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Comments for RFI of DER Orchestration Research

Additional submitted attachment is included below.

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Comments for RFI of DER Orchestration Research

This document aims to respond to the Request for Information (RFI) of DER Orchestration Research (Docket #: 23-ERDD-01). The RFI lists three categories of questions. In what follows, the author would like to comment on the first question in the first category: "*As California transitions away from traditional centralized fossil-gas generation and approaches a high penetration of intermittent renewables and inverter-based resources, what are the most needed grid service functions that aggregated DERs should be able to dispatch and that require validation in the near term?*"

Response: The service functions listed in the RFI, e.g., services for frequency regulation, voltage support, and peak shaving, can significantly benefit grid operations. However, it is technically challenging to implement these DERs/VPPs at a large scale. Significant research & development (R&D) efforts from both academia and the power industry are much more needed to future-proof the security of California's electricity infrastructure.

Challenge 1: *How do we avoid adversarial interactions among heterogeneous DERs in the electromagnetic transient (EMT) time scale when DERs provide grid services?* Many DERs (e.g., solar panels, wind turbines, battery storage, and EV charging stations) interface with the grid via power electronics inverters. However, today's inverter manufacturers tune their inverters locally without considering their system-level performance. As a result, networking these inverter-based resources (IBRs) may incur instabilities and/or sustained oscillations. The author's recent paper [1] presents that networking two locally well-tuned IBRs incurs instability in the fast (EMT) time scale. Compounding the challenges, some IBRs/DERs have been deployed in the grid, and it is impractical to reprogram the controllers of these legacy resources. To enable these DERs to provide grid services, R&D efforts are needed to ensure the stability of a grid with a mix of legacy and newly added DERs from various manufacturers. The author's recent paper [1] introduces a *decentralized* and *non-intrusive* approach to stabilize such a grid.

Challenge 2: *How do aggregated DERs/VPPs regulate frequency, given the frequency cannot be measured both fast and accurately under fast renewable fluctuations?* With the deep penetration of renewables, grid frequency may not be measured both quickly and accurately due to potential fast renewable fluctuations. One publication [2] from the author provides such an example (See Figure 1). One research question is how aggregated DERs/VPPs provide frequency regulation services without accurate frequency measurements. The author proposes a potential solution to this technical challenge in his publication [2], by leveraging the structural properties of networked IBRs.

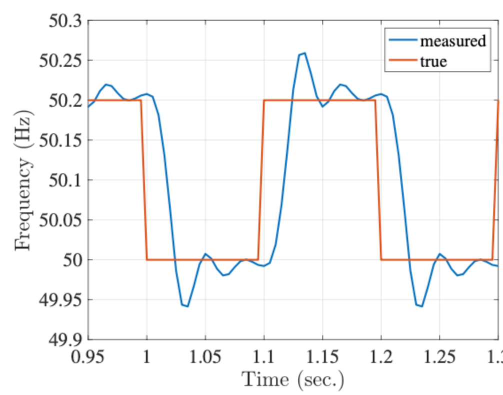

Figure 1 The true frequency cannot be accurately measured if it changes fast.

Challenge 3: *How do we model the dynamics of the aggregated DERs/VPPs when they provide frequency response to the grid?* In the context of frequency regulation, the frequency regulation services might be provided by tens to hundreds of DERs, instead of a few components. What shapes the dynamics behaviors of the aggregated DERs is not only the first principles but also the massive uncertainties from human behaviors and renewables It is an open-ended question of how to quantitively model the dynamics of the aggregated DERs for studying the transient stability of the grid.

References:

[1] T. Huang, "Non-intrusive Enforcement of Decentralized Stability Protocol for IBRs in AC Microgrids," https://arxiv.org/pdf/2208.11163

[2] T. Huang, D. Wu and M. Ilić, "Cyber-Resilient Automatic Generation Control for Systems of AC Microgrids," in *IEEE Transactions on Smart Grid*, vol. 15, no. 1, pp. 886-898, Jan. 2024,