

Draft IEEE P2800.2 Working Group Meeting Minutes, April 25-27, 2023

IEEE P2800.2 Recommended Practice for Test and Verification Procedures for Inverter-Based Resources Interconnecting with Bulk Power Systems

Chair: Andy Hoke

Secretary: Manish Patel

Vice-Chairs: Jens Boemer, Bob Cummings, Divya Kurthakoti, Julia Matevosyan, Mahesh Morjaria, Steve Wurmlinger

Meeting Date/Time/Location: April 25-27, 2023, 11 am – 3 pm ET, Virtual Meeting

April 25, 2023, Notes:

Andy Hoke kicked off the meeting with a brief introduction. This meeting was the fifth meeting of the IEEE P2800.2 Working Group. The meeting was held virtually. In lieu of a roll call, Andy Hoke requested attendees to put their name and affiliation in the chat window. Attendees were also asked to record attendance at <https://imat.ieee.org/attendance>; however, some issues were identified with the iMat system. The TEAMS attendance will be used along with data from iMat to record attendance.

Andy Hoke informed the WG that Vanessa Lalitte from IEEE is replacing Malia Zaman and will be supporting this WG going forward. Vanessa Lalitte was introduced to the WG.

Quorum was achieved. Andy Hoke presented the agenda. Pouyan Pourbeik moved to approve the agenda. Sid Pant seconded. No discussion, objection or abstentions were noted. Agenda was approved.

The IEEE SA Patents & Copyright policies along with Participants Behavior Expectations were presented.

Nath Venkit moved to approve meeting minutes for the kick-off meeting. Pramod Ghimire seconded. No discussion, objection or abstentions were noted. Meeting minutes were approved.

Andy Hoke briefly discussed the scope and objective of the IEEE P2800.2. Andy emphasized that the P2800.2 WG is large with ~130 members and encouraged everyone to contribute.

SG1 Discussion

Andy Hoke presented updates to SG1 material as follows:

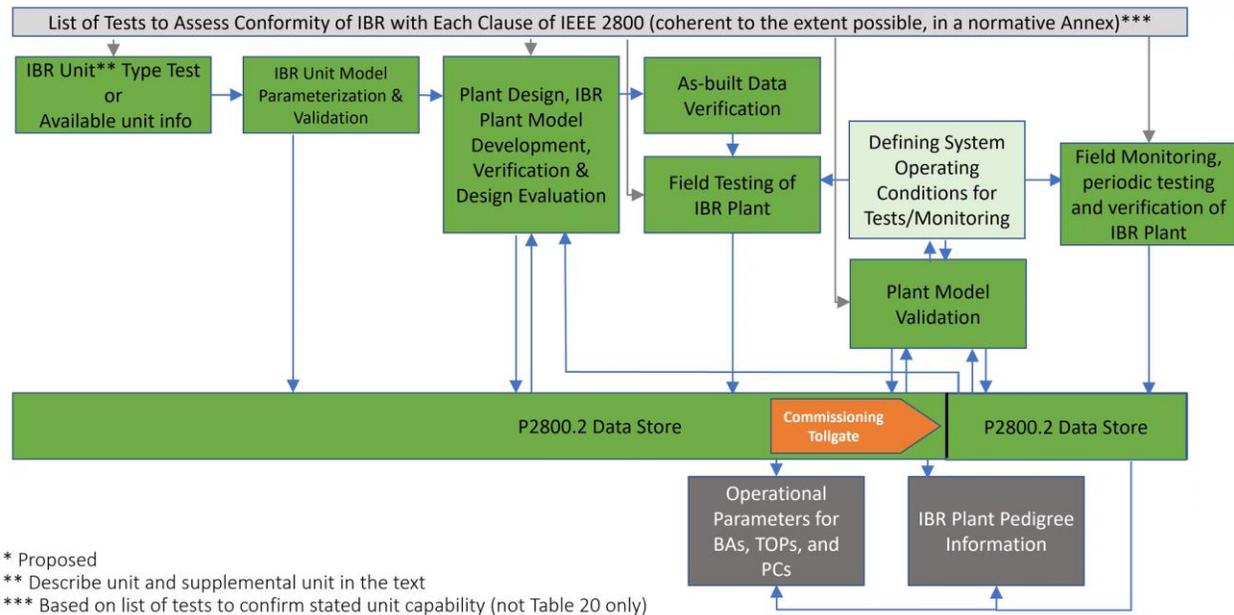
- Moved language on collaboration between parties to clause 1.5 (previously in clause 4) and removed suggested language related to “trail operation”.
- Edited language allowing alternate verification procedures for technologies not explicitly considered in 2800. Maintains intent while adding converter-interfaced hydro as another example.
- Brought in several definitions from the IEEE 2800. Aligned definition of conformity assessment with ISO IEC 17000. Finalized definitions of model validation, model benchmarking, and model verification. The proposed definitions align with proposed definitions by the NERC MOD-026 SDT.

A brief discussion took place regarding a point that recommended practices of 2800.2 may not be appropriate for converter-based hydro plants and grid-forming converters. Upon further discussion, Andy acknowledged that more discussion might be necessary for grid-forming technology. SG1 will work on it.

Andy presented minor changes to flowcharts shown in Figures 2-6 of P2800.2 D0.4. The newly created clause 4.4 to list requirements for which no verification procedures are specified in 2800.2 was also presented.

Jason McDowell and Bob Cummings presented data handoffs flowchart (shown below) put together by several WG members. This flowchart is not included in Draft 0.4; however, if the WG determines that there is value then it could be included in 2800.2.

Process flow and information handoffs for conformity assessment



The plant pedigree means the plant name plate rating, capability, limitations, etc. Manish asked if the WG sees value in this flow chart and if yes, then in what context (info or recommended practice) should it be included in 2800.2. Andy volunteered to create a poll to get feedback from the WG. (After the meeting, it was decided to bring discussion of the data handoff flowchart into SG1 rather than creating a poll.)

SG2 Discussion

Pramod Ghimire and Steve Wurmlinger led the SG2 discussion. After brief review of scope, Pramod presented type test procedure for voltage ride-through requirements. There are methods of testing: Method 1- field or grid emulator, Method 2 is based on grid emulator. Tests should be done for a SCR \geq 3.0 and at lower value defined by the OEM. Other details were also presented which are included in Draft 0.4. A couple of important questions are as follows:

Adrian Rencher: Will the type test lead to IEEE 2800 certification? Answer: No. Most requirements in IEEE 2800 applies at the POM (high side of main step-up transformer). So, type tests are done to determine capability of inverters/WTGs. There is no pass or fail criteria. So, certification is not expected.

John Schmall: With “no certification”, who determined whether a test confirms the desired performance? Answer: It is determined through a combination of design evaluation (i.e., modeling), commissioning tests, and post-commissioning monitoring.

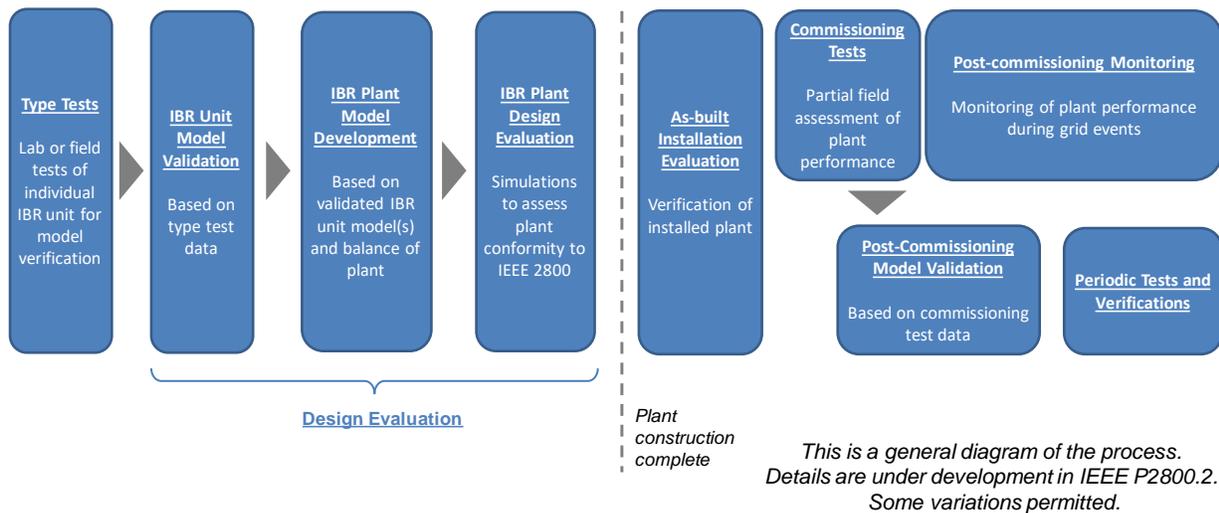
Eugen Starschich: During the test it is not just about trip or not trip, what about the verification of the current injection? Answer: Measurements are taken at M1, M2, and M3 to verify current injection requirements.

Reigh Walling: To validate the model, why not do some small magnitude voltage step changes to verify the small disturbance response of the IBR unit? Answer: SG2 will discuss and include as appropriate.

It was emphasized that the purpose of type testing is to validate the IBR unit model. Tests should be performed for extremes so that models can be validated for these extremes. The validated IBR unit model is then used to develop the IBR plant model which is then used for Design Evaluation.

Also presented were draft type test procedures for active power control, reactive power control, frequency test (PFR and FFR) and protection elements. Discussion was limited due to time constraints.

Andy Hoke then briefly discussed the role of 2800.2 in IEEE 2800 adoption. Overview of conformity assessment steps in 2800.2 can be explained based on steps in following figure:



Meeting in recess at approximately 3:03 pm ET. WG to reconvene at 11 am ET on April 26, 2023.

April 26, 2023, Notes:

Manish Patel kicked off the session with a reminder to be mindful of IEEE policies and agenda for today.

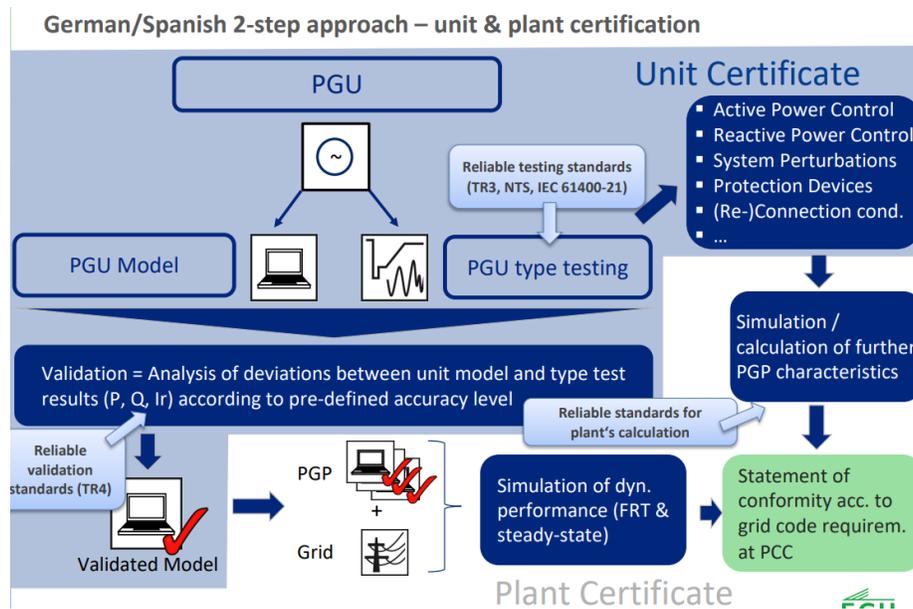
FGW Presentation – Grid code compliance verification acc. TR8 (approach, rationale and experiences)

Jens Boemer introduced Mark Meuser from FGH (Germany). Mark’s presentation is available on iMeet Central workspace at [Login / Sign In - IEEE SA \(imeetcentral.com\)](https://www.imeetcentral.com) .

General benefits of product certification are as follows: independent and impartial assessment, transparent evaluation scheme, competence and quality of the certification body, efficiency, minimizing risk, etc.

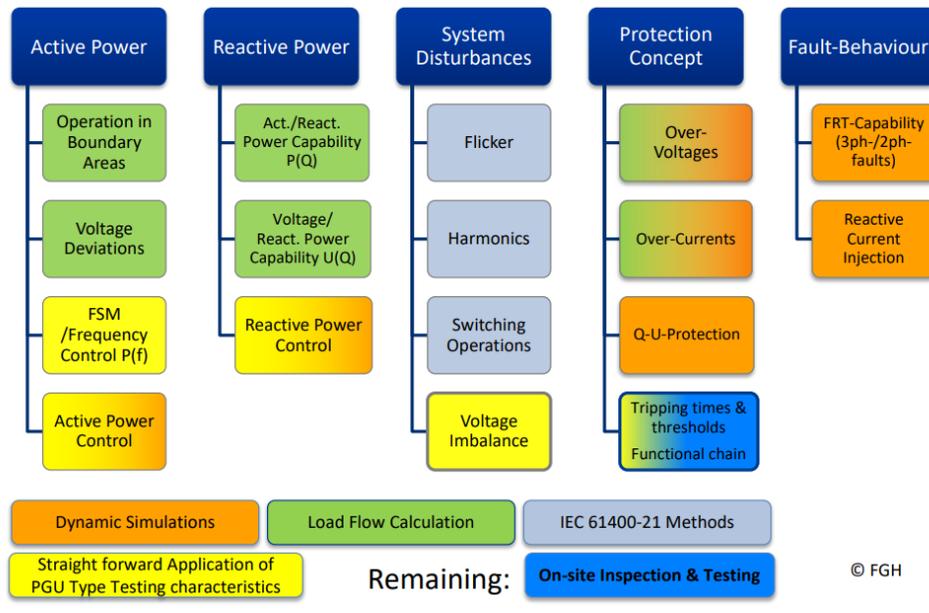
Among other things, a certification program defines applicable product standard and evaluation and assessment methodologies.

Levels of certification include unit/component certificate, plant certificate (MV, HV, EHV) and conformity declaration (MV, HV, EHV). Details are included in a figure below.



The certificates are created by accredited certification bodies. There are approximately 20 certification bodies in Germany.

The unit certificate is a basis for plant assessment. Methodologies applied in plant assessment/certificate as shown in figure below.



Jens Boemer's interpretation of FGW approach regarding unit level certificate: It includes conformity assessment for a set of mandatory IBR unit capability requirements specified at POC and optional IBR unit capability requirements specified at POM/POI.

All WG members that can access iMeet can review the FGW technical guidelines TG3, 4, 8 and 9 at <https://ieee-sa.imeetcentral.com/p/ZgAAAAA3YS3>.

Pouyan Pourbeik – What does a third-party certification add? Mark: the benefits of certification are independent and impartial assessment, transparent evaluation, competence and quality of the certification body, efficiency, etc.

Nath Venkit – What happens if OEM makes any changes after the certification process? Mark – It depends on what changes are made. In some cases, additional type testing may be necessary.

The presentation was well received with engaging Q&A.

SG3 Discussion

Jens Boemer kicked off SG3 discussion. Jens briefly reviewed SG3 contribution to Draft 0.4. The SG leadership is looking for feedback on overall structure of clause 6, definitions and responsibilities. It was noted that the SG/WG should not get hung up on when and who does design evaluation. SG3 has a consensus that IBR unit-level model validation process should have quantitative pass/fail criteria plus some form of engineering review. The SG3 spent a considerable amount of time reviewing IEC 61400-27-2 since the last WG meeting, which would help with developing unit-level model validation procedures.

Amir Kazemi – It would be difficult to develop a pass/fail quantitative criteria, considering transient responses. For steady-state response, quantitative criteria may be feasible.

Reigh Walling - it is very difficult to define quantitative model validation criteria. Consider a response that is a step. If the criterion is +/-xx% at any instant of time, and the response is 1 ms later, then the % deviation in magnitude during that time difference is huge, but the practical difference is minimal.

Nath Venkit – Nath shares the same concern regarding using quantitative criteria. If the model response is made to match test results to pass quantitative tests, then model is structurally becoming poor.

Andrew Isaacs - It is difficult, yes... I'm also not sure exactly how to set those criteria. The goal is to apply a fairly strict comparison between unit level tests and models. Perhaps "quantitative" may be applied in certain ways, while allowing for some of the potential differences being discussed. Alternatively, if a quantitative approach is used, explanations for "violations" could be provided and accepted if reasonable. Alternatively, a mix of quantitative and qualitative approaches could be used. At the end, I think the goal is *very close matching*. We want to avoid hand-waving explanations of significant differences, particularly in EMT.

Pouyan Pourbeik – shares the same concern shared by Amir Kazemi and Nath Venkit. Pouyan emphasized that there should not be automatic pass/fail. Instead of failing a test automatically, the engineering judgement is then used before declaring that the test is failed. In other words, if the model verification does not pass an initial quantitative review, further review is required.

Reigh Walling - Consider a quantitative criterion of +/- xx%. Type test shows a flat response. Model shows a response that is within the quantitative criterion. However, within this band, it is observed that there are small but growing oscillations that are not seen in the type test. I would say that the model is not valid, even if the magnitudes remain within the criterion band.

Manish Patel reminded everyone that we are just discussing a concept here. The SG/WG have yet to think about individual requirements and quantitative criteria for each of those. Given the timeline, SG3 could consider going ahead with a qualitative approach in this first version of the recommended practice.

Jens Boemer thanked everyone for feedback, SG3 to continue discussion.

Model Quality Testing: Pouyan Pourbeik explained the concept of model quality testing. MQT involves high-level sanity check of parameters and running some basic simulations to ensure that model initializes properly and responds in an orderly fashion. These tests are qualitative tests. EPRI's report on concepts of model quality testing for inverter-based resources is available at <https://www.epri.com/research/products/000000003002027506>.

Reigh Walling: "Model quality" is not the best term. Quality seems to include validity, which is not the intent here. Perhaps "model useability" would be more accurate and lead to less misunderstanding.

Test system to use for design evaluation: Jens Boemer asked Reigh Walling and Andrew Isaacs to share their thoughts very briefly.

Reigh Walling: The purpose of DE is to determine if the plant can meet IEEE 2800 requirements in a system to which it is connected. Using an example system does not make any sense.

Andrew Isaacs: Agrees with Reigh that compliance with IEEE 2800 is dependent on TS system performance. The P2800.2 has intentionally disconnected from the IC study process. At this time, the approach is to do design evaluation based on single infinite bus system.

Due to time limitations, there was no further discussion on the topic.

PQTF Discussion

Dave Mueller kicked off the discussion with a brief update on activities since the last WG meeting.

Regarding harmonics studies, Dave believes that not all plants need detailed studies, this is not necessarily a position of PQTF. In addition to work in 2800.2, there are two more related WGs in the industry as follows:

- IEEE TF on harmonic Modeling and Simulation – IBR Modeling and Simulation Group
- CGRE C4.65 WG – Specification, Validation, and Application of Harmonic Models of Inverter-Based Resources.

Amir Kazemi presented a draft of recommended practice on type testing IBR unit to develop unit level harmonic model (Norton/Thevenin model parameters). The goal is to develop a procedure that is generic enough that it can be used with different types of IBR units. The proposal is to include IBR unit step-up transformer as part of the test. Ling Chen (Sungrow) mentioned that IBR unit step up transformer is provided by third party and is not part of testing platform currently. Reigh Walling mentioned that we should not be too prescriptive and leave some open room. The PQTF will continue to work on this.

Eugen Starschich then presented content developed by the PQTF which is not reflected in Draft 0.4. Eugen also briefly discussed CIGRE TB 766 (Network modeling for harmonic studies).

Meeting in recess at approximately 3 pm ET. WG to reconvene at 11 am ET on April 26, 2023.

April 27, 2023, Notes:

Andy Hoke kicked off the meeting. Attendees were reminded to log their attendance on iMat and post their name and affiliation in the chat.

PQTF: Eugen continued presenting the PQ content. The key points discussed were as follows: IBR presentation, network model, background harmonics etc. It was recognized that the network assessment for small IBR plants may be too burdensome. The draft for exemption from design evaluation was presented, which could be based on SCR at the POM, proximity of IBR plant from other compensation devices or filter banks, etc.

Jens Boemer: When determination of design evaluation not needed would occur, early or late in process? There is no straightforward answer. Really depends on the project and available background harmonics from the TS.

Chris Milan noted that engineering firms usually push back against harmonic studies and states they are useless until the plant is built and in operation.

Reigh Walling: Part of the reason that pre-interconnection studies might be useless is because a correct representation of the IBR plant has not been provided (i.e., Thevenin source model). In-operation measurements, however, only determine the compliance for the grid conditions present at that time.

Bob Arritt: We are seeing an impact between the small-signal response and large-signal response of the IBR. For example, for resonance there is a different Thevenin Equivalent for the IBR than for a non-resonance condition. Different variables have different impacts, e.g., Z magnitude, X/R has an impact.

SG4 Discussion

Divya K. presented progress made by SG4 since the last WG meeting.

As-built evaluation: The SG4 concluded that as-built evaluation occurs after the design evaluation and unless there are changes that degrade plant performance then repeat of design evaluation is not necessary. The as-built evaluation is focused on verifying that IBR plant as delivered and installed meets or exceeds the design used in the Design Evaluation.

Andy Hoke: The content of as-built evaluation is very brief. Is that the consensus of the SG4? Answer: Yes, there is no point in repeating the design evaluation content.

Jens Boemer agrees with the brief language for as-built evaluation in clause 7. But recommends developing a coherent list of elements that need to be verified. This could be information in Annex G of the base standard and may include some additional items as necessary. Such a list could be included in an informative annex and can be used for both design evaluation and as-built evaluation. If any changes are noted between two evaluations, then that may prompt engineering judgement.

Pouyan Pourbeik suggested taking this discussion offline and perhaps in SG1.

Julia M noted that SG5 also discussed creation of such a list but then concluded that Annex G of the base standard already covers it. But agrees that we could re-think and see if there is value in creating such a list.

John Schmall expressed a general concern with using "mutual agreement and consultation among parties" in the standard. Bob Cummings agrees with John. Manish Patel stated that use of "mutual agreement" is not limited to this clause. It is used as appropriate in the base standard and other parts of the 2800.2 draft. Andrew Isaacs suggested to note John's statement that "leaving mutual agreement in here will hinder wholesale adoption by TOs."

Commissioning Tests: Divya then presented the draft content in clause 8. For some requirements (e.g., measurement accuracy), it was recognized that developing a commissioning test procedure was not feasible. In such cases, the recommendation is to verify capability. It was noted that not many changes have occurred compared to Draft 0.3.

For voltage and reactive power control modes, two options for commissioning test are provided. Nath expressed concerns with option 1 due to limitations arising due to TS operating condition and nearby plants. It was also recognized that the reactive capability of the plant may not be verified during a commissioning test. The purpose of commissioning test is to validate the plant level model and not necessarily to verify plant's reactive capability.

Divya then quickly presented commissioning tests to validate primary frequency response but noted that no significant changes have occurred compared to draft 0.3. The changes in draft 0.4 recognizes the PFR capability at the IBR unit level, where test may be performed individually or simultaneously on at least a significant sampling of IBR units.

Adrian Rencher: What is the intent of PFR testing with and without curtailment? Is it to verify proper Frequency coding in the PPC? That appears to be the only difference between the two cases. Pouyan stated that it is just to confirm the capability when plant is operating in curtailed mode.

David Deloach shared that TVA has seen a different PFR response for plant when it is curtailed versus when it is not curtailed. Mahesh, Divya, David D, Chris M, and Pouyan discussed whether PFR tests are needed in both curtailed and non-curtailed conditions. Mahesh wants to wordsmith. It will be taken back to SG4.

For commissioning tests to verify fast frequency response capability, the test is similar to PFR for PV/BESS resources, but procedures recognize the FFR capability of wind-based IBR plants. The tests are only specified for underfrequency condition as the base standard does not require capability for overfrequency condition.

The SG4 has also developed a commissioning test procedure for voltage disturbances within the continuous operating region.

SG5 Discussion

Julia M. presented progress made by SG5 since the last WG meeting. A couple of accomplishments since the last WG meetings are as follows:

- SG5 reviewed and resolved comments during the last WG meeting.
- New annex C presents concepts of field testing and model validation was written

The annex C (Concepts of field testing and model validation) includes:

- A brief recap of various types of aggregated IBR plant models
- Three approaches of representing the grid: infinite bus behind Thevenin impedance, playback, full or partial TS model
- Provides examples of model validation based on field tests for each of three approaches.

Andrew Isaacs offered some examples of EMT model validation for inclusion in the Annex. Andrew Isaacs clarified that such examples would be for actual system disturbances, i.e., faults. Such examples would be a great addition to annex C.

Julia also quickly reviewed post commissioning monitoring to evaluate the plant's performance during TS events. The SG reviewed practices in place at NE-ISO and BPA. The base standard requires disturbance monitoring equipment. But it was emphasized that event triggers have to be set carefully. The selection of trigger should be made by TS owner/operator based on location and characteristics of their respective systems.

Next steps for SG5 are as follows: review post commissioning monitoring clause, add more event-based examples to the Annex C and periodic tests/verifications.

Andrew Isaacs offered some examples of EMT model validation for inclusion in the Annex. Andrew Isaacs clarified that such examples would be for actual system disturbances, i.e., faults. Such examples would be a great addition to annex C.

Patrick Hart's question on data capture to playback approach: Given that the recorded variables include the response of the plant, how exactly can we expect that replaying the event will yield the same response in a model? Wouldn't the simulation input need to be generated where the plants response was first removed? Pouyan stated that most software tools will play back voltage and frequency and produce active and reactive power to be compared to respective measurements. Alex Pollock stated there's a bit of an art in overcoming that. Also, a frequent challenge is that the measurement location isn't the same as the slack bus (or equivalent), so one is trying to get matching response at the measurement location by changing what's happening upstream. Andrew Isaacs agreed that this is a limitation and situation is pronounced when the system is weaker.

Jason McDowell stated that disturbance data retention is very important.

Andy Hoke asked if there is any guidance on how to chose which events should be analyzed? SG5 will discuss further and may provide some guidance. Brad M mentioned that it is good to have multiple events to verify performance. The 2800.2 will likely provide some examples of the trigger at the RPA. Sid Pant clarified that trigger at the IBR unit level is already prescribed in the base standard (table 19).

Jens Boemer asked if there is the event is triggered, is it possible to record a few cycles/seconds before the disturbance occurred? Yes, the base standard requires the pre-disturbance data, but details are not specified and is left for TS to specify.

Ibrahim Karim – Will standard have some verbiage around frequency of testing of IBR units, breakers, transformers? Will the test data be required to be shared with TS owner/operator? Julia invited Ibrahim to SG5 calls to discuss further.

The final 20 minutes were used to discuss SG3 direction.

SG3 looking ahead:

1. Write procedure for IBR unit model validation.
2. Carve out model quality assessment into an annex.
3. Revision of model-based IBR plant level performance tests
4. Work with SG1 on following topics: develop an annex
 - a. Possible responsibilities to support IEEE 2800 direction
 - b. Minimum set of parameters to be verified based on generic IBR plant model

The most contentious topic seems to be what test system to use for design evaluation. The answer may be dependent on the objective of the design evaluation. There are two possible objectives:

#1: early in the interconnection process – set expectations for the IBR plant to fully conform with IEEE 2800 requirements and submit a best available model that is of good quality and represents IEEE 2800 capability and performance.

#2: towards the end of the interconnection process – verify that the IBR plant design confirms to IEEE 2800 requirements and ensure the IBR plant model is a verified model based on final design and as-built settings as well as of good quality.

Pouyan Pourbeik thinks that likely not all of us are on the same page yet. Objective #2 would fall in purview of TS owner/operator. May lean on objective #2 for now.

Mahesh Morjaria – does not treat objective #1 and #2 any differently.

Chris Milan: objective #1 applies up to SG3 while SG 4 & 5 are more focused on objective #2.

Andy Hoke: Design evaluation process could be used for both objectives. Is it possible to write generically?

Reigh Walling: We need to make sure, somehow, that the interconnection process doesn't consider the detail changes that are inevitable between interconnection impact study time and final Design Evaluation don't be interpreted as "material modifications" that kicks the project out of the queue and requires complete re-study of impact studies.

Jason McDowell: Agree with Pouyan, both have to be done. Isn't objective #1 to assure more that the plant will be designed per 2800 at the front of the interconnection process and objective #2 is to assure that the plant was designed according to 2800 once the plant is built? Seems to me that both apply here since SG2-5 covers all these stages.

Jens Boemer summarized decisions needed to move forward:

1. Objective of design evaluation – perhaps list various objectives using “may” language, then let users decide which to apply?
2. How would procedures to achieve objective #1 and objective #2 differ, if at all?
3. Level to which 2800.2 recommends quantitative pass/fail criteria for IBR unit level model validation.

SG3 will continue to work on these issues.

Andy asked meeting attendees to join any subgroups or task force they are interested in to continue to develop the technical content of IEEE P2800.2. The next meeting is tentatively scheduled for August 29-31, 2023.

Andy thanked the subgroup leads and working group members and adjourned the meeting at 3:00 pm ET.