Final Technical Report

Western Wind Strategy:

Addressing Critical Issues for Wind Deployment

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List of Acronyms

ADI – ACE Diversity Interchange
AWEA – American Wind Energy Association
BA – Balancing Authorities
BPA – Bonneville Power Administration
CAISO – California Independent System Operator
CCPG – Colorado Coordinating Planning Group
CDEi – WGA's Clean and Diversified Energy Initiative
CEDA – Colorado Energy Development Authority
CREPC –Committee on Regional Electric Power Cooperation
DOE – Department of Energy
EDT – Efficient Dispatch Toolkit
ECC – Enhanced Curtailment Calculator
EIM – Energy Imbalance Market
FERC –Federal Energy Regulatory Commission
GHG – Greenhouse Gas emissions
IOUs –Investor-owned utilities
IVGTF – NERC's Integration of Variable Generation Task Force
LBNL – Lawrence Berkeley National Laboratory
LSE – Load Serving Entities
MIC –WECC's Market Interface Committee
NETL – National Energy Technology Laboratory
NERC –North American Electric Reliability Council
NOPR –Notice of Proposed Rulemaking
NREL – National Renewable Energy Laboratory
NTTG – Northern Tier Transmission Group
NWCC – National Wind Coordinating Collaborative
RPS – Renewable Portfolio Standard
SIS – WECC's Seams Interface Subcommittee
SPP – Southwest Power Pool
SPSC –State-Provincial Steering Committee
SWAT – Southwest Area Transmission group
TAS – WECC's Technical Advisory Subcommittee
TEPPC –WECC's Transmission Expansion Planning Policy Committee
UWIG – Utility Wind Integration Group
VGS –WECC's Variable Generation Subcommittee
WAPA or Western – Western Area Power Administration
WCPSC –Western Conference of Public Service Commissioners
WECC –Western Electricity Coordinating Council
WREGIS – Western Renewable Energy Information System
WREZ – Western Renewable Energy Zone
WGA –Western Governors' Association

WIEB –Western Interstate Energy Board
WIRAB –Western Interconnection Regional Advisory Body
WWSIS – Western Wind and Solar Integration Study

Executive Summary

The goal of the Western Wind Strategy project was to help remove critical barriers to wind development in the Western Interconnection. The four stated objectives of this project were to: (1) identify the barriers, particularly barriers to the operational integration of renewables and barriers identified by load-serving entities (LSEs) that will be buying wind generation, (2) communicate the barriers to state officials, (3) create a collaborative process to address those barriers with the Western states, utilities and the renewable industry, and (4) provide a role model for other regions.

Western states' policies have been a primary driver of wind and solar energy development over the past decade with the enactment of renewable portfolio standards (RPS). Nine of the 11 states in the Western Interconnection have RPSs, some exceeding 30 percent. These policies require improvements in the technical and institutional ability to integrate higher levels of wind into the Western Interconnection power system.

The project created an ongoing avenue for the work of national laboratories to directly reach Western energy policy makers and utility regulators. For example, the project provided a forum for NREL to vet the findings from the Western Wind and Solar Integration Study with state energy policy makers and utility regulators.

The project launched a robust dialogue between Western states, the Western industry and the Federal Energy Regulatory Commission on actions to lower the cost of integrating variable generation. The project enabled states to engage and understand Western industry efforts, such as the Joint Initiatives. These topics are very technical in nature and require a considerable amount of time and effort to adequately inform policy makers and regulators.

The project led to the investigation of a Western Energy Imbalance Market by Western state public utility commissioners. This project led to a paper for Western Governors on barriers and actions to overcome barriers to lowering the cost of integrating variable generation.

This project has led to a new initiative by the Committee on Regional Electric Power Cooperation to examine ways to increase the flexibility of the Western power system through changes at the interface of the natural gas and electric power industries (e.g., coordinated scheduling of gas and electricity, increased gas surge capacity to accommodate wind and solar ramps, deployment of flexible gas-fired generation).

The project led to a report on wind and solar forecasting practices in the West, which is input to a forthcoming Internet-based "dashboard" of actions Western companies have taken to lower the cost of integrating variable generation.

The project also produced a report examining the feasibility of an advanced coal/wind power plant.

The Western Wind Strategy project has been on the forefront of identifying and informing state policy makers and utility regulators of critical issues related to wind energy and the integration of variable generation. The project has been a critical component in the efforts of states to push forward important reforms and innovations that will enable states to meet their renewable energy goals and lower the cost to consumers of integrating variable generation. By

tapping into the West's tradition of collaborative consensus building processes, the project served as a role model for other regions to develop wind energy resources.

Introduction

The goal of the Western Wind Strategy project was to help remove critical barriers to wind development in the Western Interconnection. The four stated objectives of this project were to: (1) identify the barriers, particularly barriers to the operational integration of renewables and barriers identified by load-serving entities (LSEs) that will be buying wind generation, (2) communicate the barriers to state officials, (3) create a collaborative process to address those barriers with the Western states, utilities and the renewable industry, and (4) provide a role model for other regions.

This project was directly responsible for informing and engaging state energy policy and utility regulatory officials on actions needed to integrate large amounts of variable wind generation into the power system in the Western Interconnection. The project helped inform state energy policy and utility regulatory officials about improved regional transmission planning to move larger amounts of wind generation and industry reforms that could lower the cost of integrating wind. The project provided the informational foundation for ongoing work by Western states on integrating wind into the Western Interconnection. State officials, transmission planners, and market participants also received valuable information on the feasibility of hybrid wind and advanced coal generation.

The project was instrumental in creating an ongoing avenue for the work of national laboratories to directly reach Western energy policy makers and utility regulators and has launched a robust dialogue between Western states, the Western industry and the Federal Energy Regulatory Commission on actions to lower the cost of integrating variable generation.

The Western Interstate Energy Board (WIEB) is an organization of Western states and Western Canadian provinces. The legal basis of the Board is an interstate compact, which has been ratified by Congress (PL 91-461). The Board also serves as the energy arm of the Western Governors' Association. Board members are appointed by the governor of each state and are generally the head of the state energy agency.

The Committee on Regional Electric Power Cooperation (CREPC) is a joint committee of WIEB and the Western Conference of Public Service Commissioners (WCPSC) representing 12 western states and two Canadian provinces. CREPC members consist of energy advisors to Western governors and premiers and Western state public utility commissioners. The project used regular CREPC meetings as platform for educational forums and collaborative processes with other stakeholders including the utility industry, the wind energy sector, the Department of Energy and the Federal Energy Regulatory Commission.

The project produced many important accomplishments. Educational briefings targeting wind energy and integration issues occurred at the twice yearly meetings of the Committee on Regional Electric Power Cooperation. The meetings included state-of-the-art research by national laboratories and leading experts in the field. The project engaged state and provincial representatives in the Department of Energy's multi-year project to evaluate regional wind integration in the Western Wind and Solar Integration Study. The project enabled active state involvement in technical and policy discussion surrounding consideration of the formation of a Western Energy Imbalance Market. The project informed state and provincial representatives

about the technical and economic potential for developing a hybrid wind and advance coal power generation facility.

Process used to execute the project: Five tasks were identified and carried out over the period from July 2006 to December 2011.

Task 1.0 established the Wind Integration Steering Team that consisted of five representatives across diverse areas of expertise relevant to wind energy.

Task 2.0 relied on a "living" plan with the purpose of identifying and capitalizing on opportunities for reducing the cost of integrating variable generation. The project had sufficient flexibility and adaptability to respond to fast changing developments and focus efforts on the cutting edge high priority topics related to wind energy and integration of variable generation. The project capitalized on lessons from DOE's Western Wind Solar Integration Study; collaboration with wind energy stakeholders such as the National Wind Coordinating Collaborative, the American Wind Energy Association, and the Utility Wind Industry Group; and active state participation in the process exploring the creation of a Western Energy Imbalance Market.

Task 3.0 called for bi-annual educational sessions on barriers to wind and related variable generation topics which were held during meetings of the Committee on Regional Electric Power Cooperation. The project carried out eleven educational sessions that informed state and provincial CREPC participants about wind and variable generation. In many sessions, national laboratory experts briefed CREPC on findings from their research related to wind and variable generation.

Task 4.0 examined the feasibility of hybrid wind/advanced coal generation and conveyed the study results to decision-makers. This particular task relied heavily on the technical expertise from Lawrence Berkeley National Laboratory, National Renewable Energy Laboratory, and the National Energy Technology Laboratory. The analysis identified potential opportunities and challenges to the concept of creating a hybrid wind and advanced coal generation facility.

Background

Nine of the eleven major states in the Western Interconnection have adopted renewable portfolio standards (RPS), some exceeding 30 percent. Some Western states have also adopted goals to reduce greenhouse gas (GHG) emissions. The state policies on RPS and reducing GHG emissions are drivers of increasing renewable generation in the Western Interconnection. High levels of renewable energy penetration in the Western Interconnection require improvements in the technical and institutional ability to integrate higher levels of wind on the western grid.

State energy policy and utility regulatory officials need to be informed on new state-of-the-art wind integration studies and potential opportunities to facilitate wind integration in the power system. State officials, Western utility transmission planners, and other market

participants also need information on the feasibility of hybrid wind and advanced coal generation. Educating state policy makers and state utility commission regulators about these issues is essential to removing barriers to greater development of low carbon resources such as wind energy.

The wind integration topics originally envisioned at the beginning of this project included the consolidation or virtual consolidation of Balancing Authorities, addressing wind integration issues raised by Western load-serving entities, and advancing the efficient implementation of rules governing transmission interconnection and transmission service requests, transmission tariff reform, and innovative reforms for transmission cost allocation and cost recovery. Recognizing that important wind integration issues evolve and change over time, the project was structured with sufficient flexibility to be adaptable and responsive to new topics relevant to state policy makers and regulators.

The project relied upon WIEB's experience and expertise on Western wind and electric transmission issues. WIEB staff participated in interconnection-wide transmission planning including the Seams Steering Group-Western Interconnection (SSG-WI) and the current planning efforts of the Western Electricity Coordinating Council's (WECC) Transmission Expansion Planning Policy Committee (TEPPC). WIEB staff has conveyed Western state interests and recommendations to the Federal Energy Regulatory Commission (FERC) on transmission issues, reforms to better integrate variable generation, and differences between actual transmission flows and the amount of available transmission capacity (ATC) posted by transmission operators. WIEB assisted in the development and formation of the Western Renewable Energy Information System (WREGIS) which tracks information necessary to support a viable market for renewable energy certificates.

The project supported Western state interests to meet RPS requirements and the goals of the Western Governors' Clean and Diversified Energy Initiative, which aimed to add 30,000 MW of clean energy by 2015. It also built upon pro-active transmission planning efforts to upgrade the transmission grid and utilize low cost wind resources. The project provided the foundation for Western Governors' Western Renewable Energy Zone initiative. By tapping into the West's tradition of collaborative consensus building processes, the project served as a role model for other regions to develop wind energy resources.

Results and Discussion

This project set forth four specific tasks as specified in the Statement of Project Objectives revised as of April 8, 2008. The results and discussion of these specific tasks are described below.

Task 1.0: The Wind Integration Project Steering Committee

The Wind Integration Project Steering Committee was designed to have five representatives of diverse expertise including the Committee on Regional Electric Power Cooperation (CREPC), the National Renewable Energy Laboratory (NREL), the Utility Wind Integration Group (UWIG), the wind industry and western load-serving entities. The Wind Integration Project Steering Committee members included the following:

John Savage, CREPC
Brian Parsons, NREL
Charlie Smith, UWIG
Ron Lehr, American Wind Energy Association (AWEA)
Abraham Ellis, Public Service Company of New Mexico (PNM)

A draft work plan was developed that identified high priority opportunities and was reviewed by the Wind Integration Project Steering Committee.

Task 2.0: Topics Pursued as New Opportunities

Under Task 2.0, a "living" plan was developed for the purpose of identifying and capitalizing on opportunities for reducing the cost of integrating variable generation. The project engaged in a large number of important and relevant activities related to state and provincial interests on wind energy and the integration of variable generation.

Transmission Planning Input

Interconnection-wide Transmission Planning. In 2006, the Western Electricity Coordinating Council (WECC) formed the Transmission Expansion Planning and Policy Committee (TEPPC) to conduct interconnection-wide transmission planning. WIEB staff attended meetings and participated in conference calls in support of TEPPC and its Technical Advisory Subcommittee (TAS). WIEB staff participated in three TEPPC meeting in 2006.[1] WIEB staff also participated in numerous conference calls for TEPPC and TAS regarding the development of work plans and implementation of selected tasks. Key issues for wind were development of generation scenarios, location of assumed wind generation and wind generation characteristics. The information developed by WECC is used in sub-regional planning efforts in the Western Interconnection.

In February 2007, WIEB staff briefed TEPPC and subregional planning groups on:

- WGA's Clean and Diversified Energy Initiative to solicit subregional planning group support in implementing the initiative and to collaborate on steps to facilitate transmission services for new clean energy sources.
- The announcement by Debbie Lew of the National Renewable Energy Laboratory (NREL) that NREL would be starting a large regional wind integration project in the Southwest. The study was to examine the impact of integrating wind resources from Wyoming, Colorado, New Mexico and Arizona into load centers in Phoenix and Las Vegas. WIEB solicited interest and participation in the study from the southwestern utilities. Representatives from APS, Salt River Project and others responded with interest to participate in the study.

The project cooperated with TEPPC in sponsoring a series of web-based conferences (webinars) on important topics regarding western transmission issues. WIEB staff participated in webinars on: Transwest Express transmission project (January 2007); lessons learned from the 2005 SSG-WI Reference Case modeling (February 2007); PowerBase data system used by

[1] Salt Lake City on November 3, 2006 and TAS meetings in Salt Lake City on September 6, 2006 and Scottsdale on October 11, 2006.

TEPPC (February 2007); Northern Lights transmission project (February 2007); Project Zia (March 2007); and the Frontier Line analysis tool (March 2007).

WIEB staff assumed a lead role in a focus group that identified the mix of generation to be modeled in the Western Interconnection for 2017 including the renewable generation needed for compliance with state Renewable Portfolio Standards (RPS).

TEPPC has sponsored a series of web-based conferences (webinars) on important topics regarding western transmission issues. WIEB staff participated in a webinar on wind integration in April 2007. WIEB staff also attended a TEPPC-sponsored workshop in Salt Lake City, UT in April 2007 on coordinating responses to the Federal Energy Regulatory Commission's new planning requirements under Order 890.

Subregional Transmission Planning**.** The Northern Tier Transmission Group (NTTG) consists of five utilities and state representatives in the footprint states of Oregon, Idaho, Utah, Montana, and Wyoming. WIEB coordinated participation of state members of the Committee on Regional Electric Power Cooperation (CREPC) and participated in NTTG's first meeting in Salt Lake City on November 8, 2006. WIEB staff participated in NTTG meetings (July and Augusts 2007) exploring new initiatives that would improve the technical ability of utilities to integrate higher levels of intermittent wind generators.

WestConnect is the umbrella organization for the Southwest Area Transmission group (SWAT) and the Colorado Coordinating Planning Group (CCPG). WIEB staff participated in the August 2007 joint meeting SWAT and the CCPG which examined NREL's Western Wind Integration Study, transmission providers' efforts to comply with FERC's Order 890 transmission planning requirements, and WestConnect's project to consider virtual control area consolidation and reform of transmission tariffs to eliminate rate pancaking.

Western Wind and Solar Integration Study

In 2007, the National Renewable Energy Laboratory (NREL) began a regional wind integration project known as the Western Wind and Solar Integration Study (WWSIS). The WWSIS developed a large mesoscale wind data set that provided the basis to model wind generation over a three-year period across potential sites located in the Western Interconnection. The primary study footprint covered the subregion of WestConnect that includes the states of Wyoming, Colorado, New Mexico, Arizona and Nevada. WIEB staff participated in Phase 1 of the Western Wind and Solar Integration Study (WWSIS), including the kickoff meeting in May 2007, served on the Technical Review Committee, attended stakeholder meetings, reviewed and commented on draft documents. The WWSIS found that it was technically feasible to integrate 30% wind and 5% solar if numerous steps are taken to facilitate the integration of variable generation. Important institutional reforms cited in the study were the adoption of subhourly scheduling, balancing area consolidation or virtual consolidation, and implementation state-of-the-art forecasting. WIEB staff participated in the final stakeholder meeting on February 9, 2010 in Albuquerque. Staff provided written comments on the draft report and executive summary following the stakeholder meeting.

WIEB staff organized and sponsored a webinar series on the WWSIS that was designed to provide high-level briefings to state and provincial regulatory commissions, energy agencies, policy makers, utility staff and executives, and other interested parties. The briefings focused on

key findings and policy implications on the integration of high levels of variable generation in the Western Interconnection. The schedule and topics for the webinar series is presented below.

Webinar #1: Overview of the study – February 4, 2010

- Goals
- Political, environmental, and other issues
- Assumptions and data inputs (solar, wind, load) and validation
- Scenarios – resource characteristics, siting, transmission build-outs
- Additional deep dives into specific topics
- Description of types of analysis

Webinar #2: Statistical Analysis – February 18, 2010

- Geographic diversity
- Extreme events, how often extreme events occur, when do they occur
- Sometimes variability helps you and sometimes it hurts you
- A scenario with 35% renewable energy penetration can have instantaneous penetration that is much higher

Webinar #3: Operational Analysis – March 4, 2010

- Comparison of various siting scenarios
- Fuel and emissions cost savings from 35% renewables
- The cost of wind and solar uncertainty
- The impact of storage
- How transmission buildouts affect results

Webinar #4: Intra-hour Analysis and Reliability – April 1, 2010

- Impact on reserves
- Impact of balancing authority cooperation
- ACE sharing
- Effective Load Carrying Capability

Webinar #5: Summary of Findings/Recommendations – April 13, 2010

- Balancing Area coordination/consolidation
- Intra-hour scheduling
- Wind and solar forecasting
- Changes to operating reserves
- Need for storage?
- Load participation
- Wind curtailment
- Need for new transmission

WIEB staff assisted in the planning and coordination of the formal public release of the WWSIS. The WWSIS rollout date was set for May 20, 2010 in Tempe to coordinate with the Southwest Renewable Energy Transmission Conference. These two events were coordinated to attract broad participation among stakeholders in the WestConnect region, including commissioners from the public utility commissions in Arizona, Colorado, Nevada, and New Mexico.

On March 16, 2011, NREL began Phase 2 of the WWSIS with a kickoff meeting for a large group of stakeholders in the WestConnect study regions. WWSIS Phase 2 will attempt to

quantify and assess the wear and tear impacts of wind and solar variable generation on the thermal generator operations. WIEB staff is a member ofthe Technical Review Committee for Phase 2.

Wind Energy Collaboration: NWCC, AWEA, UWIG

In 2007, the Western Governors' Association (WGA) sponsored its Clean and Diversified Energy Initiative (CDEi) to achieve the goals of deploying 30,000 MW of clean and diversified energy by 2015 and realize a 20% improvement in energy efficiency by 2020. Through the work of the WIEB staff, WGA teamed up with the National Wind Coordinating Collaborative (NWCC) to implement the CDEi wind and transmission recommendations. The NWCC and WGA held a conference, *Increasing Renewable Energy in the Western Grid Summit*, on September 26-28, 2007. WIEB staff provided much of the organization for the meeting.

Featured speakers at the conference were Colorado Governor Bill Ritter, Wyoming Governor Dave Freudenthal, Commissioner Jon Wellinghoff of the Federal Energy Regulatory Commission, Tim Meeks, Administrator of the Western Area Power Administration, Steve Wright, Administrator of the Bonneville Power Administration, and Yakout Mansour, President and CEO of the California Independent System Operator. Over two hundred people attended the conference including representatives from state energy offices, governors' energy representatives, public utility commission staff and commissioners, experts from the National Renewable Energy Laboratory and the Lawrence Berkeley National Laboratory, transmission planners from major electric utilities, developers from wind energy, solar, geothermal industry, and environmental organizations. The conference led to a proposal to identify and designate renewable energy zones across the Western Interconnection in a project that became the Western Renewable Energy Zone (WREZ) initiative.

NWCC sponsored a regular series of webinars on topics important to wind energy. WIEB staff participated in and conveyed information to Western states on the following NWCC webinar topics:

- April 2008 -- wind energy and storage by Brad Nickell of DOE and Paul Denholm of NREL.
- July 2008 -- open season solicitations for the Wyoming-Colorado Intertie transmission project by Steve Waddington of the Wyoming Infrastructure Authority; and Elliott Mainzer of the Bonneville Power Administration (BPA) explained BPA's proposed network open season
- December 2008 -- work of the North American Electric Reliability Corporation's Integration of Variable Generation Task Force (IVGTF).
- October 2009 – FERC technical conferences on Order 890 by Mason Emnett of the Federal Energy Regulatory Commission; and transmission siting policy by Ashley Brown of the Harvard Electricity Policy Group in the Kennedy School of Government

WIEB staff participated in and provided input at numerous wind energy stakeholder meetings and forums that brought stakeholders together to address leading concerns to wind energy.

- January 23-25, 2008 – A wind integration workshop sponsored by the National Rural Electric Cooperative Association, American Public Power Association,

American Wind Association, Utility Wind Integration Group, and the Western Area Power Administration. The workshop was held at the Western Area Power Administration's training facility in Golden, CO and emphasized operational issues of integrating wind into smaller utility systems.

- August 15, 2008 – The American Wind Energy Association (AWEA) meeting to engage stakeholders on its Systems Integration Action Plan.
- August 21, 2008 – AWEA sponsored webcast on the Department of Energy's report on 20% Wind in 2030.
- October 2-3, 2008 -- Utility Wind Integration Group (UWIG) Technical Workshop covering the Western Wind and Solar Integration Study and the Eastern Interconnection Wind Integration Study, the impact of wind forecasting in ERCOT, and wind integration in the Pacific Northwest. WIEB staff presented an update on the Western Renewable Energy Zone project.
- March 10, 2009 – Renewable Initiatives Forum on in Washington, D.C. The meeting was co-sponsored by the American Wind Energy Association, the National Association of Regulatory Utility Commissioners, the National Conference of State Legislatures, the Western Area Power Administration, and others.
- February 22, 2010 – NWCC's Renewables and Transmission Forum in Washington, D.C. The Forum enabled participants to engage in a dialogue with representatives of the Department of Energy's Offices of Electricity and Energy Efficiency and Renewable Energy, wildlife and conservation interests, as well as representatives from the hydropower, geothermal, solar and wind industries.
- March 2, 2010 - AWEA sponsored meeting that featured diverse stakeholders including representatives from the wind industry, states, environmental organizations, utilities, and independent power producers. WIEB staff gave a presentation on what works, what doesn't, and what needs to be done in the western interconnection.
- March 16, 2010 - NWCC sponsored call to solicit stakeholder feedback on potential transmission work group activities. The topics considered included: targeted outreach, inclusion of tribal nations, inclusion of other renewables, development of transmission planning standards, incorporation of environmental considerations in the planning process, framework for evaluating tradeoffs of wind economic development among states, and more.
- May 10, 2010 – NWCC, DOE and NREL sponsored a stakeholder meeting "Increasing Renewable Energy in the Western Grid: A Dialogue Among Stakeholders."

Joint Initiatives

The Joint Initiatives is a project of three utility subregional planning groups (ColumbiaGrid, WestConnect and the Northern Tier Transmission Group) to implement intra-hour scheduling, dynamic scheduling and I-TAP (an electronic bulletin board to speed the search for bi-lateral power sales and associated transmission).

In September 2010 WIEB staff and several states participated in a Joint Initiatives Think Tank meeting. WIEB staff requested the help of the Joint Initiatives participants in evaluating

the incremental benefits of an Energy Imbalance Market over the benefits provided by the Joint Initiatives. Staff participated in follow-up Joint Initiatives Think Tank meetings in November 2010 and August 2011. Staff monitored the progress of Joint Initiative members in implementing the 30-minute scheduling initiative, which began on July 1, 2011.

Variable Generation Subcommittee

The Western Electricity Coordinating Council (WECC) created a Variable Generation Subcommittee (VGS) to address issues associated with integrating more variable integration (such as wind and solar) into the Western Interconnection. WIEB staff was nominated and selected to become a member of the Variable Generation Subcommittee. The VGS held its initial kickoff meeting on January 15, 2009. WIEB staff participated in person or by webinar in nine VGS meetings in 2010 and 2011.[2]

WIEB staff coordinated with NREL staff on a forecasting practices survey that significantly expanded initial work done by the VGS. The survey included questions about what measures BAs are taking to address the integration of variable generation. The survey was be conducted via phone interview and email. Preliminary results of the forecasting practices survey were presented to CREPC and the State-Provincial Steering Committee at their October 2011 meeting and to the WECC VGS in December 2011.

Staff also participated in the WECC Joint Committee meetings in July 2011 to monitor a motion to each of the WECC standing committees (Planning Cooperation, Operations, Market Interface) on the future of the VGS. Staff participated in the September 2011 WECC Joint Guidance Committee meeting which oversees the VGS. The topic of discussion at the JGC meeting was the future of variable generation work at WECC.

Efficient Dispatch Toolkit and Energy Imbalance Market

WIEB staff and Western states have been instrumental in the evaluation of a potential Energy Imbalance Market in the Western Interconnection.

WIEB staff has monitored the Efficient Dispatch Toolkit (EDT) proposal that developed at the Seams Issues Subcommittee of WECC's Market Interface Committee. The proposal features two tools: (1) the Enhanced Curtailment Calculator (ECC) which is a tool to more effectively manage transmission congestion in real time across the Western Interconnection, and (2) an Energy Imbalance Market (EIM) that would provide energy balancing service among balancing areas and provide congestion redispatch service. The EDT approach is a measure that can improve balancing area coordination. Balancing area coordination and cooperation will be needed to cost-effectively integrate high levels of variable generation in the power system.

Western states and provinces urged the WECC Board to approve funding to perform a benefit-cost analysis of the EIM proposal. The Board approved funding for the benefit cost

[2] June 14-16; 2010 -- Salt Lake City; July 13, 2010 -- Salt Lake City; October 27, 2010 -- Salt Lake City; December 2-3, 2010 -- Salt Lake City; March 30-31, 2011 -- Irvine, California; June 8-9, 2011 -- Salt Lake City; July 7, 2011 -- Salt Lake City; September 1, 2011 – Portland; December 7-8, 2011 – Salt Lake City.

study and created the EDT Steering Committee and the EDT Technical Review Subcommittee. WIEB staff was a member of the EDT Steering Committee and attended meetings of the EDT Technical Review Subcommittee. During 2010 and 2011 WIEB staff participated in more than 40 WECC meetings related to the EDT and EIM effort.[3]

WIEB staff initiated and facilitated informational outreach opportunities for state regulators and energy personnel, industry entities, and other stakeholders. On June 8-9, 2010 WIEB staff and interested Western state utility regulators travelled to Little Rock, Arkansas to participate in meetings and informational sessions on the Southwest Power Pool's (SPP's) Energy Imbalance Service (EIS), which is the inspiration for the EDT.

WIEB staff organized the March 2011 EIM Crossroads Meeting of states/provinces, utilities, NGOs, generation developers and others to discuss issues that need to be addressed in order for entities in the West to make a go/no go decision on an EIM. Staff organized the Crossroads Meeting Organizing Committee, which consists of members from various balancing authorities and state public utility commissions. Staff created a website for the Crossroads Meeting. The Organizing Committee met seven times.[4] Staff conducted 4 pre-meeting webinars on EIM related topics as background material for the Crossroads meeting and posted recordings of the webinars on the Crossroads Website.

- January 28, "What is an EIM?";
- February 1, "Tariff Issues Associated with an EIM";
- February 3, "EIM Footprint and Seams with Non-participating BAs";
- February 17, "EIM Market Operator and Start-Up Financing Options"

Staff organized and participated in the EIM Crossroads meeting on March 7-8, 2011. The meeting was well-attended with 168 people in the room (63 from Balancing Authorities, 33 from states and the rest from other entities such as NGOs, federal government, and WECC) and

[3] EDT-related meetings in which WIEB staff participated

- WECC EDT Steering Committee - eleven meetings
  - June 3, July 22 and August 18, November 10, and December 8, 2010
  - January 5, February 16, and March 16, June 15, July 8, July 29, 2011
- EDT Technical Review Subcommittee – nineteen meetings
  - July 1, July 20, August 11, September 8 and September 28, November 1, December 1, and December 16, 2010.
  - January 19, February 4, March 10 and March 24, April 7, April 22, May 20, and June 14, July 8, July 26 and August 2011
- WECC stakeholder workshop on the EDT – three meetings
  - October 5, 2010
  - January 18 and April 7, 2011
- WECC Seams Issues Subcommittee (SIS) – four meetings
  - August 9, November 15-16, and December 14, 2010
  - January 13, 2011
- SIS Tariff Task Team – two meetings
  - September 30 and October 28, 2010
- SIS Tools Task Team – one meeting
  - October 11, 2010
- WECC Board – July, October and December 2010 and March, June and September 2011.

[4] January 7, January 21, February 17, February 21, February 25, February 28, and March 25, 2011.

another 67 people attending via webinar. As follow-up to the meeting, staff assembled all suggestions and questions posed at the meeting, developed answers to questions that were approved by the Organizing Committee, and sent the answers to meeting participants and others working on EIM topics. This document can be found at: http://www.westgov.org/EIMcr/meetings/07MAR11/questions.pdf.

WIEB staff continued educational work with states on an EIM and participated in the WECC benefit/cost study.

- April 2011 CREPC/SPSC meeting discussion of EIM developments.
- WIEB sponsored webinar on bid price vs. market clearing price in October 2011.
- Staff attended the June 2011 WECC Board meeting that included a presentation of the final cost benefit study results and discussion. The WECC Board decided on four next steps as a result of the benefits cost study directing WECC staff to: (1) prepare an analysis of the risk to WECC if an EIM is implemented; (2) prepare a cost analysis assuming WECC as the Market Operator; (3) prepare an analysis of the required institutional changes at WECC under an EIM; and (4) coordinate the creation of a high-level market design specification document to be drafted with input from the EDT Technical Review Subcommittee (which was later dropped).

WIEB staff also participated in subregional group calls on analyzing the individual entity benefits of an EIM. Staff participated in six meetings and/or calls of the WestConnect EIS work group in 2011. In addition, staff participated in a call of the ColumbiaGrid EIM Analysis Work Group on August 2011.

Work on a proposed EIM continues, including the creation of a PUC EIM group of 13 interested Western PUC commissioners. The PUC EIM group is leading efforts to: develop a strawman EIM market design, acquire cost estimates from SPP and the California ISO to operate a Western EIM, and received from NREL a refined analysis of the benefits of an EIM.

Other Wind Energy Activities

To advance the protect's objectives WIEB staff provided input at several other group meetings.

Southwest Renewable Energy Conference. WIEB staff participated in the Southwest Renewable Energy Conference in Flagstaff in August 2006. WIEB staff organized a session on transmission planning, and presented findings of the WGA's Clean and Diversified Energy Advisory Committee (CDEAC) report and transmission needed to support CDEAC scenarios that included large amounts of wind development.

FERC Technical Conferences. Staff attended and monitored a FERC technical conference on new transmission planning requirements under Order 890 in October 2008. Staff also monitored the December 2008 FERC technical conference on interconnection queue management. This conference examined the problems of interconnection queue backlogs in the West and Midwest, caused, in part, by large numbers of wind development projects, and

explored policy changes to address the queue. In response to questions, staff also provided technical information on queuing issues to the South Dakota Governor's Office.

Colorado Energy Development Authority. Staff gave a presentation on regional transmission issues, including transmission for wind, to the first meeting of the Colorado Energy Development Authority (CEDA) on November 1, 2008 in Denver. WIEB staff made a subsequent presentation on policies and developments concerning transmission and renewable energy in the West to CEDA on February 11, 2009. Colorado created CEDA in 2007 as a new infrastructure authority similar to such entities created in Wyoming, New Mexico, Montana, Kansas and South Dakota.

Transmission Project Stakeholder Meetings. Staff attended a stakeholder meeting for the Gateway South/Transwest Express (GWS/TWX) transmission project in November 2008. This project proposes large new transmission from Wyoming to Oregon and to the Las Vegas area and may facilitate wind energy development in Wyoming. Staff reported on the evaluation of the technical and economic feasibility of combining wind energy and advanced coal technologies.

Staff also attended the stakeholder meeting of the High Plains Express (HPX) transmission project on November 14, 2008 in Denver. The HPX project proposes new transmission linking the wind rich region of the eastern plains of Wyoming, Colorado, and New Mexico to the Phoenix-Tucson load area. .

Western Conference of Public Service Commissioners. WIEB staff gave a presentation to the annual meeting of the Western Conference of Public Service Commissioners on June 17, 2008. The presentation included a checklist of actions western PUCs should take on wind integration issues.

WECC Joint Meetings. In June 2008, WIEB staff delivered a presentation to a joint meeting of the WECC Operating Committee, Planning Committee and Market Interface Committee. The presentation addressed the emerging challenge to add increasing amounts of renewable generation into the Western grid and identified measures to integrate higher levels of variable generation.

In February 2011, staff attended the DOE Strategic Wind Planning Meeting in Washington, D.C. Staff participated in discussions on DOE's current program and made recommendations for future work.

Midwestern Governors' Association. In July 2008, WIEB staff made a presentation to a meeting of the Midwestern Governors' Association meeting "Wind Energy: Moving it to Markets" in Dearborn, MI. The meeting was co-sponsored by the National Wind Coordinating Collaborative, CapX 2020 and many other groups. The presentation covered the experience with actions taken or underway to integrate more wind into the Western Interconnection and where there may be lessons that can be learned from the Western experience.

ACE Diversity Interchange Project. In August 2008, WIEB staff participated in a meeting between the Western Electricity Coordinating Council (WECC) and the partners of the ACE (Area Control Error) Diversity Interchange (ADI) project. The meeting was organized to address WECC concerns about the ADI operations and potential reliability implications. The ADI program was temporarily halted pending resolution of these issues. The ADI program

serves to better coordinate balancing areas in the Western Interconnection and facilitate wind integration in those balancing areas.

Task 3.0: Educational Sessions for the Committee on Regional Electric Power Cooperation

WIEB organized bi-annual educational sessions on barriers to wind and related variable generation topics for meetings of the Committee on Regional Electric Power Cooperation (CREPC). The attendance at CREPC meetings has averaged 75-90 people with a minimum of 45 from state agencies and the rest from industry, NGOs and federal agencies such as the Federal Energy Regulatory Commission, Department of Energy, Bonneville Power Administration and the national laboratories. The educational session series covered 11 CREPC meetings during the project as summarized below.

September 27-29, 2006 in San Diego. The session featured a panel of experts on wind integration studies from Northwestern Energy, Xcel Energy, California ISO, the Bonneville Power Administration, the National Renewable Energy Laboratory (NREL) and the American Wind Association.

April 4-5, 2007 in Denver. Brian Parsons of NREL presented the findings from existing wind integration studies and described new projects that utilize mesoscale modeling for large regional wind integration studies in California, the Pacific Northwest and the Southwest. He also identified emerging technological and policy issues related to integrating large amounts of intermittent wind resources on the grid.

November 5-6, 2007 in Tucson. Debra Lew of NREL provided an update on the Southwest Wind and Solar Integration Project. Amol Phadke of LBNL presented preliminary findings of the analytical work on the wind/advanced coal hybrid project. Debra Lew and Doug Larson (WIEB) gave a presentation on the western renewable energy zone proposal that came from a conference sponsored by the Western Governors' Association (WGA) and the National Wind Coordinating Collaborative (NWCC) in Fort Collins. State representatives from California, Colorado, Nevada and Arizona discussed initiatives in their respective states to identify renewable energy zones and plan for associated transmission.

April 2-4, 2008 in San Diego. Nicholas Miller of GE Energy and Brian Parsons of NREL discussed findings on research on the operational impacts of integrating higher levels of renewables in the electric sector. In a second session, Brian Parsons of NREL and Charlie Reinhold of WestConnect presented the scope and purpose of the DOE funded Western Wind and Solar Integration Study. A third session explored the approaches to resource assessments at the North American Electric Reliability Corporation (NERC) and the Western Electricity Coordinating Council (WECC).

October 28-30, 2008 in Santa Fe. Debbie Lew of NREL presented an update on the Western Wind and Solar Integration Study and reported on the development of mesoscale wind data, ramping rates needed to meet wind fluctuations, balancing area consolidation, flexible markets, wind forecasting, and geographic diversity. A second panel of industry representatives reported on market innovations that will enhance the ability of the electric system to integrate higher levels of variable generation such as wind. Elliott Mainzer of the Bonneville Power

Administration (BPA) discussed wind integration issues in the Northwest including BPA's efforts to approve a new tariff, intra-hour trading, and coordination with other balancing areas. Charles Reinhold of WestConnect addressed a regional pricing experiment designed to eliminate pancaked rates in the WestConnect footprint. Additionally, seven WestConnect members initiated agreements to participate in the Ace Diversity Interchange (ADI) project. Kip Sikes of the Northern Tier Transmission Group reported on the Joint Initiatives project among Northern Tier Transmission Group, ColumbiaGrid, and WestConnect. The goal of the Joint Initiatives project is to encourage and facilitate Western Interconnection parties to jointly develop and implement high-value cost-effective regional products. Several of these products (e.g., intra-hour scheduling, dynamic scheduling) can aid in the integration of wind and solar.

April 8-9, 2009 in San Diego. A large panel of industry experts discussed their insights on opportunities to improve system flexibility. Greater system flexibility makes it easier to integrate wind and other variable generation in the electric sector. The session panelists included:

Elliott Mainzer, BPA—Moderator
Maury Galbraith, Northwest Power and Conservation Council
Charlie Reinhold, WestConnect
Sharon Helms, Northern Tier Transmission Group
Kristi Wallis, ColumbiaGrid
Brad Nickell, WECC
John Leland, NorthWestern Energy
Grant Rosenblum, CAISO
Steve Beuning, Xcel Energy
Stefan Bird, PacifiCorp

Specific issues addressed by the panel include: system balancing resources to integrate higher levels of renewable generation; supply and demand-side resources that can provide system flexibility; and the role of integrated resource planning to explicitly address system flexibility for renewable resources.

November 5, 2009 in Tempe. This CREPC meeting was coordinated with the first meeting of the State and Provincial Steering Committee (SPSC) which was established to facilitate states and provincial input to WECC's Topic A transmission planning, in order to foster more efficient use of the existing grid and lower the cost of integrating variable generation.

April 21-22, 2010 in Portland. The CREPC meeting included two important sessions on the integration of variable generation. The first session featured presentations by Richard Piwko, GE Energy, and Michael Milligan, NREL on key findings of the Western Wind and Solar Integration Study (WWSIS). The WWSIS found that it was technically feasible to integrate 30% wind and 5% solar if numerous steps are taken to facilitate the integration of variable generation. Important institutional reforms cited in the study were the adoption of sub-hourly scheduling, balancing area consolidation or virtual consolidation, and implementation state-of-the-art forecasting. A second session considered a proposal for implementation an Efficient Dispatch Toolkit (EDT), including an Energy Imbalance Market (EIM). Steve Beuning of Xcel Energy made a presentation about the proposed EIM. Carl Monroe of the Southwest Power Pool (SPP) discussed the SPP experience in implementing an EIM. SPP had estimated $80 million in

benefits but realized roughly $100 million. A panel of representatives from balancing areas (BAs) was asked to respond to a series of questions related to integrating variable generation, the WWSIS, and the proposal at WECC to study the EIM. FERC Chairman Jon Wellinghoff participated in this session.

September 13-14, 2010 in Salt Lake City. The CREPC meeting included four sessions that addressed issues related to the integration of variable generation. Mason Emnett and David Morenoff from FERC discussed the Commission's notice of inquiry on variable energy resources and notice of proposed rulemaking on transmission planning and cost allocation. A panel of western industry representatives provided feedback on the topics raised by FERC. David Hurlbut and Michael Milligan of NREL discussed the potential benefits from wind and solar forecasting to lowering the cost of integrating variable generation. Charlie Reinhold of WestConnect and Sharon Helms of NTTG presented an update of the Joint Initiatives. Michelle Mizumori of WECC presented an update on a proposed benefit-cost study of a Western EIM and Steve Beuning of Xcel Energy explored market design issue for the EIM.

April 11-12, 2011 in Seattle. This CREPC meeting included two sessions that related to the integration of variable generation. One session examined the developments related to a potential Western EIM. WIEB staff provided an overview of the EIM concept. Commissioner Ric Campbell of the Utah Public Utility Commission discussed his observations on the EIM. Michelle Mizumori, WECC staff, presented current findings of WECC's benefit-cost study. A second session featured FERC Commissioner John R. Norris speaking on recent FERC activities including FERC's notice of proposed rulemaking on integrating variable energy resources.

October 26-27, 2011 in Monterey. The CREPC meeting featured four sessions related to the integration of variable generation. One session explored developments related to ongoing work on a Western EIM. Michelle Mizumori of WECC provided an update on WECC's efforts. Consultant Larry Chaset reviewed issues discussed on a pre-meeting webinar regarding market pricing. Jack King of NREL discussed the analysis of flexible reserves in quantifying EIM benefits. Dave Olsen of the Western Grid Group discussed the utilization of the natural gas fleet under an EIM. Other sessions explored the following topics:

- Kevin Porter of Exeter Associates discussed the preliminary findings on a survey of Balancing Area (BA) wind forecasting practices;
- Charles Reinhold of WestConnect, Kristi Wallis of ColumbiGrid and Sharon Helms of NTTG provided an update of the Joint Initiatives.
- Christina Hayes, Legal Advisor to FERC Chairman Wellinghoff, provided a briefing on recent FERC actions including Order 1000 and the variable energy resources notice of proposed rulemaking.

CREPC Webinars

Wind Integration Webinars. WIEB staff organized two webinars sponsored by the Committee on Regional Electric Power Cooperation (CREPC) and the Western Interconnection Regional Advisory Body (WIRAB). These webinars are intended to educate and inform state and provincial public utility commissions and policy makers on emerging issues on wind integration.

The June 18, 2009 webinar featured a new spreadsheet model called the "Renewable Integration Calculator" developed by resource planners at Pacific Gas & Electric (PG&E).

Antonio Alvarez of PG&E presented an overview of the model and discussed how it can be used to estimate the incremental integration requirements for different levels of renewable (MW capacity) and different portfolios of variable renewable energy technologies (e.g., wind, solar PV, solar thermal). The model derives integration requirements across three operational time frames: regulation, load following, and day-ahead commitment. The model is flexible so the user can adjust key inputs such as: (1) variable resource amounts; (2) hourly load and generation profiles; (3) standard deviation of forecast uncertainty for both load and intermittent generation for day-ahead, hour-ahead and real-time dispatch timeframes; (4) correlation among uncertainties; and (5) fixed and variable costs of integration resources. This model has potential applications for other utilities, their resource planners, and public utility commissions that review resource plans.

A June 30, 2009 webinar examined the North American Electricity Reliability Corporation's (NERC's) Integration of Variable Generation Task Force (IVGTF). John Moura of NERC staff presented an overview of the IVGTF and its special report, "Accommodating High Levels of Variable Generation." This report identifies and explains the technological issues, and provides a number of recommendations relevant to planners, grid operators and policy makers. The webinar also included a presentation of the Western Electricity Coordinating Council's (WECC's) Variable Generation Subcommittee (VGS) which is addressing the challenge of integrating variable generation renewable energy into the Western Interconnection. Brad Nickell of WECC staff provided background on the VGS and discussed its work plan agenda.

Task 4.0: Evaluation of Hybrid Wind/Advanced Coal Generation

The purpose of Task 4 was to evaluate the feasibility of hybrid wind/advanced coal generation and to convey the study results to decision-makers. Under Task 4.1, WIEB collaborated with DOE's National Energy Technology Laboratory (NETL), National Renewable Energy Laboratory (NREL) and Lawrence Berkeley National Laboratory (LBNL), to conduct a "screening level" feasibility study of hybrid wind/advanced coal generation. In 2007, a steering committee for the feasibility study was established to advise the analytic team on the technical and economic feasibility of wind and advanced coal hybrid generation. The feasibility study steering committee consists of representatives of load serving entities, transmission developers, states, a wind developer, a vendor of advanced coal technologies, and environmental representatives. The members of the feasibility study steering committee were as follows.

Tom Bechtel, Coal Technology Expert
Richard Boardman, Idaho National Laboratory
Steve Ellenbecker, Wyoming Governors' Office
Tom Feiler, Clipper Wind
Mike Jaske, California Energy Commission
Lester Lave, Carnegie Mellon University
John Nielson, Western Resource Advocates
Dave Olsen, Center for Energy Efficiency and Renewable Technologies
Mark Russell, Salt River Project
Paul Smith, Arizona Public Service

Gary Tarpley, Southern California Edison
Scott Barnicki, Eastman Chemical

A June 2007 meeting of the Steering Committee provided guidance and instructions to proceed with a draft report.

In December 2007, the final report of the project, *Advanced Coal Wind Hybrid: Economic Analysis*, was released. WIEB posted the report on the WIEB website, issued a press release, and notified members of WIEB and CREPC. The findings of the report include:

- Adding fuel (syncrude or synthetic natural gas) production or syngas storage facility to an advanced coal-wind hybrid facility lowers the levelized cost of electricity by improving plant utilization.
- The net benefits of configuring wind and advanced coal in a hybrid project instead of operating them in a stand-alone manner at a remote location are positive but modest. The hybrid facility yields savings in transmission, wind integration and wind resource adequacy costs that somewhat outweigh the increased fixed costs per unit of power generation and fuel production, given lower utilization of the power generation and fuel production units in the hybrid facility.
- The preferred advanced coal-wind hybrid facility is quite competitive with other generation technologies and has a relatively low emission footprint. Assumptions regarding the price of natural gas, fuel prices, and capital costs are important factors that have a significant impact of the economics of such a project.

Accomplishments

The project informed and engaged state energy policy and utility regulatory officials on actions that can enable the integration of large amounts of variable wind generation into the power system in the Western Interconnection, which could provide a good role model for other regions. This was accomplished through interactive meetings and several webinars over the course of the project. Each meeting was attended by over 80 people including state public utility commissioners and staff, DOE and FERC officials, and industry representatives. Through this project state members and WIEB staff were also able to participate in other important meetings on integrating wind energy and provide updates to industry and to other states.

The project created an ongoing avenue for the work of national laboratories to directly reach Western energy policy makers and utility regulators. For example, the project provided a forum for NREL to vet the findings from the Western Wind and Solar Integration Study with state energy policy makers and utility regulators.

The project launched a robust dialogue between Western states, the Western industry and the Federal Energy Regulatory Commission on actions to lower the cost of integrating variable generation. The project enabled states to engage and understand Western industry efforts, such as the Joint Initiatives. These topics are very technical in nature and require a considerable amount of time and effort to adequately inform policy makers and regulators.

The project led to the investigation of a Western Energy Imbalance Market by Western state public utility commissioners. This project led to a paper for Western Governors on barriers and actions to overcome barriers to lowering the cost of integrating variable generation.

This project has led to a new initiative by the Committee on Regional Electric Power Cooperation to examine ways to increase the flexibility of the Western power system through changes at the interface of the natural gas and electric power industries (e.g., coordinated scheduling of gas and electricity, increased gas surge capacity to accommodate wind and solar ramps, deployment of flexible gas-fired generation).

The project led to a report on wind and solar forecasting practices in the West, which is input to a forthcoming Internet-based "dashboard" of actions Western companies have taken to lower the cost of integrating variable generation.

The project produced a report examining the feasibility of an advanced coal/wind power plant.

Conclusions

Western states have been a primary driver of wind and solar energy development over the past decade with the enactment of renewable portfolio standards. High levels of renewable energy penetration in the Western Interconnection require improvements in the technical and institutional ability to integrate higher levels of wind on the western grid. State energy policy and utility regulatory officials need to be informed on new state-of-the-art wind integration studies and potential opportunities to facilitate wind integration in the power system.

The Western Wind Strategy project has been on the forefront of identifying and informing state regulators and policy makers of critical issues related to wind energy and the integration of variable generation. The project has spawned major initiatives such as the investigation by Western PUCs of a Western Energy Imbalance Market, the development of a report to Western Governors on actions to lower the cost of integrating variable generation and the future development of an Internet dashboard on actions by Western companies to lower integration costs. The project served as a role model for other regions to develop wind energy resources.