Northwest **Power** and
Conservation Council

February 4, 2020

MEMORANDUM

TO: **Council Members**

FROM: **Gillian Charles**

SUBJECT: **Pacific Northwest Zero-Emitting Resources Study**

BACKGROUND:

Presenter: Greg Cullen, Energy Services and Development General Manager at Energy Northwest

Summary: Energy Northwest recently commissioned an E3 study evaluating the role of zero-emitting resources in a deeply decarbonized Northwest regional power system. The results of the study compare the relative system costs in 2045 between traditional renewable/storage/gas portfolios *vs.* portfolios with a more robust zero-emitting resource fleet (*i.e.* a relicensed Columbia Generating Station along with potential new nuclear generation). Mr. Cullen will share these results along with additional information regarding small modular reactor (SMR) technology.

More Info: Energy Northwest shared the results of this study with the Generating Resources Advisory Committee in December 2019. NuScale Power also presented information about their Small Modular Reactor technology at that meeting. Both presentations can be seen at: https://www.nwcouncil.org/meeting/generating-resources-advisory-committee-december-6-2019.

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ENERGY NORTHWEST

Pacific Northwest Zero-Emitting Resources Study

Greg Cullen, Energy Services and Development General Manager

NWPCC

February 11, 2020

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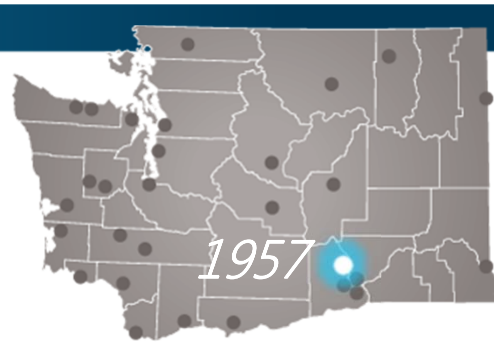
ENERGY NORTHWEST

Energy Northwest

A not-for-profit Municipal Corporation



Asotin County PUD	Clark Public Utilities	Klickitat County PUD	Seattle City Light
Benton County PUD	Ferry County PUD	Lewis County PUD	Skamania County PUD
Chelan County PUD	Franklin County PUD	Mason County PUD 1	Snohomish County PUD
City of Port Angeles	Grant County PUD	Mason County PUD 3	Tacoma Public Utilities
City of Richland	Grays Harbor County PUD	Okanogan County PUD	Wahkiakum County PUD
City of Centralia	Jefferson County PUD	Pacific County PUD	Whatcom County PUD
Clallam County PUD 1	Kittitas County PUD	Pend Oreille County PUD	

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Energy Northwest Generation Projects

- Columbia Generating Station
- Nine Canyon Wind Project
- Packwood Lake Hydroelectric Project
- White Bluffs Solar Station

Columbia Generating Station (1,207 MWe)

Nine Canyon Wind Project (96 MWe)

Packwood Lake Hydroelectric Project (27 MWe)

White Bluffs Solar Station (38 KWe)

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Energy Northwest Generation Projects (cont'd)

- Tieton Hydroelectric Project
- Portland Hydroelectric Project
- Horn Rapids Solar, Storage & Training Project (new development)

Tieton Hydroelectric Project (15 MWe)

Portland Hydroelectric Project (37.5 MWe)

Horn Rapids Solar, Storage & Training Center (4 MWe)

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Transition in the Northwest Power Industry

- Increasing capacity challenges
- Focus on carbon reduction
- Bonneville Power Administration contracts - 2028

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Energy Northwest Energy Initiatives

- Demand Side Management
  - Demand Response
  - Demand Voltage Reduction
- Electrification of Transportation
- Renewable Energy
- Energy Storage
  - Short term (solar)
  - Longer term (wind, nuclear)
- New Nuclear

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ENERGY NORTHWEST

Resource Adequacy in the Pacific Northwest

Serving Load Reliably under a Changing Resource Mix

(Energy & Environmental Economics Study)

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Study Sponsors

- **This study was sponsored by Puget Sound Energy, Avista, NorthWestern Energy and the Public Generating Pool (PGP)**
  - **PGP is a trade association representing 10 consumer-owned utilities in Oregon and Washington.**

E3 thanks the staff of the Northwest Power and Conservation Council for providing data and technical review

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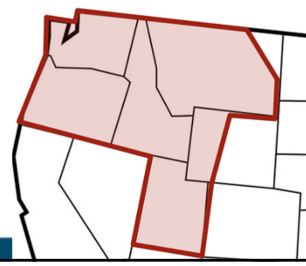
Study Region – The Greater NW

- **The study region consists of the U.S. portion of the Northwest Power Pool (excluding Nevada)**
- **It is assumed that any resource in any area can serve any need throughout the Greater NW region**
  - Study assumes no transmission constraints or transactional friction
  - Study assumes full benefits from regional load and resource diversity
  - The system as modeled is more efficient and seamless than the actual Greater NW system



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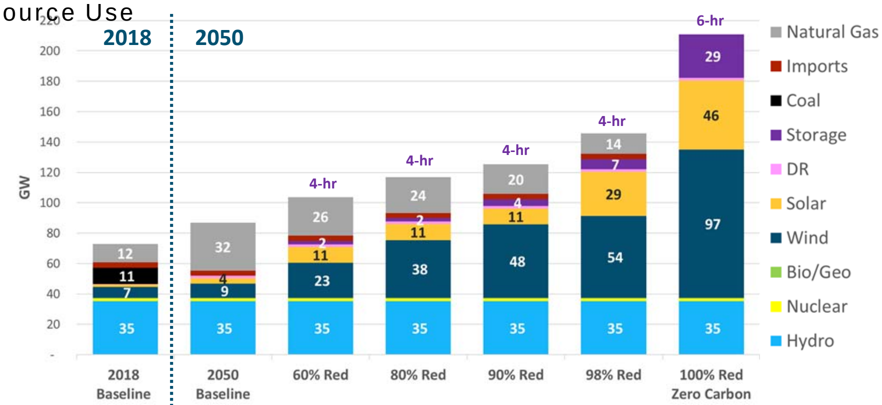
Scenario Summary

2050 Resource Use



	2050 Baseline	60% Red	80% Red	90% Red	98% Red	100% Red Zero Carbon
Renewable Capacity (GW)	13	34	49	59	83	143
Annual Renewable Curtailment (%)	Low	Low	4%	10%	21%	47%
Gas Capacity (GW)	32	26	24	20	14	0
Gas Capacity Factor (%)	46%	27%	16%	9%	3%	0%

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[1]CPS+ % = renewable/hydro/nuclear generation divided by retail electricity sales
[2]GHG-Free Generation % = renewable/hydro/nuclear generation, minus exports, divided by total wholesale load

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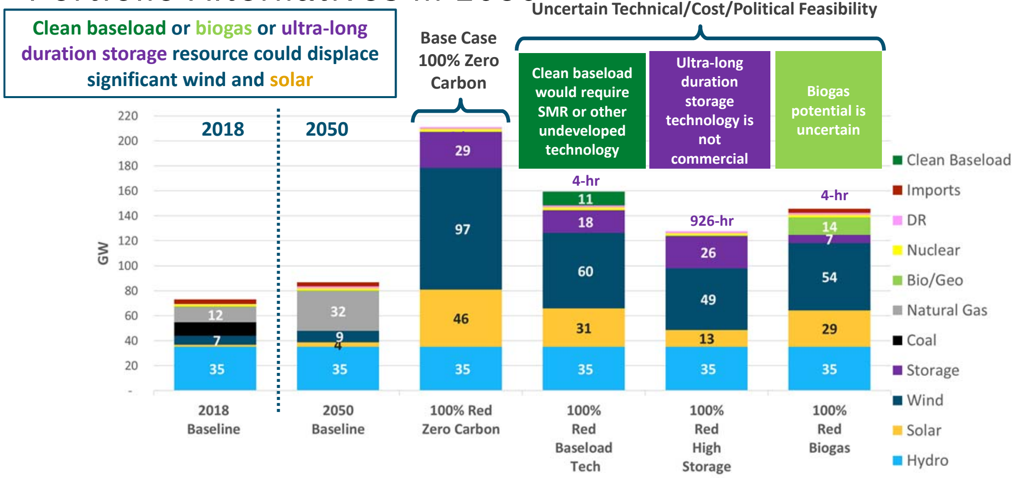
100% Reduction Portfolio Alternatives in 2050



	2018 Baseline	100% Red Zero Carbon	100% Red Baseload Tech	100% Red High Storage	100% Red Biogas
Carbon (MMT CO2)	50	0	0	0	0
Annual Cost Delta ($B)	Base	$16- $28	$14-$21	$550-$990	$4 - $9
Additional Cost ($/MWh)	Base	$52-$89	$46-$69	$1,800-$3,200	$14 - $30

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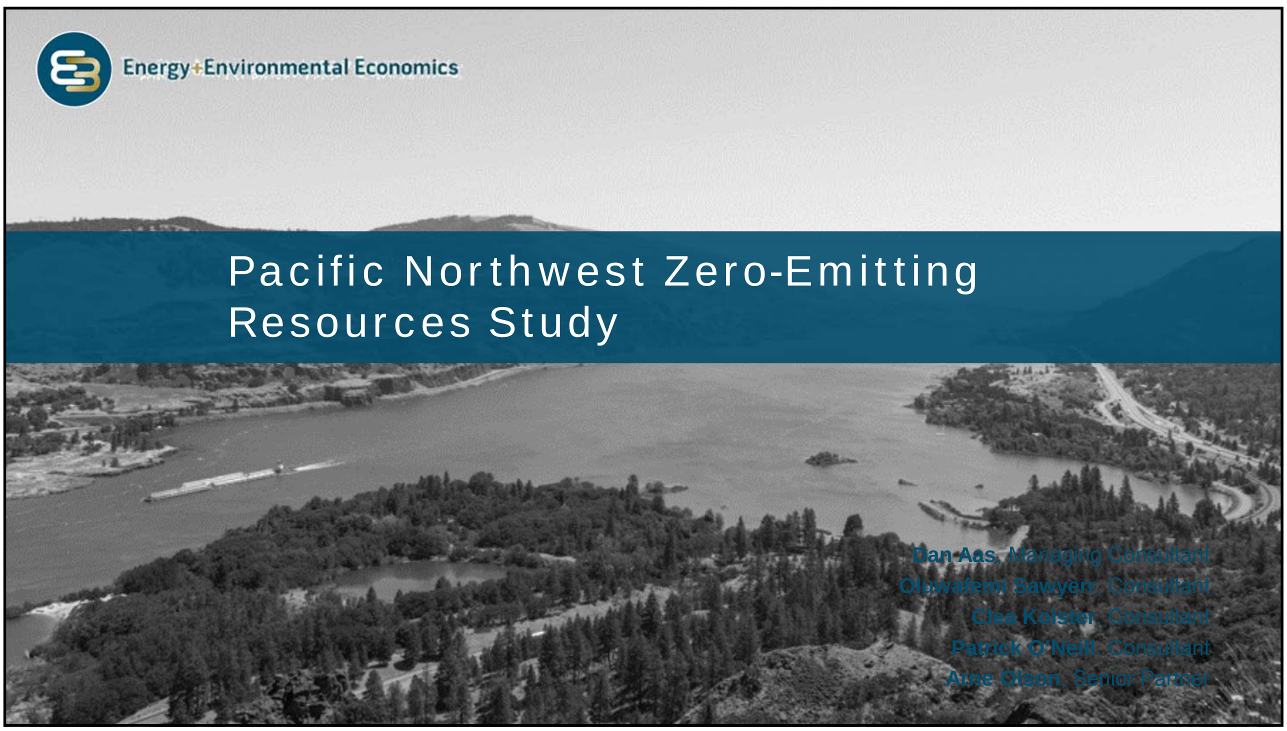
Pacific Northwest Zero-Emitting Resources Study



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Clea Kolster, Consultant
Patrick O'Neill, Consultant
Arne Olson, Senior Partner

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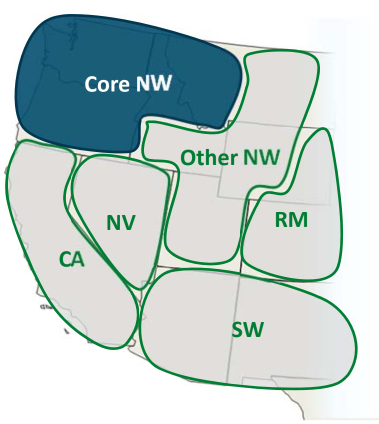
About This Study

+ **Energy Northwest retained E3 to investigate the role of zero-emitting resources in meeting future energy needs under new state-based carbon policies**
+ **The research focused on two key questions:**
  1. What are optimal electricity resource portfolios to achieve deep carbon emissions reductions in the Pacific Northwest?
  2. How does the availability of firm, zero-emitting generation affect the cost of achieving carbon goals while maintaining a reliable electric system?

Study Approach



+ **CETA is a key motivation for this study, but Washington operates in a regional electricity system**
+ **This study takes a regional view of electricity supplies, building on two key prior studies**
  - *Pacific Northwest Low Carbon Scenario Analysis*
  - *Resource Adequacy in the Pacific Northwest*
+ **The study uses E3's RESOLVE model to optimize the portfolio of resources serving loads in the "Core NW" region**

Zero-GHG resources considered in this study

Energy Limited or Variable Zero-Emitting Resources	"Firm" Zero-Emitting Resources
Hydro Flexible resource that can help balance wind and solar	**Columbia Generating Station (CGS)** Existing zero-GHG firm capacity
Wind Inexpensive energy, high quality resource, but variable	**Small Modular Reactors (SMRs)** Firm, dispatchable zero-GHG generation
Solar Inexpensive energy, high quality resource in the West, but variable	**Biomethane** Zero-GHG fuel for existing infrastructure, not yet widely commercial, competing uses
Storage Rapidly decreasing costs, but energy limited	**Carbon Capture and Sequestration** Low- to zero-GHG, not commercialized

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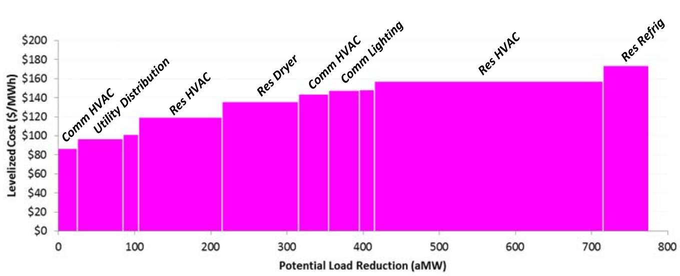
New Resource Options:
Incremental Energy Efficiency and Demand Response

Energy Efficiency

+ **Supply curve of incremental EE developed from measures not selected in the NWPCC Seventh Power Plan**
  - Resources bundled by cost and end use for selection in RESOLVE

Energy Efficiency Supply Curve ($/MWh)



Note: chart shows only EE measures that are treated as options in RESOLVE; all EE identified by NWPCC as cost-effective is included in the load forecast

Demand Response

+ **Cost & potential incorporated from Navigant's *Assessing Demand Response Program Potential for the Seventh Power Plan***
  1. **Agricultural interruptible tariff: 657 MW** available by 2050 at a cost of **$19/kW-yr.**
  2. **Residential space & water heating direct load control (DLC): 902 MW** available by 2050 at a cost of **$59/kW-yr.**

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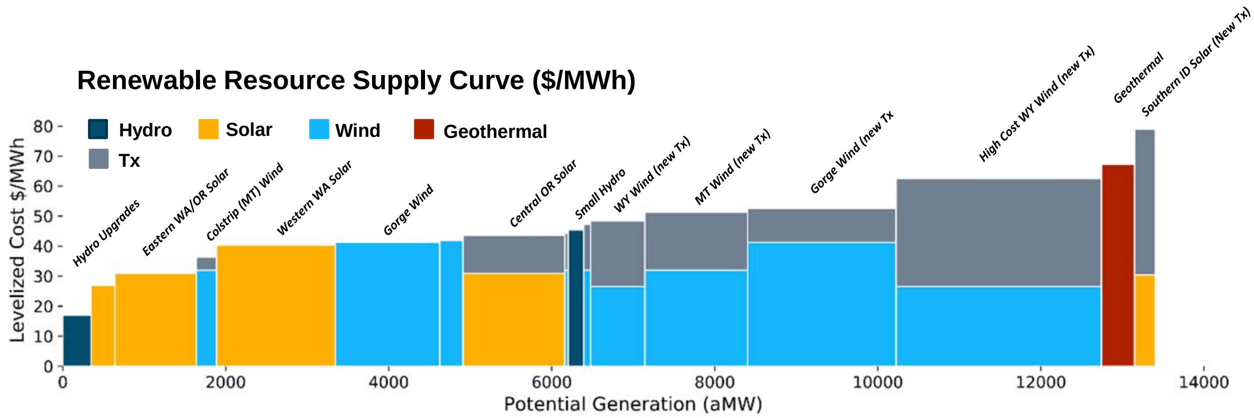
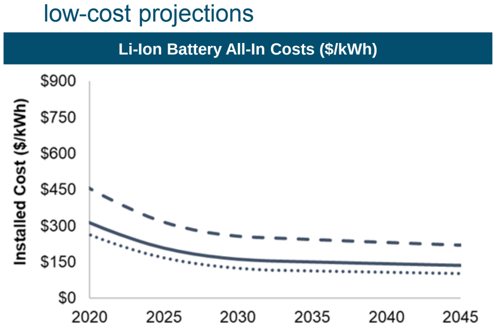
New Resource Options
Renewables

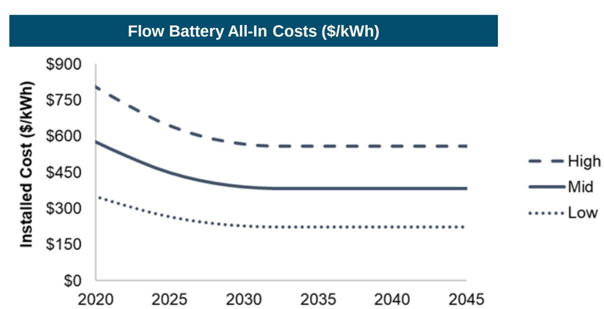
+ **Renewables available to the region are based on a supply curve that captures regional and technology diversity options for development**
+ **Transmission adders reflect the need to ensure that new renewables built in the Northwest are deliverable to loads; scenarios with more renewables require more transmission investment.**



New Resource Options
Energy Storage

+ **Pumped hydro storage: up to 5,000 MW assumed to be available at a cost of $2,450/kW based on a survey of existing literature**
  - Pumped hydro is assumed to have an ELCC of 0.5
+ **Battery storage: unlimited quantities of lithium-ion and flow batteries assumed to be available**
  - Cost assumptions (current & future) derived from Lazard Levelized Cost of Storage v4.0 high, mid and low-cost projections

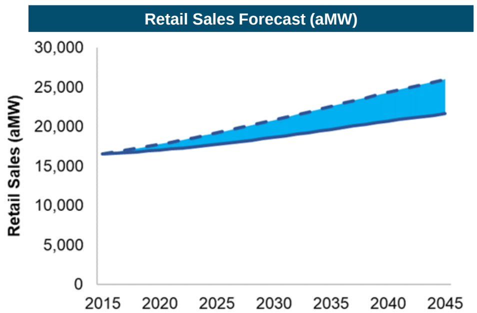


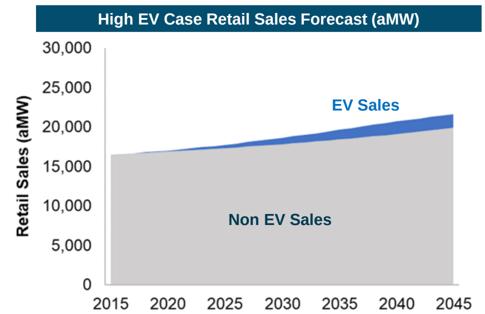


Capital costs shown for 4-hr storage devices; RESOLVE can select optimal duration for energy storage resources

Load Forecast and Transport Electrification

+ **All scenarios capture recent policies and trends:**
  - **Achievement of cost-effective energy efficiency** as identified in NWPCC 7th Power Plan
  - **Regional coal retirement plans:** WA retirements by 2025 and OR retirements by 2030 including announced Boardman (2020), Colstrip 1 & 2 (2022), Centralia (2020/'24); WA CETA and OR Coal to Clean retirements
  - **Large-scale electrification of light-duty transportation:** Passenger vehicles and truck electrification levels based on adoption scenarios in *Pacific Northwest Pathways to 2050*
+ **The pre-electrification CAGR is 0.7%, the post electrification CAGR is 0.95%**

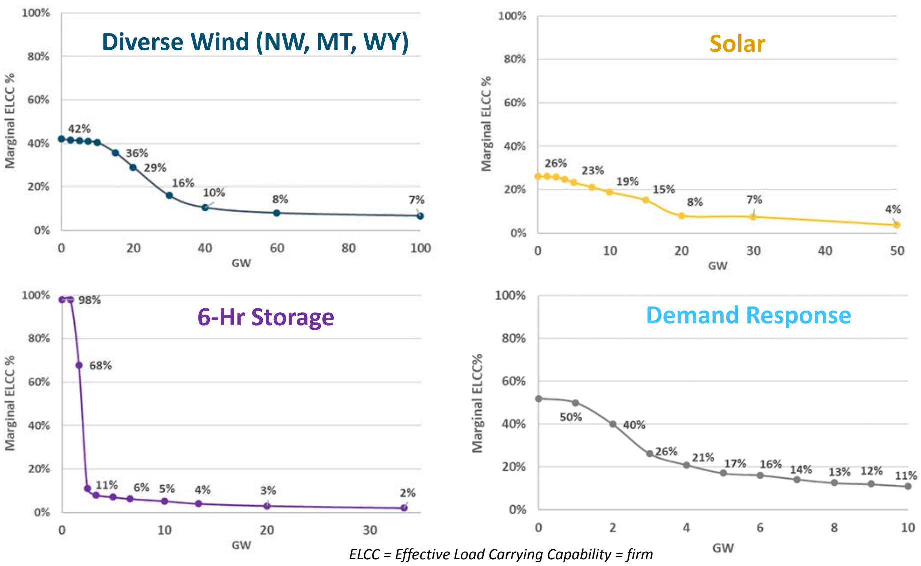




Resource Options
Cost and Operations

Resource Type	2045 Capital Cost (2018 $/kW)	2045 Fixed O&M Cost (2018 $/kW-yr)	Operations
Utility-Scale Solar PV (Single-axis tracking)	$ 980	$ 12	No fuel cost
Onshore Wind (TRG6 - ~36% CF)	$ 1,080	$ 35	No fuel cost
CGS Relicensing	$ 406	$ 162	"Must run" with scheduled maintenance outages
NREL ATB Nuclear Small Modular Reactors (SMR)	$ 5,650	$ 99	Uranium fuel; Heat rate of 10,000 Btu/kWh
NuScale "Nth of a Kind" SMR	$ 4,900	Similar to NREL	Uranium fuel; Heat rate of 9,000 Btu/kWh
Gas Combustion Turbine (Frame)	$ 850	$ 12	NG fuel; Heat rate 12,000 Btu/kWh
CCGT with Carbon Capture and Storage (Post-Combustion 90-100% Capture)	$ 1,700	$ 33	NG fuel; Heat rate 8,000 Btu/kWh
4-hour Li-Ion Battery	$ 590	$2	Round trip efficiency of 92%
Biogas (a drop-in fuel to gas units)	N/A	Equivalent to Gas CT	Very high fuel cost ~32$/MMBTU

This study incorporates new information on the capacity contribution of renewables, storage and DR



ELCC = Effective Load Carrying Capability = firm contribution to system peak load

+ A reliable electric system requires enough capacity to meet peak loads and contingencies
+ This study incorporates information from E3's 2019 report *Resource Adequacy in the Northwest* about the effective capacity contribution of renewables, storage and DR at various penetration levels

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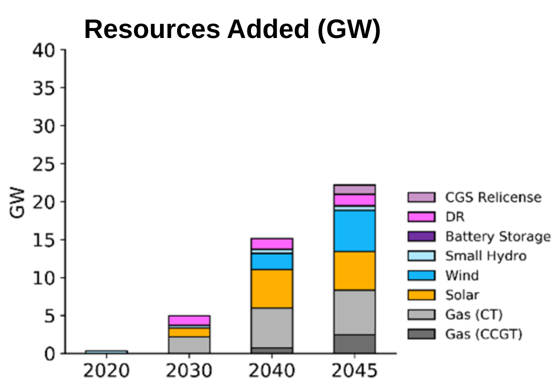
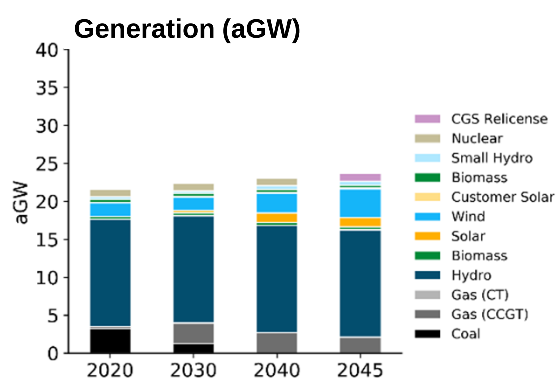
Reference Scenario

+ Coal retires post 2025 (CETA) and 2035 (Coal to Clean). Natural gas is built to replace that firm capacity
+ Most capacity selected is zero-emitting, including the relicensing of Columbia Generating Station
+ In 2045, zero-emitting electricity generation is 105% of retail loads in the Northwest





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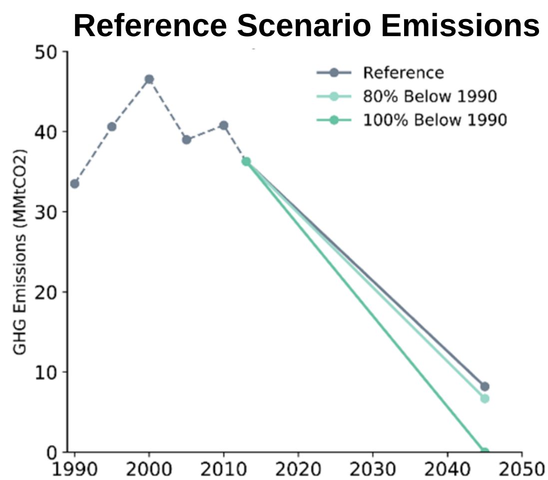
The Reference Scenario also achieves deep emissions reductions



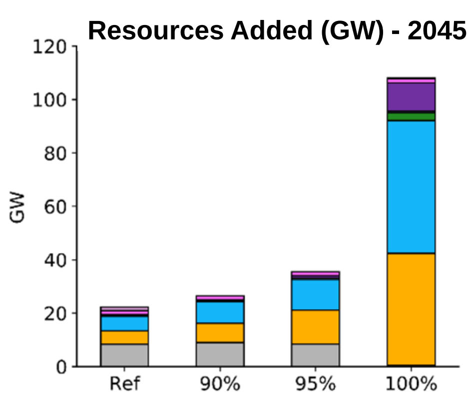
- The largest source of emissions reductions in the Reference scenario are coal retirements that are stipulated in WA and OR law
- In 2045, emissions are 76% below 1990 levels in the Core NW region or 8.0 MtCO2/year.
- The only remaining source of GHG emissions in the Reference scenario after 2035 are from natural gas generators

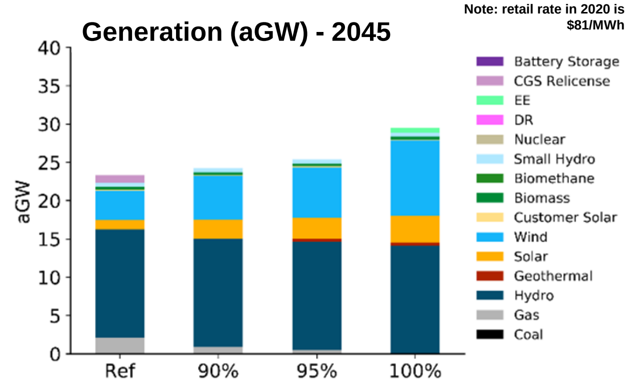
Renewables + Gas

- The pairing of renewables and gas can achieve deep emissions reductions at manageable costs
- Costs increase markedly when fossil gas is not available to provide firm capacity

	90%	95%	100%
Incr. Cost	+$200M	+500M	+$8,600M
Retail Rate ($/MWh)	$94	$94	$138
Zero-GHG %	107%	116%	123%

Note: retail rate in 2020 is $81/MWh



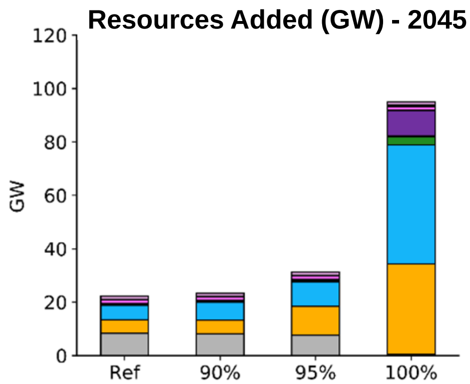


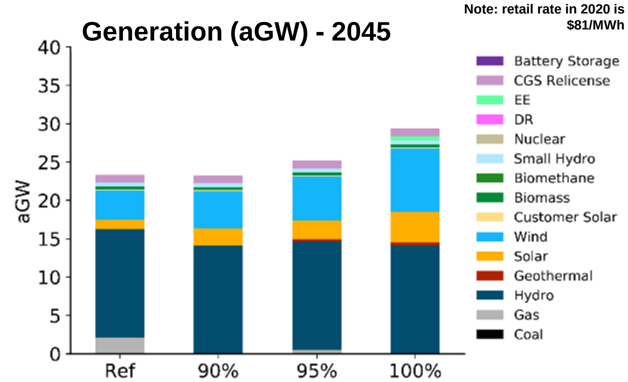
Renewables + CGS

- Relicensing CGS decreases the cost of electric sector decarbonization in the NW by between $120M and $1,350M per year in 2045
- A case with no additional firm capacity is still prohibitively expensive

	90%	95%	100%
Incr. Cost	+80M	+300M	+7,250M
Retail Rate ($/MWh)	$94	$94	$131
Zero-GHG %	105%	115%	122%

Note: retail rate in 2020 is $81/MWh





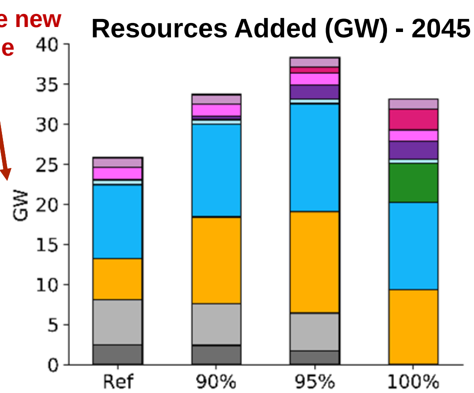
Zero-Emitting Firm, NREL SMR Costs

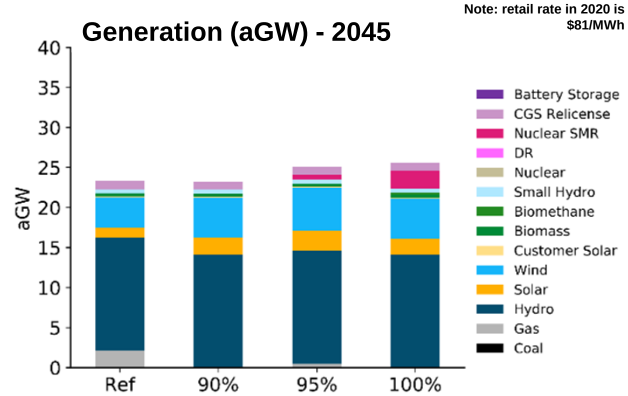
- Adding zero-emitting firm capacity reduces the cost of achieving 100% GHG reductions by $6,700M per year
- At NREL costs, zero-emitting resources include both biomethane and SMRs

	90%	95%	100%
Incr. Cost	+80M	+275M	+520M
Retail Rate ($/MWh)	$94	$94	$98
Zero-GHG %	115%	122%	127%

Note: retail rate in 2020 is $81/MWh

Note new scale



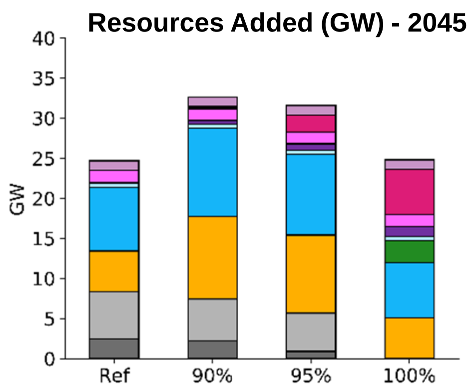


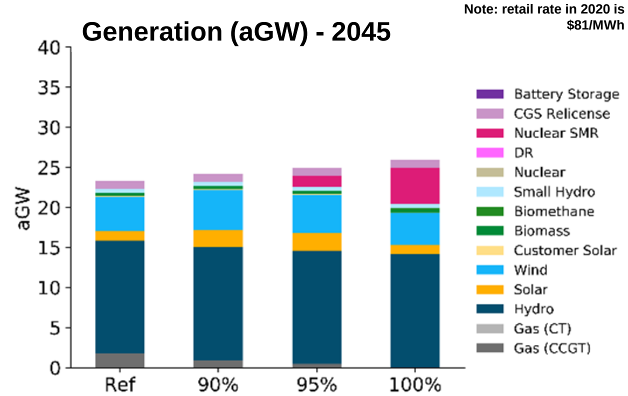
Zero-Emitting Firm, NuScale SMR Costs

- If Nuclear SMRs are available at costs provided by NuScale, additional new nuclear is built in the 95% and 100% GHG reduction cases
- The impact of lower cost SMRs is most start in the 100% GHG reduction case

	90%	95%	100%
Incr. Cost	+80M	+210M	+410M
Retail Rate ($/MWh)	$94	$94	$96
Zero-GHG %	115%	122%	129%

Note: retail rate in 2020 is $81/MWh



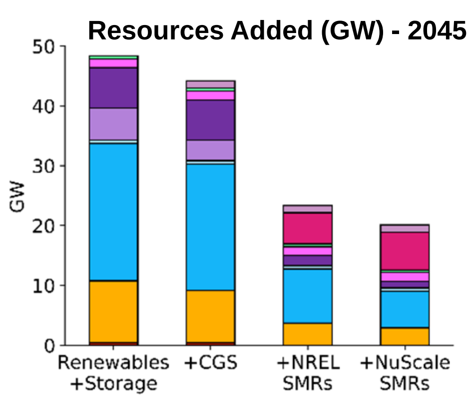


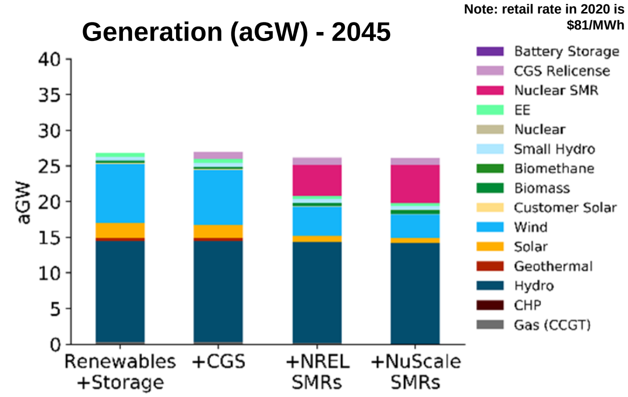
No New Gas Sensitivity (90% GHG reduction)

- No new gas leads to substantially higher costs and markedly different portfolios in all but the NuScale cost case
- These results are broadly similar across the 80%, 90% and 95% GHG reduction scenarios

	RE + Storage	+CGS	+NREL	+NuScale
Incr. Cost	+$4700M	+$3600M	+$1050M	+$690M
Retail Rate ($/MWh)	$118	$112	$97	$95
Zero-GHG %	128%	128%	127%	127%

Note: retail rate in 2020 is $81/MWh



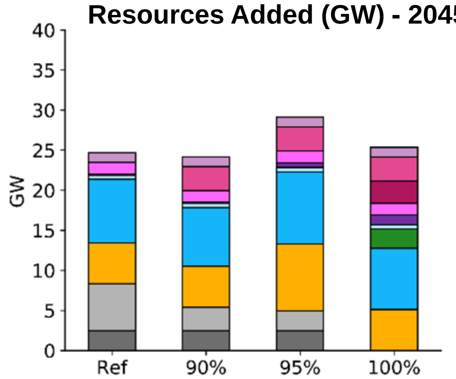


5. Nuclear Production Tax Credit, NuScale Costs

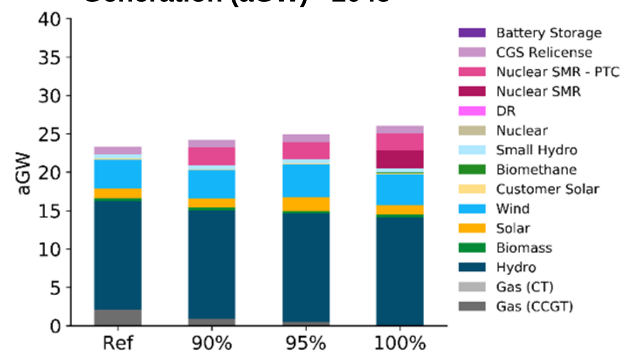
- **A nuclear production tax credit leads to Nuclear SMR generation being built in less emissions constrained scenarios**
- **In the 90% reduction case, scenario costs are slightly negative relative to Reference**

	90%	95%	100%
Incr. Cost	-47M	+11M	+247M
Retail Rate ($/MWh)	$93	$93	$95
Zero-GHG %	116%	121%	129%

Resources Added (GW) - 2045



Generation (aGW) - 2045



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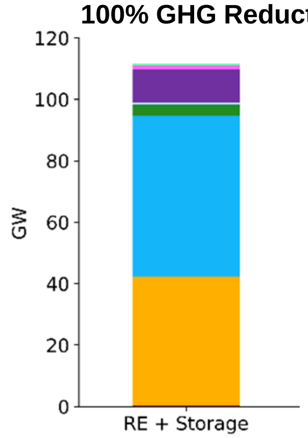
Benefits of zero-emitting firm capacity at 100% GHG reductions – (1 of 4)

100% GHG Reduction Portfolios



Key Resource Additions

10.5 GW Storage

52 GW Wind

42 GW Solar

A system that largely relies on wind, water, solar and battery storage (RE + Storage) requires over 100 GW of new capacity additions in 2045 to maintain reliability

This system costs more than $8B per year over the Reference Scenario

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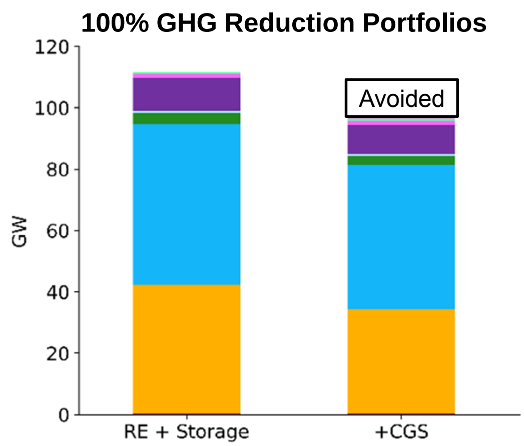
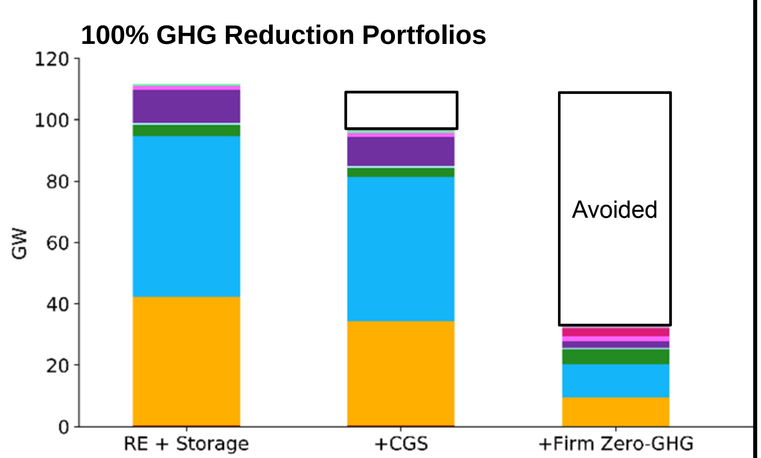
Benefits of zero-emitting firm capacity at 100% GHG reductions – (2 of 4)



Adding	Avoids
+1.2 GW CGS	-1.2 GW Storage
	-5.2 GW Wind
	-8 GW Solar
+1.2 GW Firm	-14.4 GW Non-firm

Relicensing CGS reduces the total cost of the NW electricity system by $1.4 billion per year in 2045

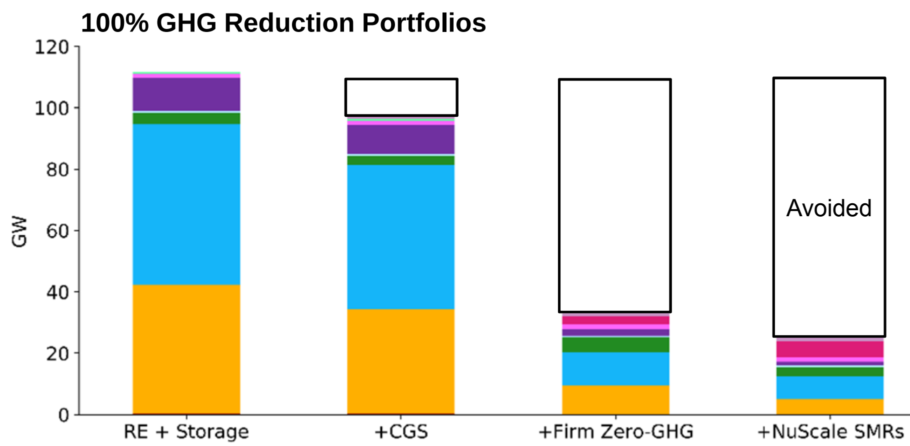
Benefits of zero-emitting firm capacity at 100% GHG reductions – (3 of 4)



Adding	Avoids
+1.2 GW CGS	-8.5 GW Storage
+2 GW Biomethane	-41 GW Wind
+2.6 GW SMRs	-32 GW Solar
+5.8 GW Firm	-81.5 GW Non-firm

CGS + additional firm, zero-GHG generation reduces electric system costs by almost $8 billion per year relative to RE+Storage

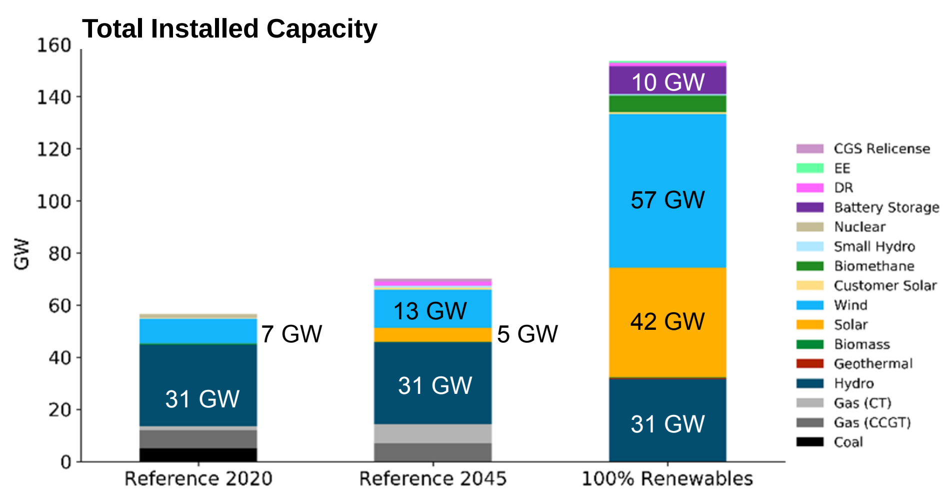
Benefits of zero-emitting firm capacity at 100% GHG reductions – (4 of 4)



Adding	Avoids
+1.2 GW CGS	-9.5 GW Storage
+5.3 GW SMRs	-44.8 GW Wind
	-37 GW Solar
+6.5 GW Firm	-91 GW Non-firm

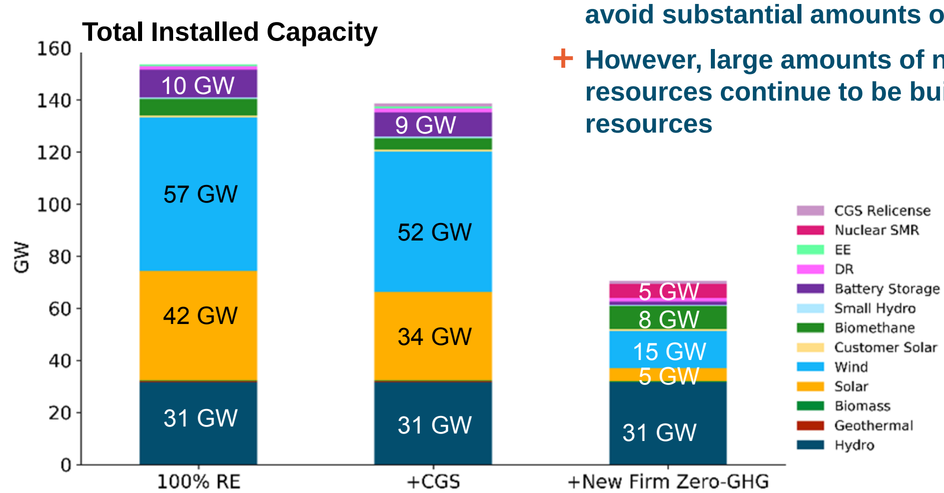
CGS + NuScale SMRs reduce system costs by almost $8B per year relative to RE + Storage

Total Installed Capacity: Reference vs 100% Renewables



Total installed capacity, 100% GHG Reduction Scenarios

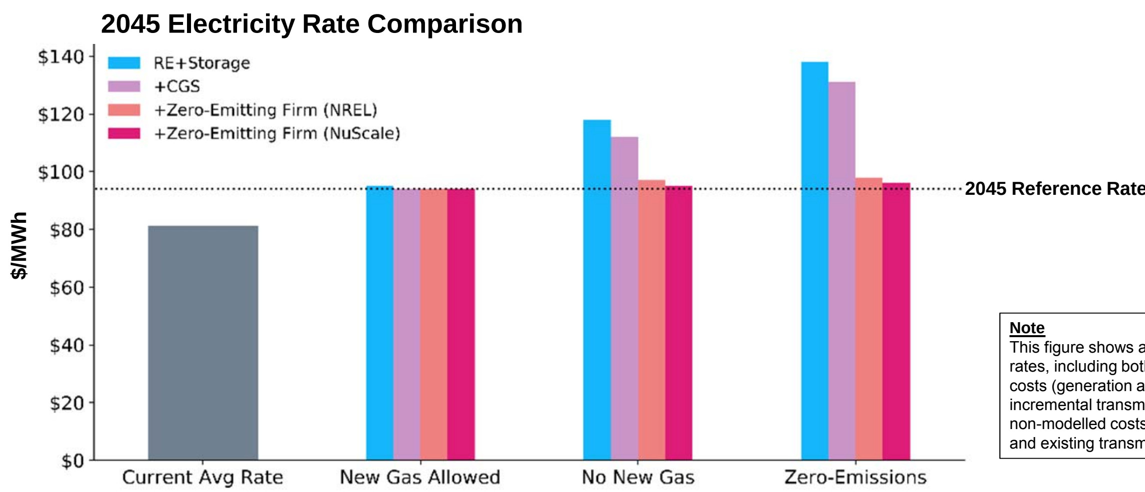
- Firm resources like nuclear SMR and biomethane avoid substantial amounts of renewable overbuild
- However, large amounts of new wind and solar resources continue to be built alongside firm resources



NW wind and solar capacities in 100% case with SMRs

Year	Wind	Solar
2020	9 GW	0.03 GW
2045	15 GW	5 GW

Zero-emitting firm resources reduce electricity rates, particularly in scenarios with gas resource limitations

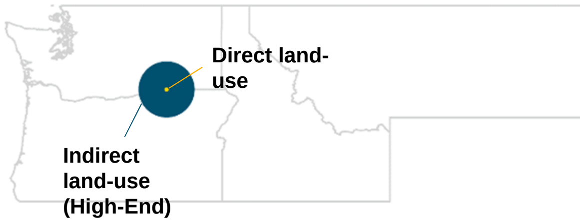


Note
This figure shows all-in retail rates, including both modelled costs (generation and incremental transmission) and non-modelled costs (distribution and existing transmission)

Achieving zero-GHG emissions with renewables alone requires a large amount of land

Estimate of land use from renewables

Note: figure is to scale, but does not denote specific locations where renewables are built



+ **Land-use impacts are split into two categories:**
  - Direct: land that cannot be used for other purposes
    - 8000 acres/GW solar, 2000 acres/GW wind
  - Indirect: land that can be used for activities like ranching or agriculture
    - Up to 140,000 acres/GW wind

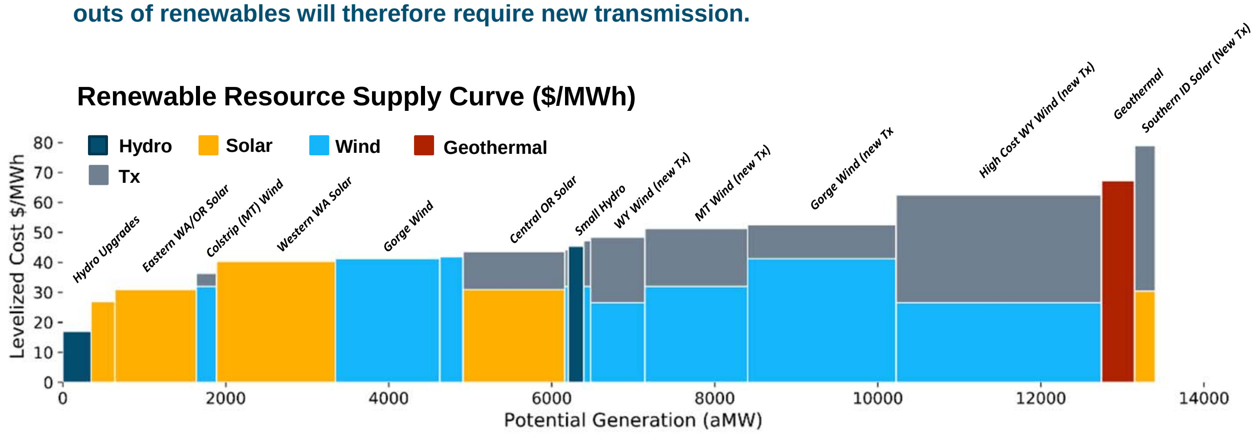
Direct land-use of wind and solar built to serve the Northwest are up to 2.5 times the area of Portland and Seattle

Indirect land-use of wind and solar are as high as 10 to 50 times the area of Portland and Seattle

Transmission implications

+ **New renewable generation tends to be located in regions of the Northwest and West that are distant from loads**
+ **While, some renewable resources can potentially repurpose transmission paths used by retiring thermal generators, the capacities of those existing paths are finite. Scenarios with large build outs of renewables will therefore require new transmission.**

Renewable Resource Supply Curve ($/MWh)



Transmission Requirements by Scenario

- The transmission requirements of each scenario depend on the amount renewables built
- In the highest case, the RE + Storage scenario, 93 GW of capacity requires new transmission to be deliverable to loads
- The lowest transmission build requirements are in the NuScale cases

New Transmission Requirements at 100% GHG Reductions

Scenario	Case	Capacity Requiring New Transmission
New Gas Allowed	NREL ATB	12 GW
	NuScale	8 GW
No New Gas	NREL ATB	15 GW
	NuScale	5 GW
Zero-GHG	RE + Storage	93 GW
	NREL ATB	18 GW
	NuScale	5 GW

- This study does not include a complete accounting of incremental transmission requirements of connecting zero-emitting firm resources. The transmission needs of these resources will depend on the degree to which they can be built at existing sites or near to existing paths.

Qualitative Non-Modelled Impacts of Resource Groups

	Variable Renewables and Batteries	Nuclear Technology Resources	Fossil-Based, Low-Carbon Resources
Land Use Requirement	High Low energy density of solar and wind require large surface coverage.	Low SMRs can be sited at existing nuclear generation sites or on limited land area as a result of high energy density of SMR units.	Mid Fossil fuel extraction, carbon sequestration and biomethane growth (assumed from waste crops and residues).
Waste Impact	Mid Variety of materials required for PV, wind turbine build, and Li-ion batteries; significant waste challenges for failed PV and end-of-life Li-ion batteries and wind turbines.	Mid Used nuclear fuel storage technology well-developed and highly regulated and can be safely stored on site in cast iron tanks for 100+ years; heavy materials required for new units.	High GHGs and non-GHG pollutants resulting from combustion.
Resiliency	Good Renewables diffuse the impact of a single outage due to modular units.	Good Low volatility of uranium price, fuel on-site, SMRs further limit the impact of a single unit outage; nuclear plants designed to withstand severe weather events.	Average Subject to volatility of natural gas price and availability of resource via Northern pipeline.
Equipment lifetime	Wind turbines - 25-30 yrs; Solar PV panels - 25-30 yrs w/ inverter replacement every 15 years; Li-ion batteries - 10-15 yrs, function of number of total cycles.	SMRs are licensed for 40 years and likely renewable to 60 years and perhaps beyond.	Gas generating plants are typically designed to last 35-40 yrs but can be recommissioned to last 60 + years.
State & Federal Incentives	ITC (end 2021) & PTC (end 2022)	Federal PTC and incentives for nuclear technology development	45Q tax credit for carbon sequestration

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Nuclear – A Carbon Free Energy Source

- **Columbia Generating Station**
  - **Extended Power Uprate (EPU)**
    - **Increase output by ~150MW**
  - **Subsequent License Renewal (SLR)**
    - **Extend operation from 2043 to 2063**
- **Small Modular Reactors at WNP-1 Site**
  - **Continue stakeholder engagement**

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A bold, new energy source

- **Smarter energy** – flexible design can support multiple applications, integrate with renewable resources, provide highly reliable power to mission critical facilities, and serve as clean baseload power.
- **Cleaner Energy** – 100% carbon-free energy – as clean as wind or solar – with a small land footprint.
- **Safer Energy** – should it become necessary, NuScale's SMR shuts itself down and self-cools for an indefinite period of time, with no operator action required, no additional water, and no AC or DC power needed.
- **Cost Competitive** – the NuScale SMR is far less complex than other designs. Off-site fabrication and assembly reduce cost. Components are delivered to the site in ready-to-install form. All of this results in construction occurring in a shorter, more predicable period of time.

NuScale Nonproprietary

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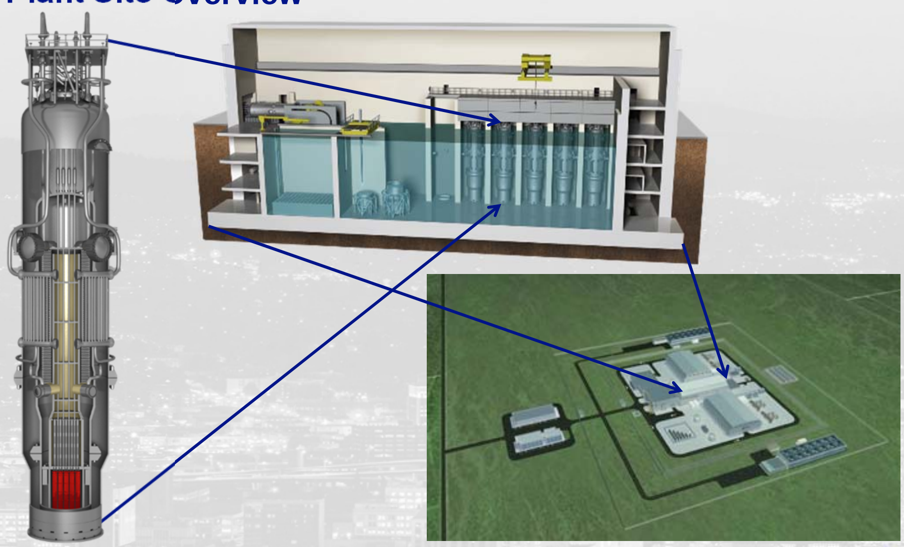
NuScale Plant Site Overview



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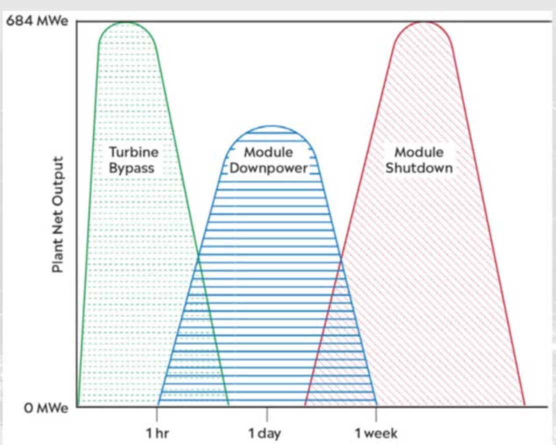
Integrating Renewables: Load Follow Strategies



Method	Up Power	Down Power
Turbine Bypass	20% to 100% (27 min) 3%/min	100% to 20% (8 min) 10%/min
Reactor Power Change	20% to 100% (96 min) 50%/hr	100% to 20% (≤ 24 min) 200%/hr
Module Dispatch	HSD to 100% (13 hrs) Refueling	100% to HSD (30 min) 200%/hr

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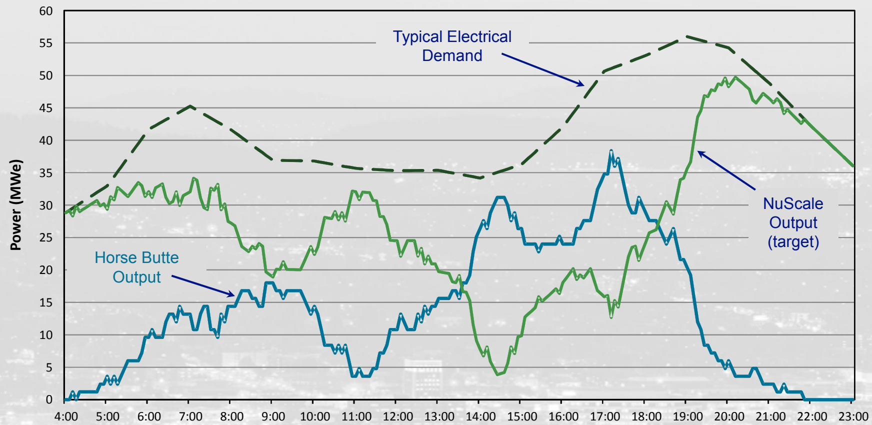
Load-Following with Wind



NuScale design meets or exceeds EPRI Utility Requirements Document (URD), Rev. 13, load following and other ancillary service requirements.

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Technology Validation

- **NuScale Integral System Test (NIST-1)** facility located at Oregon State University in Corvallis, Oregon
- **Critical Heat Flux** testing at Stern Laboratories in Hamilton, Ontario Canada
- **Helical Coil Steam Generator** testing at SIET SpA in Piacenza, Italy
- **Fuels testing** at AREVA's Richland Test Facility (RTF) in Richland, Washington
- **Critical Heat Flux** testing at AREVA's KATHY loop in Karlstein, Germany
- **Control Rod Assembly (CRA)** drop / shaft alignment testing at AREVA's KOPRA facility in Erlangen, Germany
- **Steam Generator** Flow Induced Vibration (FIV) testing at AREVA's PETER Loop in Erlangen, Germany
- **Control Rod Assembly Guide Tube (CRAGT)** FIV at AREVA's MAGALY facility in Le Creusot, France

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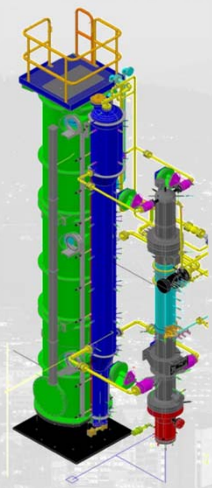
NIST-1 Integral Systems Test



- Integral Systems Test to obtain large-scale real-time integral effects data for code validation
- One-third scale, full pressure and temperature
- Includes integral reactor vessel and internals, containment vessel, reactor pool and safety systems
- Major $2M facility upgrade in 2015
- DCA testing completed:
  - o Loss of coolant accident (LOCA)
  - o Flow stability
  - o Non-LOCA
  - o Long-term cooling
- DCA supplementary testing ongoing
- Test inspected & audited by NRC

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Upper Module Mock-up

- Full-scale mockup of upper portion of module to validate maintenance and inspection capabilities
- Helps guide design finalization in upper head region
- Fabricated at Oregon Iron Works (now Vigor) in Vancouver, WA and currently located in Corvallis, OR.

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Blazing the Trail to Commercialization

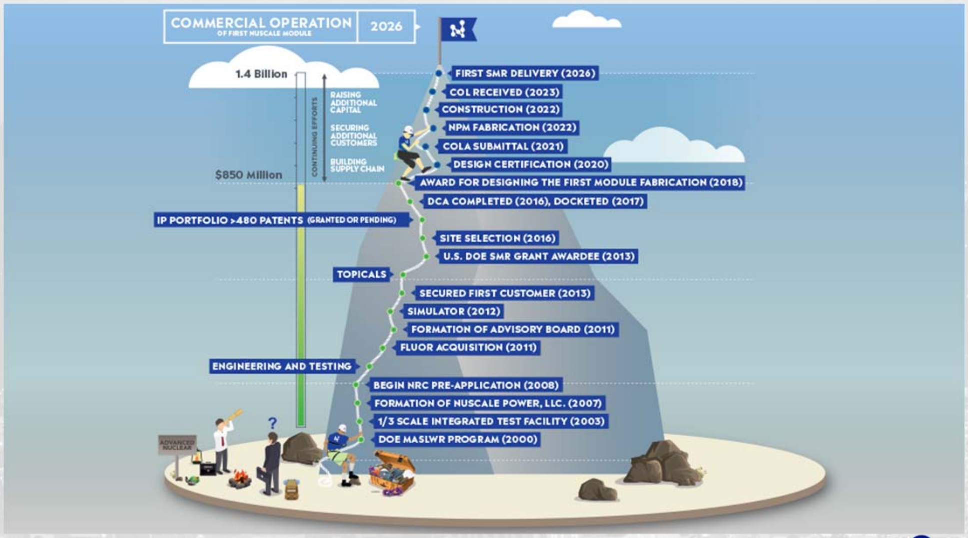

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Image courtesy of Third Way Nuclear Reimagined

Right-sizing the Emergency Planning Zone (EPZ)

- NuScale's small core size and exceptional safety, defense-in-depth make the case for a **reduced EPZ to the site boundary**.
  - NuScale plants could be sited closer to population and industrial centers – where energy is needed most
- **Tennessee Valley Authority (TVA) demonstrating that site boundary EPZ possible for SMRs**
  - TVA analysis included information on Clinch River early site permit application using NuScale Plant design
  - Shows any accident radiological impact would be limited to within site boundary
  - Analysis provides basis for exemption from 10-mile EPZ
  - NRC preliminary findings agree with TVA analysis that reduced-size EPZs for SMRs are feasible

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2021 Power Plan Recommendations

- **Modeling needs to acknowledge and incorporate established and projected carbon constraints**
- **Carbon constrained modeling needs to include an accurate reference plant for small modular reactors**
- **Modeling should incorporate potentials for additional/extended generation from Columbia Generating Station**
  - **Extended Power Uprate (EPU) increases output by ~150MW**
  - **Subsequent License Renewal (SLR) extends operation to 2063**

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