2020 Benchmark GMD Vulnerability Assessment Scope and Process

Version 1.0

Document Revisions

Date	Version	Description	Author(s)
07/01/2020	1.0	First draft	Minnie Han
			Reviewed by: Ping Yan, John Bernecker, Jeff Billo

Table of Contents

1. Introduction

The Benchmark Geomagnetic Disturbance Vulnerability Assessment (GMDVA) is the result of a coordinated planning process, performed by ERCOT System Planning with review and input by NERC registered Transmission Planners (TPs), Transmission Owners (TOs), Generator Owners (GOs), and other stakeholders. This process produces a region-wide GMDVA of the transmission system in accordance with the requirements of NERC Reliability Standard TPL-007-3 and the ERCOT Planning Guide. The 2020 Benchmark GMDVA Scope and Process document captures the scope for planning studies conducted as part of the 2020 ERCOT Benchmark GMDVA. This document also briefly describes the process and various deliverables applicable to the 2020 ERCOT Benchmark GMDVA.

2. Scope

The 2020 ERCOT Benchmark GMDVA shall identify reliability needs and Corrective Action Plans (CAPs) to meet those needs per applicable performance criteria in the ERCOT Planning Guide and the NERC TPL-007-3 reliability standard.

The 2020 Benchmark GMDVA will be based on the following cases of the final Geomagnetically-Induced Current (GIC) System models (both the GIC AC model and GIC DC model):

- 2022 Summer peak load case
- 2022 Minimum load case

To the extent practical, CAPs identified in the 2020 Benchmark GMDVA will be based on consensus between ERCOT and the NERC registered TSPs and Resource Entities with input from other market participants.

Start cases and assessment results will be made available for review via the MIS Secure and Certified area.

3. Input Assumptions

3.1. Benchmark GMDVA Start Case

The 2022 Summer Peak and Minimum Load GIC System models developed by the ERCOT Planning Geomagnetic Disturbance Task Force (PGDTF) will be used as the starting cases for the Benchmark GMDVA.

3.2. GMD Event

The Benchmark GMD Event as described in NERC TPL-007-3, a reference peak geoelectric field amplitude of 8 V/km, will be used in the GMD simulations for the 2020 ERCOT Benchmark GMDVA.

3.3. Geomagnetically Induced Reactive Power Losses

The reactive power losses produced by transformers modeled in the system are automatically generated by the GIC analysis software; however, the reactive power losses produced by DC Ties modeled without transformers are not automatically generated. The calculation of those losses will be incorporated using the following equation from the PSS/E Program Operation Manual:

$$3 - Phase\ Mvar\ Losses = I_{eff} \times K_{factor} \times \frac{V_H}{500}$$

$$= I_{eff} \times K_{factor(2)}$$

Where:

- I_{eff} = Effective GIC flow (amp/phase)
- V_H = Transformer winding highest voltage (kV)
- K_{factor} = Scaling factor defined at 500 kV of V_H (Mvar/amp)
- $K_{factor(2)}$ = Scaling factor provided in GIC data file (Mvar/amp)

If the K_{factor} is not provided by the equipment owner, a default value will be used. If the transformer core type is available, the default value will be based on the transformer core type. Otherwise, the default value will be determined by the highest winding base kV voltage level of the transformer. The default values that will be used can be found in the PSS/E Program Application Guide Volume 1.

3.4. Ratings and Limits

For voltage analysis, pre-contingency and post-contingency limits for all buses 100 kV and above will be monitored. The steady state voltage criteria used in the 2020 Benchmark GMDVA is defined in Planning Guide section 4.1.1.4

Automatic tripping will occur for elements that exceed their relay loadability limits on Transmission Facilities that are 100 kV and above. These trip settings are collected from TSPs via the SSWG process. If such ratings are not available from the TSPs, or the ratings are lower than the emergency rating of the equipment, a default limit will be used. This default limit is determined to be the lower of:

- 115% of the emergency rating; or
- 150% of the normal rating.

When applicable, Under-Voltage Load Shed (UVLS) information from TSPs, and generator over-voltage and under-voltage trip settings from Resource Asset Registration Forms (RARFs), will be modeled. Default values for generator over-voltage and under-voltage trip settings will be used if those trip settings are not available.

The default values that will be used for generator over-voltage and under-voltage trip settings are:

- For renewable generators: 0.9 pu and 1.1 pu for under-voltage and over-voltage trip settings, respectively; and
- For all other generators: the post-contingency voltage limits.

Appropriate Generic Transmission Constraint (GTC) limits, as identified by the latest planning studies, will be modeled.

4. Benchmark GMDVA Process and Method of Study

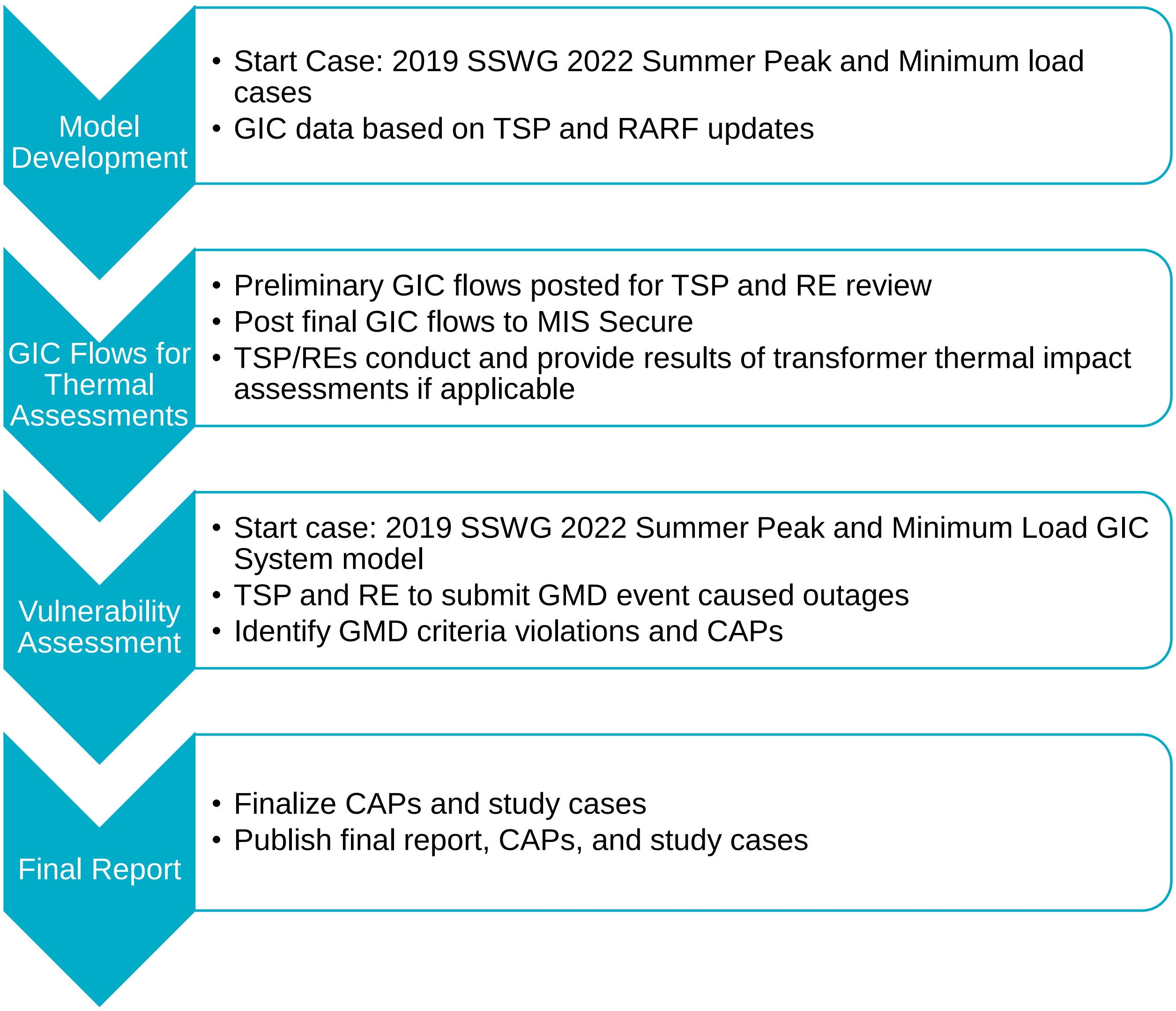

Figure 1: 2020 Benchmark GMDVA Methodology

4.1. Benchmark GMDVA Case Preparation

Both the GIC AC model and the GIC DC model will be updated and conditioned in collaboration with PGDTF to address any GIC System model issues before beginning the benchmark GMDVA. Additionally, ERCOT will tune voltages and reactive support in the GIC AC model so that voltages are within, or as close to, acceptable limits and will communicate with corresponding TSPs on specific tuning measures.

The following subsections outline updates made to the GIC System model to prepare the cases for the benchmark GMDVA.

4.1.1. Transformer Thermal Impact Assessment Results

If applicable, transformer owners with transformers that meet R6 of TPL-007-3, based on provided GIC flow information, are required to perform thermal impact assessments for any transformer with GIC flows exceeding the 75 A/phase threshold for the benchmark event so that suggested actions to mitigate the impact of GICs can be incorporated into the benchmark GMDVA start cases.

There were no transformers with GIC flows exceeding the 75 A/phase benchmark GMD event threshold in the 2020 Benchmark GMDVA.

4.1.2. Benchmark GMD Event Caused Outages

GMD event induced quasi-DC GIC currents in transformer windings result in asymmetric or half-cycle saturation of transformer cores, which high-voltage transformers are more susceptible to. Saturation of transformers can lead to increased generation of harmonics resulting in the potential removal of equipment from service due to protection system operation or misoperation.

In preparation for the 2020 Benchmark GMDVA, TSPs and Resource Entities are required to assess the impact of the benchmark GMD event to develop a list of potential equipment that may be removed from service as a result of generated harmonics.

To facilitate credible outage analysis based on the GMD events described in Planning Guide 6.11 paragraph (2)(a), TSPs and Resource Entities will categorize event outages as outlined below before submitting these outages to ERCOT to be included in the Benchmark GMDVA.

- Category A outage: equipment anticipated to have a high probability of tripping offline due to harmonics during the benchmark GMD event and may be studied simultaneously in the benchmark GMDVA.

- Category B outage: equipment anticipated to have a lower probability of tripping offline due to harmonics during the benchmark GMD event and may be studied one at a time in the benchmark GMDVA.

TSPs and Resource Entities will be requested to label each outage that could occur as a direct consequence of the benchmark GMD event only as either Category A or Category B.

4.2. Method of Study

4.2.1. Reactive Losses

The geoelectric field orientation that produces the most reactive power losses may not reveal all potential issues caused by the benchmark GMD event, thus a degree scan will be performed across the GIC system model in 10-degree increments. The case used will have a baseline configuration with the Category A outages applied to determine the reactive power losses produced for different orientations.

For each orientation selected by the degree scan, a change file with reactive losses modeled as loads having only MVAR values will be produced. The reactive power losses produced by DC Ties modeled without transformers will be calculated as described in Section 3.3.

4.2.2. Steady State Voltage Performance Analysis

The reactive power loss change files, as described in Section 4.2.1, will be used to incorporate reactive power losses to the GIC AC model for each orientation selected by the degree scan. Category B outages will be applied one at a time as contingencies and powerflow analysis will be performed to determine if the system meets the steady-state voltage performance criteria. Unsolved powerflows, which may indicate potential voltage collapse issues, will also be investigated.

Manual system adjustments, such as transmission configuration changes, transformer tap changes, and generation re-dispatch, will be implemented first to resolve any reliability criteria violations. Reliability criteria violations that cannot be resolved with system adjustments will be discussed with TSPs for feedback, which will then be used to develop CAPs as needed.

4.2.3. Cascading Analysis

Cascading analysis will be conducted to identify any potential cascading or uncontrolled separation events. Transmission Facilities (100 kV and above) that exceed their relay loadability limits will be assumed to trip automatically and will be removed from service.

Load at buses with known UVLS protection schemes where the voltage falls below their under-voltage set point and generators with buses on the low side of the Generator Step Up (GSU) transformer that experience voltages lower than its under-voltage trip limits or higher than its over-voltage trip limits will also be assumed to trip automatically.

For issues that are a result of a potential cascading event, or uncontrolled islanding, CAPs will be developed in conjunction with TSPs and Resource Entities.

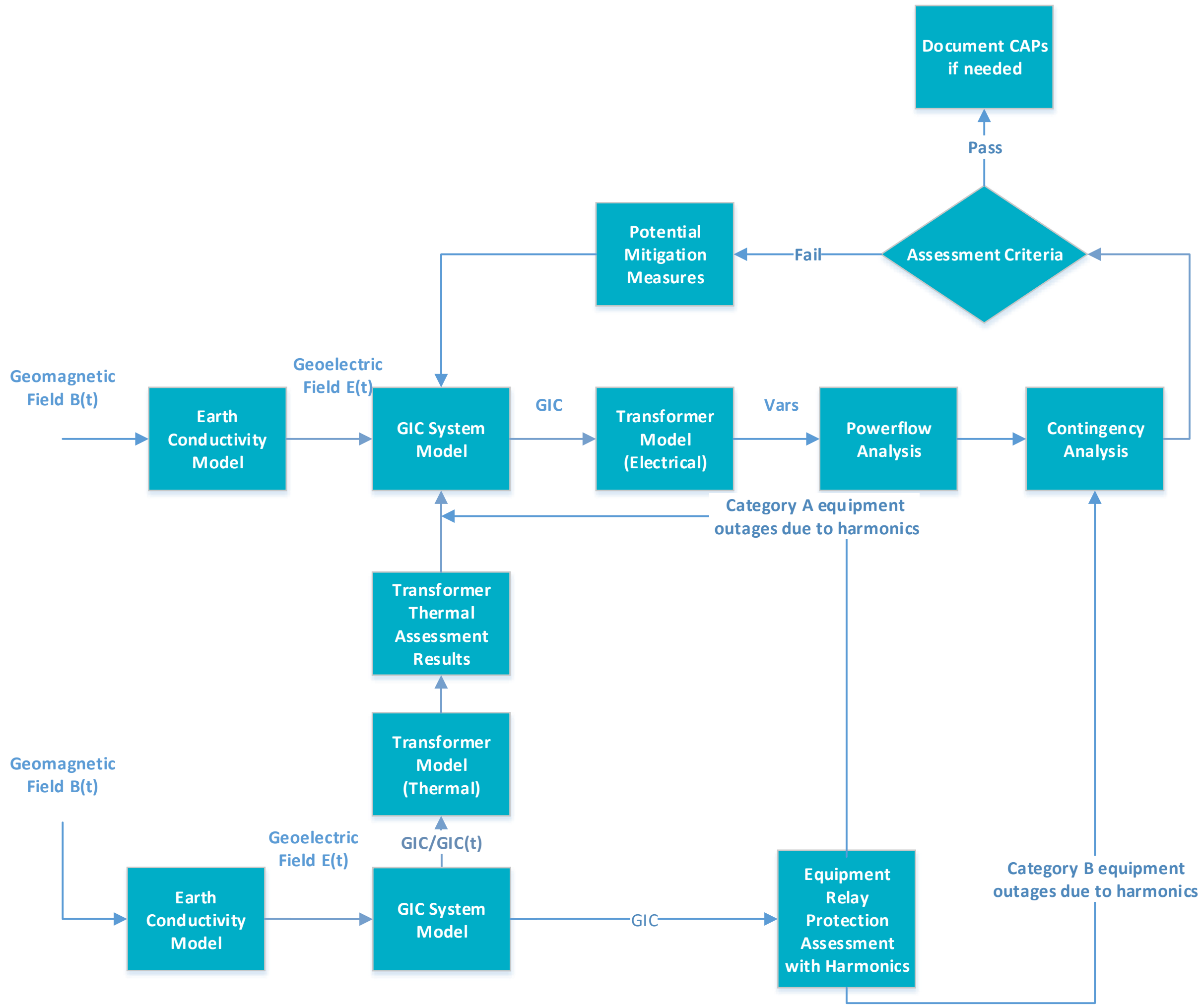

Figure 2: Benchmark GMDVA Flowchart

5. Corrective Action Plans

5.1. Identifying CAPs

ERCOT and TSPs will develop and document CAPs to meet Benchmark GMD Reliability performance requirements outlined in Section 3.3 above. Each CAP will list system deficiencies and the associated actions required to meet the Benchmark GMD Reliability Criteria. Examples of such actions include:

- Installation, modification, retirement, or removal of Transmission and generation Facilities, and any associated equipment.
- Installation, modification, or removal of protection systems or Remedial Action Schemes.
- Use of Operating Procedures, specifying how long they will be needed as part of the CAP.
- Use of Demand-Side Management, new technologies, or other initiatives.

CAPs that propose upgrades or additions subject to Protocol Section 3.11.4 will be reviewed within the Regional Planning Group Review Process. All other CAPs will be reviewed by ERCOT to ensure that it addresses reliability criteria.

6. Deliverables

In the course of the analysis, the following information, at the minimum, will be shared with stakeholders via the MIS Certified area:

- Initial GIC System model (GIC DC and AC models)[1]
- TSP and RE identified Category A and B outages
- GIC System model cases with Category A outages[1]

The following information will be shared with stakeholders via the MIS Secure area:

- GMDVA study cases (AC model)
- Reactive power losses for all orientations
- Preliminary Benchmark GMDVA Assessment results with preliminary CAPs
- Final Benchmark GMDVA Report and CAPs

[1] Cases for both the 2022 Summer Peak load and 2022 Minimum load GIC System models will be provided.