Informing the **Transmission Discussion**

A Look at Renewables Integration and Resilience Issues for Power Transmission in Selected Regions of the United States

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scottmadden
MANAGEMENT CONSULTANTS

WIRES

Regional Discussion

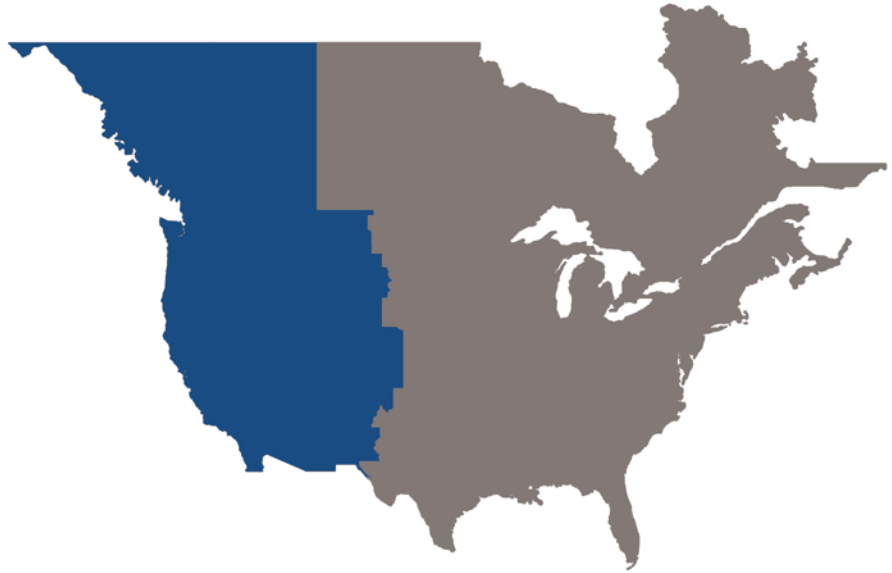
WESTERN ELECTRICITY COORDINATING COUNSEL (WECC) (EXCLUDING CAISO)

Contents

Overview

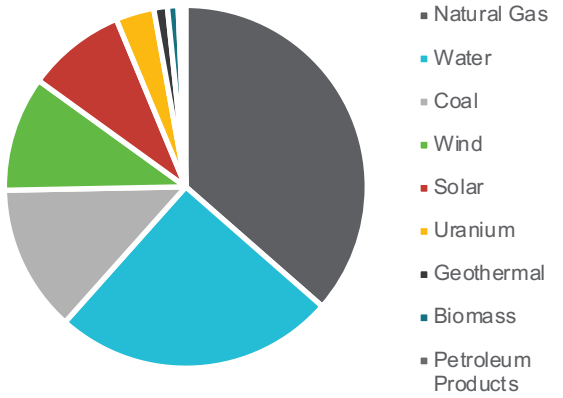
Description of Region

- The Western Interconnect is principally comprised of vertically integrated investor-owned utilities, a large federal utility, and a number of cooperative and municipal and state utilities.
- WECC, the reliability assessment area covering the Western Interconnect, is the largest and most diverse of the regional entities.
- WECC is s a summer-peaking assessment area, and WECC is divided into four U.S. assessment areas: California/Mexico (CAMX), Northwest Power Pool (NWPP), Rocky Mountain Reserve Group (RMRG), and Southwest Reserve Sharing Group (SRSG).
- No WECC subregion is expected to drop below the reference margin level before 2027.

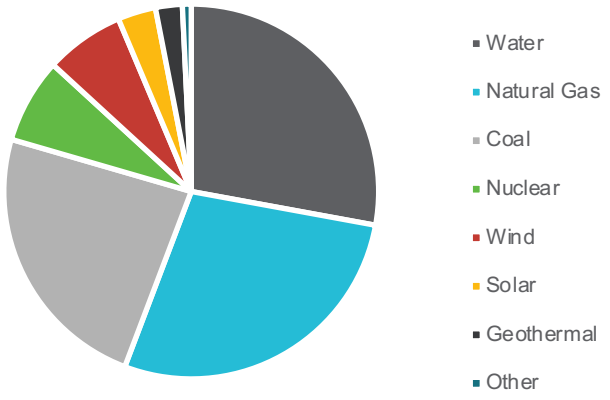


Key Regional Statistics	
States Covered	AZ, CA, CO, ID, MT, NE, NM, NV, OR, SD, TX, UT, WA, WY
Square Mi. Covered	~1,800,000
No. of Utilities	6 co-ops; 5 fed/state systems; 3 munis; 12 investor-owned utilities
No. of Customers/Pop. Served	82.2MM population
Installed Capacity	171,119 MWs
Transmission Line Miles	126,285
Peak Hour Demand (2018)†	141,740 MWs summer (109,652 MWs winter)
Net Energy for Load	734,344 GWhs
Forecast Growth (Annual)	0.50%-2.30% peak load growth -0.52%-0.1.54% demand (usage) growth

2018 Capacity Mix by Fuel



2018 Energy Mix by Fuel



Sources: NERC 2018 LTRA, NERC ES&D, SPGMI
Notes: WECC figures on this page include CAISO, CAISO has not been netted out (but the two subregions in Canada, Alberta and British Columbia, have been removed)
† Note: Not necessarily coincident; constitutes a sum of sub-regional peak hour demand for CAMX, NWPP-US, RMRG, and SRSG; net internal demand is net of demand response.

Overview (Cont'd)

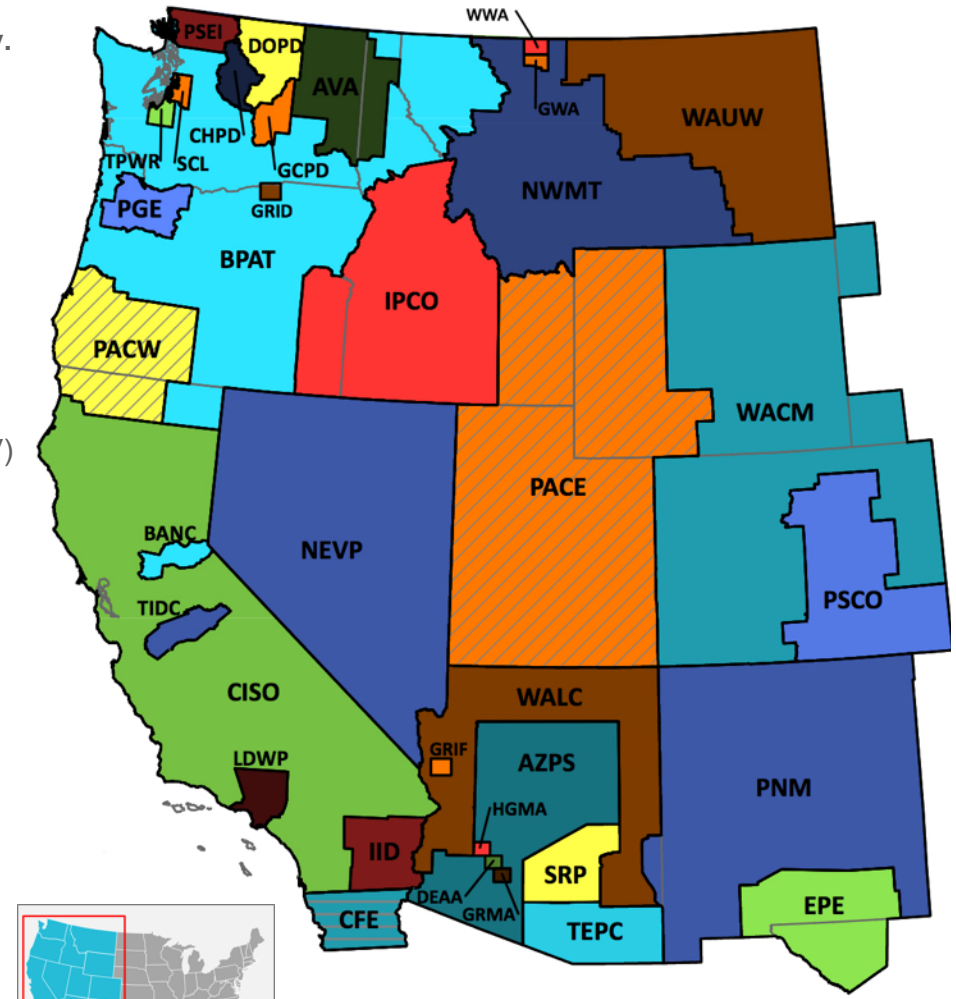
WECC is the regional entity for the Western Interconnection and is charged with coordinating and promoting bulk electric system reliability.

- WECC coordinates the operating and planning activities of its Western Interconnection members.
- Geographically, it is the largest and most diverse of the eight regional entities in NERC.
- WECC is comprised of four subregions:
  - Canada Mexico Power Area (CAMX)
  - Northwest Power Pool (NWPP)
  - Rocky Mountain Power Area (RMPA)
  - Arizona-New Mexico-Southern Nevada Power Area (AZ-NM-SNV)
- Different subregions of the West have different resource portfolios. Hydro units are dominant in the Northwest, while California and the Southwest rely heavily on natural gas. Solar units have become prevalent, especially in California, as wind capacity has grown in the Rocky Mountains and along the Columbia River.

Balancing Authorities

- WECC has 329 member organizations, including 38 different balancing authorities (pictured at right).
- Each balancing authority is responsible for balancing loads and resources within their respective boundaries. Such an organizational structure often presents challenges to reliability, particularly when integrating large amounts of variable generation.

Western Electricity Coordinating Council Balancing Areas



Legend

AESO - Alberta Electric System Operator
AVA - Avista Corporation
AZPS - Arizona Public Service Company
BANC - Balancing Authority of Northern California
BCHA - British Columbia Hydro Authority
BPAT - Bonneville Power Administration - Transmission
CFE - Comision Federal de Electricidad
CHPD - PUD No. 1 of Chelan County
CISO - California Independent System Operator
DEAA - Arlington Valley, LLC
DOPD - PUD No. 1 of Douglas County
EPE - El Paso Electric Company
GCPD - PUD No. 2 of Grant County
GRID - Gridforce
GRIF - Griffith Energy, LLC
GRMA - Sun Devil Power Holdings, LLC
GWA - NaturEner Power Watch, LLC
HGMA - New Harquahala Generating Company, LLC
IID - Imperial Irrigation District
IPCO - Idaho Power Company
LDWP - Los Angeles Department of Water and Power
NEVP - Nevada Power Company
NWMT - NorthWestern Energy
PACE - PacifiCorp East
PACW - PacifiCorp West
PGE - Portland General Electric Company
PNM - Public Service Company of New Mexico
PSCO - Public Service Company of Colorado
PSEI - Puget Sound Energy
SCL - Seattle City Light
SRP - Salt River Project
TEPC - Tucson Electric Power Company
TIDC - Turlock Irrigation District
TPWR - City of Tacoma, Department of Public Utilities
WACM - Western Area Power Administration, Colorado-Missouri Region
WALC - Western Area Power Administration, Lower Colorado Region
WAUW - Western Area Power Administration, Upper Great Plains West
WWA - NaturEner Wind Watch, LLC

Sources: WECC; NERC 2018 LTRA

Overview (Cont'd)

Transmission Planning Regions

- WECC is comprised of four different regional planning groups (Western Planning Regions, or WPRs), arrayed at right by approximate geographical location across the Western Interconnect:
  - California ISO (CAISO)
  - ColumbiaGrid
  - Northern Tier Transmission Group (NTTG)
  - WestConnect
- Each WPR develops its own transmission expansion plan, and an interregional transmission planning process is conducted to identify and approve transmission solutions which span multiple WPRs (discussed in the next section). An interregional coordination team (ICT) comprised of representatives from each region identifies interregional solutions.
- Though each region has different participants in geographically distinct regions across the western United States, the four planning regions have coordinated to establish a common language and common processes in response to FERC orders through the years.

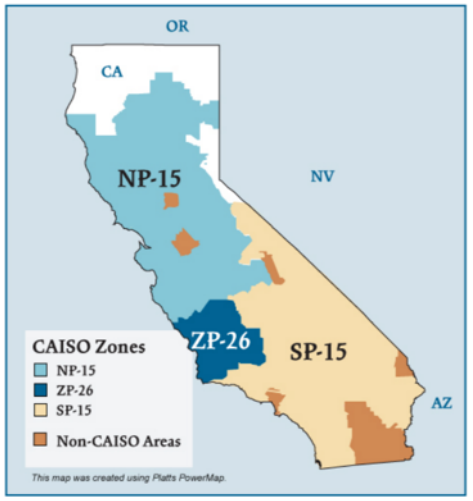
Resource Adequacy

- According to NERC's 2018 LTRA, "The Western Interconnection and all of the individual subregions are expected to have sufficient generation capacity to exceed the Reference Margin Level during the assessment period."
- Other subregional resource adequacy assessments have been conducted by the Northwest Power Conservation Council (NPCC), with the help of the Resource Adequacy Advisory Council (RAAC), which found that the power supply in the Northwest is likely to become inadequate by 2021, primarily due to the retirement of the Centralia 1 and Boardman coal plants (1,330 MWs combined). The loss of load probability (LOLP) for that year is estimated to be more than 6%, which exceeds the NPCC's standard of 5%.

ColumbiaGrid

NTTG

CAISO



WestConnect Planning Region

Sources: WECC; CAISO; ColumbiaGrid; NTTG; WestConnect

Overview (Cont'd)

ColumbiaGrid

- Members and participating utilities include:
  - Avista Corporation
  - Bonneville Power Administration
  - Chelan County Power
  - Cowlitz PUD
  - Douglas County PUD*
  - Grant PUD
  - MATL LLP
  - Puget Sound Energy, Inc.
  - Seattle City Light
  - Snohomish PUD
  - Tacoma Power

ColumbiaGrid Transmission Facilities

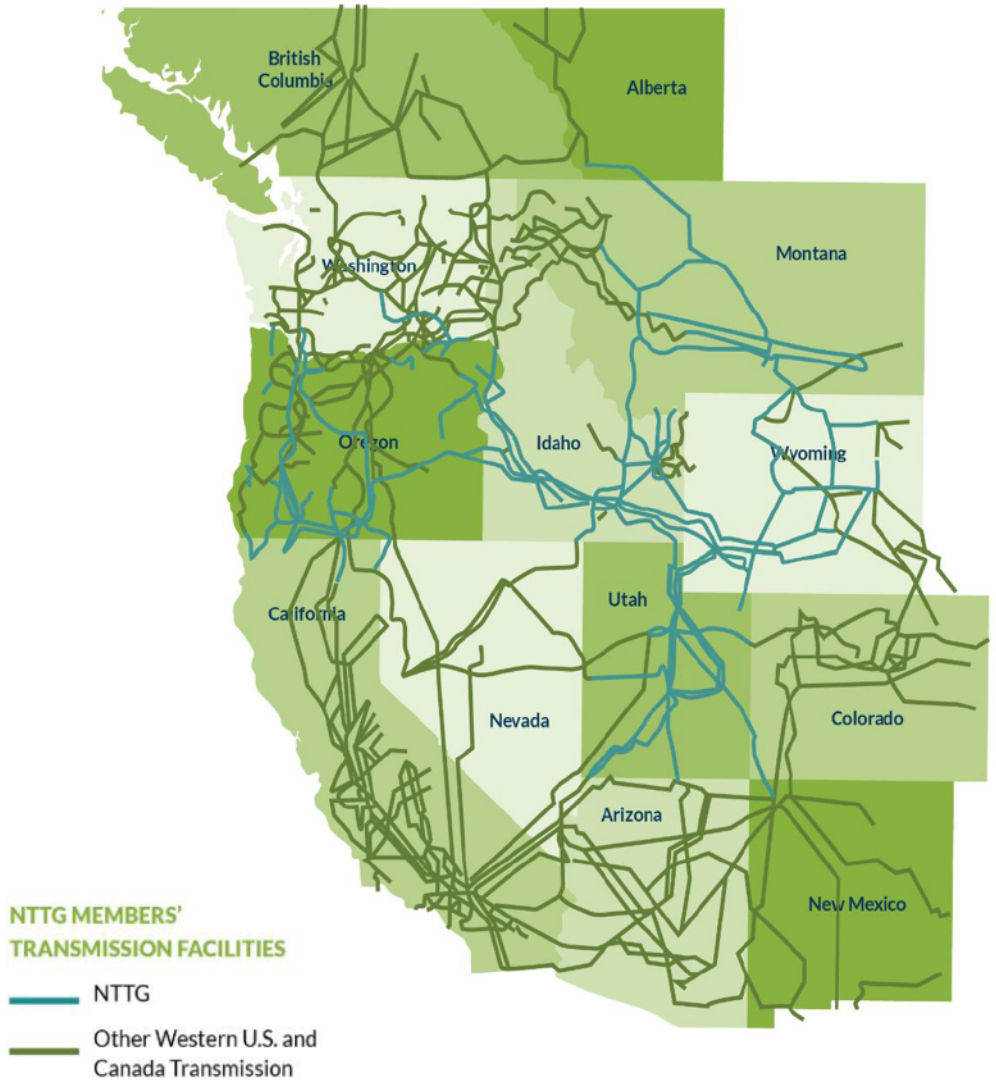
*Non-member PEFA planning participant
Sources: WECC; ColumbiaGrid

Overview (Cont'd)

NTTG

- Participating utilities include:
  - Deseret Power Electric Cooperative
  - Idaho Power
  - MATL LLP
  - Northwestern Energy
  - Pacificorp
  - Portland General Electric
  - Utah Associated Municipal Systems
- Participating state agencies include:
  - Idaho Public Utilities Commission
  - Montana Consumer Counsel
  - Montana Public Service Commission
  - Oregon Public Utility Commission
  - Utah Office of Consumer Services
  - Utah Public Service Commission
  - Wyoming Office of Consumer Advocates
  - Wyoming Public Service Commission

NTTG Map of Transmission Facilities



Sources: WECC; NTTG

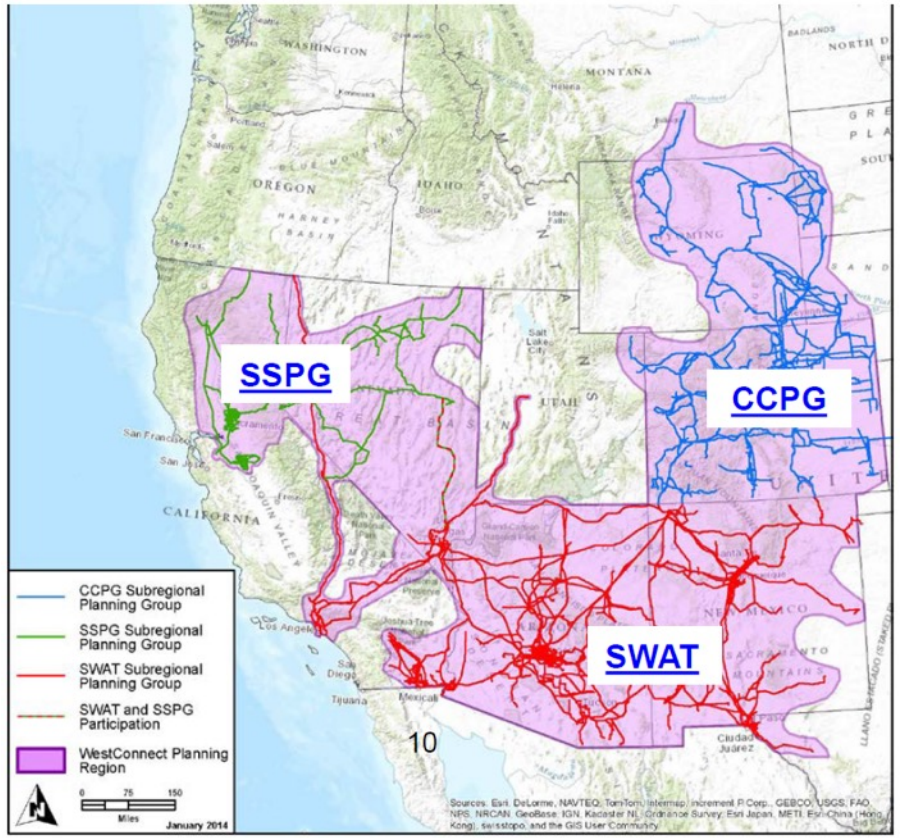
Overview (Cont'd)

WestConnect

- Enrolled transmission owners include:
  - Arizona Public Service
  - Black Hills*
  - El Paso Electric
  - NV Energy*
  - Public Service of New Mexico
  - Tucson Electric
  - Xcel –PSCo*
- Coordinating transmission owners include:
  - Arizona Electric Power Coop.
  - Basin Electric*
  - Colorado Springs Utilities
  - Imperial Irrigation District
  - L.A. Dept. of Water and Power
  - Platte River
  - Sacramento Municipal Utility District
  - Salt River Project
  - Transmission Agency of Northern California
  - Tri-State G&T
  - Western Area Power Administration

WestConnect Planning Region

WestConnect Subregional Planning Groups



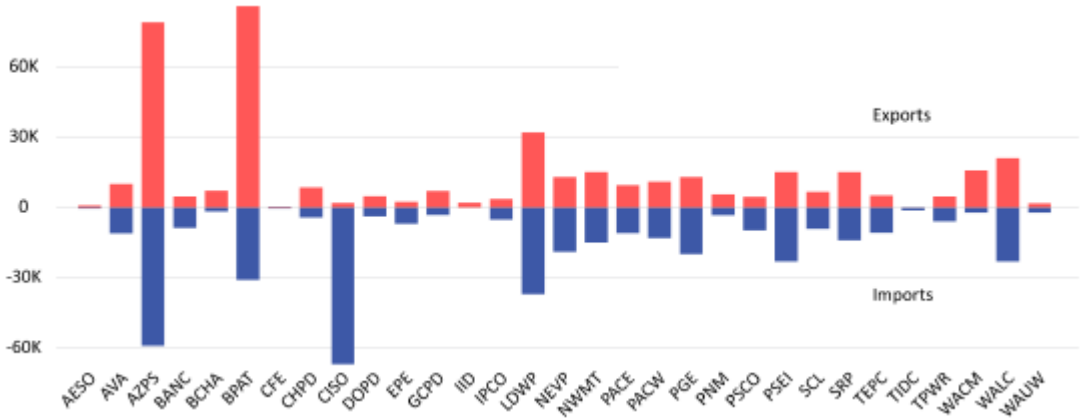
*Note: 2018 eligible transmission developer
Sources: WECC; WestConnect

Transmission Topography and Investment

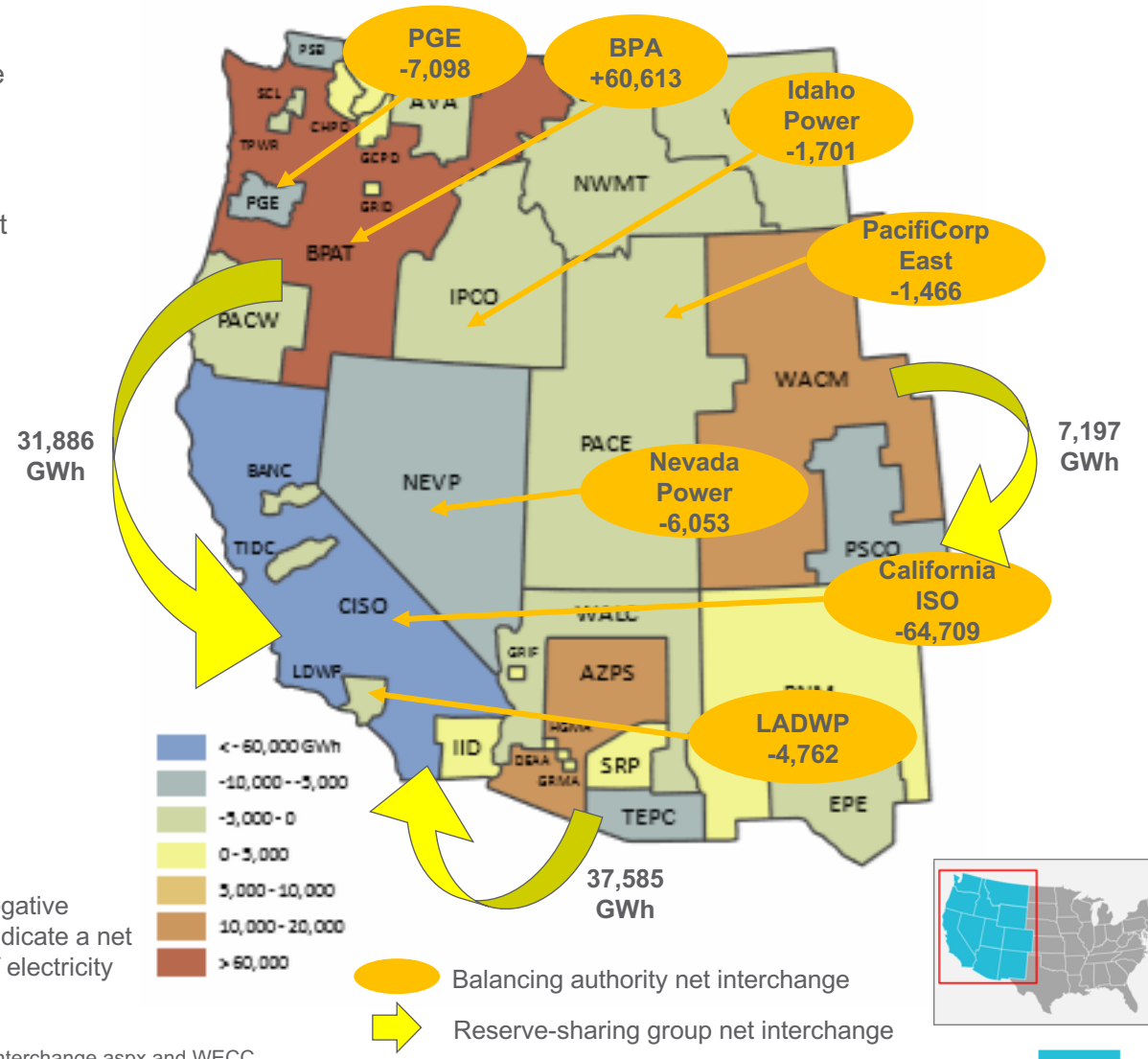
California is the largest importer of electricity in the West, importing and consuming energy generated in neighboring regions.

- Regional variation in seasonal demand and an abundance of generation capacity in the Pacific Northwest (with large amounts of hydro power) and the Southwest, combined with high demand in California, cause electricity to flow in a “doughnut” pattern.
- In 2016, the California-Mexico subregion had net imports of about 70,000 GWhs, equivalent to about 30% of CAISO net energy for demand. Volumes from the Northwest were slightly less than those from the Southwest.
- Net interchange is the difference between exports and imports.
  - The map at right shows balancing authorities that import energy (blue) compared to regions that primarily export energy (red-brown).
  - The yellow arrows show where large amounts of energy flow between reserve-sharing regions.

Imports and Exports by Balancing Authority (GWhs)



2016 Net Interchange by Balancing Authority (GWh)



Note: Negative values indicate a net import of electricity

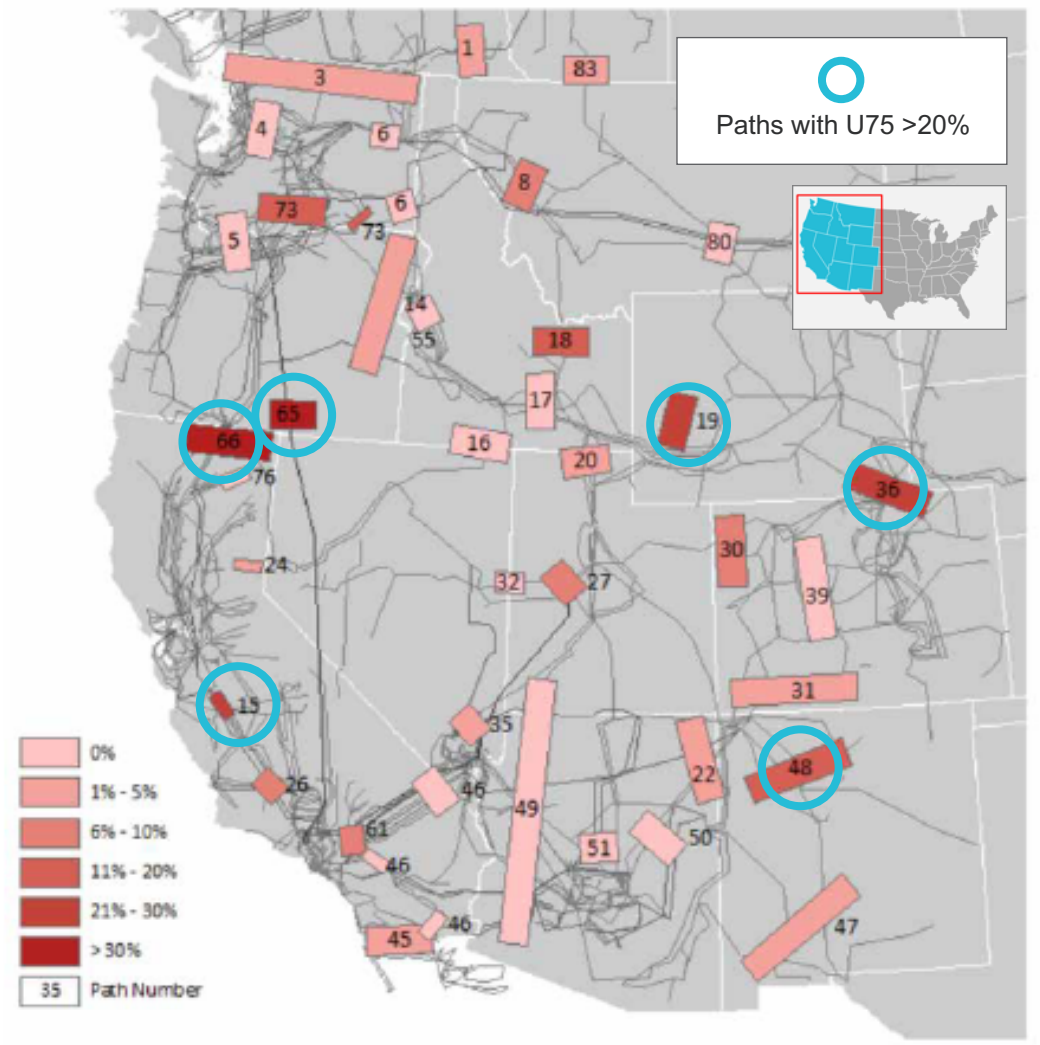
Sources: WECC, State of the Interconnection, at https://www.wecc.org/epubs/StateOfTheInterconnection/Pages/Interchange.aspx and WECC, State of the Interconnection Digest (Summer 2018) (Aug 8, 2018)

Transmission Topography and Investment (Cont'd)

WECC Transmission Paths

- WECC is characterized by long transmission lines connecting remote generation to load centers. Key transmission lines are grouped into 66 numbered paths for planning and operational purposes and illustrated in the map below.
  - One measure of congestion on WECC paths is the U75 metric, which measures the percent of time the flow on the path is above 75% of the path's operating limit.
  - A low U75 does not necessarily indicate a path is underutilized. Inversely, a high U75 does not necessarily indicate congestion. Many factors determine operating limits.
  - Some paths (e.g., Path 19) were built to carry electricity from large plants. High levels of flow are not unusual for these paths.
- The most congested paths are those in and around northern California, central California, northern New Mexico, and southwest and southeast Wyoming.

2017 U75 for WECC Major Transfer Paths



Source: WECC

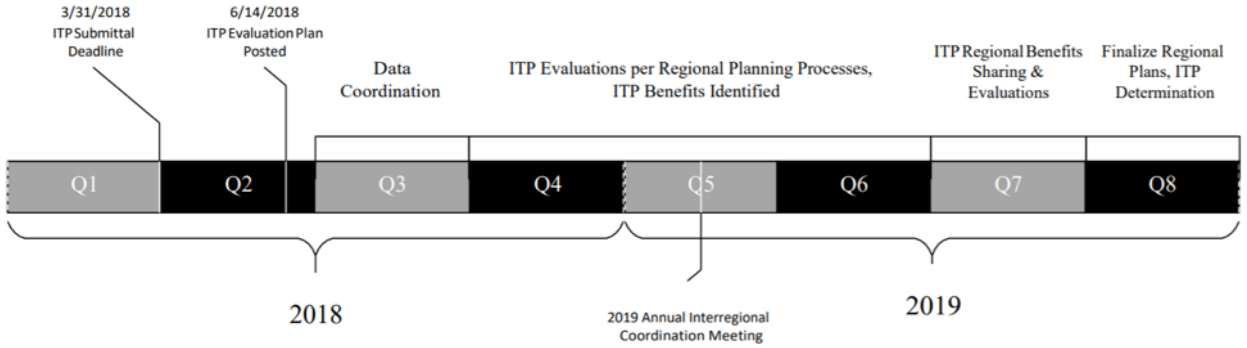
Sources: WECC, State of the Interconnection, at https://www.wecc.org/epubs/StateOfTheInterconnection/Pages/Interchange.aspx and WECC, State of the Interconnection Digest (Summer 2018) (Aug 8, 2018)

Transmission Topography and Investment (Cont'd)

Interregional Transmission Planning (ITP)

- The goal of the coordinated ITP evaluation process is to achieve consistent planning assumptions and technical data of an ITP to be used in the individual regional evaluations of an ITP.
- ITP proposals may be introduced by any of the WPRs, and relevant planning regions and cost allocation methods are identified at the time of project proposal.
- The Transmission Expansion Planning Policy Committee (TEPPC), with the assistance of WECC, conducts an interconnection-wide transmission planning activity every two years. This activity consists of developing input assumptions for the planning models, collecting and helping to develop planning scenarios, and running the planning models for 10- and 20-year scenarios.

ITP Evaluation Timeline



ITP Proposal – Cross Tie Transmission Project (Illustrative)

New ITPs Proposed in the 2018–2019 Planning Process

No	ITP Name	Submitted to	Project Proponent
1	TransWest DC	NTTG, WestConnect	TransWest Express LLC
2	TransWest AC/DC	NTTG, WestConnect	TransWest Express LLC
3	SDG&E HVDC Conversion	CAISO, WestConnect	San Diego Gas and Electric
4	TransCanyon Cross-Tie	NTTG, WestConnect	TRANSCANYON
5	SWIP North	CAISO, NTTG, WestConnect	Great Basin Transmission
6	North Gila-Imperial Valley #2	CAISO, NTTG, WestConnect	ITC Grid Development

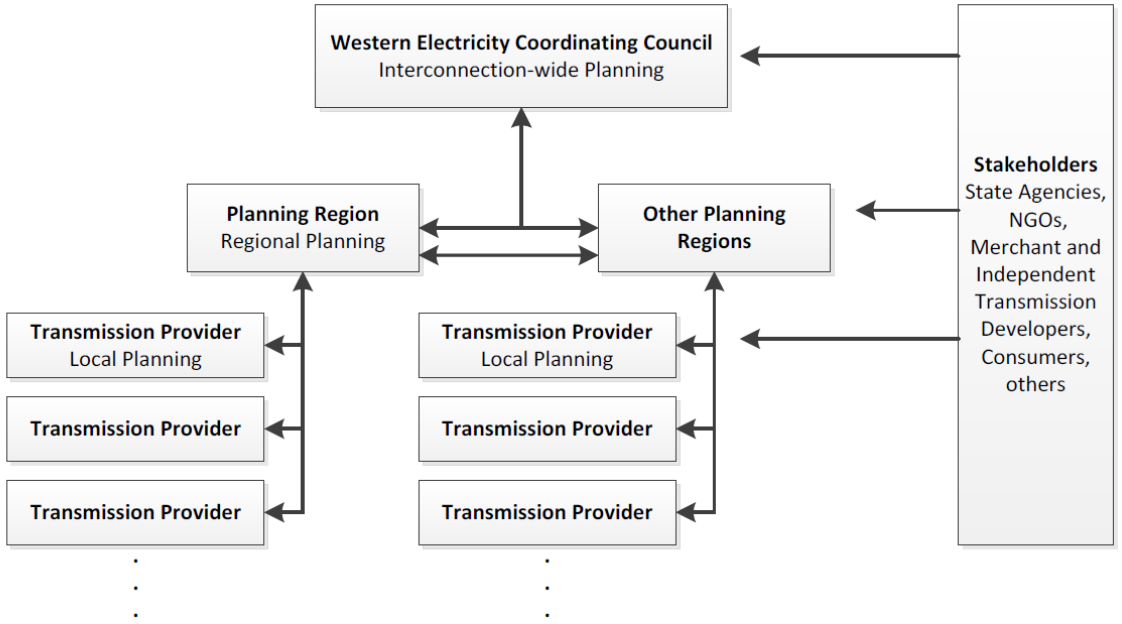
Sources: CAISO; ColumbiaGrid; NTTG; ITP Evaluation Process Plan

Transmission Topography and Investment (Cont'd)

Interregional Transmission Planning (ITP) (Cont'd)

- Needs assessments in each of the planning regions are conducted to identify three different types of needs:
  - **Reliability** – conducted to ensure compliance with NERC and WECC criteria
    - Assessment includes steady state contingency analysis and transient stability analysis.
    - Transmission elements of 100 kV and above will be monitored for performance along with any member-specified lower-voltage bulk electric system (BES) elements.
  - **Economic** – conducted to create base case for modeling
    - Assessment includes review of metrics such as congested hours and congestion cost for regional transmission elements greater than 100 kV and WECC transfer paths along with any member-specified lower-voltage BES elements.
    - Regional transmission with significant congestion is identified and verified through planning subcommittee review, historical benchmarking, and follow-up study.
  - **Public policy** – conducted to study potential needs driven by public policies that impact local transmission owners (TOs)
    - If the assessments identify regional issues that are related to enacted public policy, these may constitute a public policy-driven transmission need.
    - There is also an opportunity to make suggestions as to whether a TO's policy-driven project may constitute a public policy-driven regional transmission need.

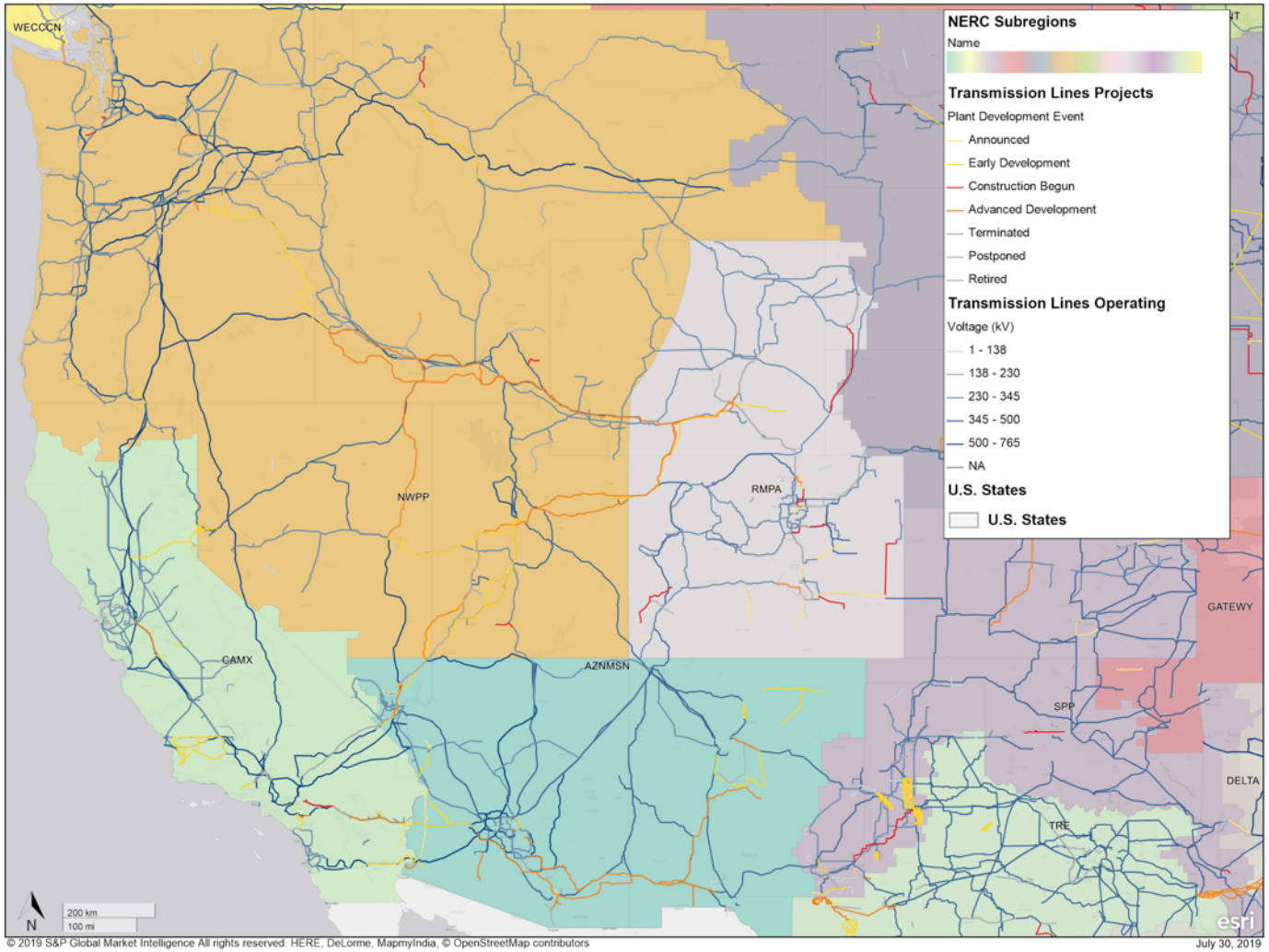
Transmission Planning Stakeholder Hierarchy



Sources: WestConnect; FERC Docket No. ER13-1447-001, et al (https://nttg.biz/site/index.php?option=com_docman&view=download&alias=2427-ferc-interregional-compliance-order-06-01-2015&category_slug=ferc-order-1000-interregional&Itemid=31)

Transmission Topography and Investment (Cont'd)

Selected WECC Subregions Transmission Lines



- There is significant internal transfer capability within WECC, which allows for transfers between subregions. In addition, WECC is interconnected with SPP and ERCOT.
- According to NERC, approximately 1,902 miles of new transmission lines are either planned stages or under construction as of late 2018, and an additional 884 miles are in the conceptual phase (see table below).
- Of the 169 projects cited by NERC, 121 are driven by reliability; 8 projects are driven by variable renewable integration, and 40 projects are driven by other needs.

Proposed Transmission Projects (Line Length in Circuit Miles) in WECC, Excluding CAISO (as of Dec. 2018)

Operating Voltage Class (kV)	Conceptual	Planned	Under Construction
100–120	76.5	468.93	64.44
121–150	12	0	0
151–199	51.7	0	0
200–299	316.4	255	349.1
300–399	0	115	85
400–599	428	565	0
Grand Total	884.6	1,403.93	498.54

Source: NERC 2018 Electricity Supply & Demand

Sources: S&P Global Market Intelligence; NERC 2018 LTRA; NERC ES&D

Transmission Topography and Investment (Cont'd)

Projected Transmission Expenditures

- Columbia Grid – According to its latest biennial transmission expansion plan published in February 2019, ColumbiaGrid estimates that total expenditures on transmission will be approximately $2.4 billion over the 10-year study period (through 2028).
- NTTG – According to its latest regional transmission plan published in June 2019, NTTG estimates that the incremental cost of all projects in the approved plan will be $879.7 million.
- WestConnect – Per its 2018–2019 base transmission plan, which includes planned transmission projects and high probability interregional transmission projects, WestConnect has $933 million in planned investment over the study period.

Joint Areas of Concern Identified in ColumbiaGrid's 2019 Biennial Transmission Expansion Plan (BTEP)

New Projects Identified in NTTG's 2018-2019 Regional Transmission Plan

Submitter	From	To	Voltage	Circuit	Type	Regionally Significant	Committed	Projects (In-service Year)
Idaho Power	Hemingway	Longhorn	500 kV	1	LTP & pRTP	Yes	No	B2H Project (2026)
	Hemingway	Bowmont	230 kV	2	LTP	Yes	No	New Line - associated with Boardman to Hemingway (2026)
	Bowmont	Hubbard	230 kV	1	LTP	Yes	No	New Line - associated with Boardman to Hemingway (2026)
	Hubbard	Cloverdale	230 kV	1	LTP	No	No	New Line (2021)
	Midpoint	Hemingway	500 kV	2	LTP	Yes	No	Gateway West Segment #8 (joint with PacifiCorp East) (2024)
	Cedar Hill	Hemingway	500 kV	1	LTP & pRTP	Yes	No	Gateway West Segment #9 (joint with PacifiCorp East) (2024)
	Cedar Hill	Midpoint	500 kV	1	LTP	Yes	No	Gateway West Segment #10 (2024)
	Midpoint	Borah	500 kV	1	LTP & pRTP	Yes	No	(convert existing from 345 kV operation) (2024)
	Ketchum	Wood River	138 kV	2	LTP	No	No	New Line (2020)
	Willis	Star	138 kV	1	LTP	No	No	New Line (2019)
Enbridge	SE Alberta		DC	1	LTP	Yes	No	MATL 600 MW Back to Back DC Converter (2024)
PacifiCorp East	Aeolus	Clover	500 kV	1	LTP & pRTP	Yes	No	Gateway South Project – Segment #2 (2024)
	Aeolus	Anticline	500 kV	1	LTP & pRTP	Yes	No	Gateway West Segments 2&3 (2020)
	Anticline	Jim Bridger	500 kV	1	LTP & pRTP	Yes	No	345/500 kV Tie (2020)
	Anticline	Populus	500 kV	1	LTP & pRTP	Yes	No	Gateway West Segment #4 (2024)
	Populus	Borah	500 kV	1	LTP	Yes	No	Gateway West Segment #5 (2024)
	Populus	Cedar Hill	500 kV	1	LTP & pRTP	Yes	No	Gateway West Segment #7 (2024)
	Antelope	Goshen	345 kV	1	LTP	Yes	No	Nuclear Resource Integration (2026)
	Antelope	Borah	345 kV	1	LTP	Yes	No	Nuclear Resource Integration (2026)
	Windstar	Aeolus	230 kV	1	LTP & pRTP	Yes	No	Gateway West Segment #1W (2024)
	Oquirrh	Terminal	345 kV	2	LTP	Yes	Yes	Gateway Central
	Cedar Hill	Hemingway	500 kV	1	LTP	Yes	No	Gateway West Segment #9 (joint with Idaho Power) (2024)
	Shirley Basin	Standpipe	230 kV	1	LTP	Yes	No	Local Wind Integration (2020)
PacifiCorp West	Wallula	McNary	230 kV	2	LTP	Yes	Yes	Gateway West Segment A (2020)
Portland General	Blue Lake	Gresham	230 kV	1	LTP	No	Yes	New Line (2018)
	Blue Lake	Troutdale	230 kV	1	LTP	No	Yes	Rebuild (2018)
	Blue Lake	Troutdale	230 kV	2	LTP	No	Yes	New Line (2018)
	Horizon	Springville Jct	230 kV	1	LTP	No	Yes	New Line (Trojan-St Marys-Horizon) (2020)
	Horizon	Harborton	230 kV	1	LTP	No	Yes	New Line (re-terminates Horizon Line) (2020)
	Trojan	Harborton	230 kV	1	LTP	No	Yes	Re-termination to Harborton (2020)
	St Marys	Harborton	230 kV	1	LTP	No	Yes	Re-termination to Harborton (2020)
	Rivergate	Harborton	230 kV	1	LTP	No	Yes	Re-termination to Harborton (2020)
	Trojan	Harborton	230 kV	2	LTP	No	Yes	Re-termination to Harborton (2020)
			115 kV	1	LTP	No	Yes	Various Load Service Additions (2019-2024)

Note: LTP is Full Funder Local Transmission Plan, PRTP is Prior Regional Transmission Plan
Sources: ColumbiaGrid; NTTG; WestConnect

Transmission Topography and Investment (Cont'd)

Transmission Projects

- Several transmission projects in WECC are being developed to facilitate the importation of renewable energy generated in states other than California.
  - TransWest Express: The 730-mile project from Wyoming to Nevada, with an expected in-service date of 2023 and a budget of $3 billion, is intended to provide transmission capacity to connect Wyoming wind resources with loads in California.
  - Ten West Link Transmission Line: The 114-mile project would interconnect future renewable energy resources in both Arizona and California to the bulk transmission grid in what was designated in 2007 as a National Interest Electric Transmission Corridor, largely following the established corridor used by the existing Devers-Palo Verde 500 kV No. 1 line that connects APS transmission facilities in Arizona to Southern California Edison (SCE) in California.

Project Name	Project Owner(s)	Project Length (miles)	Project Voltage (kV)	From State	To State	From ISO	To ISO	Yr. in Svc.	Current Development Status	Project Type	Est. Const. Costs ($000)
Aeolus to Standpipe 230kV Line Rebuild	PacifiCorp	16.00	230	Wyoming	Wyoming	WECC	WECC	2020	Adv. Development	Rebuild	NA
BB2 Line (Clines Corners 345 kV - Norton - BA Line)	NA	45.00	345	New Mexico	New Mexico	WECC	WECC	2020	Adv. Development	New	NA
Boardman (Longhorn) to Hemingway Transmission (B2H)	BPA, Idaho Power Company, PacifiCorp	297.00	500	Oregon	Idaho	WECC	WECC	2026	Early Development	New	1,200,000
Boone-La Junta Line Rebuild	Black Hills Colorado.	45.00	115	Colorado	Colorado	WECC	WECC	2020	Construction Begun	Rebuild	20,900
Gateway South – Segment F (Aeolus-Mona 500-kV)	PacifiCorp	400.00	500	Wyoming	Utah	WECC	WECC	2024	Adv. Development	New	NA
Gateway West – Segment 10 (Midpoint - Cedar Hill)	Idaho Power Company, PacifiCorp	34.00	500	Idaho	Idaho	WECC	WECC	2020	Adv. Development	New	NA
Gateway West – Segment 1Wa - (Shirley Basin to Aeolus)	PacifiCorp	17.00	230	Wyoming	Wyoming	WECC	WECC	2020	Adv. Development	New	NA
Gateway West – Segment 2 and 3 - (Aeolus to Anticline)	PacifiCorp	140.00	500	Wyoming	Wyoming	WECC	WECC	2020	Adv. Development	New	NA
Gateway West – Segment 4 - (Anticline/Jim Bridger to Populus)	PacifiCorp	203.00	500	Wyoming	Idaho	WECC	WECC	2024	Adv. Development	New	NA
Gateway West – Segment 5 - (Populus to Borah)	PacifiCorp	55.00	500	Idaho	Idaho	WECC	WECC	2024	Adv. Development	New	NA
Gateway West – Segment 6 (Borah - Midpoint) Upgrade	Idaho Power Company	88.00	500	Idaho	Idaho	WECC	WECC	2024	Adv. Development	Upgrade	NA
Gateway West – Segment 7 (Populus - Cedar Hill)	PacifiCorp	118.00	500	Idaho	Idaho	WECC	WECC	2024	Adv. Development	New	NA
Gateway West – Segment 8 (Midpoint - Hemingway)	Idaho Power Company, PacifiCorp	126.00	500	Idaho	Idaho	WECC	WECC	2020	Adv. Development	New	408,000
Gateway West – Segment 9 (Cedar Hill to Hemingway)	Idaho Power Company, PacifiCorp	161.00	500	Idaho	Idaho	WECC	WECC	2024	Adv. Development	New	NA

Note: Includes projects 15 miles or greater and 115 kV and higher and projects in Early Development, Advanced Development, and Under Construction statuses (does not include Announced)
Sources: S&P Global Market Intelligence; NERC

Transmission Topography and Investment (Cont'd)

Transmission Projects (Cont'd)

Project Name	Project Owner(s)	Project Length (miles)	Project Voltage (kV)	From State	To State	From NERC	To NERC	Yr. in Svc.	Current Development Status	Project Type	Est. Const. Costs ($000)
Gila Bend to Ajo 230 kV Transmission	Ajo Improvement Company	47.00	230	Arizona	Arizona	WECC	WECC	NA	Adv. Development	New	NA
Grants Pass – Table Rock 230-kV (Sam's Valley)	PacifiCorp	18.00	230	Oregon	Oregon	WECC	WECC	2019	Early Development	New	NA
Great Basin Energy	NA	125.00	450	Nevada	Nevada	WECC	WECC	2020	Early Development	New	850,000
Harcuvar Transmission (Bouse to D-CR)	Central AZ Water Conservation District	65.00	230	Arizona	Arizona	WECC	WECC	2020	Early Development	New	NA
Harcuvar Transmission (Bouse – Harquahala)	Central AZ Water Conservation District	30.00	230	Arizona	Arizona	WECC	WECC	2020	Early Development	New	NA
Hooper Springs- Lower Valley Energy	Lower Valley Energy, Inc.	24.00	115	Idaho	Idaho	WECC	WECC	2020	Construction Begun	New	65,000
Hot Springs-Anaconda Transmission Line Rebuild 230 kV	BPA	120.00	230	Montana	Montana	WECC	WECC	2021	Early Development	Rebuild	NA
Kalispell - Kerr Transmission Line Rebuild	BPA	41.00	115	Montana	Montana	WECC	WECC	NA	Construction Begun	Rebuild	NA
Lamar – Front Range Transmission (Burlington – Lamar)	NA	107.00	345	Colorado	Colorado	WECC	WECC	2023	Construction Begun	New	53,000
Lucky Corridor Transmission Line	Lucky Corridor, LLC	62.00	345	New Mexico	New Mexico	WECC	WECC	2023	Early Development	New	131,100
Mora Transmission Line	Lucky Corridor, LLC	110.00	115	New Mexico	New Mexico	WECC	WECC	2020	Early Development	New	65,000
Palo Verde – Saguaro 500kV Transmission line	Arizona Electric Power Cooperative, Inc.	130.00	500	Arizona	Arizona	WECC	WECC	NA	Adv. Development	New	340,000
Southline Transmission (Afton to Apache)	Southline Transmission LLC	205.00	345	New Mexico	Arizona	WECC	WECC	2020	Adv. Development	New	325,000
Southline Transmission (NM Highway 9 to Interstate 10)	Southline Transmission LLC	30.00	345	New Mexico	New Mexico	WECC	WECC	2022	Adv. Development	New	NA
Southwest Intertie – Northern (SWIP-N)	NA	275.00	500	Idaho	Nevada	WECC	WECC	2021	Adv. Development	New	525,000
Vantage-Pomona Heights 230 kV Transmission Line	PacifiCorp	41.00	230	Washington	Washington	WECC	WECC	2020	Adv. Development	New	28,900

Sources: S&P Global Market Intelligence; NERC

Resilience Issues

Overview

- WECC covers a broad area, covering roughly half of the U.S. land mass. It includes all of the population centers in the Pacific Northwest, the Rocky Mountains, and the Desert Southwest, and it also includes a vast expanse of sparsely populated rural areas.
- WECC contains a broad range of geological and weather areas, including arid plateaus and plains in the Desert Southwest; forested mountains, including two major ranges, the American Sierra Nevada and Rocky Mountains; the vast coastal shoreline of the American Pacific Coast; and the rain forests of the Pacific Northwest.
- As a frame of reference for the potential economic impact of a resilience event, the 2018 annual GDP for the states in WECC's footprint (excluding California), was $8.5 trillion, or approximately 10% of the total GDP for the United States in 2018.*
- In WECC's comments to FERC in its grid resilience docket, it cites the following resilience risk in the region:

  "An acceleration of changes in the resource mix from more synchronous generation to more non-synchronous generation, like wind and solar photovoltaics, as the region has some of the most aggressive RPS standards in the U.S. The concern is that under future scenarios with high penetrations of non-synchronous generation, there may be insufficient primary frequency response to arrest a decline in frequency and to avoid load shedding."
- WECC also confirmed that two of the assertions from the U.S. DOE staff report were observed in the region:
  - Many coal-fired generating units that were used for baseload generation in the past are no longer operating in that role at this time. Research by the Western Interstate Energy Board (WIEB) found that baseload operation of the coal fleet in the West has decreased from 52% of coal unit-operating days in 2001 to 22% in 2016.
  - Bulk power system reliability is adequate today, but there has not yet been much analysis of how much primary frequency response will be needed as the composition of the grid changes, nor how best to complement primary frequency response from traditional sources.

Reported Electric Disturbance Events Affecting WECC (2017–Apr. 2019)

Cause	2017	2018	2019 YTD
Fuel Supply Deficiency	0	0	0
Severe Weather	7	5	4
Vandalism	16	16	6
Suspected Physical Attack	1	0	0
Actual Physical Attack	3	2	3
Suspicious Activity	1	1	1
Transmission Interruption	6	4	3
Generation Inadequacy	0	0	1
System Operations	1	4	4

Note: For multiple causes, classified under one only.
Sources: DOE OE-417; ScottMadden analysis

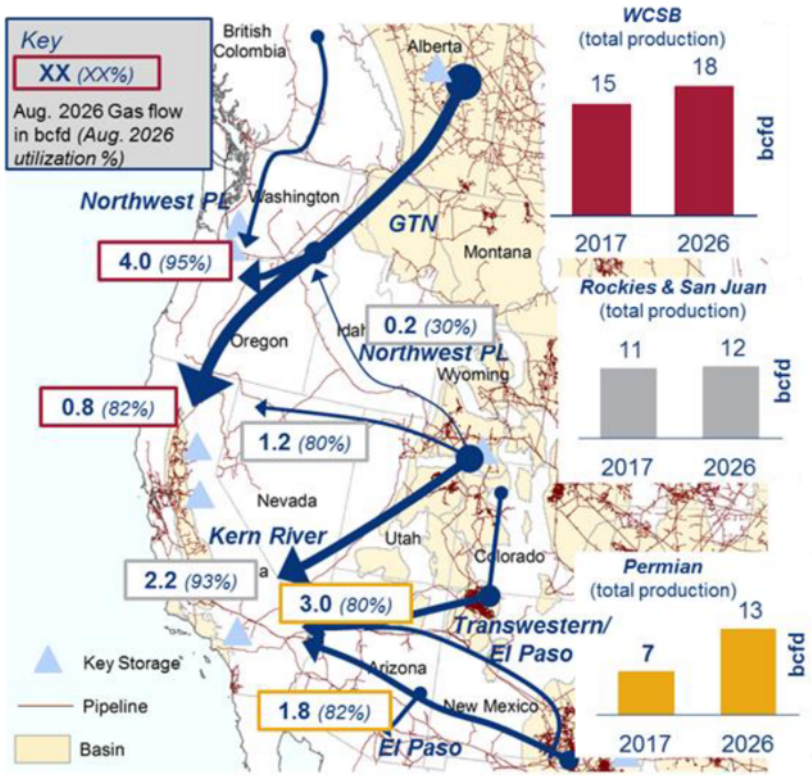
*Note: Figure applies to states of AZ, CO, ID, MT, NV, NM, OR, UT, WA, and WY (excl. CA)
Sources: NERC 2019 Summer Reliability Assessment; Bureau of Economic Analysis; NERC 2018 LTRA

Resilience Issues (Cont'd)

Fuel Security in the Western United States

- The Western Interconnection has access to diverse, abundant, and economic natural gas supply sources between the Western Canada, Permian, Rockies and San Juan basins. The combined reserves represent 350 tcf available at break evens of less than $4/MMBtu for dry gas and $50/barrel for associated gas. However, this wealth of resources is dependent on a limited number of long-haul pipelines to deliver natural gas from supply areas to large demand centers in the Pacific Northwest (PNW), California, and the Desert Southwest (DSW):
  - DSW markets (e.g., Phoenix) are essentially dependent on the El Paso and Transwestern pipelines.
  - PNW markets rely upon Northwest and GTN pipelines for their natural gas as well as gas storage.
  - Northern California markets are supplied by GTN and, to a lesser extent, Ruby pipelines as well as gas storage.
  - Southern California markets are reliant on El Paso, Transwestern, and Kern River pipelines as well as gas storage.
- This widespread reliance on long-haul pipelines results in reliability risk due to the potential for disruptions in delivery capability; a major gas disruption at a single point can have additional effects in several different markets.
- Most major interstate pipelines in the West are expected to be highly utilized (80%–95% on peak month basis, of which about half of the demand comes from power generation). Natural gas supply to the Desert Southwest will become increasingly supplied from the Permian basin, as San Juan production is expected to slowly decline over time. This switch will create a greater reliance on Permian and West Canadian gas for the WECC region, with potential reliability risks in DSW and Southern California as well as PNW.
- Gas burn is expected to increase significantly, driven by baseload coal and nuclear retirements as well as overall load growth in the region. While additional renewables capacity provides some mitigation, it will not be enough to offset the 11 GWs of retirements and will also introduce additional volatility and uncertainty into intra-day swings.
- Maintenance, and possibly expansion, of the gas system's infrastructure will likely be needed to meet reliability needs.
- The Western Interconnection has access to ample supply from several different supply basins, but its reliance on long-haul gas pipelines poses reliability risk due to the ability of a single disruption to impact multiple markets.

Western United States and Canadian Gas Pipes and Producing Basins



Source: Wood Mackenzie, Western Interconnection Gas-Electric Interface Study (Jun. 2018)

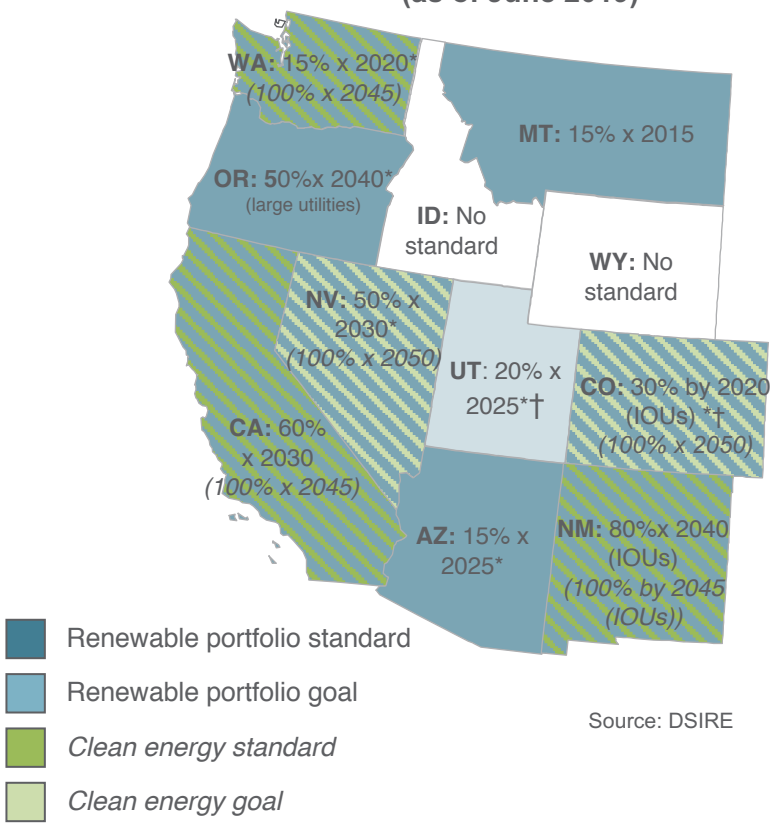
Resilience Issues (Cont'd)

Selected Major Bulk Power Events Affecting WECC	
Event	**Description**
Pacific Northwest Seismic Risk	• The potential for a Cascadian Subduction Zone (CSZ) event in the Pacific Northwest has been discussed and analyzed, and the resulting earthquake tsunami combination is expected to cause devastating damage across the coastline from northern California to southern British Columbia. • Per Oregon's Public Utility Commission, more than 50% of substations would be damaged beyond repair in the event of a magnitude 9.0 earthquake. • In addition, the vulnerability of the electric grid is highly interdependent with other critical infrastructure systems, including roads, water and sewage treatment, and natural gas pipelines. In the event of a major earthquake, damage to road networks could make it impossible to repair transmission and distribution lines, thereby preventing the restoration of all other electricity dependent lifeline services (water, sewage, telecommunications).
Pacific Northwest Hydro	• As climate change alters the seasonality of water runoffs in the Pacific Northwest, hydro electricity generation, as well as the operation and maintenance of hydroelectric dams, are expected to face challenges. • In addition to current electric power generation demand, there are also multiple competing uses for the water in the Pacific Northwest, including future (summer) electric power generation, flood control, biological opinion requirements resulting from the Endangered Species Act, as well as special river operations for recreation, irrigation, navigation, and the refilling of the reservoirs each year.
Droughts, Heat Waves, and Wildfires	• The 2018 summer season saw increased system stress due to higher than average temperatures and a continuing trend of a high number of wildfires—8,717 fires as of August 2018 compared to 9,000 for all of 2017. • The increased temperatures and wildfires are impacting most states and provinces in the Western Interconnection, but the largest incidents are located in California, Arizona, Utah, Idaho, Oregon, and British Columbia.
Gas-Power Interdependence	• Key findings from several recent studies conclude that the Western Interconnection is facing increasing volumetric and flexibility constraints, and disruptions in the natural gas system could potentially translate quickly to loss of load in the Desert Southwest and Southern California regions. • As more coal-fired generation capacity in the region is retired in coming years, the region will rely more heavily on natural gas-fired generation to balance the increasing amount of solar and wind on the system.
Cyber/Physical Security	• On April 16, 2013, a rifle attack on a PG&E substation in Metcalf, California, knocked out 17 transformers, increasing the risk of loss of electric service to large parts of Silicon Valley. While a widespread outage was avoided, the incident raised concerns about the vulnerability of the U.S. electric sector to more widespread attacks. The incident prompted utilities across the country to reevaluate and restructure their physical security programs, and it set in motion proceedings in Congress and at FERC which resulted in a new mandatory Physical Security Reliability Standard (CIP-014) for bulk power asset owners promulgated by NERC.

Sources: NERC; NWPP; Utility Dive; National Oceanic and Atmospheric Administration; Johns Hopkins and Swiss Re, Lights Out, The Risks of Climate and Natural Disaster Related Disruption to the Electric Grid (2017)

Renewables Integration

WECC State Renewable Portfolio Standards and Goals (as of June 2019)



Source: DSIRE

* Extra credit for solar or customer-sited renewables

† Includes non-renewable alternative resources

Demand-Side Considerations

- Overall demand growth in the region is generally less than 1% annually, although metro areas across the West are experiencing higher growth than rural areas.
  - Some utilities report demand reduction because of behind-the-meter distributed generation and appliance standards and expect these trends to continue into the future. Most distributed energy resources (DERs) are solar, and the current capacity of rooftop solar for WECC is 8.7 GWs (6.6 GWs of which is in California).
  - Energy efficiency and controllable and dispatchable demand response programs in the region are minimal (about 3.5 GWs in the summer and 2.9 GWs in the winter) compared with peak load.
- WECC has a mix of states with some of the most aggressive clean energy goals and standards in the United States and states with no standards at all (see map at left).
  - California, Colorado, Nevada, New Mexico, and Washington all have 100% targets, reflecting broad-based support for clean energy in those states. Oregon's target is only 50%, but the political climate there closely resembles the states with 100% goals.
  - Idaho and Wyoming have no stated standards or targets, and Wyoming has been hostile to renewable energy development initiatives, introducing, but not passing a law in 2017 that would have required 95% of utility electricity to come from sources other than wind or solar (or essentially the opposite of a renewable portfolio standard or RPS).
- A few large utilities in the region have announced carbon reduction initiatives (see following slide).

Sources: NERC 2018 LTRA; DSIRE; SEPA; S&P Global Market Intelligence

Renewables Integration (Cont'd)

Listing of Utility Companies with Operations in WECC That Have Announced Emission Reductions or Renewable Energy Goals (as of October 2019)

Utility Name (States of Operation)	Goal Type	Target Dates	Description (Date Implemented)
Arizona Public Service Company (AZ)	Emission Reduction	2032	48% reduction in carbon intensity by 2032 from 2005 levels
Avista Utilities (ID, WA)	Emission Reduction	2027 2045	Carbon neutral electricity supply by the end of 2027 100% clean energy by 2045
El Paso Electric (NM, TX)	Emission Reduction	2025 2035	25% reduction in carbon footprint from 2015 levels by 2025 40% reduction in carbon footprint from 2015 levels by 2035
Holy Cross Energy (CO)	Emission Reduction	2030	70% reduction in GHG emissions from 2014 levels by 2030
Idaho Power Company (ID, OR)	Emission Reduction	2020 2045	Average CO_2 emissions intensity of energy sources from 2010 to 2020 is 15% to 20% lower than 2005 levels, 100% clean energy by 2045
Platte River Power Authority (CO)	Renewable Energy	2030	100% non-carbon energy mix by 2030
Portland General Electric (OR)	Emission Reduction	2030 2050	Eliminate coal from energy mix by 2050 80% reduction in GHG emissions by 2050
Poudre Valley Rural Electric Association (CO)	Emission Reduction	2030	80% carbon-free energy by 2030
Public Service Company of New Mexico (NM)	Emission Reduction	2032 2040	70% emissions free energy by 2032 100% emissions free energy by 2040
Puget Sound Energy (WA)	Emission Reduction	2040	50% reduction in carbon footprint by 2040
Salt River Project (AZ)	Emission Reduction	2035 2050	62% reduction in CO_2 emissions from 2005 levels by 2035 90% reduction in CO_2 emissions from 2005 levels by 2050
Xcel Energy (CO, MI, MN, NM, ND, SD, TX, WI)	Emission Reduction/ Carbon Reduction	2017 2030 2050	35% emissions reduction by 2017 (achieved) 80% below 2005 levels by 2030 and zero-carbon by 2050 (2015)

Source: SEPA

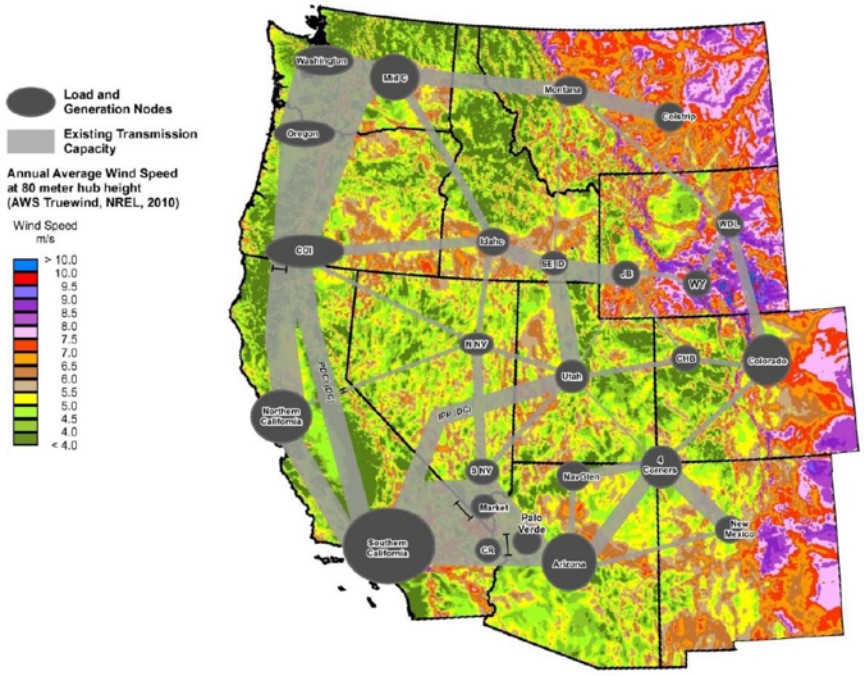
Source: SEPA

Renewables Integration (Cont'd)

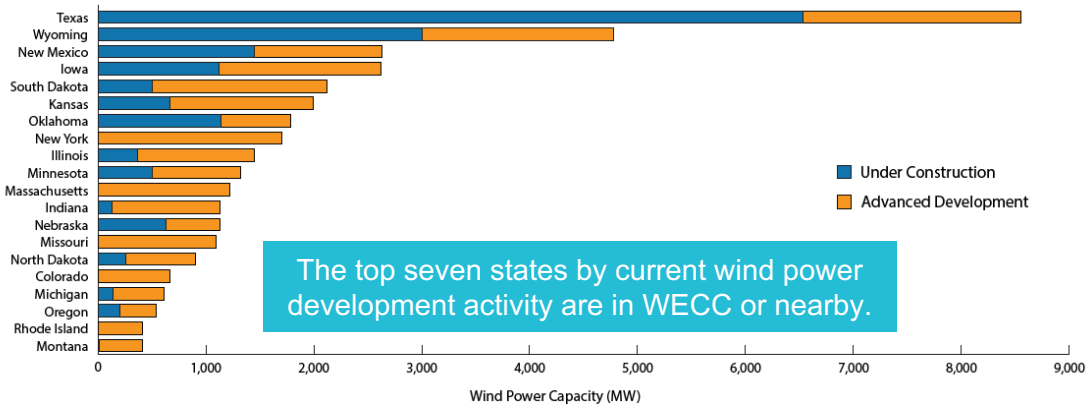
Demand-Side Considerations: Transmission Expansion to Meet California Demand

- Transmission expansion proposals and configurations
  - The highest-quality wind resources in the United States are located in the eastern area of the Western Interconnect.
  - Many planned and contemplated transmission projects in various stages propose to deliver those resources from across the West, although Wyoming and New Mexico are the most common sources given the prevalence of high-quality, low-cost, and temporally uncorrelated wind in those areas. In addition to resource delivery benefits, congestion relief, reliability enhancements, and future market efficiency would likely be realized upon the projects' completion.
- Northwest hydro: Conceptually, the idea of ramping down hydro to take advantage of low-cost excess solar is a potential economic solution. However, the Northwest hydro system has a springtime overgeneration issue (when it is a "seller") and has a series of complex flexibility limitations attributable to the physical layout of the dams and strict environmental constraints.
- Out-of-state resource and transmission combinations
  - There are several advanced transmission and resource project combinations that could provide California's utilities with realistic and actionable cost information to replace the conceptual, generic information currently used in planning.
  - California entities could use a request for information (RFI) as a tool to gather commercial-grade information from renewable developers, in partnership with existing and prospective transmission service providers. This would provide utilities and regulators with unique and detailed insights into what the procurement of out-of-state renewable resources and transmission might look like from an economic and technical perspective.
  - Grid expansion to remote resources has been in the planning stages for more than 10 years by entrepreneurial enterprises. Now, on the cusp of the next major RPS planning effort, may be a good time to allow this community to respond to California's developing need for a geographically broad and technologically diverse resource set.

Wind Resources within WECC and Existing Transmission



Top U.S. States by Wind Power Development



The top seven states by current wind power development activity are in WECC or nearby.

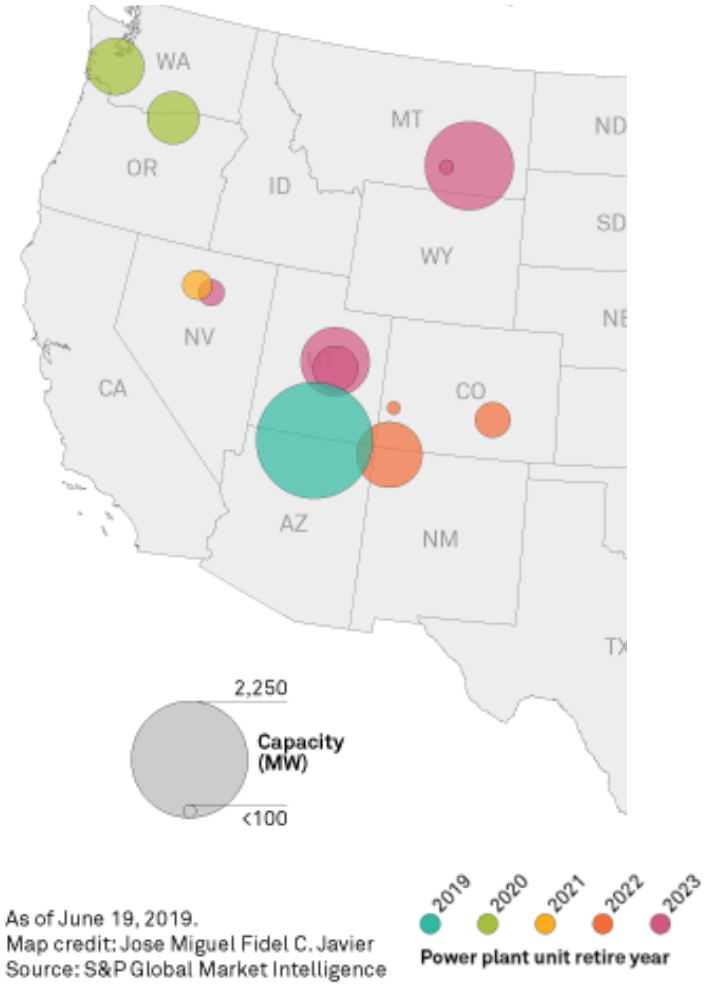
Sources: RETI 2.0 Report; AWEA Q1 2019 Market Report

Renewables Integration (Cont'd)

Supply-Side Considerations: Retirement of Large Baseload Facilities in the Western Interconnect

- Substantial coal-fired resources in WECC have been retired, and more will be retired soon.
  - More than 2,700 MWs in the Northwest are expected to be retired by 2025–28.
  - Approximately 2,400 MWs in the Navajo and Four Corners region has been retired or will be retired by 2019–29.
  - Up to 1,800 MWs could be retired in central Utah in 2025–30 and 800 MWs in Nevada by the end of 2019.
  - In aggregate, this represents at least 7,700 MWs of coal generation that will be retired in WECC over the next 10 years, and the actual number of MWs retired could be higher.
- Key findings from a recent resource adequacy study conducted to examine impacts of deep decarbonization in the Pacific Northwest conclude:
  - It is possible to maintain resource adequacy for a deeply decarbonized Northwest electricity grid, as long as sufficient firm capacity is available during periods of low wind, solar, and hydro production; natural gas generation is the most economic source of firm capacity today.
  - It would be extremely costly and impractical to replace all carbon-emitting firm generation capacity with solar, wind, and storage due to the very large quantities of these resources that would be required.
  - The Northwest is expected to need new capacity in the near term in order to maintain an acceptable level of resource adequacy after planned coal retirements.
  - Current planning practices risk underinvestment in the new capacity needed to ensure resource adequacy at acceptable levels.

Expected Coal Plant Retirements in WECC (2019–2023)



As of June 19, 2019.
Map credit: Jose Miguel Fidel C. Javier
Source: S&P Global Market Intelligence

Sources: S&P Global Market Intelligence; RETI 2.0 Report; E3 Consulting, Resource Adequacy in the Pacific Northwest (Mar. 2019)

Renewables Integration (Cont'd)

Supply-Side Considerations: Retirement of Large Baseload Facilities in the Western Interconnect (Cont'd)

- Based on WECC's current planning data set, called the Anchor Data Set (ADS), 3,267 MWs of coal and gas-fired generation is expected to be retired in coming years, and 4,906 MWs of new capacity is planned to replace retiring capacity. Planned new capacity is comprised of four technologies:
  - Gas-fired internal combustion and combined cycle (310 MWs)
  - Onshore wind turbines (2,353 MWs)
  - Solar PV (2,143 MWs)
  - Battery storage (100 MWs)
- Opportunities for repurposing existing transmission at retired/retiring baseload facilities:
  - Due to the location of new renewable resources in locations close to coal capacity being retired, it may be possible to repurpose some of the transmission capacity that may be freed up by those retirements.
  - This type of "repurposing" is currently proposed in New Mexico, where several wind projects plan to utilize some of the transmission capacity made available by the retirement of units at Four Corners to deliver wind energy to California. This potential for latent capacity utilization could also open new markets for renewable energy development to replace retired coal resources.
  - Retirements throughout WECC may free up existing transmission capacity to provide access to renewable-rich locations, reducing the need for new transmission capacity.

WECC Plant Retirement Details

State	Anchor Data Set (ADS) Unit Name	Unit Type and Fuel	Expected Retirement Date	Capacity (MW)
Arizona	H Wilson Sundt ST1	ST-NatGas	8/31/2019	75
	H Wilson Sundt ST2	ST-NatGas	8/31/2019	75
			AZ Total	150
California	Harbor CC	CCWhole-NatGas-Industrial	12/31/2026	63
	Haynes 1	ST-NatGas	12/31/2023	222
	Haynes 2	ST-NatGas	12/31/2023	222
	Scattergood 2	ST-NatGas	12/31/2024	177
	El Centro 4	ST-NatGas	6/1/2023	70
	DivisnNavalCC-Total	CCWhole-NatGas-Aero	12/31/2019	55
	NorthIslandCC-Total	CCWhole-NatGas-Industrial	12/31/2019	43
			CA Total	852
Colorado	Comanche 1	ST-Coal	12/31/2022	325
	Comanche 2	ST-Coal	12/31/2025	335
				660
Nevada	NorthValmy1	ST-Coal	12/31/2025	254
	NorthValmy2	ST-Coal	12/31/2025	268
			NV Total	522
Wyoming	Dave_Johnston_1	ST-Coal	12/31/2027	106
	Dave_Johnston_2	ST-Coal	12/31/2027	106
	Dave_Johnston_3	ST-Coal	12/31/2027	220
	Dave_Johnston_4	ST-Coal	12/31/2027	330
	Naughton3Gas	ST-NatGas	12/31/2018	330
			WY Total	1,092
			WECC Total	3,276

Planned Additions in WECC

State	Technology	Capacity (MW)
Arizona	Internal Combustion	189
	Arizona Total	**189**
Colorado	SolarPV-Tracking	707
	WT-Onshore	969
	Colorado Total	**1,676**
New Mexico	WT-Onshore	215
	SolarPV-Tracking	50
	New Mexico Total	**265**
Nevada	Combined Cycle	121
	SolarPV-Tracking	1,001
	Battery Storage	100
	Nevada Total	**1,222**
Wyoming	WT-Onshore	570
	Wyoming Total	**570**
Montana	WT-Onshore	460
	SolarPV-Tracking	80
	Montana Total	540
Oregon	WT-Onshore	60
	SolarPV-Tracking	199
	Oregon Total	**259**
Utah	WT-Onshore	79
	SolarPV-Tracking	106
	Utah Total	**185**
WECC Total		4,906

Sources: WECC Anchor Data Set (ADS) assumptions

Renewables Integration (Cont'd)

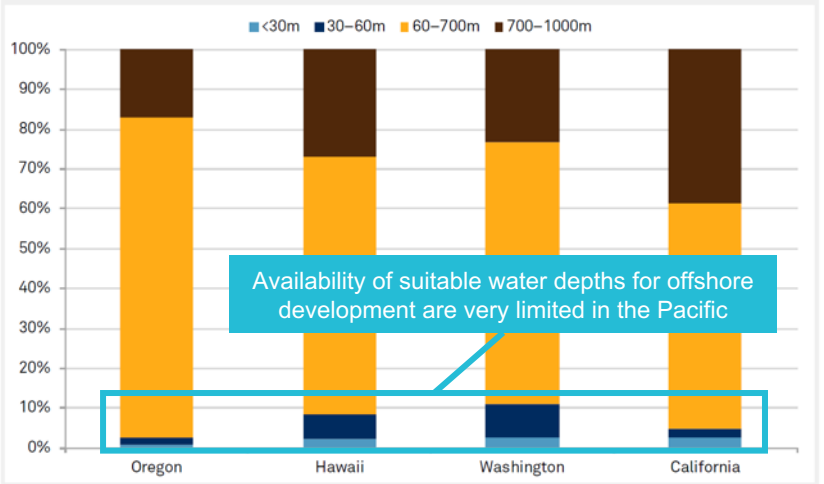
Supply-Side Considerations: Offshore Wind Is Not A Commercially Feasible Option with Today's Technology

- Offshore wind feasibility is limited with current technology, so all new wind capacity in WECC will be terrestrial for the foreseeable future (see graphic at right).
  - Though offshore wind has the potential to address both clean energy goals and resilience needs in the eastern United States, floating solutions will be required in order for offshore wind to be feasible in the Pacific due to water depths.
  - Floating foundations for offshore wind are technologically unproven and uneconomical at this time, but that could change with technology breakthroughs.

Supply-Side Considerations: Potential Market Solutions

- EIM and other potential regional market expansion options: As discussed separately in the sections on CAISO and SPP, discussions are underway to consider the expansion of existing organized markets in the West. The California ISO has expanded the footprint of the Western Energy Imbalance Market to cover territory in California, Oregon, Washington, Idaho, Utah, Wyoming, Nevada, and Arizona. Additionally, on October 13, 2017, the Mountain West Transmission Group released a proposal to expand the SPP market to cover territories in Colorado, Wyoming, New Mexico, Arizona, Utah, Montana, Nebraska, and South Dakota.
- Non-firm transmission: Non-firm or conditional firm transmission are potential means to increase transmission utilization and deliver more renewable resources to California using the existing grid. However, some stakeholders have cautioned that, historically, financiers of renewable generation projects were disinclined to have a facility's output curtailed in instances when non-firm or conditional firm transmission was unavailable.
- New power market products for overgeneration conditions: New power market products could be developed to take advantage of California's renewable energy overgeneration in the day-ahead and longer-term markets. New products could also be used to encourage and facilitate imports into California to meet morning and evening ramping needs.

Water Depths in the Pacific Coast by State

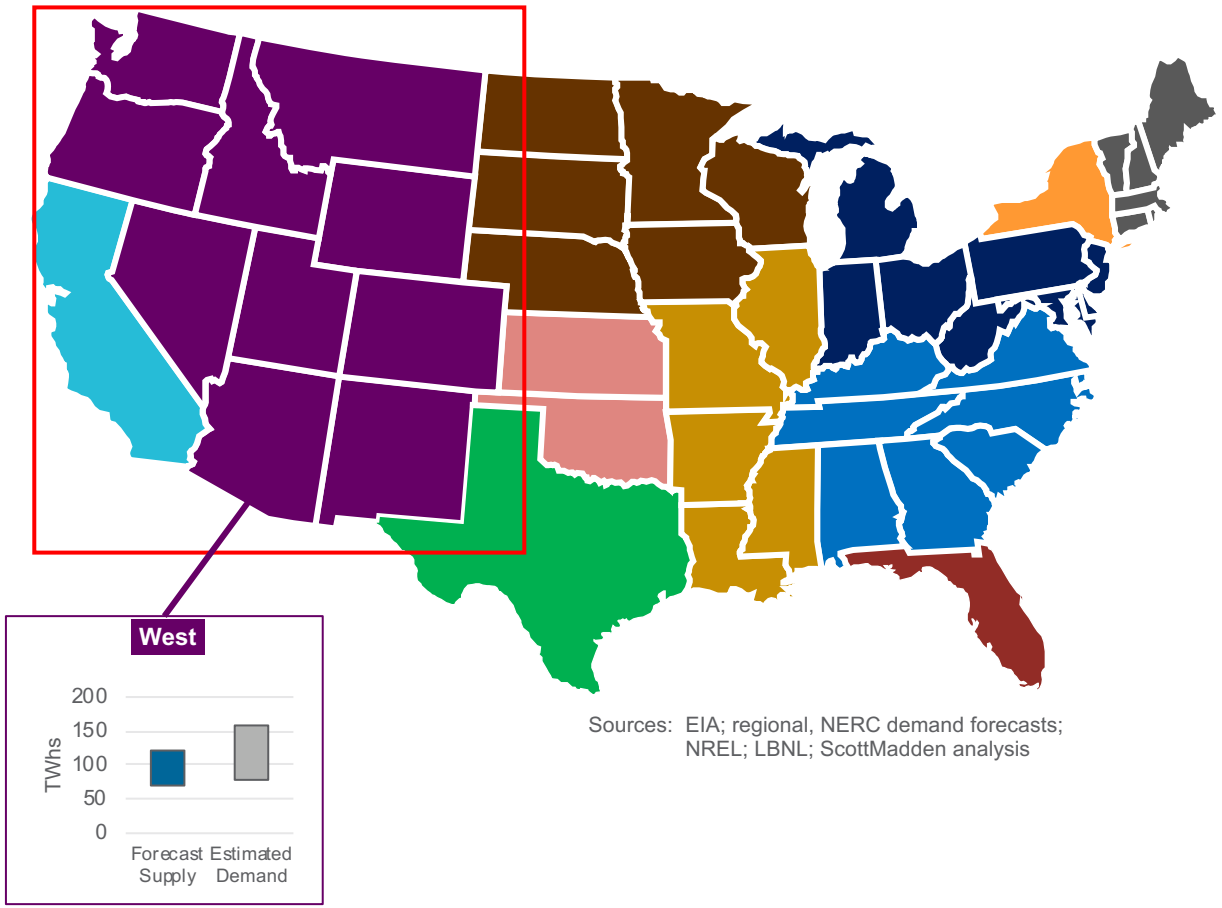


As of June 2018.
Source: National Renewable Energy Laboratory, S&P Global Market Intelligence.

Sixty meters is the maximum depth to which grounded foundations can be built for offshore wind, and availability of suitable depths for development in the Pacific is extremely limited—and mostly located very close to land where land use conflicts with shipping and fishing and concerns about line of sight would be more likely

Sources: RETI 2.0 Report; AWEA Q1 2019 Market Report

Renewables Integration (Cont'd)

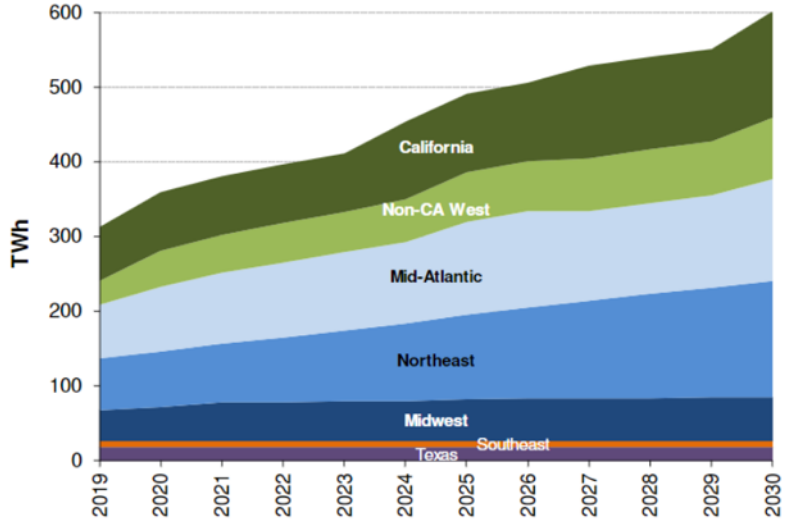


Sources: EIA; regional, NERC demand forecasts; NREL; LBNL; ScottMadden analysis

Integration Challenges – Renewables Supply and Demand

- As seen in the map at left and the non-California western U.S. section of the chart below, the WECC region has a projected demand for renewables that exceeds the forecast supply through 2030. As much of the forecast supply of renewables in the non-CAISO areas of WECC are being developed on the rationale of delivering power into CAISO, the mismatch between supply and demand may be further exacerbated.
- According to Lawrence Berkeley National Laboratory (LBNL), renewable portfolio standards policies have been a large driver in the bulk of renewable energy additions in the West, split evenly between California and other western states.
- A key question is how much and how quickly Washington's recently enacted clean energy standard will drive demand for new, non-hydro renewable resources.

Projected U.S. RPS Demand (Total Compliance Requirements) per DOE LBNL (2019–2030) (as of July 2019) (in TWh)

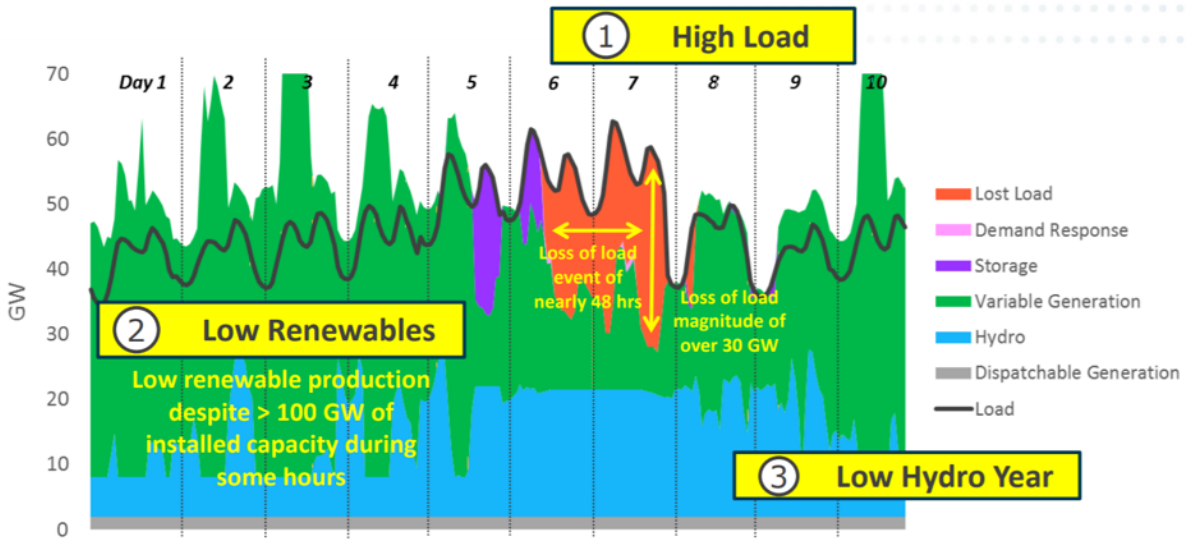


Source: LBNL

Sources: LBNL 2019 RPS Analysis; EIA; regional, NERC demand forecasts; NREL Standard Scenarios; LBNL; ScottMadden analysis

Renewables Integration (Cont'd)

Integration Challenges with High Penetrations of Wind and Solar

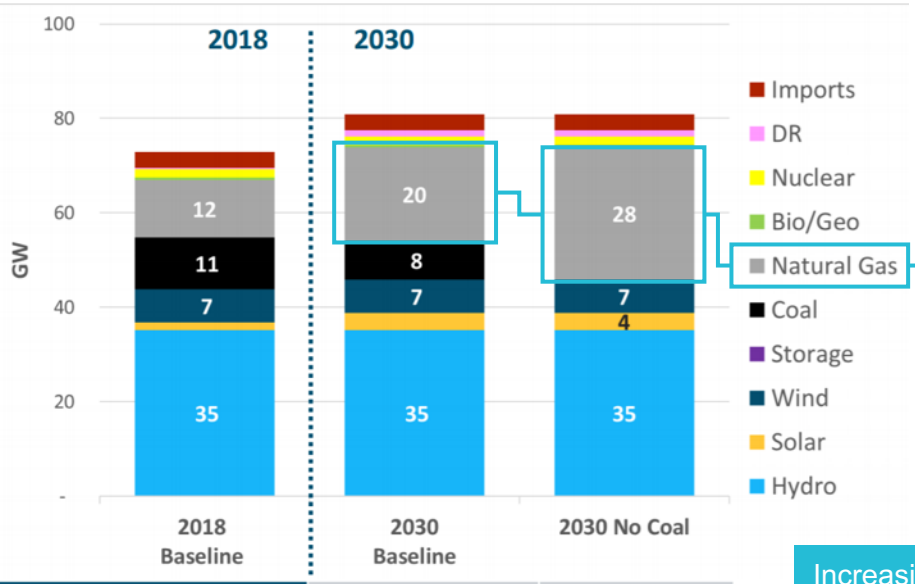


The most difficult conditions for reliable electric service are multi-day high-load, low-renewable production events.

Integration Challenges – Renewables Supply and Demand (Cont'd)

- Power systems that depend on wind and solar to provide a significant proportion of energy are more vulnerable to low-production events.
- Additional firm capacity will be required to maintain resource adequacy during periods of low wind, solar, and hydro generation production.

2030 Generation Portfolios for the Pacific Northwest



	2030 Baseline	2030 No Coal
GHG Free Generation (%)	61%	61%
Carbon (MMT CO2)	67	42
% GHG Reduction from 1990 Level	-12%*	31%

**Assumes 60% coal capacity factor*

Increasing reliance on natural gas, particularly if all coal is retired

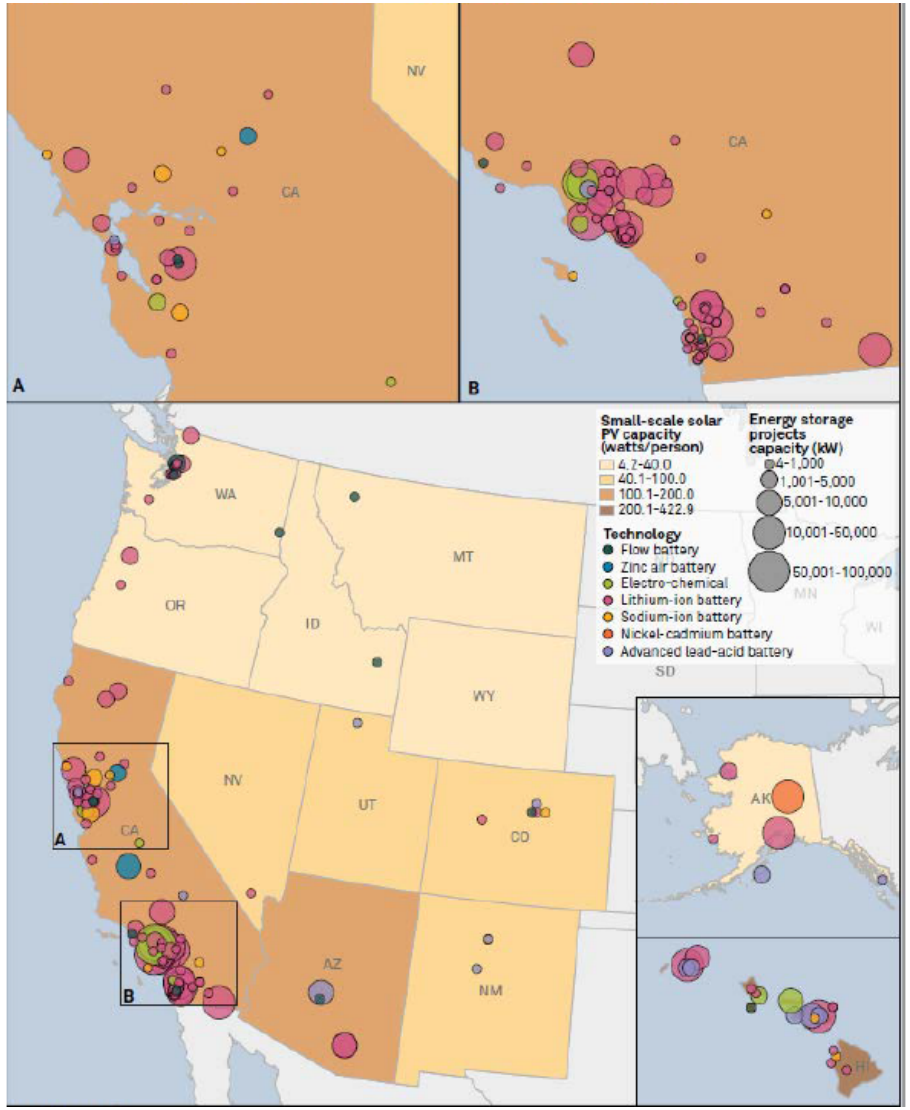
Sources: E3 Consulting, Resource Adequacy in the Pacific Northwest (Mar. 2019)

Renewables Integration (Cont'd)

Integration Challenges – Renewables Supply and Demand (Cont'd)

- Energy storage may assist with the integration of renewable energy in WECC, depending on where storage projects are located relative to renewables, and several stakeholders in the region have set aggressive energy storage targets.
  - Arizona: Energy storage is increasingly being paired with solar projects in the state as the cost of solar and storage components continues to decrease.
  - California: Legislation passed in 2018 requires IOUs in the state to procure 1,325 MWs of energy storage by 2020.
  - Colorado: Xcel Energy subsidiary Public Service Co. of Colorado announced a plan to add at least 1,100 MWs of wind, 700 MWs of solar, and 275 MWs of battery storage in support of its decarbonization efforts.
- Increasing penetration of DERs may create integration challenges, particularly in areas where penetration levels result in back feeding onto the sub-transmission and transmission voltage equipment, requiring transmission operators to develop new approaches. California is the obvious leader, as discussed separately in the CAISO section of the report, but other states in WECC are seeing significant DER developments:
  - Arizona: Arizona has the best available solar resources in the United States, and implementation of Renewable Energy Standard and Tariff (REST) legislation, which established Arizona's RPS, has helped spur solar energy development to take advantage. Beginning in 2012, 30% of the requirement was required to come from renewable distributed generation. Half of this must come from residential applications.
  - Nevada: In addition 3,000 MWs of installed utility-scale solar and an additional 4,000 MWs in the queue, the state has 280 MWs of solar DERs.
  - Oregon: The state does not currently have much solar capacity, but legislation requires 8% of aggregate IOU capacity be derived from small-scale projects of 20 MWs or less by 2025, and legislation requires utilities to develop 20 MWs of solar projects by 2020.

Small-Scale Solar Capacity (Watts/Person) and Energy Storage Projects



Sources: S&P Global Market Intelligence; ScottMadden analysis

Implications for Transmission

	Resilience	Integration of Renewables	Other Factors	Transmission Opportunities
Western Electric Coordinating Council (excl. California)	▪ Key risks related to severe weather, wildfires, and seismic events ▪ Resource "transformation" from coal to gas, intermittent resources, though to a lesser degree than other regions in the eastern United States—coal has declined from 52% of generation in 2001 to 22% in 2016, and 7.7 additional GWs of coal is expected to retire across the region over the next 10 years ▪ Amount of available hydro generation capacity in the Pacific Northwest varies with rainfall and snow melt each year ▪ There are volumetric and flexibility constraints on the natural gas system, and a disruption in the gas system could potentially translate quickly to a loss of load in the Desert Southwest, particularly due to growing reliance on long-haul pipelines	▪ Planned additions of wind and solar across the region total almost 5 GWs, comprised mostly of utility-scale solar and onshore wind capacity ▪ Highest-quality wind resources are located along the eastern portion of the footprint, stretching from MT to NM, and the highest-quality solar resources are in the Desert Southwest, stretching from southern CA to NM	▪ Extremely large geographic footprint provides weather and resource diversity ▪ Heterogeneity of state policies related to renewables creates challenges for multi-state backbone projects, and four separate planning areas within WECC create challenges; CO, NM, NV, OR, and WA have targets of 50% or higher; ID and WY have no standard ▪ Developing long-distance, high-voltage transmission through remotely populated Western areas poses unique challenges: terrain, distance, and impacts on federal, native lands ▪ Distributed solar penetration is significant only in AZ today, but it is a growing resource in NV, UT, NM, and parts of CO ▪ Frequency response adequacy is still in the study and data collection phase, but some high-renewable penetration scenarios have suggested potential future needs	▪ Opportunities to move renewable power generated where resources and land are plentiful and cheap to load centers on the coast via increased intraregional connectivity, though the majority of projects identified in the most recent plans are local, driven by needs within each of the four planning regions in WECC ▪ Interregional coordination process among the four planning regions in WECC identified six projects across seams, with varying degrees of interregional cost sharing among planning regions based on location of the projects ▪ Potential to increase transfer capacity across seams with SPP and CAISO, particularly to accommodate growing demand for renewables within CA, as well as the need to reduce curtailments at times of excess generation within CA ▪ Projected demand for renewables is expected to exceed forecast supply, suggesting more opportunity for transmission

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