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Dynamic Transfers

Dynamic Transfers for Renewable Energy in the Western Interconnection

Western Renewable Energy Zones Initiative - Phase III

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Acronyms

ACE	Area Control Error
APS	Arizona Public Service Company
BPA	Bonneville Power Administration
CAISO	California Independent System Operator
DSS	Dynamic Scheduling System
EIM	Energy Imbalance Market
FERC	Federal Energy Regulatory Commission
ITAP	Intra-Hour Transaction Accelerator Project
LMP	Locational Marginal Prices
NERC	North American Electric Reliability Corporation
NWPP	Northwest Power Pool
NSI	Net Scheduled Interchange
PNM	Public Service Company of New Mexico
RAS	Remedial Action Scheme
SPP	Southwest Power Pool
SRP	Salt River Project
VER	Variable Energy Resource
WECC	Western Electricity Coordinating Council
WIST	Wind Integration Study Team
WREZ	Western Renewable Energy Zones

Foreword

The Western Governors' Association initiated the Western Renewable Energy Zones (WREZ) project in 2008 to support development of areas with abundant, high-quality renewable resources along with the transmission network needed to deliver the energy to load centers.[1] Nine states in the Western Interconnection have chosen to require that an increasing portion of their electricity needs be met with renewable resources, and the WREZ project seeks to support these states in cost-effectively meeting their respective goals.

The WREZ project has been divided into three phases. Whereas WREZ phases 1 and 2 sought to characterize commercial renewable energy zones and to produce conceptual transmission plans to deliver energy from these zones to load centers, WREZ phase 3 explores how coordination among utilities to procure resources and build transmission can provide jointly beneficial outcomes for western states.[2] WREZ phase 3 resulted in a survey of procurement and transmission development practices in the West,[3] followed by a report, "Meeting Renewable Energy Targets in the West at Least Cost: The Integration Challenge."[4] The "Integration Challenge" report identifies nine "integration actions" that can support states in meeting their respective renewable targets. One of those recommended actions is to facilitate dynamic scheduling between balancing authorities.

This report provides regulators and policymakers with an examination of historical and emerging uses of dynamic transfers. The report describes the distinct role that dynamic transfers play in keeping integration costs down and also evaluates how dynamic transfers relate and interact with the intra-hour scheduling and energy imbalance market (EIM) initiatives in the West. The report also considers how the location of renewable generation, balancing resources, and transmission affect the ability to employ dynamic transfers. The report concludes with a discussion of priorities for transmission system capital and operational improvements that could alleviate restrictions on the use of dynamic transfers, and recommends metrics that regulators and policymakers can use to track the progress being made by utilities and balancing authorities in the western states and provinces.

Carl Linvill
Principal
Regulatory Assistance Project

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[1] Western Governors' Association. Kick-off meeting for the Western Renewable Energy Zones Project set for May 28 in Salt Lake City. Available at: http://www.westgov.org/news/77-news-2008/109-kick-off-meeting-for-western-renewable-energy-zones-project-set-for-may-28-in-salt-lake-city-52208.

[2] Western Governors' Association. (2008, July). Western Renewable Energy Zones Workplan.

[3] Western Governors' Association. (2012, March). Renewable Resources and Transmission in the West: Interviews on the Western Renewable Energy Zones Initiative. Prepared by the Regulatory Assistance Project. Available at: http://www.westgov.org/component/docman/doc_download/1555-wrez-3-full-report-2012?Itemid=.

[4] Western Governors' Association. (2012, June). Meeting Renewable Energy Targets in the West at Least Cost: The Integration Challenge. Prepared by the Regulatory Assistance Project,. Available at: http://www.westgov.org/component/docman/doc_download/1610-meeting-renewable-energy-targets-in-the-west-at-least-cost-the-integration-challenge-full-report?Itemid=.

Executive Summary

"Dynamic transfer" is a coordinated, transfer of firm energy between balancing area authorities (BAA). In the absence of dynamic transfers, all energy transferred between BAAs operates on a "static" schedule. A static schedule is submitted 20 to 75 minutes before the onset of the hour for which the schedule will apply, and it is not adjusted during that hour. With dynamic transfers energy can be scheduled more than an hour ahead or within the hour down to intervals as brief as four seconds. Dynamic transfers are made on a "firm" delivery basis. Transferring energy on a firm basis within the hour is important because the receiving BAA can depend on the delivery of the energy with a very high level of certainty. With increasing quantities of variable energy resources being developed, managing intra-hour energy variability is more important than ever. Dynamic transfer provides a mechanism for BAAs to help each other in managing variability at least cost.

Dynamic transfers have been used for decades to support firm energy exchanges between BAAs scheduled one or more hours ahead. Dynamic transfers have played an important role in facilitating the use of energy from the Palo Verde Nuclear Generating Station and the Four Corners Power Plant for decades. The Hoover Dam and BC Hydro System have used dynamic transfers to support ancillary services, real-time balancing and regulation for years. While sharing ancillary services has occurred in these few places for some time, improvements in information, communications and electricity system control technologies and improvements in communication between BAAs over the last decade have enabled increasing use of dynamic transfer on an intra-hour basis. Intra-hour dynamic transfer allows BAAs to share a wide variety of ancillary services including operating reserves, load following, energy balancing and regulation reserves. A recent example is the Sutter Generation Station in California which has taken advantage of dynamic transfers to provide ancillary services to the California Independenty System Operator (CAISO).

The benefit of using dynamic transfers in these traditional applications is to effectively increase the quantity of resources available to utilities and other energy providers within a BAA to meet its energy needs. The basic engineering of electric system operation directly implies that increasing the quantity of resources available to meet reliability requirements improves reliability. The simple economics of supply and demand directly imply that an increase in supply results in a price decrease for consumers. Dynamic transfer thus facilitates improved reliability at reduced cost.

Dynamic transfers have started to be used in the last few years to support BAA management of renewable energy variability. Dynamic transfer can support variability management by facilitating the exchange of diverse and complementary variable resources among balancing areas thus reducing variability in both BAAs. Dynamic transfer can also help manage renewable energy variability by giving BAAs with a relatively large load and relatively plentiful flexible resources direct control of imported variable resources. Transferring the integration obligation to BAAs with the ability to handle large quantities of variable resources supports the development of high quality renewable energy in remote areas and gives the receiving BAA access to lower cost or complementary variable resources. Some renewable energy facilities are already using dynamic transfers and more are expected to follow. Several recent examples include: Argonne Mesa in New Mexico, Arlington Valley Solar in Arizona, Copper Mountain in Nevada, and Hudson Ranch and CE Turbo Geothermal facilities in California.

The addition of large quantities of variable energy resources and an interest in developing high quality renewable resources in remote locations have spawned a number of initiatives in the West aimed at facilitating further renewable development and reducing the cost of integrating variable resources into the grid. The potential benefits motivating these initiatives include:

1. Supply diversification arising from geographic and resource differences in production profiles
2. Reduced cost associated with shifting the obligation

of balancing intermittent resources to BAAs that are better suited to provide balancing services
3. Increased reliability and reduced cost associated with increasing the size of the pool of resources for intra-hour services
4. More effective stabilization of load and renewable energy variability

However, in order for the initiatives to produce maximum benefit for consumers, a substantial increase in dynamic transfer will be required. Some of the more prominent initiatives are:

1. Dynamic Scheduling System (DSS)
2. Intra-Hour Transaction Accelerator Project (ITAP)
3. CAISO and Bonneville Power Administration (BPA) Mid-hour Dispatch
4. FERC Order 764 (15-minute scheduling order)
5. Energy Imbalance Market (EIM)

While dynamic transfers are highly beneficial, technical and commercial barriers to further deployment of dynamic transfers exist. Technical barriers range from limited useable transmission capacity to grid management limitations arising from the need for improved technology and data. Commercial barriers range from incomplete information on the relative value of using transmission capacity for dynamic transfers to the absence of cost allocation mechanisms to fairly share the cost of facilitating increased dynamic transfer.

A complete set of solutions to overcome the technical and commercial barriers are discussed in the paper but the highest priority actions that regulators and policy makers can take to increase the availability and use of dynamic transfer include:

1. Improve visibility of transmission system conditions by acquiring additional data and making better use of computer modeling to assess reliability.
2. Evaluate the need for an increase grid operations staff and increasingly incorporate results of real-time transmission assessment into operations.
3. Improve transmission system control and automation, including integrating actions with results from real-time transmission assessment.
4. Incorporate dynamic transfer limits and benefits of increasing limits in longer-term transmission planning assessments to ensure that transmission system upgrades include the need for dynamic transfer of energy between balancing areas.

Regulators and policy makers in western states and provinces can evaluate the relative performance of its jurisdictional utilities and BAAs by assessing their performance relative to these four metrics and establish benchmarks to track their respective progress toward increasing the availability and use of dynamic transfers.

1. What is Dynamic Transfer?

The term "dynamic transfer" is used to describe a coordinated intra-hour transfer of energy between two balancing authorities. A dynamic transfer enables the transfer of energy on a "firm basis" so the receiving balancing authority can be depend on the delivery of the energy with a very high level of certainty. In the absence of dynamic transfers, all energy transferred between balancing areas operates on a "static" schedule. A static schedule cannot be adjusted within the hour scheduling period once the schedule is submitted to the system operator. With dynamic transfers, energy transferred between balancing areas can vary intra-hour and the exchanges can be made on a firm delivery basis.

1.1 Dynamic Transfer Overview

There are 38 balancing authorities in the Western Interconnection that are responsible for operating a transmission balancing area. Within each area, the balancing authority matches generation with load on a real-time basis to maintain electric frequency of the grid.[5] Balancing authorities maintain frequency primarily by controlling the dispatch of generation and scheduling of transmission assets within their own balancing area. However, balancing authorities also arrange for the transfer of energy between their respective balancing areas.

Currently, the standard scheduling interval for energy transfers between balancing authorities in the Western Interconnection is one hour. That means energy transfers between balancing authorities are scheduled one hour in advance, and the amount of energy transferred is held constant for one whole hour. This type of transfer is referred to as a "static transfer," and scheduling using the standard one-hour interval is referred to as "static scheduling."

A dynamic transfer differs from a static transfer in that the amount of energy transferred between balancing areas can vary from one sub-hourly interval to the next on an intra-hour basis, within prescribed limits. The sub-hourly intervals can be as long as 30 minutes or as short as two to four seconds. This intra-hour scheduling flexibility is the key difference between a dynamic energy transfer and a static energy transfer.

1.2 How It Works

Dynamic transfer is effectively utilized today primarily to allow an **end-use balancing authority** that requires energy delivery to call upon generators interconnected to a neighboring **host balancing authority** to increase or decrease generation in the host balancing authority.[6] This type of dynamic transfer will be referred to as dynamic transfer with control signal (Figure 1-1). Using energy from a neighboring host balancing authority allows an end-use balancing authority to take advantage of resources located in other balancing areas to respond to second-to-second electricity shortages or surpluses in the end-use balancing authority at least cost. This process allows for the efficient use of generating resources such that balancing authorities rich in regulating capability can provide regulation services to those that have less regulation capability. Typically the end-use balancing authority customers benefit from lower cost and/or greater reliability, and the host balancing authority customers benefit by having the end-use neighbor accept part of the capacity cost of the host generating facility.

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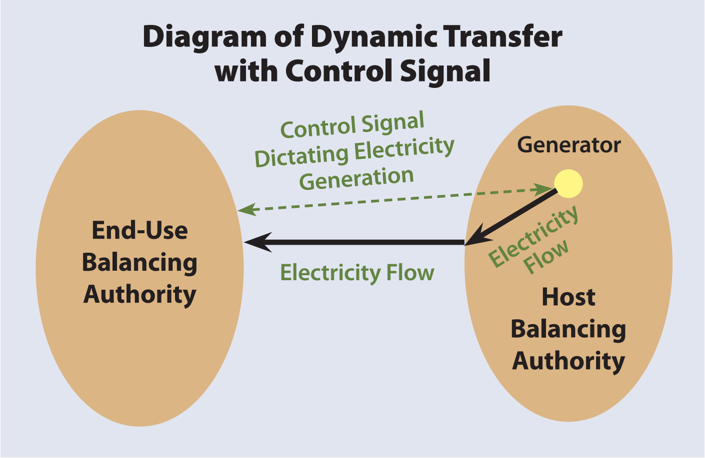
[5] An overview of balancing authorities is available in Appendix A for readers who want more information.

[6] The action of generators called upon to increase or decrease energy output in response to a control signal is called "regulation." Regulation is a vital component of electric grid operation. Regulation compensates for fluctuations in consumers' energy consumption and electricity production to ensure that the amount of energy being consumed is equal to the amount of energy being produced at any instant within a balancing area.

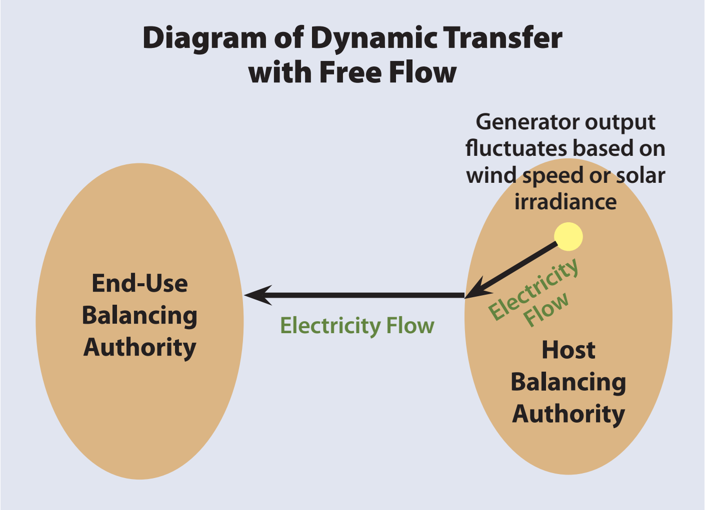
Figure 1-1



Balancing authorities may also use the dynamic transfer to share the output of resources. In the case of jointly owned generating facilities whose output is shared between multiple owners in different balancing areas, the end-use balancing authorities receive data indicating their share of output from the generation facility. That energy can vary within the scheduling period, requiring the ability for energy transfers between balancing authorities to vary intra-hour, which means a dynamic transfer is necessary.

With the advent of large amounts of renewable generation interconnecting to the electric grid, the process of dynamic transfer is evolving. Rather than a host balancing authority's generation responding and dynamically transferring electricity to an end-use balancing authority based on a control signal, the dynamic transfer flows freely between balancing authorities based on the generator's ability to produce electricity in response to varying wind speed or solar irradiance. This is similar to the use of dynamic transfers for jointly owned generating facilities described previously. This type of dynamic transfer will be referred to as dynamic transfer with free flow (Figure 1-2).

Figure 1-2



1.3 Uses of Dynamic Transfer

More than 90 percent of the energy transfers between balancing authorities in the Western Interconnection are currently static transfers. However, dynamic transfers are not a new operational concept in the ever-changing electricity markets. As the electricity markets continually change and evolve, the tools and practices implemented to support those markets and associated functions also mature and grow in response.

Both of the methods for dynamic transfer have been used extensively across the Western Electric Coordinating Council (WECC) for decades to allow balancing authorities to share resources and services for a number of purposes. Additionally, both methods are already used to take advantage of regional generation diversity and could be used to a far greater extent.

One of the first and longest-running functions that dynamic transfers have supported throughout the WECC is split unit share of large generators, in those cases where a number of utilities share ownership or have contractual arrangements that allow sharing of the output from those resources. Notable examples of split unit share include the Four Corners Power Plant in New Mexico (depicted in Figure 1-3) and the Palo Verde Nuclear Generating Station in Arizona.

Dynamic transfer with control signal also allows for balancing authorities with surpluses of flexibility to provide regulation and operating reserves to those balancing authorities that are short flexibility and/or operating reserves. Historically, dynamic transfers have been designed and utilized to support the following reliability functions:

- Ancillary services/operating reserve imports;
- Ancillary services/regulation imports;
- Real-time market balancing energy dispatch; and
- Load following.

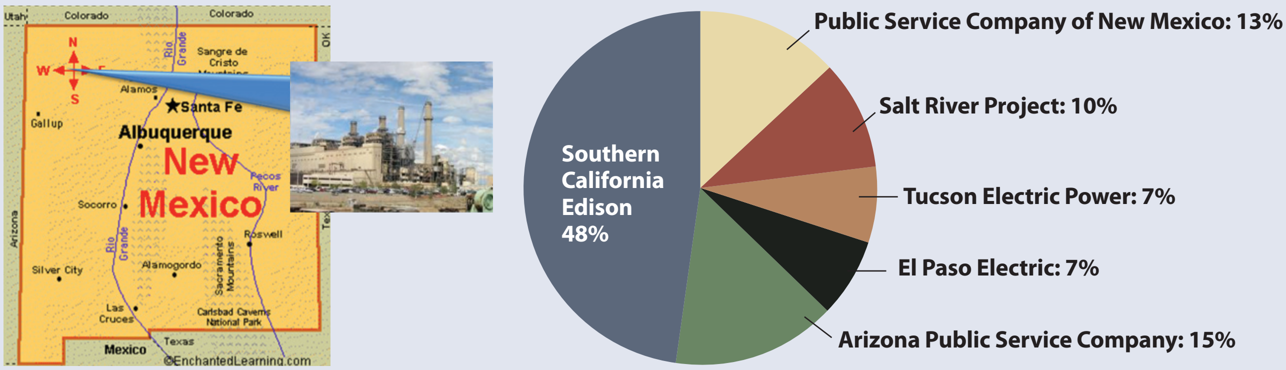
More recently, dynamic transfers have been utilized to support renewable and variable energy resource (VER) import scheduling. Dynamic transfer with free flow allows

Figure 1-3

Split Unit Share at Four Corners Power Plant, NM

Dynamic transfer enables generators with multiple owners to "divvy up" the energy output produced by the generator and schedule the energy to serve load in their respective BAAs.

Four Corners Power Plant Ownership, Units 4 & 5



for balancing authorities rich in renewable resources to transfer the variable energy output to the end-use balancing authority as it is produced. Both dynamic transfer methods allow for sharing of flexible resources[7] between balancing authorities that need to balance load and generation on a second-to-second basis.

Dynamic transfer can be used to allow imported resources to serve as ancillary services. In order for a resource to qualify as an operating reserve or to provide regulation service, energy imbalance service or load following service, the receiving BAA must have assurance that the resource will be available on a firm basis with the quantity promised within the time frame promised from the delivering BAA. The CAISO use of the Sutter Energy Center (which is in California but outside of the CAISO BAA boundary) is an example where dynamic transfer is being used to support operating reserve, regulation service, energy imbalance service and load following services. The BC Hydro System in British Columbia and the Hoover Dam in Nevada are examples of resources that provide regulation service, energy imbalance service and load following service to proximate and remote BAAs.

Dynamic transfer can also be used to support renewable or variable energy resource (VER) import scheduling. Examples of renewable resources that are dynamically

Figure 1-4

Examples of Dynamic Transfers Across the Western Interconnection

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[7] Flexible resources are generators that can be called upon by grid operators to increase or decrease energy output in response to second-to-second surpluses or shortages of generation. Flexible resources are utilized to provide regulation.

scheduled to serve a remote BAA include:

- Aragonne Mesa Wind in New Mexico
- Copper Mountain Solar in Nevada
- Arlington Valley Solar in Arizona
- CE Turbo Geothermal in California
- Hudson Ranch Geothermal in California

1.4 Clarifying the Difference Between Dynamic Schedules and Pseudo-Ties

Dynamic transfer with control signal and dynamic transfer with free flow can be deployed using a pseudo-tie or a dynamic schedule. Both pseudo-ties and dynamic schedules are utilized to accomplish the same objective, that is, to transfer energy between balancing authorities at a rate that can vary every two to four seconds as opposed to holding constant for a full hour-long scheduling period.

The difference between pseudo-ties and dynamic schedules is that pseudo-ties transfer all scheduling and dispatch of a generator from its host balancing authority to a specific end-use balancing authority, which means that all the output from the generator serves the end-use balancing authority. With a pseudo-tie, the generator becomes a part of the end-use balancing authority. Dynamic scheduling maintains the generator in the host balancing authority, which allows for the output to be scheduled between multiple end-use balancing authorities.

2. Evolution of Dynamic Transfer Uses

2.1 Dynamic Transfer Today

Dynamic transfers have allowed balancing authorities to share resources that otherwise would not have been shared. The previous section of the paper provided a number of examples in which dynamic transfer has been beneficial, ranging from facilitating split-share ownership of large base-load facilities to supporting ancillary service provision. Split-share ownership of base-load generation reduces cost by enabling economies of scale. Sharing flexible generation resources among balancing authorities allows utilities to draw upon least-cost resources to meet local needs and can obviate the need for some local generation investment. Other examples can be offered, but it suffices to say that regardless of the use of dynamic transfer, the benefits include lower costs and improved reliability.

The key requirements for effective use of dynamic transfers are availability of electric transmission capacity, effective communication between balancing authorities, and the prospect of mutually beneficial exchange. The prospect of benefits motivates the effort, but the ability to transmit energy from one balancing area to another is contingent upon firm transmission capacity between balancing authority areas being open and available for use. In addition, operators must establish communication and operational procedures that allow for seamless coordination between and among balancing authority areas.

Many balancing authorities have used dynamic transfer to enable a beneficial exchange. Although the purposes of the energy exchanges vary, each dynamic transfer required assignment of the necessary transmission capacity and establishment of the necessary communication and operations procedures. Currently, 28 of the 38 balancing authorities in the WECC have used dynamic transfer to enable a beneficial exchange.[8]

2.2 Dynamic Transfer: Emerging Uses

With an increasing number of renewable generation resources interconnecting to the grid, power system engineers have recently looked to dynamic transfers as a tool to allow for more efficient use of the western grid to integrate renewable resources. Aggregating the increment and decrement balancing needs created by variable generation resources among balancing authorities can reduce the net need for integration resources. Sharing resources from around the grid to meet the residual need for integration resources can reduce the cost of meeting the net requirements. Together, reducing the net need and accessing regional resources create benefits for electricity consumers by reducing the cost of maintaining reliable service.

One approach that uses dynamic transfers to support least-cost renewable resource integration is to allow energy transfer from areas where high-quality renewable energy generation potential is abundant but local demand for electricity is relatively small to areas where there is both

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[8] The 28 balancing authorities include: Avista, Arizona Public Service (APS), Balancing Area of Northern California, British Columbia Transmission Corporation, BPA, CAISO, Arlington Valley, El Paso Electric, PUD No. 2 of Grant County, Gila River Maricopa County, NaturEner Power Watch, Harquahala, Imperial Irrigation District, Idaho Power Company, Los Angeles Department of Water and Power, Nevada Power Company, Northwestern Energy, PacifiCorp-East, PacifiCorp-West, Portland General Electric, Public Service Company of New Mexico (PNM), Sierra Pacific Power, Salt River Project (SRP), Tucson Electric, Tacoma Power, Western Area Power Administration – Colorado-Missouri, Western Area Power Administration – Lower Colorado, Western Area Power Administration – Upper Great Plains West.

a high level of demand for electricity and a high level of demand for renewable resources. Such an exchange allows balancing authorities in the former situation to transfer the obligation of addressing generation variability to balancing authorities that have a greater capacity to accommodate this variability due to their relatively large demand and better access to flexible resources. Balancing authorities that currently employ dynamic transfers for renewable resources include: APS, BPA/Northwest, CAISO, Nevada Power Company, PNM, Imperial Irrigation District, and SRP.

As renewable energy penetration has increased over the last few years, a number of grid operation innovations have been proposed to facilitate increased intra-hour exchanges. Each proposal has a common objective of enhancing utilization of the electric grid by taking advantage of resource and geographic diversification, and increasing the pool of resources available to balancing authorities to balance load with supply. These initiatives include:

- The Joint Initiatives efforts of the Northwest Power Pool (NWPP), WestConnect, and Western Area Power Administrator (WAPA) to:
  - establish a DSS bulletin board
  - establish an ITAP;
- The NWPP's Regulation Sharing Plus initiative;
- The BPA and the CAISO 30-minute scheduling pilot;
- The NWPP's De-Centralized Energy Imbalance Exchange initiative;
- FERC Order 764 Intra-Hour Scheduling requirements;
- The WECC's Efficient Dispatch Toolkit and Enhanced Curtailment Calculator; and
- The CAISO – PacifiCorp EIM.

Each initiative has the potential of increasing intra-hour exchanges between balancing authorities and producing cost savings for participants. Each initiative also depends on the ability to transfer energy between balancing areas on a firm basis within the hour so they depend on dynamic transfer.

3. Benefits of Dynamic Transfers

Dynamic transfers facilitate energy and energy services exchanges between balancing authorities that:

- Support energy delivery hours ahead of or in real time;
- Deliver energy from adjacent balancing areas or between remote balancing areas; or
- Deliver energy or several types of ancillary services on a firm basis.

Taken together, these uses of dynamic transfers increase the supply of resources and energy services available to each participating balancing authority and thus decrease cost and improve reliability for each participant. Dynamic transfer exchanges produce benefits for participants by more effectively stabilizing load within the hour, increasing the pool of available energy services, and reducing the cost of renewable energy integration.

3.1 Dynamic Transfers Stabilize Load Within the Hour

The standard scheduling interval for energy transfer between balancing authorities is one hour. This means that energy transfers between balancing authorities are held constant for the entire hour. Balancing authorities thus make up for second-to-second variations in load-resource balance with resources within their area.

Implementing tools to reduce the energy transfer scheduling interval from the standard one-hour interval length of today to 15 minutes or less allows balancing authorities to forecast and schedule closer to the operating interval. By reducing the granularity of the scheduling period from one hour to 15 minutes or less, schedules are more closely aligned with varying load and renewable energy resources. The figure below illustrates how reducing the scheduling period granularity works to better match varying production or consumption with schedules.

Table 3-1

Comparison of Varying Load or Resource With One-Hour, 15-Minute, and 5-Minute Scheduling Periods

Scheduling Interval	Variable Resource or Load (MW)	One-Hour Schedule (MW)	15-Minute Schedule (MW)	5-Minute Schedule (MW)
1	10	14	11.67	10
2	12	14	11.67	12
3	13	14	11.67	13
4	15	14	15.33	15
5	15	14	15.33	15
6	16	14	15.33	16
7	12	14	13	12
8	14	14	13	14
9	13	14	13	13
10	15	14	16	15
11	16	14	16	16
12	17	14	16	17
Total MWh/hour	**14**	**14**	**14**	**14**

Although all three scheduling intervals are equal when averaged over one hour and match the variable resource or load during the hour (14 MW), the hour-long scheduling interval provides 14 MW for the whole hour. Any 5-minute interval is off by anywhere between negative 3 MW and positive 4 MW. The 15-minute scheduling interval reduces the difference in any interval to negative 1.33 MW to positive 1.67 MW. And the 5-minute interval has no difference.

The concept of reducing the granularity of the scheduling interval allows balancing authorities to modify schedules more frequently to better match varying output, thereby resulting in improved operational efficiency and reduced cost.

3.2 Dynamic Transfers Increase the Pool of Intra-Hour Resources

Scheduling between balancing authorities at an hourly interval precludes resources that are located outside a balancing authority's boundaries from assisting or participating in intra-hour balancing. Fifteen-minute scheduling, EIM, and dynamic transfers allow a balancing authority to increase the pool of resources that it can call upon to meet its intra-hour load-supply imbalances. By increasing the pool of resources, operational efficiency increases and the associated costs decrease.

This is especially relevant for balancing authorities with relatively small loads that rely primarily on balancing services of thermal resources that reside entirely within their balancing area. With the limited choices of resources within the balancing area, the balancing authority has to make a decision as to whether to provide balancing from its most efficient resources, which are typically newer and hence more modern and equipped to provide flexibility, or from older resources that are less efficient but are still capable of providing balancing services. The trade-off is that when the balancing authority is utilizing the more modern and efficient generator, it is sacrificing energy production that is lower in cost. When the balancing authority utilizes the less efficient generator, it requires that the generator operate at a certain output above its minimum generating level in order to be able to respond to control signals to increase or decrease generation. The minimum generating level at which it needs to operate is typically at a higher cost than market-based energy.

With dynamic transfer, a neighboring balancing authority with a more diverse set of resources could provide the balancing and allow for the less efficient (i.e., more costly) generator to be shut down and avoid the cost of generating higher-cost energy in order to provide balancing services within the balancing area.

3.3 Dynamic Transfers Reduce the Cost of Renewable Energy Integration

Dynamic transfer is an important tool for keeping the cost of integrating VERs down. Dynamic transfer allows balancing authorities to transmit energy and ancillary services from an area where available resources reside to balancing areas where the energy and services provided by the resources are needed on a firm, real-time basis. Ancillary services are important for integrating VERs, and examples of these services that may be delivered with dynamic transfer include regulation service and operating reserve service. Dynamic transfer is thus a tool that effectively increases the supply of energy and ancillary service resources to the receiving balancing authority. The fact that dynamic transfer ensures firm, real-time delivery of resources to the receiving balancing authority makes it even more valuable. Firm, real-time delivery is important because it is required for remote resources to qualify to bid into the consuming BAA ancillary service markets. Firm, real-time delivery is also important because it is also required if the consuming BAA is to assume the responsibility for meeting the integration service requirements of variable energy imports.

Dynamic transfers thus increase the supply of regional resources that can be delivered as a firm resource and thereby reduce cost, defer investment in new facilities, and increase access to high-quality renewable resources. For example, consider a balancing authority area with limited regulation service reserves. With a dynamic transfer, this BAA can contract with generation resources in another balancing authority area that enjoys excess supply of regulation reserves rather than having to purchase higher-cost resources from within the BAA. In this example, increasing the supply of regional reserves available to a balancing authority certainly reduces the price of acquiring the service for a given time period, and it may even spare the additional cost of building additional facilities in the receiving balancing authority.

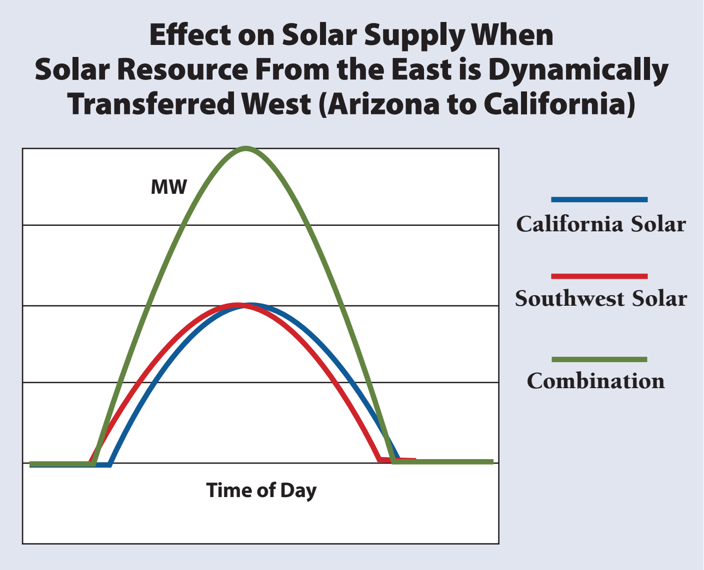
Dynamic transfers can also reduce the cost of complying with renewable resource requirements by increasing access to high-quality renewable resources. Dynamic transfers can directly reduce the cost of renewable energy procurement by making transfers of energy from balancing authority areas where sun and wind resource quality is high to balancing authority areas where renewable energy is in high demand.

Dynamic transfer can also reduce the cost of integrating VERs in two ways. First, dynamic transfer increases the supply of regulation and flexibility resources that may be required at higher levels of variable energy penetration and thus can keep costs of the services down. Second, dynamic transfer ensures real-time firm delivery of the remote resources and thus the integration services can be provided by the consuming BAA rather than the producing BAA. Because the consuming BAA often incorporates a larger load, the cost of meeting integration requirements is often lower at the consuming BAA. This is discussed further in section 3.3.2.

3.3.1 Supply Diversification

Dynamic transfers provide a mechanism to diversify the portfolio of renewable resources available to a BAA. Renewable resources in different geographic areas have different temporal generation patterns, and thus combining renewable resources in different areas can diversify the renewable portfolio in important ways. For example, dynamically transferring the output of solar facilities located in Arizona and New Mexico, where the sun rises earlier than in California, can assist California balancing authorities by making solar energy from Arizona available earlier in the morning when California's load starts to increase dramatically, but prior to when California's solar resources are able to produce energy. Figure 3-1 illustrates the effect of combining solar output from California with that of Arizona, which is dynamically transferred to California.

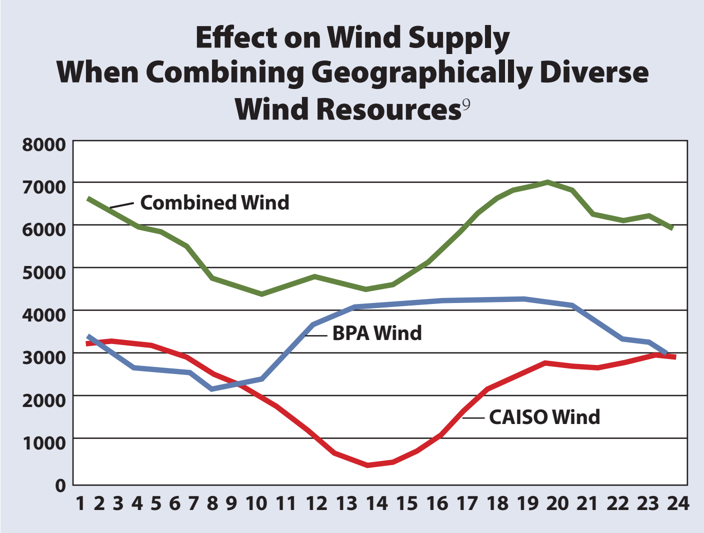
Figure 3-1



Effect on Solar Supply When Solar Resource From the East is Dynamically Transferred West (Arizona to California)

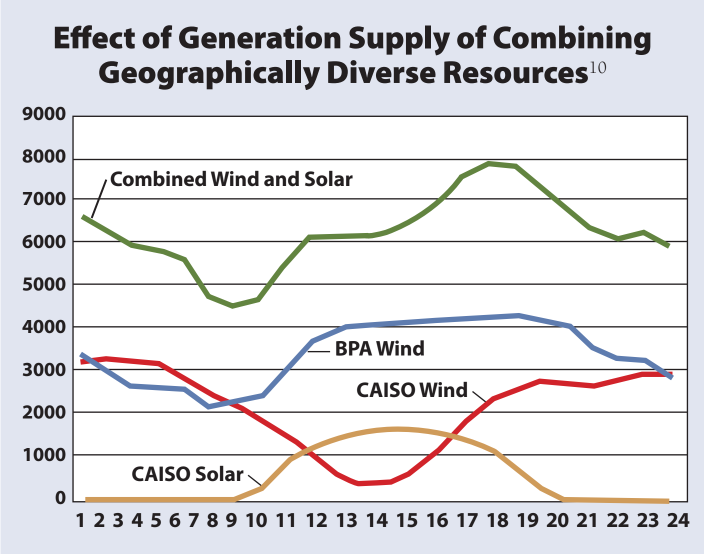
Wind generation in different locations can also be complementary. For example, wind generation in the Columbia River basin area of Oregon and Washington produces at different times from wind generation in the Tehachapi region of southern California, so a portfolio of wind generation from both regions can provide a portfolio of generation with reduced integration service requirements. Figure 3-2 shows the benefit of combining wind profiles from different regions into a common portfolio. Figure 3-3 shows the effect on generation supply of combining renewables from geographically diverse resources.

Figure 3-2



Effect on Wind Supply When Combining Geographically Diverse Wind Resources[9]

Figure 3-3



Effect of Generation Supply of Combining Geographically Diverse Resources[10]

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[9] CAISO: available at: http://www.caiso.com/green/renewableswatch.html, and BPA. Available at: http://transmission.bpa.gov/Business/Operations/Wind/

[10] Id.

3.3.2 Balancing Obligation Transfer

High-quality renewable resources are sometimes located in areas where population is sparse and the host balancing authority's load is relatively small. As a result, the ability of the host balancing authority to accommodate large amounts of renewable resources within its balancing authority is limited. Dynamic transfer allows interconnection to the grid where the resource is located while transferring the obligation to balance for it to the end-use balancing authority, which is usually larger and better suited to respond to fluctuations in output.

Figures 3-4 and 3-5 indicate where viable wind and solar resources could be located in the West.[11] The gray dots represent 30-MW wind sites and 100-MW solar sites. The larger aggregation of wind sites is located in Wyoming, Colorado, and New Mexico, far away from the largest load centers located on the Pacific coast.

Although the solar sites are not aggregated similarly to wind sites, they have the same problem with respect to being far away from the major load centers on the Pacific Coast.

Both wind and solar sites can be characterized as residing in balancing areas that are not heavily populated, and as a result do not have much load to absorb or consume the electricity produced. This poses a significant problem for these balancing areas with regard to providing balancing services for the renewable resources.

A solution to that problem is to transfer the balancing obligation to the end-use balancing area. The CAISO, which houses a large portion of the load in the WECC, instituted a pilot to provide a mechanism to transfer the balancing obligation from the host balancing area to the end-use balancing area. This accomplished two objectives. First, the balancing obligation was transferred to the entity that was receiving the benefits from the renewable energy resource (i.e., renewable energy credits). Second, the CAISO, with the larger balancing area and a more diverse set of generating resources, is better equipped to provide the balancing service.

Figure 3-6 shows Copper Mountain Solar, which was interconnected into NVE's balancing area and was the CAISO's first renewable resource that used a pseudo-tie to dynamically transfer the output from NVE to the CAISO. A pseudo-tie is one of the two forms of dynamic transfer whereby a generator in a host balancing area becomes part of the end-use balancing area by connecting control signals in a manner that requires the end-use balancing authority to respond to the generator's varying energy output.

Figure 3-4

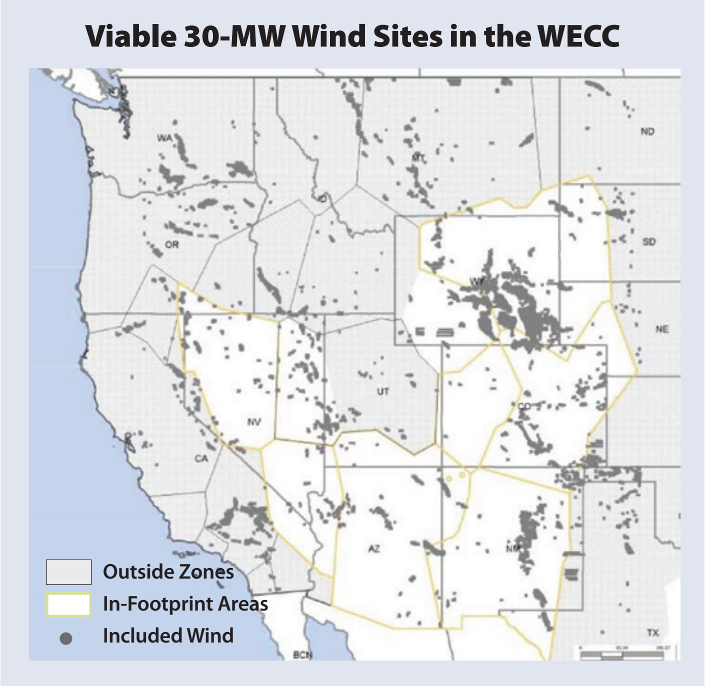
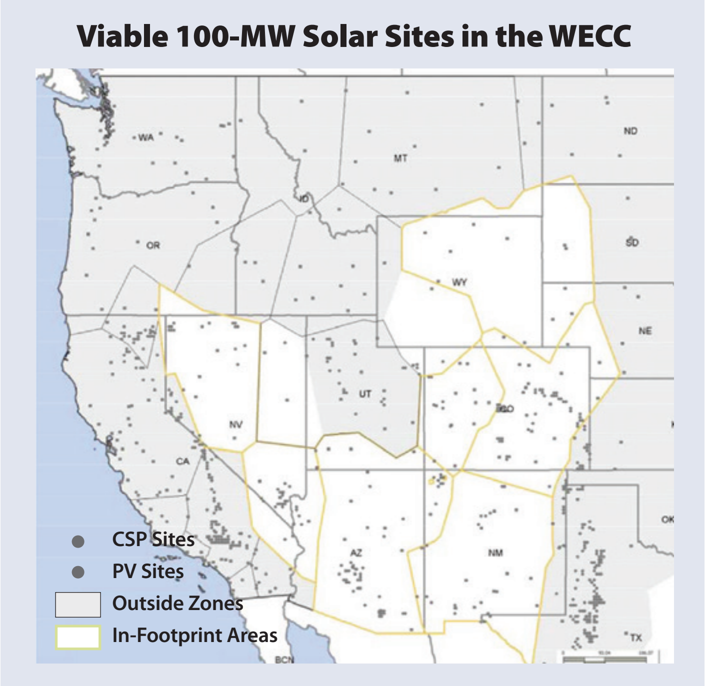

Viable 30-MW Wind Sites in the WECC

Figure 3-5


Viable 100-MW Solar Sites in the WECC

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[11] National Renewable Energy Laboratory. Western Wind and Solar Integration Study prepared by GE Energy (2010, May).

Figure 3-6

The CAISO's First Pseudo-Tie With NVE Involving a Variable Energy Resource

Figure 3-7 illustrates the dynamic transfer of a solar resource in SRP's balancing area into the CAISO's balancing area, and separately a wind resource interconnected in PNM's balancing area dynamically transferred to APS's balancing area where the energy is consumed. In both of these cases the real-time dynamic transfer of the resources from the producing BAA allows the consuming balancing authority to assume responsibility for meeting the integration service requirements.

3.4 Dynamic Transfers Can Improve Reliability

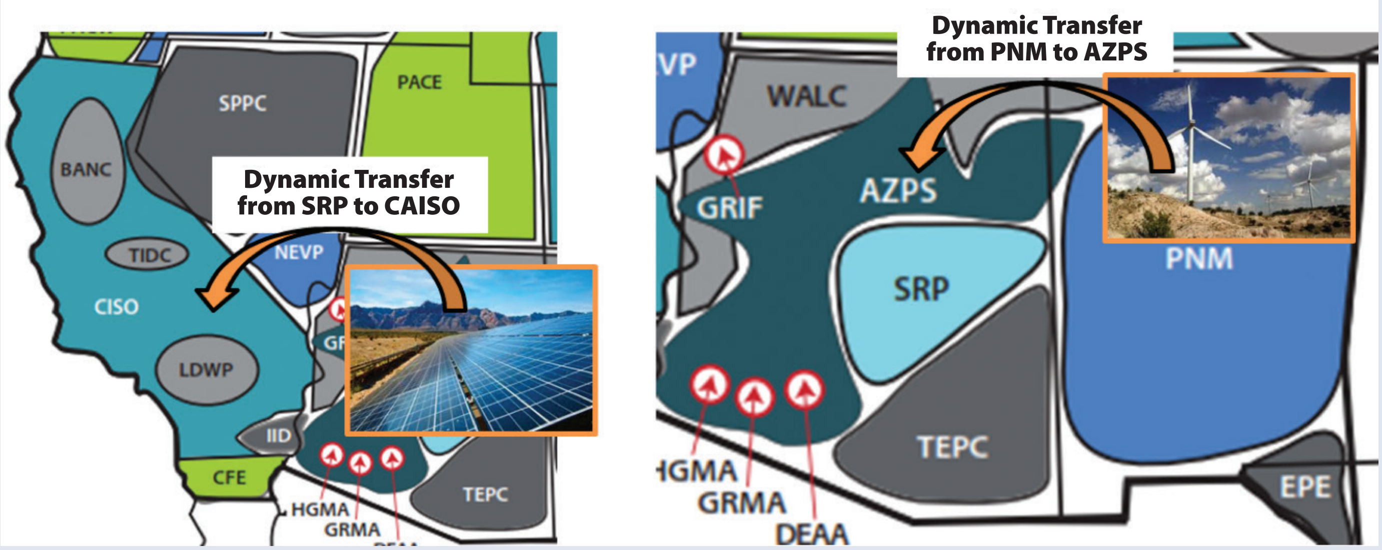
Dynamic transfers also support reliability improvements. Several reliability improvements identified by FERC in its evaluation of an EIM are improvements that will require the use of dynamic transfer. The reliability benefits include:[12]

- Increased number and types of resources available to a balancing authority from neighboring balancing areas for balancing energy supply and customer load;
- More effective use of transmission capacity based on flow of energy as opposed to contract path; and
- Improved ability to unload overloaded transmission equipment by determining the most effective resources and dispatching those resources automatically.

Dynamic transfer support also helps reduce unscheduled flow. The EIM is designed to call upon generation to ensure that transmission equipment is not overloaded. If

Figure 3-7

Dynamic Transfers Where the Obligation to Balance is Transferred to End-Use Balancing Areas Where Energy is Consumed



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[12] Federal Energy Regulatory Commission. (2013, February 26). Qualitative Assessment of Potential Reliability Benefits from a Western Energy Imbalance Market (staff paper).

transmission equipment becomes overloaded as a result of a system event, then the EIM calls upon generators to eliminate the overload in the most cost-effective manner. Exchanges such as these will require dynamic transfer support.

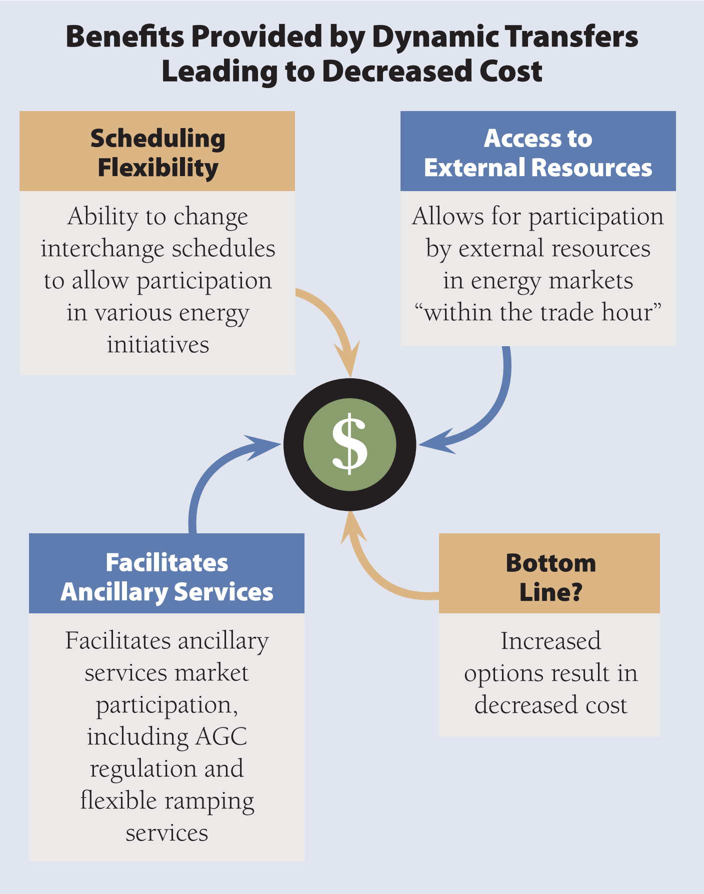
3.5 Putting it All Together

Figure 3-8 summarizes three of the main economic benefits of dynamic transfers: scheduling flexibility, access to remote energy and capacity resources, and access to remote ancillary services.

The ability to reduce the scheduling intervals from one hour to sub-hourly intervals opens up the opportunity for balancing authorities to match energy with schedules much more closely. Access to remote energy and capacity resources allows a utility to take advantage of high-quality resources and to benefit from sharing in economies of scale. Access to remote ancillary services allows a utility to expand its sources of supply and allows renewable developers in remote resource areas to take advantage of having the purchasing balancing authority provide integration services.

We have also identified in this section a number of reliability benefits enabled by dynamic transfer that add value above and beyond these economic benefits.

Figure 3-8



Benefits Provided by Dynamic Transfers Leading to Decreased Cost

Scheduling Flexibility

Ability to change interchange schedules to allow participation in various energy initiatives

Access to External Resources

Allows for participation by external resources in energy markets "within the trade hour"

Facilitates Ancillary Services

Facilitates ancillary services market participation, including AGC regulation and flexible ramping services

Bottom Line?

Increased options result in decreased cost

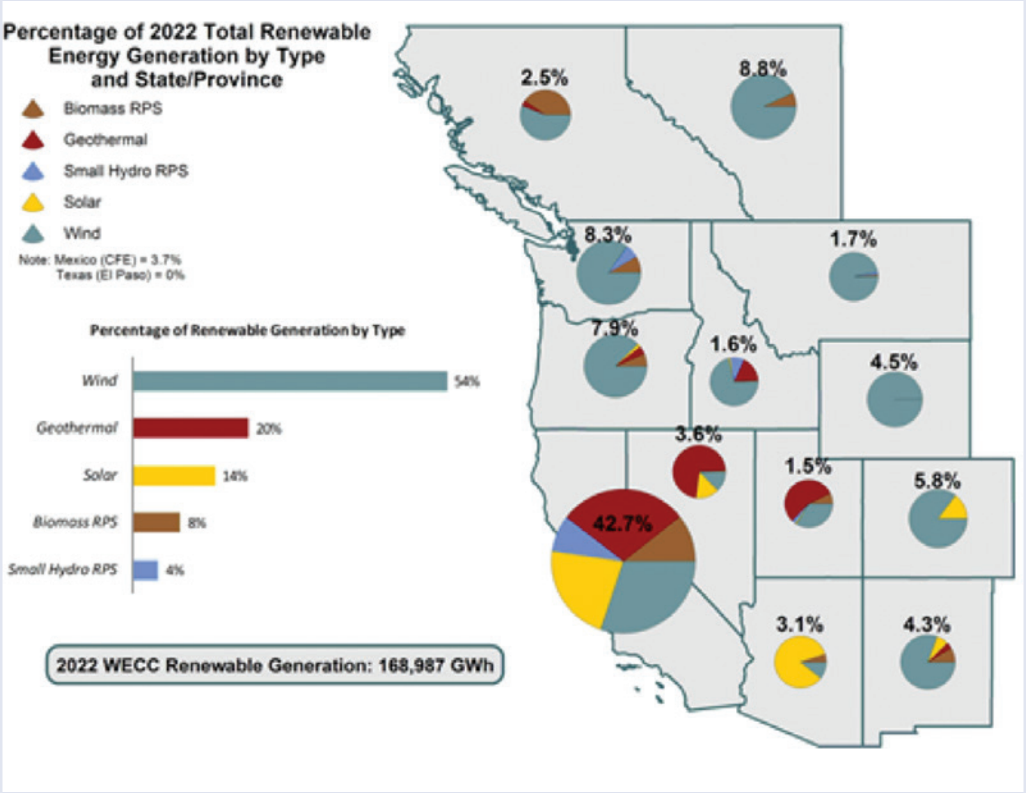
4. Initiatives to Support Variable Generation That Use Dynamic Transfer

Dynamic transfers are expected to increase steadily over the next 10 years because state renewable energy policy initiatives are leading to an unprecedented renewable energy expansion in the West. Figure 4-1, taken from the WECC 2022 Common Case,[13] shows that with current renewable energy policy targets, the western states will produce about 169,000 GWh of renewable energy by 2022. The common case serves as a beginning set of assumptions of loads and resources to generate 10-year projections, and thus can be used to represent the "expected build-out" with the best available information. Many other cases are investigated at WECC to test the transmission impacts of changing growth and generation build-out assumptions, but the common case is useful to get one reasonable snapshot of what a renewable build-out might look like in 10 years. The significant build-out evident in this graphic indicates many opportunities to obtain benefits from increased use of dynamic transfer.

System operators understand that wind resources in a given location can vary significantly over the course of the day, solar photovoltaic resources in a given location can fluctuate as cloud cover varies, and neither wind nor solar photovoltaic resources can be dispatched in response

Figure 4-1

2022 Renewable Energy Build-Out, WECC 2022 Common Case



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[13] See 2011SP_10yr_ PC1 Common Case at http://www.wecc.biz/committees/BOD/TEPPC/Pages/TAS_StudyResults.aspx, slide 4.

to changes in system needs. Wind and solar generation patterns vary by location, and if the renewable resource portfolio is focused in a small number of locations, the fluctuations tend to be highly correlated and thus can combine to provide severe changes in local generation. If the resource portfolio is situated in different locations with diverse and complementary production patterns, then the variability experienced by the control area operator may be modest. In either case, some integration requirements are introduced and grid operators will be seeking to identify regional solutions where balancing areas can meet their respective reliability objectives at least cost. Dynamic transfer can open the door to mutually beneficial exchange opportunities.

The next section outlines the factors that are driving increased use of dynamic transfer in more detail.

4.1 Factors Driving Increased Use of Dynamic Transfers

One factor driving increased use of dynamic transfer is the potential benefit of regional renewable energy diversification. The renewable resource capacity scheduled to be interconnected to the electric grid between now and 2020 will require balancing authorities to employ innovative measures to deal with variability. Some balancing authorities will have a hard time integrating renewable resources independently. Other BAAs, such as the CAISO, are large and diverse enough to absorb a large influx of renewable resources. The CAISO is actually large enough that it has some ability to act as the end-use balancing authority and allow neighboring balancing areas to transfer the balancing obligation of resources located outside of the CAISO. By taking advantage of diversity across multiple balancing authorities throughout the WECC, balancing authorities are much more able to accommodate the variations in output at a reduced cost.

A second factor is the expansion of regional markets for energy and ancillary services. As the opportunity to bid resources into regional markets expands, the need for dynamic transfer capacity will expand. The CAISO-PacifiCorp effort to establish a combined EIM has accelerated interest in the West.

A third factor is the potential for transmission capacity to be determined on an intra-hour flow basis rather than an hour-ahead schedule basis. The western grid operates on a schedule basis but schedules do not generally reflect flows, so transmission capacity is often underutilized. Scheduling identifies a transmission path from Point A (where energy is generated) to Point B (where energy is consumed) and reserves capacity on that path beforehand. Electricity follows the path of least resistance, however, so the flows often deviate from the scheduled path. Dynamic transfers can be used to support EIM transactions within the hour that can account for deviations from schedules. As intra-hour imbalance exchanges increase, the need for capacity that can be used to support dynamic transfer will also increase.

Each of these drivers indicates an increase in demand for transmission capacity that can be used to support dynamic transfer. Increasing the capability of the electric system to accommodate increased use of dynamic transfer requires careful study. In the next section, we examine a recent study undertaken by Columbia Grid and the Northern Tier Transmission Group that provides a roadmap for investigating the opportunities and barriers to further dynamic transfer expansion.

4.2 Determining the Limits of Dynamic Transfer Expansion: A Case Study by the Wind Integration Study Team

One notable situation in which balancing authorities joined to investigate the opportunities and barriers to mutually beneficial exchange was initiated by Columbia Grid and the Northern Tier Transmission Group. These two sub-regional planning groups formed the Wind Integration Study Team (WIST) in 2011 to address a fundamental question: How much and how frequently can power transfers vary across the system within a defined period before system operators are forced to make adjustments to ensure acceptable performance and reliable operation?[14]

WIST's report provides an excellent assessment of issues that needed to be addressed[15] and thus provides a solid

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[14] Wind Integration Study Team. (2011, December 21). Dynamic Transfer Capability Task Force Phase 3 Report. Available at: http://www.columbiagrid.org/DTCTF-overview.cfm

[15] Wind Integration Study Team. (2011, October 26). Integration of Intermittent Energy into the Grid: Are Dynamic Transfers Needed? Available at: http://www.westgov.org/wieb/meetings/crepcfall2011/briefing/present/r_bayless.pdf

roadmap for others seeking to develop and implement viable approaches. The roadmap includes the following steps:

- Engage technical experts from across the electric grid;
- Develop a methodology for determining limiting constraints to dynamic transfers;
- Identify limiting constraints;
- Establish dynamic transfer limits; and
- Determine how to expand dynamic transfer capability without compromising grid reliability.

The WIST report provides a number of lessons learned that indicate viable approaches for modernizing grid technology and grid operations.[16] Lessons learned from the WIST effort include:

1. Recognize that the transmission grid in the West was designed primarily to provide for transmission of energy from large-scale power plants that held output constant for extended periods of time. As a result, equipment (such as manually switched voltage control devices) was not designed to respond to rapid changes in electrical system conditions. Modernizing the grid using flexible digital technology will therefore be required as the nature of the generation portfolio evolves.
2. Recognize the limits of operating the transmission grid and assess how much variability (voltage levels and energy flow across major transmission corridors) the power system can withstand over a certain period of time before taking actions such as switching voltage control devices to mitigate the effects of variability.
3. Improve coordination among balancing authorities by:
    a. Providing balancing authorities with larger amounts of data from other balancing areas to improve visibility of neighboring areas.
    b. Providing balancing authorities with information from neighboring balancing areas regarding the acceptable range of voltage fluctuation at key substations.
    c. Sharing information between balancing authorities as to the status of those devices and resultant voltage at key substations for those balancing authorities that have automatic switching of voltage control devices.
4. Automate voltage control devices at key substations.
5. Automate the arming of remedial action schemes (RAS) when system conditions require that RAS may be needed.[17]

The next section describes a number of initiatives currently underway in the West that will require increased dynamic transfer capacity.

4.3 Initiatives that Use Dynamic Transfers

Dynamic transfers complement new energy initiatives, which require the use of shorter interchange scheduling periods, currently one hour to intra-hour granularity (30 minutes, 15 minutes, 5 minutes, 4 seconds). Each of the initiatives discussed in this section seeks to move the deadline for submitting an interchange schedule closer to real-time when the resource produces energy. By moving the scheduling deadline closer to production, forecasts of actual "real-time" production become more accurate and the opportunity to use regional resources to meet real-time needs becomes possible.

4.3.1 Dynamic Scheduling System

Whereas many balancing areas use dynamic transfer, most balancing areas are limited in how they can use them due to limitations in available transmission capacity and the absence of markets for trading transmission capacity. Exchanges of capacity and energy in the West happen largely on a bilateral basis between balancing authorities by way of an electronic or phone communication between trading partners. The DSS offers a more efficient way to implement dynamic transfer by instituting a pool-type, web-based service to facilitate bilateral exchange among any number of participating balancing areas. The DSS is primarily designed to support intra-hour regulation, load balancing, and load following service exchanges. The existence of web-based service allows a balancing authority with a need for resources to quickly identify a number of balancing authorities with available, excess resources and thus to more readily execute an exchange. The DSS is thus a step toward a market, because it clarifies the supply and demand picture for participants,

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[16] Wind Integration Study Team. (2011).

[17] RAS are actions taken by operators or systems in response to outages or system conditions to ensure that system emergencies are avoided or mitigated.

but unlike a centralized market it retains the historical practice of bilateral exchange.[18]

4.3.2 Mid-Hour Dispatch

The CAISO and BPA instituted a mid-hour scheduling pilot project for up to 200 MW in October 2011 to assess the benefits and identify issues associated with modifying schedules on a half-hour basis. The main driver for this initiative was the balancing burden that was placed upon BPA by the abundance of wind generation in BPA's balancing authority area that was being transferred to California but balanced by BPA. This mid-hour dispatch pilot was implemented via dynamic transfer, using a half-hour periodicity. The dynamic e-Tag is subsequently updated "after-the-fact" using the actual, integrated energy transfer for the entire operating hour per North American Electric Reliability Corporation (NERC) standards. This approach allows limited CAISO balancing of BPA's wind resources up to 200 MW by shifting some of the balancing responsibility to the CAISO.

4.3.3 Intra-Hour Transaction Accelerator Project

The ITAP is designed to provide an electronic bulletin board to allow counterparties to identify unused transmission capacity for the purpose of buying and selling energy and/or capacity hourly and intra-hourly in the bilateral market. The platform also allows exchanges that are more than one hour ahead. The idea is that software currently used to schedule transmission between balancing areas in the West is enhanced to allow market participants to post offers to sell and bids to buy energy and capacity on an electronic bulletin board. Transactions are executed directly between counterparties. The logistics required to finalize the transaction, that is, purchasing transmission, creating a NERC electronic tag, and submitting the information to the appropriate balancing authorities and market participants, is done in one step, thereby simplifying the multistep process.[19]

4.3.4 FERC Order 764 – 15-Minute Scheduling[20]

In order to better facilitate renewable energy integration, FERC issued Order 764 designed to reduce the current hourly interchange scheduling interval to 15 minutes or less. FERC found that the existing one-hour scheduling interval offered by transmission service providers under their open access transmission tariffs does not give generators the opportunity to mitigate generator imbalance charges (the difference between the amount of generation produced in an hour and the amount of energy scheduled in an hour), and as a result, they are subject to excessive and unduly discriminatory generator imbalance charges. In response, FERC ordered that transmission service providers change their open access transmission tariffs to offer all generators the option of scheduling transmission service at 15-minute intervals or alternatives that offer service consistent with or superior to what FERC ordered. FERC noted that although costs to implement 15-minute scheduling may be significant, the result could reduce the amount of imbalance energy that a transmission service provider must accommodate, which will reduce the cost of providing imbalance services.

As previously described in Section 3.5, the shorter and more frequent the scheduling interval, the better generation output matches generation schedules, thereby reducing the supply-load energy imbalance that a balancing authority needs to accommodate and reducing the costs borne by the

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[18] Participants in the DSS in the West have included: Arizona Public Service, British Columbia Hydro, BPA, Grant County PUD, Idaho Power, Imperial Irrigation District, NaturEner USA, Northwestern Energy, PacifiCorp, Portland General Electric, Powerex, Public Service of New Mexico, Seattle City Light, Salt River Project, Tri-State Generation and Transmission Association, Western Area Power Administration and Xcel Energy. ColumbiaGrid, Northern Tier Transmission Group, WestConnect. (2012, February 2). Joint Initiative Update. Presentation to Seam Issues Subcommittee WECC in Salt Lake City.

[19] Market participants include: Avista, Grant County PUD, Puget Sound Energy, Western Area Power Administration, Eugene Water and Electric Board, Idaho Power, Portland General Electric, Tri-State Generation and Transmission Association, Xcel Energy, Tacoma Power, PacifiCorp, Snohomish County PUD, Seattle City Light, Powerex, Public Service of New Mexico, Northwestern Energy and Iberdrola. ColumbiaGrid, Northern Tier Transmission Group, WestConnect (2012).

[20] United States of America Federal Energy Regulatory Commission; Integration of Variable Energy Resources Docket No. RM10-11-000; Order No. 764 Final Rule Issued June 22, 2012; www.ferc.gov/whats-new/comm-meet/2012/062112/E-3.pdf

Table 4-1

Comparison of Varying Load or Resource With One-Hour, 15-Minute, and 5-Minute Scheduling Periods

Scheduling Interval	Variable Resource or Load (MW)	One-Hour Schedule (MW)	15-Minute Schedule (MW)	5-Minute Schedule (MW)
1	10	14	11.67	10
2	12	14	11.67	12
3	13	14	11.67	13
4	15	14	15.33	15
5	15	14	15.33	15
6	16	14	15.33	16
7	12	14	13	12
8	14	14	13	14
9	13	14	13	13
10	15	14	16	15
11	16	14	16	16
12	17	14	16	17
Total MWh/hour	**14**	**14**	**14**	**14**

generator for balancing services. Table 4-1 illustrates the concept.

The 15-minute scheduling period may be implemented using static or "normal" block interchange schedules. However, the four-time per hour scheduling period presents challenges for the use of e-Tags to communicate and coordinate net scheduled interchange modifications attributable to the requisite manual checkout process between balancing authorities. Dynamic transfer can be used as an option to implement 15-minute scheduling functionality, essentially "automating" the intra-hour interchange schedule changes and providing for updated integrated energy transfer e-Tag revisions, after the fact.

4.3.5 Energy Imbalance Market

The WECC, Northwest Power Pool, and Southwest Power Pool have performed various assessments of the need, costs, and benefits for an EIM, over recent years. The Northwest performed in-depth studies designed to identify issues associated with implementing an EIM and potential solutions. The Northwest's efforts indicate that an EIM could be instituted by 2018, assuming that benefits, resulting from a more comprehensive study, outweigh the costs of implementation. In addition, the Northwest will continue to evaluate other initiatives (such as DSS, intra-hour scheduling, ITAP) to determine if they are able to take advantage of regional diversity, thereby reducing or obviating the need for an EIM.

The Southwest also reviewed the need for an EIM. Their initial assessment is that, given the lack of wind penetration in the southwest and a lower overall renewable energy volume interconnected to the grid, a Southwest EIM is less certain.

4.3.6 The CAISO/PacifiCorp EIM – 2014

The CAISO and PacifiCorp entered into a memorandum of understanding that would extend the CAISO's existing 5-minute EIM into PacifiCorp's eastern and western balancing areas. Each entity would be responsible for ensuring that their respective balancing area had sufficient generation resources on-line to satisfy operating reserve criteria, but the dispatch of those resources would be based on a security constrained economic dispatch (SCED) designed to determine the most cost-effective deployment of resources to satisfy the energy-load balance while ensuring that transmission system limits and constraints are respected. The transfer of energy between the PacifiCorp and the CAISO balancing areas would be managed using dynamic transfers within the operating hour.

The CAISO/PacifiCorp EIM means that the CAISO will model PacifiCorp's grid in its SCED model, thereby producing locational marginal prices (LMPs) at each of PacifiCorp's generation locations and certain substations. The LMPs consist of energy, transmission loss, and transmission components that are added together to provide PacifiCorp with prices in $/MWh at each of their generators and certain substations every 5 minutes. This provides PacifiCorp and market participants within PacifiCorp's balancing areas the ability to increase or decrease generation at those locations based on LMPs unique to each location. The end result is that PacifiCorp and the CAISO increase the pool of resources upon which to draw for balancing services, while reducing the need for balancing services because of the geographic diversity between California, Oregon, Utah, western Wyoming, and eastern Idaho. The CAISO and PacifiCorp expect to see a reduction in costs associated with providing balancing services to both PacifiCorp and the CAISO customers.

5. Potential Deployment Barriers and Solutions

Specific barriers to increasing dynamic transfers are both technical and commercial. Extending the use of dynamic transfer as a tool to integrate renewable resources on a more widespread basis is limited primarily by transmission capacity constraints between balancing authorities, and operational concerns such as voltage control, effect of dynamic transfers on system operating limits, and the absence of operational procedures for adjusting to dynamic flows. This section shows that technical and commercial issues affect these capacity and operations barriers, and thus overcoming the barriers will include technical and commercial innovation.

5.1 Technical Issues

Technical issues affecting the increased use of dynamic transfers can be broken down into the following categories.

- Availability of unused transmission capacity between balancing areas;
- Ability of the transmission grid to withstand variations in energy transfer between balancing areas;
- Ability of the transmission grid to withstand major outages in light of renewable energy resources displacing more conventional generation resources that automatically respond to system disturbances; and
- Acquisition and compilation of data to allow operators and systems to make informed operational decisions.

5.1.1 Transmission Capacity

Transmission capacity is best described as the electricity highway between balancing areas. Figure 5-1 and Table 5-1 are high-level depictions of transmission corridors and ratings in the WECC.[21]

A majority of the transmission capacity is used to

Figure 5-1

WECC Transmission Corridors and Ratings (MW)

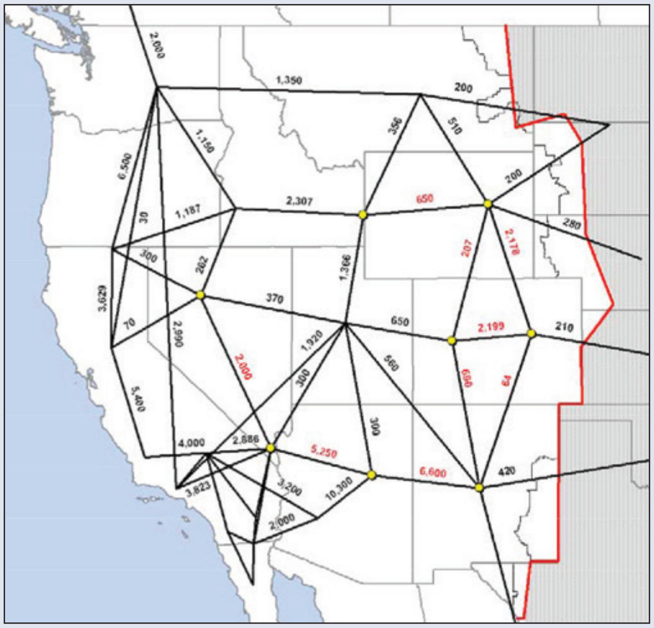

Table 5-1

Certain WECC Transmission Corridors and Ratings (MW)

WECC Path	Rating (from-to, MW)	Rating (to-from, MW)
Arizona to Southern Nevada	5,250	5,250
Colorado-East to New Mexico	64	1
Colorado-East to Colorado-West	2,199	1,468
Colorado-West to New Mexico	690	690
New Mexico to Arizona	6,225	6,660
Northern Nevada to Southern Nevada	2,000	2,000
Wyoming to Colorado-East	1,605	2,178
Wyoming to Colorado-West	309	207

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[21] Western Wind and Solar Integration Study. (2010, May). Prepared for the National Renewable Energy Laboratory by GE Energy.

transfer energy between balancing areas using the long-accepted practice of scheduling energy transfer between balancing areas at a rate held constant for a full scheduling period, which is currently one hour. The process is based on a "contract path" approach, whereby energy is scheduled on transmission between Point A and Point B. The process, although electronically based, is largely manual, as buyers and sellers go through a multistep process to locate unused transmission capacity, purchase the transmission capacity, and then schedule the energy on the transmission capacity. In addition, unutilized transmission capacity that is available for purchase is based on the amount of energy scheduled on the transmission path, as opposed to the amount of energy that flows on the transmission path. Because electricity flows follow a path of least resistance as opposed to a contract path, the result oftentimes leads to inaccurate and inefficient use of transmission capacity. Dynamic transfers need unused transmission capacity between balancing authorities in order to allow output from the dynamically transferred resource to vary its output between a minimum and maximum. Poor information about the availability of unused transmission capacity or the absence of unused transmission capacity is thus a barrier to increasing dynamic transfer.

5.1.2 Effect of Variations of Energy Transfer

Transfer variability limits are the limits to the electric grid's ability to withstand variations in energy transfer through a transmission corridor. One of the main considerations when energy flows vary is the effect on voltage. Lightly loaded lines correspond to higher voltage; heavily loaded lines correspond to lower voltage. The grid operator compensates for variations by manually or automatically calling upon voltage control devices to raise or lower voltage to keep voltage within operating limits. If line flow fluctuations are large enough to cause the need for voltage control to take place, then coordinated, automated control becomes necessary.

The ability to define the conditions when actions are necessary becomes paramount. This requires power system engineers to perform more detailed studies on the transmission grid for varying system conditions and to convert that information into a set of actions designed to ensure reliable system operation. Those actions ideally would be deployed automatically when recognized by the balancing area's computerized energy management system using real-time data acquisition, transmission system analysis and control. The absence of these automated capabilities is a barrier to dynamic transfer because it restricts the quantity of flow that can be safely accommodated.

5.1.3 Ability of Transmission Grid to Withstand Transmission Outages

The transmission grid's reliability is determined not only in its current operating state, but also in its ability to remain reliable when transmission equipment or generation resources become unavailable unexpectedly. When transmission equipment or generation trips off-line, energy flows on transmission lines and equipment change. This change in energy flows could result in overloaded transmission equipment or unacceptable voltage levels (high or low) at substations. The analysis performed by power system engineers ensures that the transmission grid can withstand any single outage of major transmission equipment or generation without falling into an overloaded or under/over-voltage state.

Generation resources fueled by steam production or water flow can automatically respond to transmission system fluctuations by sensing frequency. In response to low system frequency (typically due to loss of generation resources), those generators can increase their energy output automatically. Generation resources that are driven by wind or solar irradiance do not respond to system frequency excursions. The quantity of resources that can be dynamically transferred into a given balancing area is therefore dependent on the receiving balancing authority having the resources to respond to unexpected frequency fluctuations.

5.1.4 Data Acquisition and Compilation

GridSME in conjunction with the Lawrence Berkeley National Laboratory made a presentation to the Joint Committee on Regional Electric Power Cooperation/State-Provincial Steering Committee meeting on April 9, 2013 in Boise ID, summarizing findings and recommendations with regard to operational technologies and approaches to improve reliability and integrate variable generation.[22]

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[22] Operational Technologies and Approaches to Improve Reliability and Integrate Variable Generation. Presentation by GridSME and Lawrence Berkeley National Laboratory at Joint CREPC/SPSC meeting, April 9, 2013. Available at: http://www.westgov.org/wieb/meetings/crepcsprg2013/briefing/present/j_eto.pdf

The findings included the encouragement of data sharing, technology deployment, and institutional arrangements that enable greater coordination among operating entities. The use of dynamic transfer was identified as an important tool for integrating renewable energy.

As just described in Section 4, the ability to increase use of dynamic transfer hinges on the ability of power system engineers to effectively assess and monitor the condition of the transmission system. GridSME's findings reinforce these points, saying that, "[r]eal-time tools are an immediate and low-cost means for improving reliability and increasing utilization of existing grid infrastructure," and "[i]mproved tools and operating practices will also ease integration of variable generation."

GridSME's specific recommendations assert that balancing authorities should:

- Enhance accuracy of computer models of the transmission grid. This entails committing resources to maintaining the computer models to ensure comprehensive analysis of the transmission system rather than less inclusive analyses;
- Increase data sharing between balancing authorities;
- Better coordinate outage planning;
- Better coordinate next-day planning, with more emphasis on utilizing results of analysis as opposed to complying with operational standards; and
- Utilize new technology such as synchrophasors. Synchrophasers are high-speed data collection devices that measure power system data multiple times per second. These data provide transmission system operators with information and trends to determine if the transmission grid is operating within acceptable limits and if limits are being approached.

Assessing the capability of dynamic transfer and reliability assessment are directly aligned. The analysis, data needs, and resultant operating parameters sought by GridSME's recommendations are all similarly needed in making the reliability and dynamic transfer capability assessments. In other words, failure to implement recommendations like those of GridSME will prove to be a barrier to maximizing the quantity of dynamic transfer exchanges.

5.2 Commercial Issues

As important as the technical issues and reliability are, commercial viability will dictate how much progress is made in expanding the use of dynamic transfers. As described in Section 5.1, the availability of transmission capacity and the ability of the transmission grid to accommodate intra-hour schedules place technical limits on the quantity of potential dynamic transfer implementation. However, physical feasibility does not necessarily imply commercial desirability.

Two main commercial issues will drive the quantity of dynamic transfers. First, the market value of using a given quantity of transmission capacity for dynamic transfer must exceed the market value of using that transmission capacity for static schedules of energy. Because a majority of the transmission capacity is used for energy transfer and most of the energy is transferred via static schedules, dynamic transfer over existing or new transmission capacity will displace an equal quantity of static energy transfer. The value resources delivered by dynamic transfer will therefore have to exceed the value of the static energy transfers that it displaces. This means that the value of the energy, regulation, energy supply balancing, and capacity services delivered by dynamic transfer will have to be greater than the value of pure energy transfers delivered by static schedules for any capacity that becomes dedicated to dynamic transfer.

Second, because the nature of dynamic transfer costs and benefits are realized on an inter-balancing authority basis, allocation of costs and benefits between and among affected balancing authorities becomes an issue. Intra-balancing authority costs and benefits are typically addressed by a state public utility commission that weighs the cost and benefit impacts on ratepayers within the balancing area or utility. Once the issue crosses outside the jurisdiction of a single public utility commission, then the cost allocation will have to survive the scrutiny of several states and FERC.

5.3 Solutions

A number of solutions to overcome the technical and commercial barriers exist and can be implemented at relatively low cost. These include:

- Enhancing operational tools for grid operators, including computer modeling of the transmission grid and visibility to factors such as weather conditions and

forecasts outside the grid operators' immediate area;
- Automating control; and
- Upgrading transmission equipment.

5.3.1 Operational Tools for Grid Operators

As transmission system operation becomes more complex and grid operators need to address increased variability of operating parameters in response to increased use of renewable energy resources, electric transmission system assessment tools become more important than ever. Transmission system assessment tools such as state estimation and real-time contingency analysis have been in place for decades.[23] However, "[m]ost firms have developed visualization tools in-house and don't view [situational awareness] as a current issue or concern; more sophisticated tools – state estimation, real-time contingency analysis [real-time contingency analysis] and other analytical tools – are not widely relied on by operating staff; smaller organizations questioned the value of these tools; and compliance with standards appears to be the main focus of organization's efforts."[24]

This solution relies on existing technology and incorporates such into business practices. In addition, expanding the visibility of transmission system data, computer model results, and meteorologic data across balancing areas leads to a more broad view of the status of the transmission grid. This provides grid operators with a more global perspective that can guide actions taken locally.

5.3.2 Automate Control

As described in Section 5.1.1, the transmission grid in the West was designed primarily to provide for transmission of energy from large-scale power plants that held output constant for extended periods of time. This resulted in installing equipment, such as manually switched voltage control devices, that did not need to respond to rapid changes in electrical system conditions. By incorporating the results from real-time computer modeling and assessment described in Section 5.3.1 (state estimation and real-time contingency analysis) into automated actions such as switching in and out voltage control devices designed to raise and lower voltage at substations, transmission grid reliability can be improved and dynamic transfer capability can be expanded.

The results of the transmission grid assessment from the computer models allow grid operators to see where the transmission system is operating in relation to the operational limits. And rather than taking manual action as a result of recognizing the need to perform switching actions, automated switching can take place (consistent with operating procedures to ensure safety and reliability).

5.3.3 Transmission System Equipment Upgrades

Building new transmission lines or adding additional transmission equipment are solutions that offer the benefit of increased transmission capacity but are higher in cost to incorporate and sometimes more difficult to implement. These solutions include options such as:[25]

- Re-conductoring existing transmission lines increases the energy transfer capability of transmission corridors;
- Installing flexible alternating current transmission system devices[26] enhances voltage control capabilities and increases energy transfer limits;
- Installing phase shifting transformers allows grid operators to shift energy flow from one transmission

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[23] State Estimation is a computer model that converts real-time data measurements into a transmission system model, providing grid operators with a real-time status of energy flows and voltage across the transmission grid. The state estimator computer model is then used as the base for running "what if" contingencies to determine if loss of transmission equipment or generation resources results in an unacceptable operating state. This "what if" assessment is real-time contingency analysis.

[24] Operational Technologies and Approaches to Improve Reliability and Integrate Variable Generation. Presentation by GridSME and Lawrence Livermore National Laboratory at Joint CREPC/SPSC meeting, April 9, 2013. Available at: http://www.westgov.org/wieb/meetings/crepcsprg2013/briefing/present/j_eto.pdf

[25] WIEB Advanced Transmission Hardware Survey Results. Presentation by Black & Veatch at Joint CREPC/SPSC meeting, April 9, 2013. Available at: http://www.westgov.org/wieb/meetings/crepcsprg2013/briefing/present/t_curry.pdf

[26] Flexible alternating current transmission systems are power electronic devices such as static var compensators, voltage source converters, manually switched capacitors/reactors, and series compensation designed to control voltage and increase energy transfer capability.

corridor; and

- Energy storage allows for the transmission grid to store energy during times of oversupply and subsequently discharge energy during times of undersupply.

As described in Section 5.2, the commercial issue that needs to be addressed is what entity pays for the costs of these upgrades. For example, if a host balancing area incurs a cost to upgrade its system to allow increased dynamic transfer capability, does it pass along the costs to the end-use balancing authority? A common understanding of benefit sharing and cost allocation needs to be established. The Southwest Power Pool (SPP) introduced an approach to cost allocation called "Highway/Byway." In SPP's proposal, the focus was on the region as a whole as opposed to local reliability issues. The proposal allocated costs based on voltage level. For transmission facilities operating at 300 kV and above, costs are allocated to SPP members 100 percent. For transmission facilities operating above 100 kV and below 300 kV, the allocation is 33 percent regional and 67 percent within the zone in which transmission facilities are located. For transmission facilities operating at or below 100 kV, costs are allocated entirely to the zone in which transmission facilities are located.

Although this approach doesn't necessarily address the issues inherent to WECC, it is sound and provides a viable solution among SPP entities with competing interests.

6. Prioritizing Improvements to Accommodate Dynamic Transfers

Given the technical and commercial barriers identified in the last section, policy makers will need to formulate priorities for assessing and improving dynamic transfer capacity. Improvements to allow for implementing larger volumes of dynamic transfer fall into four categories:

- Improve system visibility and assessment
- Evaluate the need for increased grid operator staffing
- Enhance system control and automation
- Identify transmission system equipment upgrades

6.1 Improve System Visibility and Assessment

The transmission grid was built to accommodate utility-scale, controllable, and base-load generation to serve load centers. Interconnection between balancing authorities increased reliability and improved efficiencies and economic dispatch of cost-effective generation. The nature of the electric grid was that minute-to-minute variability and uncertainty was limited to load variation and loss of generation resources or transmission equipment. As a result, operational variability was limited and, except for events such as equipment failing, storms, or natural disasters, forecast on a somewhat reliable basis.

Integrating large amounts of renewable generation variability that cannot be predicted with the same accuracy as load variability has introduced the need for grid operators to seek solutions that reduce unexpected variability; this can be accomplished by providing information beforehand that allows grid operators to take preventative measures to respond to the variability. Information such as the progress of a weather front that could affect wind or solar production allows grid operators to call upon resources to respond to the expected variations in renewable generation production. In addition, operational data are being collected at more frequent intervals and disseminated to grid operators in a fashion that provides a more thorough understanding of the state of the electrical system.

The ability to improve system visibility and assessment can be observed by surveying where balancing authorities are with regard to current capabilities and plans for improving visibility and assessment of the transmission grid, with emphasis on addressing and monitoring variability of energy transfer. The initial assessment and action approach is:

- Determine whether dynamic transfers are limited to an amount less than the full capacity of the transmission corridors between balancing areas;
- Determine the factors limiting dynamic transfer capability;
- Determine whether the transmission system data and analysis tools are available and utilized to effectively identify dynamic transfer limitations and current operating state of the transmission system with respect to those limitations; and
- Identify and implement projects designed to increase dynamic transfer capability, including:
  - Data acquisition;
  - Computer modeling of transmission system;
  - Automating control of transmission system where appropriate;
  - Integrating automation with computer modeling; and,
  - Installing transmission equipment as appropriate.

The assessment and action plan formulated will need to evolve as increasing amounts of renewable generators interconnect to the grid and as grid modernization technologies advance.

6.2 Evaluate the Need for Increased Grid Operator Staffing

An issue that has been a concern to grid operators, especially in smaller balancing authorities, is the need to increase staffing levels to ensure that effective monitoring and compliance with reliability standards is in place. The concern is understood and appreciated. But there is no way around the fact that grid operation is becoming more complicated, and that it requires the expertise of experienced operators to monitor and control not only uncertainties within the balancing area, but also to manage the variability between balancing areas.

The ability of grid operators to monitor and operate the transmission system is tied to their ability to assess the current state of the transmission grid and take action as necessary. As such, staffing the control room goes hand-in-hand with system visibility and assessment described in Section 5.2.1. The ability to determine the need for increasing grid operations staff and capabilities can be observed by surveying the ability of balancing authorities to incorporate items listed in Section 5.2.1 on a real-time basis via grid operators. Grid operators are quarterbacks that rely on information to make decisions. If grid operators do not have access to information or are inundated with data that cannot be prioritized, then the initiatives to improve tools and visibility of the transmission grid are not effective. This can be determined by monitoring the following items:

- Survey the tools that grid operators utilize most often when assessing transmission conditions;
- Assess the effectiveness of computer models and items listed in Section 5.2.1 in the eyes of grid operators; and
- Determine what needs to take place in order to enhance effectiveness of items listed in Section 5.2.1, including increasing staff and/or training if necessary.

6.3 Enhance System Control and Automation

Voltage control is a concern when there are large variations in flows between balancing areas. To the extent that voltage is controlled by assigning a person to manually switch or operate the devices, the ability to manage variability is severely limited by the time it takes to operate the voltage control devices. Fluctuations in flow that require voltage control can be managed more effectively when control is performed automatically.

RAS systems that need to be armed manually also fall into this category. When an operating condition necessitates arming an RAS, automating that function allows a grid operator to address the variability in an effective manner.

Improving system control and automation relies on the ability to integrate visibility and assessment with control actions dictated by transmission system conditions. This can be observed by surveying where balancing authorities are with regard to current capabilities where they are in implementing and plans for integrating control actions with real-time computer modeling of the transmission system and associated acquisition of data. The approach is summarized below.

- Identify the control actions required in response to changing system conditions affecting dynamic transfer;
- Identify actions that can be initiated and implemented by grid operators remotely from the control center; and
- Identify actions that can be automated in response to results from real-time transmission system computer models.

6.4 Identify Transmission System Equipment Upgrades

Transmission system upgrades are the most expensive of the four categories to implement. The challenge is that almost all utilities are focused on transmission upgrades within their territory to address intra-balancing authority operational issues. Inter-balancing authority upgrades, especially across state lines, become more difficult to implement because of cost allocation issues.

Transmission assessments that incorporate the need to integrate renewable energy resources on an inter-balancing authority basis, recognizing the benefits of increasing the operating footprint and taking into account geographic diversity, lead to innovative measures such as dynamic transfer. Transmission system upgrades can then be considered on the basis of both increasing energy transfer between balancing areas as well as stabilizing transmission system response to fluctuations in energy transfer.

This effort can be observed by surveying where transmission assessment studies are taking into account the nature of varying energy transfer between balancing areas, the need for deploying operating reserves, and energy supply-load balancing services. The approach is summarized below.

- Incorporate existing dynamic transfer limits into base case assessment studies at the WECC level;
- Based on the location of renewable energy resources, and operating and balancing needs of balancing authorities, identify thresholds that limit dynamic transfers; and
- Identify transmission upgrade solutions that allow for increased energy transfer between balancing areas, increased sharing of balancing services between balancing areas, and the ability to dampen the effects of variable energy transfer between balancing areas.

7. Conclusions and Recommendations

Dynamic transfers have been used for decades to support energy exchanges scheduled one or more hours ahead of when the energy is needed, but improvements in information, communications and electricity system control technologies over the last decade have enabled increasing use of dynamic transfers on an intra-hour basis. Intra-hour dynamic transfers allow ancillary services like operating reserves, load following, energy imbalance and regulation reserves to be delivered in real time.

Dynamic transfers can also be helpful in supporting least cost, renewable energy integration. With increasing amounts of variable renewable energy resources on the grid, recognizing load and resource differences in the Western Interconnection and taking advantage of geographic diversity is more important than ever. BAAs in the West, which have relatively large loads and relatively abundant ancillary service capabilities, are often better able to integrate large amounts of variable energy resources than BAAs with sparse loads and relatively little ancillary service capabilities. Many BAAs in the West have abundant renewable energy resources but the diurnal pattern of production, the nature of resource generation variability and the dispatchability of the resources vary by BAA. Fortunately these regional differences create an opportunity for complementary exchanges among BAAs that leverage resource diversity. Dynamic transfer is an important tool for facilitating energy exchanges among BAAs in the West where these differences in loads and resources can be leveraged for mutual benefit. Mutually beneficial exchange among the BAAs using dynamic transfers produces consumer benefits because it facilitates least cost resource development and least cost variable energy resource integration in the region.

The importance of increasing the capacity for dynamic transfer in the West is highlighted by several recent initiatives that seek to improve reliability and renewable energy integration. The DSS, the ITAP, the implementation of FERC Order 764 intra-hour scheduling and the introduction of EIM are examples of such initiatives. Each of the initiatives have the potential of saving costs for consumers in the West but the amount of savings achieved will depend upon the capability to transfer energy on a firm basis between BAAs on intra-hour schedules. In other words, each of the initiatives will require increased use of dynamic transfer if maximum consumer benefits are to be achieved.

Increasing the use of dynamic transfer requires overcoming a series of technical and commercial barriers. The following chart identifies technical and commercial barriers, and the recommended solutions to overcome those barriers.

Technical Issues

1. Limited availability of unused transmission capacity between balancing areas.
2. Limited ability of the transmission grid to withstand variations in energy transfer between balancing areas.
3. Limited ability of the transmission grid to withstand major outages in light of renewable energy resources displacing more conventional generation resources that automatically respond to system disturbances.
4. Need to acquire and compile data to allow operators and systems to make informed operational decisions.

Commercial Issues

1. Demonstrate the value of dynamically transferred resources
2. Overcome cost allocation issues

Solutions

1. Enhance operational tools for grid operators, including computer modeling of the transmission grid and visibility to factors such as weather conditions and forecasts outside the grid operators' immediate area.
2. Automate control.
3. Upgrade transmission equipment.

This paper recommends priorities that state regulators and policy makers should consider as they seek to improve the capacity of their jurisdictional BAAs to use dynamic transfers. A brief summary of the implementation plan, discussed in more detail previously, is that regulators and policy makers should work with their jurisdictional BAAs and with their fellows from other states to:

1. Improve visibility of transmission system conditions by acquiring additional data and making better use of computer modeling to assess reliability.
2. Evaluate the need for an increase grid operations staff and increasingly incorporate results of real-time transmission assessment into operations.
3. Improve transmission system control and automation, including integrating actions with results from real-time transmission assessment.
4. Incorporate dynamic transfer limits and benefits of increasing limits in longer-term transmission planning assessments to ensure that transmission system upgrades include the need for Dynamic Transfer of energy between balancing areas.

Dynamic transfer is an important tool used in integrating renewable resources in the WECC and in allowing balancing areas to take advantage of diversity across the West. By recognizing where dynamic transfers are currently employed, how they are limited, and steps to address those limitations, transmission system operators and planners can enhance the use of dynamic transfers to further realize benefits while maintaining system reliability.

Appendix A.
WECC and Balancing Authority Overview

Introduction

The dynamic transfer discussion in this paper occurs within the context of the Western Electricity Coordination Council (WECC) and it refers to transfers between Balancing Area Authorities (BAA) in the western United States. The discussion presumes some basic understanding of what WECC is and what its responsibilities include and it also presumes some basic understanding of what a BAA is and what its responsibilities include. Since some readers are new to transmission planning and operation in the West, this appendix is offered to provide some basic background information. We first provide a broad overview of WECC's responsibilities with reference to the BAA responsibilities within the WECC context. We then provide a deeper dive into the technical responsibilities of BAAs.

WECC Overview

The western electricity interconnection is sometimes called the most complicated machine in the world. The interconnection includes 38 BAAs each of which is simultaneously seeking to ensure that electricity supply equals electricity demand every second of the year. WECC serves at the coordinator of energy exchanges between and among these BAAs in the Western Interconnection. WECC is responsible for ensuring that electric system reliability is maintained. Toward this end, WECC establishes and enforces rules of operation that each utility and each BAA must obey. Failure to obey can result in fines and, in extreme cases, revoking certain privileges. WECC also supports planning activities in the west to assist utilities and BAAs in their respective responsibilities to plan for new transmission to meet future system needs.

The topic of this paper is dynamic transfers and dynamic transfers occur largely within the context of electricity system operations rather than electricity system planning. Electricity system operations refers to the day to day, hour to hour, and second to second operations of the electric grid as the BAAs actively manage exchanges to ensure supply of electricity equals demand of electricity throughout their respective footprints.

WECC oversight of BAA coordinated exchange includes participation in the Western Interchange Tool. The Western Interchange Tool facilitates the use of available interchange capacity through the operation of a Net Scheduled Interchange (NSI) checkout system. The checkout process works as follows:

- A NERC e-Tag is submitted by the purchasing selling entity to process requests for interchange
- All interchange schedules (e-Tags) are "checked out" no later than 20 minutes prior to the onset of the scheduled hour using the WECC Western Interchange Tool.
- Check out 20 minutes prior to the hour in which schedules will be operative ensures that the implementation of the hourly ramp can begin at 10 minutes prior to the scheduled hour. The hourly ramp refers to the increase or decrease of energy across the interchange in anticipation of a higher or lower scheduled demand for that coming hour.
- Each BAA manages its supply-demand balance throughout the operating hour to its "pre-scheduled" NSI, which ensures reliable operation of the Western Interconnection in aggregate during that hour.
- Each BAA ensures that Area Control Error (ACE) stays within an acceptable tolerance of 60 hertz during that hour to ensure system stability for that BAA and the WECC as a whole.

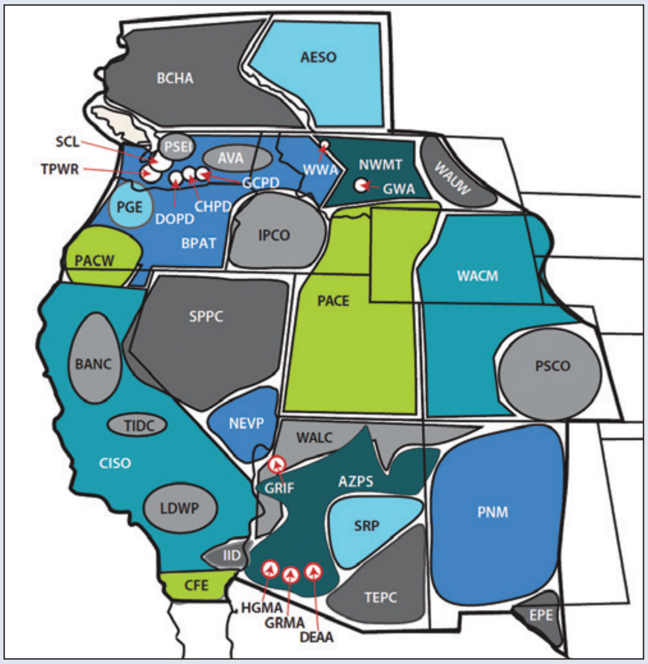
Balancing Area Authority Overview

A balancing authority is responsible for operating a transmission control area. It matches generation with load and maintains electric frequency of the grid.

The BAA operates within the metered boundaries that establish the balancing authority area. Every generator,

Figure A-1

WECC Balancing Authorities[27]



transmission facility, and end-use customer is in a BAA. The BAA's mission is to maintain the balance between loads and resources in real time within its balancing authority area by keeping its actual interchange equal to its scheduled interchange and meeting its frequency bias obligation. The load-resource balance is measured by the balancing authority's ACE. NERC's reliability standards require that the balancing authority maintain its ACE within acceptable limits.

Maintaining resource-demand balance within the balancing authority area requires eight types of resource management, all of which are the balancing authority's responsibility:

- Frequency control through tie-line bias;
- Regulation service deployment;
- Load-following through economic dispatch;
- Interchange implementation;
- Unit commitment and schedules from load serving entities;
- Role in approving interchange;
- Energy emergencies; and
- Failure to balance.

Frequency control through tie-line bias. To maintain frequency within acceptable limits, the balancing authority controls resources within its balancing authority area to meet its frequency bias obligation to the interconnection.

Regulation service deployment. To maintain its ACE within these acceptable limits, the balancing authority controls a set of generators within its balancing authority area that are capable of providing regulation service.

Load-following through economic dispatch. The organization that serves as the balancing authority will in general also perform unit commitment and economic dispatch; however, in some markets, generator operators may be permitted to perform unit commitment and economic dispatch among the fleet of generators under their control and within the requirements accepted by the market operator.

Interchange implementation. The balancing authority receives confirmed interchange from one or more interchange coordinators, and enters those interchange schedules into its energy management system.

Unit commitment and schedules from load-serving entities. The balancing authority receives resource dispatch plans from the market operator and/or unit commitment and dispatch schedules from the load-serving entities that have bilateral arrangements for generation within the market or the balancing authority area. The balancing authority provides this commitment and dispatch schedule to the reliability coordinator.

Role in approving interchange. The balancing authority approves an arranged interchange with respect to the ramping requirements of the generation that must increase or decrease to implement the interchange. The balancing authority provides its approval or denial to the interchange coordinator.

Energy emergencies. In the event of an energy emergency, the balancing authority can implement public appeals, demand-side management programs, and, ultimately, load shedding. Obviously, it must do this in concert with the reliability coordinator.

Failure to balance. The balancing authority must take action, either under its own initiative or through direction by the reliability coordinator, if the balancing authority cannot comply with NERC's reliability standards regarding frequency control and ACE.

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[27] Western Interconnection Balancing Authorities (2012). Available at: http://www.wecc.biz/library/WECC%20 Documents/Publications/WECC_BA_Map.pdf

Balancing Authority Duties

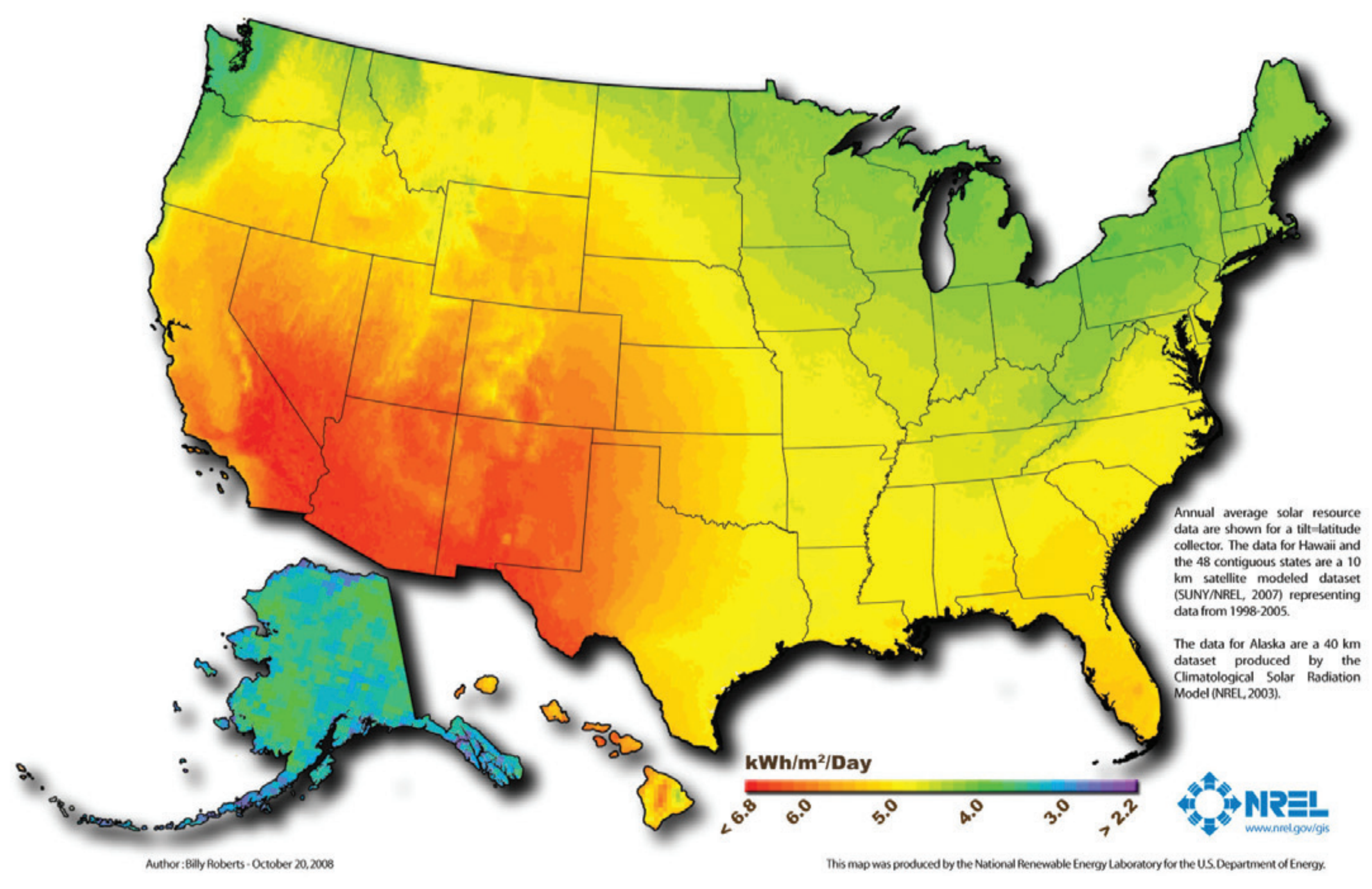
Balancing area authorities have many duties, ranging from coordinating and dispatching energy to balancing load and providing emergency assistance. A list of the primary balancing authority duties is below:

- Coordinate equipment outages;
- Schedule forward energy for both native generation and markets;
- Interchange scheduling (pre-scheduling NSI);
- Automatic generation control;
- Balance load, generation, and net scheduled interchange every four seconds throughout the operating hour;
- Dispatch balancing energy and operating reserves as required;
- Provide emergency assistance;
- After-the-fact checkout of actual interchange; and
- Coordinate operations with the Western Interconnection, including:
    - Schedules;
    - Outages;
    - Emergency energy; and
    - Communication with WECC reliability coordinators

Appendix B. Maps

Figure B-1

Map of U.S. Photovoltaic Solar Resource Potential[28]



Annual average solar resource data are shown for a tilt=latitude collector. The data for Hawaii and the 48 contiguous states are a 10 km satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2005.

The data for Alaska are a 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003).

Author: Billy Roberts - October 20, 2008

This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.

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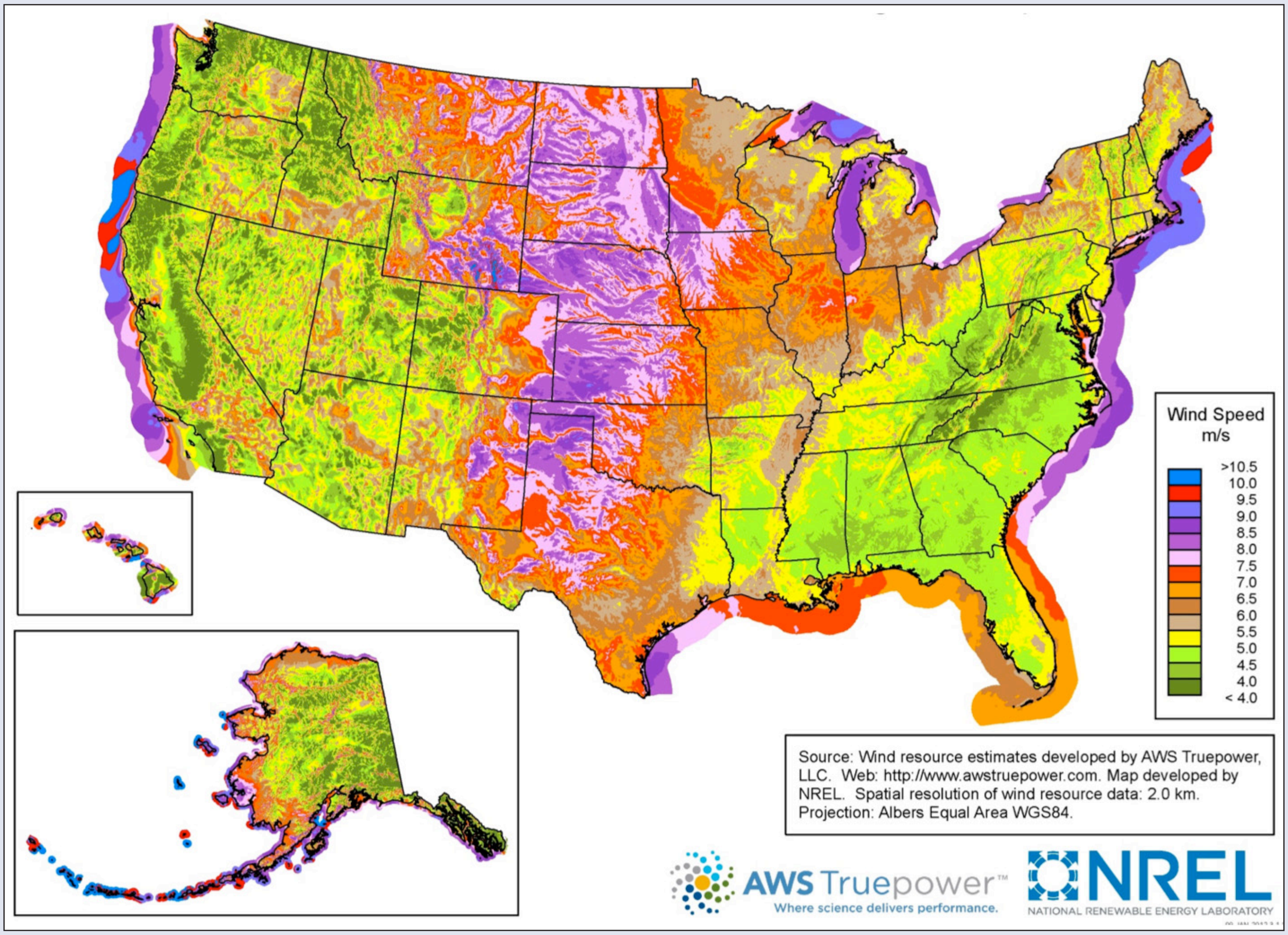
[28] National Renewable Energy Laboratory. Renewable Energy Technology Resource Maps and Technical Potential for the United States – Updated July 2012. Available at: http://www.nrel.gov/gis/docs/resource_maps_201207.pptx

Figure B-2

Map of U.S. Wind Resource (80m) Potential[29]



Source: Wind resource estimates developed by AWS Truepower, LLC. Web: http://www.awstruepower.com. Map developed by NREL. Spatial resolution of wind resource data: 2.0 km. Projection: Albers Equal Area WGS84.

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[29] National Renewable Energy Laboratory. Renewable Energy Technology Resource Maps and Technical Potential for the United States – Updated July 2012. Available at: http://www.nrel.gov/gis/docs/resource_maps_201207.pptx

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