



Second Stage in Feasibility Assessment of Synchronous Operations of the North American Eastern and Western Interconnections

Final Project Report

S-102G

Power Systems Engineering Research Center
*Empowering Minds to Engineer
the Future Electric Energy System*



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Power Systems Engineering Research Center

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Executive Summary and Abstract

The main goal of this project is an economic analysis of interconnecting Eastern Interconnection (EI) and Western Electricity Coordinating Council (WECC) ac interconnect under various load and weather conditions. The potential benefit would be the possibility of more renewable energy transfer across the interconnection or overall less renewable curtailment and accordingly less operation cost after the connection of these grids. This project builds on PSERC S-92G work on the stability analysis of these two grids. Due to the use of Critical Energy/Electricity Infrastructure Information (CEII), this report primarily outlines the general methodologies developed, reserving CEII-specific details for a separate report that includes a variety of power flow and stability models for the EI and WECC, using 2022 series EI cases and 2023 series WECC cases with the combined case having more than 123,000 buses. To facilitate combining EI and WECC cases, some WECC bus numbers were changed to avoid number overlap with the EI. The cases were then combined by adding ac interconnections at the nine interconnection points previously identified in S-92G. During this process, almost all the buses were assigned to more than 47,000 electrical substations and all the substations were geo-mapped.

A strategy is proposed to directly use weather data initially from sources like International Civil Aviation Organization (ICAO), the World Meteorological Organization (WMO), and later from the European Centre for Medium-Range Weather Forecasts (ECMWF) Re-Analysis fifth generation data (ERA5) data to calculate the output power of renewable resources. For this goal, the US Energy Information Administration Form 860 (EIA-860) dataset is used to find the types of wind turbines and solar cells. Additionally, EIA-860 data are used to create power systems using a copper plate model, which allows for generation to flow with zero impedance. Various power flow structures, such as buses, substations, and weather-dependent models, are used, and advanced visualization techniques like geographic data views and contour mapping are explored, enhancing the understanding of complex generation data. The coupling of weather information to power flow studies is highlighted as a useful tool for calculating expected wind and solar generation outputs based on weather conditions. To create load time series in each area, Federal Energy Regulatory Commission (FERC) regions are assigned to the areas and FERC form 714 is used to create load time series in each region. A clustering strategy is proposed to find interesting load and weather scenarios for economic analysis.

Also, the correlation of renewable generation across the EI and the WECC is calculated with consideration of load for the potential economic benefits of this interconnection. It is found that there is typically a solar correlation of around 0.75 and a wind correlation of 0.5 which shows that the renewable resource generation can be shared between the EI and WECC grids. Further analysis found that there are days when there is a larger difference in the wind and solar available capacities on each side. Additionally, an interesting behavior of negative correlation of wind generation between some areas in EI and WECC was found as well as zero or negative correlation for the highest producers of renewable energy, which allows even more power transfer between EI and WECC grids. Also, a negative correlation between load demand and wind generation across the EI and WECC grids refers to the need for power transfer between the two grids. This shows that a joined grid would better utilize renewable energy with its varying nature and differences in production across EI and WECC grids, promoting long-term sustainability.

Also, a strategy for scenario selection with the goal of studying a comprehensive variety of weather and load scenarios for power flow simulations is presented. With large power systems and large amounts of available data, it is computationally expensive to run simulations on all scenarios and it is required to select a wide variety of scenarios with different impacts on the operation, considering load and weather for renewable generation output. Using the K-Means method for clustering, representative points are strategically chosen to simulate various solar, wind, and load conditions. The two selected representative points include an average and an outlier. Choosing these two points allows for baseline data analysis as well as anomalies, which can cause stress in the grid. The method is then demonstrated to show its functionality and how it captures the diversity of a dataset. The resulting clusters help finding interesting scenarios by addressing the variability that is inherent in power systems. This leads to improving grid reliability by preparing for a range of scenarios.

Project Publications:

- [1] T.J. Overbye, S. Kunkolienkar, J. Snodgrass, A.B. Birchfield, “On the Existence of Dominant Inter-Area Oscillation Modes in the North American Eastern Interconnect Stability Simulations,” submitted to 2024 Hawaii International Conference on System Sciences (HICSS), January 2024, Honolulu, HI.
- [2] K. Zhgun, F. Safdarian, J. Griffin, T.J. Overbye, “Identifying Problematic AC Power Flow Alternative Solutions in Large Power Systems”, 2023 North American Power Symposium, October 2023.
- [3] J. L. Wert, T. Chen, F. Safdarian, J. Snodgrass, T. J. Overbye, “Calculation and Validation of Weather-Informed Renewable Generator Capacities in the Identification of Renewable Resource Droughts,” IEEE PowerTech 2023, Belgrade, Serbia, June 2023.
- [4] T.J. Overbye, K.R. Davis, A.B. Birchfield, “The Electric Grid and Severe Resiliency Events.” National Academy of Engineering Bridge Journal, vol. 53, no. 2, 2023, pp. 73-79, June 2023.
- [5] A.B. Birchfield, T.J. Overbye, “A Review on Providing Realistic Electric Grid Simulations for Academia and Industry,” Curr Sustainable Renewable Energy Rep, June 2023.
- [6] T.J. Overbye, S. Kunkolienkar, “On the Existence of Distinct Inter-Area Electro-Mechanical Modes in North American Electric Grids,” 2023 Kansas Power and Energy Conference (KPEC), April 2023.
- [7] S. Kunkolienkar, F. Safdarian, J. Snodgrass, T.J. Overbye, “Quantification of Area Sparsity in Large-Scale Electric Grids,” 2023 Kansas Power and Energy Conference, April 2023.
- [8] T. J. Overbye, F. Safdarian, W. Trinh, Z. Mao, J. Snodgrass, and J. H. Yeo, “An Approach for the Direct Inclusion of Weather Information in the Power Flow,” Proc. 56th Hawaii International Conference on System Sciences (HICSS), 2023.
- [9] F. Safdarian, M. Stevens, J. Snodgrass, and T. J. Overbye, “Detailed Hourly Weather Measurements for Power System Applications,” IEEE Texas Power and Energy Conference (TPEC), 2024.

Student Theses:

- [1] J. L. Wert, “EXTRACTING VALUE FROM ELECTRIC GRID INFORMATION TOWARDS A RESILIENT GRID AMIDST DECARBONIZATION EFFORTS,” (PhD Thesis, August 2023)