



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

Final Project Report

S-92G

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



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Project Team

Thomas J. Overbye, Project Leader

Komal S. Shetye

Texas A&M University

Graduate Students

Hanyue Li

Wei Trinh

Jessica Wert

Texas A&M University

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For information about this project, contact:

Thomas J. Overbye
Texas A&M University
Department of Electrical and Computer Engineering
308C, Wisenbaker Engineering Building
College Station, Texas 77843-3128
Phone: 979-458-5001
Email: overbye@tamu.edu

Power Systems Engineering Research Center

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For additional information, contact:

Power Systems Engineering Research Center
Arizona State University
527 Engineering Research Center
Tempe, Arizona 85287-5706
Phone: 480-965-1643
Fax: 480-727-2052

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Executive Summary

Most of the electricity used in North America is supplied by four major interconnects, each operating at 60 Hz but asynchronous with each other. These interconnects are the Eastern (EI), the Western (WI), Texas (ERCOT), and the Quebec Interconnection. All of these ac networks are internally synchronized, and are linked to each other only through dc ties. So far, interconnection studies have mainly focused on the economic or resource planning aspects or the use of HVDC for transmission expansion and design. A key area of improvement mentioned in these studies has been contingency and stability analyses. The feasibility of ac tie connection has been studied less frequently, with the need for improved assessments considering automatic generation control (AGC) in long-term dynamics identified in literature. System dynamics is a key concern while considering operating two large grids synchronously.

With this in view, the overall goal of this project is to consider the dynamic aspects of an ac interconnection of the North American Eastern and Western Interconnection (EI and WI) grids. However, since much of the information about these actual grids is considered critical energy infrastructure information (CEII) and hence its publication is restricted, realistic but fictitious synthetic grids are used to demonstrate the methodology. These grids cover the same geographic footprints as the real ones, use real generation information since it is publicly available and mimic load distribution from census data, but the transmission lines are entirely fictitious.

The methodology involves first overcoming challenges associated with combining actual detailed WECC and EI models and second making the actual connections between the synthetic east and west systems with ac ties, which collectively form the “Interface”. Challenges include the ability to handle very large systems with overlapping bus and area numbers; determining the location, number and types of connections needed for reasonable steady state and dynamic performance of the combined system; initializing tie flows for studies, etc. Then after assigning appropriate impedances and ratings, a few static power flow studies are performed to determine distribution of flows across each tie, and estimate the MW transfer capability. The goal of these studies is to demonstrate methods to pinpoint the heavier loaded ties and locations where modest upgrades could lead to major improvement in transfer capability.

Next, the main part of the project i.e. dynamic assessments of the interconnection involves a wide variety of dynamic simulations of the systems. The key limiting characteristic on interconnecting the EI and WI is that during generator loss contingencies in the WI, approximately 75 to 80% of the lost power will flow through the Interface from east to west. This is due to the governor response that takes place uniformly through the interconnect and most of the generation is east of the Interface. This issue is fundamental to interconnecting large grids and does require any interface joining two such larger grids be able to handle this flow (at least until AGC can respond). In particular for the EI and WECC, there need to be more than just a few tielines. For the flow to return to pre-contingency values, AGC needs to be modeled in these simulations, which is not a common practice. To address this, AGC is implemented and included in our dynamic simulations run for several minutes. In the scenarios run both for the real and synthetic interconnections, the grids are stable when AGC response is considered.

A major challenge associated with these analyses is understanding what is occurring in the large scale electric grids, particularly when they could be subject to unusual operating conditions such as those associated with a new ac interconnection. This in addition to the large quantity of simulation results, especially dynamics with hundreds of thousands of buses, models, states, etc. To this end, geographic data views (GDV), which are electric grid display objects whose location is dynamically determined from geographic information embedded in an electric grid model, are developed and used extensively. Different examples of GDV's and how they can meaningfully convey a large amount of key information are shown.

The studies shown in this report are not meant to be all-encompassing and covering all possible conditions and scenarios. Rather, these are preliminary studies performed to illustrate issues associated with the interconnection of large-scale grids with an eye towards providing a test system for other researchers. These grids i.e. the individual synthetic east and west and their ac interconnected versions are available publicly for researchers (electricgrids.tamu.edu) to access and run their own scenarios in addition to those shown in this report. This may include, 1) different ac tie connections, 2) static and dynamic contingency scenarios, 3) loading conditions, 4) renewable generation, 5) time series simulations such as those used in OPFs, and so on.

Project Publications:

- [1] Thomas J. Overbye, Jessica L. Wert, Komal S. Shetye, Farnaz Safdarian, Adam B. Birchfield, "The Use of Geographic Data Views to Help With Wide-Area Electric Grid Situational Awareness," Submitted to *Texas Power and Energy Conference (TPEC) 2021*, Feb. 2021, College Station, TX.
- [2] Komal S. Shetye, Thomas J. Overbye, Hanyue Li, Julian Thekkemathote, "Considerations for Interconnection of Large Power Grid Networks," Submitted to *Power and Energy Conference at Illinois (PECI) 2021*, Apr. 2021, Champaign, IL.
- [3] Thomas J. Overbye, Komal S. Shetye, Jessica L. Wert, Wei Trinh, Tracy Rolstad, Jamie Weber, "Techniques for Maintaining Situational Awareness During Large-Scale Electric Grid Simulations," Submitted to *Power and Energy Conference at Illinois (PECI) 2021*, Apr. 2021, Champaign, IL.