Resource Adequacy and the Energy Transition in the Pacific Northwest: Results from Phase 2

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Project Overview

E3 was retained by regional utilities and generation owners to evaluate the state of resource adequacy in the Pacific Northwest today and into the future

	Key Study Questions	Key Outputs
1	What are near-term resource adequacy needs (2025-2030)?	• Near-term RA shortfalls • NW reliability event characteristics
2	What are the main barriers to meeting near- to intermediate-term needs?	• Pace of future vs. historical build rates • Challenges of developing new generation, transmission, and natural gas infrastructure • RA contributions of new resources
3	What are the long-term resource needs (2035-2045)?	• Least-cost portfolio optimization analysis • Technology and load growth scenarios
4	What is the role of new natural gas peaking capacity?	• Cost impact of allowing new gas capacity • Risk of asset stranding for new gas • Role of substitute emerging technologies
5	What are the needs in constrained NW load pockets?	• Growth in RA need in PNW and I-5 corridor • Modeled resource and transmission solutions

STUDY SPONSORS

- Puget Sound Energy
- Public Generating Pool
  - Chelan Public Utility District
  - Clark Public Utilities
  - Cowlitz Public Utility District
  - Eugene Water & Electric Board
  - Grant Public Utility District
  - Lewis Public Utility District
  - Seattle City Light
  - Snohomish Public Utility District
  - Tacoma Power
- Avista Corporation
- Benton Public Utility District
- Douglas Public Utility District
- Emerald People's Utility District
- Franklin Public Utility District
- Idaho Power
- Klickitat Public Utility District
- Mason Public Utility District No. 3
- Northwest & Intermountain Power Producers Coalition
- NorthWestern Energy
- Okanogan Public Utility District
- Pacific Public Utility District
- Portland General Electric

Key Findings

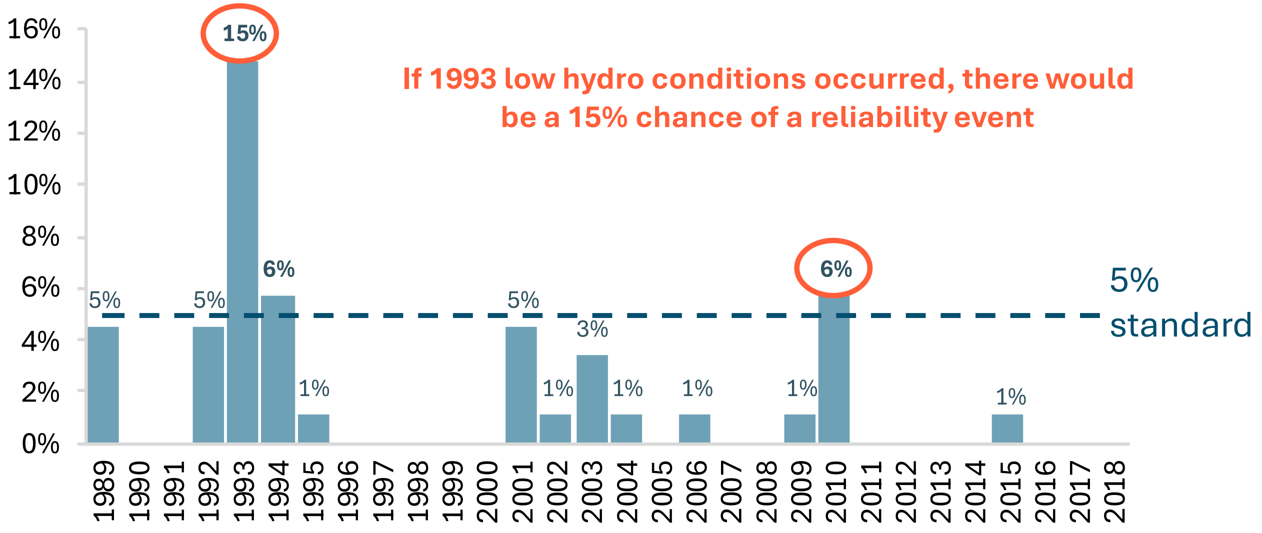
1. Accelerated load growth and continued retirements create a resource gap that grows to *9 GW of effective capacity by 2030* and *14-18 GW by 2035*
2. In the near-term, the region is not on track to fill this gap due to market and institutional barriers
3. In the long-run, it is possible to achieve deep carbon reductions while maintaining reliability and affordability by investing in a portfolio of energy efficiency, wind, solar, geothermal, and natural gas
4. New natural gas peaking capacity for backup use during low hydro or low renewable conditions is a robust long-term strategy across a wide range of future scenarios
5. There will be a growing need for new local delivery capability into Washington and Oregon, particularly in the I-5 corridor, either from new resources or transmission

Phase 2 Key Findings

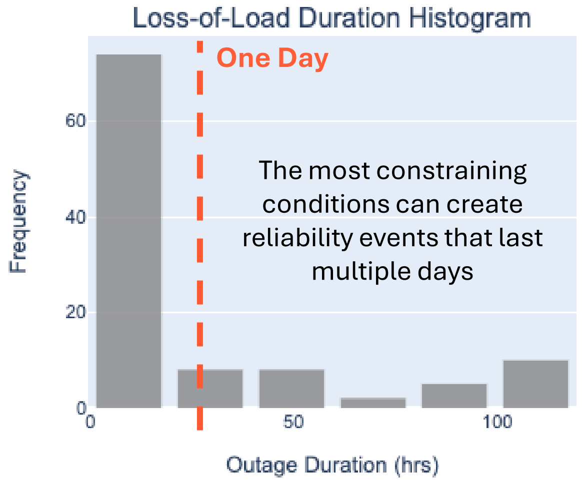
The Northwest's biggest reliability challenge is a multi-day cold weather event that occurs during a low hydro year

- Low water years create risk of multi-day energy shortfall during extended cold snap
- Simulated reliability events can last multiple days (exceeding 50-100 hours)

2025 Loss-of-Load Probability (LOLP) by Hydro Year



Distribution of Loss-of-Load Events



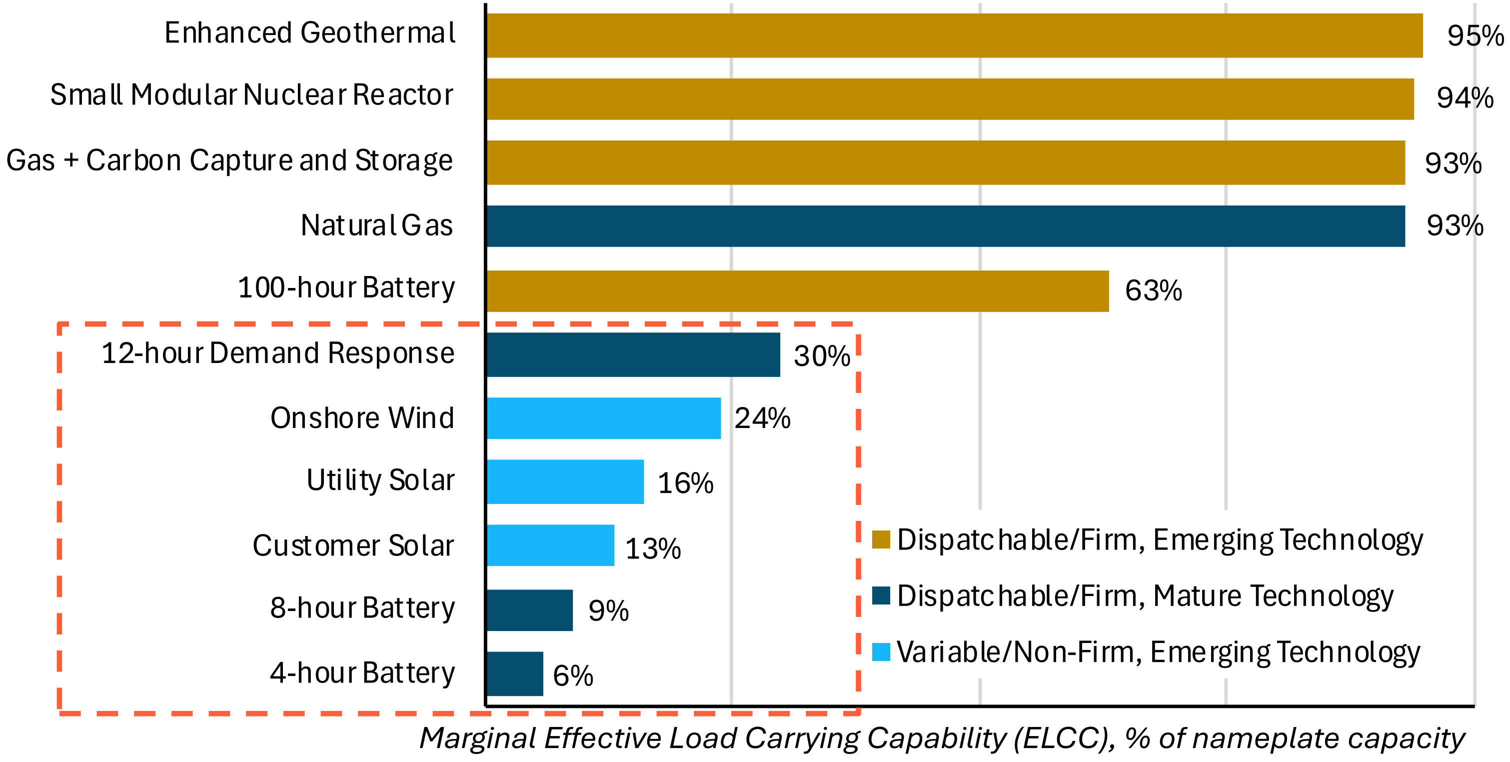
*** Greater Northwest, tuned to 1-day-in-10-year standard*

Addressing these events requires resources that can reliably deliver energy over long periods during extreme cold winter weather

Wind, solar and batteries do not provide significant reliability value in the Pacific Northwest

Reliability Contribution by Resource Type (2025)

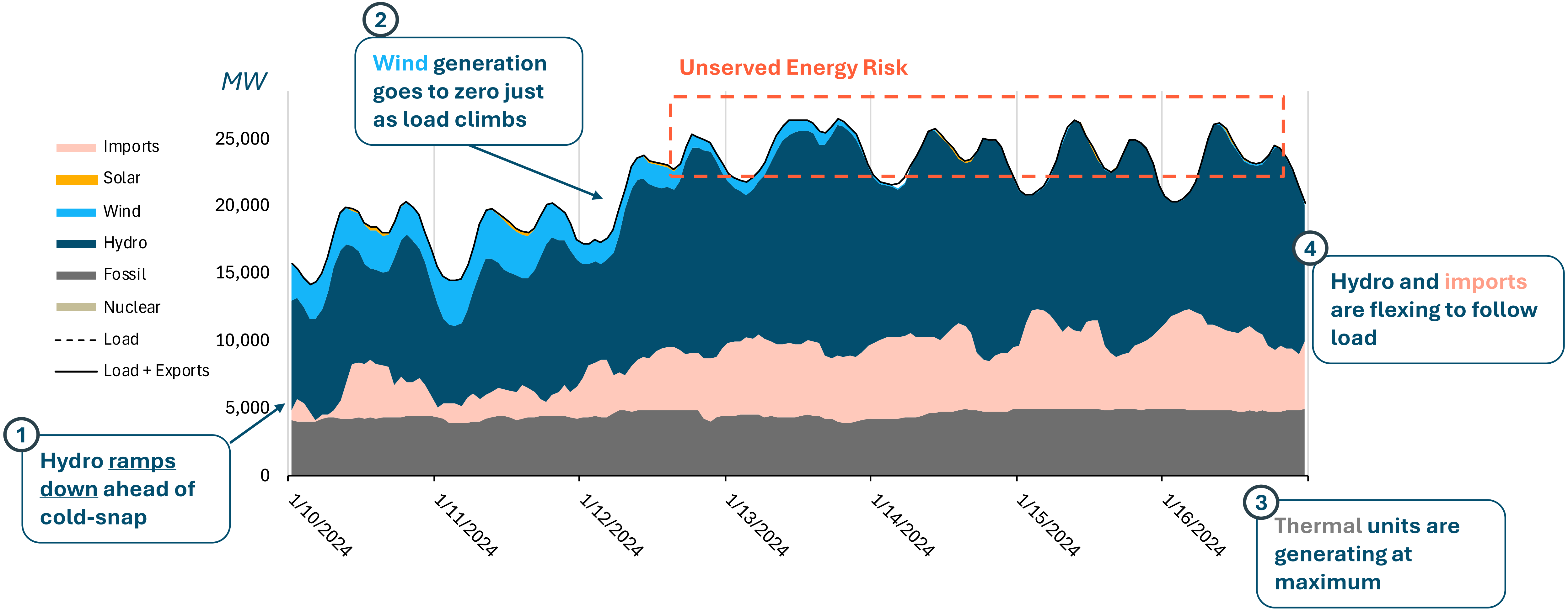
Driven by loss of load events occurring primarily during wintertime multi-day low hydro conditions



- **The region's worst reliability events occur during winter and can last 50-100+ hours**
- **Wind and solar production is low during these events**
- **Short-duration storage and demand response are quickly depleted**

Natural gas generation is the only scalable firm resource that can effectively meet the Northwest's needs today

The Northwest's most recent near reliability event was the multi-day January 2024 cold snap



Source: EIA, BPA

3. Long-term Resource Needs

- Portfolio optimization analysis through 2045
- Load, technology, and policy sensitivities
- Cost impacts
- Annual build rates

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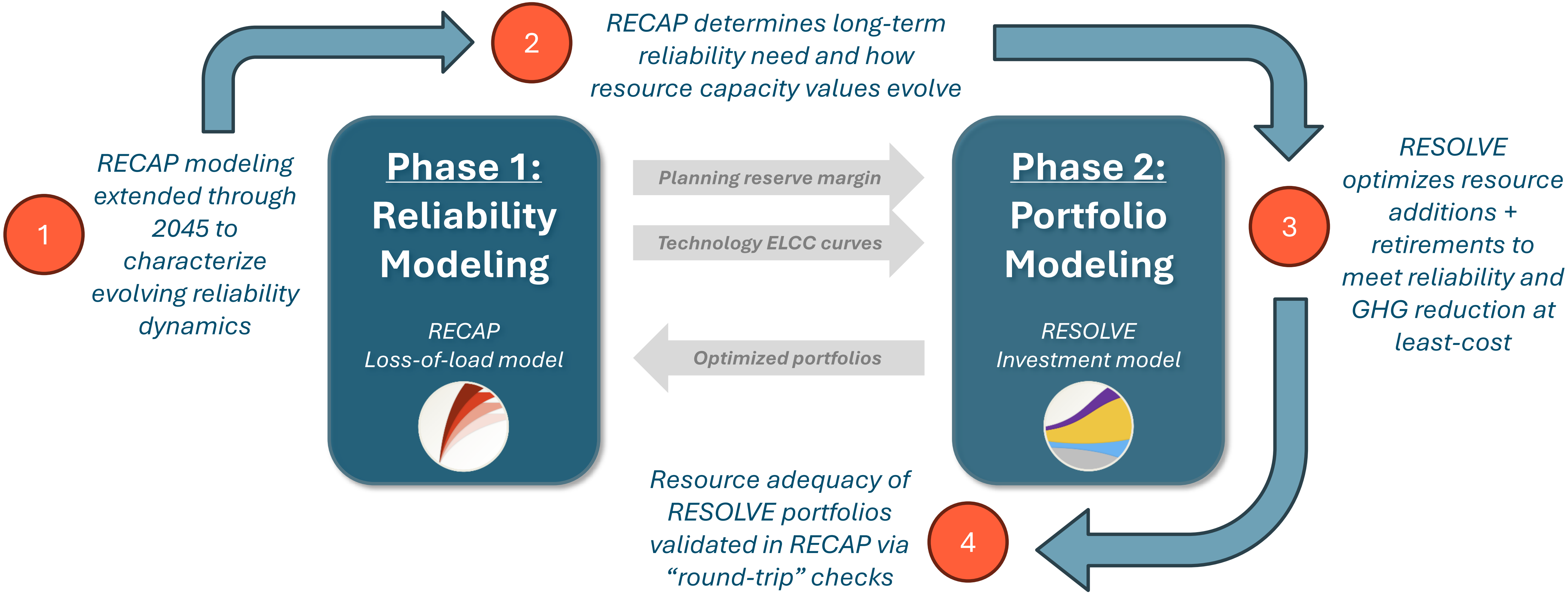
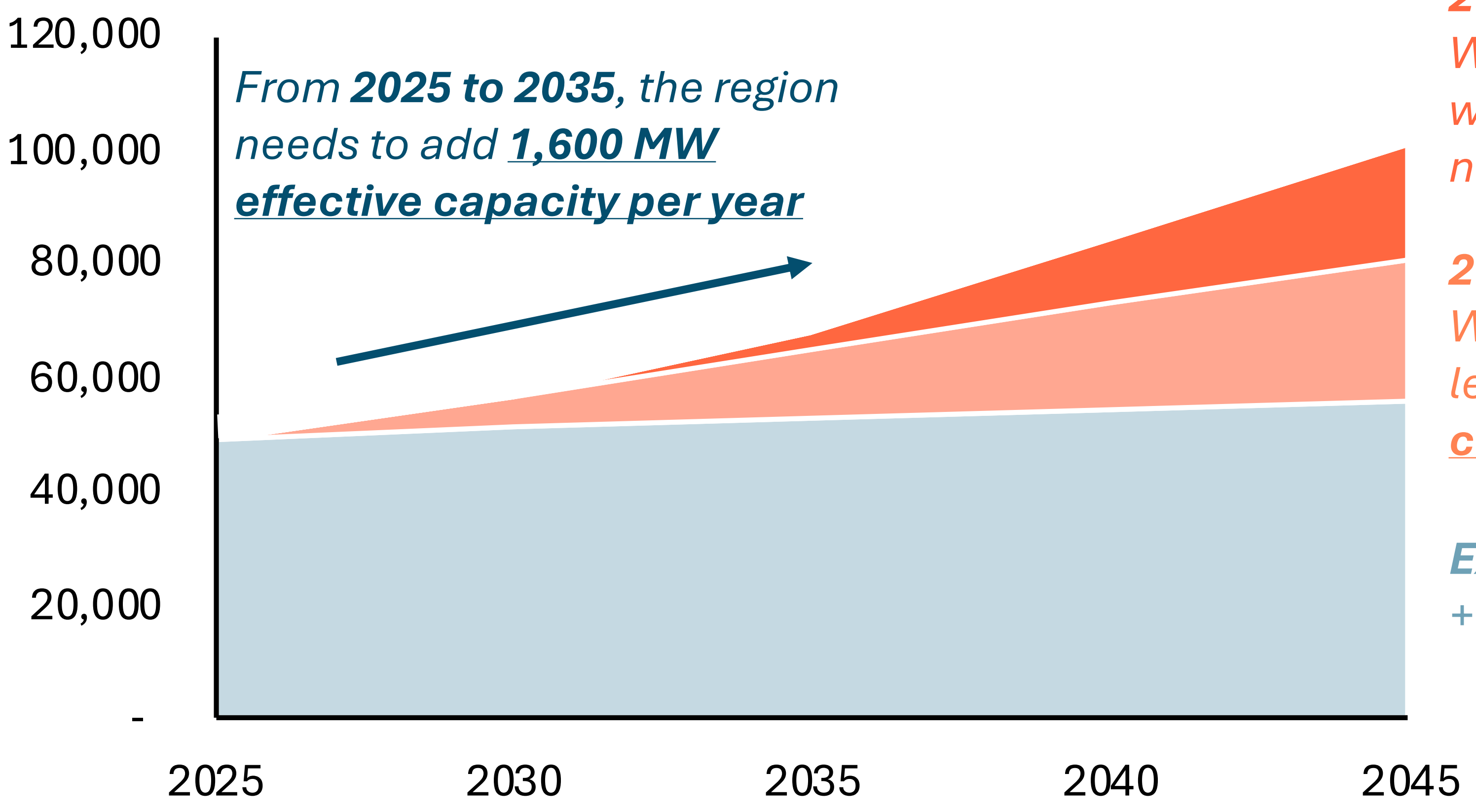
Near-term resource adequacy modeling expanded through 2045 to ensure reliability optimized portfolio expansion



Resource adequacy need will accelerate in the 2030s to support electrification for economy-wide net zero emissions goals

Greater Northwest

Total Resource Need (Peak + 9% PRM), Effective (ELCC) MW



Near-term load forecasts aligned with PNUCC utility forecasts in 2030

Long-term load forecasts follow current market trends (reference) or are modeled to achieve net-zero emissions in the Greater Northwest (high load)

2035-2045 Needs: High Load Scenario

*With high electrification to meet economy-wide net zero emissions, effective capacity need **grows to 3,200 MW per year***

2035-2045 Needs: Reference Scenario

*With continued electrification trends and legislated policies, effective capacity need **continues at 1,600 MW per year***

Existing and In-development resources

+ 3,750 MW of winter firm imports

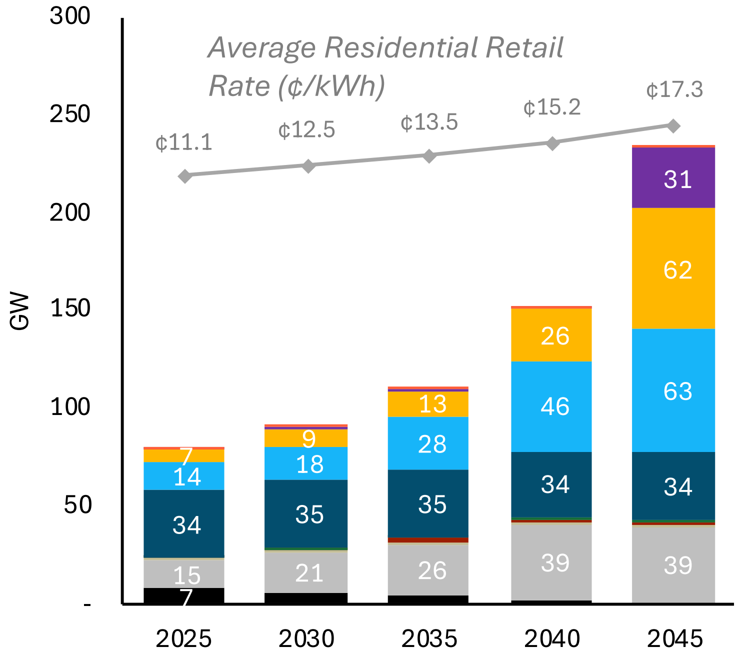
A portfolio of wind, solar, storage and natural gas is selected to meet clean energy and resource adequacy needs (High Load Case)

Greater Northwest

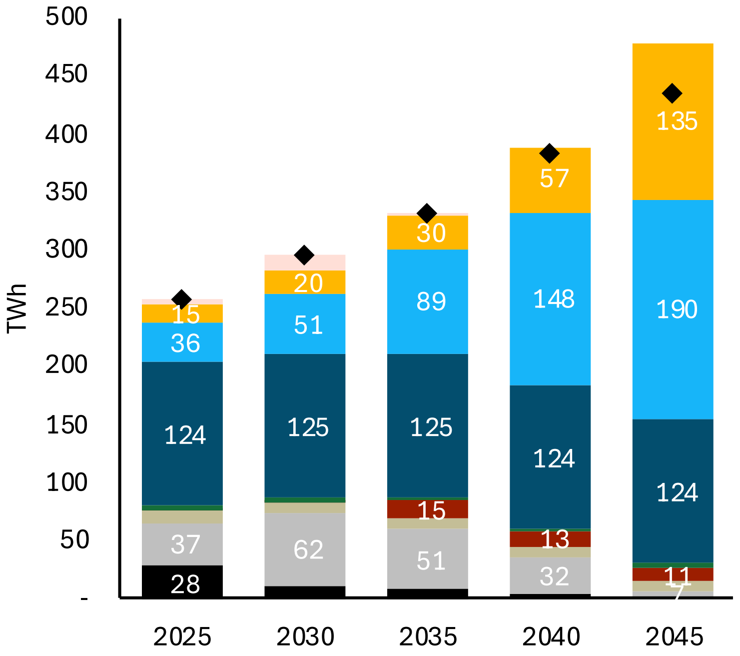
High Load 96% GHG Reduction

Demand Response
Li-ion Battery
Solar
Wind
Hydro
Geothermal
Nuclear
Natural Gas
Coal
Net Imports
Load

Installed Capacity



Generation & Loads



+ High load scenario shows large increase in resources needed

- Higher resource need primarily after 2035 as electrification to support a net-zero carbon economy increases
- **Installed capacity** of generation and associated transmission interconnection grows **more than triples**

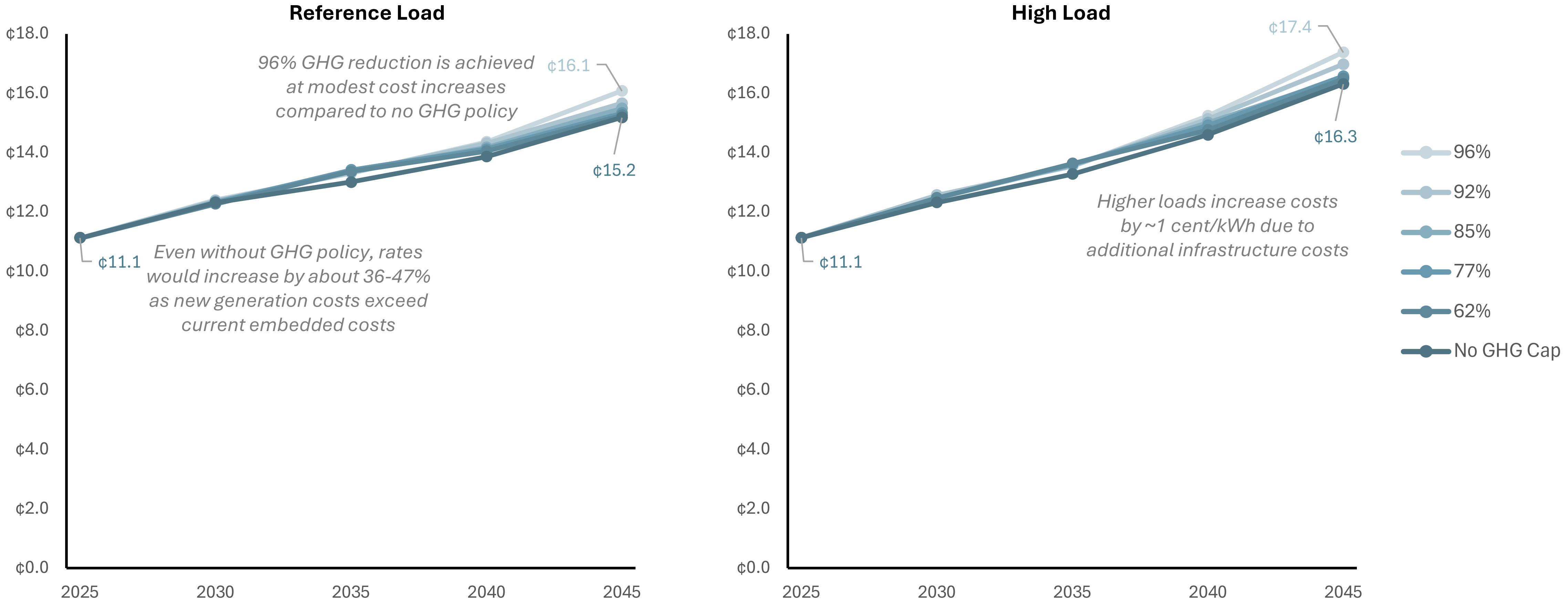
+ Annual generation nearly doubles from today

+ Costs to meet high load scenario are slightly higher, reflecting increased needs for RA and GHG reducing infrastructure

- Rate impacts shown in real 2024$ terms; some utilities may see significantly different impacts than these regional values
- Policies are modeled at least-cost, achieved on a regional basis
- Generation exceeds loads in years where the Greater Northwest is a net energy exporter

Rates increase in all scenarios, while incremental costs to achieve up to 96% GHG reduction regionwide are modest

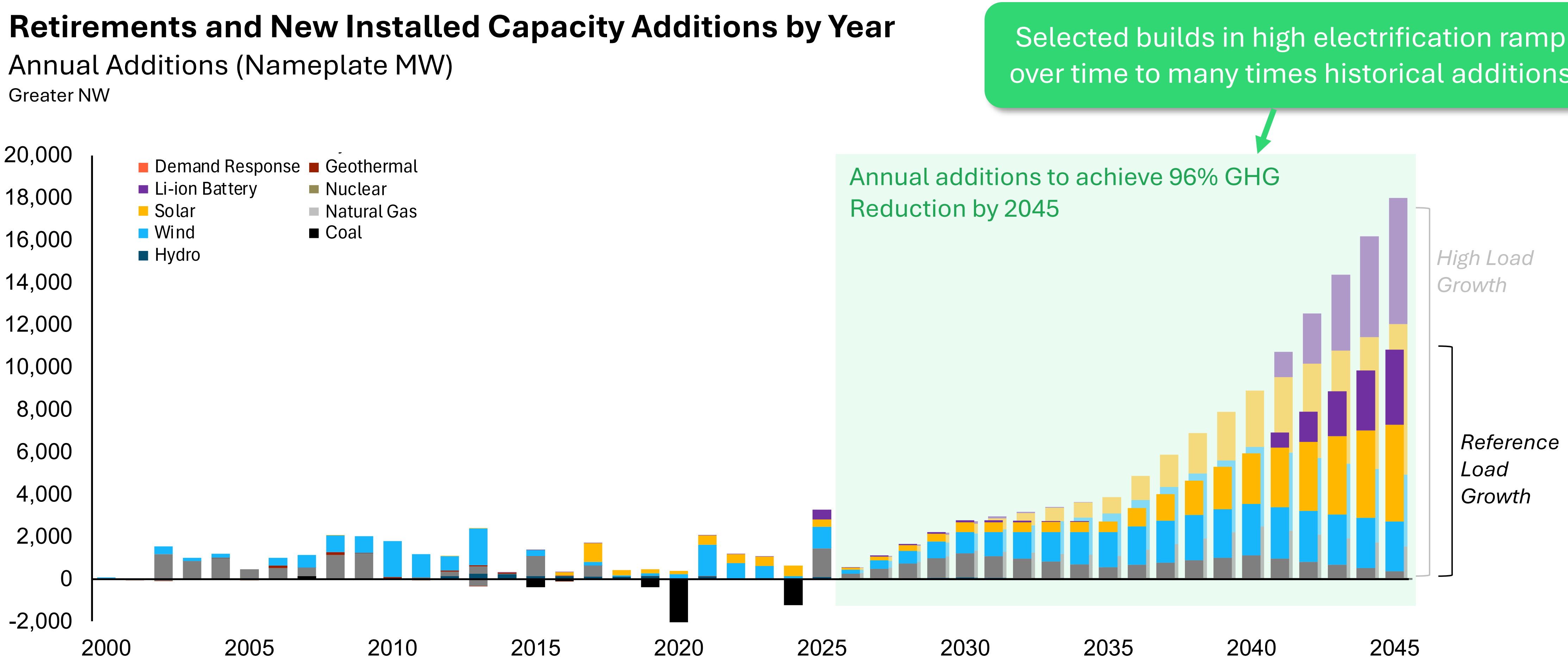
Greater Northwest Average Residential Retail Rates (¢/kWh)
GHG Reduction Scenarios



- Rate impacts shown in real 2024$ terms; some utilities may see significantly different impacts than these regional values if they cannot access the regional diversity (for RA and clean energy) modeled in this study
- Policies are modeled at least-cost, achieved on a regional basis

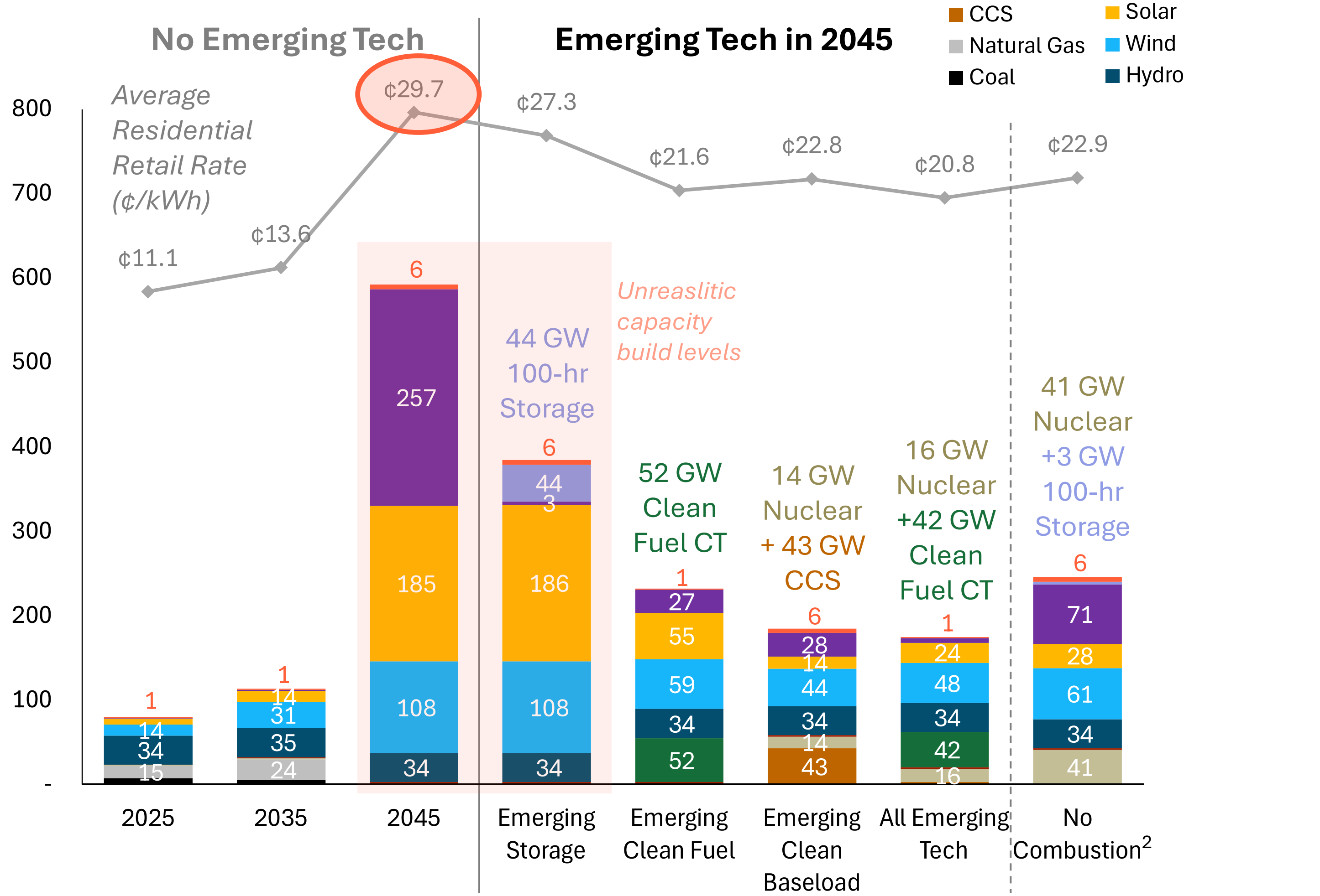
Achieving current clean energy targets requires a massive increase in annual new capacity additions

Selected builds in high electrification ramp over time to many times historical additions



Achieving 100% carbon reductions is not feasible without at least one "clean firm" technology available at scale

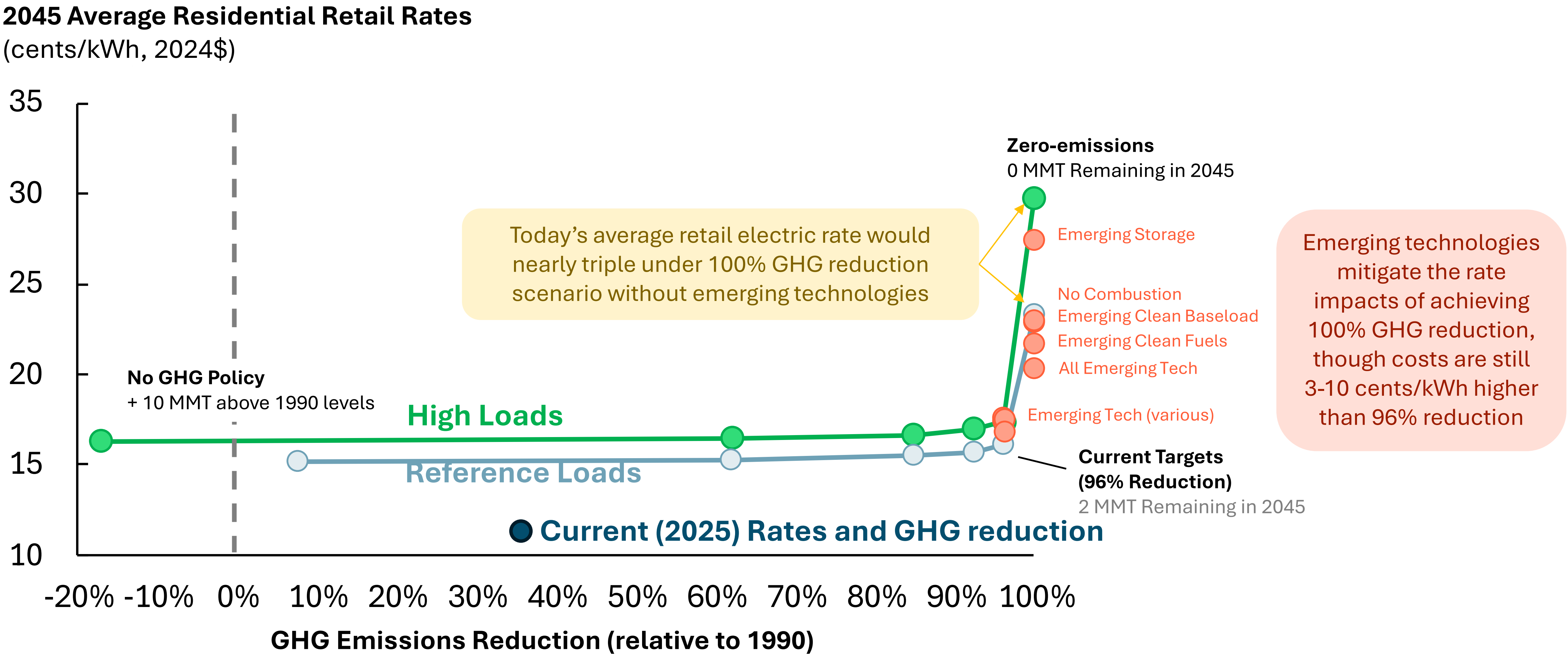
Greater Northwest Installed Capacity
100% GHG Reduction with High Load & Emerging Tech



- **Under 100% GHG reduction, all emitting coal and gas generators must retire or convert to zero-carbon fuels by 2045**
- **Achieving 100% reduction is not feasible without emerging "clean firm" technologies available at scale**
- **44 GW of Long-Duration Energy Storage displaces almost all batteries, but very high levels of renewable builds are still required**
- **57 GW of Clean Firm Baseload, such as Gas w/ CCS or Nuclear SMRs, offsets battery storage and renewables while replacing firm capacity previously provided by natural gas generation**
- **42-52 GW of clean fuel powered combustion turbines displace fossil gas generation**

- Rate impacts shown in real 2024$ terms; some utilities may see significantly different impacts than these regional values
- Note that the level and type of emerging technologies selected is sensitive to cost assumptions
- "No Combustion" sensitivity does not allow CCS, clean fuel CT, or gas in 2045

Average residential retail rates increase significantly to eliminate the last 2 MMT of GHG emissions



• Note: Emerging technologies are explored only in High Loads Scenario

Key Finding #3: A portfolio of new resources will be needed

3. In the long-run, it is possible to achieve deep carbon reductions while maintaining reliability and affordability by investing in a portfolio of energy efficiency, wind, solar, geothermal, and natural gas

+ A balanced portfolio of new renewable generation, batteries and natural gas peaking capacity enables over 90% GHG reduction at a relatively low cost
+ Emerging technologies are selected at 96% GHG reduction but provide limited ratepayer benefits absent a significant cost breakthrough
+ 100% GHG reduction cannot realistically be achieved without one least one and likely multiple emerging technologies available at significant scale – 40+ GW
+ Achieving the portfolios modeled requires overcoming institutional barriers (transmission, siting/permitting, etc.) to support a large increase in annual build rates compared to historical experience

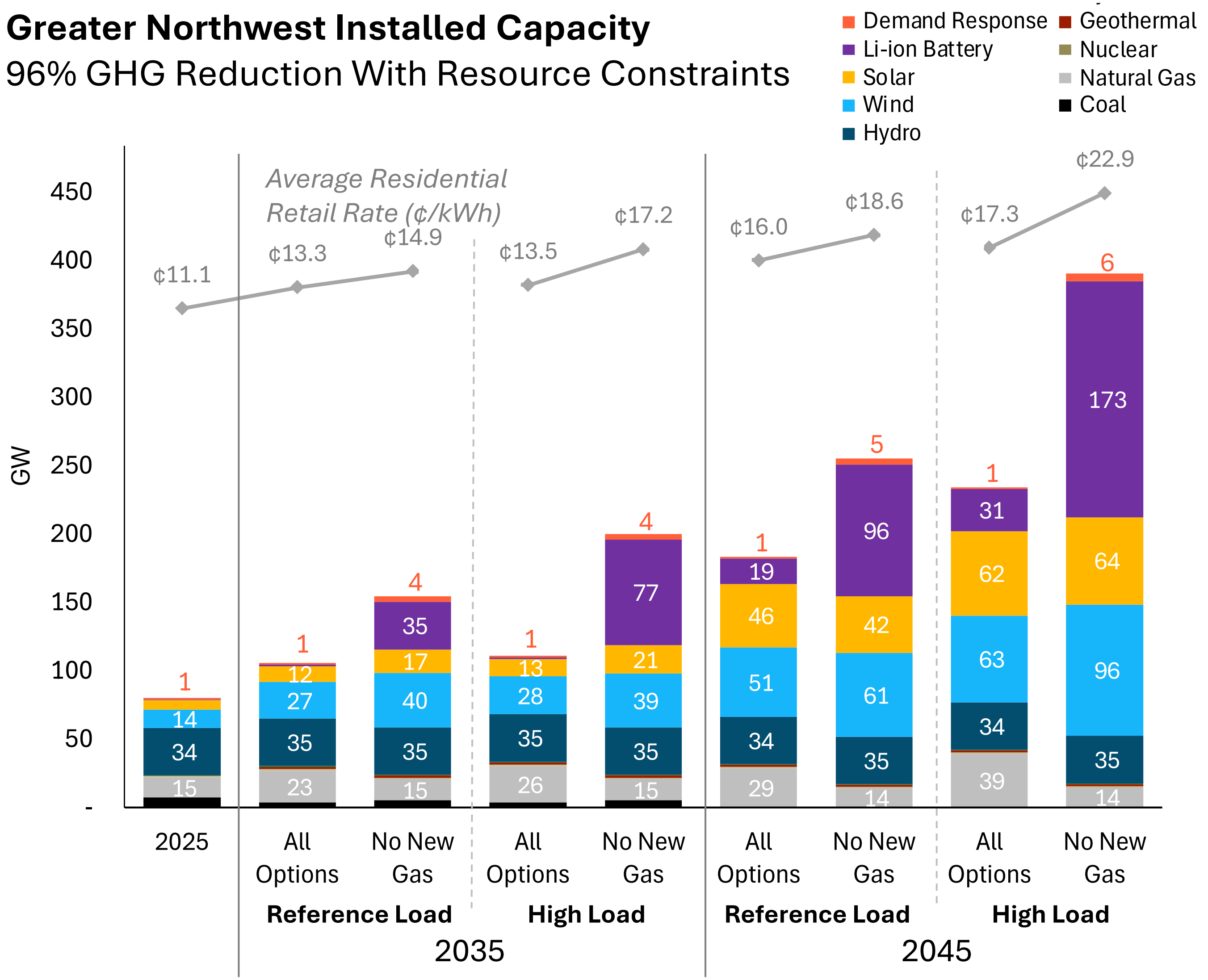
4. Role of New Natural Gas Generation

- What are resource needs + cost impacts without new gas?
- How robust is new gas selection across scenarios modeled?
- What is the risk that investments in new natural gas generation become stranded?
- How will new gas plants be utilized as the region decarbonizes?

If new natural generation is not allowed, costs and build requirements increase significantly

Greater Northwest Installed Capacity

96% GHG Reduction With Resource Constraints

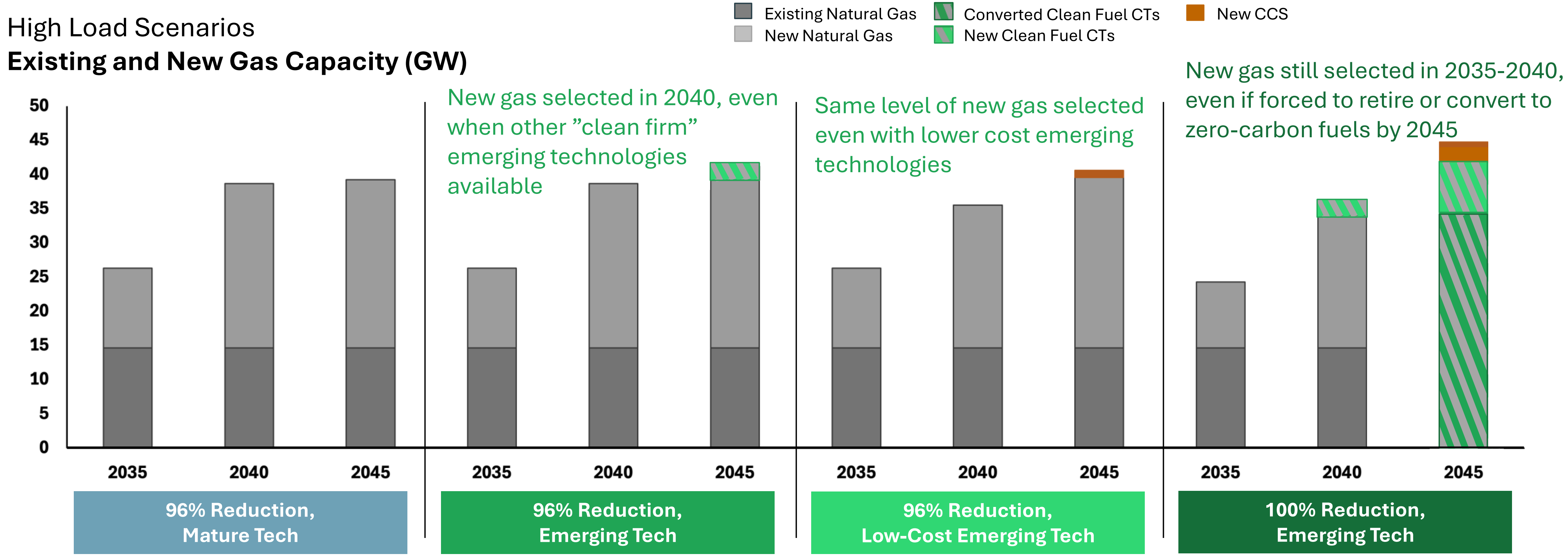


+ **In 96% GHG reduction cases with all resource options, new wind and solar decrease emissions by displacing generation from fossil resources while new natural gas capacity is added as a reliability backstop for extreme conditions**

+ **Not allowing new gas generation requires tens to hundreds of GW of additional capacity**
  - In 2035, ~35-77 GW storage, 5-8 GW solar, and 11-13 GW of additional wind is required to offset 8-11 GW of new gas generation
  - In 2045, 196 GW of wind, solar and storage
  - Without new gas generation, retail rates increase by 3-6 cents/kWh under 96% GHG reduction case

- Rate impacts shown in real 2024$ terms; some utilities may see significantly different impacts than these regional values
- Policies are modeled at least-cost, achieved on a regional basis

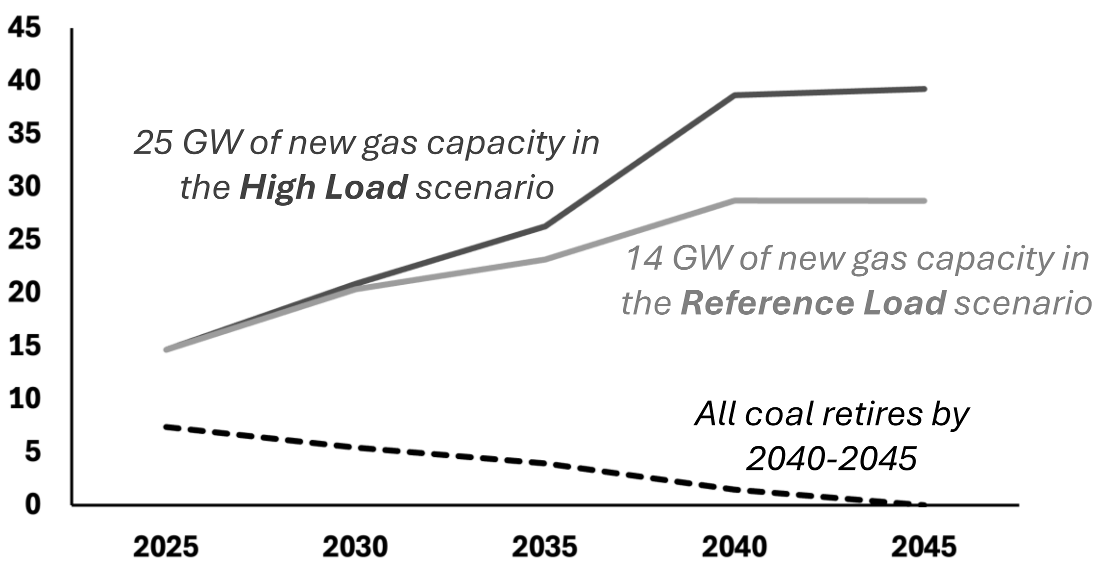
Selection of new natural gas generation is robust across all scenarios and sensitivities, unless explicitly prohibited



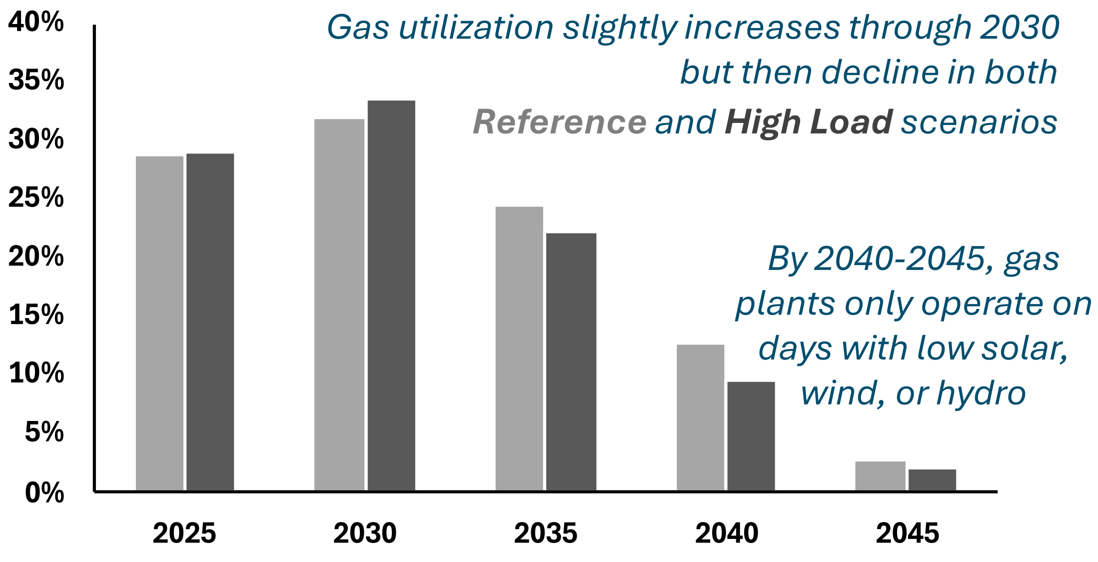
+ **New natural gas capacity is added to maintain reliability in all scenarios where allowed**
+ **Stranded asset risk eliminated if a small level of electric emissions are still allowed or an alternative zero-carbon fuel can be utilized (renewable natural gas, hydrogen, CCS)**

Natural gas plant utilization declines as clean energy policy drives solar and wind builds to reduce emissions

Natural Gas and Coal Capacity (GW)
Current Policy Targets, 96% GHG Reduction



Natural Gas Utilization (Annual Capacity Factor %)
Current Policy Targets, 96% GHG Reduction

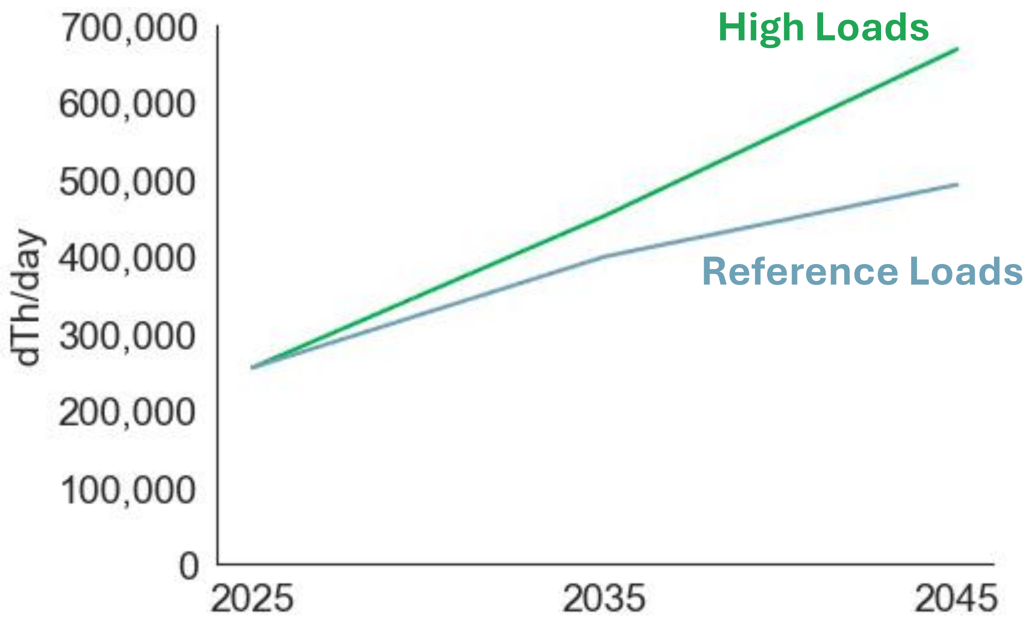


Clean energy additions drive emission reductions by displacing emitting generation, while gas capacity additions ensure sufficient backup firm power to serve loads when non-emitting energy is not available

Gas fuel delivery infrastructure needs for electricity generation increase significantly

- **New natural gas generation requires firm fuel availability for resource adequacy provision**
  - New pipeline capacity (modeled in this study)
  - Backup on-site liquid fuel (potentially feasible, dependent on duration of fuel required)
- **As electric loads grow, peak day gas throughput for electric generation more than doubles between 2025 and 2045**
  - Driven mostly by fuel switching from gas heating to electric heat pumps with resistance backup
- **Further study required to assess combined throughput for electric generation and natural gas end use demands**
  - Hybrid heat pumps with gas backup may be a more efficient use of gas combustion, reducing the need for new power plants, pipelines, and T&D infrastructure

Natural Gas Peak Day Throughput (dTh/day, Electric Gen Only)
96% GHG Reduction



Key Finding #4: Gas peaking plants are a robust reliability strategy

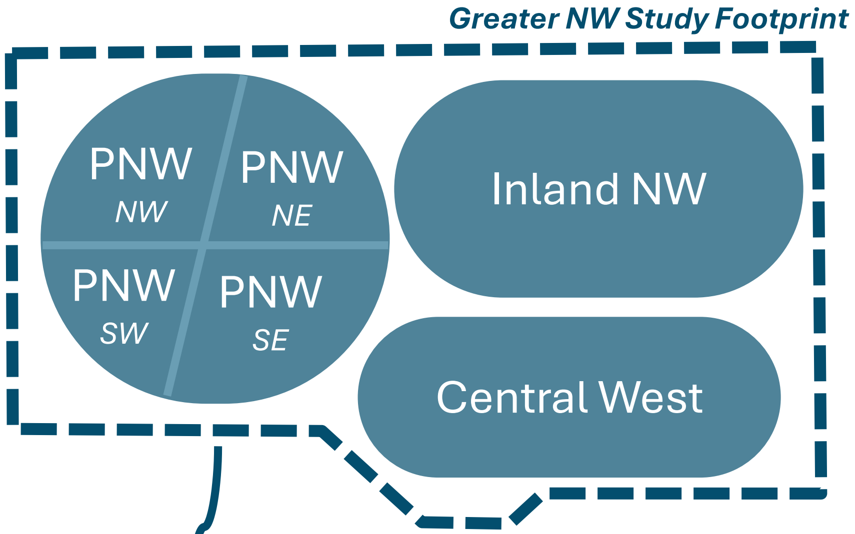
4. New natural gas peaking capacity to provide energy during low hydro or low renewable conditions is a robust long-term strategy across a wide range of future scenarios

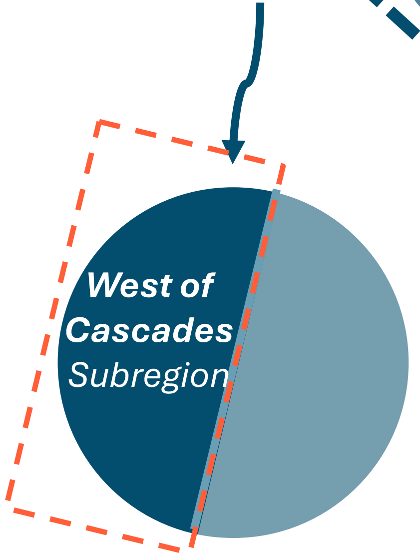
+ **Not allowing new natural gas peaking capacity leads to higher costs with no accompanying emissions benefits**
+ **New natural gas peaking capacity is selected across all scenarios unless prohibited**
  - **24-34 GW** of new natural gas capacity is selected under 96% GHG reduction, reducing retail electric rates by **3-6 cents/kWh**
  - Natural gas capacity is dispatched less frequently as clean generation is added, with capacity factors falling to 10-12% in 2040 and 2-3% in 2045
  - Even under a 100% GHG reduction scenario, new natural gas capacity is selected in 2040 only to be retired (or converted to zero-carbon fuels) in 2045

Pacific Northwest and Westside Resource Adequacy Needs

- As loads grow, when do resource adequacy needs in the Washington and Oregon load pockets exceed existing transmission capabilities?
- How much new local delivery capability is needed?
- What mix of resource and transmission solutions are selected by RESOLVE to meet sub-regional resource adequacy needs?

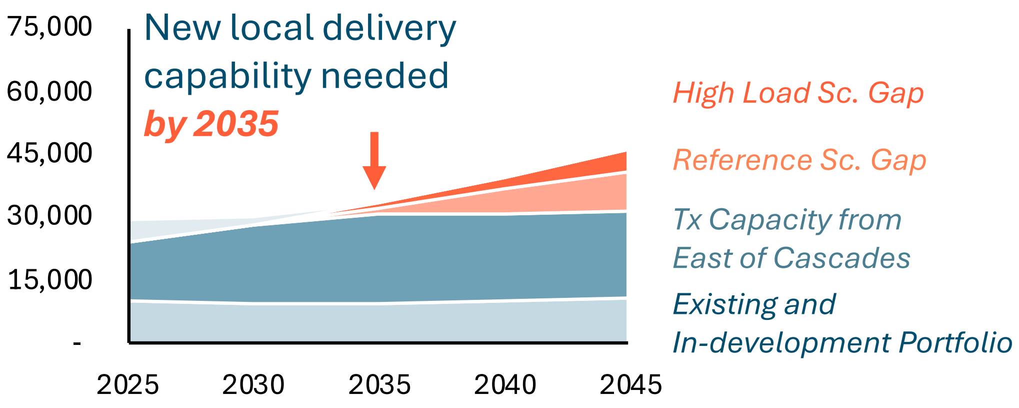
Subregional RA needs grow in OR/WA and West of the I-5 corridor as west coast population centers electrify



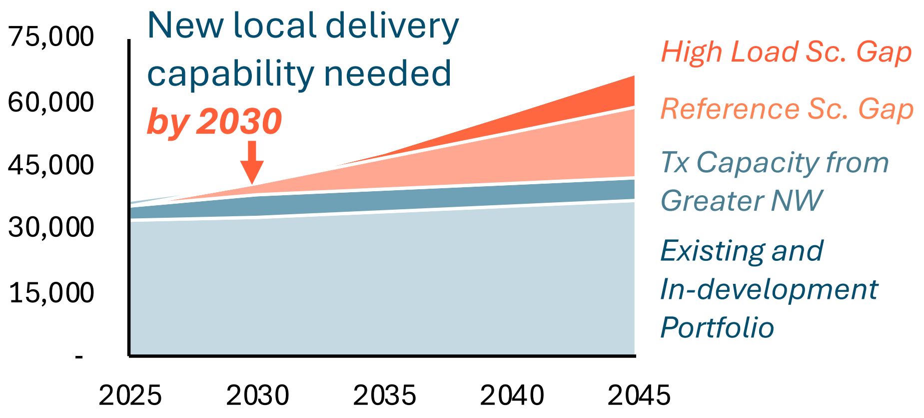


- **Load in modeled subregions is growing faster than planned transmission upgrades, driving subregional RA needs**
- **Subregional RA needs can be met by:**
  - **New inter-regional transmission**, which provides RA value to subregions and enables access to higher quality WY+MT wind resources
  - **New local resources in the subregions**, which was the only option by 2035 since new transmission is modeled starting in 2040

West of Cascades *Subregion*
Total Resource Need, Effective (ELCC) MW



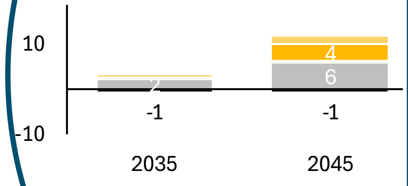
Pacific Northwest *Subregion*
Total Resource Need, Effective (ELCC) MW



New resources are distributed across the Greater Northwest alongside new transmission to meet subregional RA needs

96% GHG Reduction - High Load Scenario

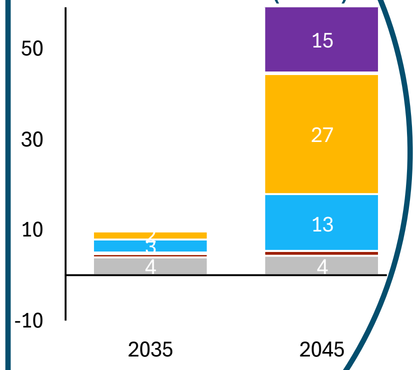
Pacific Northwest
West of Cascades
Resource Build (GW)



East to West Cascades
Tx Interface (MW)

2025	19,250
2035	**21,400 (+2,150)**
2045	**27,890 (+8,640)**

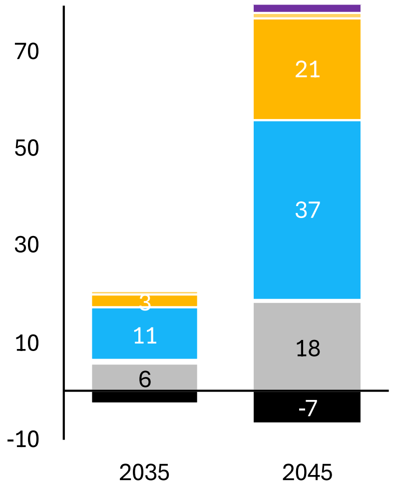
Pacific Northwest
East of Cascades
Resource Build (GW)



Inland Northwest & Central West
into Pacific Northwest
Tx Interface (MW)

2025	4,600
2035	**6,200 (+2,600)**
2045	**8,908 (+4,308)**

Inland Northwest & Central West
Resource Build (GW)



The West of Cascades subregion requires over 4 GW of new delivery capability by 2035 and 17 GW by 2045

The Pacific Northwest subregion requires over 11 GW of new delivery capability by 2035 and 31 GW by 2045

Results show RESOLVE's optimal solution to meet local needs, but those needs could be plausibly met by different combinations of local resources and transmission upgrades. For instance, siting batteries for local capacity values West of the Cascades is an alternative to the East of Cascades siting and upgraded cross-cascades transmission that RESOLVE selected.

Key Finding #5: Increased local delivery needed, especially west of the cascades

5. There will be a growing need for new local delivery capability into Washington and Oregon, particularly in the I-5 corridor west of the Cascades, either from new local resources or new regional transmission

+ **Amidst growing loads, the Pacific Northwest (OR+WA) and the West-of-Cascades subregions become locally constrained, requiring new delivery capacity**
  - Pacific Northwest (OR+WA) subregion: 11 GW of new local firm generation or transmission needed by 2035, 31 GW by 2045
  - West of Cascades subregion: 4 GW of new west-side firm generation or cross-Cascades transmission needed by 2035, 17 GW by 2045
+ **Local resource options are limited West of Cascades given low wind and solar availability**
  - Energy storage may be able to help meet some of the local need – further study is needed
  - 9 GW of new transmission selected implies 5-6 new cross-Cascades corridors

Key Findings and Recommendations

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Key Findings

1. Accelerated load growth and continued retirements create a resource gap that grows to *9 GW of effective capacity by 2030* and *14-18 GW by 2035*
2. In the near-term, the region is not on track to fill this gap due to market and institutional barriers
3. In the long-run, it is possible to achieve deep carbon reductions while maintaining reliability and affordability by investing in a portfolio of energy efficiency, wind, solar, geothermal, and natural gas
4. New natural gas peaking capacity for backup use during low hydro or low renewable conditions is a robust long-term strategy across a wide range of future scenarios
5. There will be a growing need for new local delivery capability into Washington and Oregon, particularly in the I-5 corridor, either from new resources or transmission

Phase 2 Key Findings

Study results require key institutional changes to support the construction of modeled portfolios

DSM: continuation of historical EE+DR programs, new need to consider flexibility for data centers and electric vehicles

Siting and permitting: ensure efficient processes for siting new generation and transmission

Natural gas: coordinated development of new peaking capacity and expanded gas delivery system, joint planning for electric and gas end use demands

Emerging technologies: balance of federal funding, private capital, and state/utility support to commercialize new technologies

Transmission: efficient reformed interconnection processes, proactive transmission buildout, effective pathways for interregional line selection and cost allocation

Regional coordination: foundational to least-cost renewable integration

- **Energy markets** ensure efficient regional commitment and dispatch
- **Capacity markets** allow pooling of regional RA resources (e.g., WRAP), define regional and sub-regional RA needs, and send efficient market signals for entry/exit
- **Clean energy markets** support least-cost regional diversity and tradeable products instead of piecemeal BA-level planning

Phase 2 Long-Term Optimal Portfolio Evaluation: Recommendations (1 of 3)

1. **Continue to address barriers to new resource development**
   - Coordinated regional transmission planning to support proactive grid buildout and reduced interconnection challenges
   - Ensure policy support for the resources needed to meet reliability and clean energy needs
   - Continue to streamline resource permitting processes
2. **Address energy and capacity risks unique to the Pacific Northwest in regional programs**
   - Work with WRAP, NWPCC, WECC, and other regional organizations to ensure ongoing regional resource adequacy assessments appropriately capture the risk of energy shortfalls associated with low hydro conditions along with potential capacity shortfalls
3. **Consider strategic investments in new clean firm technologies**
   - Strategic investments in market transformation may help emerging "clean firm" technologies such as advanced nuclear, carbon capture and sequestration, enhanced geothermal, clean fuels or multi-day energy storage achieve commercialization
   - Policy actions should recognize the limited impact that Northwest entities alone are likely to have and leverage the potential for industry and geographical partnerships

Phase 2 Long-Term Optimal Portfolio Evaluation: Recommendations (2 of 3)

4. **Ensure that regional planning efforts appropriately consider the growing need for new delivery capability into the I-5 corridor**
   - West-side needs are more difficult to serve due to geographic barriers; however electric loads are expected to continue to grow on the west side due to building and transportation electrification policies and new large loads on top of organic population and economic growth
   - West-side capacity needs can be met with demand management programs, new supply resources, and/or new transmission; regional planning efforts should consider the cost and environmental tradeoffs among all these options
5. **Develop a coordinated process to consider electricity and natural gas delivery needs**
   - Northwest consumers currently rely on both electricity and natural gas to meet heating needs during severe cold weather events; electric reliability during these events will be dependent on natural gas combustion for the foreseeable future
   - Increased policy focus on building electrification may exacerbate this dependence due to higher peak electric loads, requiring investment in new gas delivery capability
   - A coordinated planning process should identify the lowest societal cost solutions for meeting the needs of consumers across the combined electricity and natural gas systems

Phase 2 Long-Term Optimal Portfolio Evaluation: Recommendations (3 of 3)

6. **Continue to support regional coordination and markets for energy, capacity, clean energy, and transmission**
   - Portfolio optimization modeling, including the conclusions of limited costs to reach 96% GHG reduction, assumes efficient and seamless regional markets
   - Organized regional wholesale energy markets support efficient commitment and dispatch
   - Organized regional capacity constructs capture load and resource diversity to reduce overall resource adequacy build requirements
   - Coordinated transmission planning is needed to identify new projects that support subregional resource adequacy needs and renewable energy interconnection and delivery
   - Regional clean energy markets support achieving clean energy policy goals at least-cost versus higher cost pathways where each utility is forced to meet its load with its own clean energy portfolio on an hourly basis

Thank you!

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