facility. Generators having DF value larger than a threshold (5% for this study) are dispatched up to their Pmax one by one, in order of their DF (highest to lowest), against all units in the importing area until any of the following events happens: 1) the facility thermal violations occur; 2) no more generator to turn on/up; 3) total transfer level has reached 8000 MW. The result of the Generator Sensitivity study is a list of branch/contingency thermal violations (N-0 is contingency #0 in MUST).

Not all facility thermal violations found in this step are due to credible dispatch conditions. This will be addressed in Step 3 and 4.

Step 3: Construct the DF (OTDF/PTDF) list (post process)

Purpose of Step 3: Determine the contribution factor of each generator on potential constraints to be used by Step 4. This is the first post-processing step to determine which, if any, generators are bottled up by each constraint.

For each identified potential constraint in Step 2, use the MUST function "monitored element sensitivity" to obtain the distribution factor (DF) of all generators in area MISO_EXP on that facility under corresponding contingency.

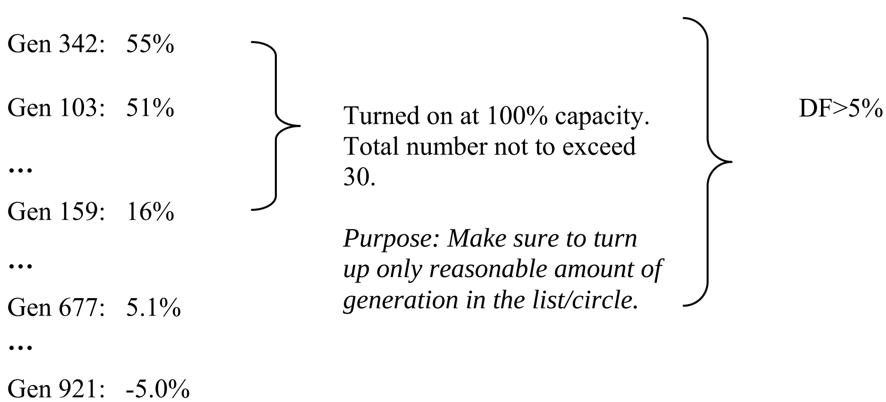


For a new generator seeking NRIS through interconnection study process, each constrained facility is analyzed to determine his impact on that facility. If the new generator does not increase the line loading or only provides counter-flow to potential constraints, the generator is deliverable. New generators that have contributing flow on any facility are flagged for further study.

Step 4: Define "severe yet credible" dispatch – "Top 30 DF" list

Purpose of Step 4: For each potential constraint, find a severe yet credible dispatch and thus a severe yet credible facility loading. The intent is to stress the constraint without "piling on" an outrageously large number of generators that contribute to the constraint.

The steps in determining the severe yet credible flow are as follows. For each overloaded facility from Step 2, a list is created to include all NR (or equivalent) units with a 5% or greater DF on the potential constraint. The list is sorted in order of descending DF value. Then, these NR units in the list with the highest DF are sequentially turned up to their full capacity, if it is not already dispatched at the maximum level, until either all units with 5% or greater DF to the constraint are selected, or the top 30 units are included – "Top 30 DF" list.



Estimate the "severe yet credible" loading on each facility shown in Step 2:

$$P_{est} = P_{base} - \sum P_{gen} * DFAX + \sum (P_{max} - P_{gen}) * DFAX$$

ERs with >=5%dfax *NR in* the "Top 30 DF" list

Local Capacity Resource (LCR) is treated the same way as NR in deliverability study. The second term to the right of the equal sign is to eliminate the positive loading contribution from the ERs that were turned on in the Deliverability Case merely to meet Midwest ISO load, loss, and interchange requirements, if that exists.

Step 5. Loading Adder -- Account for "remote" offline generators with large impact

Purpose of Step 5: Because the impact of flows from large offline generators that are outside of the "Top 30 DF" list are not captured in Step 4, but can be non-negligible, this step captures that contribution.

To account for the impact of these large offline NR's that are outside of the "Top 30 DF" list, any offline generator whose DF is greater than 5% AND its MW impact (Pmax*DF) on the constraint is larger than 20% of the line rating is turned on to its Pmax. The incremental line flow on the constraint from these generators is called Loading Adder.

$$\text{Loading Adder} = \sum_{\text{Offline NR outside the "Top 30 DF" list}} (\text{Requested Capacity*DF})$$

Adjusted line loading is then:
$P_{adj} = P_{est}$ + Loading Adder

P_{adj} is then compared to line MW rating. Cases within which P_{adj} is larger than line MW rating will be passed to Step 6.

Step 6. AC verification

Purpose of Step 6: For verification purpose, an AC load flow is run on selected constraints with the "Top 30 DF" list dispatched at full output and the state of the case (contingency, or pre-contingency) modeled. This provides a sanity check on the results from step 4.

During AC verification, all units within the "Top 30 DF" list are turned up to their P_{max} in the Deliverability Case. All remaining units in MISO are proportionally displaced to maintain the original interchange. AC power flow solution is then performed to verify the facility loading with the DC result obtained in Step 4. The purpose is to avoid not certifying any units that would otherwise be certified by comparing actual AC power flow solution with apparent branch rating. AC verification is not required if P_{adj} is higher than 110% of line MVA rating. (On the other hand, in order to avoid missing some AC overloads in DC power flow, we used a 98% rating multiplier and the estimated MW rating during DC run in Step 2.)

Step 7. Result

If the verified AC loading plus the Loading Adder (adjusted to MVA value using the line flow power factor) is greater than the actual line MVA rating, all the generators in the "Top 30 DF" list and Loading Adder are not simultaneously fully deliverable. If some unit outside of “Top 30 DF” list connecting to a common transmission bus with some generator within “Top 30 DF” list, this unit will also be deemed as contributing to the constraint and not simultaneously fully deliverable with units in the “Top 30 DF” list.

While testing a new generator, the subject generator is deemed as not deliverable even if it is not within the “Top 30 DF” list or the Loading Adder list if this is true: some line was not overloaded in the “before” case (without this subject generator in case) but is overloaded in the “after” case (case where this generator is added and dispatched), and the generator’s DF is greater than 5%.

All deliverability limiting constraints should be verified with Transmission Owner/Provider as part of Ad Hoc study group process.

Operating guide is considered when the deliverability is tested on all existing generators. Operating guide is considered for new interconnection request only if the guide does not involve restriction of existing generators or acceptable regional practice.

Treatment of Failed Generators

For an existing Designated Network Resource (DNR), the failed MW become Local Capacity Resource (LCR) and can only be designated by the load who had firm transmission right to it before the commence of the Midwest Energy Market to meet this specific load’s resource adequacy requirement.

For an existing non-DNR, the generator can submit an Interconnection Request to MISO requesting for Network Resource Interconnection Service (NRIS). MISO will perform study to see what system upgrade is necessary to make it deliverable.

For an interconnection request under study, the interconnection customer can choose either to make the network upgrades to eliminate the constraint, or to proceed with Energy Resource Interconnection Service (ERIS) instead.