Western Flexibility Assessment

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

Draft Study Materials

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

Project Team and Structure

Project Steering Committee

Western Interstate Energy Board

State of Oregon 1859

Invenergy

AWEA American Wind Energy Association

EDF renewables

NextEra Energy

nationalgrid ventures

ORION Renewable Energy Group LLC

AVANGRID

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

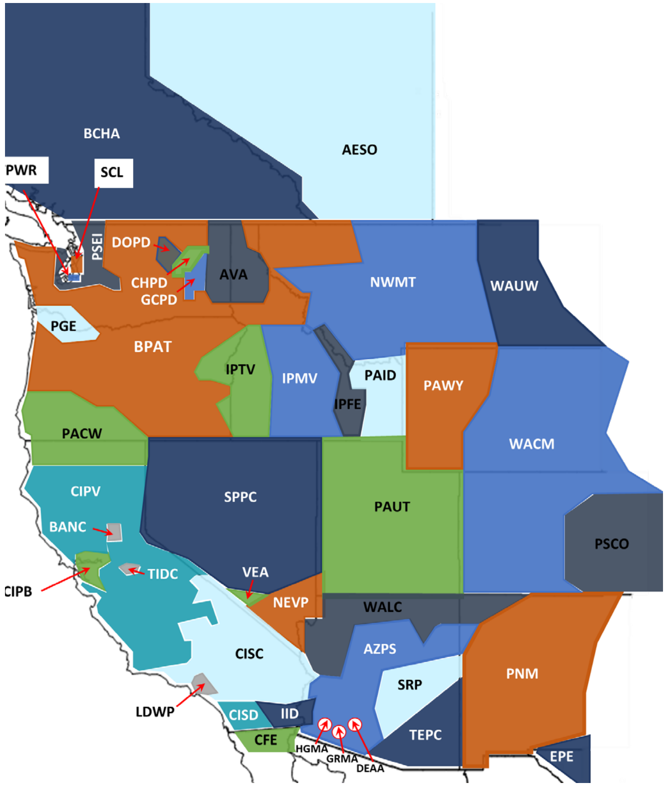
Ben Brownlee, Gary Simonson, Kathleen Fraser, Daniel Ramirez, Caitlin Liotiris, Keegan Moyer

- **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**

Study Footprint:

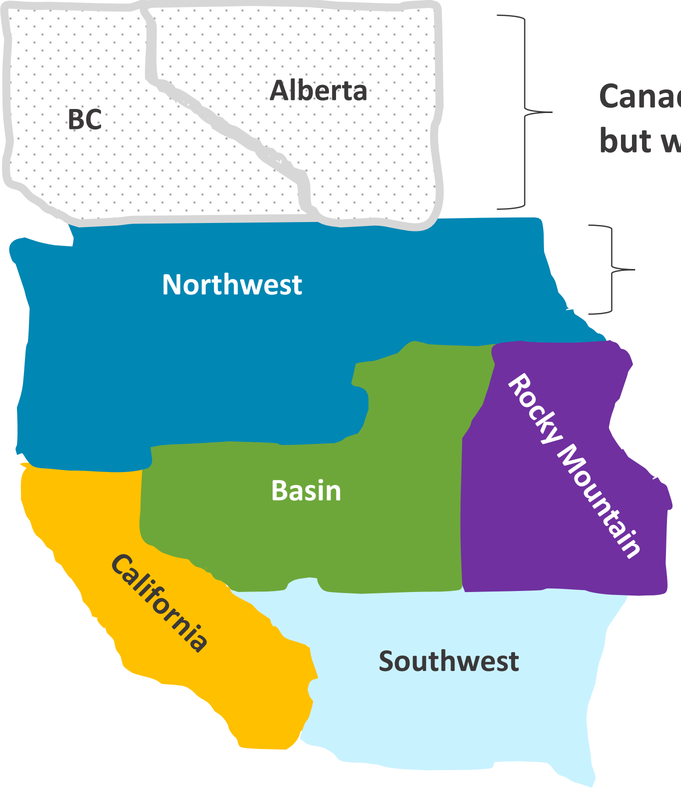
Results conveyed at regional-level, but modeling performed on full grid

WECC Balancing Areas



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

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

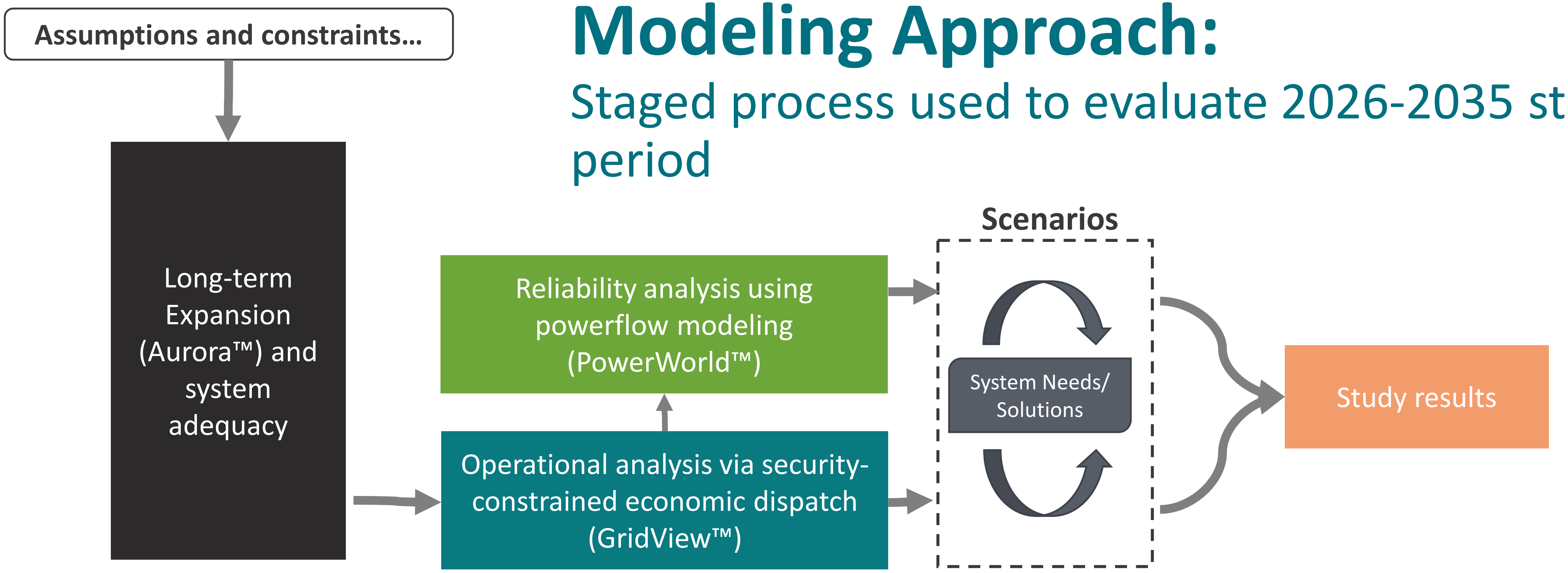
Assumed RPS/Clean Energy Targets State

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%	Cap and Invest	35%	Carbon Cap and 80% RPS by 2035	28%	15%	34%	0%	44%	0%	15%	30%	Study Period
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%	

*Shaded cells indicate assumed policy incremental to BAU

Modeling Approach:

Staged process used to evaluate 2026-2035 study period



1. An expansion plan was developed to meet state policies and adequacy, with extra adequacy studies for Northwest.

2. Production cost modeling was performed to evaluate system performance. Solutions were evaluated and system conditions during stressed hours are passed to powerflow model.

3. Powerflow modeling evaluates reliability for steady-state performance. Needs and solutions are considered.

4. Results from all studies synthesized to draw conclusions

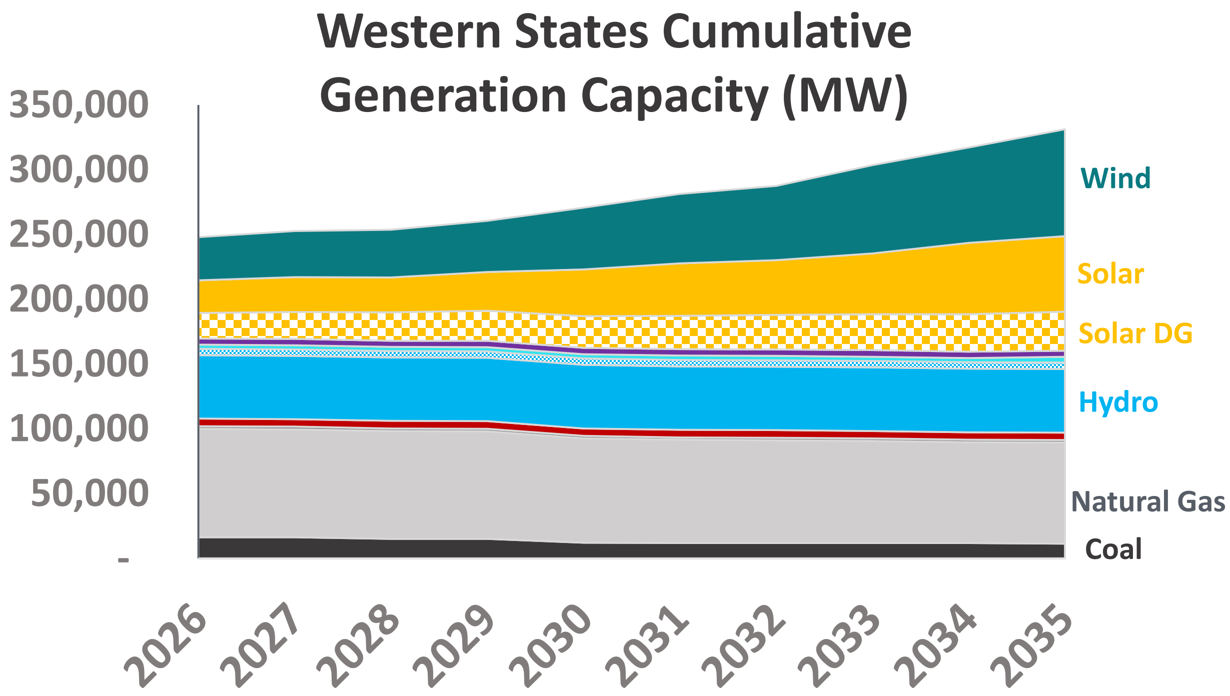
BASELINE CASE RESULTS

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

Clean Energy Target Based on Assumed Policies

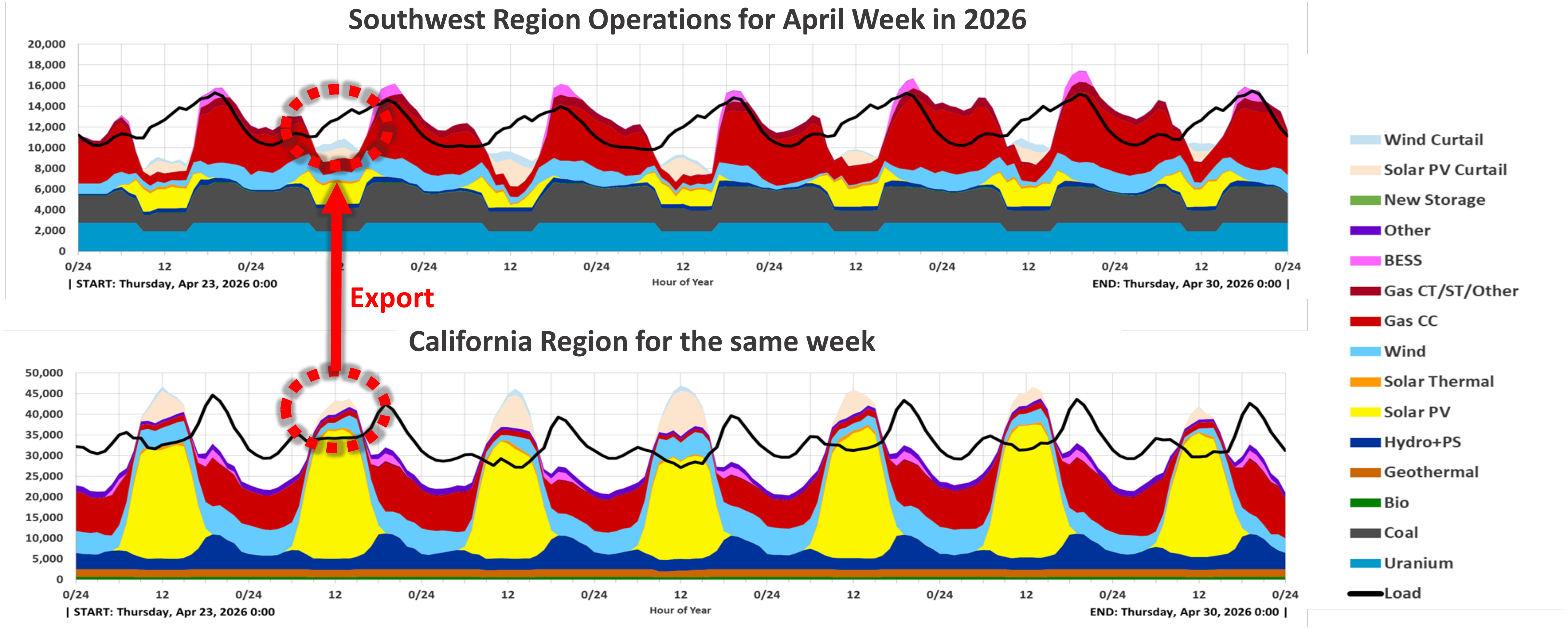
33%	64%
2026	2035



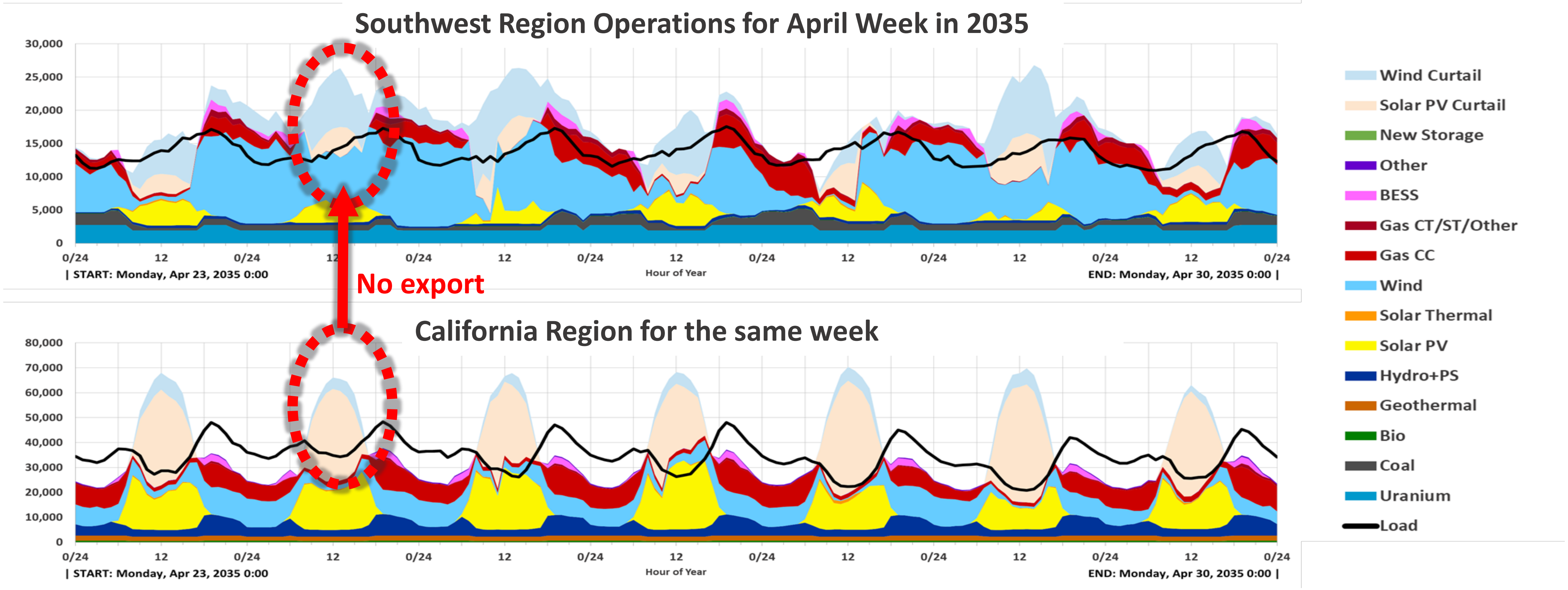
Baseline Case

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

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



…a lack of buyers for excess renewable power is partially to blame for the flexibility challenges apparent in the 2030s



ENERGY STRATEGIES

SCENARIOS

Scenarios:

Consider flexibility levels <u>higher</u> and <u>lower</u> than the Baseline Case

Default level of system flexibility

Baseline

Increases flexibility through investments in grid resources

- ✓ 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 (middle of day)
- ✓ Additional resource diversity and enhanced generator siting

Integration Strategies

Increases system flexibility

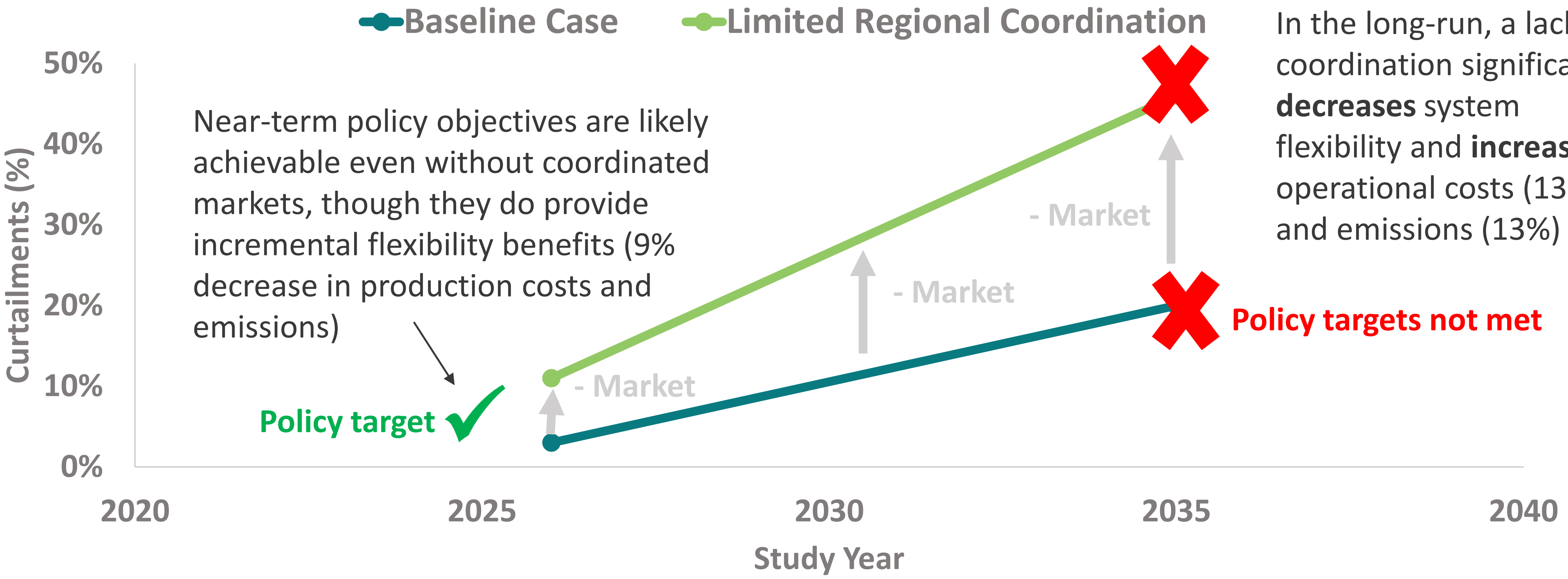
Limited Regional Coordination

Decreases system flexibility

Removes institutional flexibility built into Baseline Case in the form of wholesale market coordination

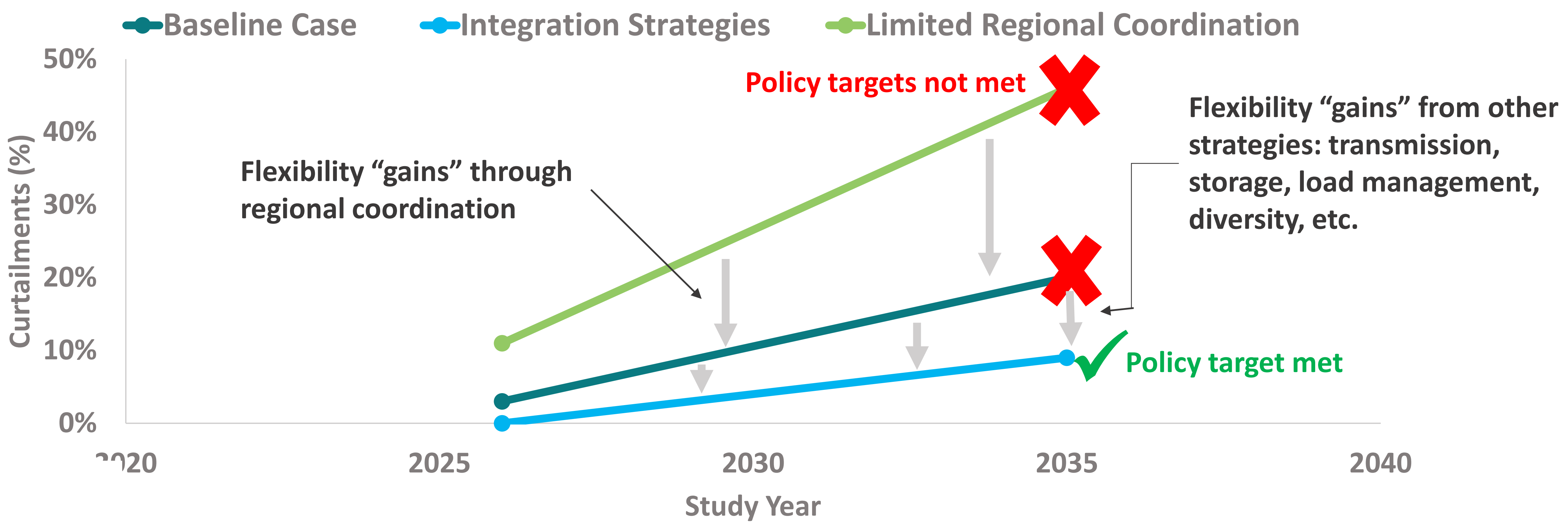
- ✓ Western EIM continues, but a West-wide day-ahead wholesale market does not materialize
- ✓ Flows on key paths are limited to historical maximums
- ✓ Ramping of flows on key paths are limited to historical maximums

Coordinated wholesale markets increase system flexibility across the West

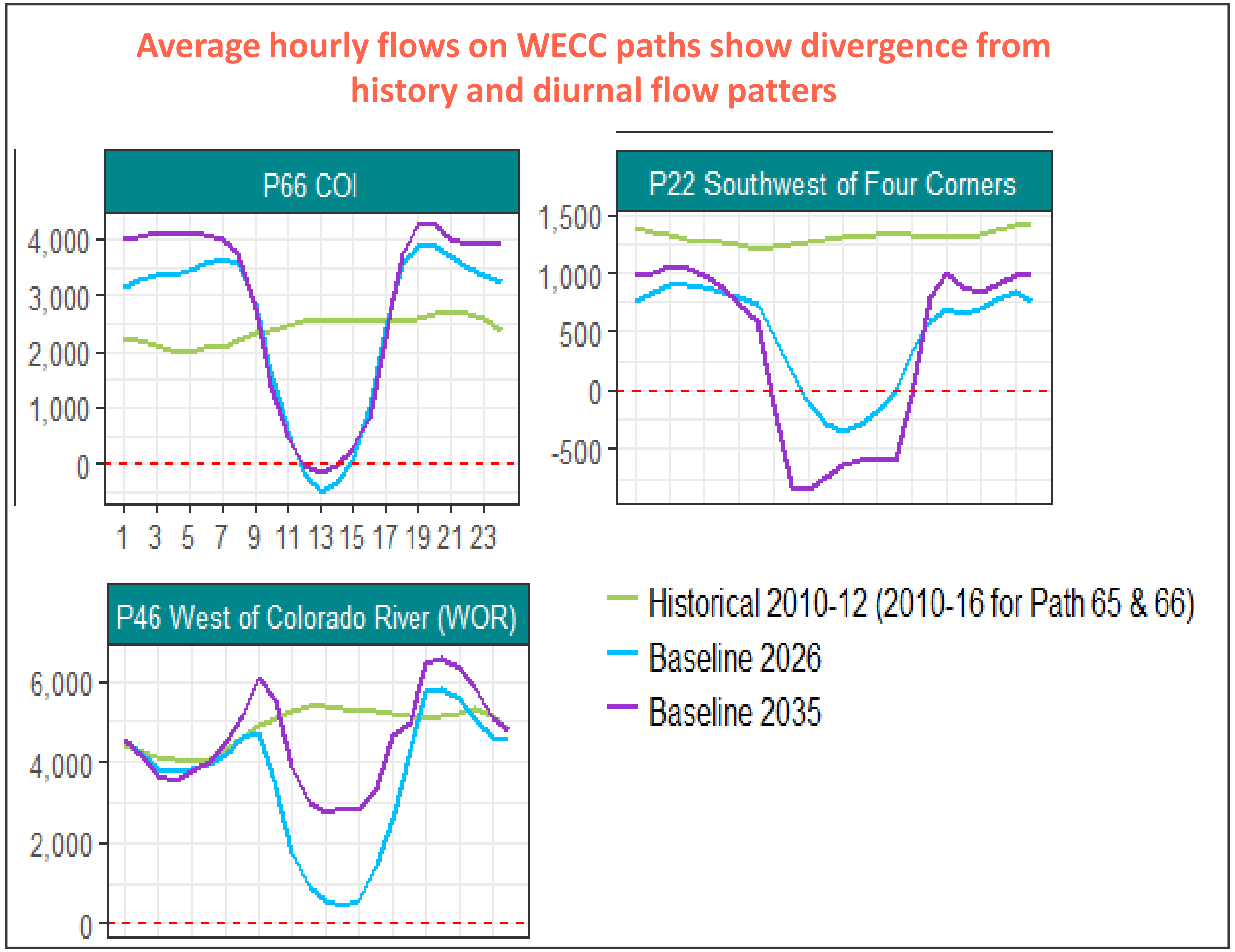


In the long-run, a lack of coordination significantly **decreases** system flexibility and **increases** operational costs (13%) and emissions (13%)

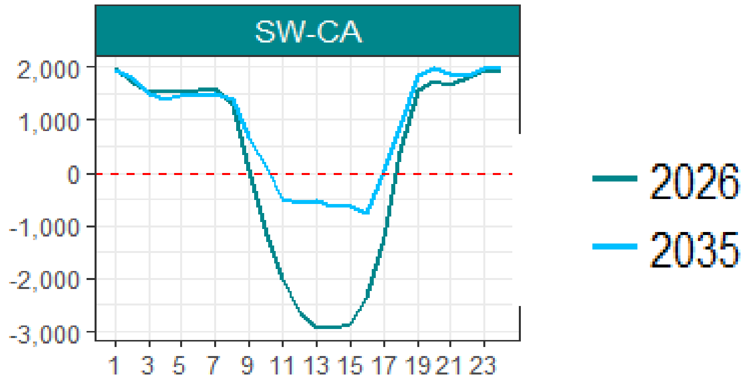
A balanced set of solutions are likely needed to increase system flexibility to levels necessary for assumed policy goals



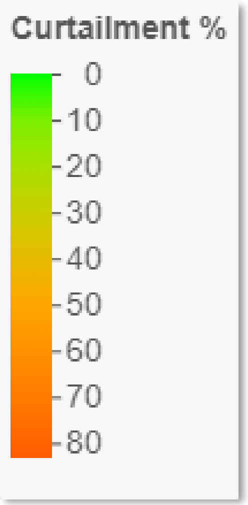
Interregional power flows increase and support system flexibility

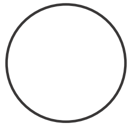


- **Results indicate that interregional power flows may change significantly from historical levels – more dynamic use of system indicates "unplanned" value in system**
- **Diurnal changes in flow patterns become the new norm**
- **In certain instances, interregional power flows decrease under high penetrations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

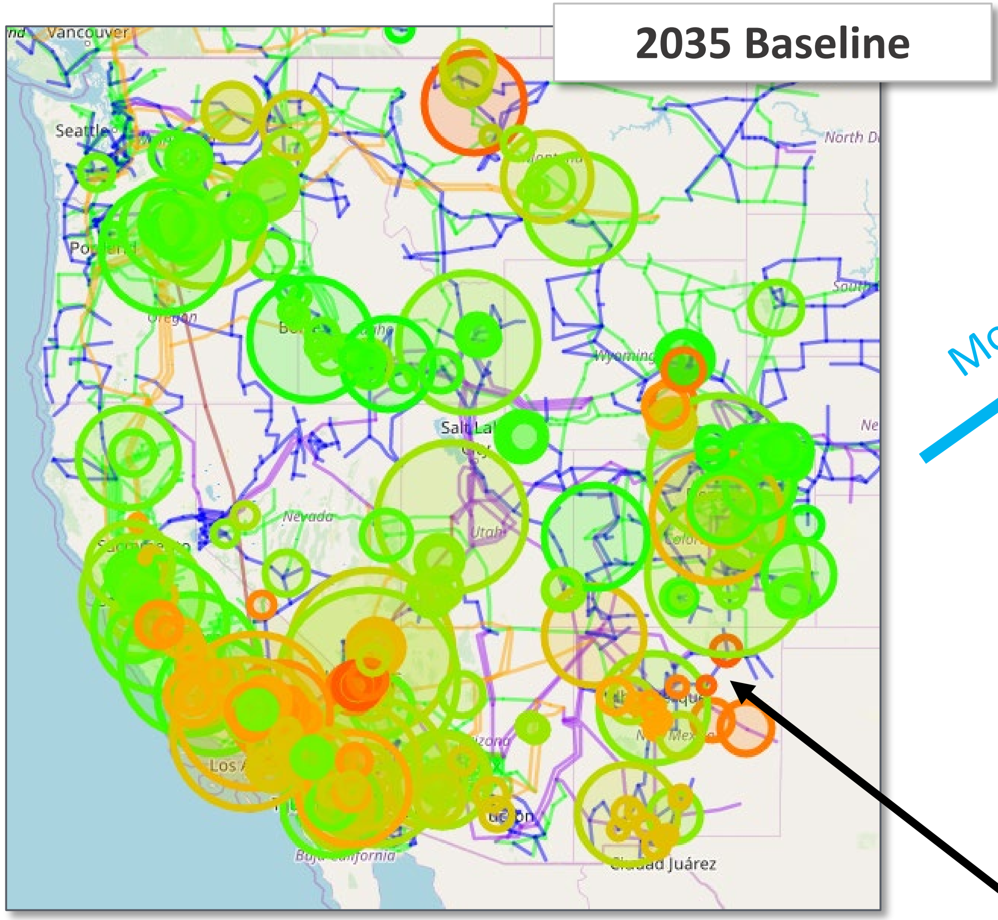


Transmission “shortages” increase into the 2030s and significant build-outs may be required

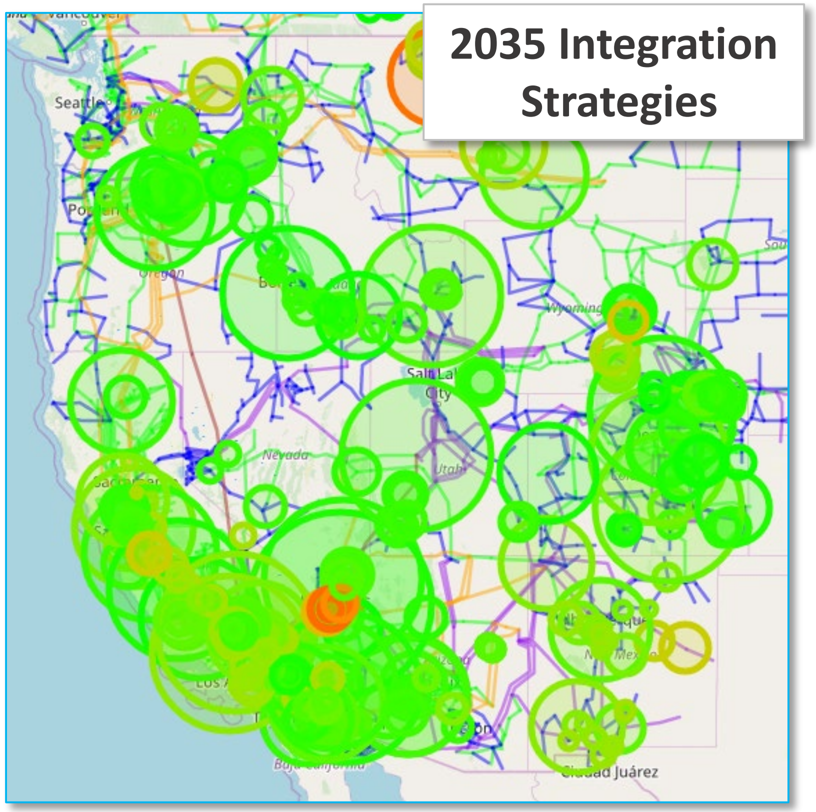




Circle size indicates interconnected renewable capacity



More transmission



Integration Strategies scenario included substantive transmission builds in California, Colorado, New Mexico, Wyoming/Utah, and Montana, with minor upgrades in the rest of the NW region

Localized curtailments are caused by a lack of transmission

Summary of Key Study Findings

- ✓ The West can **achieve near-term policy targets** with **modest curtailments** and without major changes to system flexibility. However, over time **policy targets become more difficult to achieve because of system inflexibility**.

- ✓ Regions will **rely heavily on imports/exports** to meet flexibility needs, and transfers between regions will increase significantly in the coming years. However, exporting power, on its own, is not a viable flexibility solution in the long run.

- ✓ 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 required to achieve policy goals.

- ✓ By the 2030s, the **"flexibility cost"** of not having coordinated wholesale markets becomes severe.

- ✓ The Western **transmission system is robust and dynamic**, providing value in unanticipated ways. If the full capabilities of the system are used, the bulk power system can accommodate renewable penetrations in line with near-term state policy targets with minimal congestion/limitations. However, **more transmission will likely be needed** to provide capacity/flexibility sufficient for long-term policy goals.

THANK YOU

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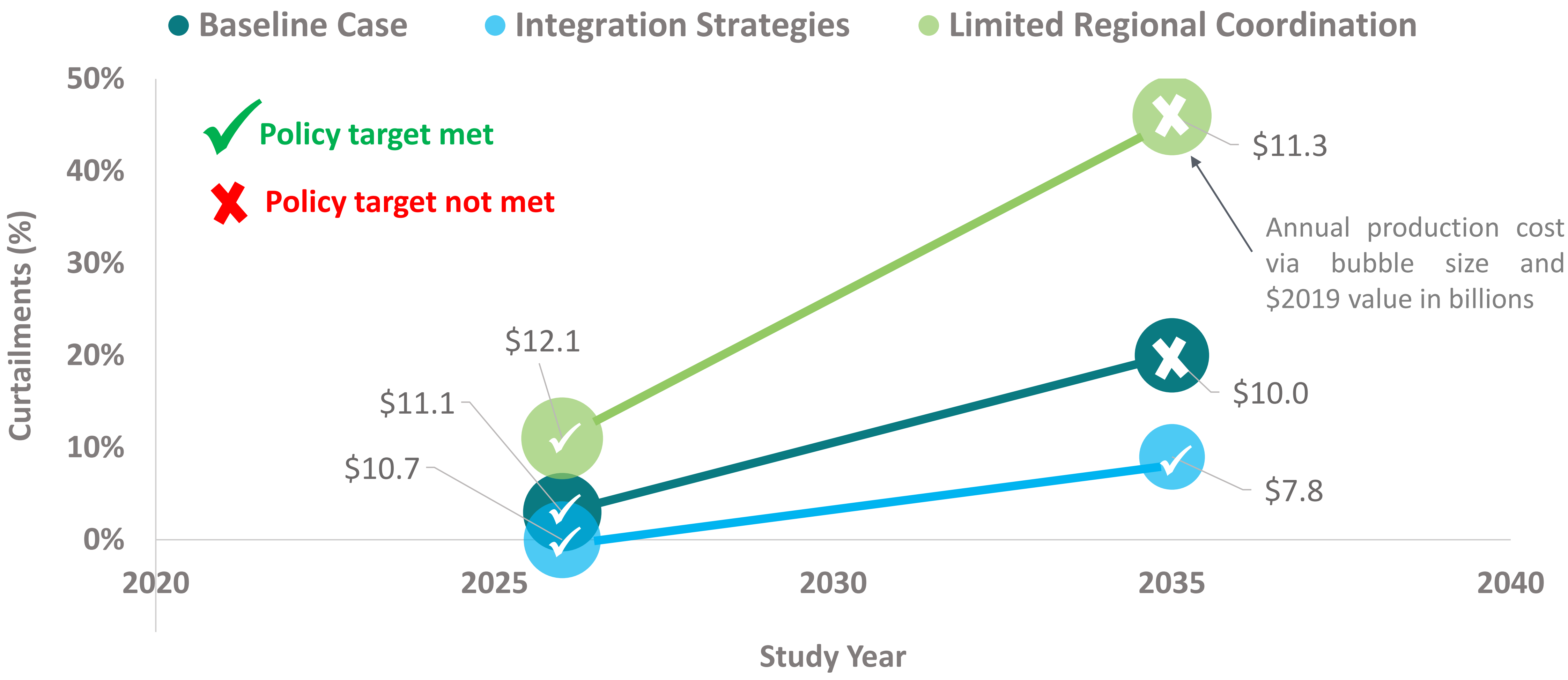
Supplemental Slides

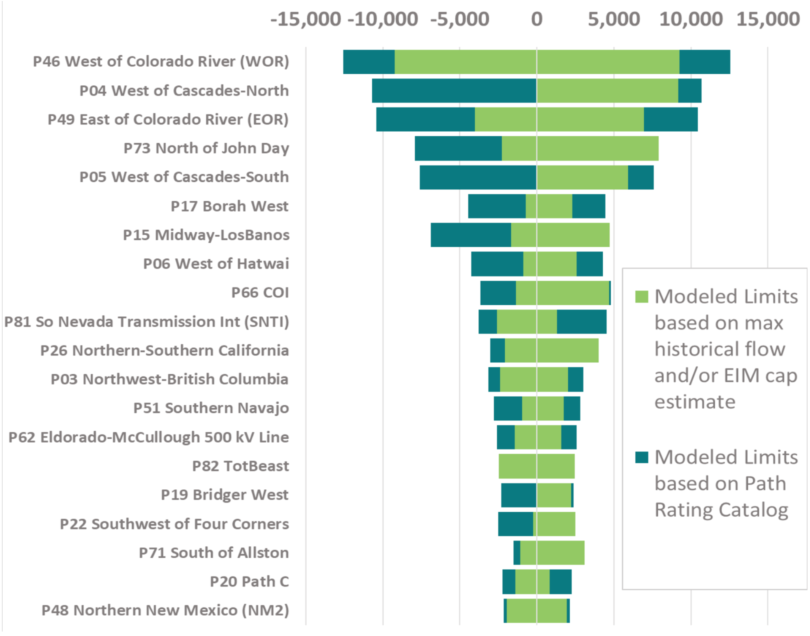
Summary of Key Study Metrics



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



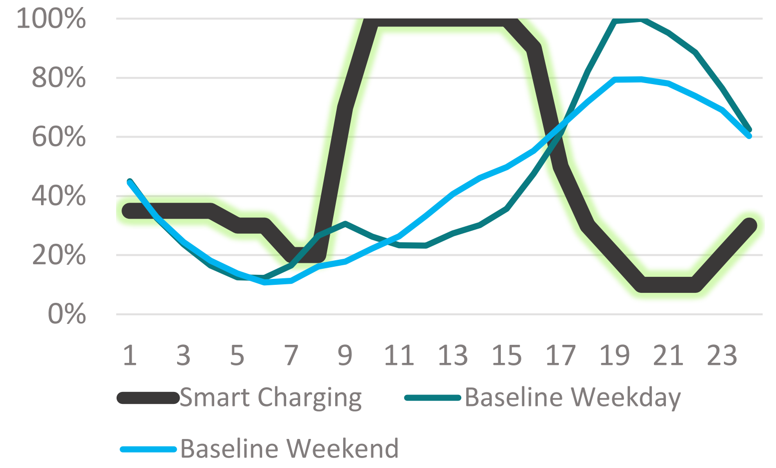
On-Peak & off-peak non-firm wheeling charges assumed for all day-ahead transactions

Business-as-usual transmission operations and efficiency

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)

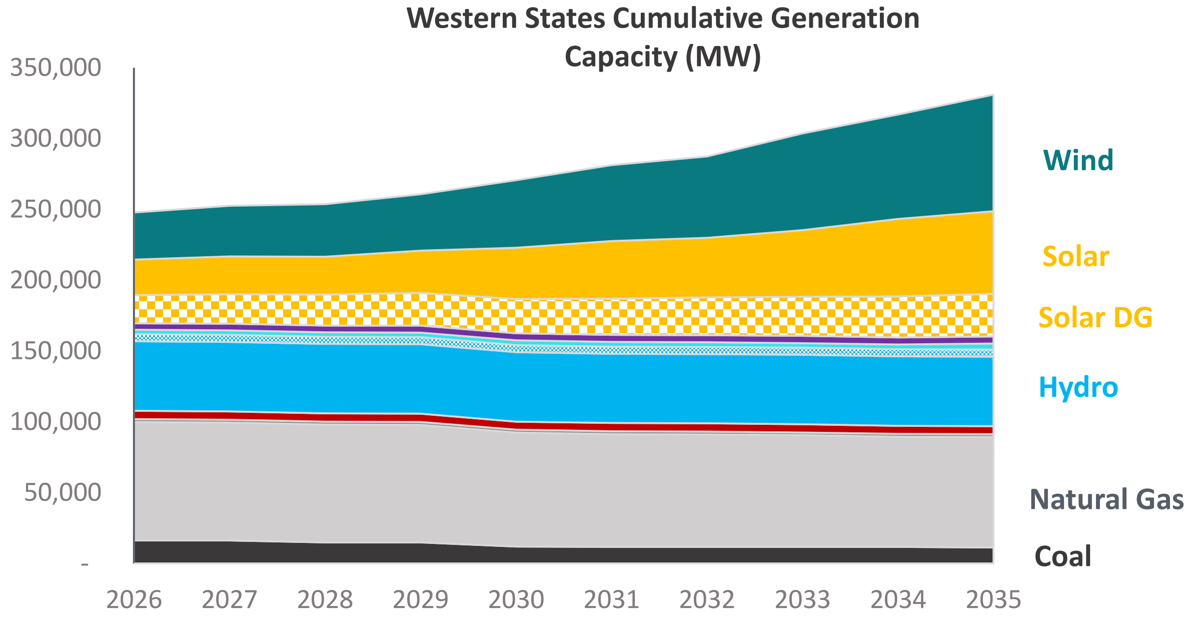


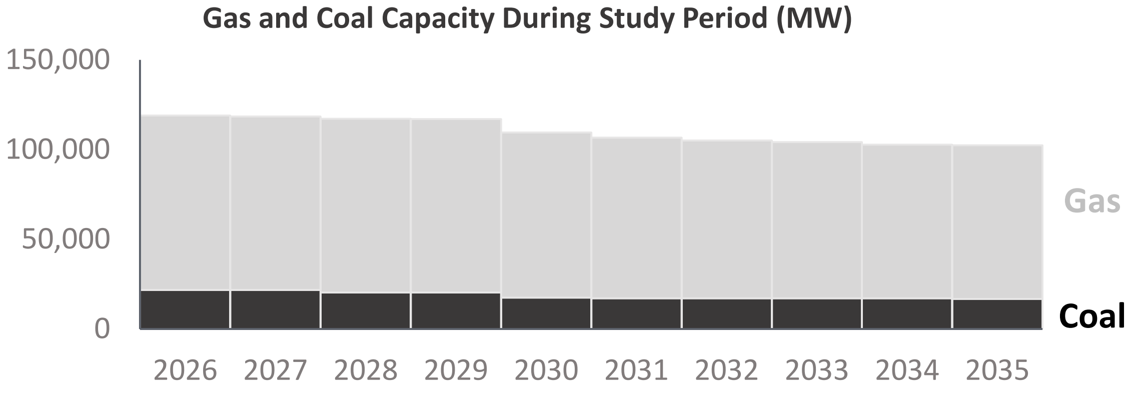
Assumed Incremental Storage (GW)

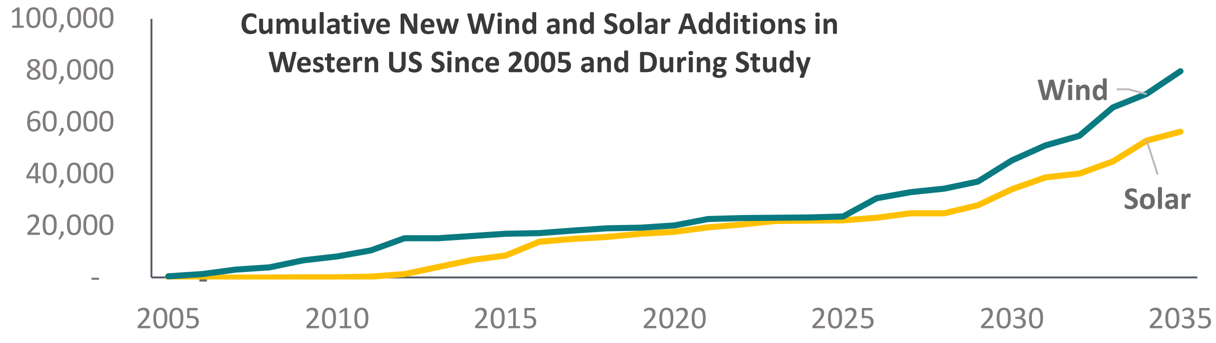
Technology	2026	2035
4-hr Battery	2.1	32.5
12-hr Pumped Storage	0.60	10.2

Resource Expansion and Generation Mix

- **By 2035, zero-emission resources provide 72% of generation 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**

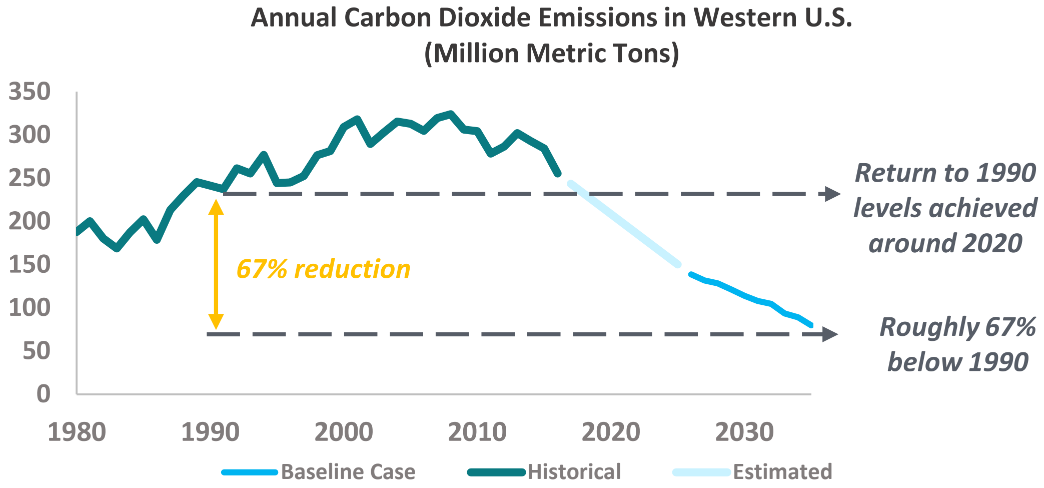


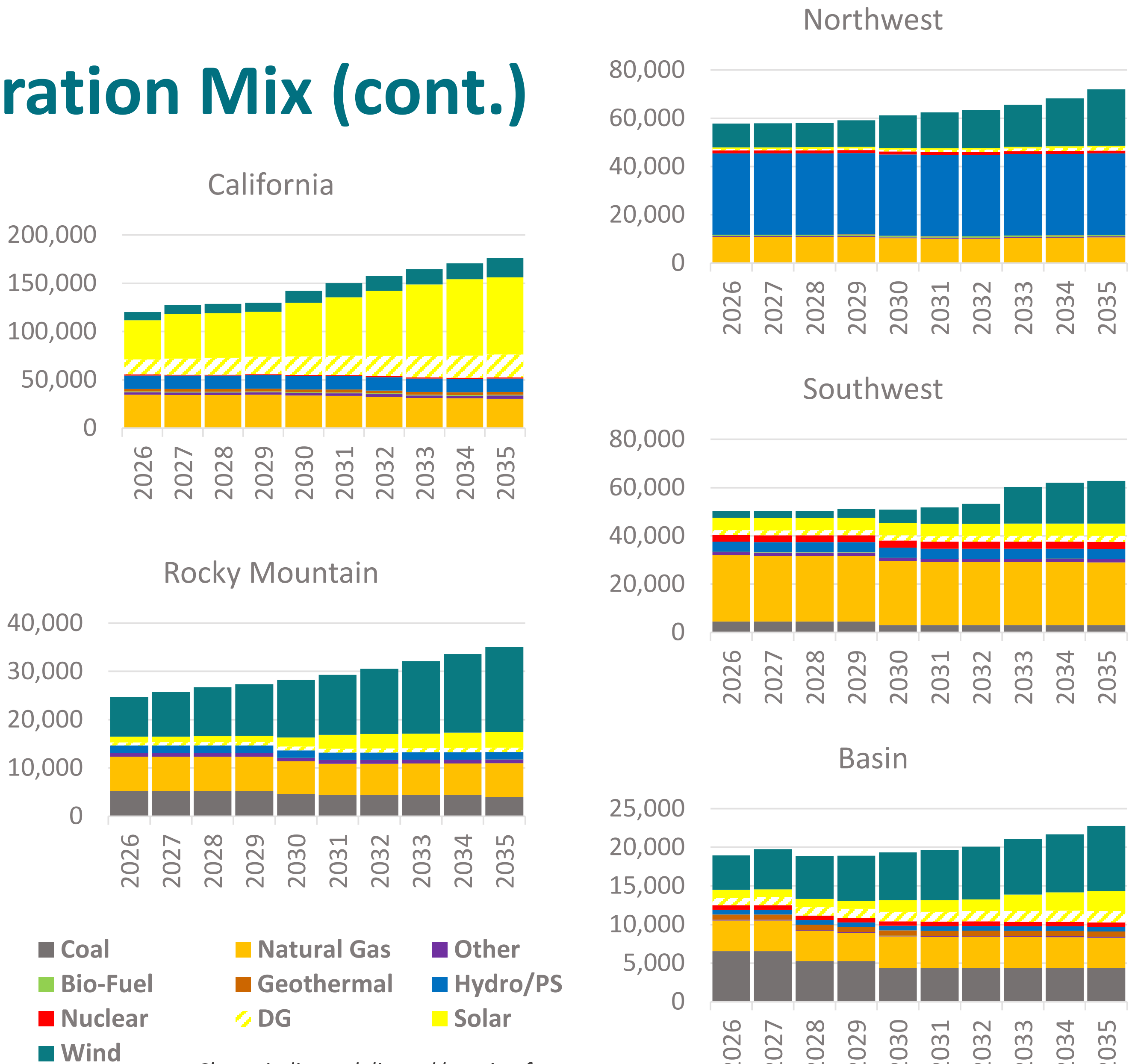




Resource Expansion and Generation Mix (cont.)

- **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**





Charts indicate delivered location for resources

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%

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%