An Analysis of the Impact of Balancing Area Cooperation on the Operation of WECC and the Compounding Effect of Wind and Solar Generation

Gary Jordan and Dick Piwko

GE Energy

Wilmington, Delaware

NREL Technical Monitor: Debra Lew

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Subcontract Report

NREL/SR-5500-53095

February 2013

Contract No. DE-AC36-08GO28308

An Analysis of the Impact of Balancing Area Cooperation on the Operation of WECC and the Compounding Effect of Wind and Solar Generation

Gary Jordan and Dick Piwko
GE Energy
Wilmington, Delaware

NREL Technical Monitor: Debra Lew

Prepared under Subcontract No. AAM-8-77557-01

National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, Colorado 80401
303-275-3000 • www.nrel.gov

Subcontract Report
NREL/SR-5500-53095
February 2013

Contract No. DE-AC36-08GO28308

This publication received minimal editorial review at NREL.

Available electronically at http://www.osti.gov/bridge

Available for a processing fee to U.S. Department of Energy
and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone: 865.576.8401
fax: 865.576.5728
email: mailto:reports@adonis.osti.gov

Available for sale to the public, in paper, from:

U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
phone: 800.553.6847
fax: 703.605.6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/help/ordermethods.aspx

Cover Photos: (left to right) PIX 16416, PIX 17423, PIX 16560, PIX 17613, PIX 17436, PIX 17721

Printed on paper containing at least 50% wastepaper, including 10% post consumer waste.

An Analysis of the Impact of Balancing Area Cooperation on the Operation of WECC and the Compounding Effect of Wind and Solar Generation

Introduction

One of the issues that arose in the Western Wind and Solar Integration Study, WWSIS, was the impact of Balancing Area (BA) size and the amount of coordination and cooperation necessary. Most of the production simulation cases in WWSIS assumed that the thermal and hydro generation in WECC would coordinate within the limits of the transmission system to best address variability and uncertainty imposed by wind and solar generation. This analysis uses a similar production simulation database, but with varying BA sizes and hurdle rates to examine this question in greater detail.

WWSIS used a Western Electricity Coordinating Council (WECC) database developed from Ventyx data in 2008. The system was broken into 104 separate load and generation areas and used a simple “bubble model” to represent transmission constraints. This new database uses the November 2010 Ventyx version of a key source and uses a full transmission system representation. In both cases, the year 2017 was chosen for simulation. The average price assumed for natural gas was $7.50/Mbtu and carbon costs were ignored. The new version of the database models WECC with 41 load and generation areas that are largely aligned with the existing BAs in the WECC system. These areas were grouped into 28 companies and five large regions. These are defined in Table 1 and shown in Figure 1. Note that all the “areas” within the California Independent System Operator (CAISO) footprint were grouped into one “company” called CAISO.

It is not the intent of this analysis to exactly model the operation of the BAs within WECC. Rather, it is to examine the operational benefits of increased cooperation between a large number of operating regions. To that end, some approximations were taken with the data. Although they operate mostly independently, the separate companies do have remotely owned and jointly owned generation. Where that information was available, it was included in the analysis. In addition, each company was required to maintain a spinning reserve equal to 3% of the hourly load in this simulation.

Table − 1 Breakdown of Areas, Companies, and Regions.

Area Abrieviation	Area Name	Company Name
AESOA	Alberta	AESO_CO
AZPSA	Arizona Public Service Co	AZPS_CO
EPEA	El Paso Electric	EPE_CO
NEVPA	Nevada Power Co	NEVP_CO
PNMA	Public Service Co of New Mexico	PNM_CO
SRPA	Salt River Project	SRP_CO
TEPCA	Tucson Electric Power Co	TEPC_CO
WALCA	WAPA - Desert Southwest	WALC_CO
CFEA	CFE - North Baja California	CAISO_CO
CISOPGEA	Pacific Gas & Electric - Main	CAISO_CO
CISOSCEA	Southern California Ediso	CAISO_CO
CISOSDGA	San Diego Gas & Electric	CAISO_CO
CISO-SFA	Pacific Gas & Electric - ZP26	CAISO_CO
CISOZ26A	Pacific Gas & Electric - SF	CAISO_CO
IIDA	Imperial Irrigation District	CAISO_CO
LDWPA	Los Angeles Department of Water and Power	CAISO_CO
SMUDA	Sacramento Municipal Utilities District	CAISO_CO
TIDA	Turlock Irrigation District	CAISO_CO
AVAA	Avista	AVA_CO
BCTCA	British Columbia Hydro and Power Authority	BCTC_CO
BPATA	Bonneville Power Administration	BPAT_CO
CHPDA	PUD No 1 of Chelan County	CHPD_CO
DOPDA	PUD No 1 of Douglas County	DOPD_CO
GCPDA	PUD of Grant County	GCPD_CO
IPCOA	Idaho Power	IPCO_CO
NWMTA	Northwestern Energy - Montana	NWMT_CO
PACE-IDA	PACE - Idaho	PACE_CO
PACE-UTA	PACE - Utah	PACE_CO
PACE-WYA	PACE - Wyoming	PACE_CO
PACWA	Pacificorp West	PACW_CO
PGEA	Portland General Electric	PGE_CO
PSEIA	Puget Sound Energy	PSEI_CO
SCLA	Seattle City Light	SCL_CO
SPPCA	Sierra Pacific Power Co	SPPC_CO
TPWRA	Tacoma Public Utilities-Tacoma Power	TPWR_CO
WAUWA	WAPA - Upper Great Plains	WAUW_CO
PSCO-EA	Public Service of Colorado - East	PSCO-E_C
PSCO-WA	Public Service of Colorado - West	PSCO-W_C
WACM-CEA	WAPA - Colorado Missouri (Colorado East)	WACM_CO
WACM-CWA	WAPA - Colorado Missouri (Colorado West)	WACM_CO
WACM-WYA	WAPA - Colorado Missouri (Wyoming)	WACM_CO

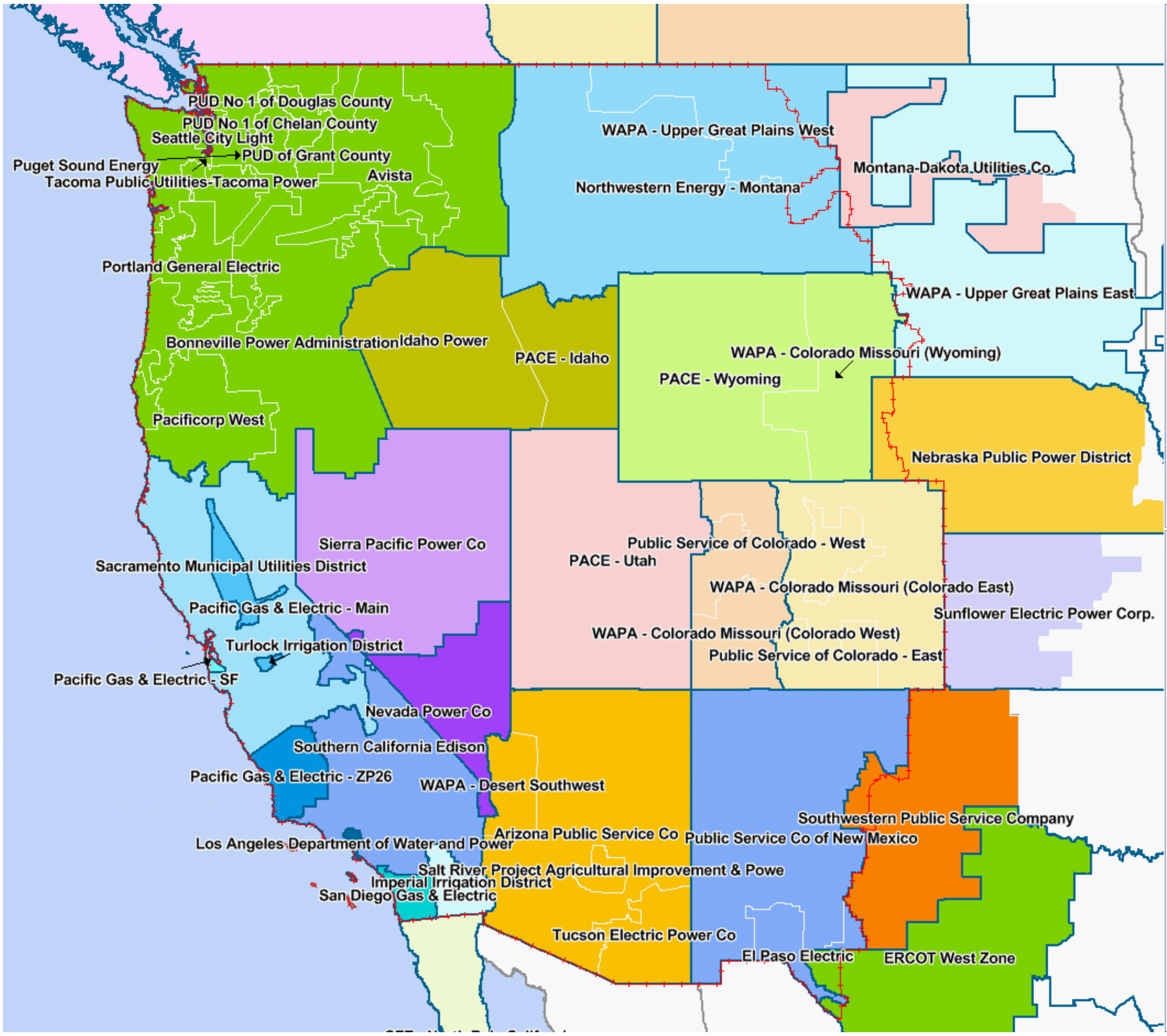

Figure 1 – Map of WECC areas.

Source: Ventyx, 2010.

Methodology

Even in an environment of BA cooperation, it was felt that there would be some threshold on the economic interchange of energy. To model this, a $5/MWh "hurdle rate" was assumed between the neighboring companies in both the commitment and dispatch in the "ideal" case, which represents a high level of BA cooperation. With this assumption, neighboring companies would commit additional generation for sale if their cost were at least $5/MWh cheaper than the current bid price. Similarly, companies would de-commit generation if it appeared to be cheaper to purchase it from someone else. This "optimum" commitment would then be used in the real time dispatch and the energy interchange would take place as long as the hurdle rate was exceeded and the transmission system allowed.

To approximate a level of reduced cooperation, a $25/MWh hurdle rate was assumed in both generation commitment and dispatch. This would largely eliminate energy interchange unless there was an extreme difference in price.

An intermediate step was also modeled that assumed a $25/MWh hurdle rate in the commitment. In this way, the day-ahead commitment would predominantly use each company's generation resources to meet their load. In the real-time dispatch, the hurdle rate was lowered to $5/MWh so that increased economical interchange could take place among the committed generators.

These three levels of operation were then coupled with two penetration levels of wind and solar generation. The lowest level only modeled the renewable generation in place by the end of 2008. This was a negligible amount of solar and slightly over 2% energy penetration for wind (~ 7,500 MW). This roughly corresponds to the "Preselected" scenario in WWSIS. The next level included announced sites along with additional generation to meet projected Renewable Portfolio Standards (RPS) by 2017. This was slightly over 1% penetration for the solar (~8,000 MW) and 6% for wind (~22,000 MW). Wind and solar contribution patterns were drawn from the WWSIS database. Future analysis beyond the scope of this study may examine higher levels of wind and solar energy penetration.

The entire analysis was then repeated with the hurdle rates only imposed between the five regions. This represents a high level of regional coordination with varying levels of inter-regional cooperation. In these cases, each region was required to carry a spinning reserve equal to 3% of the load. The 6 cases examined are summarized in Table 2.

Table 2 − Scenario case matrix.

		Company level operation	
Commitment hurdle rate	**Dispatch hurdle rate**	**Low renewable penetration**	**Medium renewable penetration**
$5/MWh	$5/MWh	X	X
$25/MWh	$5/MWh	X	X
$25/MWh	$25/MWh	X	X

Results

The total operating costs for the various cases are shown in Figure 2. The general trends are as expected. Increasing the boundaries between the companies, in either just the commitment or for both the commitment and dispatch, increases the total operating costs. The spinning reserve was held at 3% of load in all cases. In practice, the company-level spinning reserve may need to be higher than assumed here because 3% of the load may not be sufficient to cover generator contingencies in all hours. Increasing the penetration of renewable generation reduces the total operating costs, but shows the same general trends.

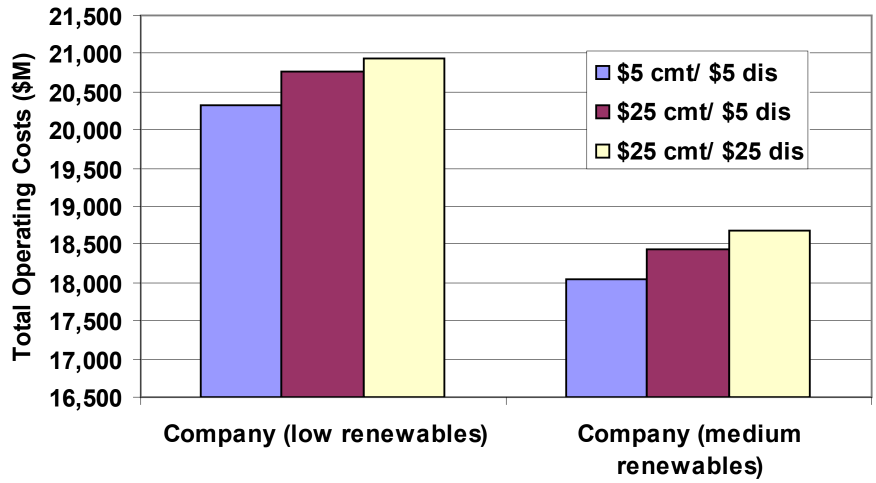

Figure 2 − Total operating costs.

Figure 3 shows the reduction from the high hurdle rate case for commitment and dispatch. This figure highlights the fact that increasing the coordination between the companies in both the commitment and dispatch will significantly increase the overall savings. (Note: Reducing the commitment and dispatch hurdle rate below the $5/MWh level did not have any significant impact on the operating costs. That indicates that it is the trade off of gas and coal energy that is providing the savings and not just the incremental value of slightly better heat rates.) Reducing the hurdle rate in the dispatch only and keeping the same level of commitment provides 20% to 40% of the total savings potential.

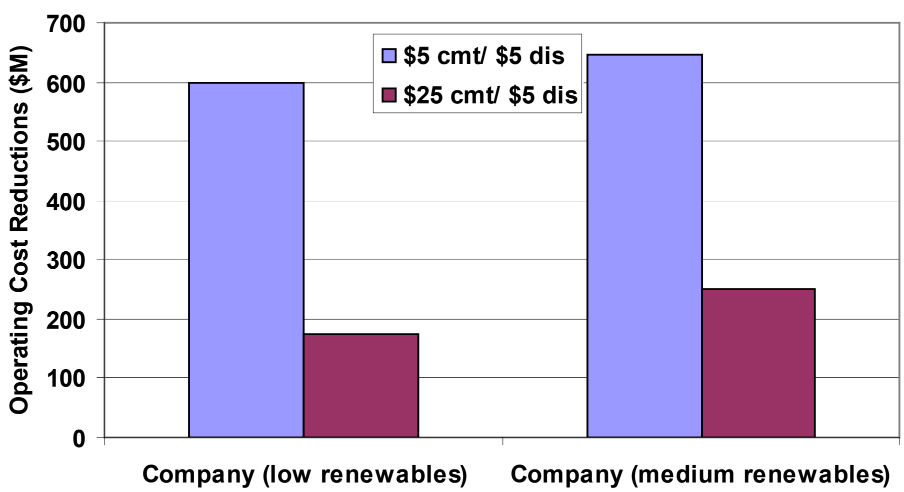

Figure 3 − Operating cost reductions from high hurdle rates.

Another aspect of operation with renewables is the amount of spilled energy (i.e., wind or solar or hydro energy that could not be used). Figure 4 shows that low levels of cooperation in the company level dispatch results in higher levels of spilled energy. This shows that increasing the level of cooperation in the real time dispatch, even without modifying the commitment, will significantly reduce the amount of spilled energy. This result is even more important as the penetration levels increase.

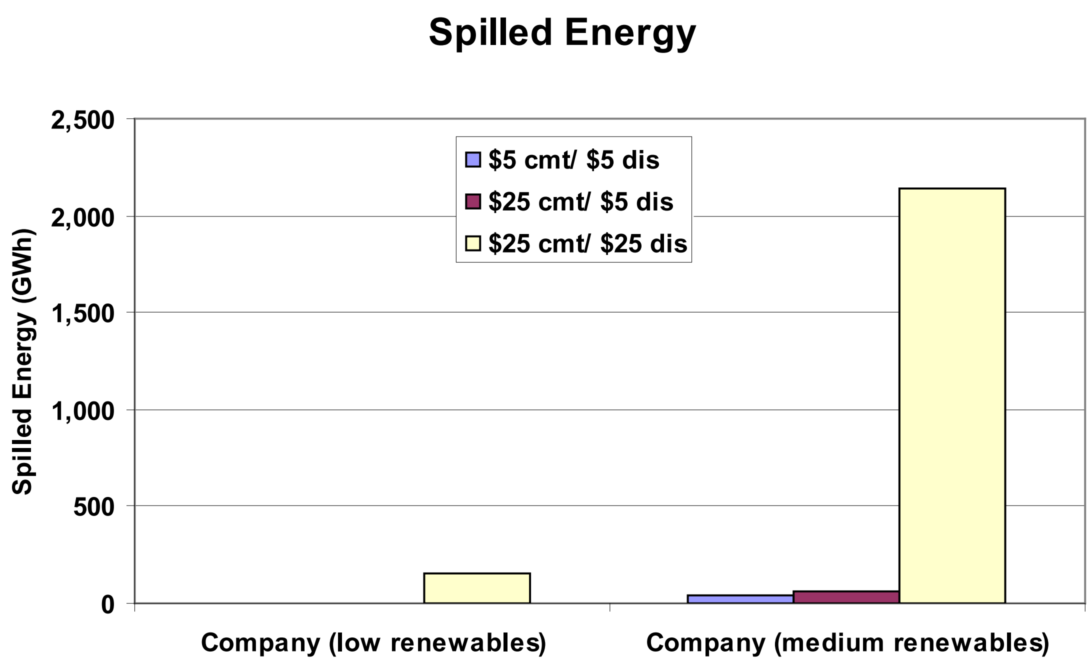

Figure 4 − BA impact on WECC-US spilled energy.

Figure 5 shows the impact on the level of generation by type for the company-level dispatch. For both levels of renewable penetration, increasing the hurdle rates for either just the commitment or for both the commitment and dispatch will reduce the operation of the base and intermediate generators (coal and combined cycle), and increases the generation from peaking units (gas turbines and gas steam units). Increasing the dispatch hurdle rate encourages companies to operate higher cost resources rather than taking advantage of cheaper resources available on neighboring systems. Having a high hurdle rate in the commitment makes a company less likely to turn on a low cost resource to sell to their neighbor.

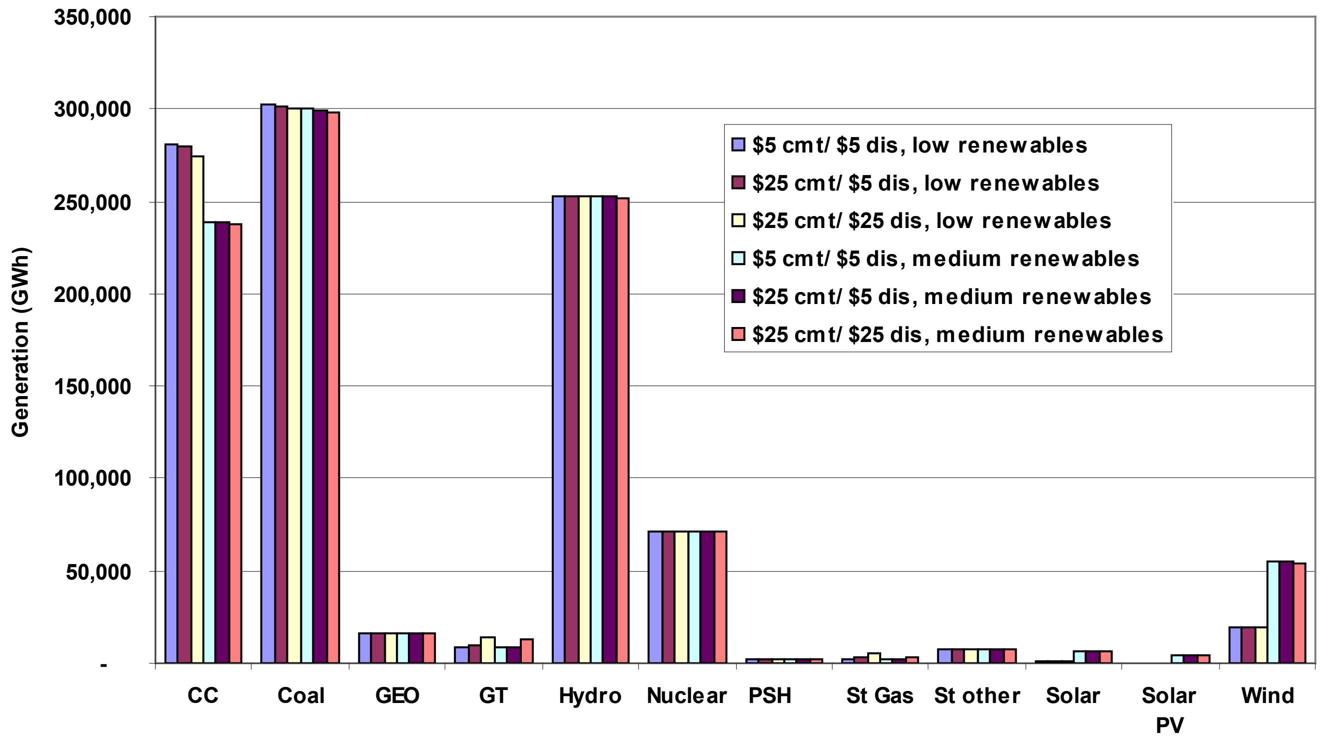

Figure 5 − Generation by type and company-level operation.

Conclusions

Increasing the cooperation between the many BAs within WECC can significantly reduce operating costs. Increased BA cooperation becomes more beneficial as levels of renewable generation increase. Maintaining existing commitment strategies, but increasing coordination in the real-time dispatch will significantly reduce the amount of spilled energy, but will only capture 20% to 40% of the total operating cost savings potential. The maximum savings result when both commitment and dispatch of generation is coordinated across the system.