**UNITED STATES OF AMERICA**
**BEFORE THE**
**FEDERAL ENERGY REGULATORY COMMISSION**

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| Freeman Solar, LLC<br>Complainant, | ) | |
| | ) | |
| v. | ) | Docket No. EL24-135-000 |
| | ) | |
| PJM Interconnection, L.L.C.<br>Respondent. | ) | |

**ANSWER OF PJM INTERCONNECTION, L.L.C.**

Pursuant to Rule 213 of the Federal Energy Regulatory Commission's ("Commission") Rules of Practice and Procedure,[1] PJM Interconnection, L.L.C. ("PJM"), submits this Answer to the Complaint filed by Freeman Solar, LLC ("Freeman Solar" or "Complainant") in the captioned proceeding.[2] Freeman Solar has not shown that PJM violated the Federal Power Act ("FPA") or its Tariff by terminating and withdrawing Freeman Solar's New Service Request, designated as PJM Project #AG1-529 ("AG1-529 Project"), for not providing a response that included the data necessary to correct the newly created deficiencies resulting from Freeman Solar's late-stage changes to its New Service Request as of the deadline set forth in the Tariff. The Commission therefore should deny the Complaint.

[1] 18 C.F.R. § 385.213.

[2] *PJM Interconnection, L.L.C.*, Complaint and Request for Fast Track Processing of Freeman Solar LLC, Docket No. EL24-135-000 (Aug. 23, 2024) ("Complaint"). The Complaint was brought pursuant to Federal Power Act ("FPA") sections 204, 306 and 309. 16 U.S.C. §§ 824e. 825e and 825h. This Answer is supported by the Affidavit of Mr. Andrew J. Lambert, a PJM Manager, Interconnection Planning Projects ("Lambert Aff.") and by the Affidavit of Mark Sims, a PJM Senior Manager, Interconnection Analysis ("Sims Aff."). Capitalized terms not defined herein have the meaning set forth in the PJM Open Access Transmission Tariff ("Tariff").

As a complainant under FPA section 206, Freeman Solar has the burden of showing that the Tariff or PJM's practices are unjust, unreasonable, unduly discriminatory, or preferential.[3] In addition, any "replacement" rate or practice must be just and reasonable,[4] and Freeman Solar's proposal to re-insert its project into Transition Cycle No. 1 of PJM's interconnection process does not meet this test. Freeman Solar has neither satisfied the Tariff requirements nor met its FPA section 206 burden, and its Complaint should be denied.

## I. SUMMARY

The AG1-529 Project is a proposed 75-megawatt project that would be physically located in Sussex County, Delaware, and interconnect with transmission facilities owned by Delmarva Power & Light Company.[5] Consistent with the Tariff's Transition Period Rules, PJM studied the AG1-529 Project as part of Transition Cycle No. 1, and, following Decision Point I, evaluated the Complainant's submission to determine whether it satisfied the Tariff's requirements for inclusion in Phase II of that Cycle.

The bedrocks of PJM's interconnection process are efficient and diligent processing of the interconnection queue.[6] In order for PJM to process the queue efficiently, it is imperative that Project Developers meet the deadlines sets forth in the

[3] FPA section 206(b), 16 U.S.C. § 824e(b) (stating "[T]he burden of proof to show that any rate, charge, classification, rule, regulation, practice, or contract is unjust, unreasonable, unduly discriminatory, or preferential shall be upon the Commission or the complainant.)."

[4] FPA section 206(a), 16 U.SC. § 824e(a) (stating that if the Commission finds the complained about rate or practice to be "unjust, unreasonable, unduly discriminatory or preferential, the Commission shall determine the just and reasonable rate, charge, classification, rule, regulation, practice, or contract to be thereafter observed and in force, and shall fix the same by order.").

[5] Attachment 2, Affidavit of Mark Sims on Behalf of PJM Interconnection, L.L.C., at ¶ 4 ("Sims Aff.").

[6] *See, e.g., PJM Interconnection, L.L.C.*, 181 FERC ¶ 61,162, at P 7 ("Interconnection Reform Order") (recognizing PJM's prioritization of efficiency in the interconnection queue process), *order on reh'g*, 184 FERC ¶ 60,006 (2022).

Tariff and provide the information required of them within the time frames set forth in the Tariff. Freeman Solar through its Complaint effectively seeks an exemption from the Tariff that would have its project re-inserted into Transition Cycle No. 1 despite the fact that it did not meet the Tariff's requirements to advance to the next phase of the Cycle.

Since entering the queue in 2020, Freeman Solar submitted its original project configuration at multiple opportunities, including as part of its Decision Point I submission.[7] Freeman Solar did so notwithstanding the fact that PJM had identified a reactive power factor deficiency with respect to Freeman Solar's project in September 2021.[8] It was up to Freeman Solar to propose a solution after this deficiency was identified in 2021. Freeman Solar could have reached out with a solution prior to the Decision Point I, but did not. When Freeman Solar submitted the AG1-529 Project's Decision Point I package it did not address the reactive power factor issue, and PJM let them know that the reactive power factor deficiency was still an issue.

PJM provided a substantial amount of education and resources to all Project Developers, including Freeman Solar, regarding the opportunity to make equipment changes at Decision Point I and guidance for successfully making such changes including the development of the PJM Dynamic Model Guidelines. Only in response to PJM's deficiency determination, when PJM *again* identified the outstanding reactive power factor deficiency, did Freeman Solar take action to address this issue by significantly

[7] "As such, prior to PJM's evaluation of AG1-529 during Decision Point I of Transition Cycle No. 1…AG1-529 had been studied by PJM three times." Complaint at 9.

[8] The Complaint (at 9) erroneously asserts that "at no point in conducting these multiple studies did PJM ever conclude that there was any deficiency with respect to AG1-529." However, this statement is demonstrably incorrect, and contradicts the emails included with the Complaint reference PJM's September 15, 2021 notification to Freeman Solar of the reactive power factor deficiency. Complaint, Exhibits B (pdf page 38) and D (pdf page 58).

modifying its project configuration. In doing so, Freeman Solar not only rendered the previously submitted Phase II System Impact Study data for the original project configuration inapplicable to the modified project configuration, but also did not provide the requisite modeling data for the new configuration. As a result, because Freeman Solar did not comport with the Tariff's requirements by the conclusion of the deficiency review process, the project was deemed terminated and withdrawn, rather than included in Phase II.

In advancing its Complaint, Freeman Solar argues that certain of the deficiencies relate to Phase II System Impact Study data, and suggests that such deficiencies are not subject to the Tariff deficiency review provision. However, Freeman Solar has misconstrued the relevant Tariff provisions and does not consider others that must be read in conjunction in order to allow PJM to effectively administer both the deficiency review process and the Phase II System Impact Study process. Therefore, granting Freeman Solar's requested relief would allow Freeman Solar to depart from the requirements of the Tariff without adequate justification, and to the detriment of other Project Developers that followed the Tariff procedures.

The Commission should deny the Complaint. The relevant Tariff provisions are clear and unambiguous: New Service Requests that satisfy the requirements of Tariff, Part VII, Subpart D, section 309 move to Phase II. Projects that do not meet those requirements are terminated and withdrawn, as occurred in the case of the AG1-529 Project. Freeman Solar has not satisfied its burden of proof under FPA section 206 to demonstrate that the Tariff or PJM's practices are unjust, unreasonable, unduly discriminatory, or preferential.[9] Moreover, Freeman Solar's proposed remedy of re-inserting its project back into Transition Cycle No. 1 would delay the Phase II System Impact Study that began on June 21, 2024, the first part of which was completed on September 3, 2024, when PJM's Transition Cycle No. 1 Phase II study models were completed and posted. It would also adversely impact the availability of the models used in the analytical reliability simulations for other Project Developers in Transition Cycle No. 1 and PJM Transmission Owners working on related Facilities Studies. Based on PJM's good faith estimate, reinstating a project that has been terminated and withdrawn would delay completion of the Phase II System Impact Study and therefore Transition Cycle No. 1 by approximately five weeks, a delay that will be compounded if other, similarly situated projects also file complaints or waiver requests seeking to be placed back in Transition Cycle No. 1 after being terminated.[10]

Finally, granting this Complaint also would send the wrong signal to the 95% of projects in Transition Cycle No. 1 (representing more than 30 gigawatts of mostly renewable and hybrid generation located across 12 states) that demonstrated the diligence necessary to comply with the requirements of the Tariff and successfully progress through Decision Point I to Phase II.

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[9] *See supra* n.3.

[10] This concern about additional entities filing complaints or waiver requests is valid and, in fact, has been borne out by events. Big Shoulders Storage, LLC recently filed a request to waive retroactively the same Tariff provisions addressed in the Freeman Solar Complaint. Big Shoulders Storage, LLC Request for Limited Waiver, Expedited Action, and Shortened Comment Period of Big Shoulders Storage LLC, Docket No. ER24-2698-000 (Aug. 2, 2024). As PJM explained in its protest of the Big Shoulders waiver request, the retroactive relief requested should be denied as contrary to the filed rate doctrine, and as otherwise unsupported. *See Big Shoulders Storage, LLC*, Protest of PJM Interconnection, L.L.C., Docket No. ER24-2698-000, at 17-20 (Aug. 2, 2024). On September 6, 2024, Hummingbird Energy LLC submitted a request for retroactive waiver of the same Tariff provisions addressed in the Freeman Solar Complaint and the Big Shoulders waiver request. *Hummingbird Energy, LLC*, Request for Limited Waiver of Hummingbird Energy LLC, Docket No. ER24-3006-000 (Sept. 6, 2024).

## II. BACKGROUND

### A. Overview of PJM Transition Cycle No. 1

PJM's Transition Cycle No. 1 included 214 New Service Requests that elected to proceed to Decision Point I. Of those Decision Point I submissions, 95% (i.e., 204) met the Tariff requirements and proceeded to the next phase. The remaining 5% (i.e., 10) of the New Service Requests were terminated and withdrawn for failing to meet the applicable Tariff requirements.[11]

#### *1. PJM Transition Period Rules*

On June 14, 2022, PJM submitted comprehensive reforms to its generator interconnection process in order to replace its existing "first-come, first-served" serial study approach with a "first-ready, first-served" Cycle study approach.[12] On November 29, 2022, the Commission accepted PJM's June 14 Filing, without modification, subject to conditions.[13]

As part of these reforms, PJM proposed "Transition Period Rules," setting forth the procedures and rules governing the transition from the interconnection process in effect at the time of the filing through the commencement of the new interconnection process.[14] On the July 10, 2023 Transition Date, PJM began processing New Service

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[11] *PJM Reaches Next Interconnection Milestone*, PJM Interconnection, L.L.C., (Aug. 6, 2024), https://insidelines.pjm.com/pjm-reaches-next-milestone.

[12] *PJM Interconnection, L.L.C.*, Tariff Revisions for Interconnection Process Reform, Request for Commission Action by October 3, 2022, and Request for 30-Day Comment Period, Docket No. ER22-2110-000 (June 14, 2022) ("June 14 Filing").

[13] *See generally* Interconnection Reform Order (accepting PJM's proposed interconnection reforms, without modification, subject to the submission of informational reports).

[14] Interconnection Reform Order at P 60 (finding PJM's "Transition Period Rules are just and reasonable and not unduly discriminatory or preferential"). Transition Period Rules apply to projects in the AE1, AE2, AF1, AF2, AG1, AG2, and AH1 queue windows, where projects were not tendered an Interconnection Service Agreement or wholesale market participation agreement as of the Transition Date. *Id.* at P 37; *see also* Tariff, Part VII, Subpart A, section 300 (definition of Transition Date).

Requests under the Transition Period Rules.[15] Projects that did not qualify for the Expedited Process[16] have been processed as part of Transition Cycle No. 1.[17]

### 2. *Decision Points and System Impact Studies*

Transition Cycle No. 1 includes three study phases, each of which is followed by a Decision Point: (1) Phase I System Impact Study ("Phase I") and Decision Point I; Phase II System Impact Study ("Phase II") and Decision Point II; and Phase III System Impact Study ("Phase III") and Decision Point III.[18] The Phase I, II, and III System Impact Studies "are a regional analysis of the effect of adding to the Transmission System the new facilities and services proposed by valid New Service Requests and an evaluation of their impact on deliverability to the aggregate of PJM Network Load."[19] At each Decision Point, a Project Developer must make certain informational showings in order to move forward with its project or elect to withdraw. In addition, a project can be

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[15] PJM provided stakeholder education on the transition timeline. *See, e.g.*, Jonathan Thompson, *Transition Timeline, June 2023 IPS*, PJM Interconnection, L.L.C. (June 21, 2023), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2023/20230626/20230626-item-06---interconnection-projects-ips-transition-window.ashx.

[16] Tariff, Part VII, Subpart B, section 304(C)(2)(a). Based on the transition sorting results released in December 2023, 308 projects entered the Expedited Process and 308 entered Transition Cycle No. 1. *See also* Mojtaba Hoshmand, *Interconnection Analysis Transition Sorting Retool, Expedited Process, Transition Cycle 1 & Model Availability*, PJM Interconnection, L.L.C., at 7 (Dec. 21, 2023), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2023/20231221/20231221-item-04---ips-presentation.ashx.

[17] PJM provided stakeholder education on the transition sorting process. *See, e.g.*, Interconnection Process Subcommittee, Fast Lane vs. Transition Cycle #1 Sort Analysis, PJM Interconnection, L.L.C. (July 31, 2023), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2023/20230731/20230731-item-03---retool-study-process-to-determine-fast-lane-vs-tc1-and-model-availability.ashx; *see* Mojtaba Hosmand, *Fast Lane/ TC1 Classification*, PJM Interconnection, L.L.C. (July 31, 2023), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2023/20230731/20230731-item-04---fast-lane-and-tc1-classification.ashx.

[18] Tariff, Part VII, Subpart D, sections 309(A)(1), 311(A)(1), and 313(A); *see also* Attachment 1, Affidavit of Andrew J. Lambert on Behalf of PJM Interconnection, L.L.C., at ¶ 4 (Lambert Aff."); Sims Aff. at ¶ 3.

[19] Tariff, Part VII, Subpart D, section 307(A)(2)(a); *see* John Reid, *Interconnection Analysis Transition Sort Retool & Model Availability*, PJM Interconnection, L.L.C., 8 (Sept. 27, 2023), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2023/20230927/20230927-item-05--transitionsortretoolandmodelavailability.ashx.

removed from PJM's interconnection queue if it does not meet the Tariff requirements at that stage.[20]

a. Phase I

PJM commenced Phase I of Transition Cycle No. 1 on January 22, 2024,[21] and concluded Phase I on May 20, 2024.[22] During Phase I, PJM performed the applicable studies with respect to the New Service Requests placed in Transition Cycle No. 1.[23]

b. Decision Point I

The 30-day period following Phase I (i.e., May 21, 2024, to June 20, 2024) represented the Decision Point I window.[24] During Decision Point I, a Project Developer has the option of either withdrawing its New Service Request or remaining in Transition Cycle No. 1.[25] A Project Developer electing to remain in Transition Cycle No. 1 is required to demonstrate satisfaction of the requirements set forth in Tariff, Part VII, Subpart D, section 309 on or before the end of the Decision Point I window (June 20, 2024). Tariff, Part VII, Subpart D, section 309(A) lists the information a Project Developer must provide and the steps it must take at Decision Point I, including

[20] Tariff, Part VII, Subpart D, sections 309(A)(1), 311(A)(1), and 313(A)(1); *see* Lambert Aff. at ¶ 4; Sims Aff. at ¶ 3.

[21] Lambert Aff. at ¶ 4; *see* Jonathan Thompson, *TC1 DP1 Progress Update*, PJM Interconnection, L.L.C., at 2 (July 24, 2024), https://pjm.com/-/media/committees-groups/subcommittees/ips/2024/20240729/20240729-item-04---tc1-dp1-status.ashx ("July 2024 Update").

[22] Lambert Aff. at ¶ 5; July 2024 Update at 2.

[23] *See* Lambert Aff. at ¶ 4.

[24] Tariff, Part VII, Subpart D, section 309(A) ("The Decision Point I shall commence on the first Business Day immediately following the end of Phase I."); *see* Lambert Aff. at ¶ 5; Sims Aff. at ¶ 5 and Figure 1.

[25] Tariff, Part VII, Subpart D, section 309(A).

providing Readiness Deposit No. 2, providing evidence of Site Control,[26] and the submission of data required for the Phase II System Impact Study.[27]

In advance of the Decision Point I deadline, PJM provided extensive stakeholder education during the monthly Interconnection Planning Subcommittee ("IPS") meetings.[28] The IPS was formed in 2022 to provide a stakeholder forum to investigate and resolve specific issues related to the generation interconnection process and associated agreements, governing documents, and manuals, and is intended to, among other things, provide information and education outreach to stakeholders. Of particular relevance to the Freeman Solar AG1-529 Project, PJM provided the information below to stakeholders:

- PJM prepared and posted "PJM Dynamic Model Development Guidelines for Interconnection Analysis," Revision 0 (September 18, 2023).[29]
- Starting in October 2023, PJM presented educational material to stakeholders regarding PJM's Dynamic Model Guidelines for stability

[26] Tariff, Part VII, Subpart D, section 309(A)(1)(b). This includes the requirement to provide the Site Control certification set forth in Tariff, Part VII, Subpart D, section 302(A)(9) (at each point in a Cycle at which a Project Developer is required to provide evidence of Site Control, the Project Developer must also provide a certificate from a corporate officer or other authorized representative verifying that the Site Control requirements had been met).

[27] Tariff, Part VII, Subpart D, section 309(A)(1)(f).

[28] The IPS was formed in 2022 to provide a "stakeholder forum to investigate and resolve specific issues related to the Interconnection Process and associated agreements, governing documents, and manuals." *Interconnection Planning Subcommittee (IPS) Charter*, PJM Interconnection, L.L.C., at 1 (July 14, 2022), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/postings/ips-charter.ashx ("IPS Charter"). The IPS is intended to facilitate, among other things, "[e]ducation of the various aspects of the current and future interconnection processes and agreements including clarifications around implementation." IPS Charter at 1. PJM began providing stakeholder education related to the new interconnection rules at the January 27, 2023 IPS meeting. *See* Jonathan Thompson, *Transition Update, January 2023 IPS*, PJM Interconnection, L.L.C. (Jan. 27, 2023), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2023/20230130/item-04---transition-update---ips---jan-2023.ashx.

[29] *See* Lambert Aff. at Exhibit A, Interconnection Analysis & Interconnection Planning Analysis Departments, *PJM Dynamic Model Development Guidelines for Interconnection Analysis, Revision 0*, PJM Interconnection, L.L.C. (Sept. 18, 2023), https://pjm.com/-/media/planning/services-requests/pjm-dynamic-model-development-guidelines.ashx ("Dynamic Model Guidelines").

studies.[30] ***PJM explained that the Dynamic Model Guidelines are "applicable to Transition Cycle 1 projects, that choose to make changes at Decision Point 1 and/or 2"[31] and "failure to comply or cure deficiencies will result in withdrawal."***[32]

- In October 2023,[33] November 2023,[34] and December 2023.[35] PJM announced the release of a series of training videos addressing various topics, including Cycle Process Overview; Phase 1, 2, and 3 Analysis; Decision Point I, II, and III Requirements; and Model Building and Availability.[36]

- On January 29, 2024, shortly after the start of Phase I, PJM announced that Transmission Cycle No. 1 projects "currently have the opportunity to submit updated dynamic model data to PJM prior to TC1/DP1 *in accordance with the PJM Dynamic Model Development Guidelines*" and reiterated that "Project Developers will need to follow the Dynamic Model Development Guidelines document posted on PJM.com."[37]

- In March 2024, PJM again reviewed with stakeholders the Dynamic Model Guidelines for Decision Point I submissions.[38] ***PJM highlighted***

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[30] Interconnection Planning Subcommittee, *PJM Dynamic Model Development Guidelines for Stability Studies, Interconnection Process Training for Developers*, PJM Interconnection, L.L.C. (Oct. 25, 2023), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2023/20231030/20231030-item-06---dynamic-modeling-guidelines-for-stability-studies_updated-10-20-23.ashx.

[31] *See id*. at 6.

[32] *Id*. at 3.

[33] Christina Andalora, *Interconnection Process Training for Project Developers*, PJM Interconnection, L.L.C. (Oct. 30, 2023), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2023/20231030/20231030-item-07---developer-training_oct-ips.ashx.

[34] Christina Andalora, *Interconnection Process Training for Project Developers*, PJM Interconnection, L.L.C. (Nov. 20, 2023), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2023/20231120/20231120-item-05---developer-training_nov-ips.ashx ("November 2023 Posting").

[35] At the December IPS meeting, PJM suggested Transition Cycle No. 1 projects refer to the training materials on topics including Decision Point I Requirements and Model Building and Availability. *See* Christina Andalora, *Interconnection Process Training for Project Developers*, PJM Interconnection, L.L.C. (Dec. 21, 2023), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2023/20231221/20231221-item-05---developer-training.ashx.

[36] November 2023 Posting at 3.

[37] Heather Reiter, *Interconnection Analysis Expedited Process & Transition Cycle 1 Status*, PJM Interconnection, L.L.C., at 10 (Jan. 29, 2024), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2024/20240129/20240129-item-04---fast-lane---tc1-status-update.ashx.

[38] Lambert Aff. at Exhibit B, Anisha Fernandes, *PJM Dynamic Modeling Development Guidelines for DP 1 Submissions*, PJM Interconnection, L.L.C. (July 10, 2024), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2024/20240322/20240322-item-06---dynamic-modeling-guidelines-for-dp1-submissions.ashx ("March 2024 Posting").

***that any allowable changes made at Decision Point I, including equipment changes, required the submission of an updated dynamic model package***.[39] PJM also alerted stakeholders to commonly observed deficiencies,[40] detailed the components of each deliverable,[41] and provided a checklist to assist Project Developers in preparing their updated dynamic model information.[42]

- In April 2024, PJM presented a fourth review to stakeholders of the Dynamic Model Guidelines as they relate to the submission for Decision Point I.[43] PJM further reviewed other requirements related to Decision Point I submissions, including the deficiency review process.[44]

- In May 2024, PJM highlighted the need to comply with the Dynamic Model Guidelines for the fifth time and provided to stakeholders a second overview of the deficiency review process.[45]

- In June 2024, PJM provided to stakeholders a third overview of the deficiency review process.[46]

- In July 2024, PJM provided to stakeholders a fourth overview of the deficiency review process.[47]

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[39] *Id*. at 3.

[40] *Id*. at 5.

[41] *Id.* at 6-7.

[42] *Id.* at 8-9.

[43] Anisha Fernandes, *PJM Dynamic Model Development Guidelines: Requirements for DP 1 Submissions*, PJM Interconnection, L.L.C. (April 22, 2024), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2024/20240422/20240422-item-08---dynamic-modeling-guidelines-for-dp1-submissions.ashx.

[44] Megha Tiwari, *Decision Point I Requirements*, PJM Interconnection, L.L.C., at 8 (June 25, 2024), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2024/20240422/20240422-item-05---decision-point-i-requirements.ashx.

[45] Kyle Copeland, *Fast Lane Progress Update*, PJM Interconnection, L.L.C., at 6-7 (May 31, 2024), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2024/20240529/20240529-item-03-04---fast-lane-progress-update---model-availability.ashx.

[46] Michelle Farhat, *Fast Lane & TC1 Progress Update*, PJM Interconnection, L.L.C., 5 at (June 18, 2024), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2024/20240621/20240621-item-03---fast-lane-and-tc1-progress-update.ashx.

[47] Jonathan Thompson, *TC1 DP1 Progress Update*, PJM Interconnection, L.L.C., at 2 (July 25, 2024), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2024/20240729/20240729-item-04---tc1-dp1-status.ashx.

c. Phase II

On June 21, 2024, Phase II of Transition Cycle No. 1 commenced.[48] It is important to note that Freeman Solar's Decision Point I submission provided the original project information and equipment configuration that was submitted in 2020, even though PJM had identified and notified Freeman Solar of a reactive power factor deficiency in September 2021.[49] The Decision Point I deficiency review process also started on that date[50] and, as allowed by the Tariff,[51] the Decision Point I and Phase II System Impact Study work streams ran co-extensively.[52] Tariff, section 309(A)(1) requires a Project Developer to provide the following information at Decision Point 1: (a) Readiness Deposit No. 1; (b) Site Control evidence in accordance with Tariff sections 302 and 308(1)(a)1(b); (c) information applicable to Transmission Interconnection Requests (not applicable to the AG1-529 Project); (d) evidence of air and water permits, if applicable; (e) information applicable to state-level, non-jurisdictional interconnection projects (also not applicable to the AG1-529 Project); and (f) submission of New Service Request data for PJM's Phase II system impact study.[53] Tariff, section 309(A)(1)(g) states: "If Project Developer or Eligible Customer fails to submit all of the criteria in (a) through (f) above,

[48] Lambert Aff. at ¶ 10; Sims Aff. at ¶ 5.

[49] Lambert Aff. at ¶ 10.

[50] *Id.* at ¶ 10.

[51] Tariff, Part VII, Subpart D, section 309(A)(1)(h)(iv).

[52] Lambert Aff. at ¶ 9.

[53] Freeman Solar refers to these as Elements (A) through (F). The Complaint focuses on Element (F), the obligation to provide New Service Request data for Phase II. This data "generally includes company information, Point of Interconnection information, generator information (such as size, capability, and seasonal ratings), fuel supply, inverter and transformer ratings, impedances and equipment configuration." Lambert Aff. at ¶ 6.

before the close of the Decision Point I phase, Project Developer's or Eligible Customer's New Service Request shall be deemed terminated and withdrawn."

Tariff, section 309(A)(1)(h) establishes a deficiency review period and states as follows:

> at the close of the Decision Point I, Transmission Provider will begin the deficiency review of the elements set forth in (b) through (e) above, as follows:
>
> > i. Transmission Provider will exercise Reasonable Efforts to inform Project Developer or Eligible Customer of deficiencies within 10 Business Days after the close of Decision Point I.
> >
> > ii. Project Developer or Eligible Customer then has five Business Days to respond to Transmission Provider's deficiency determination.
> >
> > iii. Transmission Provider then will exercise Reasonable Efforts to review Project Developer's or Eligible Customer's response within 10 Business Days, *and then will either terminate and withdraw* the New Service Request, *or include the New Service Request in Phase II*.
> >
> > iv. Transmission Provider's review of the above required elements may run co-extensively with Phase II.[54]

As described above, the Tariff does not afford more than a single five-Business Day window to a Project Developer to respond to any deficiency determinations. The Tariff also states "Transmission Provider may deem a New Service Request terminated and

[54] Tariff, Part VII, Subpart D, sections 309(A)(1)(h) (i)-(iv) (emphasis added); s*ee also* June 14 Filing at 45 n.143, 51, 56, and Affidavit of Jason R. Shoemaker on Behalf of PJM Interconnection, L.L.C. (Attachment D) ¶¶ 18, 39, 48 (explaining the deficiency review process). Tariff, Part VII, Subpart D, sections 309(A)(1)(b) and (d) require a Project Developer to provide evidence of Site Control consistent with Tariff, Part VII, Subpart A, section 302 and evidence of air and water permits, if applicable. Tariff, Part VII, Subpart D, section 309(A)(1)(c) requires information relevant to Transmission Interconnection Requests and Tariff, Part VII, Subpart D, section 309(A)(1)(e) requires that for state-level, non-jurisdictional interconnection projects, evidence of participation in the state-level interconnection process with the applicable entity be provided.

withdrawn *for failing to meet any of the Decision Point I requirements*, as set forth in this Tariff, Part VII, Subpart D, section 309."[55]

The Tariff lists the types of changes a Project Developer may make to its project at Decision Point I, including equipment changes.[56] With regard to equipment changes, the Tariff states, "[d]uring Decision Point I, Project Developer may modify its Interconnection Request for updated equipment data. Project Developer shall submit machine modeling data as specified in the PJM Manuals before the close of Decision Point I."[57] This requirement is also spelled out in PJM Manual 14H, New Service Requests Cycle Process, which states:

> Modeling Data required for Stability analysis must be provided with the submitted application in PJM data submission tool. Project Developers shall follow PJM Dynamic Model Development Guidelines on the PJM website to submit stability data specific to their project. Project Developers should pay special attention to PJM Dynamic Model Development Guidelines to ensure all deliverables are met. If stability data submission is not approved at the end of the deficiency review period, the application will be withdrawn.[58]

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[55] Tariff, Part VII, Subpart D, section 309(A)(4)(b) (emphasis added).

[56] *Id.* at section 309(B).

[57] *Id.* at section 309(B)(6)(a); *see also* Megha Tiwari, *Decision Point I Requirements and Off-Ramp to Final Agreement*, PJM Interconnection, L.L.C., at 4 (July 10, 2024), https://www.pjm.com/-/media/committees-groups/subcommittees/ips/2024/20240322/20240322-item-05---decision-point-i-requirements-and-off-ramp-to-final-agreement.ashx (stating "[m]odification to interconnection request for updated equipment data is permitted. Project shall submit machine modeling data as per PJM Manuals and Dynamic Modeling Guidelines"); *see* March 2024 Posting at 4 (same); *see also* Anisha Fernandes, *PJM Dynamic Model Development Guidelines for DP1 Submissions*, PJM Interconnection, L.L.C. (Mar. 19, 2024), https://pjm.com/-/media/committees-groups/subcommittees/ips/2024/20240322/20240322-item-06---dynamic-modeling-guidelines-for-dp1-submissions.ashx; *see* System Planning Division, *PJM Manual 14C: Interconnection Facilities, and Network Upgrade Construction, Revision: 16*, PJM Interconnection, L.L.C., at 52 (July 26, 2023), https://www.pjm.com/~/media/documents/manuals/m14c.ashx.

[58] Interconnection Projects Department, *PJM Manual 14H, New Service Requests Cycle Process, Revision: 00*, at section 2.1.2 (July 26, 2024), https://pjm.com/-/media/documents/manuals/m14h.ashx.

Contemporaneous with the deficiency review process of Decision Point I submissions, PJM must commence the Phase II System Impact Study,[59] and use Reasonable Efforts to complete Phase II within 180 days from the start of Phase II.[60] Per the Tariff, "[o]nly New Service Requests meeting the requirements of Tariff, Part VII, Subpart D, section 309, Decision Point I phase, will be included in the Phase II System Impact Study."[61] As part of the Phase II System Impact Study, PJM must retool load flow results and perform short circuit[62] and stability analyses[63] as required.[64] PJM began updating Transition Cycle No. 1 Phase II models on June 21, 2024, per the Tariff. PJM's Transition Cycle No. 1 Phase II study models were completed and posted as of September 3, 2024.

### B. Description of Freeman Solar's Decision Point I Submission Deficiencies and Failure to Address Deficiencies Pursuant to the Tariff's Deficiency Review Process

Decision Point I of Transition Cycle No. 1 closed on June 20, 2024, and PJM commenced deficiency reviews of the Decision Point I submissions provided by Project

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[59] Tariff, Part VII, Subpart D, section 310(A)(1)(e) ("Phase II shall start on the first Business Day immediately following the end of the Decision Point I . . . .").

[60] *Id*. at section 310(A)(1)(e)(ii).

[61] *Id.* at section 310(A)(1).

[62] Short circuit analyses ensure that the high-voltage circuit breakers on the transmission system are sufficiently rated to interrupt fault currents. *See* Transmission Planning Department, *PJM Manual 14B: PJM Region Transmission Planning Process, Revision: 56*, PJM Interconnection, L.L.C., at Attachment G, section G.7 (June 27, 2024), https://www.pjm.com/directory/manuals/m14b/index.html#about.html.

[63] The New Service Request stability analysis that is part of the Phase II System Impact Study is designed to meet North American Electric Reliability Corporation criteria. PJM Manual 14B, Attachment G, section G.3. These stability studies identify needed reinforcements and determine cost responsibility for these reinforcements due to New Service Requests stability issues, and any upgrade responsibilities are memorialized in a Project Developer's Generator Interconnection Agreement. *Id.* at section G.3.2.

[64] Tariff, Part VII, Subpart D, section 310(A)(1)(a).

Developers, including Freeman Solar, the following day.[65] In accordance with the timing required by the Tariff, on June 28, 2024,[66] PJM notified Freeman Solar of the following deficiencies in its Decision Point I submission: [67]

(1) Officer Certification: the Officer Certification required as part of its Site Control showing had an inaccurate date that needed correction;

(2) Equipment Information: missing required data related to modeling of the main power transformer, missing one line diagram and lack of other data elements required by the PJM Dynamic Model Guidelines; and

(3) Generator Information: the project did not meet the reactive power factor requirement at the main power transformer's high side.

As to the deficiency review process, the Tariff provides that a "Project Developer . . . then has five Business Days to respond to Transmission Provider's deficiency determination." [68] Accordingly, the deficiency notice specifically directed Freeman Solar to login into its account and address the comments or provide additional information within five Business Days (close of business of July 8, 2024).[69]

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[65] *Id.* at section 309(A)(1)(h) ("If Project Developer . . . submits all elements in (a) through (f) above, then, at the close of Decision Point I, Transmission Provider will begin the deficiency review of the elements set forth in (b) through (e) above, as follows . . . .").

[66] Tariff, Part VII, Subpart D, section 309(A)(1)(h)(i) ("Transmission Provider will exercise Reasonable Efforts to inform Project Developer or Eligible Customer of deficiencies within 10 Business Days after the close of Decision Point I.").

[67] *See* Complaint, Exhibit B, Email from Queue Point, to Edward Shambeau, Manager, Technical Services, Brookfield Renewable U.S. ("Brookfield") (setting forth deficiency notice).

[68] Tariff, Part VII, Subpart D, section 309(A)(1)(h)(ii).

[69] *See* Complaint, Exhibit B, Email from Queue Point, to Edward Shambeau, Manager, Technical Services, Brookfield Renewable U.S. ("Brookfield") (setting forth deficiency notice).

On July 3, 2024, Freeman Solar provided information that corrected the Officer Certification, and that was intended to address to other deficiencies. This included a report prepared by its consultant Telos Energy ("Telos Report").[70] The Telos Report describes significant modifications to the AG1-529 Project's original equipment configuration, including replacing the thirty 2.5 megavolt-ampere ("MVA") SMA inverters with twenty-two 4.4 MVA Sungrow inverters.[71] Notwithstanding the submission of the Report, Freeman Solar did not provide the model data required by Tariff, section 309 at this point.

Pursuant to the Tariff, the final step of the deficiency review process involves PJM "exercis[ing] Reasonable Efforts to review Project Developer's . . . response within 10 Business Days, *and then* [PJM] *will either terminate and withdraw the New Service Request, or include the New Service Request in Phase II.*"[72] By email dated July 31, 2024, PJM notified Freeman Solar of the following deficiencies that were created as a result of the significant equipment changes introduced as part of Freeman Solar's deficiency response, and that its project was terminated and withdrawn, stating:

> I'm reaching out to notify you that AG1-529 has been withdrawn from Transition Cycle 1 for failure to cure the Decision Point I deficiencies by the deficiency cure deadline (by close of business on 7/8/24.) Stability data was still deficient. Please see the below for more information on the deficiency:
>
> 1. Queue Point Data Application form data (e.g. inverters type, number of inverters and their capacity) is not updated according to the data provided in the dynamic model report.

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[70] The Telos Report is included as Attachment C to the Complaint.

[71] Telos Report, Attachment C, page 1.

[72] Tariff, Part VII, Subpart D, section 309(A)(1)(h)(iii); *see id.* at section 310(A)(1) ("Only New Service Requests meeting the requirements of Tariff, Part VII, Subpart D, section 309, Decision Point I phase, will be included in the Phase II System Impact Study."); *see also id.* at section 309(A)(1)(f) (requiring the submission of New Service Request data for Phase II System Impact Study at Decision Point I).

2. MFO and PF assessment not provided.

3. .idv, .cnv, .snp and .sld not provided.

4. Out and log files of results not provided; and

5. Dynamic model setting does [not] meet FERC Order 827 automatic voltage regulation and Confirmation Momentary Cessation.[73]

In short, because Freeman Solar made significant equipment changes, the previously provided dynamic model representation of the AG1-529 project was no longer valid.[74] Moreover, making these equipment changes required Freeman Solar to follow the PJM Dynamic Model Guidelines and provide the required updated modeling information.[75] Freeman Solar's July 3, 2024 submission, however, did not provide updated modeling data for the changed AG1-529 Project equipment configuration that followed the PJM Dynamic Model Guidelines.

Additionally, and as described above, Freeman Solar submitted its original project configuration multiple times since entering the queue in 2020, including as part of its Decision Point I submission.[76] Freeman Solar did so notwithstanding the fact that PJM had identified a reactive power factor deficiency with respect to Freeman Solar's project on September 15, 2021.[77] PJM provided a substantial amount of education and resources

[73] Complaint at Exhibit L (email from Christina Catalano, Senior Engineer II, PJM, to Edwards Shambeau, Manager, Technical Services, Brookfield (July 31, 2024)); Lambert Aff. at Exhibit D (same). Freeman Solar refers to these as Deficiency No. 1 through Deficiency No. 5.

[74] Tariff, Part VII, Subpart D, section 309(A)(1)(f) (requiring the submission of New Service Request data for Phase II System Impact Study).

[75] *Id.* at section 309(B)(6); *see also* Manual 14H, section 2.1.2.

[76] Lambert Aff. at ¶ 14; Complaint at 9 (stating "prior to PJM's evaluation of AG1-529 during Decision Point I of Transition Cycle No. 1…AG1-529 had been studied by PJM three times.").

[77] As noted above, the Complaint (at 9) erroneously asserts that "at no point in conducting these multiple studies did PJM ever conclude that there was any deficiency with respect to AG1-529." However, this statement is demonstrably incorrect, and contradicts the emails included with the Complaint that reference

to all Project Developers, including Freeman Solar, regarding the opportunity to make equipment changes at Decision Point I and guidance for successfully making such changes. Only in response to PJM's deficiency determination, when PJM *again* identified the outstanding reactive power factor deficiency, did Freeman Solar take action to address this issue by significantly modifying its project configuration. In doing so, Freeman Solar not only rendered the previously submitted Phase II System Impact Study data for the original project configuration inapplicable to the modified project configuration, but also did not provide the requisite modeling data for the new configuration. As a result, because Freeman Solar did not comport with the Tariff's requirements by the conclusion of the deficiency review process, the project was deemed terminated and withdrawn, rather than included in Phase II.[78]

## III. ANSWER TO COMPLAINT

### A. Overview of the FPA's Complaint Requirements

A party filing a complaint under FPA section 206 has the burden of showing that the complained-about rates or practices are unjust, unreasonable, unduly discriminatory or preferential.[79] In addition, the replacement rate or practice must be just and reasonable.[80] Despite Freeman Solar's assertions to the contrary,[81] PJM's actions in determining the AG1-529 Project was terminated and withdrawn are proper and consistent with the Tariff. Freeman Solar did not correct the identified deficiencies

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PJM's September 15, 2021 notification to Freeman Solar of the reactive power factor deficiency. Complaint, Exhibit B and Exhibit D.

[78] *See* Tariff, Part VII, Subpart D, sections 309(A)(4)(b) and 310(A)(1).

[79] FPA section 206(b), 16 U.S.C. § 824e(b); *see also supra* n.3.

[80] FPA section 206(b), 16 U.S.C. § 824e(a); *see also supra* n.4.

[81] Complaint at 19-29.

within the required period by providing the required modeling data necessitated by the significant equipment changes presented for the first time after PJM had reviewing Freeman Solar's Decision Point I submission. In addition, the Complaint focuses most on the deficiencies that relate to Phase II System Impact Study data (Element F), which Freeman Solar claims is not subject to the deficiency review and therefore does not provide a basis for terminating its New Service Request. However, this claim misconstrues the requirements and PJM's authority under Tariff section 309, and ignores the other deficiencies Freeman Solar failed to correct. Freeman Solar has not met its burden under section 206 of the FPA to demonstrate that PJM's actions are unjust, unreasonable, unduly discriminatory or preferential. Furthermore, Freeman Solar's proposed solution – inserting its project back into the interconnection process – is not just and reasonable,[82] and the Commission therefore should deny the Complaint.

[82] Because Freeman Solar does not sustain its initial burden of proof, the Commission does not need to consider the remedy or other issues raised in the pleadings. *EDF Renewables Energy, Inc. v. Midcontinent Indep. Sys. Operator, Inc.*, 165 FERC ¶ 61,071, at P 19 (2018) (stating the Commission did not to review the proposed remedy because complaint "because EDF did not meet the burden of proof demonstrating that MISO's actions and the current DPP process are unjust and unreasonable."); *New England Power Generators Ass'n, Inc. v. ISO New England Inc.*, 150 FERC ¶ 61,053, at P 35 (rejecting complaint filed by the New England Power Generators Association, Inc. ("NEPGA") finding that as complainant has failed to meet its section 206 burden to demonstrate the relevant tariff mechanisms were unjust and unreasonable, the Commission "need not address whether NEPGA's proposed alternative is just and reasonable"); *reh'g denied*, 153 FERC ¶ 61,222, at P 35 (stating "[i]f NEPGA had met its section 206 burden to show that the existing tariff provisions were unjust and unreasonable, the Commission would then have determined a just and reasonable replacement rate, whether by accepting NEPGA's proposal, if supported by record evidence, or implementing its own solution."); *Coalition of MISO Transmission Customers v. Midcontinent Indep. Sys. Operator, Inc.*, 181 FERC ¶ 61,005, at PP 61, 66 (2022) (rejecting complaint because complainants had not met their section 206 burden, and stating "[b]ecause [c]omplainants have failed to demonstrate that the Tariff is unjust and unreasonable for the reasons discussed above, we need not address the other issues raised in the protests, comments, and answers."). The fact that PJM is making this argument should not in any way be construed as an admission that the Complaint is justified.

### B. Freeman Solar's Claims That PJM Cannot Terminate and Withdraw Its Project Based on Deficient Phase II System Impact Study Data Is Incorrect

Freeman Solar first asserts that termination and withdrawal of its project based on deficient Phase II System Impact Study data (Element F) is improper because the deficiency review provisions only apply to Elements B through E.[83] However, this claim misstates both what occurred and PJM's Tariff authority. PJM terminated and withdrew the AG1-529 Project for several reasons, including not providing the modeling required in connection with the project's significant equipment changes.[84] In addition, the Tariff states "Transmission Provider may deem a New Service Request terminated and withdrawn *for failing to meet any of the Decision Point I requirements*, as set forth in this Tariff, Part VII, Subpart D, section 309."[85] Moreover, section 310 states, "*Only New Service Requests meeting the requirements of Tariff, Part VII, Subpart D, section 309, Decision Point I phase*, will be included in the Phase II System Impact Study."[86] Under the Tariff, PJM has a clear obligation to ensure a Project Developer's Decision Point I submission demonstrates satisfaction of the requirements necessary to progress to Phase II, which commenced coincident with the deficiency review process. Thus, any claim that the Tariff precludes PJM deeming a project terminated and withdrawn at Decision Point I for any reason other than not satisfying Elements B through E deficiencies is misplaced.

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[83] Complaint at 16-17. Elements B though F refer to the requirements set forth in Tariff, Part VII, Subpart D, sections 309(A)(1)(b)-(f).

[84] Tariff, Part VII, Subpart D, section 309(B) (6)(a).

[85] *Id.* at section 309(A)(4)(b) (emphasis added).

[86] *Id.* at section 309(A)(4)(b) and 310(A)(1) (emphasis added).

Moreover, Freeman Solar's stability data submission had not been approved as of the end of the Decision Point I deficiency review period. As Freeman Solar acknowledges, PJM Manual 14H states "[i]f stability data submission is not approved at the end of the deficiency review period, the application will be withdrawn."[87] Freeman Solar claims that this provision of Manual 14H is in conflict with the Tariff because, in its view, a project can only be terminated for failure to correct Elements B through E deficiencies. However, this assertion is incorrect as it ignores PJM's authority under the Tariff to ensure only projects ready for Phase II are advanced,[88] and thus Freeman Solar's arguments should be rejected.

### C. Freeman Solar Did Not Comply with PJM's Decision Point I Requirements; Therefore, Deeming the AG1-529 Project Terminated and Withdrawn Is Appropriate

Freeman Solar asserts that it provided all of the relevant modeling and stability data submissions for the Phase II System Impact Study.[89] Freeman Solar then cites to the discussion in the June 14 Filing referencing the use of load flow data as part of the initial retool process, and points out that PJM informed it that "there were no issues with the load flow data provided by Freeman Solar on June 18, 2024."[90] It is unclear what Freeman Solar is attempting to show in this argument, because the filing also clearly discusses the need to assess short circuit and system stability issues.[91] However,

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[87] Complaint at 8,18, (*citing* Manual 14H, section 2.12). That section of Manual 14H also expressly cautions Project Developer that they "should pay special attention to PJM Dynamic Model Development Guidelines to ensure all deliverables are met." Freeman Solar did not follow that caution.

[88] *See* Tariff, Part VII, Subpart D, sections 309(A)(4)(b) and 310(A)(1).

[89] Complaint at 19.

[90] *Id.* at 19.

[91] The Complaint seems to acknowledge the need to correct short circuit and system stability data. *See* Complaint at 11, and Exhibits B, D, E and I.

Freeman Solar may be trying to argue that because its load flow data was not deemed deficient, it materially complied with PJM's data submission requirements.[92]

Freeman Solar seems to be confusing its concepts. PJM agrees that the initial deficiency notice did not identify load flow data deficiencies; it instead identified deficiencies in the short circuit, stability and reactive power factor data, as well as other errors such as the wrong data in the Officer Certification.[93] Contrary to Freeman Solar's assertion, it had not provided all applicable modeling and stability data needed for PJM to perform the Phase II System Impact Study. As detailed in the Affidavit of Mark Sims, Phase II involves more than just load flow studies.[94] The stability data Freeman Solar provided as part of its deficiency response was inadequate, incomplete, and was not sufficient to correct the deficiency stability and short circuit deficiencies.[95] Thus, the AG1-529 Project was terminated and withdrawn after the Decision Point I deficiency review period ended per the Tariff.

Freeman Solar also claims that it corrected Deficiency No. 1.[96] However, it did not provide the machine modeling data required due to its inverter change as specified in the Dynamic Modeling Guidelines.[97] While Freeman Solar states that the reason for the

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[92] Freeman Solar throughout the Complaint makes representation that it "materially complied" with the Tariff's requirements, or that PJM's rejections of its data and other submissions exalt form over substance. *See* Complaint at 2, 19, 20-21, 23. While PJM disagrees with Freeman Solar's characterizations of PJM's actions, each of these statements is a tacit admission by Freeman Solar that it did not follow the Tariff.

[93] *See supra* Part II.B; Complaint, Exhibit B, Email from Queue Point, to Edward Shambeau, Manager, Technical Services, Brookfield (setting forth deficiency notice).

[94] Sims Aff. at ¶¶ 8-9.

[95] Lambert Aff. at ¶ 17.

[96] *See supra* Part II.B. Deficiency No.1 is "Queue Point Data Application form data (e.g. inverters type, number of inverters and their capacity) is not updated according to the data provided in the dynamic model report." Complaint at 15.

[97] Tariff, Part VII, Subpart D, section 309(B)(6)(a); *see also supra* n.58.

inverter change was to respond to the identified reactive factor power deficiencies identified in PJM's June 28, 2024 Deficiency Notice,[98] it is important to point out that the reactive power factor deficiency was first flagged in September 2021. Even so, changing the project configuration by reducing the number of inverters during the deficiency review process does not excuse Freeman Solar's failure to provide the necessary modeling data at that time. Freeman Solar indicates that it chose the inverter changes because it viewed them as a way to address the issues in a manner that was cost-effective and in line with industry practices.[99] However, Freeman Solar had other options available to it that would not trigger the need to comply with the Dynamic Modeling Guidelines. For example, Freeman Solar could have added a capacitor onsite or added more of the original submitted inverters. While Freeman Solar is free to make whatever choice it sees fit, it needs to comply with any Tariff requirement triggered by that choice. It did not do that here.[100]

Freeman Solar claims that it resolved Deficiency Nos. 2, 3, and 4, and that any deficiencies are due to the fact the data was submitted in the wrong format.[101] While Freeman Solar attempts to minimize these errors,[102] these formats are required by the

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[98] Complaint at 21.

[99] *Id.* at 22; Lambert Aff. at ¶ 18.

[100] Lambert Aff. at ¶ 15. Freeman Solar also points to the fact that PJM made minor corrections to its modeling data that brought into compliance with PJM's requirements. Complaint at 20 (citing Complaint, Exhibit F (Email from M. Saffari, CF Power Ltd., to E. Shambeau, Manager Technical Services, Brookfield, (July 19, 2024) (on file with PJM)). However, PJM later clarified that the consultant sent the information in error. *See* Complaint, Exhibit H (email from S. Eedupuganti, Senior Engineer II, PJM, to E. Shambeau, Brookfield (July 25, 2024) (on file with PJM)). Regardless of this mistaken communication, it does not to disprove that fact Freeman Solar did not correct its deficiencies or submit the necessary information within the timeframe required by Tariff section 309.

[101] Complaint at 21; *see also supra* Part II.B. Deficiencies Nos. 2, 3 and 4 are: Deficiency No. 2 – MFO and PF assessment not provided; Deficiency No. 3 – idv, .cnv, .snp and .sld not provided; and Deficiency No. 4 – out and log files of results not provided.

[102] Complaint at 21.

Dynamic Model Guidelines with which the Project Developer is required to comply. These formats are necessary to allow PJM to take the data and manipulate it using the various interconnection analysis programs that we use to study projects. Having all Project Developers use a uniform set of formats – especially given the volume of projects that PJM studies and the timing that PJM aims to follow – promotes the efficient administration of the queue. Any of the 204 projects that had to follow the guidelines did so and progressed to Phase II. PJM cannot afford preferential treatment to Freeman Solar.[103] The bottom line is that Freeman Solar did not provide PJM with the information needed, and in the format required by the Dynamic Modeling Guidelines.[104]

Finally, Freeman Solar asserts that it corrected Deficiency No. 5, which indicated that the dynamic model setting does not meet the requirements of Order No. 827.[105] Freeman Solar asserts that deficiencies in this data were corrected by the PJM consultant on July 19, 2024. However, this correction was made after the time by which Freeman Solar was required to correct all deficiencies. While PJM has provided education and guidance to assist all Project Developers in providing all necessary information, it is ultimately a Project Developer's responsibility to provide complete and accurate information required to advance its project through the various stages of the generation interconnection process.[106]

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[103] Lambert Aff. at ¶ 19.

[104] *Id.* at ¶ 17.

[105] Complaint at 22; *see Reactive Power Requirements for Non-Synchronous Generation*, Order No. 827, 155 FERC ¶ 61,277, FERC Stats. & Regs., Regs. Preambles ¶ 31,385, *order on reh'g and clarification*, 157 FERC ¶ 61,003 (2016).

[106] Lambert Aff. at ¶ 20.

### D. Freeman Solar's Proposed Remedy of Inserting the AG1-529 Project Back into the Interconnection Process Is Neither Just nor Reasonable

As noted above, a complainant has the burden under FPA section 206 of demonstrating that the complained-about rate or practice is unjust, unreasonable, unduly discriminatory, or preferential.[107] In addition, the replacement rate or practice, which the Commission does not need to evaluate if complainant does not meet the initial burden, must also be just and reasonable.[108] Assuming for purposes of argument that Freeman Solar has met its burden of showing that termination and withdrawal of the AG1-529 Project was not just and reasonable, its proposed remedy is not just and reasonable.

The fact of the matter is that re-inserting the AG1-529 Project into Transition Cycle No. 1 of the interconnection process at this point would be extremely disruptive and contrary to efficient queue administration,[109] and would also result in direct harm to other Project Developers in Transition Cycle No. 1 that have fully complied with all the requirements of Tariff, Part VII, Subpart D, section 309. PJM's Transition Cycle No. 1 is structured to have Project Developers provide equipment changes and updated dynamic modeling data as part of their Decision Point I submissions, so that PJM can perform all necessary studies, including stability studies during Phase II.

Mr. Sims' affidavit illustrates how re-inserting a project that has been terminated and withdrawn can threaten to delay completion of the Phase II studies. This impact is especially egregious given the fact that Freeman Solar did not follow the process that

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[107] *See supra* n.3.

[108] *See supra* n.4.

[109] The Commission has routinely recognized that efficient queue administration is in the public interest. *See PJM Interconnection, L.L.C.*, 174 FERC ¶ 61,075, at P 38 (2021) (denying request for waiver and finding notices of cancellation in the public interest); *Midcontinent Indep. Sys. Operator, Inc.*, 176 FERC

95% of the projects in Transition Cycle No. 1 successfully followed, and now seeks to be excused from its last-minute decision to substantially modify its project.

As noted above, PJM conducts studies during Phase I, Phase II, and Phase III. Phase II may run co-extensively with the Decision Point I deficiency review period, and Phase III may run co-extensively with the Decision Point II deficiency review period.[110] Phase I of Transition Cycle No. 1 commenced on January 22, 2024. Phase I ended on May 20, 2024, and Decision Point I commenced on May 21, 2024.[111] PJM exercised Reasonable Efforts to inform Project Developers of deficiencies within 10 Business Days (by July 5, 2024) of the close of Decision Point I.[112] Project Developers had five Business Days to respond to PJM's deficiency determination communication, and PJM was required to use Reasonable Efforts to complete its final review of these developer responses in 10 Business Days.[113] Phase II started on June 21, 2024, co-extensively with the start of PJM's Decision Point I deficiency reviews.[114] Figure 1 below provides a timeline for the Transition Cycle No. 1 process.

¶ 61,161, at P 24 (2021) (granting waiver in part on the basis that no other projects in the interconnection queue will be affected or require restudy as a result).

[110] *See* Sims Aff. at ¶ 3.

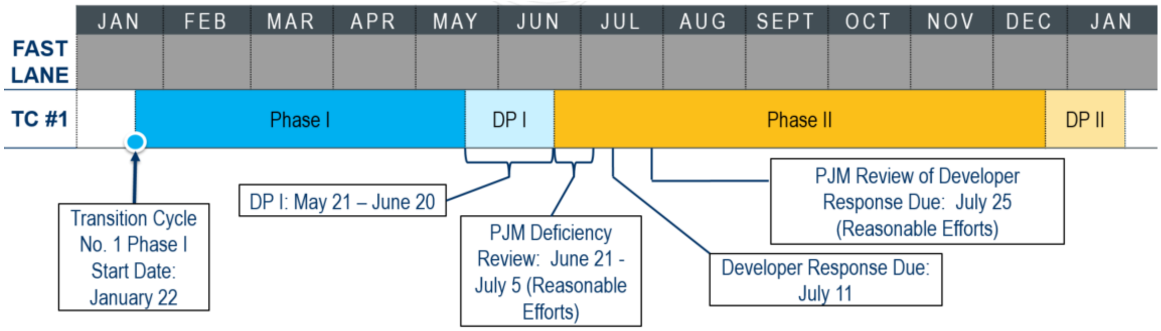
[111] Sims Aff. at ¶ 5.

[112] *Id.* at ¶ 5.

[113] *Id.* at ¶ 6. As part of Phase II, PJM started the analytical reliability simulations for Phase II on July 22, 2024, and provided the results to its Transmission Owners on August 30, 2024.

[114] *Id.* at ¶ 5.

**FIGURE 1**




As part of Phase II, PJM started the analytical reliability simulations for Phase II on July 22, 2024 and provided the results to its Transmission Owners on August 30, 2024. PJM started the simulations (preliminary studies that form the basis for the System Impact Study) for Phase II on July 22, 2024.[115] PJM provided the results of the Phase II analytical reliability simulations simulation study results to its Transmission Owners on August 30, 2024.[116] PJM provides this information to the Transmission Owners so they can undertake Facilities Studies to determine the required Transmission System modifications necessary to implement the conclusions of the System Impact Studies and complete any additional studies or analyses and determine the required Transmission System modifications based on the PJM findings and any such additional Transmission Owner studies.[117] Any change at this time would require PJM to update and re-calibrate affected models, re-run the simulations, and provide revised results to any affected Transmission Owners. Affected Transmission Owners would need to begin processing the updated results that they previously received on August 30, 2024.[118]

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[115] *Id.* at ¶ 6.

[116] *Id.* at ¶ 6.

[117] *Id.* at ¶ 6.

[118] *Id.* at ¶ 6.

PJM undertakes load flow simulations as part of the Phase II studies,[119] and delays in completing this process could also affect the processing of the Phase II studies and PJM's interconnection queue. PJM develops several simulation models, including two seasonal models.[120] In the event a terminated and withdrawn project is re-introduced in the queue, PJM would need to reflect the project in all of these models.[121] Additionally, any changes to the models used by PJM, such as re-introducing a terminated and withdrawn project, would require corresponding model adjustments and re-simulations of all models.[122] It would take PJM an approximate minimum of five weeks to rebuild and re-calibrate the models to get back to the same point it would be if these changes had not been required.[123] The Phase II schedule would also be extended, as would Decision Points II and III and the other subsequent studies under the Tariff.[124]

PJM also undertakes dynamic stability stimulations.[125] PJM has 72 cluster models already developed for these simulations.[126] To re-introduce any project, PJM would need to take a look at the location of the re-introduced project and determine in which model(s) the re-introduced generation is appropriately included.[127] It would need then to re-calibrate and re-run its cluster models.[128] While this might affect one model or

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[119] *Id.* at ¶ 7.

[120] *Id.* at ¶ 7.

[121] *Id.* at ¶ 7.

[122] *Id.* at ¶ 7.

[123] *Id.* at ¶ 7.

[124] *Id.* at ¶ 7.

[125] *Id.* at ¶ 8.

[126] *Id.* at ¶ 8.

[127] *Id.* at ¶ 8.

[128] *Id.* at ¶ 8.

several models, identifying the affected model(s) takes time and would delay the Phase II studies.[129]

Finally, PJM also undertakes short circuit simulations.[130] However, in this situation, PJM only uses a single model.[131] PJM would need to perform additional short circuit work if a project is re-introduced into the queue, but the overall schedule would likely not be delayed due to the relatively shorter analytical timeframes needed for short circuit analysis.[132]

Each of the paragraphs above describe the delays that would result from re-inserting a project such as the AG1-529 Project into Transition Cycle No. 1 of the interconnection process. This conclusively shows that Freeman Solar's proposed remedy is not just and reasonable.

## IV. AFFIRMATIVE DEFENSES PURSUANT TO 18 C.F.R. § 385.213(c)(2)(ii)

PJM's affirmative defenses are set forth above in this answer, and include the following, subject to amendment and supplementation:

1. Freeman Solar, as the Complainant, has failed to satisfy its burden of proof under FPA section 206 (16 U.S.C. § 824e).

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[129] *Id.* at ¶ 8.

[130] *Id.* at ¶ 9.

[131] *Id.* at ¶ 9.

[132] *Id.* at ¶ 9.

## V. CONCLUSION

For the reasons set forth in this answer, the Commission should deny the Complaint.

Respectfully submitted

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***PJM Interconnection, L.L.C***

September 12, 2024

Attachment 1

Affidavit of Andrew J. Lambert
On Behalf of
PJM Interconnection, L.L.C.

**UNITED STATES OF AMERICA**
**BEFORE THE**
**FEDERAL ENERGY REGULATORY COMMISSION**

| | | |
|---|---|---|
| Freeman Solar, LLC<br>Complainant, | ) ) ) | |
| v. | ) | Docket No. EL24-135-000 |
| PJM Interconnection, L.L.C.<br>Respondent. | ) ) ) | |

## I. INTRODUCTION

1. My name is Andrew J. Lambert. I am a Manager, Interconnection Planning Projects, at PJM Interconnection, L.L.C. ("PJM") and have been in that position since January 2023. My duties and responsibilities include managing a team of engineers and analysts supporting the PJM interconnection process, ensuring the interconnection process is implemented in accordance with the PJM Open Access Transmission Tariff ("Tariff"), and leading the department responsible for all aspects of interconnection, from initial application to commercial operation. The purpose of my affidavit is to respond to certain arguments raised by the Freeman Solar LLC ("Freeman Solar") August 23, 2024 Complaint and Request for Fast Track Processing.[1] My affidavit includes the following exhibits:

- Exhibit A: Dynamic Model Development Guidelines
- Exhibit B: Dynamic Model Development Guidelines for DP1 Submissions
- Exhibit C: TC1 – Phase II Analysis Update

[1] *Freeman Solar LLC v. PJM Interconnection, L.L.C.*, Complaint and Request for Fast Track Processing of Freeman Solar LLC, Docket No. EL24-135-000 (Aug. 23, 2024) ("Complaint").

- Exhibit D: Deficiency Notification Email.

To assist with identifying the key dates at issue in this matter, I have also prepared a timeline of relevant events that is included in my affidavit.

2. Prior to becoming Manager of Interconnection Planning Projects at PJM, I was a Senior Engineer II from May 2021 to December 2022. Prior to that time, I held engineering positions at PPL Corporation and Exelon Corporation. I graduated from The Pennsylvania State University with a Bachelor of Science Degree in Electrical Engineering in May 2010 and received a Master of Business Administration from Villanova University in May 2015. PJM, as a Regional Transmission Organization, ensures the reliability of the high-voltage electric power system serving 65 million people in all or parts of 13 states and the District of Columbia. PJM coordinates and directs the operation of the region's transmission grid, which includes 88,115 miles of transmission lines, administers a competitive wholesale electricity market, and plans regional transmission expansion improvements to maintain grid reliability and relieve congestion. PJM's regional grid and market operations produce annual savings of $3.2 billion to $4 billion. PJM, under the terms of its Tariff, has the responsibility for planning the expansion and enhancement of the PJM Transmission System on a regional basis.

3. Freeman Solar requests that the Federal Energy Regulatory Commission direct PJM to re-instate its project into Transition Cycle No. 1. I will explain below PJM's requirements for Decision Point I submissions and the timing associated with such requirements for Transition Cycle No. 1. I will also provide details regarding PJM's engagement with stakeholders to prepare them for Decision Point I submissions. Finally, I will describe PJM's application of these requirements to

Freeman Solar's New Service Request.

## II. PROJECT DEVELOPER OBLIGATIONS IN TRANSITION CYCLE NO. 1 AND STAKEHOLDER ENGAGEMENT ON DECISION POINT I SUBMISSION REQUIREMENTS

4. PJM commenced Phase I of Transition Cycle No. 1 (which included the Freeman Solar AG1-529 Project) on January 22, 2024. Under Part VII of the Tariff, Transition Cycle No. 1 contains three study phases, each of which is followed by a Decision Point: (1) Phase I System Impact Study ("Phase I") and Decision Point I; Phase II System Impact Study ("Phase II") and Decision Point II; and Phase III System Impact Study ("Phase III") and Decision Point III. At each Decision Point, a Project Developer must make certain informational showings in order to move forward with its project or elect to withdraw. In addition, a project can be removed from PJM's interconnection queue if it does not meet the Tariff requirements at that stage.

5. PJM concluded Phase I on May 20, 2024. The 30-day period following Phase I (i.e., May 21, 2024, to June 20, 2024) represented the Decision Point I window. During Decision Point I, a Project Developer had the option to withdraw its New Service Request or remain in Transition Cycle No. 1. Project Developers electing to remain in Transition Cycle No. 1 were required to demonstrate satisfaction of the requirements set forth in Tariff, Part VII, Subpart D, section 309 on or before the end of the Decision Point I window.

6. Tariff, Part VII, Subpart D, section 309(A) lists the information a Project Developer must provide and the steps it must take at Decision Point I, including providing Readiness Deposit No. 2, providing evidence of Site Control, and the submission of data required for the Phase II System Impact Study. The Phase II System Impact

Study data generally includes company information, Point of Interconnection information, generator information (such as size, capability, and seasonal ratings), fuel supply, inverter and transformer ratings, impedances and equipment configuration.

7. Tariff, Part VII, Subpart D, section 309(B) also lists the types of changes a Project Developer may make to its New Service Request as part of its Decision Point I submission, including equipment changes. Specifically, during Decision Point I, a Project Developer may modify its Interconnection Request for updated equipment data. If the Project Developer makes such a modification, it must submit machine modeling data as specified in the PJM Manuals *before the close of Decision Point I*.[2] Machine modeling data includes dynamic model data for stability analysis. PJM Manual 14H discusses the modeling data required for the stability analysis that a Project Developer must provide and states:

> Modeling Data required for Stability analysis must be provided with the submitted application in PJM data submission tool. Project Developers shall follow PJM Dynamic Model Development Guidelines on the PJM website to submit stability data specific to their project. Project Developers should pay special attention to PJM Dynamic Model Development Guidelines to ensure all deliverables are met. If stability data submission is not approved at the end of the deficiency review period, the application will be withdrawn.[3]

The PJM Dynamic Model Development Guidelines, which are posted on PJM.com, provide additional guidance and are attached to this Affidavit.

8. In advance of the Decision Point I deadline, PJM provided extensive stakeholder education during the monthly Interconnection Planning Subcommittee ("IPS")

[2] Tariff, Part VII, Subpart D, section 309(B)(6)(a) (emphasis added).

[3] *PJM Manual 14H, New Service Requests Cycle Process, Revision: 00*, section 2.1.2 (July 26, 2024), https://pjm.com/-/media/documents/manuals/m14h.ashx.

meetings. The IPS was formed in 2022 to provide a stakeholder forum to investigate and resolve specific issues related to the generation interconnection process and associated agreements, governing documents, and manuals, and is intended to, among other things, provide information and education outreach to stakeholders. Of particular relevance to the Freeman Solar AG1-529 Project, PJM provided the information below to stakeholders:

- On September 18, 2023, PJM prepared and posted Dynamic Model Development Guidelines for Interconnection Analysis (also referred to as the "Dynamic Model Guidelines") on the PJM website.
- Starting in October 2023, PJM presented to stakeholders educational material regarding PJM's Dynamic Model Guidelines for stability studies. PJM explained that the Dynamic Model Guidelines are "applicable to Transition Cycle 1 projects that choose to make changes at Decision Point 1 and/or 2" and "failure to comply or cure deficiencies will result in a withdrawal."[4]
- In October 2023, November 2023, and December 2023, PJM announced the release of a series of training videos addressing various topics, including Cycle Process overview; Phase 1, 2, and 3 Analyses; Decision Point I, II, and III Requirements; and Model Building and Availability.
- On January 29, 2024, shortly after the start of Phase I, PJM announced that Transmission Cycle No. 1 projects "currently have the opportunity to submit updated dynamic model data to PJM prior to TC1/DP1 in

[4] *Id*. at 3.

accordance with the PJM Dynamic Model Development Guidelines" and reiterated that "Project Developers will need to follow the Dynamic Model Development Guidelines document posted on PJM.com."

- In March 2024, PJM again reviewed with stakeholders the Dynamic Model Guidelines for Decision Point I submissions. PJM highlighted that any allowable changes made at Decision Point I, including equipment changes, required the submission of an updated dynamic modeling package. PJM also alerted stakeholders to commonly observed deficiencies, detailed the components of each deliverable, and provided a checklist to assist Project Developers in preparing their updated dynamic modeling information.
- In April 2024, PJM presented to stakeholders a fourth review of the Dynamic Model Guidelines as they relate to the submission for Decision Point I. PJM further reviewed other requirements related to Decision Point I submissions, including the deficiency review process.
- In May 2024, PJM highlighted the need to comply with the Dynamic Model Guidelines for the fifth time and provided to stakeholders a second overview of the deficiency review process.
- In June 2024, PJM provided to stakeholders a third overview of the deficiency review process.
- In July 2024, PJM provided to stakeholders a fourth overview of the deficiency review process.

9. On June 21, 2024, Phase II of Transition Cycle No. 1 commenced. At the same time, PJM began the Decision Point I deficiency review process for Decision Point I submissions and the Phase II System Impact Study. With respect to the deficiency

review process, the Tariff requires PJM to use Reasonable Efforts to inform Project Developers of any deficiencies in the Project Developer's Decision Point I submission within 10 Business Days of the close of Decision Point I, and the Project Developer then has five Business Days to respond to PJM's deficiency determination. Following Developer's five Business Day window PJM has 10 Business Days, using Reasonable Efforts, to review the Project Developer's deficiency response and determine whether the response is sufficient. If yes, then the Project Developer's New Service Request is included in Phase II. If no, the New Service Request is deemed terminated and withdrawn.

## III. DEFICIENCY REVIEW PROCESS FOR FREEMAN SOLAR AG1-529 PROJECT

10. PJM commenced deficiency reviews of the Decision Point I submissions on June 21, 2024. These reviews included submissions provided by 214 Project Developers, including Freeman Solar. It is important to note that Freeman Solar's Decision Point I submission provided the original project information and equipment configuration that was submitted in 2020, even though PJM had identified and notified Freeman Solar of a reactive power factor deficiency in September 2021.

11. As required by the Tariff, on June 28, 2024, PJM notified Freeman Solar of the following deficiencies in its Decision Point I submission:

(1) Officer Certification: the Officer Certification required as part of its Site Control showing had an inaccurate date that needed correction;

(2) Equipment Information: missing required data related to modeling of the main power transformer, missing one line diagram and lack of other

data elements required by the PJM Dynamic Model Guidelines; and

(3) Generator Information: the project still did not meet the reactive power factor requirement at the main power transformer's high side.

PJM also notified Freeman Solar that its response to PJM's deficiency determination would be due by July 11, 2024.

12. On July 3, 2024, Freeman Solar provided to PJM information that corrected the Officer Certification and that was intended to address other deficiencies. This included a revised model in the form of a report prepared by its consultant Telos Energy ("Telos Report").[5] The Telos Report included significant revisions to the AG1-529 Project's equipment configuration, including replacing the thirty 2.5 megavolt-ampere ("MVA") SMA inverters with twenty-two 4.4 MVA Sungrow inverters.[6] Freeman Solar did not provide the model data required by Tariff, section 309 at this point.

13. By email dated July 31, 2024, PJM notified Freeman Solar of the following deficiencies, notifying Freeman Solar that its project has been terminated and withdrawn, stating:

> I'm reaching out to notify you that AG1-529 has been withdrawn from Transition Cycle 1 for failure to cure the Decision Point I deficiencies by the deficiency cure deadline (by close of business on 7/8/24.) Stability data was still deficient. Please see the below for more information on the deficiency:
>
> 1. Queue Point Data Application form data (e.g. inverters type, number of inverters and their capacity) is not updated according to the data provided in the dynamic model report.

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[5] *Freeman Solar LLC v. PJM Interconnection, L.L.C.*, Complaint and Request for Fast Track Processing of Freeman Solar LLC, Docket No. EL24-135-000, Exhibit C (Telos Report) (Aug. 23, 2024).

[6] Telos Report at 1.

2. MFO and PF assessment not provided;

3. .idv, .cnv, .snp and .sld not provided;

4. Out and log files of results not provided; and

5. Dynamic model setting does [not] meet FERC Order 827 automatic voltage regulation and Confirmation Momentary Cessation.[7]

14. Since entering the queue in 2020, Freeman Solar submitted its original project configuration at multiple opportunities each, including as part of its Decision Point I submission.[8] Freeman Solar did so notwithstanding the fact that PJM had identified a reactive power factor deficiency with respect to Freeman Solar's project on September 15, 2021.[9] Once this deficiency was identified in 2021, it was up to Freeman Solar to propose a solution. Freeman Solar could have reached out in the meantime with a solution prior to the Decision Point I, but did not. When Freeman Solar submitted the AG1-529 Project's Decision Point I package, it did not address the reactive power factor issue, and PJM let Freeman Solar know that the reactive power factor deficiency was still an issue.

15. PJM provided a substantial amount of education and resources to all Project Developers, including Freeman Solar, regarding the opportunity to make equipment changes at Decision Point I and guidance for successfully making such changes, including the development of the PJM Dynamic Model Guidelines. Only

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[7] Freeman Solar refers to these as Deficiency Nos. 1 through 5, respectively. Complaint at 20-22.

[8] Complaint at 9 (stating that "prior to PJM's evaluation of AG1-529 during Decision Point I of Transition Cycle No. 1…AG1-529 had been studied by PJM three times.").

[9] The Complaint (at 9) erroneously asserts that "at no point in conducting these multiple studies did PJM ever conclude that there was any deficiency with respect to AG1-529." However, this statement is demonstrably incorrect and contradictory, as the emails included with the Complaint reference PJM's September 15, 2021 notification to Freeman Solar of the reactive power factor deficiency. Complaint, Exhibit B (pdf page 38) and Exhibit D (pdf page 58).

in response to PJM's deficiency determination, when PJM *again* identified the outstanding reactive power factor deficiency, did Freeman Solar take action to address this issue by significantly modifying its project configuration. In doing so, Freeman Solar not only rendered the previously submitted Phase II System Impact Study data for the original project configuration inapplicable to the modified project configuration, but also did not provide the requisite modeling data for the new configuration. As a result, because Freeman Solar did not comport with the Tariff's requirements by the conclusion of the deficiency review process, the project was deemed terminated and withdrawn, rather than included in Phase II.

## IV. RESPONSE TO FREEMAN SOLAR TECHNICAL ARGUMENTS

16. Freeman Solar asserts that it provided all of the relevant modeling and stability data submissions for the Phase II System Impact Study.[10] Freeman Solar then cites to PJM's June 14, 2022 filing proposing the changes to its generation interconnection process for a discussion on the use of the load flow study as part of the initial retool process.[11] It then asserts PJM informed it that there were no issues with load flow data provided by Freeman Solar on June 18, 2024.[12] It is unclear what Freeman Solar is attempting to show with its reference to load flow data, because the filing also clearly discusses the need to assess short circuit and system stability issues,[13] but it may be trying to argue that because its load flow data was not deemed deficient, it materially complied with PJM's data submission requirements.

[10] Complaint at 19.

[11] Complaint at 19.

[12] Complaint at 19 nn.65-67.

[13] The Complaint seems to acknowledge the need to correct short circuit and system stability data. *See* Complaint at 11, Exhibits B, D, E and I.

17. Freeman Solar seems to be confusing its concepts. While PJM's June 28, 2024 communication did not identify load flow data deficiencies, it had identified deficiencies in the short circuit, stability, and reactive power factor data, as well as other errors, such as the wrong date in the Officer Certification.[14] Contrary to Freeman Solar's assertion, it had not provided all applicable modeling and stability data needed for PJM to perform the Phase II System Impact Study. As detailed in the Affidavit of Mark Sims, Phase II involves more than just load flow studies. The data Freeman Solar provided as part of its deficiency response was inadequate, and was not sufficient to correct the stability and short circuit deficiencies. Thus, the AG1-529 Project was terminated and withdrawn after the Decision Point I deficiency review period ended, per the Tariff.

18. Freeman Solar also claims that it corrected Deficiency No. 1.[15] However, it did not provide the machine modeling data required due to its inverter change as specified in the Dynamic Modeling Guidelines.[16] While Freeman Solar states that the reason for the inverter change was to respond to the identified reactive power factor deficiencies identified in PJM's June 28 Deficiency Notice,[17] it is important to point out that the reactive power factor deficiency was first flagged in September 2021. Even so, changing the project configuration by reducing the number of inverters during the deficiency review process still does not excuse Freeman Solar's failure

[14] *Freeman Solar LLC v. PJM Interconnection, L.L.C.*, Complaint and Request for Fast Track Processing of Freeman Solar LLC, Docket No. EL24-135-000, Exhibit B (Email from Queue Point to Edward Shambeau, Manager, Technical Services, Brookfield) (Aug. 23, 2024) (setting forth deficiency notice).

[15] Deficiency No.1 is "Queue Point Data Application form data (e.g. inverters type, number of inverters and their capacity is not updated according to the data provided in the dynamic model report)." Complaint at 15.

[16] *See* Tariff, Part VII, Subpart D, section 309(B)(6)(a).

[17] Complaint at 21.

to provide the necessary modeling data at that time. Freeman Solar indicates that it chose the inverter changes because it viewed them as a way to address the issues in a manner that was cost-effective and in line with industry practices.[18] However, Freeman Solar had other options available to it that would not trigger the need to comply with the Dynamic Modeling Guidelines. For example, Freeman Solar could have added a capacitor onsite or added more of the original submitted inverters. While Freeman Solar is free to make whatever choice it sees fit, it needs to comply with any Tariff requirement triggered by that choice. It did not do that here.

19. Freeman Solar claims that it resolved Deficiency Nos. 2, 3, and 4, and that any remaining deficiencies are due to the fact the data was submitted in the wrong format.[19] While Freeman Solar attempts to minimize these errors,[20] these formats are required by the Dynamic Model Guidelines with which the Project Developer is required to comply. These formats are necessary to allow PJM to take the data and manipulate it using the various interconnection analysis programs that we use to study projects. Having all Project Developers use a uniform set of formats – especially given the volume of projects that PJM studies and the timing that PJM aims to follow – promotes the efficient administration of the queue. Any of the 204 projects that had to follow the guidelines did so and progressed to Phase II. PJM cannot afford preferential treatment to Freeman Solar. The bottom line is that

[18] Complaint at 21.

[19] Complaint at 21. Deficiencies Nos. 2, 3 and 4 are: Deficiency No. 2 – MFO and PF assessment not provided; Deficiency No. 3 – idv, .cnv, .snp and .sld not provided; and Deficiency No. 4 – Out and log files of results not provided.

[20] Complaint at 21.

Freeman Solar did not provide PJM with the information needed, and in the format required by the Dynamic Modeling Guidelines.

20. Freeman Solar also asserts that it corrected Deficiency No. 5, which indicated that the dynamic model setting does not meet the requirements of Order No. 827.[21] Freeman Solar asserts that deficiencies in this data were corrected by the PJM consultant on July 19, 2024. However, this correction was made after the time by which Freeman Solar was required to correct all deficiencies. While PJM has given education and guidance to assist all Project Developers by providing all necessary information, it is ultimately a Project Developer's responsibility to provide complete and accurate information required to advance its project through the various stages of the generation interconnection process

21. This concludes my affidavit.

[21] Complaint at 22.

| TIMELINE | |
|---|---|
| July 11, 2023 | • PJM Transition Date |
| December 15, 2023 | • PJM's transition sorting process closes, and PJM posts the results indicating the classification of projects in the Expedited Process or Transition Cycle No. 1.<br>• Freeman Solar placed in Transition Cycle No. 1. |
| January 22, 2024 | • Transition Cycle No. 1 begins. |
| May 20, 2024 | • Phase I concludes.<br>• Phase I System Impact Studies are completed. |
| May 21, 2024 | • Decision Point I window opens. |
| June 20, 2024 | • Decision Point I submission deadline.<br>• Freeman Solar makes Decision Point I submission. |
| June 21, 2024 | • Phase II begins.<br>• PJM commences Phase II System Impact Studies.<br>• PJM commences deficiency reviews of Decision Point I submissions. |
| June 28, 2024 | • PJM informs Freeman Solar of deficiencies and identifies July 11, 2024, as the response deadline for Freeman Solar response |
| July 3, 2024 | • Freeman Solar submits its responses to PJM.<br>• Freeman Solar's responses include changes to the equipment configuration submitted as part of the AG1-529 Project's Decision Point I submission. Freeman Solar responses do not include appropriate modeling data. |
| July 25, 2024 | • PJM issues notification of termination and withdrawal |

**UNITED STATES OF AMERICA**
**BEFORE THE**
**FEDERAL ENERGY REGULATORY COMMISSION**

| | | |
|---|---|---|
| Freeman Solar, LLC<br>Complainant, | ) | |
| | ) | |
| v. | ) | Docket No. EL24-135-000 |
| | ) | |
| PJM Interconnection, L.L.C.<br>Respondent. | ) | |

**VERIFICATION**

I, Andrew J. Lambert, pursuant to 28 U.S.C. § 1746, state, under penalty of perjury, that I am the Andrew J. Lambert referred to in the foregoing "Affidavit of Andrew J. Lambert on Behalf of PJM Interconnection, L.L.C.," that I have read the same and am familiar with the contents thereof, and that the facts set forth therein are true and correct to the best of my knowledge, information, and belief.

DocuSigned by:
Andrew J. Lambert
E15D56D5A40A408...

Andrew J. Lambert

Executed on: 9/12/2024

# Exhibit A

# PJM Dynamic Model Development Guidelines for Interconnection Analysis

# PJM Dynamic Model Development Guidelines for Interconnection Analysis

Prepared by:

Interconnection Analysis & Interconnection Planning Analysis Departments

PJM Interconnection

Revision 0

September 18, 2023

For Public Use

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# Contents

# 1 Revision History

| Revision | Date | Description |
| --- | --- | --- |
| 0 | 09/18/2023 | Initial version |

# 2 Introduction

This document provides a guideline to develop the dynamic model representation (in .idv & .dyr format) for New Service Request projects (including projects with an ISA/GIA requesting a Necessary Study or submitting As Built Data) to be used by PJM in dynamic transient stability studies. All electrical facilities must be designed, built and operated in accordance with applicable NERC, PJM and Interconnection Transmission Owner(s) standards and criteria. For New Service Request projects and Necessary Study requests, the model shall be parameterized as closely as possible to the intended design. The As Built Data model must reflect the settings after commissioning.

This document is meant to serve as a guideline in the development of the dynamics model for your project. It is aimed at facilitating an efficient and timeous model submission and acceptance process. The short review of WECC Power Plant Models; typical values for Generator/Converter, Electrical Controls, and Plant Controller modules; and examples of .dyr files are intended to bring clarity and set a minimum standard of the expectation on dynamic model data submission. The checklist should also help promote good practice of model development by the Project Developers, facilitate consistent model reviews by the Transmission Planners and ensure the dynamic models meet applicable interconnection requirements. As the technology evolves, so will the modeling techniques. This document may not cover every specific scenario. Any unique scenarios or settings that may be required for your project model shall be noted in the Dynamic Model Report and brought to the attention of PJM in the Queue Point Data Application form.

## *2.1 Expectation from Project Developer*

The Project Developer shall use this guideline to develop a dynamic model for their project to be used by PJM in dynamic transient stability studies. The Project Developer will be required to meet the requirements outlined in Section 8 “Deliverables” in order for PJM to consider the submission as valid. In accordance with PJM Manual 14H section 2.1.2, failure to comply with the requirements of this document or cure deficiencies within the deficiency review period will result in the application being withdrawn.

The Dynamic Model Report and Dynamic Model Checklist submitted must include quality assurance sign offs from responsible parties, to ensure these guidelines were reviewed and followed. This document applies to the following types of submissions:

a. **New Service Request Projects** - To be submitted in Queue Point during the Application Phase of the Cycle.
   For any allowable changes made to the New Service Request project at Decision Point 1 or 2, the Project Developer must update the dynamic model for their project and resubmit the Dynamic Model Report and Checklist per the Section 8 “Deliverables” in the required timeframe.
b. **Necessary Study Requests –** To be submitted in Queue Point along with the Necessary Study data submission.
**c. As Built Data** Submissions **-** To be submitted in Queue Point along with the As Built data submission.

# 3 Software Compatibility

The power flow (.idv) and dynamic models (.dyr) provided as representation of the New Service Request project must be usable by the software platform used to perform the simulation. PJM uses Siemens PTI PSS/E to perform transient stability analysis, and dynamic models and files provided must be compatible with the specific version listed for each queue/cycle, and also with any later version listed (for inclusion into future year base cases).

**Table 1.** PSS/E Versions by Queue/Cycle

| PJM Queue/Cycle | PSS/E Version |
|---|---|
| AC1 | 33.7.0 |
| AC2 | 33.7.0 |
| AD1 | 33.7.0 |
| AD2 | 33.7.0 |
| AE1 | 33.7.0 |
| AE2 | 33.7.0 |
| AF1 | 33.12.1 |
| AF2 | 33.12.1 |
| AG1 | 34.7 |
| TC1[1] | 34.7 |

# 4 Inverter Based Resources

## 4.1 General Modeling Requirements

The following modeling requirements, as provided in the WECC Solar Photovoltaic Power Plant Modeling and Validation Guideline[2], are adopted for all inverter-based power plants and provided below.

The power flow model for an inverter-based power plant includes:

- An explicit representation of the interconnection transmission line
- An explicit representation of all station transformers
- An equivalent representation of the collector systems for projects with an MFO ≥ 20 MW.
- An equivalent representation of inverter pad-mounted transformers with a scaled MVA rating
- An equivalent representation of generators scaled to match the total capacity of the plant
- An explicit representation of all plant-level reactive compensation devices either as shunts (fixed or switchable) or as generators (FACTs devices), if applicable
- An explicit representation of any station and/or auxiliary loads

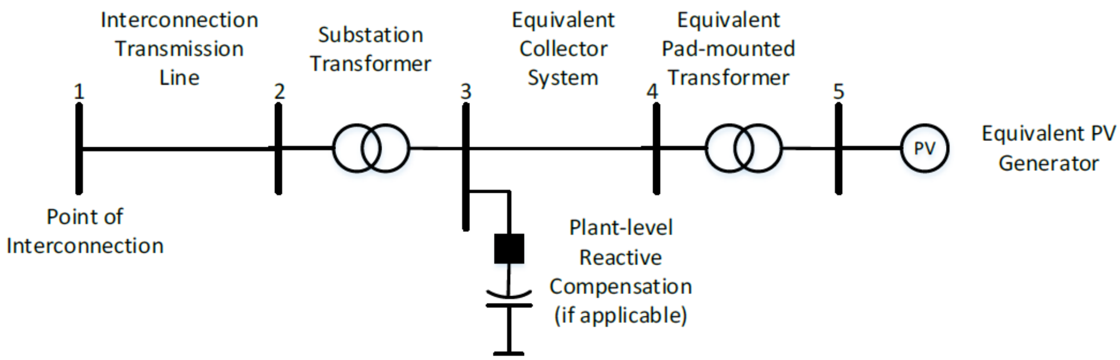
The figures below show examples of a Solar PV plant representation, which can be applied to other Inverter Based Resources (IBRs).

A typical inverter based plant is represented by the single machine equivalence, as depicted in Figure 1.

[1] Transition Cycle 1

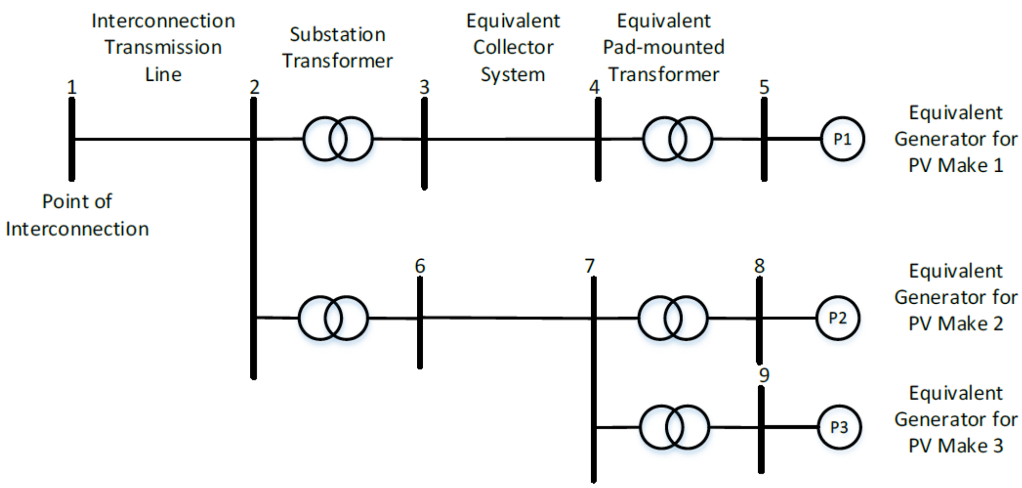
[2] Solar Photovoltaic Power Plant Modeling and Validation Guideline

**Figure 1.** Single-Generator Equivalent Power Flow Representation for a Solar PV Power Plant




An inverter based plant that comprises of different inverter manufacturers having different reactive capability, control setup and protection setup would need to use a multi-generator representation as shown in Figure 2.

**Figure 2.** Multiple-Generator Equivalent Power Flow Representation for a Solar PV Power Plant




The dynamic model includes:

- A generator/converter module representing the typical inverter based resource in the plant, scaled-up to match the plant's aggregate nameplate rating
- A local electrical control module which translates real and reactive power references into current commands
- A plant-level control module which sends real and reactive power references to the local electrical controller, if the plant-level control is put in place
- Frequency and voltage protection modules, which show inverter protection settings under abnormal frequency and voltage conditions

PJM strongly encourages the use of PSSE library models. Dynamic models listed on the Unacceptable Models List, Appendix 10.2 of this document, are not allowed.

If a User Defined Model (UDM) is provided, the requirements in the Deliverables section of this document must be met. For UDMs, the developer will be responsible to update their project's dynamic model to support higher PSSE versions as these become available in the future (updated idv & dyr with version specific DLL files and supporting files as applicable). See Dynamic Data (.DYR) – User Defined Models section below for additional details.

## *4.2 PJM Dynamic Model Configuration*

The Data Application form shall be completed and submitted in Queue Point. The data and information provided in the form shall match the data and parameters provided as the model for the project. Refer to the Appendix of this document for a sample format for the .idv and .dyr files submitted.

### 4.2.1 Project Specific Data

**Generator Data:**

a. The MW per inverter specified in the generator data section of the Data Application form will be the initial modeling point. If the MW net output of the plant at the Point of Interconnection (POI) is above or below the Maximum Facility Output (MFO), the MW per inverter shall be adjusted within the units MVA capability.
b. The inverter manufacturer and model shall match any additional documentation provided in the Data Application form.
c. Terminal voltage shall match the low side winding of the Inverter Step Up Transformer.

**Maximum Facility Output (MFO):**

a. The full facility model must be checked to ensure the gross active power output of the generator(s) can meet the MFO at the POI considering loads and losses for the facility.
b. The net active power output must be equal to the MFO requested.
c. If the MFO is not met at the POI, adjustments would need to be made to ensure the MFO requested can be achieved at the POI.
d. The analysis will be performed with the queue project meeting the MFO at the POI.

**Reactive Power Capability Curve:**

a. Must be provided with the Data Application form
b. The MVA capability must match the MVA base per inverter in the Data Application form
c. The PQ curve must match the inverter make and model name as provided in the Data Application form
d. A reasonable ambient temperature of 95F (35C) should be assumed. Justification along with supporting documentation must be included with your submission, for exceptions to this ambient temperature assumption.
e. The reactive power (Qmax/Qmin) modeled for power flow is determined using this curve based on the MW operating point required to meet the MFO.

### 4.2.2 Modeling Files

#### *4.2.2.1 Power Flow (.IDV)*

The facility shall be modeled in a response file (.idv) that uses RDCH to specify the data. The .idv provided must always include a full representation of the facility configuration, instead of updating just specific portions of the model. The .idv model submitted to PJM for the queue project shall include the following configuration:

**Generator:**

a. Modeled at the terminal voltage specified in the Data Application form.
b. The Pgen and Pmax shall be set equal to each other to meet the MFO at the POI, with unity power factor measured at the high side of the main transformer.
c. The Qmin and Qmax limits shall be set based on the reactive capability curve for the active power operating point.
d. MVA base and active and reactive power limits should all be set as the equivalent of the aggregate number of inverters multiplied by the capability per inverter.
e. The generator source impedance should be selected such that the short circuit current contribution is negligible (i.e. a large value).
f. The control mode should be set to '1 Standard Qt, QB limits' if the model uses PSS/E library models.
g. Remote bus can be set to 0.

**Inverter Step Up Transformer:**

a. Inverter Step Up (ISU) Transformer should be included. Note: Inverters without the ISU Transformer explicitly being modeled shall include a note from the inverter manufacturer that the reactive capability curve and the dynamic model is prepared for a 34.5 kV terminal voltage.
b. Impedance I/O Code set to '2 Zpu (winding kV winding MVA)'. All other I/O codes can be left at the default PSS/E values.
c. Winding MVA shall be the equivalent of the aggregate number of ISU transformers multiplied by the capability per transformer. Include the winding configuration (per TO requirements)
d. Include load tap changer settings (Number of taps and voltage % per tap)

**Collector System:**

a. The equivalent collector system impedance shall be modeled for all projects
b. The total branch positive and negative sequence impedances (R, X and B) shall be provided in per unit on a 100MVA base

**Additional Reactive Compensation:**

a. If additional reactive compensation is needed, the specific size, step details, and control mode shall be modeled.
b. Modeled at the low side bus of the Main Station transformer

**Main Station Transformer:**

a. Impedance I/O Code set to '2 Zpu (winding kV winding MVA)' All other I/O codes can be left at the default PSS/E values.
b. Include the winding configuration (per TO requirements)
c. Include load tap changer settings (Number of taps and voltage % per tap)

**Loads:**

a. Auxiliary Load shall be modeled using the ID "XA"
b. Station Service Load shall be modeled using ID "XS"

**Attachment Line:**

a. The attachment line impedance data and line length shall be included.

#### *4.2.2.2 Dynamic Data (.DYR) – Library Models*

The dynamic representation of large-scale IBRs requires the use of three renewable energy modules as listed below. Wind turbine models may also need additional modules such as WTDTAU1/WTDTA1, WTARAU1/WTARA1, WTPTAU1/WTPTA1 and WTTQAU1/WTTQA1. These modules shall be provided in .dyr format with suitable parameters to represent the project over the entire range of operating conditions.

1| REGC (REGC_*) module, used to represent the generator/converter (inverter) interface with the grid. It processes the real and reactive current command and outputs of real and reactive current injection into the grid model.
**Key points to note:**
  a. Momentary Cessation (MC) Check:
    i. If LVPLSW (ICON(M)) is 1, then check if Zerox (CON(J+3)) is greater than zero, then this is a possible active current reduction contributing to MC
    ii. If Lvpnt0 (CON(J+7)) is greater than zero, then this is a possible active current reduction contributing to MC
  b. Acceleration Factor, Accel (CON(J+13)): This parameter may be adjusted, if needed, between >0 and <= 1. If adjustment of this value provided with the model is not recommended, please indicate this with your model submission.

2| REEC (REEC_*) module, used to represent the electrical controls of the inverters. It acts on the active and reactive power reference from the REPC module, with feedback of terminal voltage and generator power output, and gives real and reactive current commands to the REGC module.
**Key points to note:**
  a. The REECB model is not an acceptable model
  b. REECA: To be used for PV projects and DC coupled hybrid (DC side charging only)
    i. PFFlag (ICON(M+1)) should be set to 0 if a REPC model is provided.

ii. PQFlag (ICON(M+5)): Preference is Q priority but if P priority is selected please provide a brief description of the reasoning
iii. Qmax (CON(J+13)) and Qmin (CON(J+14)): Shall match the maximum and minimum reactive power capability from the reactive capability curve
iv. Pmax (CON(J+25)) and Pmin (CON(J+26)): Shall match the maximum and minimum active power capability from the reactive capability curve.
v. Imax (CON(J+27)): Value is typically 1.0 p.u. but if greater than 1 review real and reactive current limits for model closely.
vi. Voltage Dependent Logic (VDL) Vq1 (CON(J+29)) to Ip4 (CON(J+44)): If current is reduced to zero check if this is a current reduction contributing to MC. Note the first Vq and Vp entries that are 0 signal the end of the V-I pairs in PSS/E.

c. REECC: To be used for BESS projects and DC coupled hybrid (grid charging only)
   i. PQFlag (ICON(M+4): Preference is Q priority but if P priority is selected please provide a brief description of the reasoning
   ii. Qmax (CON(J+10)) and Qmin (CON(J+11)): Shall match the maximum and minimum reactive power capability from the reactive capability curve
   iii. Pmax (CON(J+21)) and Pmin (CON(J+22)): Shall match the maximum and minimum active power capability from the reactive capability curve.
   iv. Imax (CON(J+23)): Value is typically 1.0 p.u. but if greater than 1 review real and reactive current limits for model closely
   v. Voltage Dependent Logic (VDL) Vq1 (CON(J+25)) to Ip4 (CON(J+40)): If current is reduced to zero check if this is a current reduction contributing to MC. Note the first Vq and Vp entries that are 0 signal the end of the V-I pairs in PSS/E

**3|** REPC (REPC_*) module, used to represent the plant controller. It processes voltage and reactive power output to emulate volt/VAr control at the plant level. It also processes frequency and active power output to emulate active power control. This module gives active reactive and power commands to the REEC module.
***Key points to note:***

**a.** Remote bus for voltage control (ICON(M)) should be set to POI

**b.** ICON (M+1) to (M+3) should be set to the generator tie line branch with ICON (M+2) being the POI bus. When projects share the attachment line, then this should be specified according to the collector system/branch.

**c.** RefFlag (ICON(M+5)): Should be set to 1 since POI voltage control is preferred

**d.** Fflag (ICON(M+6)): Shall be set to 1 for frequency regulation for projects entering the queue/cycle after Oct 1, 2018.

**e.** Qmax (CON(J+13)) and Qmin (CON(J+14)) shall be set to the limits modeled in the power flow case with +/-0.001 p.u. addition to prevent log messages about the model initializing at a limit.

**f.** Deadband for Frequency Control (CON(J+18) to (J+19)): Frequency deadband cannot be greater than +/-0.0006 p.u. (+/-0.036 Hz).

**g.** Pmax (CON(J+22)) and Pmin (CON(J+23)) shall be set to the limits modeled in the power flow case with +/-0.001 p.u. addition to prevent log messages about the model initializing at a limit.

**h.** Droop for frequency control Ddn (CON(J+25)) and Dup (CON(J+26)): Maximum frequency droop of 5% is allowed, therefore Ddn and Dup value cannot be less than 20. Note PV and wind may provide 0 for Dup.

**Note**: For different inverters or wind turbines, or if a single plant controller is being used for multiple inverter models, the PLNTBU1 plant controller may be utilized. This model has to be used with other models like REAX4BU1 (auxiliary signal model for Type 4 wind machines), REAX3BU1 (auxiliary signal model for Type 3 wind machines), SVCAXBU1 (auxiliary signal model for SVC), FCTAXBU1 (auxiliary signal model for FACTS device), or SYNAXBU1 (auxiliary signal model for synchronous condenser). The inputs to models REAX4BU1, REAX3BU1, SVCAXBU1 and SYNAXBU1 are the output from the PLNTBU1 model.

In addition to the above three modules, the **actual** inverter high and low Voltage and Frequency Protection settings shall also be included in the dyr file using the VTGTPAT/FRQTPAT or VTGDCAT/FRQDCAT models. Voltage and Frequency protection characteristics shall meet or exceed NERC PRC-024-3 requirements. **Limits provided shall reflect the intended settings for the facility**. Note that most inverters are capable of riding through voltage and frequency excursions beyond the minimum ride though characteristics defined in PRC-024-3. If the minimum ride though characteristics in PRC-024-3 are provided please provide a brief description on the justification.

**1|** VTGTPAT/VTGDCAT Under/Over voltage generator trip relay:

a. Low and high voltage settings not intended to be utilized shall be set to a value that prevents the unit from unintentionally tripping.

b. Conflicting pickup times for the same voltage threshold shall be eliminated.

c. No values shall be within the no trip zone of PRC-024-3.

**2|** FRQTPAT/FRQDCAT Under/Over frequency generator trip relay

a. Low and high frequency settings not intended to be utilized shall be set to a value that prevents the unit from unintentionally tripping.

b. Conflicting pickup times for the same frequency threshold shall be eliminated.

c. No values shall be within the no trip zone of PRC-024-3.

d. The Over/Under Frequency relay settings should be selected not to operate for numerical frequency deviations observed in PSSE during the disturbances. Instantaneous tripping shall not be allowed.

e. Note PSS/E can result in erroneous frequency deviations following fault clearing of local faults that can be minimized by metering a point closer to the POI in the plant.

#### *4.2.2.3 Dynamic Data (.DYR) – User Defined Models*

A user defined model needs to meet the same requirements laid out above for the library model.

The user defined model and all modules shall be provided in .dyr format with suitable parameters to represent the project. Written documentation/user manual from the manufacturer must be supplied explaining the dynamic device parameters and performance characteristics. The model manual must show control block diagrams, design logic, descriptions of all model parameters, a list of which parameters are commonly tuned for site-specific settings, and a description of procedures for using the model in dynamic simulations.

Any benign warning messages that are generated by the model code at compilation time shall also be documented. Source code, .dll file, and Object file(s) shall be provided for the user defined model(s) in the applicable PSSE version. Any available higher versions of the user defined model shall also be provided. To support future basecase development, updated PSSE versions and supporting documentation for your user model must be provided when requested by PJM, within 30 days.

The **actual** inverter high and low Voltage and Frequency Protection settings shall also be included in the dyr file provided, using the appropriate PSSE models.

Details on Momentary Cessation, whether present or not, must be provided.

# 5 Synchronous Generators

## *5.1 General Modeling Requirements*

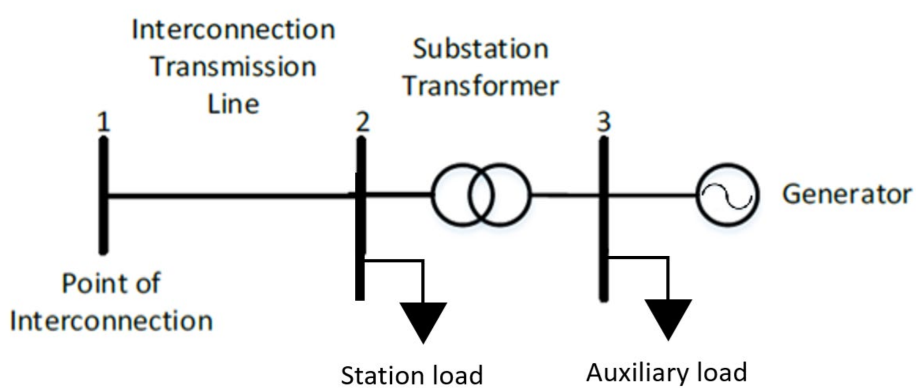
The following modeling requirements are adopted for synchronous units.

The power flow model for synchronous generator facility includes:

- An explicit representation of the interconnection transmission line
- An explicit representation of all main power transformer(s)
- As explicit representation of any station service and/or auxiliary load(s)
- An explicit representation of synchronous generator(s)
- An explicit representation of all plant-level reactive compensation devices either as shunts (fixed or switchable), if applicable

The **Figure 3** shows an example of a single synchronous generator facility representation.

**Figure 3.** One line representation of a single synchronous generator



## *5.2 PJM Dynamic Model Configuration*

The Data Application form shall be completed and submitted in Queue Point. The data and information provided in the form shall match the data and parameters provided as the model for the project. Refer to the Appendix of this document for a sample format for the .idv and .dyr files submitted.

### 5.2.1 Project Specific Data

**Maximum Facility Output (MFO):**

a. The full facility model must be checked to ensure the gross active power output of the generator(s) can meet the MFO at the POI considering loads and losses for the facility.
b. The net active power output must be equal to the MFO requested.
c. If the MFO is not met at the POI, adjustments would need to be made to ensure the MFO requested can be achieved at the POI.
d. The analysis will be performed with the queue project meeting the MFO at the POI.
e. For uprate requests, provide documentation of existing contractual MFO values prior to the uprate request.

**Reactive Power Capability & Saturation Curve:**

a. Must be provided with the Data Application form
b. Indicate the curve (based on ambient temperature, cooling water temperature, etc.) to be used for maximum Summer and/or Winter Gross MW operating values.
c. A reasonable ambient temperature of 95F (35C) should be assumed. Justification along with supporting documentation must be included with your submission, for exceptions to this ambient temperature assumption.
d. The reactive power (Qmax/Qmin) modeled for power flow is determined using the specified curve based on the Gross MW operating point for Summer and/or Winter
e. For uprate requests, provide documentation of the contractual power factor requirements prior to the uprate request.
f. Saturation curves must be provided.

### 5.2.2 Modeling Files

#### *5.2.2.1 Power Flow (.IDV)*

The facility shall be modeled in a response file (.idv) that uses RDCH to specify the data. The .idv provided must always include a full representation of the facility configuration, instead of updating just specific portions of the model.

The .idv model submitted to PJM for the queue project shall include the following configuration:

**Generator:**

a. Modeled at the terminal voltage specified in the Data Application data form.
b. The Pgen and Pmax shall be set equal to each other to meet the MFO at the POI with unity power factor.
c. The Qmin and Qmax limits shall be set based on the reactive capability curve for the active power operating point.

d. The generator source impedance (Zsource) shall be set equal to the unsaturated sub transient reactance value (X"d)

**Main Station Transformer:**

a. Impedance I/O Code set to '2 Zpu (winding kV winding MVA)' All other I/O codes can be left at the default PSS/E values.
b. Ensure correct transformer MVA base is provided per the cooling class designations specified
c. Include the winding configuration (per TO requirements)
d. Include load tap changer settings (Number of taps and voltage % per tap)

**Loads:**

a. Auxiliary Load shall be modeled using the ID "XA"
b. Station Service Load shall be modeled using ID "XS"

**Attachment Line:**

a. The attachment line impedance data and line length shall be included.

#### 5.2.2.2 Dynamic Data (.DYR) – Library Models

a. Utilize the appropriate model(s) to represent your facility (i.e.: Hydro, Nuclear, etc.)
b. The dynamic model data must include, at a minimum, a generator model, a governor model, an exciter model, and if applicable, a power system stabilizer model and an excitation limiter model.
c. For Steam Turbines operating in sliding pressure mode, a governor model is not required. Provide an explanation for this.
d. Generator inertia constant H (kWs/kVA) must be the combined Turbine-Generator-Exciter Inertia
e. Unsaturated values for all reactance values must be entered for the generator model
f. All reactance and resistance values must be provided in per unit on the machine MVA base at machine terminal voltage.

#### 5.2.2.3 Dynamic Data (.DYR) – User Defined Models

If a user defined model must be provided, it shall be in .dyr format with suitable parameters to represent the project. Written documentation/user manual from the manufacturer must be supplied explaining the dynamic parameters and performance characteristics. The model manual must show control block diagrams, design logic, descriptions of all model parameters, a list of which parameters are commonly tuned for site-specific settings, and a description of procedures for using the model in dynamic simulations.

Any benign warning messages that are generated by the model code at compilation time shall also be documented. Source code, .dll file, and Object file(s) shall be provided for the user defined model(s) in the applicable PSSE version. Any available higher versions of the user defined model shall also be provided. To support future basecase development, updated PSSE versions and supporting documentation for your user model must be provided when requested by PJM, within 30 days.

# 6 Other New Service Requests

For New Service Requests not covered in this guideline, such as but not limited to, HVDC requests, Offshore Wind requests, etc., a complete power flow model (.idv) and dynamic model (.dyr) for the project and the manufactures dynamic modeling guidelines describing parameter meanings and range of settings for the project, as planned to be installed, up to the Point of Interconnection must be provided.

The PJM Model Testing Requirements and Deliverables listed in the sections below must be met.

# 7 PJM Model Testing Requirements

Develop a .idv and .dyr file for the queue project model using a single machine infinite bus system in the appropriate PSS/E version, following the guidelines provided in the sections above. The SMIB shall connect to the POI using the equivalent Thevenin impedance with a SCR of 3 and X/R of 5. The project specific bus numbers will be applied when the files are submitted to PJM.

See sections in Appendix 10 to help with meeting the PJM Model Testing Requirements and Deliverables listed below for your dynamic model submission.

## *7.1 MFO Assessment*

Verify that the MFO requested by the New Service Request project is achievable at the POI.

- The full facility model must be checked to ensure the gross active power output of the generator(s) can meet the MFO at the POI considering loads and losses for the facility.
- The net active power output must be equal to the MFO.
- If the MFO is not met at the POI, adjustments would need to be made to ensure the MFO requested can be achieved at the POI.

**Table 2.** Sample MFO Assessment table

| | Active Power (MW) |
|---|---|
| Requested MFO | 650 |
| Gross MW | 662 |
| Station Load + Auxiliary Load | 8.15 |
| Losses | 3.85 |
| MW at the POI | 650 |
| **MW at the POI meets requested MFO** | **Yes** |

## 7.2 Power Factor Assessment

In accordance with FERC Order No. 827[3] and Section 4.7 of Attachment O of the PJM Open Access Transmission Tariff[4], the following power factor requirements apply to New Service Request projects connecting to the PJM Transmission system:

- New and uprates to a non-synchronous generator shall provide 0.95 leading and 0.95 lagging power factor at the high-side of the main station transformer or the onshore station Transformer. The power factor range between 0.95 leading and 0.95 lagging shall be dynamic.
- New synchronous generators (> 20 MW) shall provide 0.95 leading and 0.90 lagging power factor at the generator terminals.
- New synchronous generators (≤ 20 MW) shall provide 0.95 leading and 0.90 lagging power factor at the point of interconnection.
- Uprates to synchronous generators (> 20 MW) shall provide 1.00 leading and 0.90 lagging power factor at the generator terminals.
- Uprates to synchronous generators (≤ 20 MW) shall provide 1.00 leading and 0.90 lagging power factor at the point of interconnection.
- For uprates to prior queue projects or existing units the reactive power requirements in the Interconnection Service Agreement (ISA) is used for that respective MFO portion of the unit.

A power factor assessment shall be performed to determine if the facility can provide the reactive power necessary to meet the requirement at the specified measurement point, **while meeting the MFO requested, for both lagging and leading**. If the unit cannot meet the requirement, the Interconnection Customer is required to indicate how they intend to modify the design of their facility to meet the requirement. The assessment considers the following:

**Inverter Based Resources:**

1| Reactive Capability of the Inverter:
   a. Use the PQ curve submitted for V=1.0pu from the inverter manufacturer. Determine the Qmax and Qmin available at the Gross MW output of the inverter. Multiply the results by the number of turbines/inverters by type, and sum.
   b. The inverters shall have a minimum dynamic reactive capability range of 0.95 leading to 0.95 lagging at the terminals.

2| Reactive Capability at the POI:
   a. Use Single Machine Infinite Bus (SMIB) to set the POI voltage to the voltage schedule per Manual 03[5].
   b. Model the transmission attachment line, the main power transformer, the equivalent collector system, auxiliary and/or station service loads, the equivalent step up transformers and inverters.

[3] FERC Order No. 827

[4] PJM OATT Attachment O, Section 4.7

[5] PJM Manual 03

c. Set the inverter's active power dispatch to meet the MFO requested at the POI.

d. Model any switched shunts and include any STATCOM or SVC devices if provided.

   i. **Lagging test:**
      - Ensure all reactive compensation devices (E.g.: Inverters, shunt capacitors, SVC, STATCOMs) within the facility are at the maximum capacitive output allowing the steady-state solution to converge.
      - Set the inverter to output its maximum reactive power capability, without exceeding 1.1 pu terminal voltage.
      - In cases where the inverter is not outputting the maximum capacitive reactive power capability with terminal voltage under 1.10 p.u., the transformer taps can be adjusted to ensure capacitive maximum reactive power output from the inverter. Document changes made.
      - Verify that the MFO is met. If it does not, adjust the inverter's active power to meet the MFO and determine the inverter's new maximum reactive power based on PQ curve.
      - Calculate the reactive power losses.
      - Calculate the Total Available Reactive Power at High Side of Main transformer
      - Determine whether the project meets the reactive power requirements or not.

**b. Leading test**

   i. Ensure all reactive compensation devices (E.g.: Inverters, SVC, STATCOM's) excluding shunt reactors within the facility are at the maximum inductive output allowing the steady-state solution to converge.
   ii. Set the inverter to output its minimum reactive power capability, without exceeding 0.90 pu terminal voltage.
   iii. In cases where the inverter is not absorbing the maximum inductive reactive power capability with terminal voltage above 0.90 p.u., the transformer taps can be adjusted to ensure maximum inductive reactive power is absorbed from the inverter. Document changes made.
   iv. Verify that the MFO is met. If it does not, adjust the inverter's active power to meet the MFO and determine the inverter's new minimum reactive power based on PQ curve.
   v. Calculate the reactive power losses.
   vi. Calculate the Total Available Reactive Power at High Side of Main transformer
   vii. Determine whether the project meets the reactive power requirements or not.

**Table 3.** Sample Power Factor Assessment Table for IBRs

| Generator | MFO (MW) | Required Power Factor Range | | Maximum Lagging Qmax (Mvar) | Maximum Leading Qmin (Mvar) |
|---|---|---|---|---|---|
| | | Lagging | Leading | | |
| AE1-xxx | 120 | 0.95 | 0.95 | | |
| AF2-xxx (uprate) | 7 | 0.95 | 0.95 | | |
| **Total Reactive Power Required** | | | | 41.74 | -41.74 |
| **Reactive Power from Generators at Gross MW (obtained from D curve)** | | | | **Qmax** | **Qmin** |
| | | | | 79.5 | -79.5 |
| **Reactive Power Losses (includes any planned compensation)** | | | | -22.63 | -33.94 |
| **Station Load + Auxiliary Load** | | | | -0.18 | -0.18 |
| **Total available reactive power at high side of main transformer** | | | | 56.69 | -113.62 |
| **Deficiency in Reactive Power** | | | | Meet | Meet |

Customer Planned Compensation, if any, included in assessment above = X MVAR

For reactive deficiencies, the Interconnection Customer is required to indicate how they intend to meet the power factor requirement and include this with their model submission. Capacitor bank size cannot be greater than the reactive power losses. An updated power factor assessment table must be provided showing that the plant meets the power factor requirements.

See Appendix 10.3.2 for IBR dynamic model parameters settings to operate in automatic voltage control mode.

**Synchronous Generators:**

a. Power factor assessment shall be performed for each individual unit (eg: CT, ST) and not for the facility as a whole
b. For uprate requests, the breakdown or split of the requested uprate MW's among each of the units (eg: CT1, CT2 and ST) must be provided.
c. Typically performed for Winter energy values.
d. If the unit has ambient air cooling that can vary with ambient temperature, then a reactive assessment shall be performed for winter energy and summer energy values. Include another set of tables of similar format using the summer energy values.
e. Use the reactive capability curve provided by the generator manufacturer to obtain the Qmax and Qmin available at the Gross MW output of the unit.

**Table 4.** Sample Power Factor Assessment Table for Synchronous Generators (CT1, CT2, ST)

| Generator (CT 1, 2) | Winter MFO (MW) | Required Power Factor Range | | Maximum Lagging (Mvar) | Maximum Leading (Mvar) |
|---|---|---|---|---|---|
| | | Lagging | Leading | | |
| AA1-xxx | 117 | 0.9 | 0.95 | 56 | -38 |
| AC2-xxx (uprate) | 4.75 | 0.9 | 1 | 2 | 0 |
| **Total Reactive Power Required** | | | | 58 | -38 |
| **Total Available Reactive Power from Generators at Gross MW (121.75 MW)** | | | | **Qmax** | **Qmin** |
| | | | | 80 | -45 |
| **Deficiency in Reactive Power** | | | | Meet | Meet |

| Generator (ST) | Winter MFO (MW) | Required Power Factor Range | | Maximum Lagging (Mvar) | Maximum Leading (Mvar) |
|---|---|---|---|---|---|
| | | Lagging | Leading | | |
| AA1-xxx | 135 | 0.9 | 0.95 | 62.47 | -44.1 |
| AC2-xxx (uprate) | 0.5 | 0.9 | 1 | 0 | 0 |
| **Total Reactive Power Required** | | | | 62.47 | -44.1 |
| **Total Available Reactive Power from Generators at Gross MW (135.5 MW)** | | | | **Qmax** | **Qmin** |
| | | | | 62.47 | -66.15 |
| **Deficiency in Reactive Power** | | | | Meet | Meet |

For reactive deficiencies, the Interconnection Customer is required to indicate how they intend to meet the power factor requirement and include this with their model submission.

## *7.3 Flat Start Test*

The power flow and dynamic models for any type of generator must be usable by the Siemens PTI PSSE software platform to perform the simulation. The usability requirement includes three aspects:

1| All the models and associated parameters should be read by the simulation software correctly.
   a. The number of each power flow element including buses, lines, transformers, generators, shunts must match the number in the .sav file.
   b. Parameters read into the software must match the values in the .sav file.
   c. The number of dynamic models read into the software must match the number of dynamic models in the .dyr file.
   d. Parameters read into the software must match the values in the .dyr file.

2| There are no initialization errors for the dynamic models and the warning messages are reviewed with resolution or explanation.

3| The models must flat start (i.e.: produce flat lines) for a 20-second no-disturbance simulation. The PJM definition of flat start is variations of generator outputs Pgen and Qgen over 20 seconds no greater than 0.1 MW or 0.1 MVAR movement. The results of the flat start test shall show the unit(s) initializes without any DSTATE errors or suspect initial conditions in the log file and the real power, reactive power, voltage and frequency remain consistent thought out the simulation in the out file and the plots.

### *7.4 Voltage Ride Through (VRT) Test (for IBRs)*

For inverter based resources a three-phase fault is applied at the POI for 9 cycles. The fault is cleared without the loss of any elements. The results of the VRT test shall show the unit(s) does not trip, the real and reactive power recovers to the prefault value. The response shall also be reviewed to see if the unit(s) entered Momentary Cessation if both the real and reactive current went to 0. See Appendix 10.3.3 for details.

### *7.5 Momentary Cessation (for IBRs)*

Momentary Cessation is when no current is injected into the grid by the inverter during low or high voltage conditions outside of the continuous operating range.
Reference: NERC Reliability Guideline "*BPS-Connected Inverter-Based Resources Performance",* September 2018
https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Inverter-Based_Resource_Performance_Guideline.pdf

The NERC recommendation is to eliminate Momentary Cessation (MC) to the extent possible. If Momentary Cessation cannot be eliminated due to equipment limitations, notify PJM when submitting the dynamic model for the project.

### *7.6 Primary Frequency Response*

Verify the relevant dynamic model parameters are set to provide primary frequency response.

FERC Order No. 842[6] and Section 4.7.2 of Attachment O of the PJM Open Access Transmission Tariff[7] includes the requirement that a "Generator Interconnection Customer shall ensure the primary frequency response capability of its Customer Facility by installing, maintaining, and operating a functioning governor or equivalent controls."

The ISA/GIA states the "Generator Interconnection Customer is required to install a governor or equivalent controls with the capability of operating: (1) with a maximum 5 percent droop and +/- 0.036 Hz deadband" and "the droop characteristic shall be: (1) based on the nameplate capacity of the Customer Facility, and shall be linear in the range of frequencies between 59 to 61 Hz that are outside of the deadband parameters". See Appendix 10.3.4 for details.

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[6] FERC Order No. 842

[7] PJM OATT Attachment O, Section 4.7.2

# 8 Deliverables

A **Dynamic Model Report** with the **Dynamic Model Checklist** in Appendix 10.4 must be submitted along with quality assurance sign offs from responsible parties. Report shall include a summary of model development per guidelines in this document. Deliverables shall include:

1| **Completed Queue Point Data Application form** along with all requested files to be submitted via the Queue Point portal.

2| If a **Library model** is submitted, provide the .idv and .dyr files for the project developed using the guidelines in this document. See Appendix 10.1 for sample format.

3| If a **UDM** is submitted, provide a properly compiled PSSE version .sav case along with .idv, .dyr and .DLL files appropriately parameterized for the project using the guidelines in this document. Also include:

- a. A **report on how the settings of the model were parameterized** along with the manufacturer's documentation, including user guide of the UDM
- b. **Block diagram** for the model and sub modules, along with values, names and detailed explanation of all model parameters

4| Provide the **.raw, .sav case, .cnv, .snp and .sld file** for the project (case setup folder/files)

5| Verify that all testing requirements are met. Must provide:

- c. MFO assessment table for the project
- d. **Power Factor Assessment table** for the project along with PQ curve used, along with case setup for power factor assessment (lagging & leading scenarios)
- e. Confirmation that the unit meets FERC Order No. 827 with regards to **automatic voltage regulation**, with appropriate model settings included in the Dynamic Model report
- f. **Results for the flatstart test** including log, out and test plots showing Power, VARs, Eterm, Freq and Volt for each inverter(s)/generator(s)
- g. **Results for the VRT test** including log, out and test plots showing Power, VARs, Eterm, Freq and Volt for each inverter(s). Provide confirmation that **Momentary Cessation is eliminated** (if not, provide reason)
- h. Confirmation that Primary Frequency Response is enabled

Place all files required per the Deliverables above, including the Dynamic Model Report and Dynamic Model Checklist in a folder, zip and attach/upload in Queue Point under the Generator Information Section > Stability Models.

# 9 References


1| Solar Photovoltaic Power Plant Modeling and Validation Guideline, MVWG, December 9, 2019 https://www.wecc.org/_layouts/15/WopiFrame.aspx?sourcedoc=/Reliability/Solar%20PV%20Plant%20Modeling%20and%20Validation%20Guidline.pdf&action=default&DefaultItemOpen=1

2| Reliability Guideline: Improvements to Interconnection Requirements for BPS-Connected Inverter-Based Resources, NERC IRPTF, September 2019

https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_IBR_Interconnection_Requirements_Improvements.pdf

3| PJM Manual 14B

https://pjm.com/-/media/documents/manuals/m14b.ashx

4| PRC-024-3

https://www.nerc.com/pa/Stand/Reliability%20Standards/PRC-024-3.pdf

5| WECC Wind Power Plant Power Flow Modeling Guide https://www.wecc.org/Reliability/WECCWindPlantPowerFlowModelingGuide.pdf

# 10 Appendix

## 10.1 Sample Format for .idv and .dyr files

The .idv and .dyr file provided for your project must include the following header at the top of the file, with the relevant information filled out.

/******************************************************
/*** Project Number:
/*** Project Name:
/*** POI location:
/*** TO Zone:
/*** MFO:
/*** Fuel Type:
/*** Inverter Details (Number x MW/inverter) **OR** Generators (CT, ST configuration):
/*** PSSE Version:
/*** Date:
/*** Description of Changes: (not required if this is the first file submission for the project)
/******************************************************
Start .idv/.dyr modeling information here

## 10.2 Unacceptable Models List

| Model | Description |
|---|---|
| WT3G1, WT3G2 | Doubly-Fed Induction Generator (Type 3) |
| WT4G1, WT4G2 | Wind generator model with power converter (Type 4) |
| WT3E1 | Electrical control for Type 3 wind generator |
| WT4E1, WT4E2 | Electrical control models for Type 4 wind generator |
| WT3T1 | Mechanical system model for Type 3 wind generator |
| WT3P1 | Pitch control model for Type 3 wind generator |
| WT12A1 | Pseudo-governor model for Type 1 and Type 2 wind generators |
| REECB1, REECBU1 | Renewable Energy Electrical Control model (for large scale PV) |
| GENSAL | Salient pole generator model |
| GENCLS | Classical generator model |
| GENTRA | Transient Level Generator Model |
| SEXS | Simplified excitation system model |
| EX2000 | EX2000 Excitation System |
| COMPCC | Voltage Regulator Current Compensating Model for Cross-Compound Units |
| URGS3T | WECC gas turbine governor model |
| GAST | Gas Turbine-Governor |
| GAST2A | Gas Turbine Model |
| GASTWD | Woodward Gas Turbine-Governor Model |
| IEEEG2 | 1981 IEEE type 2 turbine-governor model |
| WESGOV | Westinghouse digital governor for gas turbine |
| PVGU1 | User written generator model to represent photo-voltaic (PV) systems |
| PVEU1 | User written electrical control model for photo-voltaic(PV) systems |

### 10.3 Dynamic Model Descriptions for IBRs

The WECC approved dynamic models required to represent inverter-based resources (IBRs) are shown in this section. Examples of typical values are given for different modules for Renewable Energy Resources (RES). Table 1 shows voltage and frequency protection modules applicable to all IBRs. Table 2 illustrates the different approved modules and their applicability.

| **Voltage and Frequency protection modules** | |
|---|---|
| Model Name for Generator Protection | For All Facilities, Solar PV, Wind & Storage |
| Low/High Frequency Ride-Through | FRQTPAT, FRQDCAT |
| Low/High Voltage Ride-Through | VTGTPAT, VTGDCAT |

| **Applicable WECC Approved IBR Dynamic Models** | | |
|---|---|---|
| Model Name | Model Name in Siemens PTI PSS®E | Applicability |
| Generator/Converter | REGCAU1(v 33); REGCA1 (v34 & v35) | All IBR |
| | REGCBU1 (v34 & v35) | All IBR, voltage source interface to grid for numerical robustness |
| Electrical Controls | REECAU1 (v33); REECA1 (v34 & v35) | Type 3 and 4 WTG Solar PV DC-coupled: BESS not charging from grid |
| | REECCU1 (v33 & v34); REEC1 (v35) | Stand-alone BESS DC-coupled: BESS charging from grid |
| | REECDU1 (v34 & v35) | All IBR, enhanced modeling capability from reecau1/reeca1 & reecbau1_ |
| Plant Controller | REPCTAU1 & REPCAU1 (v33); REPCTA1 & REPCA1 (v34 & v35) | For single generator control (except for plant level PF control) |
| | PLNTBU1 (v33, v34 & v35) | For single and multiple generator control |
| Mechanical Models for Wind Turbines | | |
| Two-mass model of the WTG drive-train | WTDTAU1 (v33); WTDTA1 (v34 v35) | Type 3 WTG Type 4 WTG if pflag = 1 in reecau1/reeca1 |
| Aero-dynamic model for the type 3 WTG | WTARAU1 (v33); WTARA1 (v34 & v35) | Type 3 WTG |
| Model of the pitch control system | WTPTAU1 (v33); WTPTA1 (v34 & v35) | Type 3 WTG |
| Model of the torque control system | WTTQAU1 (v33); WTTQA1 (v34 & v35) | Type 3 WTG |
| New refined pitch-controller model | WTGPB | Type 3 WTG |

The modules fall into four (4) categories:

1| **Renewable Energy Generator/Converter (REGC_*) models:** These modules are used to model the electrical generator and/or power converter interface between the generation unit and the grid. There are three (3) such modules:

a. REGCAU1 (v33)/REGCA1 (v34 & v35) – this is the original model. It is a current-source model. It is adequate for modeling the generator dynamic behavior of the generator/converter interface. It is not suitable for weak-grid connection points, where the short-circuit ratio (SCR) of the point of interconnection may be 3 or less.

b. REGCBU1 (v34 & v35) – this is a newly developed and approved voltage-source generator/converter interface model. It is better suited to weak-grid conditions, and if parameterized appropriately has been shown to be accurate numerically down to SCRs close to 1.

c. REGCCU1 – this is a new model yet to be fully implemented and approved by all the software vendors. It incorporates a generic representation of the phase-locked loop (PLL) and inner-current control loops, as well as being a voltage-source model.

Presently REGCAU1/REGCA1 and REGCBU1 are approved models and can be used for modeling the generator/converter interface of a RES. The choice of the model should be based on whether the IBR is connected at a weak point or strong point and the best data currently available for the plant being modeled. The point-of-interconnection of a plant may become weak over time as additional inverter-based resources interconnect in the vicinity of the plant. In such cases there may be a need to transition from a REGCAU1/REGCA1 model to a REGCBU1 model.

2| **Renewable Energy Electrical Controls (REEC_*) models**: These modules are used to model the electrical controls at the individual generating unit level, including individual wind turbine generators and individual PV inverters. There are three (3) such modules:

a. REECAU1/REECA1 – this is the original model developed and can be used, if appropriately parameterized for wind and PV generators.

b. REECCU1/REEC1 – this module was developed specifically for battery-energy storage systems (BESS) or can also be used to model hybrid PV-BESS systems, particularly when the BESS and PV are coupled on the dc-side of the inverter and share one common inverter.

c. REECDU1 – this is the latest electrical controls model developed which contains main new features, such as extended voltage-dependent current limit tables. As such, when modeling new facilities this model may offer greater flexibility and features. It can be used to model wind, PV and BESS. All three of the above REEC_* models are approved and can be used for modeling the electrical controls of the appropriate RES.

The REECBU1 model is **no longer approved** although still used in a number of ISOs/RTOs. The REECBU1 model does not have the "VDL" logic.

The REECAU1, REECCU1 and REECDU1 models have the "VDL" V-I characteristic curve parameters that define the momentary cessation characteristics. At VDL voltages V1 to V4 the corresponding limits for the active and reactive current commands Ip and Iq are defined. This enables the models to reduce or completely stop producing active and/or reactive power when low voltages are observed and then ramp back up once voltages increase. There are other parameters in the models that can impact this behavior. The REGCAU1 model includes an ICON for LVPL switch that enables the LVPL characteristic that can also define reduction in active power at low voltages, however, this characteristic is a single, linear-slope while the VDL logic is piece-wise linear.

3| **Renewable Energy Plant Controller (REPC_*) models**: These modules are used to model the plant level controls that monitor the point of common coupling (PCC), or point of interconnection (POI), of a plant and issues real and reactive power commands to all the individual generating units in the plant to control the real and reactive power at the PCC (or POI). There are three (3) such models:

a. REPCTAU1 & REPCAU1/REPCTA1 & REPCA1 – this is the original simple plant level controller. It allows for volt/var control and active power control. It does not include power factor control.
b. PLNTBU1 – this is a complex-plant controller to be used primarily for hybrid-plants which include multiple technologies, for example a combination of two different wind turbine technologies, or wind and PV, and other combinations. It does also allow for power factor control at the PCC (POI).
c. REPC_C – this model is not yet finalized and approved. It presents significant additional features and flexibility including, power factor control at the PCC (POI), ability to have coordinated and automatically switched shunt devices at the PCC (POI), and extra features for active power control.

Presently REPCTAU1 & REPCAU1/REPCTA1 & REPCA1 and PLNTBU1 are approved and can be used for modeling the appropriate plant controller.

4| **Mechanical Element Models for Wind Turbine Generators**: specifically for wind turbine generators (WTGs) there are a series of mechanical side models. Presently, for type 4 WTGs the only mechanical model used is an emulation of the drive-train dynamics. All the other models are used only for type 3 WTGs. The models are:

a. WTDTAU1/WTDTA1 – this is a two-mass model of the WTG drive-train.
b. WTARAU1/WTARA1 – this is a very simple aero-dynamic model for the type 3 WTG.
c. WTPTAU1/WTPTA1 – this is a simple model of the pitch control system.
d. WTTQAU1/WTTQA1 – this is a simple model of the torque control system.
e. WTGP_B – this is a new refined pitch-controller model, which provides added flexibility in the limits of the pitch controller.

WTDTAU1/WTDTA1, WTARAU1/WTARA1, WTPTAU1/WTPTA1 and WTTQAU1/WTTQA1 are all currently approved models and should be used when modeling a type 3 WTG. When modeling a type 4 WTG, due to the full-converter interface, for stability simulations it has been shown that none of these models are necessary.

### 10.3.1 IBR data submission and typical values

The dynamic model shall be submitted in a table and a Siemens PTI PSS®E version 34 dyr format. Examples dyr files and tables showing typical values for PV Solar, Wind, and Battery Storage modules are shown below.

#### *10.3.1.1 PV Solar*

The generator/converter REGCA1, electrical controls REECA1, and plant controls REPCA1 models with typical values for PV Solar are shown in the following three tables.

Lvplsw - Enable (=1) or disable (=0) Low Voltage Power Logic, LVPL

| Generator/Converter Module | | |
|---|---|---|
| **REGCA1 (v34 & v35) / REGCAU1 (v33)** | | |
| **Parameter** | **Description** | **Typical Values** |
| Tg | Converter time constant (s) | 0.02 |
| Rrpwr | Low Voltage Power Logic (LVPL) ramp rate limit (pu/s) | 10.0 |
| Brkpt | LVPL characteristic voltage 2 (pu) | 0.90 |
| Zerox | LVPL characteristic voltage 1 (pu) | 0.40 |
| Lvpl1 | LVPL gain (pu) | 1.22 |
| Volim | Voltage limit (pu) for high voltage reactive current management | 1.2 |
| Lvpnt1 | High voltage point for low voltage active current management (pu) | 0.8 |
| Lvpnt0 | Low voltage point for low voltage active current management (pu) | 0.4 |
| Iolim | Current limit for high voltage clamp logic (pu on mbase) | -1.0 to -1.5 |
| Tfltr | Terminal voltage filter (for LVPL) time constant (s) | 0.02 |
| Khv | Overvoltage compensation gain used in high voltage reactive current management | 0.7 |
| Iqrmax | Maximum rate-of-change of reactive current (pu/s) | 999.9 |
| Iqrmin | Minimum rate-of-change of reactive current (pu/s) | -999.9 |
| Accel | High voltage reactive current management acceleration factor, p.u. | 0.7 |

| Electrical Controls Module | | |
|---|---|---|
| **REECA1 (v34 & v35) / REECAU1 (v33)** | | |
| **Parameter** | **Description** | **Typical Values** |
| PFFLAG | 1 if power factor control<br>0 if Q control, which can be controlled by an external signal | 1 or 0 |
| VFLAG | 1 if Q control<br>0 if voltage control | 1 or 0 |
| QFLAG | 1 if voltage or Q control<br>0 if constant pf or Q control | 1 or 0 |
| PFLAG | 1 if active current command has speed dependency<br>0 for no dependency | 1 or 0 |
| PQFLAG | P/Q priority flag for current limit:<br>0 for Q priority<br>1 for P priority | 1 or 0 |

| REECA1 (v34 & v35) /REECAU1 (v33) | | |
|---|---|---|
| Vdip | Low voltage threshold to activate reactive current injection logic | [0.00, 0.90] |
| Vup | Voltage above which reactive current injection logic is activated | [1.10, 1.30] |
| Trv | Voltage filter time constant. | [0.02, 0.05] |
| dbd1 | Voltage error dead band lower threshold (≤0) | [-0.10, 0.00] |
| dbd2 | Voltage error dead band upper threshold (≥0) | [0.00, 0.10] |
| Kqv | Reactive current injection gain during over and under voltage conditions | 2.0 |
| Iqh1 | Upper limit on reactive current injection Iqinj | [0.00, 1.10] |
| Iql1 | Lower limit on reactive current injection Iqinj. | [-1.10, 0.00] |
| Vref0 | User defined reference (if 0, model initializes it to initial terminal voltage) | 0.0 |
| Iqfrz | Value at which Iqinj is held for Thld seconds following a voltage dip if Thld > 0 | |

| | | |
|---|---|---|
| Thld | Time for which Iqinj is held at Iqfrz after voltage dip returns to zero | 0.0 |
| Thld2 | Time of holding the active current command after voltage dip returns to 0, sec. | 0.0 |
| Tp | Filter time constant for electrical power. | [0.02, 0.05] |
| Qmax | Maximum limit for reactive power regulator when vflag = 1, p.u. | [0.00, 0.43] |
| Qmin | Minimum reactive power when vflag = 1, p.u. | [-0.43, 0.00] |
| VMAX | Maximum limit for voltage control (pu) | [1.05, 1.15] |
| VMIN | Minimum limit for voltage control (pu) | [0.85, 0.95] |
| Kqp | Local Q regulator proportional gain, p.u. | |
| Kqi | Local Q regulator integral gain, p.u. | |
| Kvp | Local voltage regulator proportional gain, p.u | |
| Kvi | Local voltage regulator integral gain, p.u | |
| Vbias | Inner-loop voltage control reference, p.u., user-defined bias (normally 0) | 0.0 |
| Tiq | Reactive current regulator lag time constant, sec. Time constant on delay s4 | [0.02, 0.05] |
| dPmax | Active power up-ramp limit, p.u./sec | 999.00 |
| dPmin | Active power down-ramp limit, p.u./sec | -999.00 |
| PMAX | Maximum active power, p.u | 1.00 |
| PMIN | Minimum active power, p.u | 0.00 |
| Imax | Maximum limit on total converter current, Maximum apparent current, p.u. | [1.00, 1.70] |
| Tpord | Power filter time constant; Inverter power order lag time constant (s) | [0.02, 0.05] |
| Vq1 | Reactive Power V-I pair, voltage (pu) | -1 |
| Iq1 | Reactive Power V-I pair, current (pu) | 1 |
| Vq2 | (Vq2>Vq1), Reactive Power V-I pair, voltage (pu) | 2 |
| Iq2 | (Iq2>Iq1), Reactive Power V-I pair, current (pu) | 1 |
| Vq3 | (Vq3>Vq2), Reactive Power V-I pair, voltage (pu) | 0 |
| Iq3 | (Iq3>Iq2), Reactive Power V-I pair, current (pu) | 0 |
| Vq4 | (Vq4>Vq3), Reactive Power V-I pair, voltage (pu) | 0 |
| Iq4 | (Iq4>Iq3), Reactive Power V-I pair, current (pu) | 0 |
| Vp1 | Real Power V-I pair, voltage (pu) | 0.5 |
| Ip1 | Real Power V-I pair, current (pu) | 0 |
| Vp2 | (Vp2>Vp1), Real Power V-I pair, voltage (pu) | 0.7 |
| Ip2 | (Ip2>Ip1), Real Power V-I pair, current (pu) | 0.8 |
| Vp3 | (Vp3>Vp2), Real Power V-I pair, voltage (pu) | 0.9 |
| Ip3 | (Ip3>Ip2), Real Power V-I pair, current (pu) | 0.98 |
| Vp4 | (Vp4>Vp3), Real Power V-I pair, voltage (pu) | 1 |
| Ip4 | (Ip4>Ip3), Real Power V-I pair, current (pu) | 1 |

Voltage-dependent active currents Ip1 to Ip4 and voltage-dependent reactive currents Iq1 to Iq4 are from the voltage-dependent current limits (VDL) tables (VDL1 and VDL2) and are used to model cessation of both active and reactive current respectively. The parameter Vdip in REECA1 must be equal or higher than the low voltage momentary cessation threshold vblkl and Vup must be equal or lower than the high voltage threshold vblkh to ensure inverter controls are frozen during the cessation period.

**Low Voltage Power Logic Switch:** It is best to set lvplsw in REGCA1 to 0 to prevent the generator/converter model from contradicting the VDL1 and VDL2 settings in the REECA1 model.

| Plant Controls Module | | |
|---|---|---|
| **REPCA1 & REPCTA1 (v34 & v35)** | | |
| **Parameter** | **Description** | **Typical Value** |
| VCFlag | Droop flag:<br>0 – with droop if power factor control<br>1 – with line drop compensation | 1 or 0 |
| RefFlag | Flag for V or Q control<br>0 – Q control<br>1 – V control | 1 or 0 |
| Fflag | Flag to disable frequency control<br>1 – enable control<br>0 – disable control | 1 or 0 |
| | | |
| **REPCA1 & REPCTA1 (v34 & v35) /REPCAU1 & REPCTAU1 (v33)** | | |
| Tfltr | Voltage and reactive power filter time constant, sec. | [0.02, 0.05] |
| Kp | Volt/VAr /Reactive power PI control proportional gain (pu) | - |
| Ki | Volt/VAr /Reactive power PI control integral gain (pu) | - |
| Tft | Plant controller Q output lead time constant, sec | 0.00 |
| Tfv | Plant controller Q output lag time constant, sec. | [0.02, 0.15] |
| Vfrz | Voltage for freezing Volt/VAr regulator integrator, p.u | [0.00, 0.90] |
| Rc | Line drop compensation resistance, p.u. | ≥ 0.0 |
| Xc | Line drop compensation reactance, p.u | ≥ 0.0 |
| Kc | Reactive droop gain, p.u | |
| emax | Maximum Volt/VAr error, p.u; upper limit on deadband output (pu) | 999.00 |
| emin | Minimum Volt/VAr error, p.u.; lower limit on deadband output (pu) | -999.00 |
| dbd1 | Lower threshold for reactive power control deadband (<=0) | |
| dbd2 | Upper threshold for reactive power control deadband (>=0) | |
| Qmax | Max plant reactive power command/Upper limit on output of V/Q control (pu) | [0.00, 0.43] |
| Qmin | Min plant reactive power command/Lower limit on output of V/Q control (pu) | [-0.43, 0.00] |
| Kpg | Real power control proportional gain, p.u | - |
| Kig | Real power control integral gain, p.u. | - |
| Tp | Real power measurement filter time constant (s) | [0.02, 0.05] |
| fdbd1 | Frequency deadband downside, p.u. | -0.0006 |
| fdbd2 | Frequency deadband upside, p.u | 0.0006 |
| femax | Maximum power error in droop regulator/frequency error lower limit (pu) | 999.00 |
| femin | Minimum power error in droop regulator/frequency error lower limit (pu) | -999.00 |
| Pmax | Upper limit on power reference/Maximum plant active power command, p.u. | 1.00 |
| Pmin | Lower limit on power reference/Minimum plant active power command, p.u | 0.00 |
| Tg | Plant controller P output lag time constant, sec. | [0.02, 0.15] |
| Ddn | Reciprocal of droop for over-frequency conditions (p.u.) | 20 |
| Dup | Reciprocal of droop for under-frequency conditions (pu) | [0. 20] |

For PV Solar, an example of a function call in the .dyr file is shown below.

```
4444, 'USRMDL', 1, 'REGCAU1', 101, 1, 1, 14, 3, 4
/ Lvplsw
     0
/ Tg        Rrpwr      Brkpt      Zerox    Lvpl1
0.020       10.0       0.90        0.50     1.10
/ Volim     Lvpnt1     Lvpnt0     Iolim    Tfltr
 1.10          0.9        0        -1.0     0.01
/ Khv       Iqrmax     Iqrmin     Accel
 0.0          99.0      -99.0       1.00


4444, 'USRMDL', 1, 'REECAU1', 102, 0, 6, 45, 6, 9
/ Bus#      PFflag     Vflag      Qflag     Pflag     PQflag
   0          0          1          1         0          1
/ Vdip      Vup        Trv        dbd1      dbd2
  0.90      1.10       0.01       -0.10      0.10
/ Kqv       Iqh1       Iql1       Vref0     Iqfrz
  2.0       1.0        -1.0        1.00      0.0
/ Thld      Thld2      Tp         QMax      QMin
  0.0       0.0        0.01        0.60      -0.60
/ Vmax      Vmin       Kqp        Kqi       Kvp
  1.10       0.9        1           5         1
/ Kvi       Vbias      Tiq        dPmax     dPmin
  3.0       0.0        0.016668    999       -999
/ Pmax      Pmin       Imax       Tpord     Vq1
   1         0          1.0        0.10      0.0
/ Iq1       Vq2        Iq2        Vq3       Iq3
  1.0       0.4        1.0        0.6       1.0
/ Vq4       Iq4        Vp1        Ip1       Vp2
  0.8       1.0        0.0        1.0       0.4
/ Ip2       Vp3        Ip3        Vp4       Ip4
  2.0       0.6        1.0        0.8       1.0

4444, 'USRMDL', 1, 'REPCAU1', 107, 0, 7, 27, 7, 9
/ Bus#   LDC_FromBus   LDC_ToBus   LDC_ID   VCFlag   Refflag   Fflag
 4444       4445          4446        '1'      0        1         1
/ Tfltr     Kp         Ki         Tft       Tfv
 0.05       0.5        3          0         0.05
/ Vfrz      Rc         Xc         Kc        emax
  0.9       0          0          0.1       0.05
/ emin      dbd1       dbd2       QMax      QMin
  -0.05      0          0         0.3669    -0.3669
/ Kpg       Kig        Tp         fdbd1     fdbd2
  0.5       0.25       0.25       -0.0006   0.0006
/ femax     femin      Pmax       Pmin      Tg
   999       -999      0.9304      0         0.7
/ Ddn       Dup
20.000      20.000


/ LOW VOLTAGE PROTECTION example
    1  'VTGDCAT'   4444   4444 '1 '
                      / Vlow      Vup       RlTm      BrTm
                        0.90      10.00     120.00    0.00
    2  'VTGDCAT'   4444   4444 '1 '
                      / Vlow      Vup       RlTm      BrTm
                        0.80      10.00     60.000    0.00
    3  'VTGDCAT'   4444   4444 '1 '
                      / Vlow      Vup       RlTm      BrTm
```

```
                    0.70        10.00       21.000       0.00
    4  'VTGDCAT'   4444   4444 '1 '
                   / Vlow       Vup         RlTm         BrTm
                    0.50        10.00       10.000       0.00

/ HIGH VOLTAGE PROTECTION example
    5  'VTGDCAT'   4444   4444 '1 '
                   / Vlow       Vup         RlTm         BrTm
                    0.00         1.10        120.00       0.00
    6  'VTGDCAT'   4444   4444 '1 '
                   / Vlow       Vup         RlTm         BrTm
                    0.00         1.15        60.000       0.00
    7  'VTGDCAT'   4444   4444 '1 '
                   / Vlow       Vup         RlTm         BrTm
                    0.00         1.20        2.000        0.00
    8  'VTGDCAT'   4444   4444 '1 '
                   / Vlow       Vup         RlTm         BrTm
                    0.00         1.25        0.200        0.00

/ LOW FREQUENCY PROTECTION example
    9  'FRQDCAT'   4460   4444 '1 '
                   / Flow       Fup         RlTm         BrTm
                    56.5        100.0       6.000        0.00

/ HIGH FREQUENCY PROTECTION example
    10  'FRQDCAT'   4460   4444  '1 '
                   / Flow       Fup         RlTm         BrTm
                    00.0         63.5        6.000        0.00
```

#### *10.3.1.2 Wind Power Plants*

For wind power plants based on Type 3 and 4 WTGs, the required modules are listed below. The second-generation models for PSSE v34 in table 3 have significantly improved with respect to the previous WECC generic model, in terms of structure and functionality.

- REGCAU1 (v33) module, used to represent the generator/converter processes the real and reactive current commands, and outputs real and reactive current injection into the grid model.
- REECAU1 (v33) module, used to represent the WTG electrical controls acts on the active and reactive power reference from the REPCAU1 module, with feedback of terminal voltage and generator power output, and provides real and reactive current commands to the REGCAU1 module.
- REPCAU1 (v33) modules, used to represent the plant controller processes voltage and reactive power output to emulate volt/var control at the plant level. It also processes frequency and active power output to emulate active power control. This module provides active reactive power command to the REECAU1 module.
- WTDTAU1 (v33) module, used to represent the turbine.
- WTARAU1 (v33) module, used to represent the aerodynamic conversion (Type 3 only).
- WTPTAU1 module, used to represent the pitch controller (Type 3 only).
- WTTQAU1 module, used to represent the torque controller (Type 3 only).

| 2nd Generation WECC Models in PSS/E v34 Format | | | | |
|---|---|---|---|---|
| **Model Name** | **Wind Type 3** | **Wind Type 4** | **Solar Photovoltaic** | **Energy Storage** |
| Generator/Converter | REGCA1 | REGCA1 | REGCA1 | REGCA1 |
| Electrical Controller | REECA1 | REECA1 | REECDU1 | REECCU1 |
| Plant Controller | REPCTA1 | REPCA1 | REPCA1 | REPCA1 |
| Drive-Train | WTDTA1 | WTDTA1 (optional) | | |
| Pitch Control | WTPTA1 | | | |
| Aerodynamic | WTARA1 | | | |
| Torque Control | WTTQA1 | | | |

Lvplsw - Enable (1) or disable (0) low voltage power logic

| REGCAU1 (v33) /REGCA1 (v34 & v35) Input Parameters | | |
|---|---|---|
| **Name** | **Description** | **Typical Values** |
| Tg | Converter time constant (s) | 0.02 |
| Rrpwr | Active current up-ramp rate limit on voltage recovery (pu/s) (LVPL) | 10.00 |
| Brkpt | LVPL breakpoint (pu voltage) | 0.9 |
| Zerox | LVPL zero crossing (pu voltage) | 0.4 |
| Lvpl1 | LVPL gain breakpoint (pu current on mbase / pu voltage) | |
| Volim | Voltage limit for high voltage clamp logic (pu) | 1.2 |
| lvpnt1 | High voltage point for low voltage active current management (pu) | 0.8 |
| lvpnt0 | Low voltage point for low voltage active current management (pu) | 0.4 |
| Iolim | Current limit (pu) for high voltage reactive current management | -1.0 to -1.5 |
| Tfltr | Terminal voltage filter (for LVPL) time constant (s) | 0.01 to 0.02 |
| Khv | High voltage clamp logic acceleration factor | 0.7 |
| Iqrmax | Maximum rate-of-change of reactive current (pu/s) | 999.9 |
| Iqrmin | Minimum rate-of-change of reactive current (pu/s) | -999.9 |
| Accel | acceleration factor (0 < Accel < 1) | 0.4 |

| REECAU1 (v33) /REECA1 (v34 & v35) Input Parameters | | |
|---|---|---|
| **Name** | **Description** | **Typical Values** |
| PFflag | Constant Q (0) or PF (1) local control | 1 or 0 |
| Vflag | Voltage control (0) or Q control (1) | 1 or 0 |
| Qflag | Bypass (0) or engage (1) inner voltage regulator loop | 1 or 0 |
| Pqflag | Priority to reactive current (0) or active current (1) | 1 or 0 |
| Vdip | Low voltage condition trigger voltage (pu) | 0.0 to 0.9 |
| Vup | High voltage condition trigger voltage (pu) | 1.1 to 1.3 |
| Trv | Terminal bus voltage filter time constant (s) | 0.01 to 0.02 |
| dbd1 | Overvoltage deadband for reactive current injection (pu) | -0.1 to 0.0 |
| dbd2 | Undervoltage deadband for reactive current injection (pu) | 0.0 to 0.1 |
| Kqv | Reactive current injection gain (pu/pu) | 0.0 to 10.0 |

| | | |
|---|---|---|
| Iqhl | Maximum reactive current injection (pu on mbase) | 1.0 to 1.1 |
| Iqll | Minimum reactive current injection (pu on mbase) | -1.1 to -1.0 |
| Vref0 | Reference voltage for reactive current injection (pu) | 0.95 to 1.05 |
| Iqfrz | Value at which Iqinj is held for Thld seconds following a voltage dip if Thld > 0 (pu) | |
| Thld | Time for which Iqinj is held at Iqfrz after voltage dip returns to zero (sec) | |
| Thld2 | (>=0), Time for which the active current limit (IPMAX) is held at the faulted value after voltage dip returns to zero (sec) | |
| Tp | Active power filter time constant (s) | 0.01 to 0.02 |
| Qmax | Maximum reactive power when Vflag = 1 (pu on mbase) | - |
| Qmin | Minimum reactive power when Vflag = 1 (pu on mbase) | - |
| Vmax | Maximum voltage at inverter terminal bus (pu) | 1.05 to 1.15 |
| Vmin | Minimum voltage at inverter terminal bus (pu) | 0.85 to 0.95 |
| Kqp | Local Q regulator proportional gain (pu/pu) | - |
| Kqi | Local Q regulator integral gain (pu/pu-s) | - |
| Kvp | Local voltage regulator proportional gain (pu/pu) | - |
| Kvi | Local voltage regulator integral gain (pu/pu-s) | - |
| Vbias | User-defined bias (normally 0) | 0.00 |
| Tiq | Reactive current regulator lag time constant (s) | 0.01 to 0.02 |
| dPmax | Power reference max. ramp rate (pu/s) | > 0 |
| dPmin | Power reference min. ramp rate (pu/s) | < 0 |
| Pmax | Maximum active power (pu on mbase) | 1.0 |
| Pmin | Minimum active power (pu on mbase) | 0.0 |
| Imax | Maximum apparent current (pu on mbase) | 1.0 to 1.3 |
| Tpord | Inverter power order lag time constant (s) | - |
| Vq1 | Reactive Power V-I pair, voltage | -1 |
| Iq1 | Reactive Power V-I pair, current | 1 |
| Vq2 | (Vq2>Vq1), Reactive Power V-I pair, voltage | 2 |
| Iq2 | (Iq2>Iq1), Reactive Power V-I pair, current | 1 |
| Vq3 | (Vq3>Vq2), Reactive Power V-I pair, voltage | 0 |
| Iq3 | (Iq3>Iq2), Reactive Power V-I pair, current | 0 |
| Vq4 | (Vq4>Vq3), Reactive Power V-I pair, voltage | 0 |
| Iq4 | (Iq4>Iq3), Reactive Power V-I pair, current | 0 |
| Vp1 | Real Power V-I pair, voltage (pu) | 0.5 |
| Ip1 | Real Power V-I pair, current (pu) | 0 |
| Vp2 | (Vp2>Vp1), Real Power V-I pair, voltage (pu) | 0.7 |
| Ip2 | (Ip2>Ip1), Real Power V-I pair, current (pu) | 0.8 |
| Vp3 | (Vp3>Vp2), Real Power V-I pair, voltage (pu) | 0.9 |
| Ip3 | (Ip3>Ip2), Real Power V-I pair, current (pu) | 0.98 |
| Vp4 | (Vp4>Vp3), Real Power V-I pair, voltage (pu) | 1 |
| Ip4 | (Ip4>Ip3), Real Power V-I pair, current (pu) | 1 |

| **WTARAU1 (v33) /WTARA1 (v34 & v35) Input Parameters** | | |
|---|---|---|
| **Name** | **Description** | **Typical Values** |
| Ka | Aero-dynamic gain factor (pu/deg) | 0.007 |
| $\theta_0$ | Initial pitch angle (deg) | 0.0 |

| **WTPTAU1 (v33) /(WTPTA1 v34 & v35) Input Parameters** | | |
|---|---|---|
| **Name** | **Description** | **Typical Values** |
| Kiw | Pitch control integral gain | 25.0 |
| Kpw | Pitch control proportional gain | 150.0 |
| Kic | Pitch compensation integral gain | 30.0 |
| Kpc | Pitch compensation proportional gain | 3.0 |
| Kcc | Proportional gain | 0.0 |
| Tpi | Pitch time constant (sec) | 0.30 |
| TetaMax | Maximum pitch angle (deg) | 27.0 – 30.0 |
| TetaMin | Minimum pitch angle (deg) | 0.0 |
| RTetaMax | Maximum pitch rate (deg/sec) | 5.0 – 10.0 |
| RTetaMin | Minimum pitch rate (deg/sec) | -10.0 – -5.0 |

| **WTTQAU1(v33) /WTTQA1 (v34 & v35) Input Parameters** | | |
|---|---|---|
| **Name** | **Description** | **Typical Values** |
| Kpp | Proportional gain | 3,00 |
| Kip | Integral gain | 0.60 |
| Tp | Power measurement lag time constant (sec) | 0.05 to 0.1 |
| Tωref | Speed reference time constant (sec) | 30.0 to 60.0 |
| Temax | Maximum torque (pu) | 1.1 to 1.2 |
| Temin | Minimum torque (pu) | 0.00 |
| p1 | User-defined pair of points, function f(Pe) | 0.15 |
| spd1 | | 0.85 |
| p2 | | 0.23 |
| spd2 | | 0.95 |
| p3 | | 0.35 |
| spd3 | | 1.10 |
| p4 | | 0.46 |
| spd4 | | 1.20 |
| TRATE | Total turbine rating (MW) | * |

* TRATE (CON J+14) needs to be set to limit modeled in the power flow case or set to 0 to use the Mbase.

| REPCAU1 & REPCTAU1 (v33) / REPCA1 & REPCTA1 (v34 & v35) Input Parameters | | |
|---|---|---|
| **Name** | **Description** | **Typical Values** |
| RefFlag | Plant level reactive power (0) or voltage control (1) | 1 or 0 |
| VCFlag | Droop flag<br>0: with droop if power factor control<br>1: with line drop compensation | 1 or 0 |
| Fflag | Flag to disable frequency control<br>1: Enable control<br>0: disable | 1 or 0 |
| Tfltr | Voltage and reactive power filter time constant (s) | 0.01 to 0.02 |
| Kp | Volt/VAR regulator proportional gain (pu/pu)m | |
| Ki | Volt/VAR regulator integral gain (pu/pu-s) | |
| Tft | Plant controller Q output lead time constant (s) | |
| Tfv | Plant controller Q output lag time constant (s) | 0.15 to 5.0 |
| Vfrz | Voltage for freezing Volt/VAR regulator integrator (pu) | 0.0 to 0.9 |
| Rc | Line drop compensation resistance (pu on mbase) | - |
| Xc | Line drop compensation reactance (pu on mbase) when VcompFlag = 1 | - |
| Kc | Reactive droop (pu on mbase) when VcompFlag = 0 | - |
| emax | Maximum Volt/VAR error (pu) | - |
| emin | Minimum Volt/VAR error (pu) | - |
| dbd1 | lower threshold for reactive power control deadband | <=0 |
| dbd2 | upper threshold for reactive power control deadband | >=0 |
| Qmax | Maximum plant reactive power command (pu on mbase) | - |
| Qmin | Minimum plant reactive power command (pu on mbase) | - |
| Kpg | Droop regulator proportional gain (pu/pu) | - |
| Kig | Droop regulator integral gain (pu/pu-s) | - |
| Tp | Active power filter time constant (s) | 0.01 to 0.02 |
| fdbd1 | Deadband for frequency control, lower threshold (<=0) | -0.0006 |
| fdbd2 | Deadband for frequency control, upper threshold (>=0) | 0.0006 |
| femax | Maximum power error in droop regulator (pu on mbase) | - |
| femin | Minimum power error in droop regulator (pu on mbase) | - |
| Pmax | Maximum plant active power command (pu on mbase) | 1.0 |
| Pmin | Minimum plant active power command (pu on mbase) | 0.0 |
| Tg | Plant controller P output lag time constant (s) | 0.15 to 5.0 |
| Ddn | Reciprocal of droop for over-frequency conditions (pu) | 20.0 |
| Dup | Reciprocal droop for under-frequency conditions (pu) | 0.0 |

For a wind power plant with Type 3 WTGs, the function call in the .dyr file would be as shown in the example below.

```
2222, 'USRMDL', 1, 'REGCAU1', 101, 1, 1, 14, 3, 4
  / Lvplsw
       1
    / Tg        Rrpwr      Brkpt      Zerox       Lvpl1
   0.02          3.0        0.9        0.5        1.23
    / Volim     Lvpnt1     Lvpnt0      Iolim       Tfltr
```

```
       1.2          0.1          0.01         -1.3         0.02
   / Khv        Iqrmax       Iqrmin       Accel
     0.2          999.0        -999.0       0.7


2222, 'USRMDL', 1, 'REECAU1', 102, 0, 6, 45, 6, 9
    / Bus#       PFflag      Vflag       Qflag       Pflag       PQflag
        0            0           1           1           0           0
    / Vdip       Vup         Trv         dbd1        dbd2
     0.9          1.1         0.02        -0.05       0.05
   / Kqv        Iqh1        Iql1        Vref0       Iqfrz
     0.0         1.0025      -1.0025      1.05        0.10
    / Thld       Thld2       Tp          QMax        QMin
       0.0         0.0         0.05        0.4421      -0.4421
   / Vmax       Vmin        Kqp         Kqi         Kvp
      1.1          0.9         0.0         0.41        1.0
   / Kvi        Vbias       Tiq         dPmax       dPmin
    60.0         0.0         0.02        99.0        -99.0
  / Pmax        Pmin        Imax        Tpord       Vq1
    0.8998        0           1.0025      0.02        0.5
  / Iq1         Vq2         Iq2         Vq3         Iq3
    0.99         0.9         0.54        1.1         0.54
     / Vq4        Iq4         Vp1         Ip1         Vp2
       1.25        1.26        0.0         0.0         0.5
     / Ip2        Vp3         Ip3         Vp4         Ip4
     0.0         0.9         1.23        1.0         1.107


2222, 'USRMDL', 1, 'WTDTAU1', 103, 0, 0, 5, 4, 3,
    / H          DAMP        Htfrac      Freq1       Dshaft
    3.22         0.0         0.01        1.88        1.5

2222, 'USRMDL', 1, 'WTPTAU1', 104, 0, 0, 10, 3, 1,
   / Kiw        Kpw         Kic         Kpc         Kcc
    50.0         200.0       0.0         0.0         0.0
    / Tp         TetaMax     TetaMin     RTetaMax    RTetaMin
     0.3          27.0        0.0         10.0        -10.0


2222, 'USRMDL', 1, 'WTARAU1', 105, 0, 0, 2, 0, 1,
    / Ka         Theta
    0.007        0.0


2222, 'USRMDL', 1, 'REPCTAU1', 107, 0, 7, 27, 7, 9,
  / Bus#        LDC_FromBus  LDC_ToBus  LDC_ID      VCFlag      Refflag     Fflag
    2223        2224        2225        '1'         0           1           1
  / Tfltr       Kp          Ki          Tft         Tfv
     0.5          2.0         1.0         0.02        0.25
   / Vfrz       Rc          Xc          Kc          emax
      0.7         0.0         0.0         0.0         0.1
  / emin        dbd1        dbd2        QMax        QMin
     -0.1          0           0           0.4421      -0.4421
   / Kpg        Kig         Tp          fdbd1       fdbd2
     1.2          0.14        0.1         -0.0006     0.0006
  / femax       femin       Pmax        Pmin        Tg
      999.0       -999.0      0.8211      0           0.25
   / Ddn        Dup
    20.0         0.0


2222, 'USRMDL', 1, 'WTTQAU1', 505, 0, 1, 15, 3, 3,
```

```
 / Tflag
    1
 / Kpp      KIP     Tp      Twref    Temax
   0.01     0.1     0.1     60.0     1.2
 / Temin    p1      spd1    p2       spd2
   0.04     0.2     0.69    0.4      0.78
 / p3       spd3    p4      spd4     TRATE
   0.6      0.98    0.74    1.2      0.0

/  OVER VOLTAGE PROTECTION example

 222201  'VTGTPAT'   2224   2234  '1'
  / Vlow        Vup         RITm        BrTm
    -1.0000     1.2000      1.00              0.0000
 222202  'VTGTPAT'   2224   2234  '1'
  / Vlow        Vup         RITm        BrTm
   -1.0000      1.175000    2.00              0.0000
 222203  'VTGTPAT'   2224   2234  '1'
  / Vlow        Vup         RITm        BrTm
   -1.0000      1.1500      3.0000            0.0000
 222204  'VTGTPAT'   2224   2234  '1'
   / Vlow       Vup         RITm        BrTm
    -1.0000     1.100       5.0000            0.0000

/ UNDER VOLTAGE PROTECTION example

 222205  'VTGTPAT'   2224   2234  '1'
   / Vlow       Vup         RITm        BrTm
    0.45000     5.0000      1.0000            0.0000
 222206  'VTGTPAT'   2224   2234  '1'
   / Vlow       Vup         RITm        BrTm
    0.650000    5.0000      5.0000            0.0000
 222207  'VTGTPAT'   2224   2234  '1'
 / Vlow         Vup         RITm        BrTm
    0.75000     5.0000      10.000      0.0000
 222208  'VTGTPAT'   2224   2234  '1'
   / Vlow       Vup         RITm        BrTm
    0.9000      5.0000      20.000      0.0000

/ OVER FREQUENCY PROTECTION example

 222209  'FRQTPAT'   2224   2234  '1'
  / Flow        Fup         RITm        BrTm
   -100.00      61.800      10.000      0.0000
 222210  'FRQTPAT'   2224   2234  '1'
   / Flow       Fup         RITm        BrTm
   -100.00      60.500      650.00      0.0000

/ UNDER FREQUENCY PROTECTION example

 222212  'FRQTPAT'   2224   2234  '1'
   / Flow       Fup         RITm        BrTm
    57.800      100.00      10.000      0.0000
 222213  'FRQTPAT'   2224   2234  '1'
   / Flow       Fup         RITm        BrTm
    59.500      100.00      1800.00     0.0000
```

#### *10.3.1.3 Battery energy storage systems*

Typical values for Battery Storage modules are shown below.

| **Generator/Converter Module** | | |
|---|---|---|
| **REGCA1 (v34 & v35) / REGCAU1 (v33)** | | |
| **Parameter** | **Description** | **Typical Values** |
| Tg | Converter time constant (s) | 0.02 |
| Rrpwr | Low Voltage Power Logic (LVPL) ramp rate limit (pu/s) | 1.00 |
| Brkpt | LVPL characteristic voltage 2 (pu) | 0.75 |
| Zerox | LVPL characteristic voltage 1 (pu) | 0.00 |
| Lvpl1 | LVPL gain breakpoint (pu current on mbase / pu voltage) | 0.23 |
| Volim | Voltage limit (pu) for high voltage reactive current management | 2.00 |
| Lvpnt1 | Low voltage active current management breakpoint (pu) | 0.10 |
| Lvpnt0 | Low voltage active current management breakpoint (pu) | 0.00 |
| Iolim | Current limit for high voltage clamp logic (pu on mbase) | -0.42486 |
| Tfltr | Terminal voltage filter (for LVPL) time constant (s) | 0.02 |
| Khv | Overvoltage compensation gain used in high voltage reactive current management | 0.00 |
| Iqrmax | Maximum rate-of-change of reactive current (pu/s) | 10.00 |
| Iqrmin | Minimum rate-of-change of reactive current (pu/s) | -10.00 |
| Accel | High voltage reactive current management acceleration factor, p.u. | 1.00 |

| **Electrical Controls Module** | | |
|---|---|---|
| **REECCU1 (v33 &v34) /REEC1 (v35)** | | |
| Vdip | Low voltage condition trigger voltage, p.u. | 0.90 |
| Vup | High voltage condition trigger voltage, p.u. | 1.10 |
| Trv | Terminal bus voltage filter time constant, sec. | 0.02 |
| dbd1 | Overvoltage deadband for reactive current injection, p.u. | -0.10 |
| dbd2 | Undervoltage deadband for reactive current injection, p.u | 0.10 |
| Kqv | Reactive current injection gain, p.u | 0.00 |
| Iqh1 | Maximum reactive current injection, p.u. | 0.42486 |
| Iql1 | Minimum reactive current injection, p.u. | -0.42486 |
| Vref0 | Reference voltage for reactive current injection, p.u | 1.00 |
| Tp | Active power filter time constant, sec. | 0.05 |
| Qmax | Maximum reactive power when vflag = 1, p.u | 0.42486 |
| Qmin | Minimum reactive power when vflag = 1, p.u. | -0.42486 |
| VMAX | Maximum voltage at inverter terminal bus, p.u | 1.50 |
| VMIN | Minimum voltage at inverter terminal bus, p.u | 0.80 |
| Kqp | Local Q regulator proportional gain, p.u. | 0.5 |
| Kqi | Local Q regulator integral gain, p.u. | 5.0 |
| Kvp | Local voltage regulator proportional gain, p.u | 0.5 |
| Kvi | Local voltage regulator integral gain, p.u | 5.0 |
| Tiq | Reactive current regulator lag time constant, sec. | 0.02 |
| dPmax | Active power up-ramp limit, p.u./sec | 10.00 |

| | | |
|---|---|---|
| dPmin | Active power down-ramp limit, p.u./sec | -10.00 |
| PMAX | Maximum active power, p.u | 1.00 |
| PMIN | Minimum active power, p.u | -1.00 |
| Imax | Maximum apparent current, p.u. | 1.00 |
| Tpord | Inverter power order lag time constant (s) | 0.02 |
| Vq1 | Reactive Power V-I pair, voltage (pu) | 2.00 |
| Iq1 | Reactive Power V-I pair, current (pu) | 1.00 |
| Vq2 | (Vq2>Vq1), Reactive Power V-I pair, voltage (pu) | 0.00 |
| Iq2 | (Iq2>Iq1), Reactive Power V-I pair, current (pu) | 0.00 |
| Vq3 | (Vq3>Vq2), Reactive Power V-I pair, voltage (pu) | 0.00 |
| Iq3 | (Iq3>Iq2), Reactive Power V-I pair, current (pu) | 0.00 |
| Vq4 | (Vq4>Vq3), Reactive Power V-I pair, voltage (pu) | 0.00 |
| Iq4 | Reactive Power V-I pair, current (pu) | 0.00 |
| Vp1 | Real Power V-I pair, voltage (pu) | 0.20 |
| Ip1 | Real Power V-I pair, current (pu) | 0.00 |
| Vp2 | (Vp2>Vp1), Real Power V-I pair, voltage (pu) | 0.75 |
| Ip2 | (Ip2>Ip1), Real Power V-I pair, current (pu) | 0.23 |
| Vp3 | (Vp3>Vp2), Real Power V-I pair, voltage (pu) | 0.85 |
| Ip3 | (Ip3>Ip2), Real Power V-I pair, current | 0.85 |
| Vp4 | (Vp4>Vp3), Real Power V-I pair, voltage | 1.00 |
| Ip4 | (Ip4>Ip3), Real Power V-I pair, current | 1.00 |
| T | Battery discharge time (sec) | 3600 |
| SOCini | Initial state of charge (pu) | 0.50 |
| SOCmax | Maximum allowable state of charge (pu) | 1.00 |
| SOCmin | Minimum allowable state of charge (pu) | 0.00 |

| **Plant Controls Module** | | |
|---|---|---|
| **REPCA1 & REPCTA1 (v34 & v35) /REPCAU1 & REPCTAU1 (v33)** | | |
| Tfltr | Voltage and reactive power filter time constant, sec. | 0.02 |
| Kp | Volt/VAr regulator proportional gain, p.u. | 5.0 |
| Ki | Volt/VAr regulator integral gain, p.u. | 50.00 |
| Tft | Plant controller Q output lead time constant, sec | 0.00 |
| Tfv | Plant controller Q output lag time constant, sec. | 0.10 |
| Vfrz | Voltage for freezing Volt/VAr regulator integrator, p.u | 0.80 |
| Rc | Line drop compensation resistance, p.u. | 0.00 |
| Xc | Line drop compensation reactance, p.u | 0.00 |
| Kc | Reactive droop gain, p.u | 0.1314 |
| emax | Maximum Volt/VAr error, p.u | 1.00 |
| emin | Minimum Volt/VAr error, p.u. | -1.00 |
| dbd1 | Lower threshold for reactive power control deadband (<=0) | -0.001 |
| dbd2 | Upper threshold for reactive power control deadband (>=0) | 0.001 |
| Qmax | Maximum plant reactive power command, p.u | 0.42486 |
| Qmin | Minimum plant reactive power command, p.u. | -0.42486 |
| Kpg | Real power control proportional gain, p.u | 0.50 |
| Kig | Real power control integral gain, p.u. | 11.00 |
| Tp | Active power filter time constant, sec. | 0.02 |
| fdbd1 | Frequency deadband downside, p.u. | -0.0006 |
| fdbd2 | Frequency deadband upside, p.u | 0.0006 |
| femax | Maximum power error in droop regulator, p.u | 999.00 |
| femin | Minimum power error in droop regulator, p.u. | -999.00 |
| Pmax | Maximum plant active power command, p.u. | 1.00 |
| Pmin | Minimum plant active power command, p.u | -1.00 |
| Tg | Plant controller P output lag time constant, sec. | 0.02 |
| Ddn | Reciprocal of down regulation droop, p.u. | 20.00 |
| Dup | Reciprocal of up regulation droop, p.u | 20.00 |

For a Battery Energy Storage System, the function call in the .dyr file would be as shown in the example below. This .dyr file example correlates with the examples of the Converter, Electrical Controls and Plant Controller modules above.

```
3333 'USRMDL'  1  'REGCAU1'  101  1  1  14  3  4  1
     0.0200     1.0000     0.75000     0.00000     0.23000
     2.0000     0.1000     0.00000    -0.42486     0.02000
     0.0000     10.000    -10.0000     1.0000
3333 'USRMDL' 1 'REECCU1'  102    0    5    45    7    6
     0 0 1 1 0
     0.9 1.1 0.02 -0.1 0.1
     0 0.42486 -0.42486 1 0.05
     0.42486 -0.42486 1.5 0.8 0.5
     5.0 0.5 5.0 0.02 10
     -10 1 -1 1 0.02
     2.0 1.0 0.0 0.0 0.0
     0.0 0.0 0.0 0.2 0 0.75
```

```
    0.23 0.85 0.85 1 1
    3600 0.5 1.0 0.0

3333 'USRMDL' 1 'REPCAU1' 107 0 7 27 7 9
    3334   3335   3336   '1'   1   0   1
    0.02      5.0      50.00     0.0        0.1
    0.8       0.0      0.0      0.1314      1.0
   -1.0      -0.001     0.001    0.42486    -0.42486
    0.5      11.0      0.02    -0.0006      0.0006
    999      -999       1.0     -1.0        0.02
    20       20

333801  'VTGTPAT'   938713   938714 '1'  -1.0000     1.4000     0.1600     0.0000
333802  'VTGTPAT'   938713   938714  '1' -1.0000     1.2000     1.0000     0.0000
333803  'VTGTPAT'   938713   938714  '1' -1.0000     1.1800     2.0000     0.0000
333804  'VTGTPAT'   938713   938714  '1' -1.0000     1.1600     3.0000     0.0000
333805  'VTGTPAT'   938713   938714  '1' -1.0000     1.1200     5.0000     0.0000
333806  'VTGTPAT'   938713   938714  '1'  0.45000    5.0000     0.5000     0.0000
333807  'VTGTPAT'   938713   938714  '1'  0.60000    5.0000     5.0000     0.0000
333808  'VTGTPAT'   938713   938714  '1'  0.70000    5.0000     10.000     0.0000
333809  'VTGTPAT'   938713   938714  '1'  0.88000    5.0000     20.000     0.0000
333810  'FRQTPAT'   938713   938714  '1' -100.00    63.250      2.0000    0.0000
333811  'FRQTPAT'   938713   938714  '1' -100.00    61.800     10.000     0.0000
333812  'FRQTPAT'   938713   938714  '1' -100.00    60.600     650.00     0.0000
333813  'FRQTPAT'   938713   938714  '1'   57.00   100.00      10.000    0.0000
333814  'FRQTPAT'   938713   938714  '1'   59.000  100.00      600.00    0.0000
```

### 10.3.2 Automatic Voltage Regulation Requirement

IBRs that are subject to FERC Order 827 are required to operate in automatic voltage control mode to support voltage regulation and voltage stability. There are several valid control modes available to control voltage, using different combinations of pfflag, vflag and qflag in the REEC_* models and refflag in the REPC_* models. Table 4 lists all the compliant plant-level voltage control mode combinations.

Dynamic model parameter descriptions are as follows:

- Pfflag: Local power factor flag; voltage or reactive power control (0); power factor control (1)
- Vflag: Local voltage control flag; voltage control (0); reactive power control (1)
- Qflag: Local reactive power control flag; constant power factor or reactive power control (0); voltage control (1)
- Refflag: Plant-level reactive power control (0); plant-level voltage control (1); plant-level power factor control (2)

| **Plant-level Voltage Control Mode Combinations** | | | | | |
|---|---|---|---|---|---|
| **REEC_*** | | | **REPC_*** | **FERC Order 827 compliance** | |
| pfflag | vflag | qflag | refflag | Mode | Compliant |
| 0 | N/A | 0 | 0 | Plant Q | No |
| 0 | 1 | 1 | 0 | Plant Q and Local Q/V | Yes |
| 0 | N/A | 0 | 1 | Plant V | Yes |
| 0 | 0 | 1 | 1 | Plant V and Local V | Yes |
| 0 | 1 | 1 | 1 | Plant V and Local Q/V | Yes |
| 0 | N/A | 0 | 2 | Plant PF | No |
| 0 | 1 | 1 | 2 | Plant PF and Local Q/V | Yes |

Plant level volt/var control could be set to voltage control, reactive power control or power factor control. Automatic voltage regulation can be implemented directly at the plant level (Plant V control), or at the inverter level (Plant Q or PF and Local Q/V), or both (Plant V and Local Q/V). Some key parameters to coordinate plant level control with inverter control and provide automatic voltage regulation include [repc_*].vfrz, [reec_*].vdip, [reec_*].vdup, [reec_*].kqv, [reec_*].kvp, [reec_*].kvi.

Existing IBRs not subject to FERC Order 827 shall have the model reflect the field settings and the IBR operation.

### 10.3.3 Ride-Through Requirement

Momentary cessation (namely, ceasing to inject current during a fault without mechanical isolation) is prohibited unless transient high voltage conditions rise to 1.20 per unit or more. For transient low voltage conditions, the Asynchronous Generating Facility's units are required to inject reactive current. The level of this reactive current injection shall be directly proportional to the decrease in per unit voltage at the inverter AC terminals. The inverter shall produce full rating reactive current when the AC voltage at the inverter terminals drops to a level of 0.50 per unit. The Asynchronous Generating Facility must continue to operate and absorb reactive current for transient voltage conditions between 1.10 and 1.20 per unit. Upon the cessation of transient voltage conditions and the return of the grid to normal operating voltage ($0.90 < V < 1.10$ per unit), the Asynchronous Generating Facility's inverters automatically must transition to normal active (real power) current injection. The Asynchronous Generating Facility's inverters must ramp up to inject active (real power) current with a minimum ramping rate of at least 100% per second (from no output to full available output). The total time to complete the transition from reactive current injection or absorption to normal active (real power) current injection must be one second or less. The total time to return from momentary cessation, if used, during transient high voltage conditions over 1.20 per unit or more must be one second or less.

Momentary cessation, if used by the facility, should be modeled correctly in the reec_d model.

***Transient Low Voltage***

To meet the reactive injection requirement, the reactive current limit shall be non-zero under transient low voltage and at least 1.0 p.u. if the voltage is below 0.5. The effective reactive current limit is determined from the PQ priority (pqflag) and VDL1 and VDL2 parameters.

There are other ways to meet the requirement on the amount of reactive current injection. It depends on the setup of voltage dip logic and the control mode. Below are a couple of examples:

- Using voltage dip logic: vdip between 0 and 1.0 (typically 0.9) and kqv ≥ 2; or
- If voltage dip logic is disabled, the set qflag=1 and kvp ≥ 2

***High Transient Voltage***

The reactive current limit for voltage between 1.1 and 1.2 shall be non-zero and the control shall be in the right direction to lower voltage. A typical setup to meet the high transient voltage requirement is:

using voltage dip logic: vup at least 1.1 and non-zero kqv.

***Return into Normal Operation***

The inverters should return to normal active MW injection within 1 second once the voltage is normal. Therefore, [regc_*].rrpwr shall be no less than 1.0 p.u./sec. Active power reaching 95% of the pre-fault level is considered returning to normal.

### 10.3.4 Primary Frequency Response Requirement

IBRs are required to provide active power primary frequency response capability with a 5% droop for both under and over-frequency conditions, and a maximum deadband of ±36 mHz. The required control options to simulate the primary frequency response in dynamic simulations are shown below.

Active power primary frequency response is controlled by the plant-level controller (REPC_*) model. Dynamic model parameter descriptions are as follows:

- Frqflag: Governor response; disable (0) or enable (1)
- Ddn: Down regulation droop response to over-frequency condition (20 on the generator nameplate capacity base for 5% droop)
- Dup: Up regulation droop response to under-frequency condition (20 on the generator nameplate capacity base for 5% droop)
- Fdbd1: Over-frequency deadband for governor response (-0.0006 p.u./36mHz)
- Fdbd2: Under-frequency deadband for governor response (0.0006 p.u./36mHz)

## 10.4 Dynamic Model checklist

This checklist below must be completed by the Project Developer and included with the project submission in Queue Point along with the Deliverables in Section 8 above.

| Item | Description | Comment | Check |
|---|---|---|---|
| 1 | Completed Queue Point Data Application form along with all requested files are submitted via Queue Point portal | | |
| 2 | If a PSSE library model is submitted (preferred), .idv and .dyr files developed using the guidelines in this document are included | | |
| 3 | If a UDM is submitted, a properly compiled PSSE version .sav case along with .idv, .dyr, and .dll files appropriately parameterized for the project using the guidelines in this document in included | | |
| 3a | A report on how the settings of the model were parameterized along with the manufacturer's documentation, including a user guide of the UDM | | |
| 3b | Block diagram for the model and sub modules, along with values, names and detailed explanation of all model parameters | | |
| 4 | .raw, .sav case, .cnv, .snp, and .sld file for the project (case setup folder/files) are submitted | | |
| 5 | Verify all testing requirements are met: | | |
| 5a | MFO assessment table is included in the Dynamic Model report | | |
| 5b | Power Factor Assessment table along with PQ curve used and case setup for power factor assessment (lagging and leading scenarios) is included in the Dynamic Model report | | |
| 5c | Confirm that the unit meets FERC Order No. 827 with regards to automatic voltage regulation, with appropriate model settings included in the Dynamic Model report | | |
| 5d | Results for the flatstart test including log, out and test plots showing Power, VARs, Eterm, Freq and Volt for each inverter/generator is included | | |
| 5e | Results for the VRT test including log, out and test plots showing Power, VARs, Eterm, Freq and Volt for each inverter. Provide confirmation that Momentary Cessation is eliminated (if not, provide reason) | | |
| 5f | Confirm Primary Frequency Response is enabled | | |

# Exhibit B

# PJM Dynamic Model Development Guidelines for DP 1 Submissions

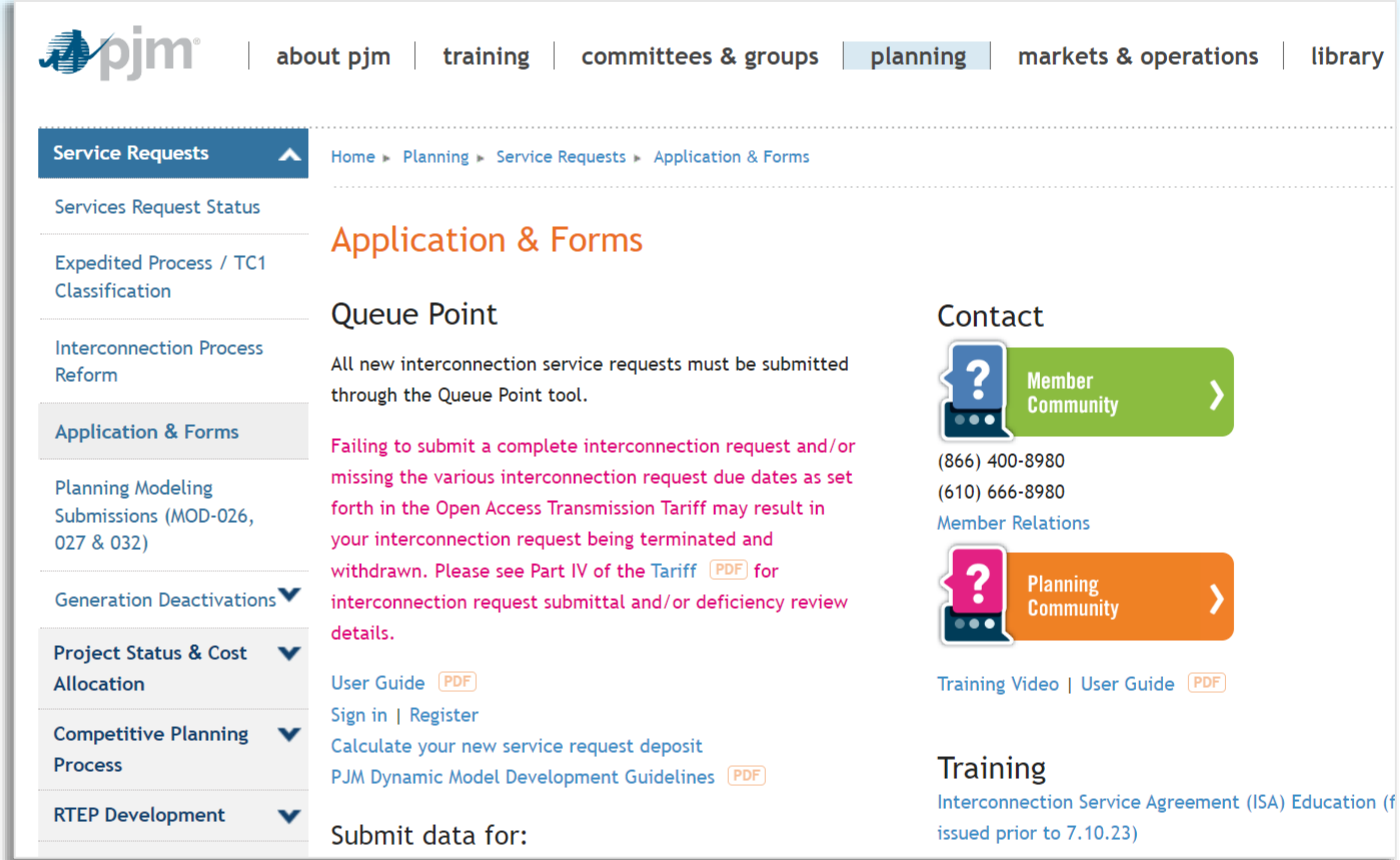
# PJM Dynamic Model Development Guidelines for DP1 Submissions

March 2024 IPS

Anisha Fernandes, Sr. Lead Engineer
Interconnection Planning Analysis

PJM Dynamic Model Development Guidelines posted on

**PJM.com > Planning > Service Requests > Application & Forms**




## Used for:

- New Service Request Projects
- Necessary Study Requests
- As-built Data Submissions

# Transition Cycle 1 – Decision Point 1

MW reduction

Equipment changes

For any allowable changes made at DP 1, an **updated dynamic model package following the PJM Dynamic Modeling Guidelines must be submitted** in Queue Point

POI modification (per Tariff rules)

Removal of fuel type from multi-fuel requests

# Transition Cycle 1 – Decision Point 1 (cont'd)

**Requirements**

- Updated dynamic model & equipment up to the POI
- Meet all Section 8, Deliverables for submission to be considered valid
- Include a Dynamic Model Report & Checklist (Appendix 10.4)

**Consequences**

- Per PJM Manual 14H, Section 2.1.2, failure to comply or cure deficiencies within DP1 deficiency review period will result in withdrawal

**Queue Point Attachment**

- Dynamic Model package must be uploaded in Queue Point with the updated Queue Point Data Application Form during the DP1 window of TC1

# Common Deficiencies Observed

Data/values on QP form does not match data/values provided in attachments and/or single line diagram

Values are not entered in the requested format (eg.: per unit vs percent)

Discrepancies in MFO (Net MW's) based on Gross MW and Station/Aux load values entered

Missing dynamic model report and/or checklist files; Ensure that the Modeling Guideline checklist is reviewed, completed and submitted.

Files provided in the incorrect PSSE version

# Deliverables

| Deliverable | Included items |
|---|---|
| **Dynamic Model Report:** | • Quality Assurance sign-offs<br>• Completed Dynamic Model Checklist must be included<br>• Dynamic Model package/folder containing relevant files as outlined in the Checklist |
| **Completed Queue Point Application Form:** | All required data and documentation |
| **Dynamic Model:** | • Library Models (preferred): PSSE .idv and .dyr<br>• User Defined Models: PSSE .sav, .idv, .dyr and .DLL appropriately parameterized |

# Deliverables (cont'd)

| Deliverable | Included items |
|---|---|
| **PSSE Case:** | Full build of generator project (.raw, .sav, .cnv, .snp, and .sld file) |
| **Test Results:** | • MFO assessment table<br>• Power Factor Assessment Table (including .sav cases for this assessment)<br>• Confirmation unit meets FERC Order No. 827 AVR requirements<br>• Results of flatstart test including log, out and test plots<br>• Results of VRT test including log, out and test plots |

Refer to Section 8 for complete list of Deliverables.

# Dynamic Model Checklist

| Item | Description | Comments | Check |
|---|---|---|---|
| 1 | Completed Queue Point Data Application form along with all requested files are submitted via Queue Point Portal. | | |
| 2 | If a PSSE library model is submitted (preferred), .idv and .dyr files developed using the guidelines in this document are included. | | |
| 3 | If a UDM is submitted, a properly compiled PSSE version .sav case along with .idv, .dyr, and .dll files appropriately parameterized for the project using the guidelines in this document is included. | | |
| 3a | A report on how the settings of the model were parameterized along with the manufacturer's documentation, including a user guide of the UDM. | | |
| 3b | Block diagram for the model and sub modules, along with values, names, and detailed explanation of all model parameters. | | |
| 4 | .raw, .sav case, .cnv, .snp, and .sld file for the project (case setup folder/files) are submitted. | | |

# Dynamic Model Checklist (cont'd)

| Item | Description | Comments | Check |
|---|---|---|---|
| 5 | Verify all testing requirements are met. | | |
| 5a | MFO assessment table is included in the Dynamic Model report. | | |
| 5b | Power Factor Assessment table along with PQ curve used and case setup for power factor assessment (lagging and leading scenarios) is included in the Dynamic Model report. | | |
| 5c | Confirm that the unit meets FERC Order No. 827 with regards to automatic voltage regulation, with appropriate model settings included in the Dynamic Model report. | | |
| 5d | Results for the flatstart test including log, out and test plots showing Power, VARs, Eterm, Freq and Volt for each inverter/generator is included. | | |
| 5e | Results for the VRT test including log, out and test plots showing Power, VARs, Eterm, Freq and Volt for each inverter. Provide confirmation that Momentary Cessation is eliminated (if not, provide a reason). | | |
| 5f | Confirm Primary Frequency Response is enabled. | | |

# Necessary Study Requests

**Purpose:** Once a Necessary Study Agreement is initiated, the PJM Dynamic Modeling Guideline must be used to develop the dynamic model for the project

**Expectations:** The dynamic model shall be parameterized as closely as possible to the intended design/settings

**Queue Point Attachment:** The dynamic model and files per the Deliverables section must be uploaded in Queue Point with the completed Necessary Study data submission

Submissions that do not include the dynamic model and files per the modeling guideline will be marked deficient, resulting in delays

# As Built Data Submissions

As Built data is **required** to be submitted within (1) one month following commercial operation

**Purpose:** The PJM Dynamic Modeling Guideline must be used to develop the dynamic model for an As Built project submission

**Expectations:** The As Built dynamic model must reflect the facility settings after commissioning. ALL projects, irrespective of size or kV level, must submit As Built data per these requirements.

**Queue Point Attachment:** The dynamic model and files per the Deliverables section must be uploaded in Queue Point with the completed As Built Data submission. A Factory Acceptance Test (FAT) report for each transformer is also required.

Submissions that do not include the dynamic model and files per the modeling guideline will be marked deficient, resulting in delays

# Applicability

## New Service Request Projects

- All projects beginning with Transition Cycle 2
- Transition Cycle 1 projects, that choose to make changes at Decision Point 1 and/or 2

## Necessary Study Requests & As Built Data Submissions

- Effective immediately, for any new requests/submissions made after 9/20/23

# Contact

Presenters:


Anisha Fernandes, Sr. Lead Engineer
Interconnection Planning Analysis
Anisha.Fernandes@pjm.com


Member Hotline

(610) 666 – 8980

(866) 400 – 8980

custsvc@pjm.com

# Exhibit C

# TC1 – Phase II Analysis Update

# TC1 - Phase II Analysis Update

Akim Faisal

Interconnection Analysis

# Overall Timeline

**June 21st**

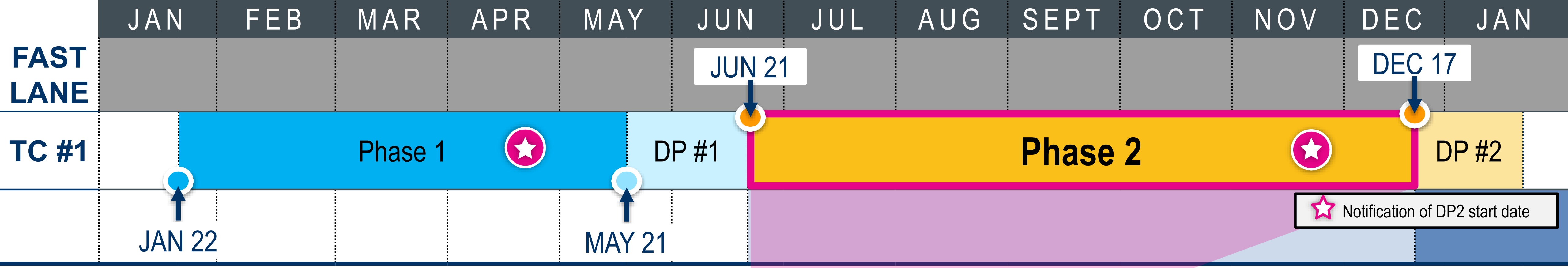
- Start of DP1 Review period (completed)
- Start of Phase II

**June – Dec.**

- PJM analysis for all study disciplines
- TO analysis review and network upgrade scope/estimates
- TO Interconnection FAC study
- PJM builds Phase II SIS report

**December 17th**

- Anticipated close of Phase II
- TOs issued PH II reports for review prior to posting
- PH II Report Posted to PJM.com




| Fast Lane | TC1 Phase 1 (120 Days) | TC1 Phase 2 (180 Days) |
|---|---|---|
| • Refreshed analysis (LF/SC/Stability)<br>• Facilities Studies (interconnection facilities & network upgrades)<br>• Final agreements | • Load flow analysis to determine Cycle upgrades<br>• Planning-level costs to interconnect | • DPI Deficiency Reviews<br>• GenDeliv Retool<br>• Short Circuit<br>• Stability<br>• Special Studies<br>• TO Analysis<br>• Interconnection Facilities Study |

# TC1 Phase II Analysis Activities

Application Phase: Submission | Review

Phase 1 → 1 (Decision Point)

Phase 2 → 2 (Decision Point)

Phase 3

Final Agreement Negotiation Phase → 3 (Decision Point)

| PJM ANALYSIS ACTIVITIES | | TO ACTIVITIES |
|---|---|---|
| • **DPI Deficiency Reviews**<br>• **Phase II Model Updates**<br>• **Test LF Topology-Type Reinforcements**<br>• **Generator Deliverability Retool** (Summer, Light Load)<br>• **Short Circuit**<br>• **Stability and Reactive Power Assessment** (Study Clusters) | • **Special Studies (MTX)** (N-1 & N-1-1, Load Deliv.)<br>• **Special Studies (Storage)** (N-1 Voltage)<br>• **Affected System Operator Analysis** (MISO, NYISO, Duke, LGEE, TVA) | • **Renew TO Analysis** (FERC Form 715, Local Criteria)<br>• **Review PJM Analysis Results** and update/provide desk-side estimates for reliability reinforcements<br>• **Provide Facility-Level Estimates** for Interconnection Facilities (FAC Study) |

# Phase II Report

| | | | | | | |
|---|---|---|---|---|---|---|
| Impacts for all Phase II analysis with DP1 changes | Network Upgrade cost estimates | TO facility-level estimate for Interconnection Facilities | TO Analysis<br><br>(FERC 715 Local Criteria) | Affected System Study report from Affected System Operator<br><br>(if required and available) | Readiness Deposit 3 Calculation | Adverse Study Impact<br><br>(If applicable) |

# Model Availability

## LF (SP/LL)

- Available on PJM web: 9/3/2024→ ** Pardot Announcement **
  - *CEII access required

## Short Circuit

- Available via Individual CEII request (9/3/2024)

## Stability

- Available via Individual CEII request (9/3/2024)

# Contact

Presenter:

Akim Faisal

Lead Engineer,
Interconnection Analysis

Akim.Faisal@pjm.com

Member Hotline

(610) 666 – 8980

(866) 400 – 8980

custsvc@pjm.com

# Exhibit D

# Deficiency Notification Email

## Dave S. Berman

**From:** Catalano, Christina <Christina.Catalano@pjm.com>
**Sent:** Wednesday, July 31, 2024 3:55 PM
**To:** Shambeau, Edward
**Cc:** Clifford, Kyle M.; Eedupuganti, Subbarao
**Subject:** AG1-529 Withdrawn from TC1

Hi Edward,

I'm reaching out to notify you that AG1-529 has been withdrawn from Transition Cycle 1 for failure to cure the Decision Point I deficiencies by the deficiency cure deadline (by close of business on 7/8/24.) Stability data was still deficient. Please see the below for more information on the deficiency:

1. Queue Point Data Application form data (e.g. inverters type, number of inverters and their capacity) is not updated according to the data provided in the dynamic model report.
2. MFO and PF assessment not provided.
3. .idv, .cnv, .snp and .sld not provided
4. Out and log files of results not provided
5. Dynamic model setting does meet FERC Order 827 automatic voltage regulation and Confirmation Momentary Cessation.

Please note that only AG1-529 data submitted to PJM by the deficiency cure deadline was considered in the PJM Decision Point I review. Let me know if you have any questions.

Thank you,

Christina Catalano, P.E.
Sr. Engineer II, Interconnection Projects

610-937-8799 | Christina.Catalano@pjm.com
PJM Interconnection | 2750 Monroe Blvd. | Audubon, PA 19403

# Attachment 2

# Affidavit of Mark Sims
# on Behalf of
# PJM Interconnection, L.L.C.,

**UNITED STATES OF AMERICA**
**BEFORE THE**
**FEDERAL ENERGY REGULATORY COMMISSION**

| | | |
|---|---|---|
| Freeman Solar, LLC<br>Complainant,<br><br>v.<br><br>PJM Interconnection, L.L.C.<br>Respondent. | )<br>)<br>)<br>)<br>)<br>)<br>) | Docket No. EL24-135-000 |

**AFFIDAVIT OF MARK SIMS ON**
**BEHALF OF PJM INTERCONNECTION, L.L.C.**

1. My name is Mark Sims. My business address is 2750 Monroe Blvd., Audubon, Pennsylvania, 19403. I currently serve as Senior Manager, Interconnection Analysis for PJM Interconnection, L.L.C. ("PJM") and have held that position since April 2021. I joined PJM in 1999. I have a Bachelor of Science degree in Electrical Engineering and a Masters of Engineering in Systems Engineering, both from The Pennsylvania State University.

2. The purpose of my affidavit is to support PJM's answer ("Answer") in response to the August 23, 2024 Complaint and Request for Fast Track Processing of Freeman Solar LLC ("Freeman Solar"). Specifically, my affidavit addresses the impact of re-introducing into PJM's Transition Cycle No. 1 projects that have been removed from the PJM interconnection queue, such as the Freeman Solar Project designated as Project Identifier # AG1-529 ("Project").

3. PJM has begun the process of implementing reforms to its generator interconnection process in order to replace its existing "first-come, first-served" serial study approach with a "first-ready, first-served" Cycle study approach. PJM currently is in Transition Cycle No. 1, the first of two Transition Cycles under Part

VII of the PJM Open Access Transmission Tariff ("Tariff").[1] Transition Cycle No. 1 includes three study phases, each of which is followed by a Decision Point: Phase I System Impact Study ("Phase I") and Decision Point I; Phase II System Impact Study ("Phase II") and Decision Point II; and Phase III System Impact Study ("Phase III") and Decision Point III. The Phase I, II, and III System Impact Studies together are a regional analysis of the effect of adding to the Transmission System the new facilities and services proposed by valid New Service Requests and an evaluation of their impact on deliverability to the aggregate of PJM Network Load. At each Decision Point, a Project Developer must make certain informational showings in order to move forward with its project or elect to withdraw. In addition, a project can be removed from PJM's interconnection queue if it does not meet the Tariff requirements at that stage. Phase II may run co-extensively during the Decision Point I deficiency review period, and Phase III may run co-extensively during the Decision Point II deficiency review period.

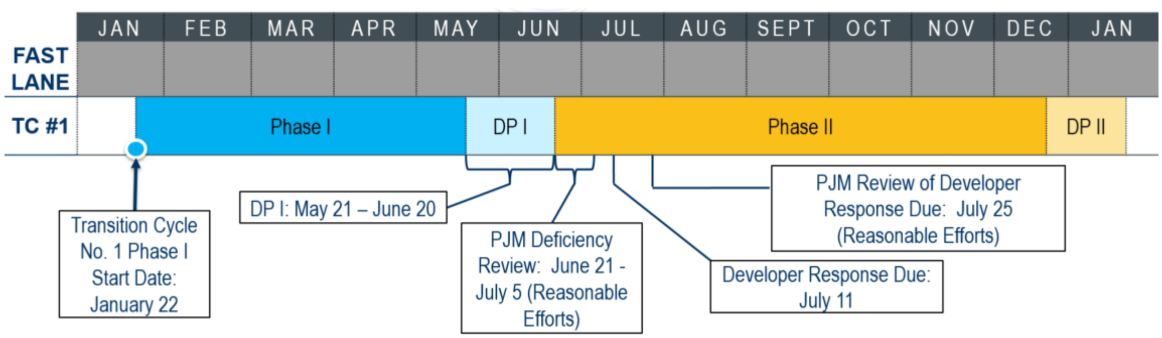
4. The Freeman Solar Project is a proposed 75-megawatt facility that would be physically located in Sussex County, Delaware. The project was terminated and deemed withdrawn from the PJM interconnection queue after the close of Decision Point I for failure to correct certain deficiencies during the Decision Point I deficiency review. The Answer and the accompanying affidavit of Mr. Andrew J. Lambert, a PJM Manager, Interconnection Planning Projects, detail PJM's deficiency review process and Freeman Solar's failure to correct deficiencies introduced during the deficiency review process within the time frame allowed

[1] Capitalized terms not defined herein have the meaning set forth in the Tariff.

under the Tariff. My affidavit focuses on the impact on Transition Cycle No. 1 of re-introducing into the queue a project that has been deemed withdrawn and terminated from the queue at the conclusion of the deficiency review process following Decision Point I.

5. Figure 1 below provides a timeline for the Transition Cycle No. 1 process. Phase I of Transition Cycle No. 1 commenced on January 22, 2024. Phase I ended on May 20, 2024. Decision Point I commenced on May 21, 2024, and closed on June 20, 2024. PJM exercised Reasonable Efforts to inform Project Developers of deficiencies within 10 Business Days (i.e., by July 5, 2024) of the close of Decision Point I. Project Developers had five Business Days to respond to PJM's deficiency determination communication, and PJM was required to use Reasonable Efforts to complete its final review of these developer responses in 10 Business Days, i.e., by July 25, 2024. Phase II started on June 21, 2024, co-extensively with the start of PJM's Decision Point I deficiency reviews.

**FIGURE 1**




6. As part of Phase II, PJM started the analytical reliability simulations for Phase II on July 22, 2024 and provided the results to its Transmission Owners on August 30, 2024. PJM provides these results to the Transmission Owners so they can

undertake Facilities Studies to determine the required Transmission System modifications necessary to implement the results of the System Impact Studies. This information also allows Transmission Owners to complete any additional studies or analyses and determine the required Transmission System modifications based on the PJM findings and any such additional Transmission Owner studies. Any change at this time would require PJM to update and re-calibrate affected models, re-run the simulations and provide revised results to any affected Transmission Owners. Affected Transmission Owners would need to begin processing the updated results that they previously received on August 30, 2024.

7. PJM undertakes load flow simulations as part of the Phase II studies. PJM develops several simulation models, including two seasonal models. In the event a terminated and withdrawn project were to be re-introduced into the queue, PJM would need to reflect the project in all of these models. Additionally, any changes to the models used by PJM, such as re-introducing a terminated and withdrawn project, would require corresponding model adjustments and re-simulations of all models. It would take PJM an approximate minimum of five weeks to rebuild and recalibrate the models to get back to the same point it would be if these changes had not been required as a result of re-introduction of a withdrawn project. The Phase II schedule would be extended, and Decision Points II and III and the other subsequent studies under the Tariff would necessarily be postponed as a result.

8. PJM also undertakes dynamic stability simulations in Phase II. PJM has 72 cluster models already developed for these simulations. To re-introduce any project, PJM would need to review the location of the re-introduced project and determine in which model(s) the re-introduced generation is appropriately included. It then

would need to re-calibrate and re-run its cluster models. While re-introducing a project might affect one model or several models, identifying the affected model(s) takes time, and the analysis of those cluster models would be delayed.

9. PJM also undertakes short circuit simulations in Phase II. However, PJM only uses a single model for short circuit simulations. PJM would need to perform additional short circuit work if a project is re-introduced into the queue, but the overall schedule would likely not be delayed due to the relatively shorter analytical timeframes needed for short circuit analysis.

10. This completes my affidavit.

**UNITED STATES OF AMERICA**
**BEFORE THE**
**FEDERAL ENERGY REGULATORY COMMISSION**

| | | |
|---|---|---|
| Freeman Solar, LLC<br>Complainant, | ) | |
| v. | ) | Docket No. EL24-135-000 |
| PJM Interconnection, L.L.C.<br>Respondent. | ) | |

**VERIFICATION**

I, Mark Sims, pursuant to 28 U.S.C. § 1746, state, under penalty of perjury, that I am the Mark Sims referred to in the foregoing "Affidavit of Mark Sims on Behalf of PJM Interconnection, L.L.C.," that I have read the same and am familiar with the contents thereof, and that the facts set forth therein are true and correct to the best of my knowledge, information, and belief.

Signed by:
Mark Sims
350C8BE16B2C458...

Mark Sims

Executed on: 9/12/2024

**CERTIFICATE OF SERVICE**

I hereby certify that I have this day served the foregoing document upon each person designated on the official service list compiled by the Secretary in this proceeding.

Dated at Washington, D.C., this 12th day of September 2024.

*/s/* David *S. Berman*

***Attorney for PJM Interconnection, L.L.C.***