Consideration of Comments

Project 2020-06 Verification of Models and Data for Generators
MOD-026-2 Draft 1 | Posted May – July, 2022

Comments Received Summary
There were 79 sets of responses, including comments from approximately 180 different people from approximately 110 companies representing 10 of the Industry Segments as shown in the table on the following pages.

All comments submitted can be reviewed in their original format on the project page. If you feel that your comment has been overlooked, please let us know immediately. Our goal is to give every comment serious consideration in this process. If you feel there has been an error or omission, you can contact Vice President of Engineering and Standards Howard Gugel (via email) or at (404) 446-9693.

Consideration of Comments
The Project 2020-06 standard drafting team (SDT) thanks all of industry for your time and comments. The SDT revised the proposed MOD-026-2 standard based on industry comment and feedback from the Quality Review team. Due to the similar nature of multiple comments received during the initial ballot and comment period, the SDT has chosen to respond to comments in summary format as described in Section 4.12 of the Standard Processes Manual.

Abbreviations

- Generator Owner (GO)
- Transmission Owner (TO)
- Transmission Planner (TP)
- Planning Coordinator (PC)
- Electromagnetic transient (EMT)
- Inverter-based resource (IBR)
- Original equipment manufacturer (OEM)

Question 1. Combine MOD-026/027 into a single standard, MOD-026-2

1. Clarify whether verified models for R2/R3 or R4/R5/R6 need to be provided to the TP at the same time. For example, if an excitation system for synchronous generator is changed per Requirement R7, then an updated model would be provided for Requirement R2, but not needed for Requirement R3.

   - Change made. See update to Requirement R7. Requirements R2/R3 or R4/R5/R6 do not need to be performed at the same time. Compliance with each Requirement and periodicity

can be demonstrated independently from the other Requirements, including when a change happens under Requirement R7. However, an applicable entity may find it more efficient to perform the required actions in a similar timeframe.

2. Request additional clarification of how a hybrid or collocated resources are to be modeled.

- As of August 17, 2022, reference the *ERO Enterprise CMEP Practice Guide for Application of the Bulk Electric System Definition to BESS and Hybrid Resources* for examples of hybrid resources.

- The TP will identify which positive sequence and EMT models are acceptable to use, and how hybrid/collocated plants are to be equivalenced under Requirement R1.

- *See Figure 16: Synchronous + BESS, Sync. 2x 25 MVA, Aggregate Plant 70 MVA, Sync. BES Resources and BESS non-BES Resource.* For this Facility, Inclusion I2 is met, since each synchronous generator is greater than 20MVA, whereas the BESS are non-BES Resource. Therefore, Requirements R2 and R3 apply. Provide a verified positive sequence dynamic model(s), associated parameters, and accompanying information that represent the in-service equipment of the Facility. The BESS resources need not be included in the verified model.
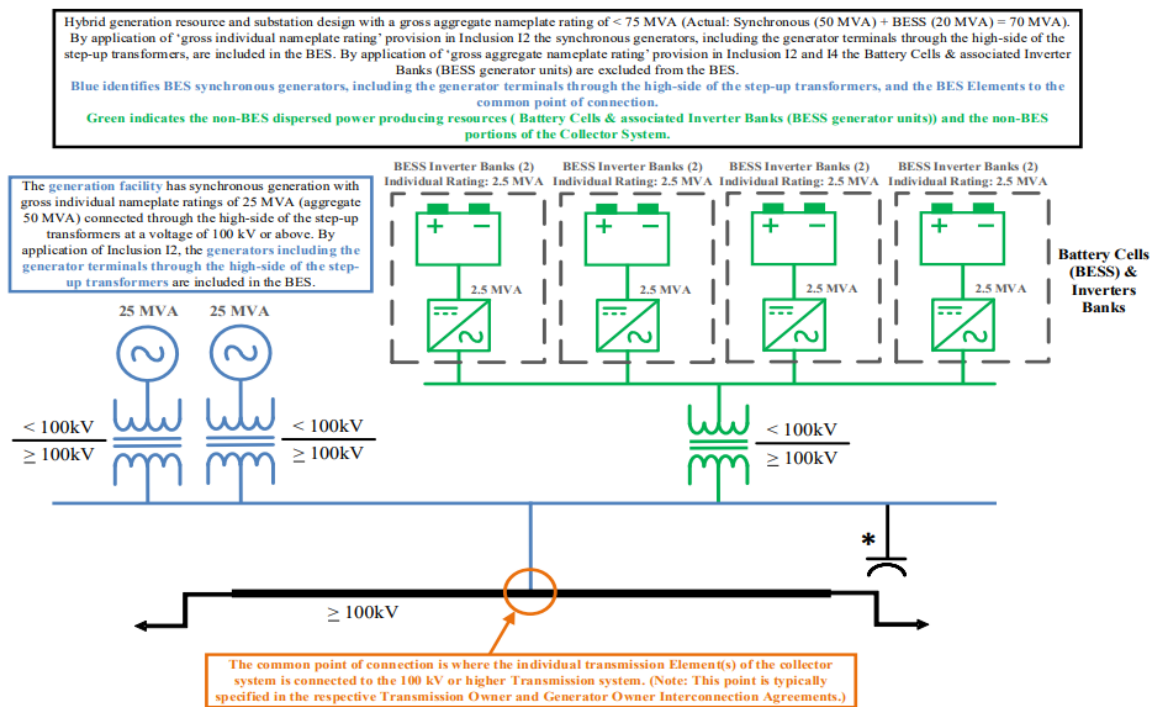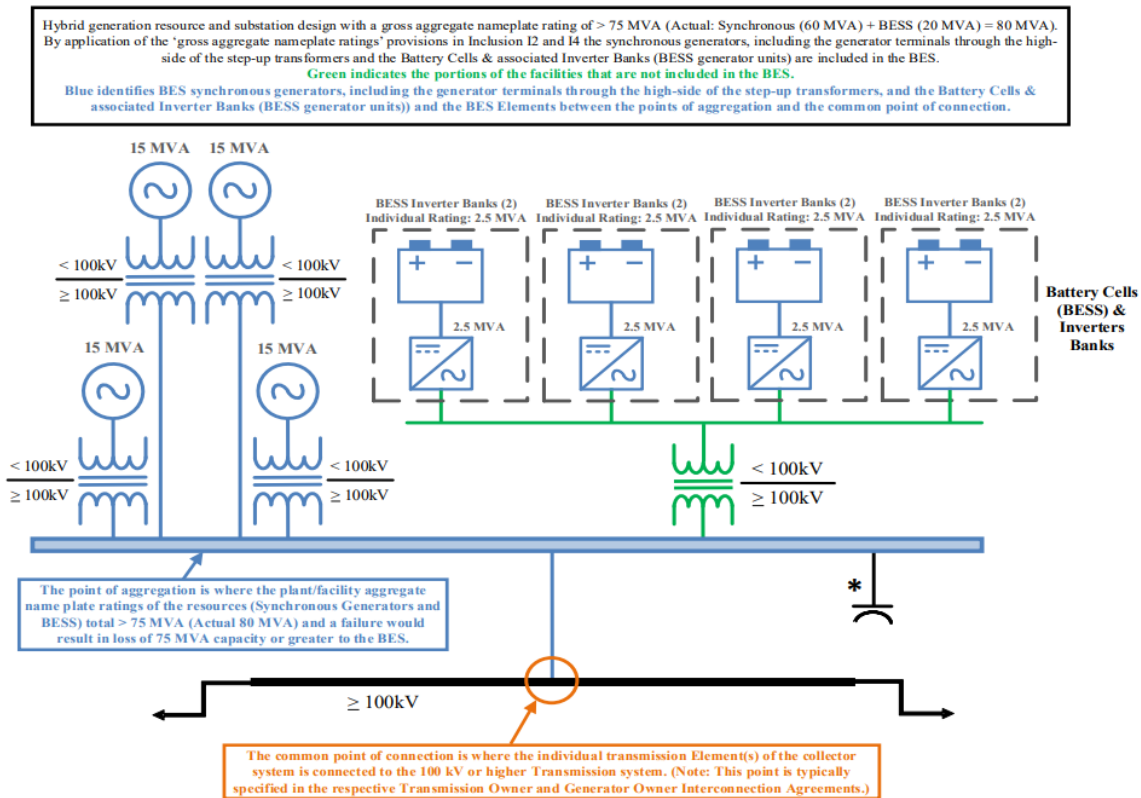

Figure 16: Synchronous + BESS, Sync. 2x 25 MVA, Aggregate Plant 70 MVA, Sync. BES Resources and BESS non-BES Resources

- *See Figure 17: Synchronous + BESS, Sync. 4 x 15 MVA, Aggregate Plant 80 MVA, BES Resource.* For this Facility, Inclusion I2 is met. Therefore, Requirements R2 and R3 apply for the synchronous generators. Provide a verified positive sequence dynamic model(s), associated parameters, and accompanying information that represent the in-service equipment of the Facility, specifically the synchronous generators. For this Facility, Inclusion I4 is also met. Therefore Requirement R4, R5, and R6 also apply for the BESS resources.

Figure 17: Synchronous + BESS, Sync. 4 x 15 MVA, Aggregate Plant 80 MVA, BES Resources

3. For a Facility without a frequency control system or for Facility not required to have a Primary Frequency Response (PFR), clarify there is an exemption for Requirement R3 and R5 in Attachment 1 Row 9.

- No change to Attachment 1, Row 9. The Facility described should be exempt from Requirement R3 and R5, since it would be covered under "New or existing applicable unit does not have an installed frequency control system or has a disabled frequency control system. Additionally, for Requirement R3 and R5 the verified model(s) must represent in-service equipment of the Facility. Therefore, if the Facility does not have a frequency control system installed or enabled it would not need to be modelled.

Question 2. Requirement R1

1. EMT models should not be required for a synchronous generation Facility.

   - No change. EMT models are not required under MOD-026-2 for a synchronous generation unit/Facility. Requirement R2 and R3 are applicable for synchronous generators and synchronous condensers. Requirement R4, R4, and R5 are applicable for IBR Facilities, FACTS devices, and HVDC equipment.

2. No justification or technical rationale outlining the need for EMT models for all IBR Facilities. Similarly, EMT models should only be provided when deemed necessary by the TP.

   - No change. See Technical Rationale for Requirement R6. EMT models are needed to understand the large signal disturbance response of an IBR Facility. NERC has published multiple disturbance reports, including the *Odessa Disturbance Report of May and June 2021 (page 22-31), and 2021 California Solar PV Disturbances of June and August 2021 (page 20-33)*. In both reports, NERC raised significant concerns regarding positive sequence modeling practices and the need for industry to verify and validate the accuracy of the models being used for reliability studies. From the Odessa Disturbance Report, most of the causes of solar PV reduction identified in this event and past events analyzed by NERC cannot be properly represented in positive sequence dynamic models. High quality, vendor-specific EMT models are required to identify these causes of tripping.

   - The SDT believes a verified EMT model for all IBR Facilities with commissioning date after the date specified in Attachment 1 Row 11, should be provided to the respective TP. EMT models are easier to obtain from the OEM around the time of initial commissioning. By having the TP define its need at any given time in the future, would create an emergent issue for the GO to obtain a backdated EMT model. For example, if a TP would require a verified EMT model in 2025, for a Facility commissioned in 2014, then the GO/TO would likely only have 1 year to interact with the OEM to get the model, verify the EMT model, then provide the verified model to the TP. Whereas, with this approach all verified EMT models will need to be provided, if the Facility is commissioned after a specified date, which is a more straight forward approach.

3. Portions of Requirement R1 are vague or ambiguous, such as the terms parameterization checks, usability, initialization, and interoperability.

   - Change made. See Technical Rationale, Requirement R1, Part 1.3. Model data review and parameterization checks are mentioned in the Technical Rationale. A description for the other terms was added to the section.

4. Each TP should be allowed to establish their own methods, requirements, processes, and acceptance criteria without constraints, boundaries, or need of consistency with other industry participants. For GO in multiple TP areas, various types of data or in different formats may be required based upon TP preferences.

   - No change. The intent of Requirement R1 is to allow the TP the necessary means to define what they need for the model verification process, while specifying the minimum amount

required in Requirement R1. This should be done in conjunction with the PC to ensure their perspective is considered, and to create broader consistency with model verification processes when possible.

5. The PC should be included in language for R1.3, R1.4, and R1.6.

    *   No change. As described in Requirement R1, "Each Transmission Planner and its Planning Coordinator shall jointly develop dynamic model verification requirements and processes." However, the PC does not need to be explicitly mentioned in each of the requirement subparts. For example, the TP will use the acceptance criteria developed in Requirement R1.3, to review and accept the submitted information as part of Requirement R8, which does not involve the PC.

6. Concern with overlap between the proposed R1 language and the requirements in MOD-032-1. MOD-026-2, R1 states: "Each Transmission Planner and its Planning Authority shall jointly develop dynamic model requirements and processes." MOD-032-1, R1 states: "Each Planning Coordinator and each of its Transmission Planners shall jointly develop steady-state, dynamics, and short circuit modeling data requirements..."

    *   Change made. Changed "model requirements" language in R1 to "model <u>verification</u> requirements" to ensure MOD-026 scope focuses on model verification, and not model development.

7. R1.6 language appears to remove the 90 day response time requirement. This implies TPs are required to create a method and timeframe for GOs to obtain the information. The SRC requests to keep the 90 day response time requirement, as 90 days acts as a back stop to assure GOs have a date certain to obtain models and provide to their contracted model reviewers.

    *   Change made. Added "within 90 days of a written request" added to Requirement R1.6.

8. It is unclear whether model(s) for R2/R3/R4/R5 should be provided as an aggregate or individual for each generating resource/unit.

    *   No change. In Requirement R1.1, the TP would define what the "Acceptable positive sequence dynamic models, format, and level of detail."

    *   Additionally, as stated in R2-R6, the model(s) with associated parameters, and accompanying information that represent the in-service equipment of the Facility.

9. The TP and its PA should jointly determine the required minimum modeling requirements and level of the modeling details as stated in Requirement R1.1. If the TP and PA determine that some or all of these listed minimum requirements are needed for the model or the type of studies performed, they can include such requirements as part of the R1.1. [related comment] Manitoba Hydro: R1 - We think that it is up to the TP / PA to determine the required minimum modeling requirements and level of the modeling details as stated in R1 (1.1). If the TP / PA determines that some or all of these listed minimum requirements are needed to include in the model base or the type of performed studies they can include these as part of the R1 (1.1, level of detail).

- No change. The SDT believes that the listed equipment, control functions, and protections are the minimum necessary for dynamic simulation purposes and thus need to be verified and validated as stated. The Technical Rationale explains why the SDT believes these are the minimum necessary.

10. The SDT, industry, or equipment manufacturers need to determine the criteria/requirements that are to be used for modeling, not the TP. Especially for EMT models, since the TP is not in a position to determine which models or parameters are best.

   - No change. The intent of Requirement R1 is to allow the TP the necessary means to define what they need for the model verification process, while specifying the minimum amount required in Requirement R1. Examples and references to industry's best practices will be included in the technical rationale section to support TPs that lack modeling expertise.

Question 3. Requirement R2/R3

1. For R2 and R3, remove the requirement to include excitation limiters in the model.

   - Change made. Excitation limiters moved to R2.3, which means the excitation limiter(s) and associated model parameters require verification. Excitation limiters must be included in the verified model, since they can impact the dynamic response of the model. However, excitation limiters would not be required to be validated via staged test as part of Requirement R2.4, since they are no longer part of R2.2.

2. For R2 and R3, remove the requirement to include "enabled Protection Systems", since this is redundant with PRC-019, or could be requested under MOD-032. (Rob, Jerry, Brad)

   - No change. The SDT believes the addition of Protection System for model verification is within the scope of this project, as described in the Technical Rationale. Requirement R2.3 and R3.3, require the GO/TO to submit <u>verified</u> dynamic models of the protection systems. This is not covered by either PRC-019 or MOD-032. MOD-032 has no requirements pertaining to the verification of data, nor does it explicitly call for Protection Systems in Attachment 1 table. Performing PRC-019 activities does satisfy a portion of the verification requirement, PRC-019 does not require submittal of the data to the TP, nor does it require that data to be input into a model for study purposes. For these reasons the SDT believes verification of enabled Protection Systems should be included in MOD-026.

3. The wording for Requirement R2.4 (dynamic volt or VAR event) and R3.4 (dynamic active power or frequency event) is vague. Commenter suggested "dynamic voltage or reactive power event" to align with parallel R3.4 phrases.

   - Change made. The SDT revised Requirement R2.4, R4.4, and R6.4 to the following phrase "dynamic reactive power or voltage event" in order to better align with R3.4 wording.

4. The PC should be provided verified model information as part of Requirements R2 and R3.

   - No change. The PC has a shared responsibility with the TP, as outlined in Requirement R1. Whatever is specified by the TP in R1 must gain the agreement of the PC to satisfy R1.

Additionally, nothing precludes the PC from asking the TP for any MOD-026 analysis it may have done, or from the TP to share its analysis with the PC. However, this does not need to be a requirement of MOD-026-2, but can be worked out between the two parties.

5. If GO or TO makes changes to Protection Systems under R2/R3, clarify the timeframe that will be required to complete and submit updated models to the TP after protection system changes.

   • Change made. Requirement R7 updated to include R2.3, R3.3, R4.3, R5.3, and R6.3. Based on the newly proposed language for Requirement R7, the GO/TO would have 180 days to either update the model or provide a mutually agreed upon plan to the TP to update the model.

6. Clarify "mode of operation" in R3.1.

   • Change made. In R3.1, "mode of operation" was replaced with "type of control". This includes controls that are utilized during the unit online operation connecting to the grid, such as turbine speed droop control, load control with or without frequency bias, gate/valve position control, temperature control, pressure control or various other types of controls. These types of controls are mentioned in the Reliability Guideline-Application Guide for Turbine-Governor Modeling-2019-05-07-CLEAN (nerc.com).

7. Clarify "outer loop controls that override governor response" and "mode of operation" in R3.2.

   • Change made. Reworded Requirement 3.2 "Model(s) representing the turbine, governor control system, and any other controls which impact the dynamic active power or frequency performance due to a system disturbance (e.g. load controller), but excluding automatic generation control." This is to clarify the purpose of R3.2 to include the model(s) representing primary frequency response of synchronous generation and avoid missing unique or customized controls due to generation types, operation requirements or limitations.

Question 4. Requirement R4/R5

1. Clarify GO/TO obligations related to R4 4.3 and R5 5.3 as pertaining to GO and TO modifications for protection systems. Specifically clarify the timeframe required to submit and update models to TP after protection changes.

   • Change made. Requirement R7 updated to include R2.3, R3.3, R4.3, R5.3, and R6.3. Based on the newly proposed language for Requirement R7, the GO/TO would have 180 days to either update the model or provide a mutually agreed upon plan to the TP to update the model.

2. The PC should be provided verified model information as part of Requirements R4 and R5.

   • No change. The PC has a shared responsibility with the TP, as outlined in Requirement R1. Whatever is specified by the TP in R1 must gain the agreement of the PC to satisfy R1. Additionally, nothing precludes the PC from asking the TP for any MOD-026 analysis it may have done, or from the TP to share its analysis with the PC. However, this does not need to be a requirement of MOD-026-2, but can be worked out between the two parties.

3. Requirement R4 and R5 could be duplicative and have overlapping requirements. Review to eliminate duplication.

- No change. The SDT had multiple discussions around this topic during development. The volt/VAR and active power/frequency response are typically represented in the same model for IBRs. However, the issue is that the two control paths captured with R4 and R5 are largely independent in settings, operations, and performance. Additionally, if an applicable entity wants to perform validation via staged testing on different dates or periodicity. Therefore, the SDT felt it best the Requirements be left separate.

4. The verification that enabled protection functions and limiting functions are represented in positive sequence dynamic models (R4 and R5) is not justified.

- No change. Requirement R4.3 and R5.3 state that the verified model shall include "Model(s) representing enabled protections and limiting functions, that either directly trip IBR unit(s) or plant, or limit active/reactive output of the IBR unit or plant." The model(s) associated with R4.3 and R5.3 do not require validation by staged test or monitored system disturbance.

- Enabled protection functions and limiting functions an IBR Facility affect the large signal disturbance response. As outlined in the IRPTF white paper, IRPTF Review of NERC Reliability Standards, which is the technical basis for the SAR, "MOD-026-1 and MOD-027-1 should either be revised or a new model verification standard should be developed for IBRs since these standards stipulate verification methods and practices which do not provide model verification for the majority of the parameters within an inverter-based resource. For example, the test currently used to comply with MOD-026-1 does not verify the model parameters associated with voltage control behavior during large disturbance conditions."

5. Model data being required in MOD-026-2 must match what is available in industry grid simulation tools. Similarly, approved models need development and technical attachment is needed to clarify expectations.

- No change. There are continuous efforts to improve standard library model representation for IBR. By the time this version of MOD-026-2 is effective, based on the Implementation Plan, the landscape will have improved for model availability.

6. Potential conflict between R1 requiring the development of dynamic model requirements and processes, and R4/R5 prescribing the minimum requirement of the verified model and accompanying information.

- No change. MOD-026-2 structure has significant conformity to the original version of the Standard(s), but updated to be applicable to IBR and expansion of scope. The TP/PC specific model verification requirements and processes defined in Requirement R1.1, R1.2, and R1.3 should not conflict with what the GO/TO is expected to provide as part of Requirement R4/R5/R6.

7. Protection System coordination should remain under PRC-019. Any new TP reporting R4.3 and R5.3 should be added to PRC-019.

- No change. Coordination of protection systems (PRC-019) does not preclude the need for the Transmission Planner to model protection systems.

8. Will TP be using all of data supplied? R4.3, R4.4, R5.3, and R5.4 are already covered in MOD-032.

- No change. Yes, the intent is for the TP to include all of the modeling information provided. Note that MOD-032 requires the model information to be conveyed, not for the model information to be verified. As such, there is no overlap with MOD-032 for this content.

9. We believe specifics on what plant equipment and characteristics should be modeled belongs in MOD-032.

- No change. Note that MOD-032 requires the model information to be conveyed, not for the model information to be verified. As such, there is no overlap with MOD-032 for this content.

10. The intent of requiring software/firmware version number in the context of positive sequence dynamic model isn't clear in Requirements R4 and R5. The models are developed to capture product features relevant to assessing performance of the IBR when connected to the bulk power system and aren't intended to capture all functionalities in the product. Clarification on this be provided in MOD-026 as it is not reasonable to reflect every change to IBR and plant firmware in the model.

- No change. The SDT believes that tracking the firmware revision number will be an input to data retention and quality assurance of the models.

11. Requirements R4 and R5 are almost identical. It is recommended they be grouped into one requirement.

- No change. The SDT considered this approach during the standard development process, but resolved to keep them separate similar to R2 & R3 structure.

12. R4 provision 4.2 sub-note 4 should be expanded to explicitly include phase locked loop (PLL) controls, as implicated in the Odessa IBR tripping event root cause investigation. R5 provision 5.4 excludes a time duration, negating the ability to demonstrate "ride through" as contemplated in the draft update for IBRs in PRC-024.

- No change. The SDT believes that not all positive sequence models include representation of PLL controls. Industry development identifies that representation of PLL controls is necessary specifically in weak grid environments. As such, this feature is not specifically identified.

13. As proposed, R4 and R5, each contains a list of information that verified models and accompanying information "shall include at a minimum." Consider revising that statement to read as follows: "As applicable, the verified model(s) and accompanying information shall include, but are not limited to, the following…." This revision would address those instances in which such modeling parameters do not exist. For example, proposed R4.2, R4.3, R5.2 and R5.3 require information related to protection elements. The model components should only be required to include that information if the corresponding device or protection elements exist in the field.

- No change. Please note that R4 and R5 specify the information be provided for in-service equipment. With this provision, 'as-applicable' is inherent to the following sub-requirements.

14. The commenter recommends the following (as provided in our response to Question 3), we recommend adding clarifying titles to the sections, "R4 Inverter Based Resource Excitation Control System or Plant Volt/Var Control Functions Model and Data Submittals" and "R5 Inverter Based Resource Load Control or Active Power/Frequency Control Functions Model & Data Submittals." For frequency protection, during the simulation, the TP could normally assume that the units meet the requirements in NERC standard PRC-024-2. So, as long as, the power system transient stays inside 'off nominal frequency capability curve' the units should not trip. If the TP is to try to study extreme system conditions, maybe the TP could collect the relay information based on the special study requirement. Therefore, we believe the frequency relays should not be included in MOD-026-2 documents as they are duplicative to PRC-006 or PRC-024.

   - Partial change. We have included headings prior to R2 for sync machines, and prior to R4 for IBR. PRC-024 allows for exception of the ride-through criteria due to equipment capability. Therefore the assumption of using PRC-024 thresholds does not provide accuracy. Similarly, there have been issues with the industry misinterpreting PRC-024 ride-through curves as trip requirements. This practice could exacerbate the issue.

Question 5. Requirement R6

1. No justification or technical rationale outlining the need for EMT models for all IBR Facilities. Similarly, EMT models should only be provided when deemed necessary by the TP.

   - See Question 2, Theme 2 response.

2. EMT model verification Requirements should be part of a separate Reliability Standard. (Jason)

   - No change. See Question 2, Theme 2. Additionally, EMT model validation is necessary to meet the objectives of the SAR. The standard is written to validate positive sequence and EMT models for large signal disturbances. There are aspects of R4 and R5 that count on validation of EMT models in R6 to be accomplished. Therefore, EMT models need to be included in this standard. Past experience has shown that it is best to have all the model requirements in one place. Otherwise, the models will too easily get out-of-synch where one model type has been updated but not another and comparisons were performed against different models than what the PA/TP has on file.

3. There is a lack of industry expertise in developing and using EMT models.

   - No change. The SDT acknowledges this consideration, and the reliance of OEMs or a third party. The SDT provided a longer implementation plan to provide a longer runway to implement MOD-026-2.

4. Concerns regarding getting the OEMs, which are not NERC entities, to provide the attestations in R6. Other comments suggest adding what would be acceptable reasons to document why the attestation is not available.

- No change. The SDT acknowledges this consideration, the compliance obligation is placed on the GO/TO, even though there is a reliance on OEMs. The SDT added specific exemptions for Requirement R6 in Attachment 1, and within Requirement R6.1, and R6.2.

5. Potential conflict between R1 requiring the development of dynamic model requirements and processes, and R6 prescribing the minimum requirements of <u>what</u> must be included in verified EMT model and accompanying information. (Brad)

- No change. R6 does not require the TP to develop a minimum set of requirements, only R1 does. R6 requires the GO to submit an attestation from the OEM, device tests, an EMT model that represents different parts of the plant, validation results, and a comparison with positive sequence dynamic models. The verified EMT model that is submitted by the GO in R6 must meet the modeling requirements of the TP under R1.

6. For Requirement R6.3, while listing the voltage and frequency protections in positive sequence models is straightforward, full protection lists in EMT models are not (from the IBR equipment perspective). OEMs cannot list all associated parameters while maintaining a reasonable level of complexity and the required level of propriety in the communication. For the IBR unit aspect of 6.3, the IBR OEM should only have to confirm that all relevant protections for the IBR unit are included in the EMT model.

- Change made. The SDT made a revision to R6.3, "Facility EMT model(s) <u>with</u> associated parameters". There is no specific requirement in R6.3 to specifically document all protection parameters, rather to submit an EMT model that contains the appropriate parameters to reflect the in-service equipment, commensurate with the attestation given in R6.1.

- A conforming change was also made to Requirement R2-R6 by adding the word "with."

7. Need to define or describe large signal disturbance.

- Change made. A description of large signal disturbance was added to the Technical Rationale. Examples of large signal disturbance tests for R6.5 are already included in the Technical Rationale.

8. For R6.2, please provide a reference for definition of a large signal disturbance, as OEM's will be unable to perform testing on an unlimited number of fault types, should they be requested differently by various RTO's. The industry should agree on standard large signal tests for best coordination in the execution of this standard, such as those defined by IEC 61400-21.

- No change. A description of large signal disturbance was added to the Technical Rationale. The standard intentionally does not specify the device test procedures or methods related to Requirement R6.2. The device test results are intended to show the model accurately predicts the device's response to large disturbances common in the BPS. These include balanced and unbalanced faults on the transmission system, changes in frequency due to loss of a resource or a major load, and voltage phase angle changes due to switching of heavily loaded transmission lines.

- See Section 3, 8 and 9 from *Draft Test Plan and Candidate Inverter List: Adaptive Protection and Validated Models to Enable Deployment of High Penetrations of Solar PV* (PV-MOD). EPRI, Palo Alto, CA: 2021. Milestones 1.3.2 and 1.3.3 report for DOE. https://publicdownload.epri.com/PublicAttachmentDownload.svc/AttachmentId=74496

Question 6. Requirement R7/R8/R9

1. The current MOD-026-1 standard (Attachment 1 Row 5) allows for model submission (as per R7) within 365 days after the submittal of the verification plan. The new MOD-026-2 draft (Attachment 1 Row 6) shortens the deadline to 180 days. Why was this deadline shortened?

    - No change. Note that the 180-day timer starts on the verification date specified in the submitted plan, not the date of submitting the plan. Since the verification date is typically at least several months after the submittal of the plan, the deadline in Attachment 1 Row 6 is largely consistent with the current standard. The purpose of making this change is to ensure there is a consistent amount of time (180 days) allocated for the two choices defined in Attachment 1 Row 5 and Row 6. Having a 180-day timer that starts on the planned verification date does not only provide the GO/TO with the flexibility to schedule the field testing but also allows for sufficient time (180 days) to complete the verification work.

2. R7 is vague on whether R2-R6 can be separately submitted.

    - Change made. Changed R7 to the following: "Each Generator Owner or Transmission Owner shall provide to its Transmission Planner an updated verified model(s) or a mutually agreed upon plan to verify the model in accordance with <u>one or more</u> of Requirements R2-R6 to its Transmission Planner within 180 calendar days of making a change, <u>including a hardware, software, firmware, control mode, or setting change</u>, to in-service equipment <u>specified in Part 2.2, 2.3, 3.2, 3.3, 4.2, 4.3, 5.2, 5.3 and 6.3</u> that alters the equipment response characteristic."

3. R7 should not require GO/TO to have a "mutually agreed upon plan" with TP to verify the model. R7 should simply state "a plan to verify the model".

    - Change made. The SDT revised wording in R7 to "a plan to verify the model(s)." Attachment 1, Row 6 timing was also updated to "365 calendar days after the submittal of verification plan."

4. R7 should be triggered by making a change to protection systems.

    - Change made. Changed R7 to the following: "Each Generator Owner or Transmission Owner shall provide to its Transmission Planner an updated verified model(s) or a mutually agreed upon plan to verify the model in accordance with <u>one or more</u> of Requirements R2-R6 to its Transmission Planner within 180 calendar days of making a change, <u>including a hardware, software, firmware, control mode, or setting change</u>, to in-service equipment <u>specified in Part 2.2, 2.3, 3.2, 3.3, 4.2, 4.3, 5.2, 5.3 and 6.3</u> that alters the equipment response characteristic."

5. Theme R7 is vague on what is considered "alters the equipment response characteristic". Footnote 13 contains important information that should be moved to the body of the standard (Requirement R7).

  - Change made. The SDT revised R7 language to add the footnote into the Requirement R7 language.

6. R8 should specify that TP shall review the material of R2-R7 & R9 submissions

  - Change made. The SDT revised R8 to the following: "Each Transmission Planner shall, review materials submitted under Requirement R2-R7 or R9, and provide written response to the submitter within 120 calendar days from receiving each submission."

7. R8 should provide TP with 120 days to review and provide a written response, which allows for the added scope of reviewing EMT models.

  - Change made. See proposed change to Requirement R8.

8. Add PC to R7/R8/R9

  - No change. The SDT believes that the TP has the sole responsibility for reviewing and accepting the verified model information, which is consistent with the current standard. In the instance the TO and TP may be the same company (registered entity), the registered entity must still perform the acceptance criteria of Requirement R1.

9. MOD-026-2 R7 should change the "Transmission Planner" to "Transmission Planner or Planning Coordinator". In many RTO/ISOs, there are instances in which the Transmission Owner and the Transmission Planner are the same entity. Requiring a Transmission Owner to send modeling information to itself would not achieve the intended verification of modeling accuracy.

  - No change. The spirit of MOD-026-2 R7 is to make the TP the sole entity to directly interact with TO/GO and review and accept verified models. The PC is expected to receive verified model data following the process developed as per R1.5. Changing "TP" to "TP or PC" without clearly defining the individual responsibility could result in misinterpretation of roles and responsibility and is prone to reliability risk.

Question 7. Cost effectiveness

1. Adding Requirement R6 of GO/TO to provide verified EMT model to TP would require the GO/TO incur a significant implementation cost, such as software, additional personnel, staff training, and/or vendor costs); or the need for EMT models was not explicitly stated in the SAR.

  - No change. The SDT understands additional cost will be incurred by the applicable entities. However, the added cost is warranted to address the increasing reliability risk of IBR Facilities being inadequately or inaccurately modelled. As outlined in the IRPTF white paper, *IRPTF Review of NERC Reliability Standards*, which is the technical basis for the SAR, "MOD-026-1 and MOD-027-1 should either be revised or a new model verification standard should be developed for inverter-based resources (IBRs) since these standards stipulate verification methods and practices which do not provide model verification for the majority of the

parameters within an inverter-based resource. For example, the test currently used to comply with MOD-026-1 does not verify the model parameters associated with voltage control behavior during large disturbance conditions."

- Additionally, see Question 2, Theme 2 regarding recommendations from the *Odessa Disturbance Report*, and *2021 California Solar PV Disturbances Report.*

2. The requirements of MOD-026-2 (such as Requirement R1/R8/R9) seem duplicative with MOD-032, or already covered in another standard.

- No Change. The SDT understands that MOD-032 R1, R2 and R3 have provided TP or PC with a leverage to specify model data requirement, receive model data updates and address their technical concerns on suspicious data. However, the general principal for developing a NERC standard is that each standard should have a self-contained process in itself. If MOD-026-2 has to cross-reference another standard to close the loop for model review and updating, it would unnecessarily complicate the compliance management and auditing process.

- Therefore, the SDT believes that MOD-026-2 R7/R8/R9 should be retained in parallel with MOD-032 model review and update process.

3. The addition of R2.3 and R3.3 requirements related to limiters and Protection System will require considerable resources (time and money) from GO who will likely need the support of OEMs and / or other 3rd party companies

- No change. The SDT understands additional cost will be incurred by the applicable entities. The Technical Rationale for the addition requirements is outlined. Additionally, models are available for the Protection Systems listed in R2.3 and R3.3. Input data for the models is also available from PRC-019, PRC-024, etc.

Question 8. Implementation Plan

1. The timeframe to implement EMT modeling should be four or five years after FERC approval date, since the GO/TO/TP will need several years for staff training, obtaining software, and interaction with OEMs.

   - Change made. For newly applicable Facilities, the SDT changed the implementation plan to 4 years total. Overall, most comments suggest four or five years rather than two years for implementation. The SDT feels extending the implementation plan to five years would be too long of a delay.

   - For a newly applicable Facility, see section *Compliance Date for MOD-026-2 – Requirements R2, R3, R4, R5, and R6*.

   - For an existing Facility which is already compliant under MOD-026-1 R2 or MOD-027-1 R2, see section *Initial Performance of Periodic Requirements.* MOD-026-3 Requirement R6 compliance date is associated with MOD-026-2 Requirement R4 or R5 performance, whichever is sooner, regardless of if the previous submission (MOD-026-1 R2 or MOD-027-1 R2) included a verified EMT model.

2. Extend & clarify the implementation duration for newly applicable units/Facilities for MOD-026-2 (new MVA threshold 20-100 MVA, FACTS devices, HVDC equipment).

   - Change made. The SDT changed the implementation plan to 4 years total (3 years after the effective date of MOD-026-2). For newly applicable Facilities, the effective date of the new standard, MOD-026-2, is the date that an entity must comply with R1, R7, R8, and R9. The compliance date for MOD-026-2 R2-R6 allows an additional three years to comply with those requirements. In Implementation Plan, see Section *Compliance Date for MOD-026-2 – Requirements R2, R3, R4, R5, and R6*.

3. Clarify the implementation plan for an existing Facility.

   - No change. See Implementation Plan section, *Initial Performance of Periodic Requirements.* This section describes that for an existing Facility that has previously performed compliance under MOD-026-1 R2 and MOD-027-1 R2, the 10 year periodicity apply and shall not be exceeded. For example, if the previous verified model was transmitted January 1, 2020, then the next compliance date for MOD-026-2 (R2/R3, or R4/R5/R6) would be before January 1, 2030.

4. Clarify whether verified models for R2/R3 or R4/R5/R6 need to be provided to the TP at the same time. For example, if an excitation system for synchronous generator is changed per Requirement R7, then an updated model would be provided for Requirement R2, but not needed for Requirement R3.

   - See Question 1 (combine MOD-026/027), Theme 1.

5. Need more implementation time overall, since the number of applicable units will increase considerably for particular entities. General comments about adding more units, and needing more time for the entire implementation.

- Change made. The SDT changed the implementation plan to 4 years total (3 years after the effective date of MOD-026-2). For newly applicable Facilities, the effective date of the new standard, MOD-026-2, is the date that an entity must comply with R1, R7, R8, and R9. The compliance date for MOD-026-2 R2-R6 allows an additional three years to comply with those requirements. In Implementation Plan, see Section *Compliance Date for MOD-026-2 – Requirements R2, R3, R4, R5, and R6*.

6. Some entities commented they prefer the implementation plan to be a shorter duration, or for the requirements to be effective quicker.

   - No change. The SDT has increased the timelines for the Implementation Plan as requested by multiple entities as GOs and TOs need this time to perform testing. Expediting this time frame will not be possible for many owners.

7. Need R1 processes and requirements within 24 months of regulatory approval.

   - No change. MOD-026-2 will become effective on the first day of the first calendar quarter that is twelve (12) months after the effective date of the applicable governmental authority's order approving the standard. Meaning entities must comply with R1, R7, R8, and R9 by that effective date.

Question 9. General

1. Provide more clarification between verification, verified model, and validation.

   - No change. Using Requirement R2 as an example, the verified positive sequence dynamic model(s), associated parameters, and accompanying information must represent the in-service equipment of the Facility. The GO/TO shall conduct verification actions for Requirement R2.1, R2.2, and R3.3. Verification involves the static process of checking documents and files, and comparing them to model parameters, model structure, or equipment settings.

   - Secondly, the GO/TO must conduct validation actions for Requirement R2.4, in which the validation of positive sequence model(s) of Part 2.2 response using the recorded response from a staged test or system disturbance. Validation refers to the dynamic process of testing or monitoring the in-service equipment behavior, and then using the testing or monitoring results and comparing them to the model simulated response.

   - Collectively, the actions to create "verified positive sequence dynamic model(s), associate parameters, and accompanying information" include both verification and validation activities.

2. Consider adding section headers similar to TPL-007.

   - Change made. Section headers were added to the standard.

3. There is inconsistent use of "applicable unit" and "Facility" throughout the standard. Recommend stating "applicable unit" or "applicable Facility or Facility" in the Applicability section, then being consistent throughout standard and Attachment 1.

- Change made. "Applicable Facility" and "Facility" terms are defined in the applicability section. For the equivalent-unit clause in Attachment 1, Row 7, the phrase "applicable unit" is updated to be specific for generating unit or synchronous condenser.

4. For Section 4.2 Applicable Facilities, recommend replacing "identified through" with "meeting the criteria set by."

- Change made. See Applicability Section 4.2.

5. Replace Planning Authority with Planning Coordinator throughout the standard, since this is the more commonly used term.

- Change made. See updates to MOD-026-2.

6. Update "Facilities" Section 4.2, for each item replace" identified through" with "meeting the criteria set by" Inclusion XX of the BES definition."

- Change made. See updated to Section 4.3

7. Generators are able to provide the best available models to the TP, but the TP would need to validate the model and provide changes back to the GO and TO.

- No change. The TP cannot validate the modeling of equipment it does not own or operate.

8. There needs to be a technical attachment added to this requirement clarifying the expectations.

- No change. The technical rationale is in a separate file.

Periodicity and Exemptions (Attachment 1)

1. There is some uncertainly on exactly what generators could apply for the exemption in Row 9 - for example, combined cycle steam units.

- The SDT added Technical Rationale for Attachment 1, Row 9, which contains more detailed information.

- Change made to Attachment 1, Row 9. "Applicable unit is not responsive to ~~both over- and under-~~ frequency excursion events during normal operation (The applicable Facility does not operate in a frequency control mode, except during normal start up and shut down, that would result in a prime mover/governor and load control or active power/frequency control mode response.) OR New or existing applicable unit does not have an installed frequency control system or a disabled frequency control system."

- A clarifying sentence was also added, "If the applicable Facility is operating in a frequency control mode that is responsive to a frequency excursion event in only one direction (over- or under-frequency), then R3 and R5 are still applicable."

- Required Action was clarified to the following, "Perform verification per the periodicity specified in Row 2 for a "Newly commissioned Facility" (or new equipment) only if responsive control mode operation for connected operations is established."

- If the applicable Facility is operating in a frequency control mode and is responsive for an <u>under-frequency event</u>, Requirement R3/R5 still applies and the verified model shall represent the in-service equipment of the Facility.

- If the applicable Facility is operating in a frequency control mode and is responsive for an <u>over-frequency event</u>, Requirement R3/R5 still applies and the verified model shall represent the in-service equipment of the Facility.

2. Confusion on Row 7 in regard to verification during the implementation period; Row 5 - Should refer to R7, not R8; and define "newly commissioned Facility."

   - Change made. In Row 7, the SDT deleted the phrase "Applies to Row 1 when calculating generation fleet compliance during the implementation period" to avoid confusion about implementation. The equivalent-unit exemption of Row 7 would apply when all criteria listed under Verification Condition column are met.

   - Change made. Row 5 refers to R7, not R8.

   - No change. The context for Row 2 implies that it applies for new Facility, not an overhaul or a component upgrade. Additionally, "commissioning" is used in the Glossary of Terms and commonly used.

3. "Unit" and "Facility" are generator terms, and this standard applies to both transmission and generation facilities.

   - Change made. See General comment regarding "applicable Facility."

4. Add a statement regarding "headroom" not being required.

   - No change. MOD-026-2 makes no statement anywhere regarding equipment capability.

5. Add an exemption in case the OEM will not provide the EMT model.

   - No change. The SDT believes enough exemptions are made for the GO/TO in Attachment 1, Row 11 and in the Requirement R6.1 and R6.2 language.

6. Allow TP/PC to develop timelines instead of standard timelines.

   - No change. Timelines were set both in the old standard MOD-026-1 and MOD-027-1 and in other standards such as MOD-25. Changing from standardized timelines to allowing the PC/TP to develop timelines would be a major change and is beyond the scope of this SDT.

7. Issue with deadlines (180 versus 365 days). Startup, commissioning and initial operation of facilities can be lengthy and have a number of changes during the first period of operation. It seems prudent to allow additional time for the operator to finalize the plant operation and control prior to requiring model submission.

   - No change. This unchanged from the previous version, MOD-026-1 and MOD-027-1.

8. Clarify "Change" in R7

- Change made. Any change to in-service equipment that that alters the equipment response characteristic. Footnote 13 was moved into the Requirement R7 language.

9. Allow exemptions requested under older standard to apply to the new standard.

   - No change. The standard does not require an exemption process, only a written statement to the TP of the equipment limitation.

10. Ten years too long for periodicity to verify the model IBRs under R4/R5/R6. Small firmware updates change response, recommend a 5 year verification periodicity.

    - No change. Per Requirement R7, additional changes to in-service equipment that alters the equipment response characteristic would require a model to be re-submitted, such as a firmware update that changes the model response.

11. Various comments related to Attachment 1 Periodicity:

    - Row 1: Clarify "implementation period"

      - Change made. The statement referencing Row 7 was deleted to avoid confusion about implementation period. The initial implementation period for MOD-026-1 and MOD-027-1 would end July 1, 2024 (10 years from July 1, 2014), so applicable Facilities should already be compliant with MOD-026-1 and MOD-027-1 by that date. Therefore, Row 1 should only apply to newly applicable Facilities, and the MOD-026-2 Implementation Plan specifies when compliance must be met.

    - Row 2: Use registration date instead of commissioning date

      - No change. Registration date is also not a defined term, "commissioning" is in the Glossary of Terms and commonly used.

    - Row 4 refer to R3 and R5

      - No change. Row 4 exemption applies to Requirement R3 and R5.

    - Row 5 & 6 refer to R7 - R9, which do not refer to the attachment

      - No change. The Requirement language and Attachment 1 are both clear about the time specifications for Requirements R7, R8, and R9.

    - Row 5 should reference R7, not R8

      - Change made. See Theme 2.

    - Row 7 - expand on "same components and settings"

      - No change. This uses the same language as the previous standard version.

    - Row 8 and 9 - move to requirement language

      - No change. This uses the same language as the previous standard version.

    - Row 10: capacity factor should not exclude the machine from model validation.

      - No change. This uses the same language as the previous standard version.

12. Requirements section use "its Transmission Planner", Attachment 1 uses "the Transmission Planner"

   - No change. The SDT believes this language is clear and unambiguous.

13. Suggest the following changes to Row 11, noting that OEMs are under no specific obligation to provide the models identified in MOD-026-2, unless such a requirement was written into the contract at the time the resource was purchased. Add the phrase, "OEM is unwilling (or otherwise unable) to provide the supporting model(s) for in-service equipment at the Facility."

   - No change. The SDT feels the statement, "OEM no longer supports model(s) for in-service equipment at the Facility" covers most instances that an OEM would be unable or unwilling to provide a model to the GO/TO.

Other Comments

1. MOD-026-02 should state that each requirement (R1 to R9) can be met individually, including dates, periodicity, content, transmittal of information, etc.

   - Change made. See response for Question 1, Theme 1.

2. Include units that connect to transmission line less than 100 kV, or at minimum retain MOD-026-1 Applicability Section 4.2.4. There are examples of over 100 MVA unit connecting to 69/72 kV lines.

   - No change. The SDT will further evaluate this comment during the next comment period to determine if there is a reliability gap.

3. Pertaining to Applicability, commenter suggests that the 20MVA threshold identified in Applicability section 4.2.4 should be inclusive of multiple units aggregated to 20 MVA at a station (substation, switching station, and generating station). Some locations may have multiple smaller (example 15MVA) reactive resources of the types mentioned in R4.2.4.1 in order to meet reliability criteria which can consider the contingent loss of one or a number of the resources. The impact of multiple units (example 2 units of 15MVA each) on the results of analysis can be more notable than a single 20MVA resource

   - No change. The applicability is aligned with the BES definition for consistency across multiple standards.

Other Comments for Requirement R2 and R3

1. Language should be included that clearly indicates that R2 and R3 do not have to be completed at the same time, otherwise this will be left to the interpretation of the auditors. Practically these are not always completed together.

   - No change. Nothing in the standard requires R2 and R3 activities to be scheduled/performed at the same time.

2. R2 and R3 - The standard should focus on verifiable modeling data that are necessary for performing simulations and avoid requirements for superfluous information. The standard should

not set "at a minimum" expectations in R2 and R3 while requiring the TP/PC to establish their dynamic modeling data needs in R1, potentially creating a conflict.

- No change. R1 does not give the TP/PC latitude to make any verification or validation optional or required; it only allows them to specify criteria for acceptance and process details.

3. R2.3 - For voltage relays, we could normally assume that the units meet the requirements in NERC standard PRC-024-2. As long as the power system transient stays inside 'OFF NOMINAL FREQUENCY CAPABILITY CURVE' and 'Voltage Ride-Through Time Duration Curve', the units should not trip. As a result, the voltage relays should not be included in MOD-026-2 documents as they are duplicative to PRC-006 or PRC-024. [related comment] R2.3 and R3.3 - PRC-024 requires generators to meet region-specific voltage and frequency ride through requirements and to provide the settings for it voltage and frequency protection to TPs. In addition, PRC-006 requires the provision of UFLS tripping data that includes generator frequency ride through trip settings. Adding these to MOD-026 does nothing more than make GOs prove compliance with multiple standards for the same action.

- No change. PRC-006 has no GO applicability. PRC-024 requires a GO to provide data if settings exist in the no-trip zone or by request of TP or PC but does not require verification of settings. Simulations may produce voltage or frequency excursions outside the boundaries of PRC-024 attachments and it should be necessary to see what would or would not trip in those cases.

4. R2 and R3 each contains a list of information that verified models and accompanying information "shall include at a minimum." Consider revising that statement to insert "As applicable." Model components should only be required to include if the corresponding device or protection elements exist in the field.

- No change. R2 and R3 require verification of "in-service" equipment only.

5. Requirements R2 and R3 are almost identical. It is recommended they be grouped into one requirement.

- No change. R2 and R3 are separated so as not to imply they should be complied with at the same time.

6. We are assuming that R2.2 includes a power factor controller in the description of the outer loop control. If this assumption is incorrect then the language needs to be modified. We suggest adding a footnote stating the outer loop control includes power factor controllers.

- No change. R2.2 does not specify which outer-loop controls so it does encompass power factor controllers as well as other possible outer-loop controls.

7. R2.3 and R3.3 - The Protection Systems that directly trip the generator/synchronous condenser include typically protection functions that use positive, negative or zero sequence quantities. Since the planning/ operating tools are typically using positive sequence models, the current wording can be confusing. When renewable energy resources (wind or solar farms) are aggregated in equivalent

models, the accuracy required by protection functions installed at turbine/inverter /feeder level might be difficult to achieve, leading to simulated erroneous protection actions/non-actions.

- No change. Only protection that can be represented in positive sequence simulations needs to be modeled. The specific protection functions required under R2 and R3 are listed. Since aggregated modeling does not see the individual turbine or inverter level, it is true that the modeling of protection is simplified and approximate to a degree. The SDT believes it is still necessary though.

8. Texas RE requests clarification on the term "turbine-generator" in Requirement Part 3.3.

- No change. "Turbine generator" in context of synchronous generation is a commonly found term and should not need clarification.

9. R2 and R3 only have the interest of the TP in mind when gathering pertinent data to conduct their analysis. From our perspective, the PC should have access to the TP analysis data (final results) to ensure they can identify the same risks as the TP in reference to the reliability of the grid.

- No change. MOD-032 is the standard requiring any updated modeling data to be sent to the PC. Adding a requirement to this effect in MOD-026-2 would cause a duplication.