Northwest **Power** and **Conservation** Council

April 7, 2020

MEMORANDUM

TO: **Council Members**

FROM: **Ben Kujala**

SUBJECT: **Presentation on Western Flexibility Assessment**

BACKGROUND:

Presenter: Thomas Carr, Staff Attorney and Economist, Western Interstate Energy Board

Summary: Tom will cover the findings of WIEB's Western Flexibility Assessment Report released in December 2019.

The purpose of the Western Flexibility Assessment is to investigate the flexibility of a future grid in which renewable resources are deployed at levels consistent with enacted and foreseeable public policy requirements of Western states.

The study provides government and industry decision makers insights on potential options to improve the flexibility of the grid. The study considers the 2025-2035 time horizon and evaluates system flexibility for this future using modeling tools designed to simulate grid operations, transmission capabilities, and system reliability.

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Background: Tom serves as a staff attorney and economist for the Western Interstate Energy Board. He works on behalf of western states and provinces in a collaborative modeling effort at the Western Electricity Coordinating Council's (WECC) Transmission Expansion Planning Policy Committee (TEPPC) and its successor, the Reliability Assessment Committee (RAC). He designs and manages scenarios of future renewable energy development, distributed generation, and carbon emissions for purposes of reliability assessment and transmission planning.

More Info: Full report: https://westernenergyboard.org/wp-content/uploads/2019/12/12-10-19-ES-WIEB-Western-Flexibility-Assessment-Final-Report.pdf

ENERGY STRATEGIES

Western Flexibility Assessment

Investigating the West's Changing Resource Mix and Implications for System Flexibility

Thomas A. Carr, Western Interstate Energy Board

April 14, 2020

Northwest Power and Conservation Council Meeting

Prepared by Energy Strategies for submission under Agreement with the Western Interstate Energy Board

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Project Team and Structure

Project Steering Committee

Technical Advisory Committee

- 16 industry experts from across the West, representing utilities, regional planning bodies, NGOs, states, and National Labs

WIEB Project Manager

Tom Carr, WIEB Staff

ENERGY STRATEGIES

Ben Brownlee, Daniel Ramirez, Gary Simonson, Caitlin Liotiris, Kathleen Fraser, Keegan Moyer

- **Study benefited from technical support and data provided by WECC, BPA, and the Northwest Power and Conservation Council (NWPCC)**
- **Cameron Yourkowski (EDPR) and Tony Usibelli (WA) were instrumental in developing the original project proposal and organizing funders and committee structure**

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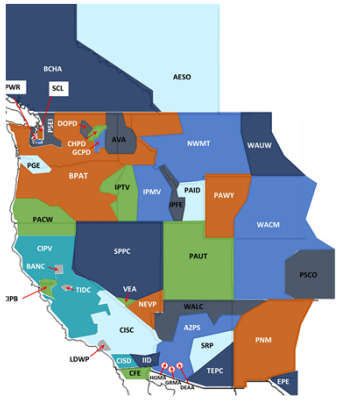
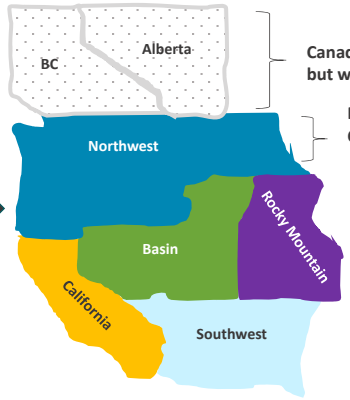
Study Footprint:
Results conveyed at regional-level, but modeling performed on full grid

WECC Balancing Areas



Study Regions



Canadian footprints are represented in modeling but were not focus of study – assumed BAU

Northwest region consistent with NW Power and Conservation Council footprint

Capacity expansion study captures transmission limitations between regions and limits inter-region resource selection based on inter-regional transmission limitations when appropriate

Full nodal analysis used in congestion and powerflow studies represent detailed system (no regional aggregation)

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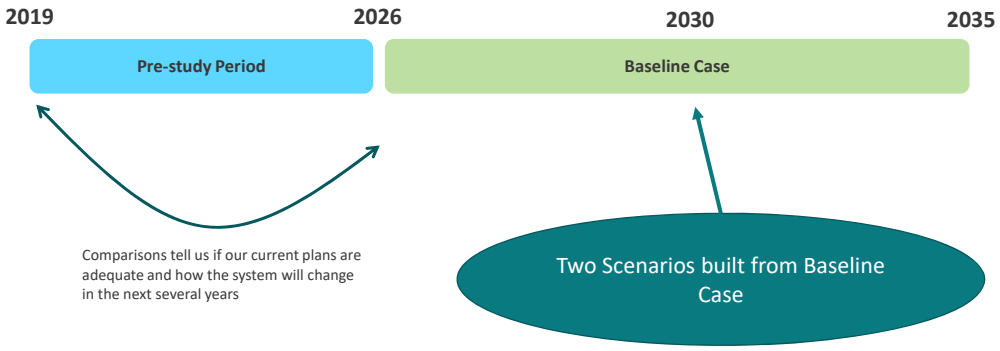
Study Period



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Projected RPS/Clean Energy Targets State

Year	California	Northwest				Intermountain		Rockies		Southwest	
	CA	OR	WA	ID	MT	NV	UT	CO	WY	AZ	NM
2020	33%	20%	15%	4%	15%	22%	0%	30%	0%	10%	20%
2021	33%	20%	15%	8%	15%	22%	0%	30%	0%	11%	20%
2022	33%	20%	15%	12%	15%	26%	0%	30%	0%	12%	20%
2023	33%	20%	20%	16%	15%	26%	0%	32%	0%	13%	20%
2024	44%	20%	25%	20%	15%	34%	0%	36%	0%	14%	20%
2025	44%	27%	30%	24%	15%	34%	0%	40%	0%	15%	25%
2026	44%	27%	35%	28%	15%	34%	0%	44%	0%	15%	30%
2027	52%	27%	40%	32%	15%	42%	0%	48%	0%	20%	35%
2028	52%	27%	45%	36%	15%	42%	0%	52%	0%	25%	40%
2029	52%	27%	50%	40%	15%	42%	0%	56%	0%	30%	45%
2030	60%	35%	55%	44%	15%	50%	0%	60%	0%	35%	50%
2031	63%	35%	60%	48%	15%	50%	0%	64%	0%	40%	53%
2032	66%	35%	65%	52%	15%	50%	0%	68%	0%	45%	56%
2033	69%	35%	70%	56%	15%	50%	0%	72%	0%	50%	59%
2034	72%	35%	75%	60%	15%	50%	0%	76%	0%	55%	62%
2035	75%	45%	80%	64%	15%	50%	0%	80%	0%	60%	65%

Study Period

Cap and Invest

Carbon Cap and 80% RPS by 2035

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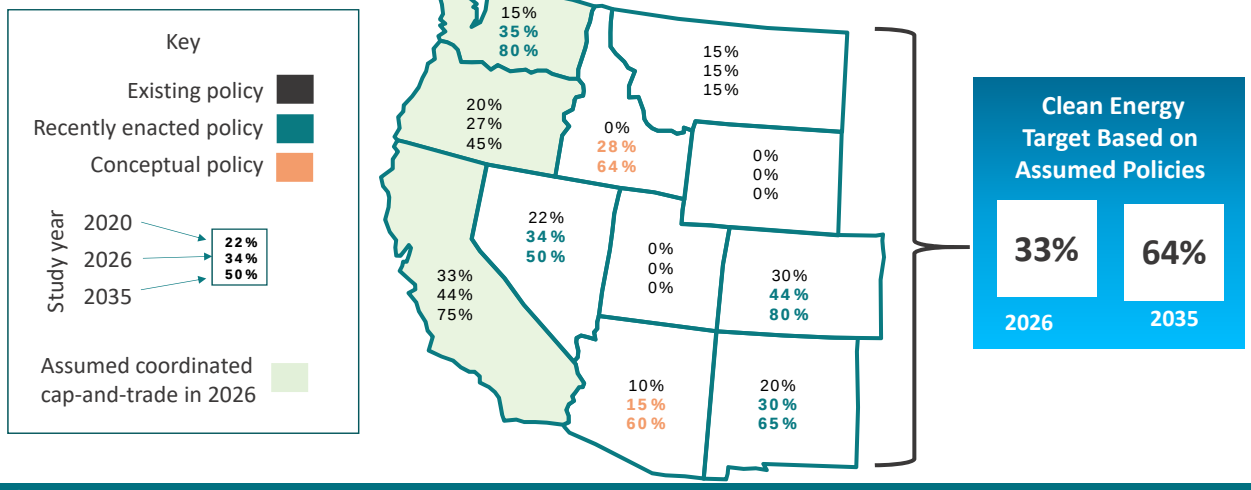
Assumed RPS and Clean Energy Policies for Western States:

Modeling western policies to help investigate system flexibility needs

Clean/Renewable Penetration Requirements in Baseline Case



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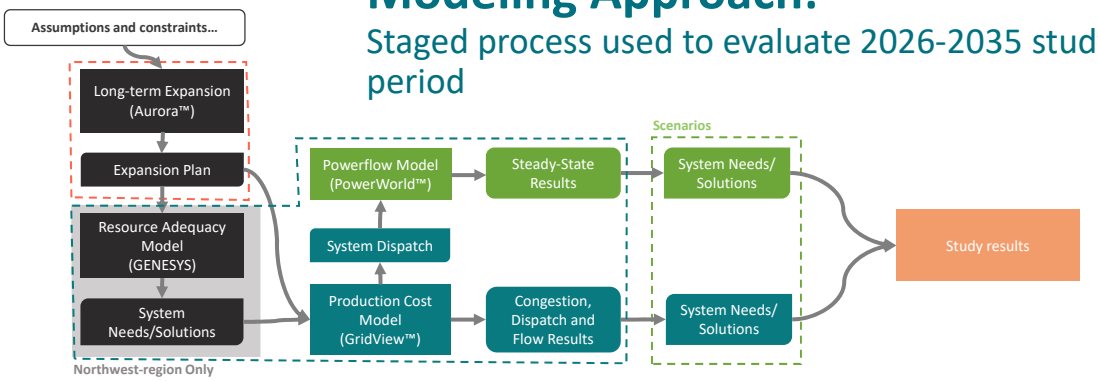
Modeling Approach:

Staged process used to evaluate 2026-2035 study period



1. An expansion plan is developed to meet state policies and extra scrutiny is given to Northwest resource adequacy. The plan is adjusted based on this analysis.
2. Production cost modeling is performed to evaluate system performance. Solutions are evaluated and system L&R during stressed conditions are passed to powerflow model.
3. Powerflow modeling evaluates reliability performance for steady-state and dynamic studies. Needs and solutions are considered.
4. Results from all studies synthesized to draw conclusions regarding resource build, adequacy, integration challenges, and effectiveness of solutions

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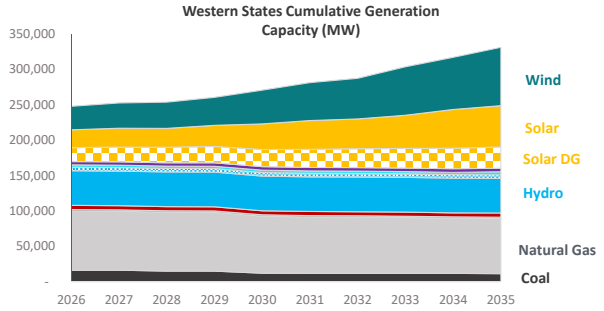
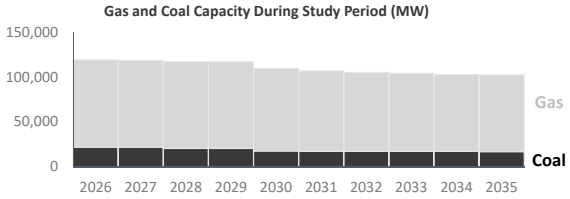
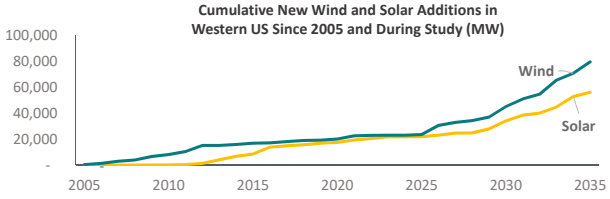
Resource Expansion and Generation Mix

- **By 2035, zero-emission resources make up 72% of Western capacity**
  - Includes wind, solar, geothermal, hydro, and nuclear
  - Storage accounted for in separate studies
- **Zero-emission generation contributes nearly 80% of the system's energy needs by 2035**
- **Wind and solar additions from 2025 to 2035 total nearly 9 GW per year**
- **By 2035, coal nearly eliminated from the generation fleet, but gas continues to provide significant capacity (although its energy output is limited)**







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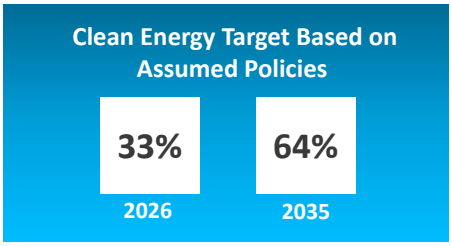
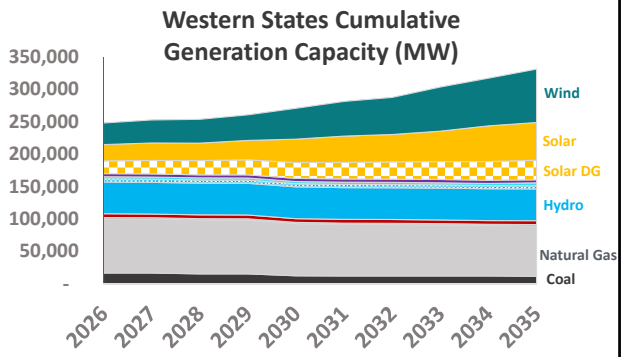
Baseline Case represents "default" amount of system flexibility

- **Renewable resources** are deployed to meet modeled state clean energy policy requirements
- **Regionalization** of energy markets occurs (i.e. no transmission service charges between BAAs)
- **Load growth** occurs consistent with recent regional and balancing area forecasts – 165 GW by 2035
- Assumed near-term integrated resource portfolios (IRPs) resources are constructed, then capacity expansion modeling (AURORA™) **added resources** for remainder of study period
- Announced and assumed **coal retirements** total 7 GW by 2026
- Assumes a small set of **"near-term" transmission projects** with a direct path to cost recovery are built





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Baseline Case	Study Year 2026	2035
Curtailments (%)	3%	20%
Clean Energy Penetration (%)	✓ Hit target 33% — 36%	✗ Missed target 64% — 52%
Transmission Congestion	Isolated/Low	High
Production Costs ($B)	$11.1	$10.0
CO_2 Emissions (Million Metric Tons)	161	134

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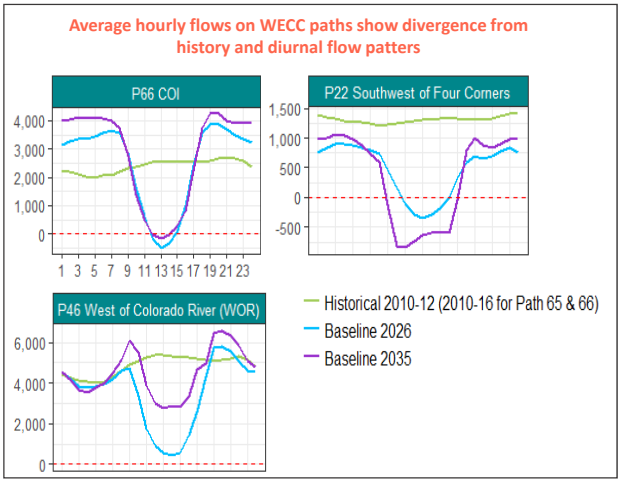
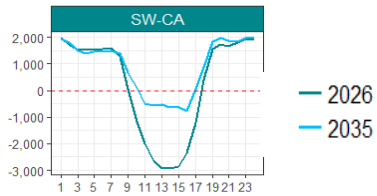
Interregional power flows increase and support system flexibility



- Results indicate that interregional power flows may change significantly from historical levels – more dynamic use of system indicates "unplanned" value in system
- Diurnal changes in flow patterns become the new norm
- In certain instances, interregional power flows can decrease under high penetrations of renewables



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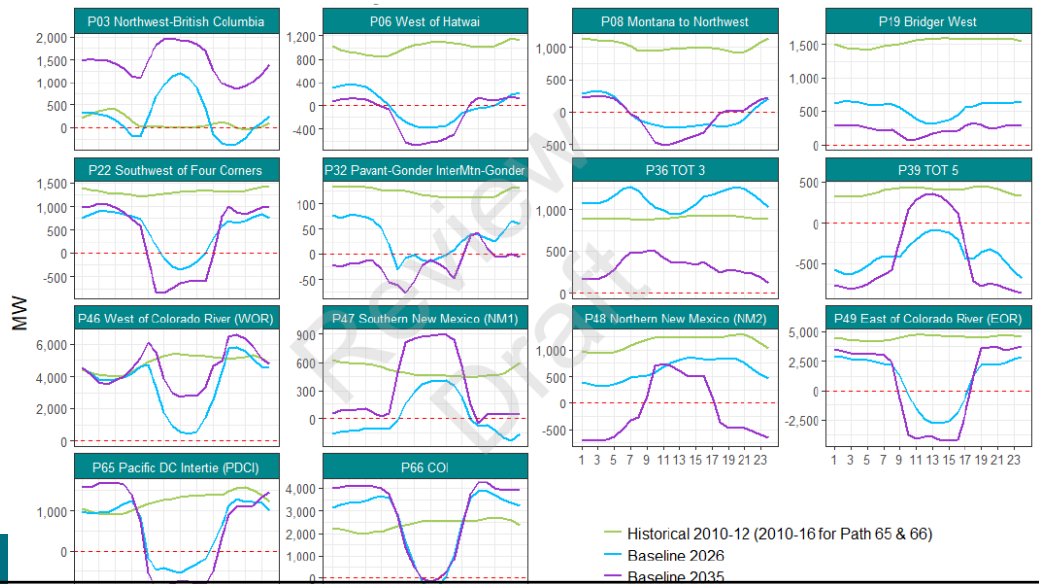
Changes in Daily Power Flows on Major WECC Paths



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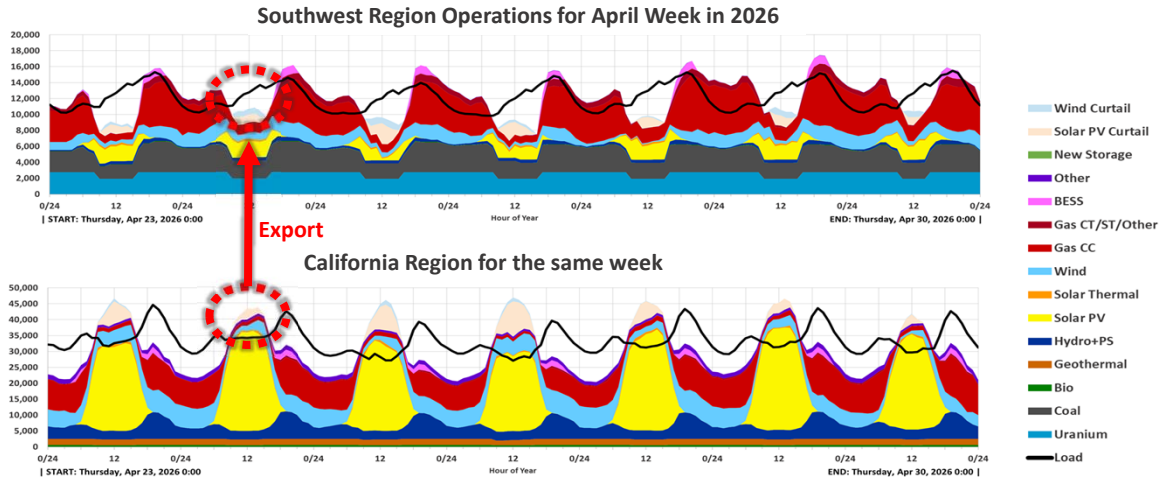
In the 2020's, interregional exchange is viable and common flexibility strategy



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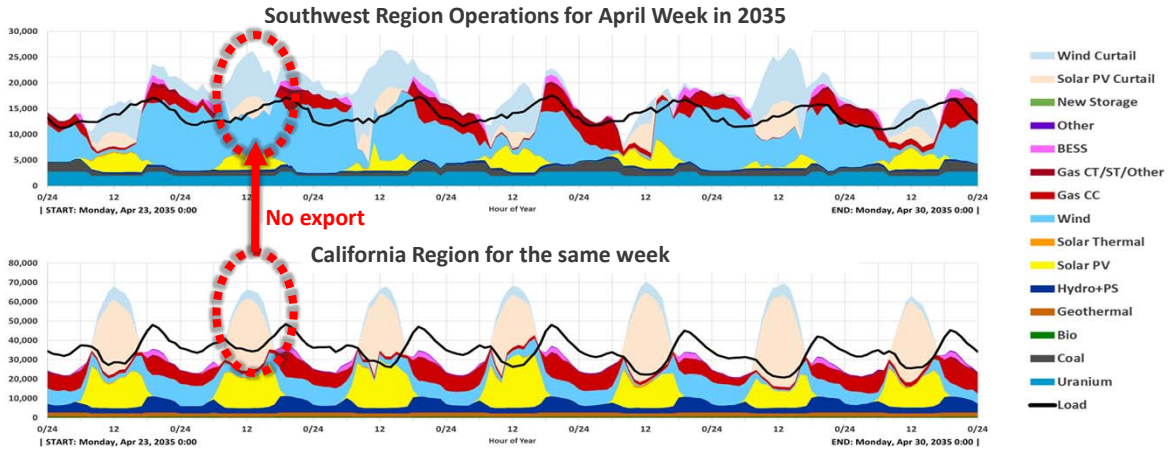
By the 2030s, a lack of buyers for excess renewable power is partially to blame for the flexibility challenges



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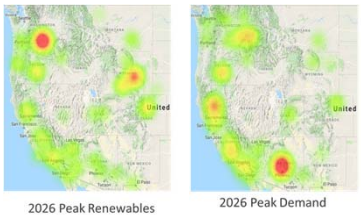
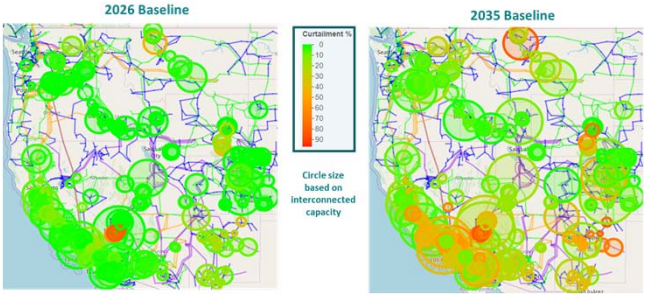
The transmission system is robust and versatile, but it does have limitations

- The near-term transmission system, as represented this study, proved to be robust from a reliability standpoint
- With few exceptions, there is very little system congestion in 2026 (with the assumed regional coordination in place), but transmission limitations represent a material barrier to achieving the assumed policy targets in 2035
- Depending on where resources are sited, there is a potential need for significant transmission expansion to meet long-run policy goals,

Few reliability "hot spots" identified in 2026



Isolated congestion in 2026, but more widespread transmission constraints by 2035



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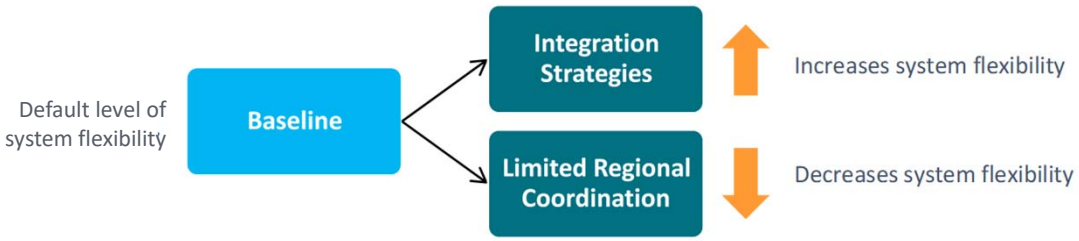
Baseline Case – "expected future"
Scenarios: (1) higher flexibility and (2) lower flexibility



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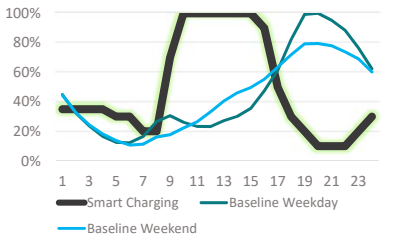
Integration Strategies Scenario

- ***Increases flexibility*** **not already built into Baseline Case**
  - ❖"How effective are investments or decisions that increase system flexibility?"
- **Key assumptions:**
  - ❖New **transmission upgrades** to help deliver renewable power to loads
  - ❖Major build-out of long-duration **storage** (10 GW) and 4-hour battery storage co-located at new renewable energy facilities (32 GW)
  - ❖**Managed charging** of EV-loads
  - ❖Additional **resource diversity** and enhanced generator siting

Assumed EV Charging Shape (avg. day)



Assumed Incremental Storage (GW)

Technology	2026	2035
4-hr Battery	2.1	32.5
12-hr Pumped Storage	0.60	10.2

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Integration Strategies Scenario *Compared to Baseline*	Study Year 2026	2035
Curtailments (%)	0% ↓	9% ↓
Clean Energy Penetration (%)	✓ Hit target 37% ↑	✓ Hit target 69% ↑
Transmission Congestion	Very Low ↓	Low ↓
Production Costs ($B)	$10.7 ↓ 4%	$7.8 ↓ 22%
CO_2 Emissions (Million Metric Tons)	159 ↓ 1%	108 ↓ 19%

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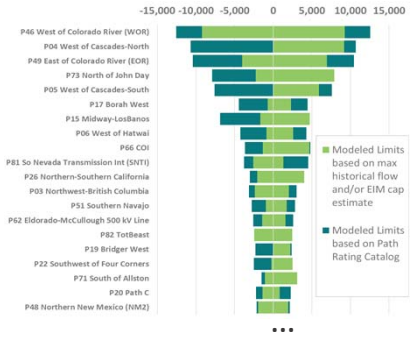
Limited Coordination Scenario

- ***Removes institutional flexibility*** **built into Baseline Case in the form of wholesale market coordination**
  - ❖"What if increased coordination of Western wholesale power markets **does not occur**"?
- **Key assumptions:**
  - ❖ Western EIM continues, but a West-wide day-ahead wholesale market does not materialize
  - ❖ Flows on key paths are limited to historical maximums
  - ❖Ramping of flows on key paths are limited to historical maximums

Path limits based on historical values



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On-Peak & off-peak non-firm wheeling charges assumed for all day-ahead transactions

Business-as-usual transmission operations and efficiency

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Limited Coordination Scenario *Compared to Baseline*	Study Year 2026	2035
Curtailments (%)	11% ↑	46% ↑
Clean Energy Penetration (%)	✓ Hit target 34% ↓	✗ Missed target 49% ↓
Transmission Congestion	Low ↑	Very High ↑
Production Costs ($B)	$12.1 ↑ 9%	$11.3 ↑ 13%
CO_2 Emissions (Million Metric Tons)	165 ↑ 9%	151 ↑ 13%

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Key Results from the 3 Scenarios

Study Year	System Flexibility: / Study Case:	Lower ↓ / Limited Coordination	Benchmark / Baseline	Higher ↑ / Integration Strategies
2026	Curtailments (%)	11%	3%	0%
2035		46%	20%	9%
2026	2026 Target 33% Renewable Penetration (%) 2035 Target 66%	34% ✓	36% ✓	37% ✓
2035		49% ✗	52% ✗	69% ✓
2026	CO2 Emissions (Million Metric Tons)	165	161	159
2035		151	134	108
2026	Production Costs ($ Billions)	$12.1	$11.1	$10.7
2035		$11.3	$10.0	$7.8

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Resource Adequacy in the Northwest: Details of the Approach

Modeling Approach

- Study performed using GENESYS – same model used by BPA and NWPCC
- Reflects nuances and limited nature of NW hydro system
- Stochastic representation of wind, solar, load, and hydro
- Adequacy target based on NWPCC 5% LOLP threshold

Key Assumptions

- Footprint identical to NWPCC study area
- Assumed load growth consistent with the NWPCC 7th Power Plan (0.58% CAGR)
- Reflects 4.4 GW of announced or anticipated coal retirements by 2027
- Generation mix in Northwest region established through Baseline Case capacity expansion studies to ensure compliance with assumed policies
- Varied incremental generation additions and loads

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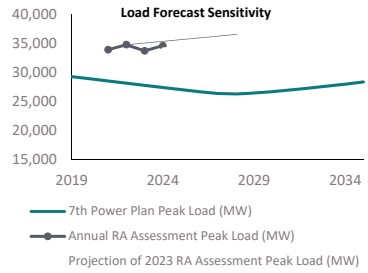
Resource Adequacy in the Northwest: Findings

- **If no generation is added, capacity need of 1,100 MW occurs no later than 2030**
- **Results indicate that Baseline Case includes sufficient capacity to maintain Northwest reliability through 2035**
  - ❖ Assumes that 16 GW of renewables, 3.2 GW of gas, and 5.9 GW of thermal retirements occur (by 2035)
- **If no gas is added in Baseline, 500 MW capacity need arises by no later than 2030 (8% LOLP), increasing to a 1,500 MW need in 2035 (23% LOLP)**
  - ❖ Even if public policy needs in the region are met, a minimum of 1.5 GW of firm capacity is still needed to ensure reliability
- **Long-term capacity needs for the Northwest system, after accounting for capacity supplied by policy-driven resources, can be met with: gas, long-duration storage, or increased access to market purchases**
- **The results of this study were very sensitive to the load forecast assumption**
  - ❖ The timing and magnitude of Northwest adequacy shortages are highly dependent on load forecast assumptions
  - ❖ The firm capacity need of the region may be as large as **2.8 GW and could occur no later than 2027**
  - ❖ Conversations about region's resource adequacy needs must consider the most appropriate load forecast

When load loss events do occur in these study cases, they are for extended periods: Up to 36 GW and 24 hour durations



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Summary

- ✓**The West can achieve near-term (2026) policy targets with modest curtailments and without major changes to system flexibility. However, over time policy targets become more difficult to achieve.**
- ✓**Regions will rely heavily on imports/exports to meet flexibility needs, and transfers between regions will increase significantly in the coming years. Interregional power flows will change from historic patterns.**
- ✓**By the 2030s, the "flexibility cost" of not having coordinated wholesale markets becomes severe and policy goals may not be attained without more flexibility to the system.**
- ✓**A balanced set of flexibility solutions are likely needed. The urgency in implementing these solutions increases over time. Market coordination, flexibility investments, customer programs and new operational practices are all going to help and are all likely to be required.**
- ✓**The Western transmission system is robust and dynamic, providing value in unanticipated ways. However, more transmission will likely be needed to provide capacity/flexibility to meet long-term policy goals.**

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THANK YOU

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ENERGY STRATEGIES

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ENERGY STRATEGIES

Supplemental Slides

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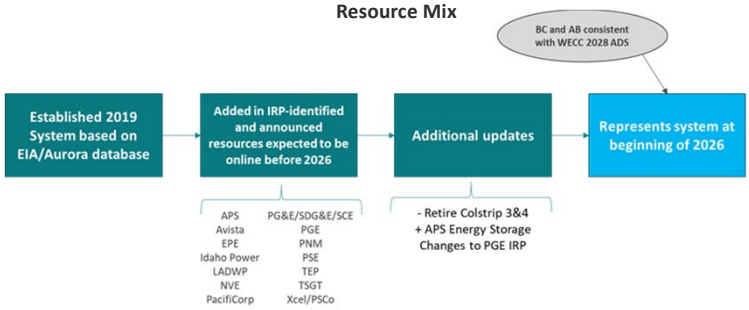
Approach to Define Resource Mix:
Existing + Plans + Modeled Capacity Expansion

Analytical Process to Develop Starting Point Resource Mix



Summary of Existing and Planned Resources in Western U.S. (MW)

Resource Type	2019	2025	Change
Coal	34,336	23,863	(10,473)
Natural Gas	100,105	98,044	(2,062)
Geothermal	3,181	3,268	87
Bio-Fuel	3,359	3,465	106
Hydro/PS	71,822	72,627	805
Nuclear	7,443	6,908	(535)
Solar	19,144	24,522	5,378
Wind	28,230	32,607	4,377
DG	11,774	18,741	6,967
Other	2,354	4,957	2,603
TOTAL	281,750	289,002	7,252

- Baseline Case existing resource assumptions, including announced retirements, were sourced from multiple databases
- Assumptions for planned resource additions were also incorporated into the Baseline Case
- Capital expansion modeling determined incremental resources additions (beyond existing and planned) and economic retirements for Baseline Case during the 2026-2035 study period

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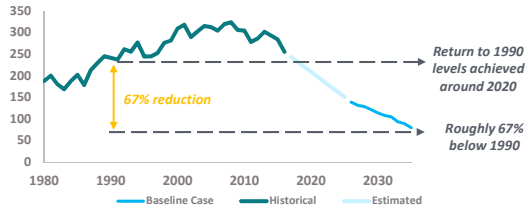
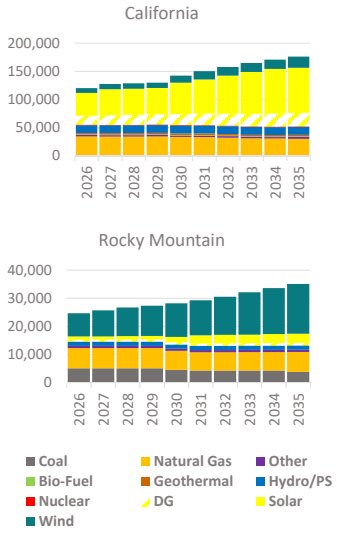
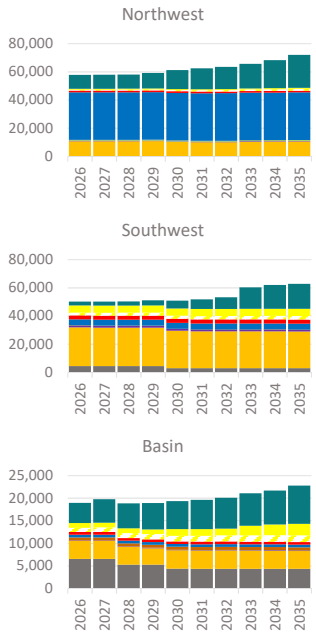
Resource Expansion and Generation Mix (cont.)

- **Significant resource diversity forecasted for all regions by the end of the study period**
- **Resource additions in the Baseline Case do not surpass technical potential limits considered in the study**
- **Policy goals and subsequent resource additions modeled in the Baseline Case cause West-wide carbon emissions to fall to 67% below 1990 levels by 2035**

Annual Carbon Dioxide Emissions in Western U.S. (Million Metric Tons)







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Baseline Case Details

- **What it is:** Assumes that planned or potential RPS or GHG reduction policy is implemented in certain states; intended to represent an expected future
- **What it is NOT:** An endorsement or prediction of any specific policy or a determination around specific infrastructure needs

Western Mix (MW): Forecast for Baseline Case in 2025

Resource Type	2019	2025	Change
Coal	28,112	20,670	(7,442)
DG	12,534	18,744	6,210
Gas	83,712	82,358	(1,354)
Geo	2,666	2,753	87
Hydro	49,161	48,912	(248)
Nuclear	7,443	6,321	(1,122)
Other	2,400	2,738	338
Other Thermal	756	586	(171)
Solar	16,062	20,769	4,707
Storage	5,260	8,082	2,822
Wind	21,627	26,186	4,559
TOTAL	**229,732**	**238,118**	**8,386**

Data sources: EIA, WECC Anchor Data Set, California PUC IRP (2017-18), utility IRPs

Assumed State Policy for Baseline Case

Year	California		Northwest				Intermountain		Rockies		Southwest	
	CA		OR	WA	ID	MT	NV	UT	CO	WY	AZ	NM
2020	33%	Cap and Trade	20%	15%	4%	15%	22%	0%	30%	0%	10%	20%
2021	33%		20%	15%	8%	15%	22%	0%	30%	0%	11%	20%
2022	33%		20%	15%	12%	15%	26%	0%	30%	0%	12%	20%
2023	33%		20%	20%	16%	15%	26%	0%	32%	0%	13%	20%
2024	44%		20%	25%	20%	15%	34%	0%	36%	0%	14%	20%
2025	44%		27%	30%	24%	15%	34%	0%	40%	0%	15%	25%
2026	44%		27%	35%	28%	15%	34%	0%	44%	0%	15%	30%
2027	52%		27%	40%	32%	15%	42%	0%	48%	0%	20%	35%
2028	52%		27%	45%	36%	15%	42%	0%	52%	0%	25%	40%
2029	52%		27%	50%	40%	15%	42%	0%	56%	0%	30%	45%
2030	60%		35%	55%	44%	15%	50%	0%	60%	0%	35%	50%
2031	63%		35%	60%	48%	15%	50%	0%	64%	0%	40%	53%
2032	66%		35%	65%	52%	15%	50%	0%	68%	0%	45%	56%
2033	69%		35%	70%	56%	15%	50%	0%	72%	0%	50%	59%
2034	72%		35%	75%	60%	15%	50%	0%	76%	0%	55%	62%
2035	75%		45%	80%	64%	15%	50%	0%	80%	0%	60%	65%

Cap and Invest; Carbon Cap and 80% RPS by 2035; Study Period

*Shaded cells indicate assumed policy incremental to BAU

Load	Transmission	Generation	Other
WECC-wide gross load at **0.8% CAGR**	Only approved upgrades assumed in-service	Announced and anticipated coal retirements	DA market implemented by 2025
25 GW of distributed PV by 2035	No Full Gateway, B2H, other regional projects	2030 CA build consistent with 17-18 IRP	2035 carbon price based on CEC IEPR: $36.44 / ton (2019$)
8.3 GW of new demand from EVs by 2035	Montana transmission available in 2025	Resource potential capped at state-level	Henry Hub (2019$/mmBtu) 2026: $3.83 2035: $4.77

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Baseline Case Curtailment and Clean Energy Penetration by Regions

Regional load served by clean energy[28]	2026		2035	
	Curtailment (%)	Penetration (%)	Curtailment (%)	Penetration (%)
Basin	0%	14%	15%	32%
California	3%	49%	25%	56%
Northwest	1%	26%	12%	60%
Rocky Mountain	5%	35%	26%	65%
Southwest	2%	34%	18%	36%
Western U.S.	**3%**	**36%**	**20%**	**52%**
	Clean energy target: 33%		**Clean energy target: 64%**	

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Integration Strategies Curtailment and Penetration by Regions

Regional load served by clean energy[36]	2026		2035	
	Curtailment (%)	Penetration (%)	Curtailment (%)	Penetration (%)
Basin	1%	13%	12%	34%
California	0%	51%	8%	81%
Northwest	1%	26%	7%	68%
Rocky Mountain	0%	37%	11%	76%
Southwest	0%	35%	8%	55%
Western U.S.	**0%**	**37%**	**9%**	**69%**
	Clean energy target: 33%		**Clean energy target: 64%**	

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Limited Regional Coordination Curtailment and Penetration by Regions

Regional load served by clean energy[37]	2026		2035	
	Curtailment (%)	Penetration (%)	Curtailment (%)	Penetration (%)
Basin	23%	13%	51%	30%
California	12%	46%	33%	53%
Northwest	2%	26%	15%	56%
Rocky Mountain	3%	32%	26%	54%
Southwest	7%	34%	36%	34%
Western U.S.	**11%**	**34%**	**46%**	**49%**
	Clean energy target: 33%		**Clean energy target: 64%**	

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