



WECC Response to DOE Quadrennial Energy Review

Transmission in the West

Introduction

The Western Electricity Coordinating Council (WECC) is the Reliability Assurer for the Western Interconnection. We help assure Bulk Electric System reliability in the Western Interconnection by providing information on the future transmission network under a wide variety of plausible future scenarios which consider the implications of proposed policy, varying generation mixes, and changes in transmission development. WECC's Transmission Expansion Planning Policy Committee (TEPPC) guides and informs this work through an open and transparent stakeholder process.

From 2010 through 2013, WECC's Scenario Planning Steering Group (SPSG) developed four future scenarios for the Western Interconnection which became the basis for four long-term (20-year) study cases included in the [2013 WECC Interconnection-wide Transmission Plan](#) (Plan). Each scenario evaluated uncertainties in the most significant drivers to create four plausible futures for the Western Interconnection. The goal for developing these scenarios was to identify strategic choices regarding transmission expansion and reliability needs that WECC and its stakeholders may need to address in the 20-year planning horizon. In addition to the four SPSG scenarios, WECC conducted numerous other studies that are summarized in the Plan. Currently, WECC's efforts are oriented toward establishing the next set of models, tools, and datasets that will be used to evaluate futures in the 2024 and 2034 study timeframes.

As it relates to transmission planning, it is important to note that WECC focuses efforts on conducting studies that inform recommendations related to opportunities for transmission development, deliverability of power, resource adequacy, and impacts of enacted and proposed state and federal policy (e.g., Renewable Portfolio Standard (RPS) compliance). WECC does not site projects, approve projects, or have the authority to require a developer to build a particular project. We do not own or operate transmission assets. Importantly, WECC does work with, provides data to, and supports the regional planning entities in their FERC Order 890 and 1000 planning processes. We are unique, however, in that we are the only institution in the West with the view of the entire Western Interconnection, including the Canadian provinces of British Columbia and Alberta, and Baja California in Mexico.

Key Western Considerations

It is important to recognize that the West has a unique industry structure and resource mix, and thus, unique transmission needs:

- The Western Interconnection does not operate via an organized market, nor does it have an established Regional Transmission Organization. While California and Alberta do have organized markets and Independent System Operators with regional transmission planning functions, the West as a whole does not. As a result, the process for conceiving, siting, and gaining cost recovery for transmission is highly complex, with various responsibilities being divided between local, regional, and interconnection-wide (i.e. WECC) planning entities.
- The industry in the West is a mélange of investor owned utilities, public power agencies, municipal/public utilities, power trading companies, generator owners, transmission owners, and merchant transmission and generation companies, all of which are spread across states and regions with disparate political landscapes and regulatory processes. These organizational complexities, coupled with the varying political and regulatory landscape, make the planning and operation of a reliable and cost-effective Western Interconnection a nuanced and challenging endeavor.
- The evolution of the Western Interconnection, which has been driven by economics, reliability, and today more than ever, public policy, resulted in a system where power is typically generated near the fuel source and transferred to load via relatively long transmission lines (as opposed to moving fuel and generating power near load). The wealth of geographically distant resources in the West, including the Northwest hydro-electric capacity, the large coal capacity, and the significant and growing wind and solar resources, makes the Western Interconnection unique compared to other parts of the country. The Western Interconnection is designed to share these resources and take advantage of seasonal and, to a lesser extent, geographic diversity.

WECC Perspectives

1. The Expected Future

The expected future grid appears to be adequate for the Western Interconnection to meet its load and RPS requirements over the 10-year timeframe. This finding is based on the planning work conducted with TEPPC, where anticipated levels of transmission, generation, load, and statutory requirements are taken into account to create a 10-year expected future where:

- Over 2,400 miles of regionally significant high voltage transmission are projected to be built over the next 10 years, with half of that amount already under construction today.
- Based on the anticipated set of resource additions and retirements, which includes both those driven by policy and reliability, that suite of transmission projects should ensure full deliverability of power to loads.
- The above information is based on the draft version of the 2024 Common Case, the TEPPC base case dataset for the 10-year study timeframe. Since the dataset is

currently in draft version, the 2022 Common Case and corresponding report, which was released in 2013, provides similar but a more comprehensive set of study findings. This information, and a wealth of other material, is summarized in the [2013 Interconnection-wide Transmission Plan](#).

2. Significant Uncertainties and Developing Risks

New major transmission additions could be needed under different alternative futures. Despite the observations stemming from the expected future case, a number of important uncertainties need to be considered, and transmission needs will likely be driven by the changing policy landscape and reliability needs. WECC has identified three important and evolving factors which will shape the longer-term transmission needs for the Western Interconnection:

- **Continued expansion of variable generation.** Between 2014 and 2024, we anticipate that nearly 13 GW of wind and 12 GW of solar will be added to the resource mix. These resources will not only impact transmission system requirements, but will require the balance of the system to be increasingly responsive and flexible in order to provide the ramping capability required to deal with rapid changes in generation levels from an increasing percentage of the resource mix. Further expansion of variable generation could be driven by increases in state RPS requirements, state compliance plans for EPA 111(d), as well favorable economics of resources in certain regions.
- **Retirement and replacement of large amounts of baseload capacity.** Our forecasts suggest nearly 25 GW of thermal, baseload resources are likely to retire in the coming years. The proposed EPA 111(d) rules will likely drive this number even higher. California's once-through-cooling regulations coupled with the age of the coal fleet (complicated by environmental uncertainty) are the main drivers for the retirements. One of the main uncertainties, and key drivers for the change in the resource mix, is how those resources will be replaced, both from a fuel perspective as well as from a geographic perspective, and this in turn will undoubtedly impact longer-term transmission needs.
- **Increasing penetration of distributed (behind-the-meter) resources.** Our studies anticipate that approximately 7,300 MW of solar PV distributed generation will be added in the next 10 years. The anticipated expansion of distributed generation will impact the balance of the system. Since these resources are generally not dispatchable nor visible to the system operators, the challenges they create for stability are significant and need to be better understood.

3. Improving Models

One of WECC's analytical priorities is to better integrate our models to provide needed reliability-focused insights for Western decision makers, which include policy makers, utility executives, regulators, and other industry leaders. Our objective is to develop a robust

analytical platform such that cross-functional studies can be undertaken to address key reliability issues, such as those mentioned above. To do this, we are reconciling our models' data sets such that we can conduct power flow studies on future resource and transmission scenarios. This will allow us to test the stability of potential future systems and to identify technical and other issues that the industry needs to address as the overall electricity system reconfigures around a potential new set of generating resources.

Conclusion

We have a high degree of confidence in the ability of the West to construct the needed transmission to ensure long-term reliability and deliverability of power to the electricity consumers in the West. The West, maybe more so than other regions of the country, is poised for a significant resource revolution driven by retirements of baseload resources and continued policy support for expansion of renewables. Given the length of time it takes to plan, site, and ultimately construct electric transmission assets, we believe that ongoing scenario analysis will remain critical to inform the evolution of the industry as uncertainties are removed (and new ones created) over time.

WECC would like to provide the QER effort with the materials listed on the following pages which provide substantial and unique information on transmission planning from the Interconnection-wide perspective. Many of these materials were made possible through grant funding provided to WECC by the DOE.



Transmission Plans		
WECC 2011 10-Year Regional Transmission Plan	The Western Electricity Coordination Council (WECC) 10-Year Regional Transmission Plan (2011 Plan) provides information on expected future transmission and generation in the Western Interconnection, what transmission capacity may be needed under a variety of futures, and other insights.	http://www.wecc.biz/library/StudyReport/Wiki%20Pages/Home.aspx
WECC 2013 Interconnection-wide Transmission Plan	The 2013 Western Electricity Coordinating Council (WECC) Interconnection-wide Transmission Plan (2013 Plan) is a perspective of the Western Interconnection transmission system under a wide variety of possible 10- and 20-year futures. The objective of the 2013 Plan is to provide information to stakeholders to support their decision-making processes.	http://www.wecc.biz/committees/BOD/TEPPC/Pages/2013_Plans.aspx
Transmission Plan Inputs		
WECC Scenarios	The Scenarios recommended by the Scenario Planning Steering Group (SPSG) assist the Transmission Expansion planning Policy Committee (TEPPC) in evaluation of long-term transmission capacity needs in the Western Interconnection by providing a comprehensive set of plausible future load, resource, and policy states. The Scenarios and subsequent analysis form a comprehensive package of stakeholder-vetted planning models, data and transmission plans for the Western Interconnection.	http://www.wecc.biz/committees/BOD/TEPPC/Pages/ScenarioNarratives.aspx

Foundational Transmission Project List (2011)	The 2011 Foundation Transmission Projects List reflects the minimum transmission system additions that have a sufficient level of commitment or defined need to provide WECC with a starting point for the development of its Interconnection-wide Transmission Plans	http://www.wecc.biz/committees/BOD/TEPPC/External/100811_SCG_FoundationalTransmissionProjectList_Report.pdf
2022 Common Case Transmission Assumptions (2013)	The 2022 Common Case Transmission Assumptions (CCTA) represent a set of “high probability” transmission projects that are likely to be in service during the approaching 10-year timeframe. They serve as the starting point assumption for TEPPC modeling.	http://www.wecc.biz/committees/BOD/TEPPC/External/SCG_CCTA_Report.pdf
2024 Common Case Transmission Assumptions (2014)	The 2024 Common Case Transmission Assumptions (CCTA) represent a set of “high probability” transmission projects that are likely to be in service during the approaching 10-year timeframe. They serve as the starting point assumption for TEPPC modeling.	http://www.wecc.biz/committees/BOD/TEPPC/External/RP/CG_2024CCTA_Report.pdf
2013 Plan Data and Assumptions	The assumptions and data used to create the 2013 Plan span numerous sources and categories such as loads, existing and incremental generation facilities, generation characteristics, and existing and incremental transmission facilities. Aside from these data and assumptions required to model the <i>physical</i> aspects of the Western Interconnection, WECC staff and stakeholders also develop assumptions and gather equally important data on policies, costs, reliability and environmental considerations.	http://www.wecc.biz/committees/BOD/TEPPC/Pages/2013Plan_Data.aspx

TEPPC 2010 Backcast Case	The TEPPC 2010 Backcast Case is a dataset using 2010 loads, resources, and transmission. The intention of the 2010 Backcast Case is to provide a benchmark of production cost model (PCM) results against actual system operations.	http://www.wecc.biz/committees/BOD/TEPPC/External/TEPPC_2010_BackcastCase.docx
2020 Common Case (2011 Plan)	The 2020 Studies were focused on the impact to the Western Interconnection of variations in the loads, EE and DSM assumptions, carbon adders, and the location of renewable resources with in the Western Interconnection.	
2022 Common Case (2013 Plan)	The 2022 PC1 Common Case (“Common Case”) is used as a starting point to evaluate the implications of options to meet existing and potential future energy policies, including the impact technology changes and external drivers might have on transmission needs and costs in the Western Interconnection.	http://www.wecc.biz/committees/BOD/TEPPC/External/TEPPC_2022_StudyReport_PC1%20Common%20Case.docx
2032 Reference Case (2013 Plan)	The 2032 Reference Case represents the load, resource and transmission topology characteristics that would be present in 2032 if the assumptions used to create the 2022 Common Case are carries out to 2032. The Reference Case serves as a point of reference for planners as they navigate the uncertainties in the 20-year planning horizon.	http://www.wecc.biz/committees/BOD/TEPPC/External/TEPPC_2032_ReferenceCase.docx
Assorted datasets	Includes those developed since 2013 Plan, and those currently in draft form.	http://www.wecc.biz/committees/BOD/TEPPC/Pages/TAS_Datasets.aspx

Planning Reports		
VGS BA Cooperation Study	The objective of the Variable Generation Subcommittee (VGS) Balancing Authority (BA) cooperation Study was to understand Interconnection-wide, the financial benefit of intra-hour scheduling compared to hourly scheduling. The study also sought to analyze how that benefit would change by altering input assumptions in different scenarios.	http://www.wecc.biz/committees/BOD/TEPPC/External/VGS_BalancingAuthorityCooperationConcepts_Intra-HourScheduling.pdf
10 Year Plan Follow up report	A group of TEPPC volunteers was directed to review the follow-up recommendations in the 2011 Plan. The purpose of this Group was to report back to TEPPC possible options for addressing the gaps identified in the 2011 Plan for inclusion in the 2013 Plan. From group discussions and documents, WECC staff authored this report that contains a number of recommended actions for discussion by TEPPC.	http://www.wecc.biz/committees/BOD/TEPPC/External/201110YrPlan_FollowUpReport.docx
Transmission Capital Cost Report	This report details the transmission and substation costs and development efforts, including the assumptions, methodology, and results. The report also describes the tool developed by Black & Veatch for WECC to be used to estimate transmission and substation costs that will be integrated into WECC's planning process. The report discusses the benchmarking of this methodology to several recent transmission project examples. This was completed to ensure that the theoretical costs reasonably reflect actual transmission development costs in the WECC Region.	http://www.wecc.biz/committees/BOD/TEPPC/External/BV_WECC_TransCostReport_Final.pdf

2011 WECC Path Reports	WECC Paths provide a comprehensive and effective medium for congestion and transmission expansion related discussions. These observations draw from current project development, historical information, and forward looking congestion analysis. Paths are discussed individually in this analysis.	http://www.wecc.biz/library/StudyReport/Documents/PathWriteUps.pdf
2013 WECC Path Reports	The Path reports provide stakeholders with information on WECC Transmission Paths that draw on WECC's rich database of historical, current, and future planning data. By integrating the historical analysis into the Path Reports, readers can view historical, current and future planning data and information together.	http://www.wecc.biz/committees/BOD/TEPPC/PathReports/TAS_PathReports_Combined_FINAL.pdf
2013 Plan Variable Generation Integration Report	Following the 2011 Plan, TEPPC committed to identifying and evaluating the challenges of integrating the VG assumed in the 2011 Plan and identifying possible options to address these challenges. This report, which is included in the 2013 Plan, takes steps toward this objective and lays important groundwork for future VG integration analyses within the context of transmission expansion planning.	http://www.wecc.biz/committees/BOD/TEPPC/External/2013Plan_VariableGenerationIntegration.docx
Sandia Labs – Water Usage in Transmission Planning	This report focuses on information on water resources in the Western U.S. to support WECC's long range transmission planning process. This data has been assimilated into a set of targeted inputs to the Long-term Planning Tool. The developed inputs, in terms of maximum allowable new generation and associated costs for water, are used to constrain the siting of new thermoelectric power generation and associated transmission in basins with limited water resources.	http://www.wecc.biz/committees/BOD/TEPPC/NonWECC%20Documents/Sandia_Water_Usage_TransmissionPlanning.pdf

Power Plant Cycling Costs- APTECH	This report provides a detailed review of the most up to date data available on power plant cycling costs. Increasing variable renewable generation on the electric grid has resulted in increased cycling of conventional fossil generation. The objective of this report is to increase awareness of power plant cycling cost, the use of these costs in renewable integration studies and to stimulate debate between policy makers, system dispatchers, plant personnel and power utilities.	http://www.wecc.biz/committees/BOD/TEPPC/NonWECC%20Documents/Aptech_Power_Plant_Cycling_Cost-Lower_Bound.pdf
Planning Tools		
Transmission Capital Cost Calculator	A tool developed by Black & Veatch for WECC and used to estimate transmission and substation costs that were integrated into WECC's planning process	http://www.wecc.biz/committees/BOD/TEPPC/External/121101_TEPPC_TransCapCost_Calculator.xlsx
WECC Long-Term Planning Tool	The WECC Long-term Planning Tool (LTPT) consists of the Study Case Development (SCDT) tool that transforms potential energy future scenarios into cases that can be analytically studied. The Network Expansion Tool (NXT) optimally derives physically feasible network expansions necessary to meet the load and generation requirements of each scenario study case while minimizing the net present value of capital costs.	http://www.wecc.biz/Planning/TransmissionExpansion/RT/TEP/LTPT/default.aspx

Base Case Coordination System	A base case is a computer model of projected or starting power system conditions for a specific point in time. In WECC, base cases include both steady state dynamics data. Base cases contain very large amounts of data necessary to model power system behavior. The Base Case Coordination System (BCCS) is a web-accessible, centralized database that automates existing processes. The BCCS increases accuracy and timeliness of the base case development.	http://www.wecc.biz/Planning/BCCS/default.aspx
WECC Environmental and Cultural Data Viewer	The WECC Environmental and Cultural Data Viewer is a web mapping application that provides the ability to view and access the environmental/cultural risk classification data Layers. Data layers available through this application are intended for use in regional transmission expansion planning and siting level analyses for specific transmission projects.	http://www.wecc.biz/committees/BOD/TEPPC/Pages/EDTF_DataViewer.aspx
WECC Project Information Portal	The Project Information Portal is a public database of major transmission projects in the Western Interconnection known to WECC. It provides a single location where interested parties can find basic information about major transmission projects in the Western Interconnection. Information in the Portal is provided by the respective project developer.	http://www.wecc.biz/Planning/TransmissionExpansion/Map/Pages/default.aspx
Environmental Data, Tools, and Reports		
Preferred Environmental Data Set	The Preferred Environmental Data Set is a spreadsheet that lists all data sets obtained or reviewed for environmental and cultural data providers.	http://www.wecc.biz/committees/BOD/TEPPC/External/EDTF_Data_Inventory.xlsx

Environmental Mitigation Cost Study	This report is based on data that has been collected regarding actual and estimated environmental mitigation costs incurred in the Western Interconnection for 20 documented transmission projects.	http://www.wecc.biz/committees/BOD/TEPPC/External/Mitigation_Cost_Study_FinalReport.pdf
Transmission Alternative Comparison Methodology (for environmental factors)	This document compares the environmental and cultural risk of future transmission alternatives. The goal of this comparison process is to inform decision-makers, planners, and stakeholders of the relative environmental and cultural risks of transmission alternatives being considered during transmission planning.	http://www.wecc.biz/committees/BOD/TEPPC/External/WECC_TransmissionAlternative_ComparisonMethodology.docx
Environmental Recommendations for Transmission Planning	This document describes the EDTF's recommendations for incorporation into the 2011 Plan. Recommendations summarized in this overview and supporting findings are presented in more detail in this report.	http://www.wecc.biz/committees/BOD/TEPPC/External/Environmental_Recommendations_for_Transmission_Planning.pdf

Communications		
Four years of bi-weekly newsletters	Bi-weekly newsletters are published as updates to the Transmission Expansion Planning work being conducted by and through WECC. The newsletters include updates on the activities and deliverables following WECC transmission expansion planning groups.	http://www.wecc.biz/committees/BOD/TEPPC/Pages/Newsletters.aspx
University Work		
Ten Educational Modules on Transmission Planning	As part of the RTEP project, WECC is to produce educational materials to help persons involved in transmission planning better understand technical topics germane to the subject. Given the complexity of the topics and the goal to disseminate useful information broadly, 15 streaming video educational modules have been created.	http://www.wecc.biz/Training/RTEP/Pages/default.aspx
Arizona State University	Numerous reports on powerflow modeling, expansion optimization, transmission line design, reliability analyses, and line-ratings.	http://www.wecc.biz/committees/BOD/TEPPC/Pages/2013Plan_Non-WECC.aspx
Washington State University	ASU/WSU exploring six-phase transmission system for power delivery	http://www.wecc.biz/committees/BOD/TEPPC/NonWECC%20Documents/ASU_WSU_6PhaseTransmission.pdf

Colorado State University	Study case on the effects of predicted wind farm power outputs on unscheduled flows in transmission networks.	http://www.wecc.biz/committees/BOD/TEPPC/NonWECC%20Documents/CSU_UnscheduledLoopFlow_Wind.pdf
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