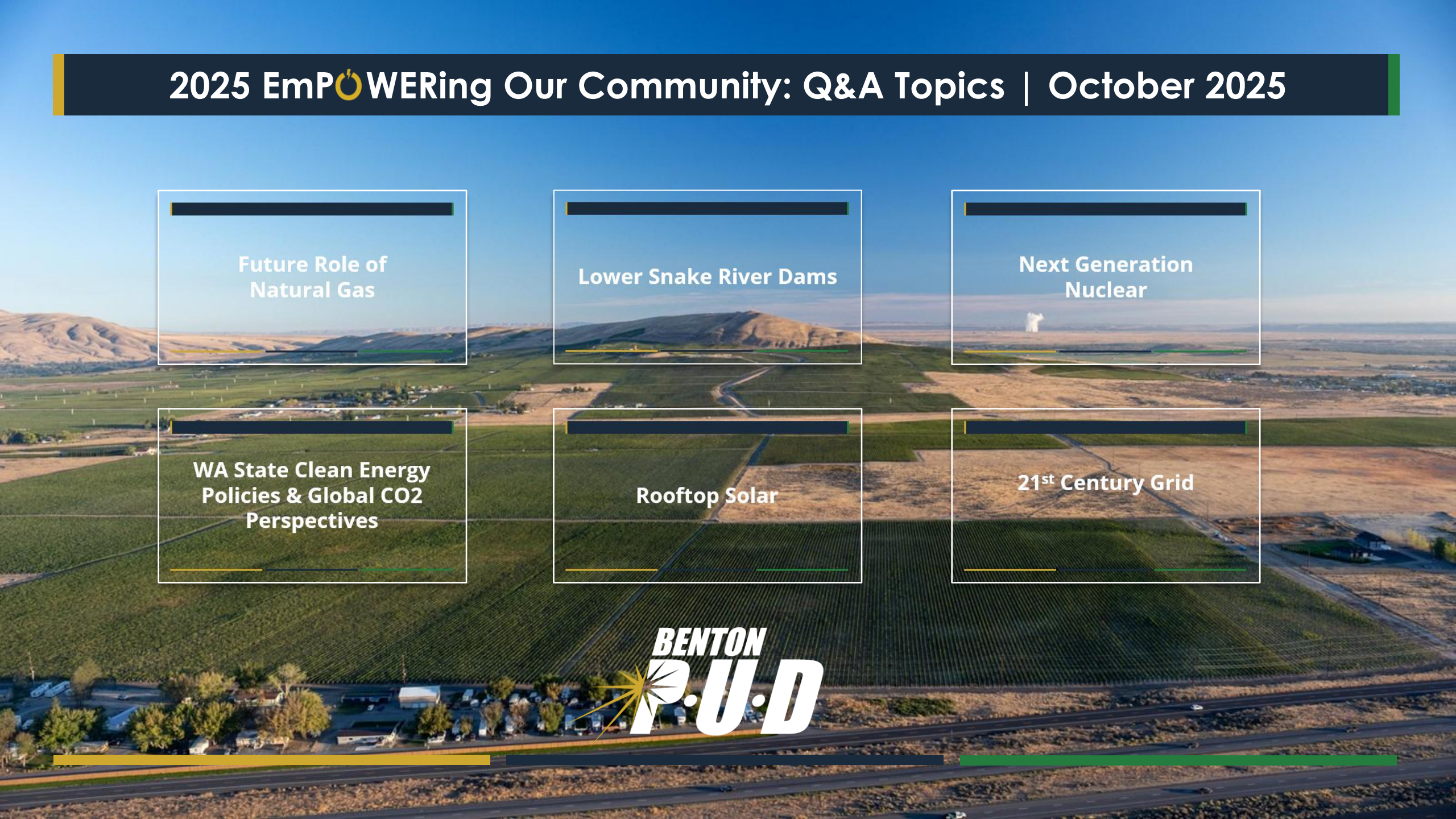
2025 EmPOWERing Our Community: Q&A Topics | October 2025



Thank you

BENTON P·U·D

Future Role of Natural Gas

Future Role of Natural Gas

Natural Gas in the Northwest

2024

Pacific Northwest Gas Market Outlook

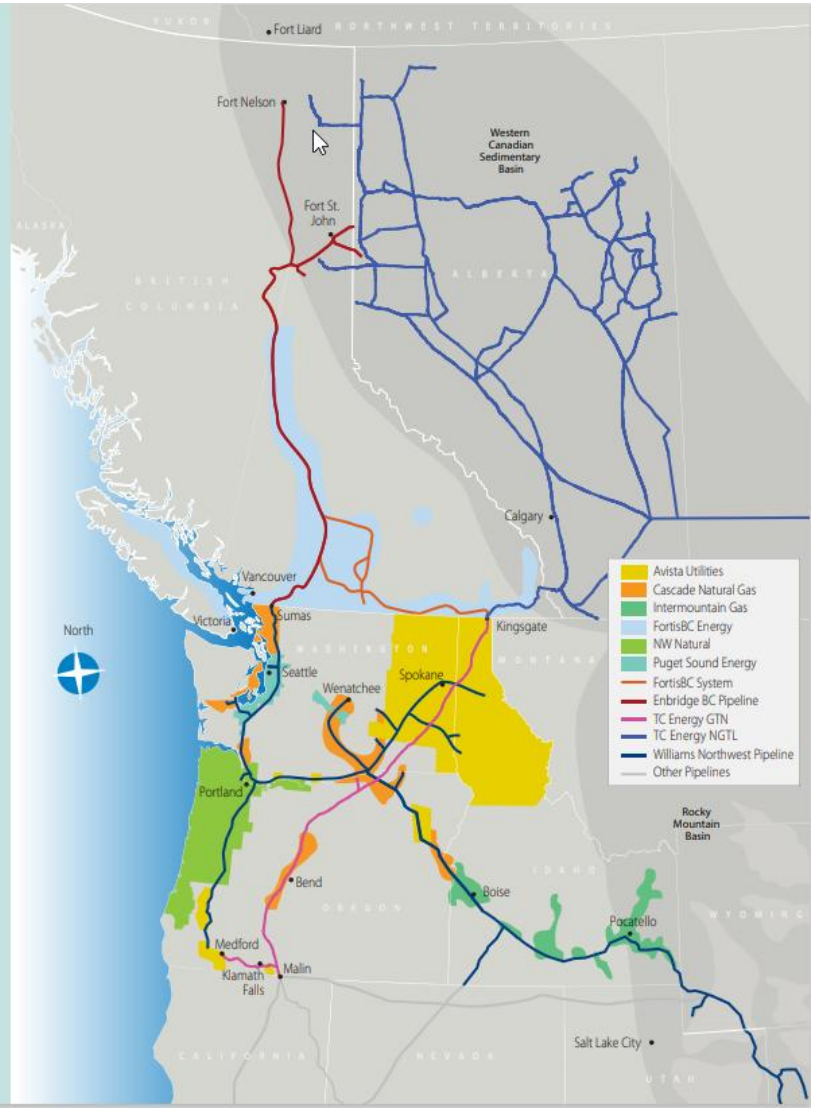
Natural Gas Supply, Prices, Demand and Infrastructure Projections through October 2033

This report, compiled by the Northwest Gas Association (NWGA), provides a consensus industry perspective on the current and projected natural gas supply, prices, demand and delivery capabilities in the Pacific Northwest through the 2032/33 heating year (Nov-Oct).

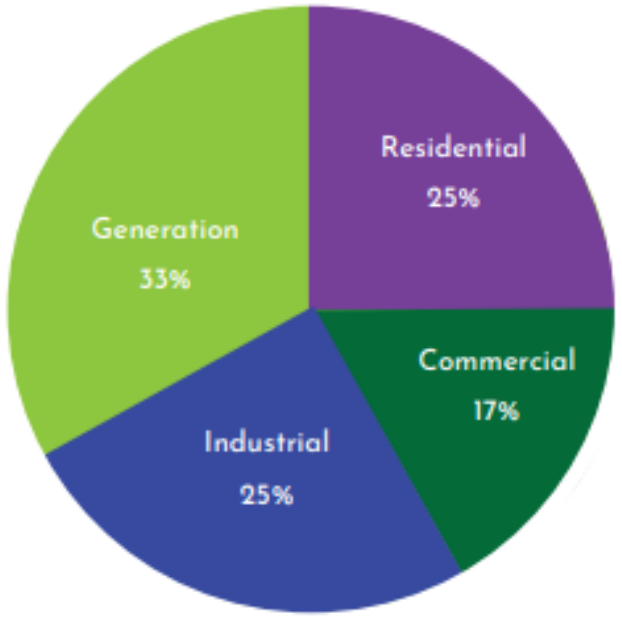
For purposes of this report, the Pacific Northwest includes British Columbia (BC), Idaho, Oregon and Washington.

Additional information can be found at www.nwga.org.

NWGA Northwest Gas Association



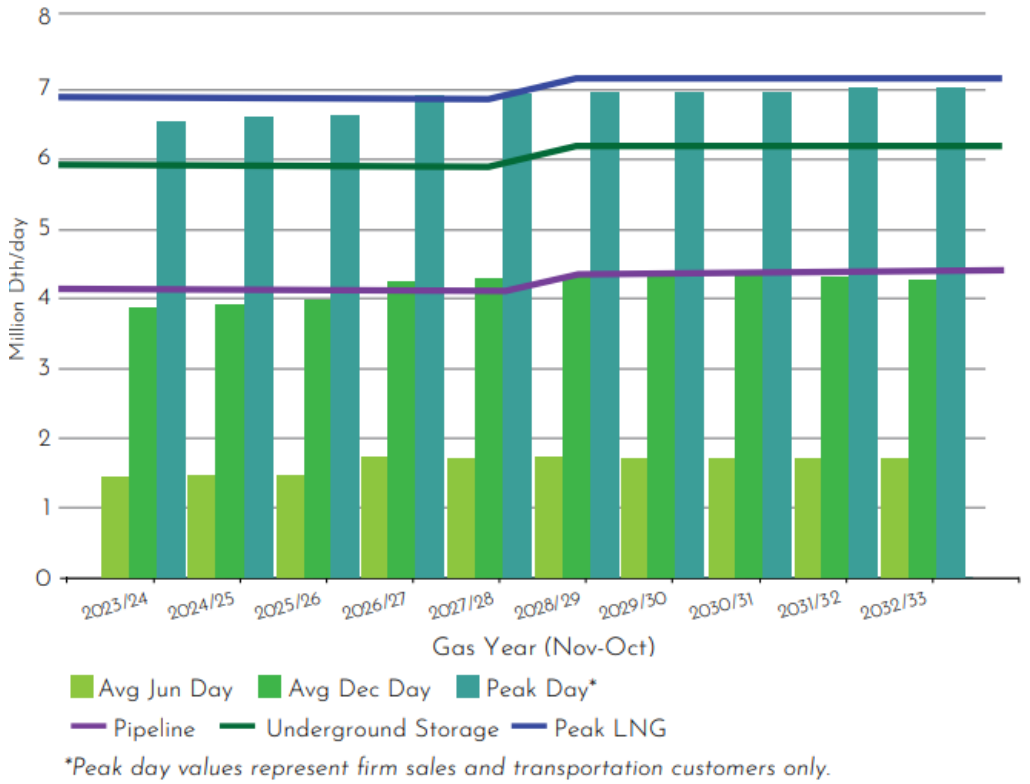
How Natural Gas is Used in the Pacific Northwest



More than half of the total energy consumed in the region — either used directly for space and water heat or in industrial processes, or as gas-generated electricity. (Excludes transportation uses.)

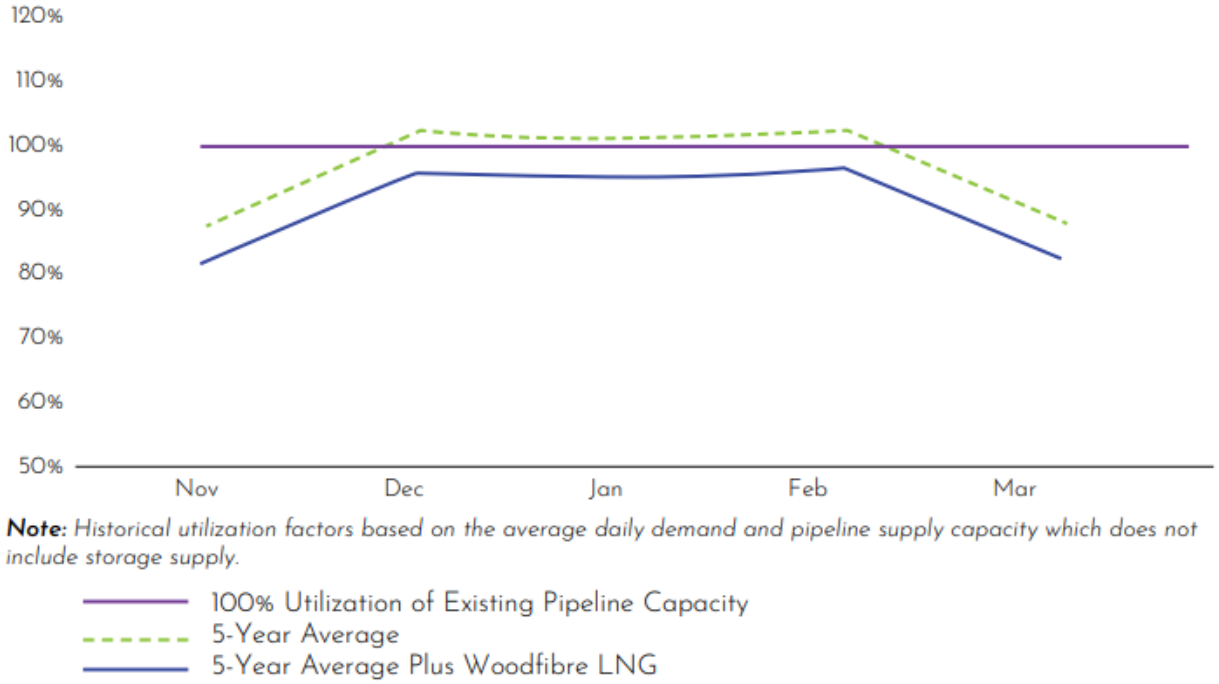
Natural Gas in the Northwest – Pipeline Capacity Maxed Out

FIGURE 11. Peak and Average Day Supply/Demand Balance



*Peak day values represent firm sales and transportation customers only.

FIGURE 12. Regional Pipeline Capacity Utilization



Note: *Historical utilization factors based on the average daily demand and pipeline supply capacity which does not include storage supply.*

"… the region's delivery system has very little excess capacity to serve peak loads, which can be challenging during an extended, region-wide, cold weather event…"

"The region's existing storage assets would not be able to make up the 90-day capacity deficiency if the region experiences a cold winter."

Natural Gas in the Northwest – Today & Future Forecast

FIGURE 6. Historic Regional Demand by Sector

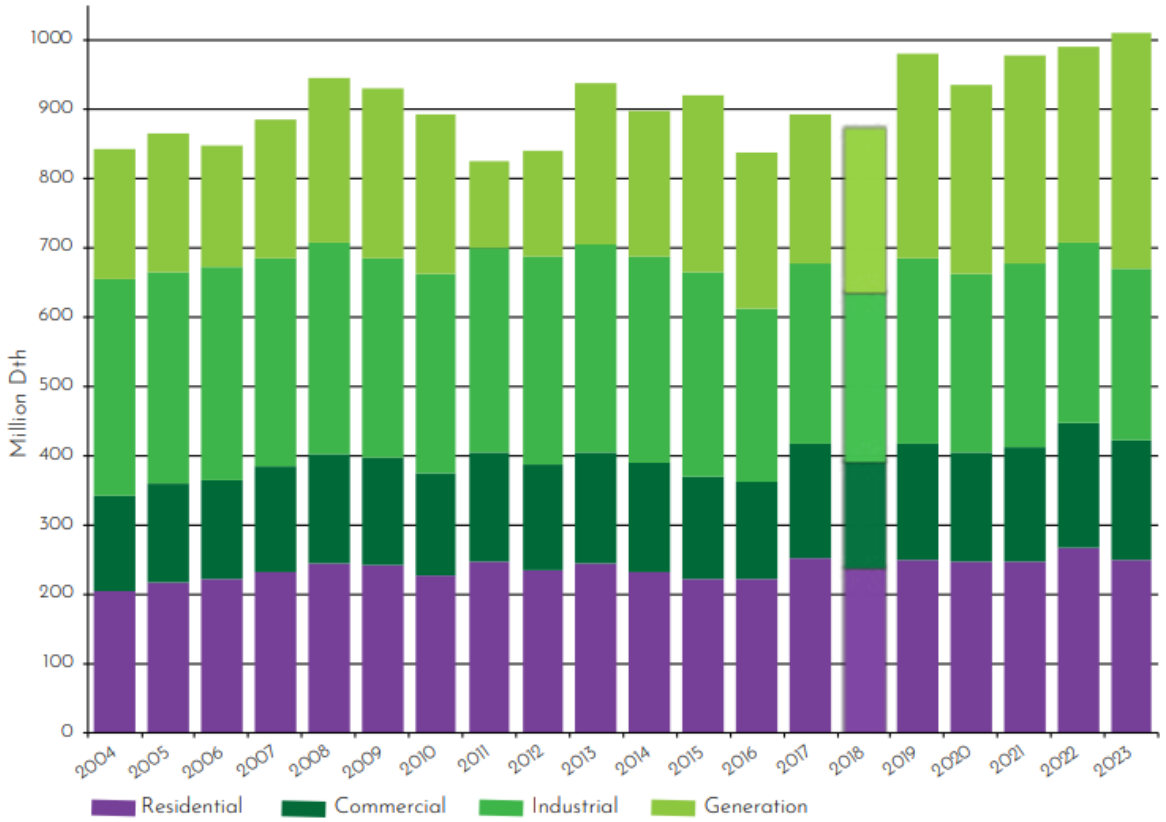
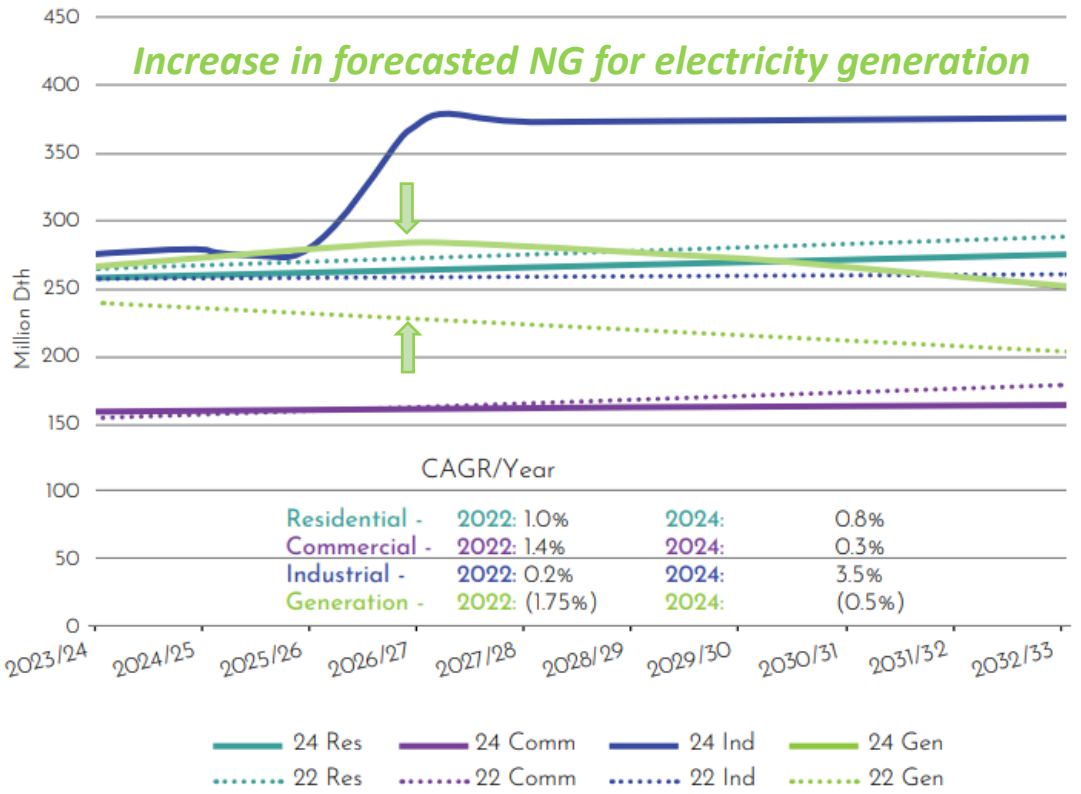


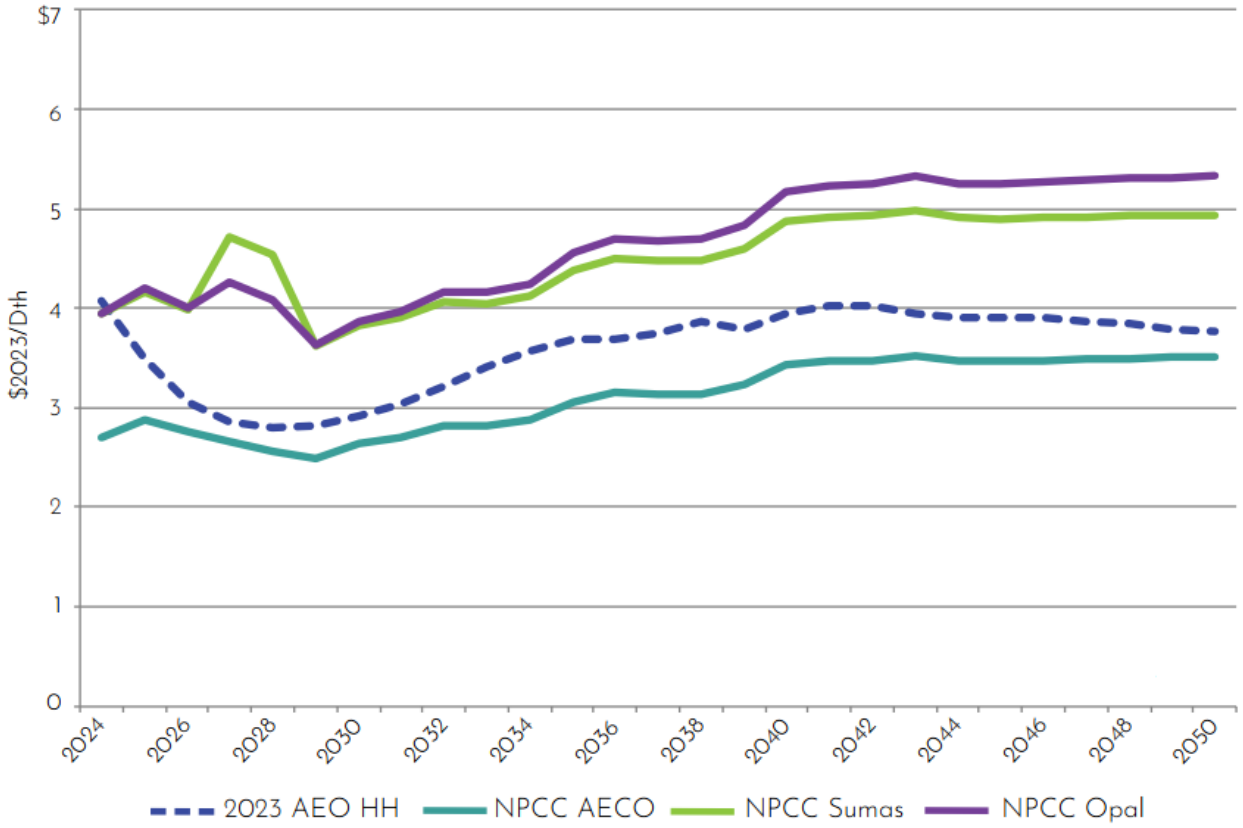
FIGURE 8. Expected Case Forecast by Economic Sector – 2022 to 2024 Comparison



- ✓ *replace power from decommissioned coal plants*
- ✓ *balance intermittent renewable sources*

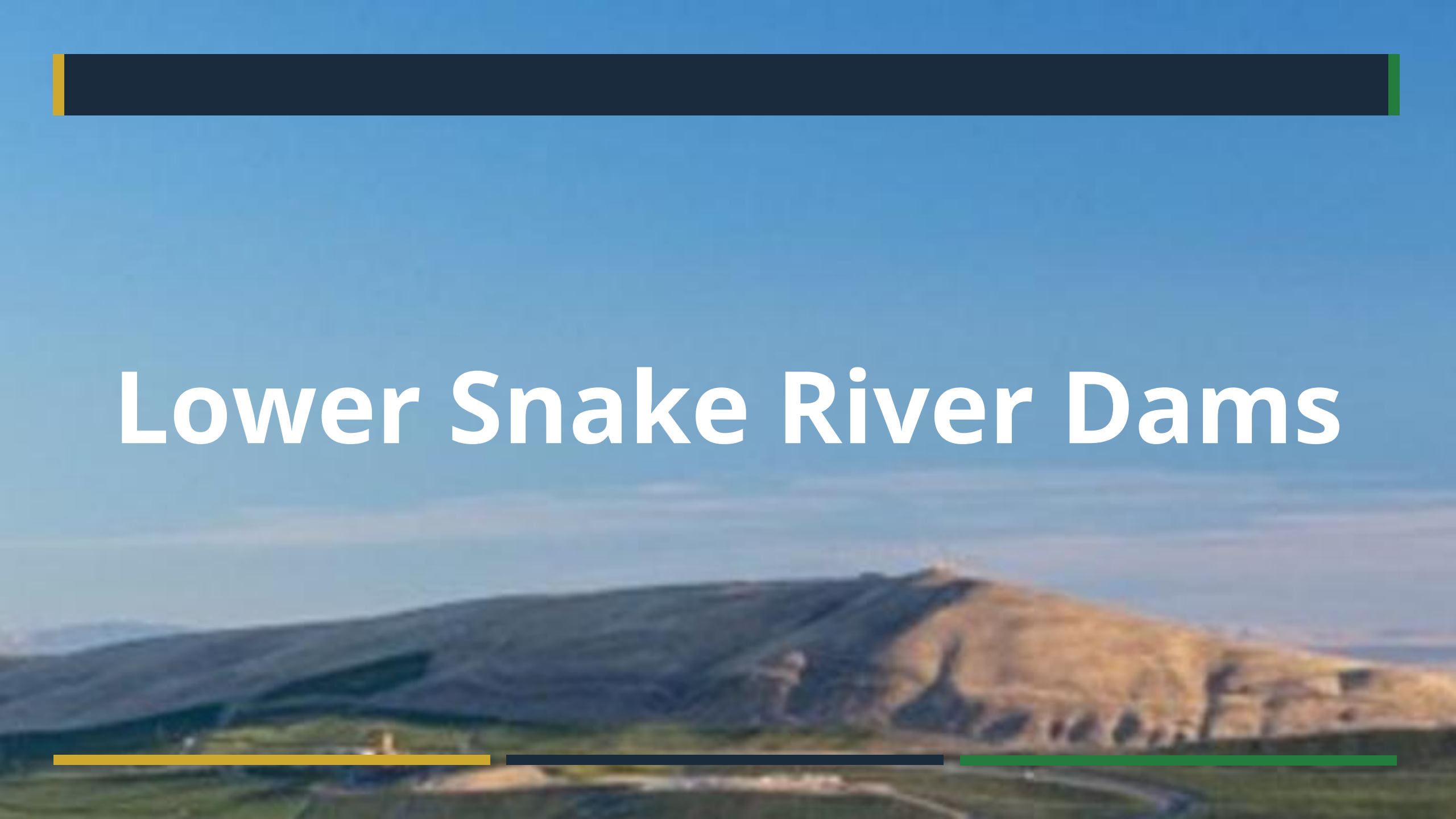
Natural Gas in the Northwest – Price Forecast

FIGURE 4. Natural Gas Price Forecast Comparisons



Sources: *EIA 2023 Annual Energy Outlook; NPCC Fuel Price Forecast, December 2023 Update*

- ***Through 2024:** Regional gas prices will remain lower than Henry Hub (HH) prices, under the EIA's 2023 AEO forecast (dashed blue line in Figure 4).*
- ***After 2025: HH prices will drop below those of Sumas and Opal, reflecting the ongoing expectation for robust U.S. natural gas supplies throughout the forecast period (through 2033) and beyond.***
- ***HH prices will then slowly increase, per the EIA, driven by steady demand growth in the U.S. industrial (primarily LNG exports) and power generation sectors, but remain below those of Sumas and Opal.***



Lower Snake River Dams

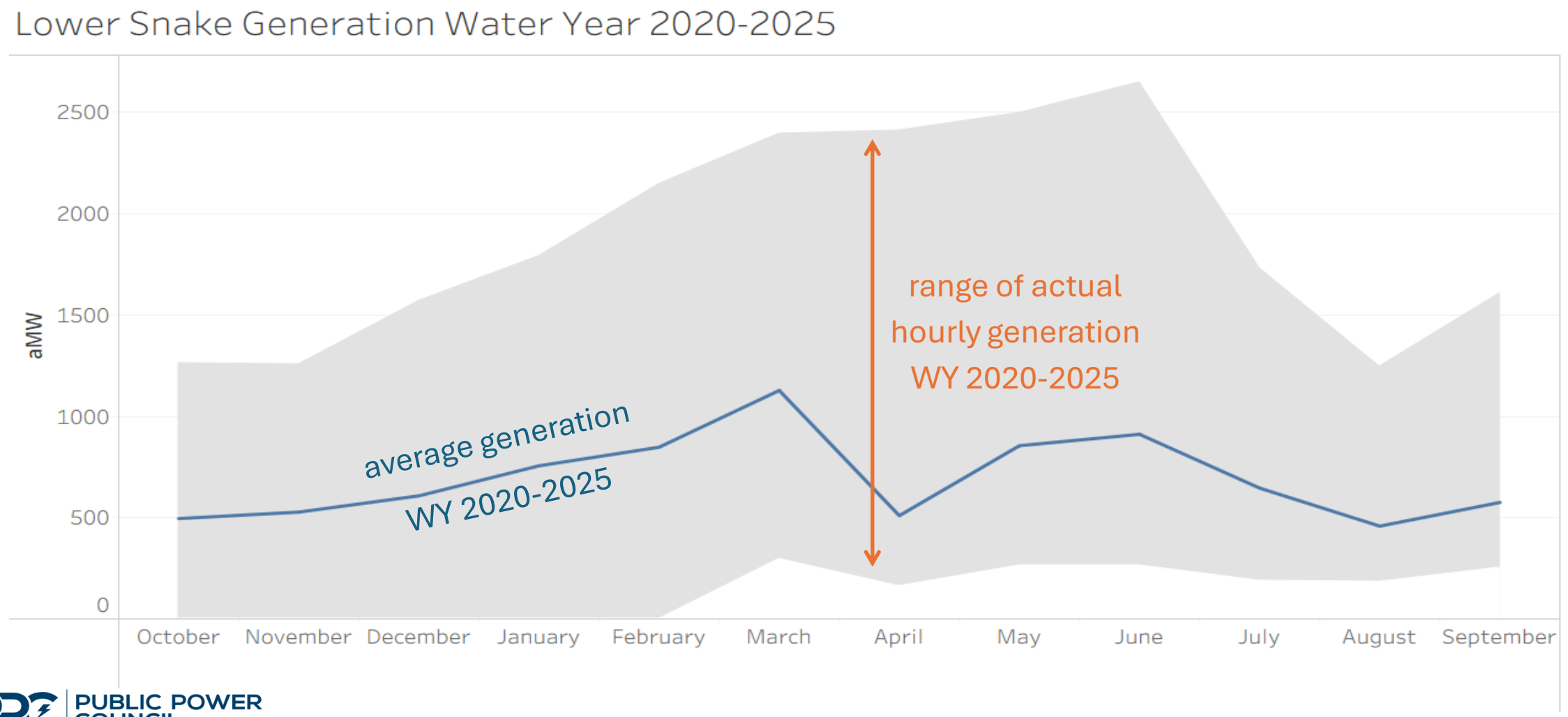
Lower Snake River Dams

LSRD by the Numbers

Ice Harbor Dam	603 MW
Lower Monumental Dam	810 MW
Little Goose Dam	810 MW
Lower Granite Dam	810 MW
Total	**3,033 MW**

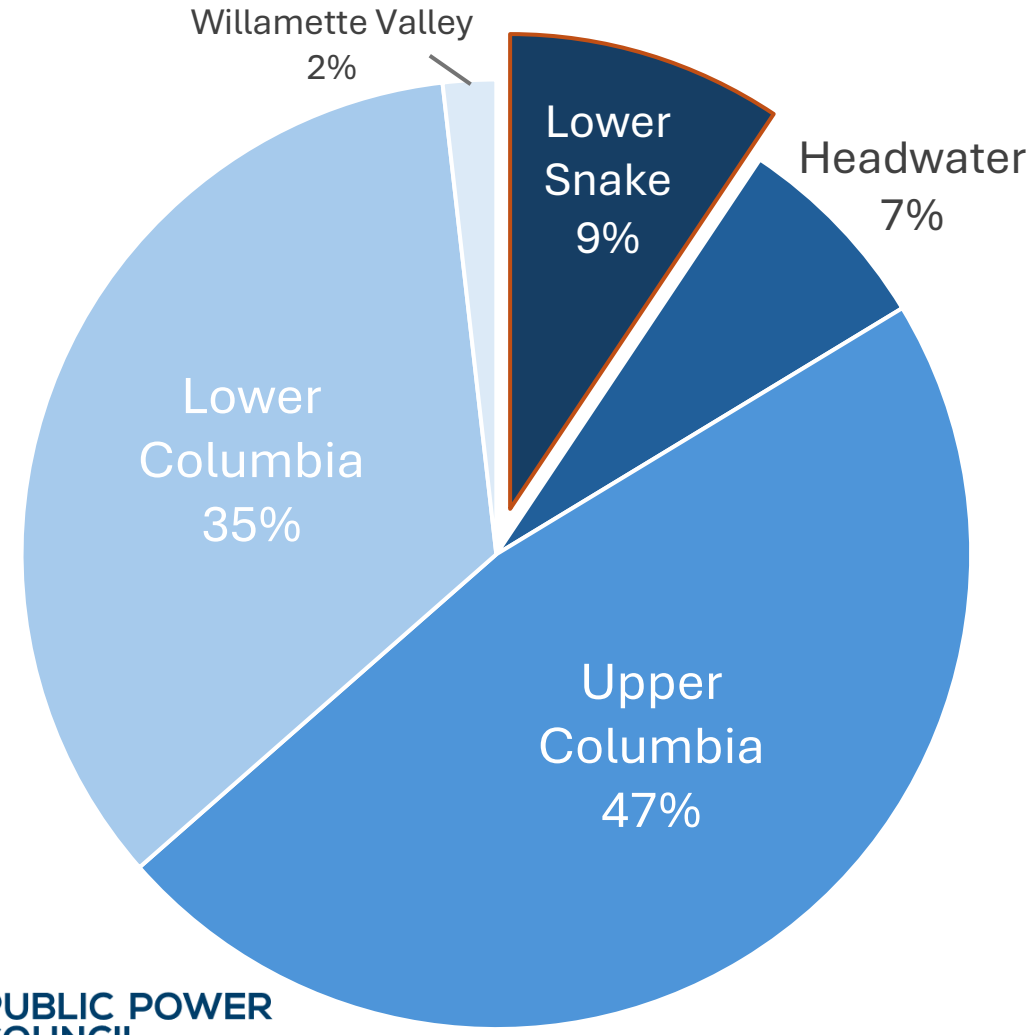
- LSRD's
  - Not Expensive (Hydro is least cost by far)
  - Not Outdated (world class fish bypass)
  - Not Surplus (+130 BPA Customer portfolios)
- As much as 25% of BPA Operating Reserves
  - Blackout Insurance
- We need every drop of hydropower we can get
  - 100% Carbon Free CETA Mandates

LSRD by the Numbers



PUBLIC POWER COUNCIL

LSRD by the Numbers



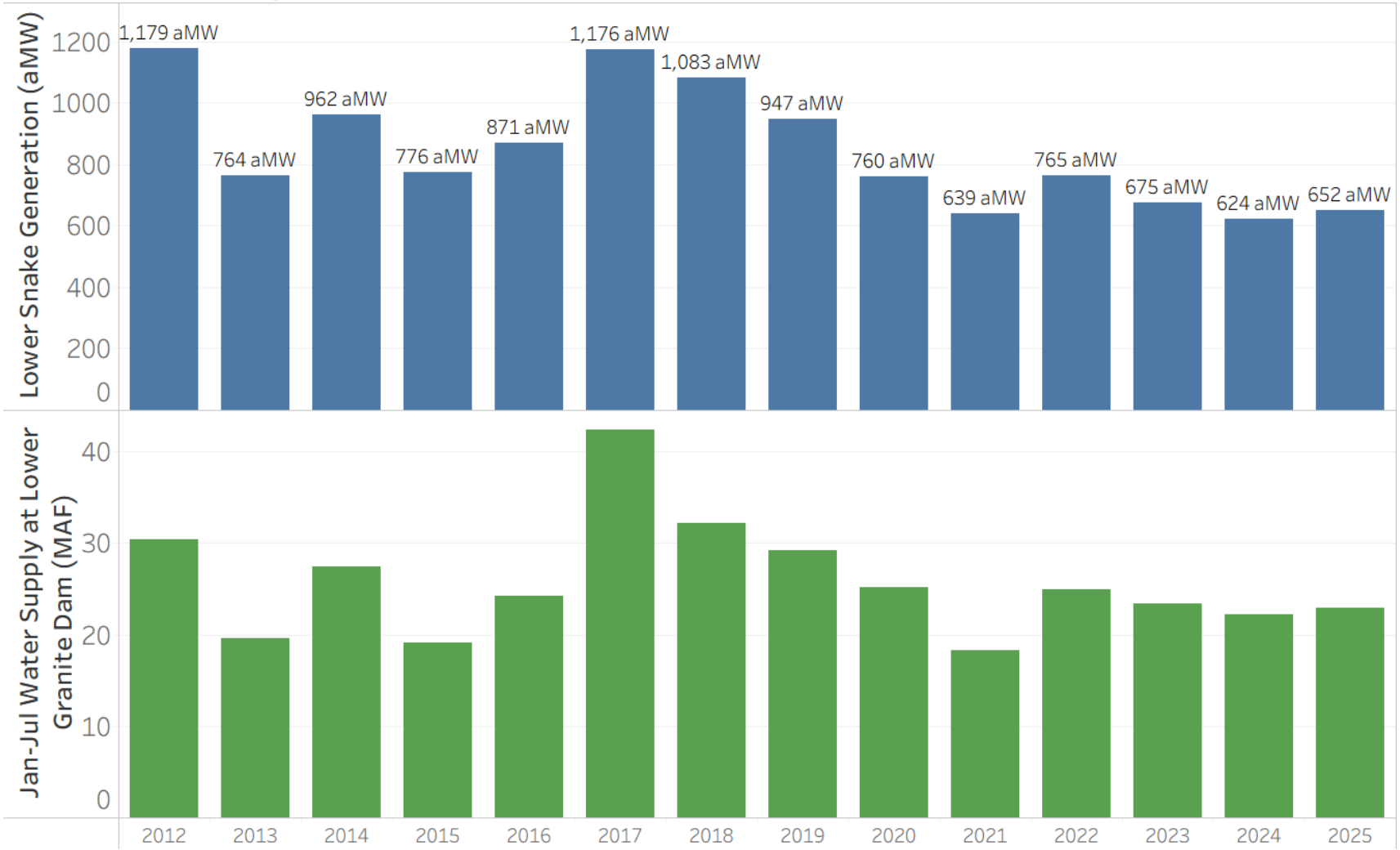
Average Annual Generation From the Federal Columbia River Power System
Water Year 2020-2025

Project Basin	aMW
Lower Snake	686
Headwater	509
Upper Columbia	3456
Lower Columbia	2535
Willamette Valley	132
Total	**7,319**

PUBLIC POWER COUNCIL

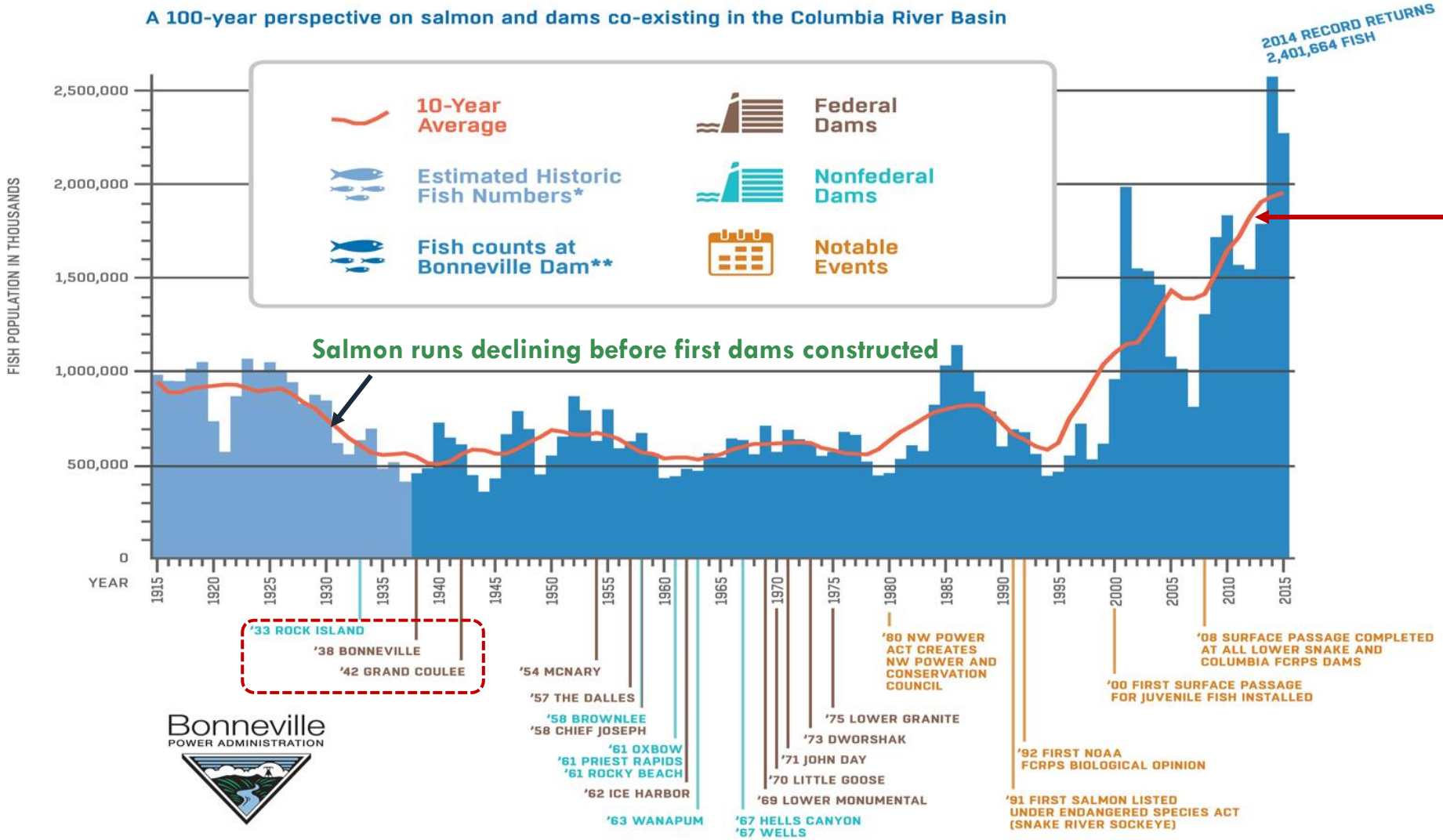
LSRD by the Numbers

Average Generation From the Lower Snake Dams by Water Year



- ✓ ***Less water means less generation***
- ✓ ***Higher required spill also reduces generation***

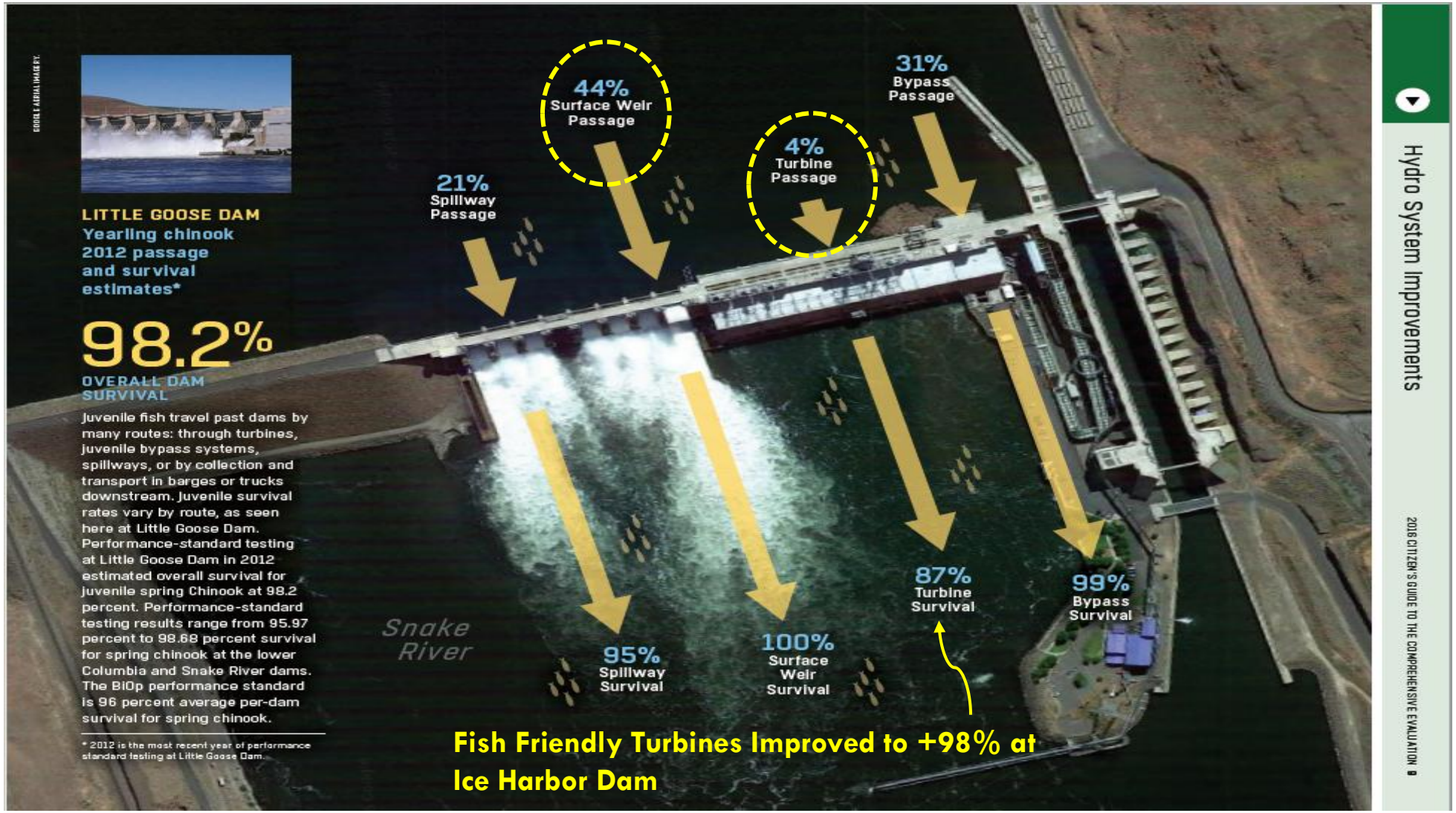
Salmon Runs: Historical Data



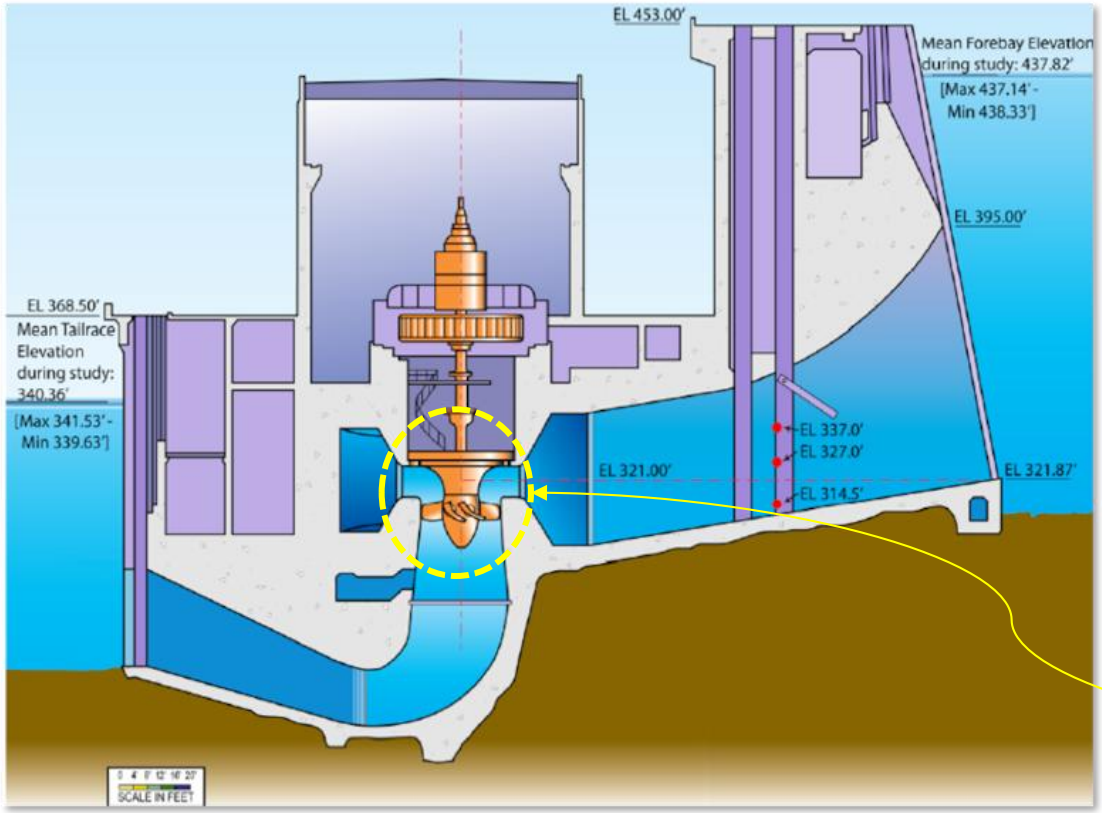
Salmon runs improving with financial investments and management of:

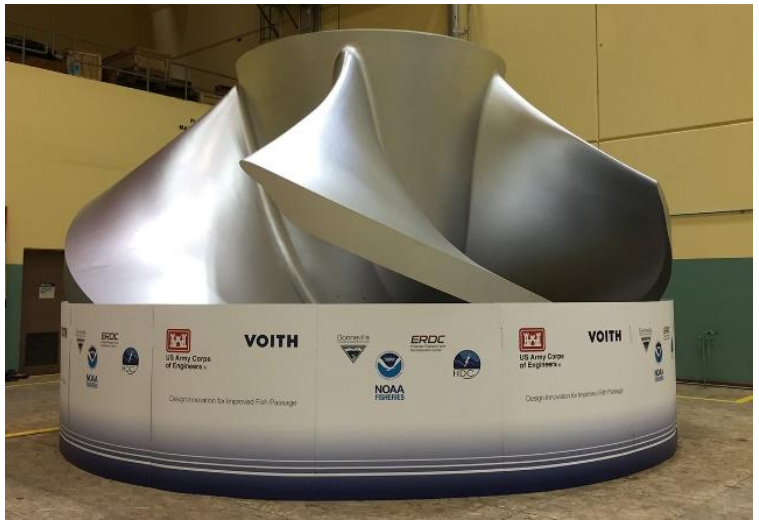
- ✓ *Hydro*
- ✓ *Habitat*
- ✓ *Hatcheries*
- ✓ *Harvest*

Fish Bypass Technology Investments



Fish Friendly Turbine Design

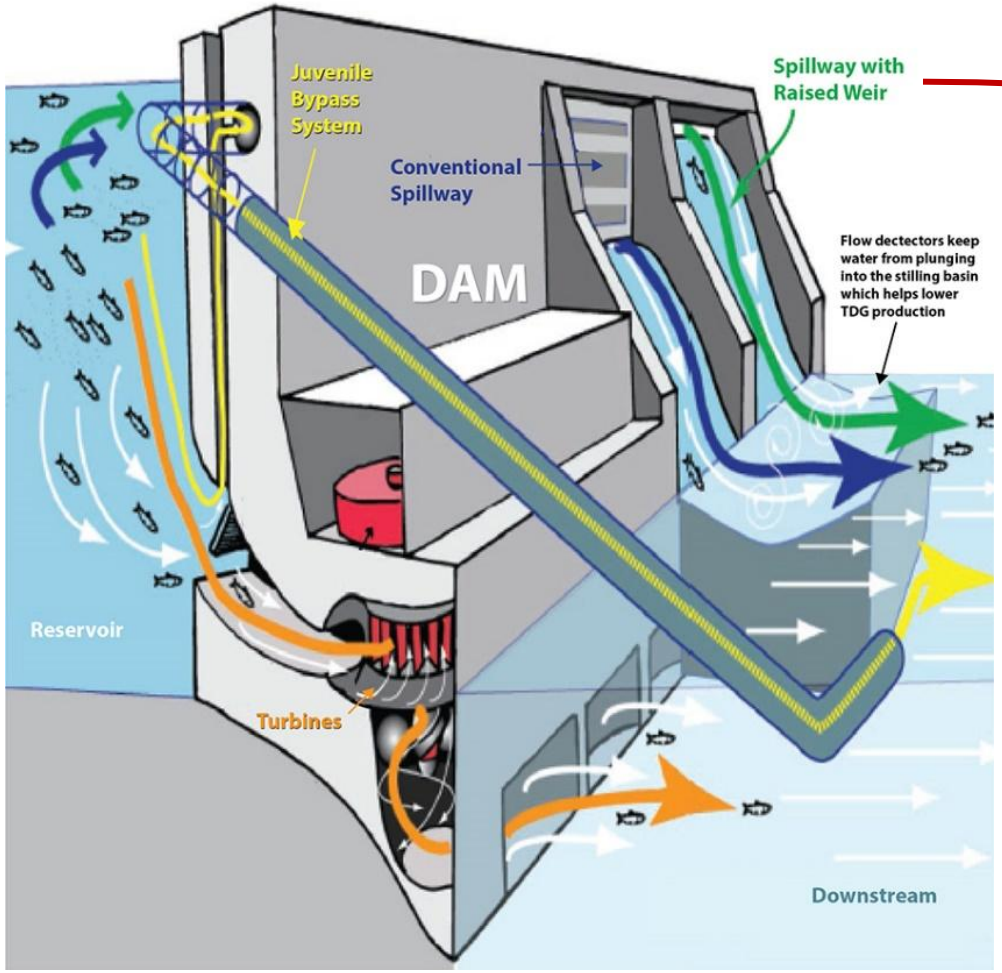


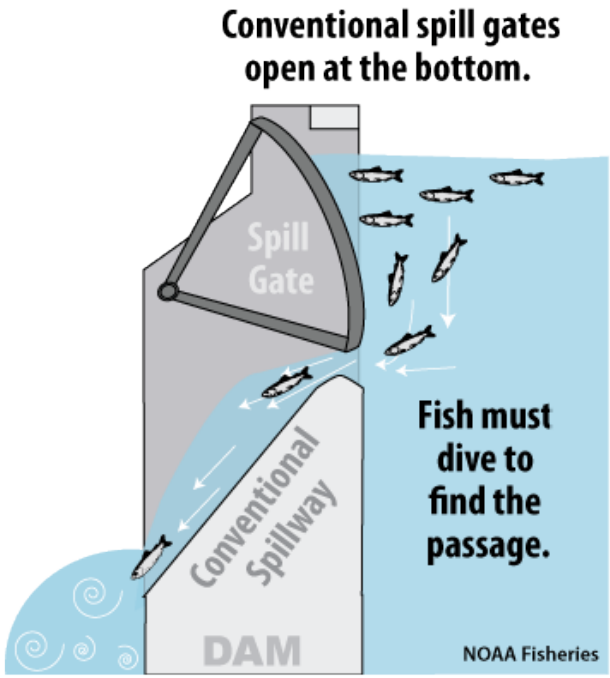


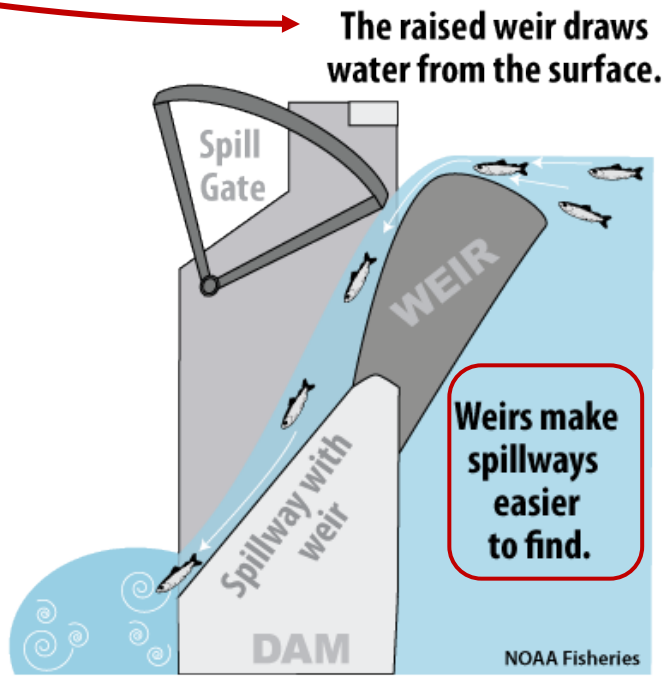
"...biological testing using balloon tagged fish in October 2019 resulted in a 98.25% direct survival rate."

https://www.nww.usace.army.mil/Media/News-Stories/Article/2991190/modernizing-hydropower-on-the-snake-river/

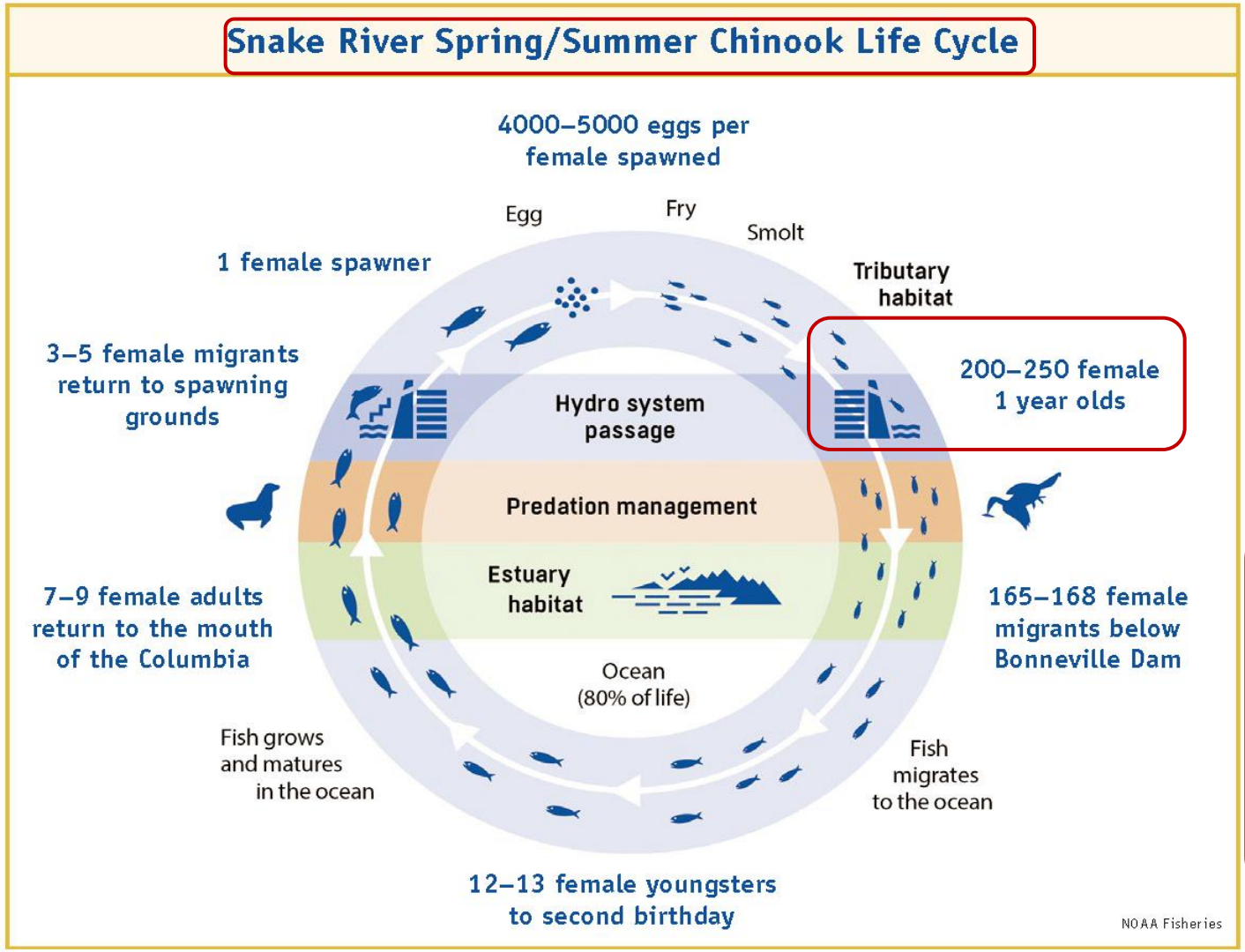
Raised Spillway Weirs







Chinook Salmon Life Cycle



- ✓ **Smolt take 10 to 50 days to travel rivers and get to the estuary/ocean**
- ✓ **Delayed mortality hypothesis is driving calls for LSRD breaching w/o scientific evidence**

7 July 2022 KINTAMA p. 1/8.

The Case for Snake River Dam Removal is Scientifically Dishonest

-David Welch, Ph.D. & President, Kintama Research Services.

"If delayed mortality doesn't exist…then other approaches to getting more salmon should be considered".

Salmon Runs: Historical Data at Bonneville Dam w/ Shad

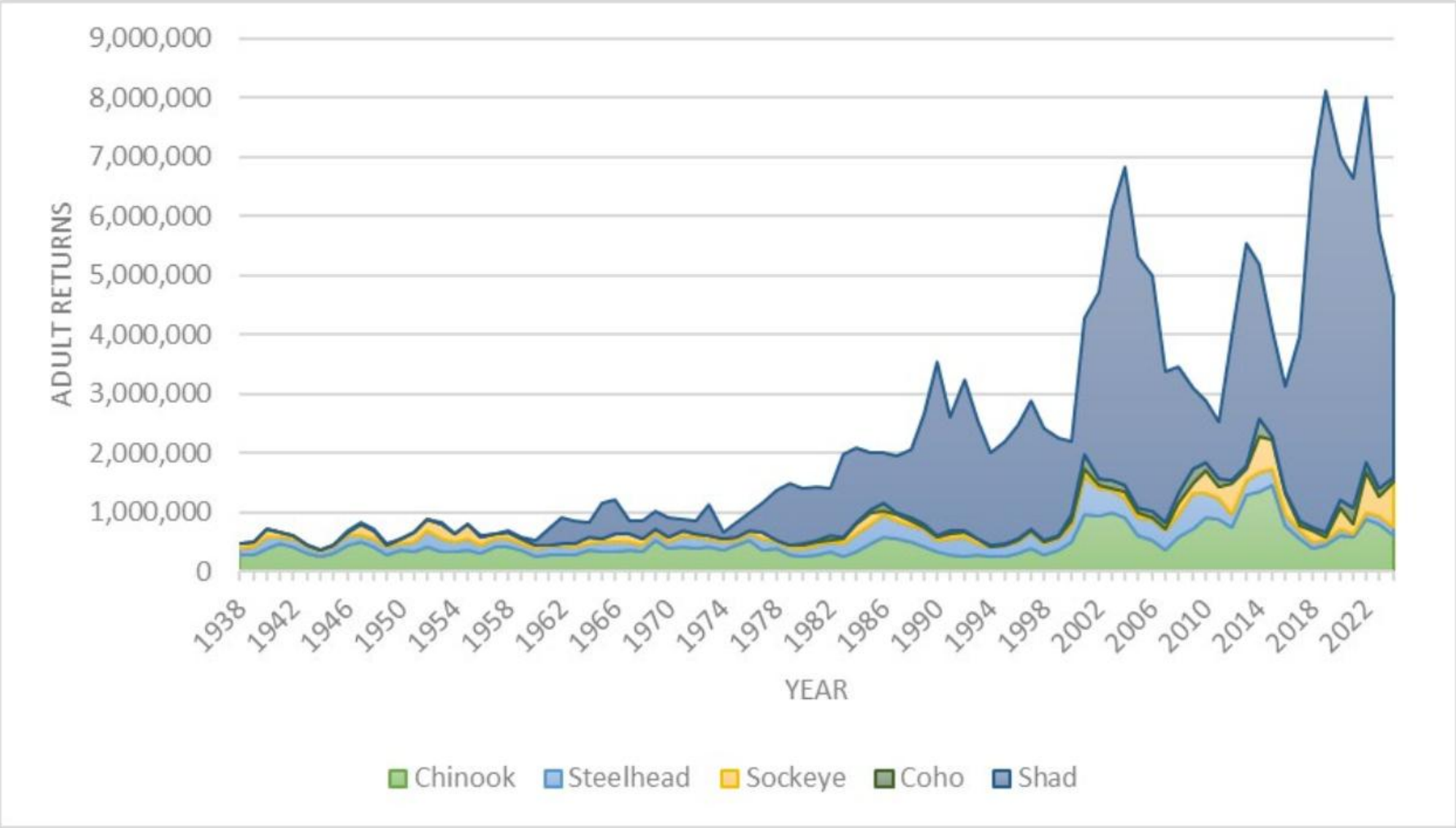


Figure 6. Returns Bonneville Dam for salmon, steelhead, and shad, 1938–2024. Chinook and Coho data account for adults and jacks. The steelhead data account for wild and hatchery fish. Calculated from Columbia River DART (University of Washington).

Killer Whales and Snake River Chinook

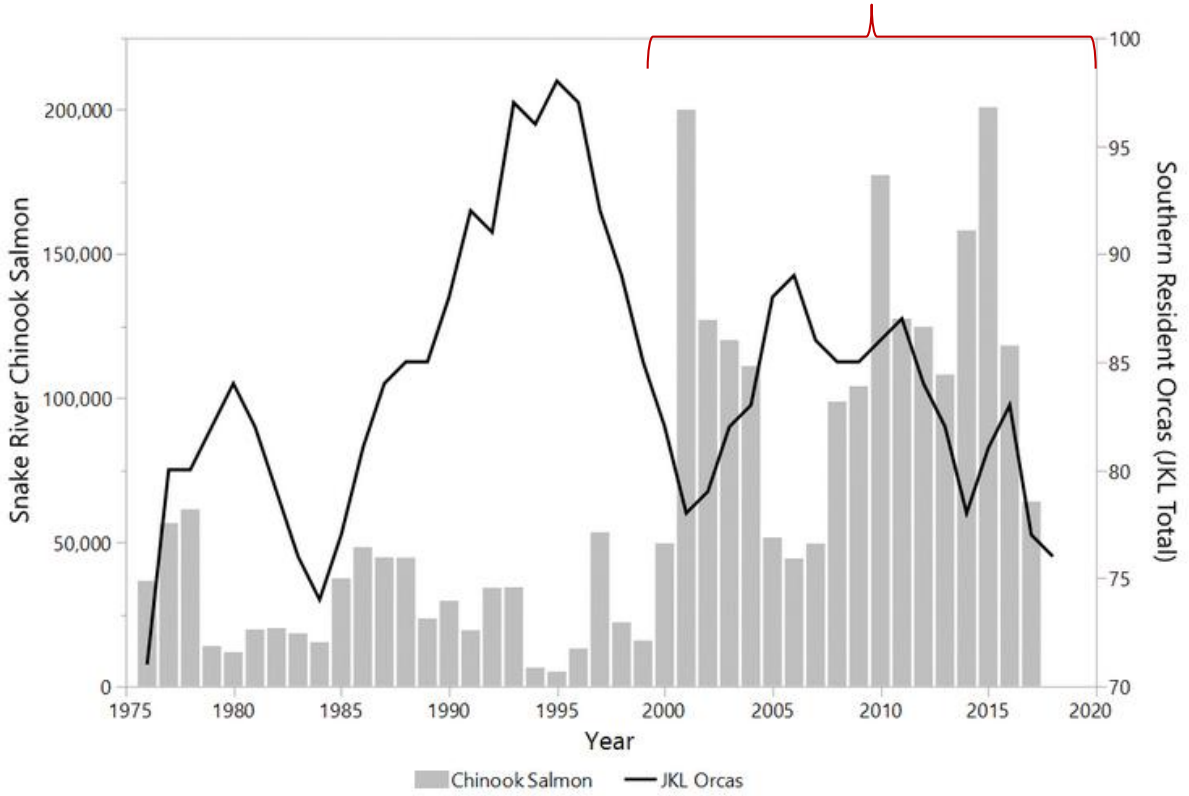
Abundance of Orcas Related to Snake River Chinook Salmon?

Published on August 14, 2018 Edit article | View stats

Photo by Leigh Calvez

Joshua Murauskas
Principal Scientist at Four Peaks Environmental Science & Data Solutions
6 articles

JKL Orca populations declined during time of increasing Snake River Chinook Salmon abundance



Next Generation Nuclear

Next Generation Nuclear

Modular Reactors: Small Footprint, Scalable & Always On

An artist's rendering of NuScale Power's small modular nuclear reactor plant. Photo courtesy of NuScale

Energy contained in a ***gummy bear pellet*** *of uranium fuel*

= ***2,000 pounds*** *of coal*

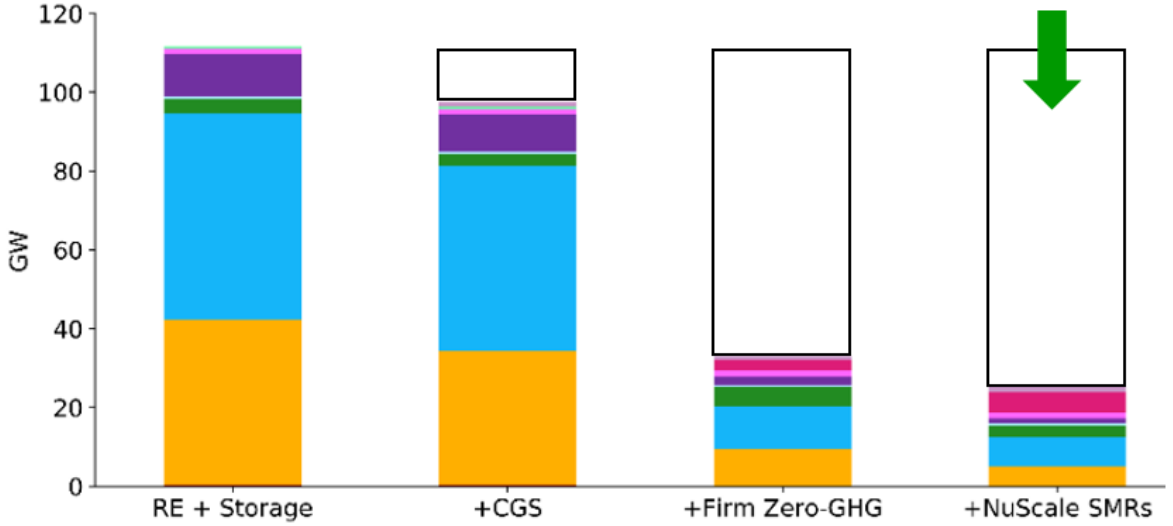
Modular Reactors: Mitigates Wind & Solar Land-Use Impacts

ENERGY NORTHWEST

Benefits of zero-emitting firm capacity at 100% GHG reductions

Avoids 80 to 150 Seattle-Sized Wind Farms & 112 M solar panels

100% GHG Reduction Portfolios



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

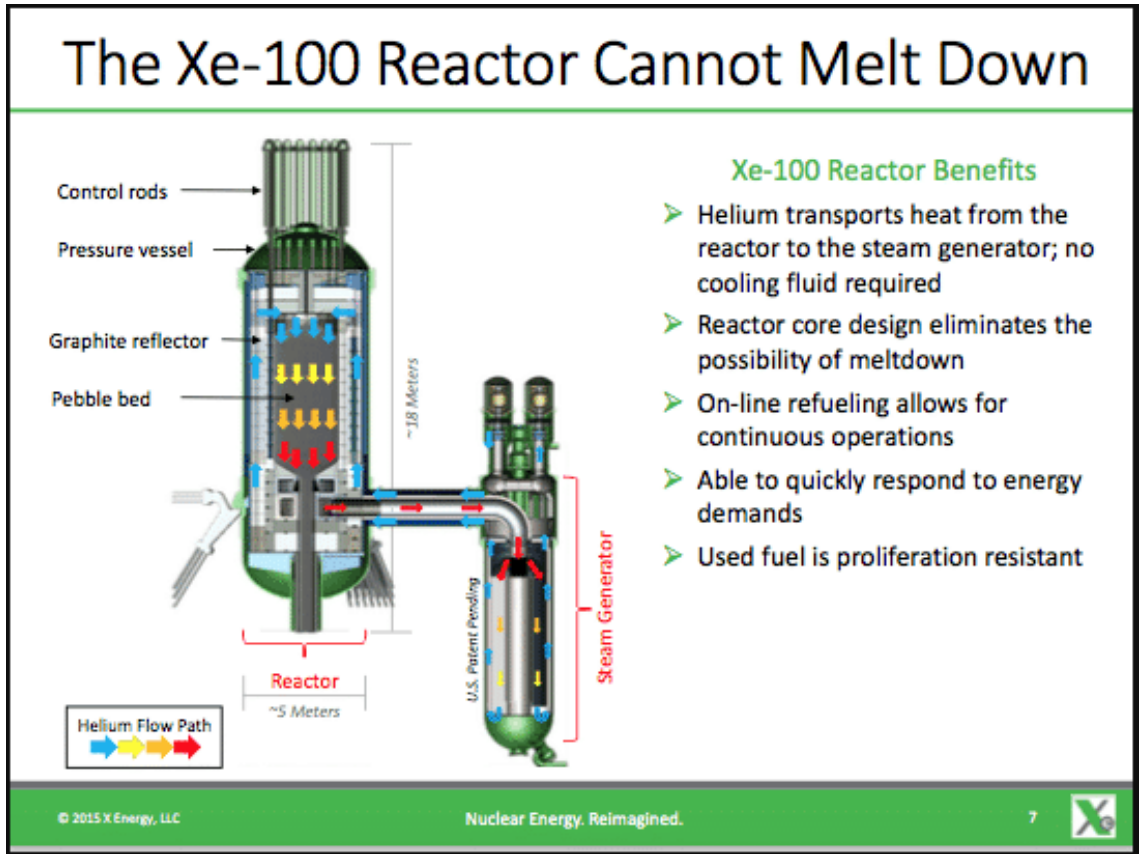
CGS + NuScale SMRs reduce system costs by almost $8B per year relative to RE + Storage

Energy Northwest: Site 1 Small Modular Reactor Project

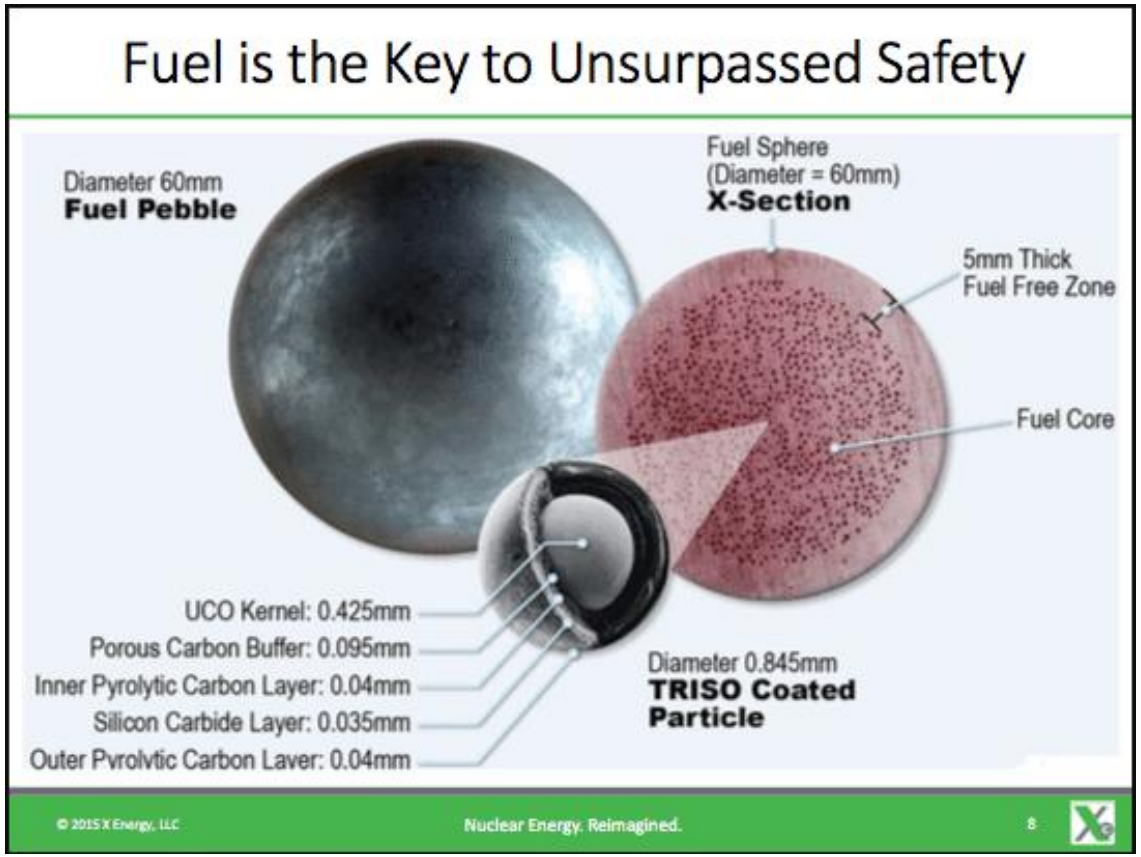
- ✓ Amazon providing development funding for ***4 modules***
- ✓ Energy Northwest has option to build additional ***8 modules***
  - Additional power available to ***Amazon and northwest utilities***
- ✓ On-Line goal = Early 2030s

Xenergy Small Modular Reactor Technology

Meltdown-Proof



Walk-Away-Safe



Terrapower Technology

Natrium®

The next generation of power is here – the Natrium® Reactor and Energy Storage System

Built for the 21st century grid, TerraPower's Natrium technology is one of the fastest and lowest-cost paths to advanced, zero carbon energy.

The Nuclear + Storage Solution

Unlike today's Light Water Reactors (LWR), the Natrium reactor is a **345-megawatt sodium fast reactor** coupled with TerraPower's breakthrough innovation—a molten salt integrated energy storage system, providing **built-in gigawatt-scale energy storage**. The Natrium reactor maintains constant thermal power at all times, maximizing its capacity factor and value. Molten salt energy storage is more resilient, flexible and cost-effective than current grid-scale battery technology.

THE NATRIUM TECHNOLOGY'S ADVANCED DESIGN ENABLES SIMULTANEOUS PRODUCTION OF CARBON-FREE ELECTRICITY, HEAT AND STEAM TO SUPPORT DECARBONIZATION OF POWER AND INDUSTRIAL SECTORS.

TerraPower Begins Construction on Advanced Nuclear Project in Wyoming

June 10, 2024

- ✓ 345 MW sodium-cooled fast reactor
- ✓ 500 MW with molten salt-based energy storage
- ✓ PacifiCorp is Utility Purchaser

Terrapower Technology

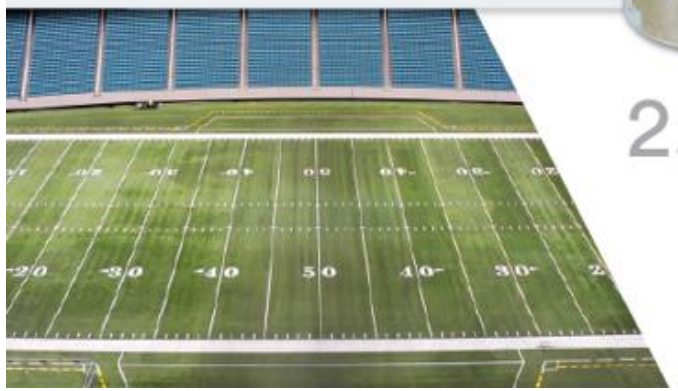
- ✓ Natrium reactors are not pressurized like existing plants and use sodium, instead of water, as a coolant.
- ✓ The reactor operates at a temperatures greater than 350 degrees Celsius (the equivalent of 662 degrees Fahrenheit) and far below the boiling point of sodium.
- ✓ Design capitalizes on natural forces, such as gravity and thermal convection, enabling passive cooling and significantly reducing safety-related costs compared to conventional reactors.

Spent Nuclear Fuel

5 Fast Facts on **Spent Nuclear Fuel**

1. Spent fuel is a solid and is typically made up of **ceramic pellets in metal rods.**

Spent fuel assemblies inside a dry storage cask. >>>



2. The U.S. has produced roughly **90,000 metric tons** of spent fuel. This could all fit on a football field at a **depth of less than 10 yards** if it could be stacked together.

3. Spent fuel from power reactors is safely and securely stored at more than **70 sites in 35 states.**

Underwater storage at Indian Point in Buchanan, NY

4. Spent fuel is safely transported across the U.S. with more than **2,500 cask shipments over the last 55 years.**

5. Spent fuel can be recycled. **More than 90% of its potential energy still remains in the fuel.**

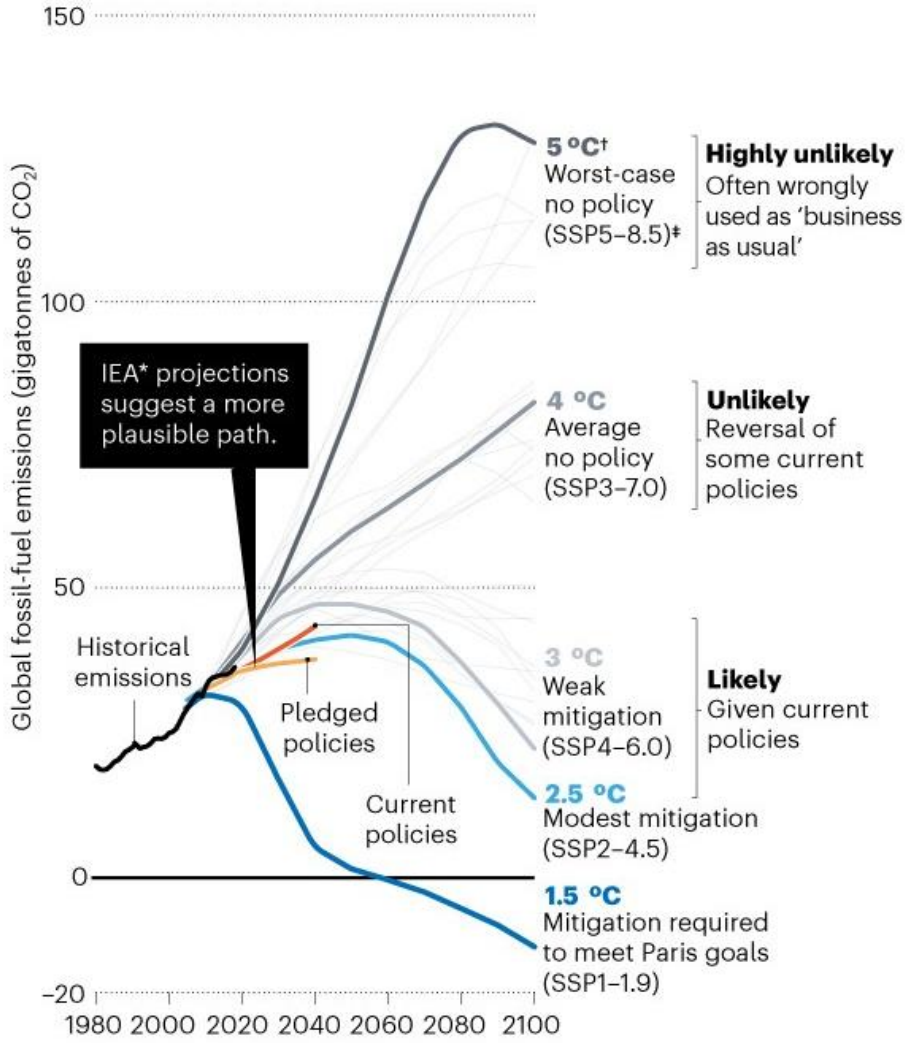
Dry storage casks at Dresden Generating Station. >>>

https://www.energy.gov/ne/articles/infographic-5-fast-facts-about-spent-nuclear-fuel

WA State Clean Energy Policies & Global CO2 Perspectives

WA State Clean Energy Policies & Global CO_2 Perspectives

Global CO_2 Emissions – Things to Consider (IPCC RCP8.5)



COMMENT | 29 January 2020

Emissions – the 'business as usual' story is misleading

Stop using the worst-case scenario for climate warming as the most likely outcome – more-realistic baselines make for better policy.

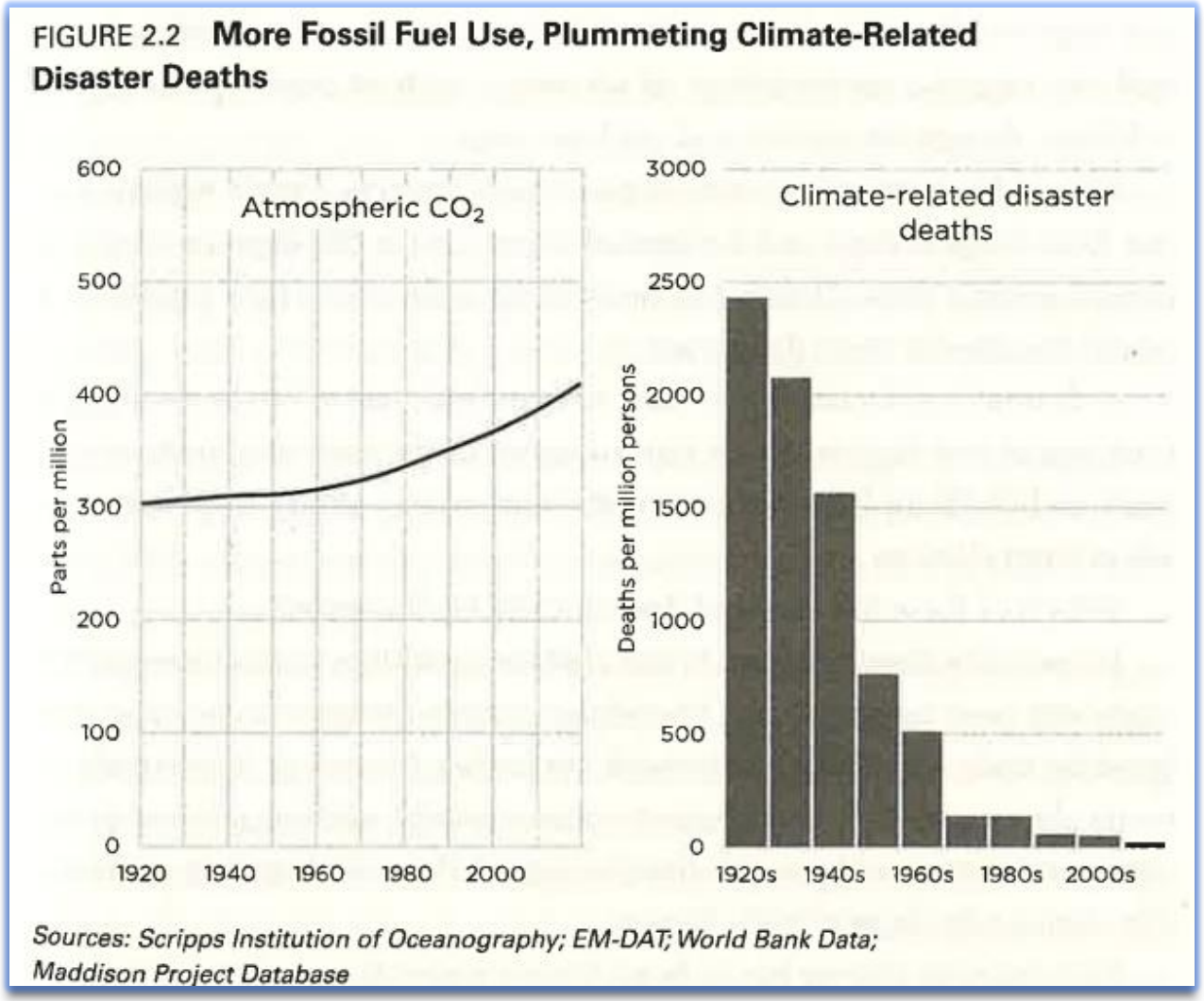
Zeke Hausfather & Glen P. Peters

Intergovernmental Panel on Climate Change (IPCC) Representative Concentration Pathways (RCPs)

RCP8.5 "… paints a dystopian future that is fossil-fuel intensive and excludes any climate mitigation policies, leading to nearly 5 °C of warming by the end of the century,"

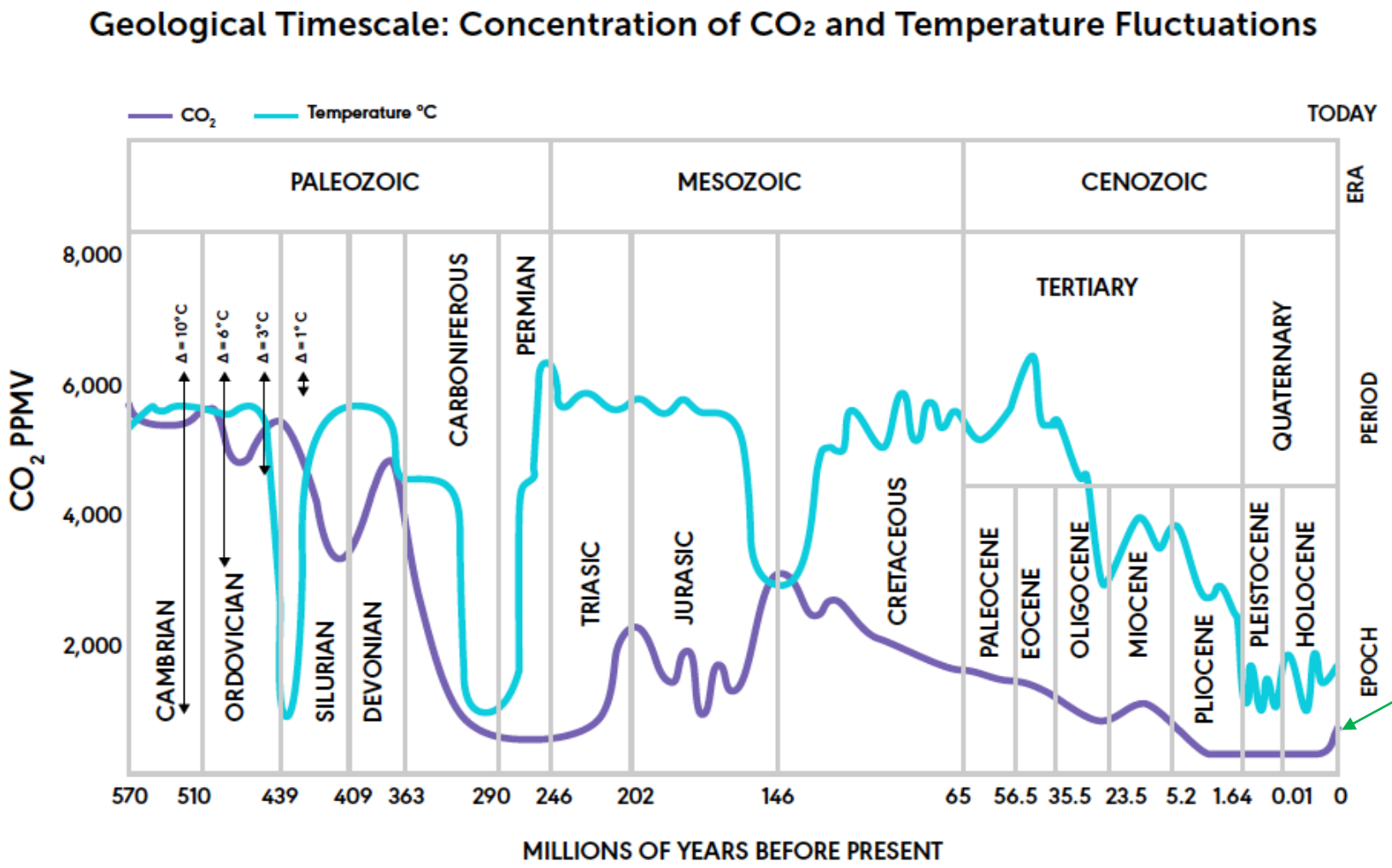
"RCP8.5 was intended to explore an unlikely high-risk future. But it has been widely used by some experts, policymakers and the media as something else entirely: as a likely 'business as usual' outcome."

Global CO_2 Emissions – Things to Consider (Climate-disasters)



- ✓ Rate of climate-related disaster **deaths has fallen by 98%** over the last century
  - Includes deaths from droughts, floods, storms, and extreme temperatures
- ✓ World **life expectancy has increased** from just over 30 years in 1900 to over 70 years today
- ✓ **What is role of human innovation and adaptation to changes in climate?**

Global CO_2 Emissions – Things to Consider (parts per million)



CO_2 Concentration

PPM = Parts Per Million

+5,000 PPM millions of years ago

420 PPM today

<280 PPM before industrial revolution

<200 PPM end of some plant life

<150 PPM end of all plant life

Global CO_2 Emissions – Things to Consider (Saturation)

Richard Lindzen
Professor of Earth, Atmospheric, and Planetary Sciences, Emeritus
Massachusetts Institute of Technology

William Happer
Professor of Physics, Emeritus Princeton University

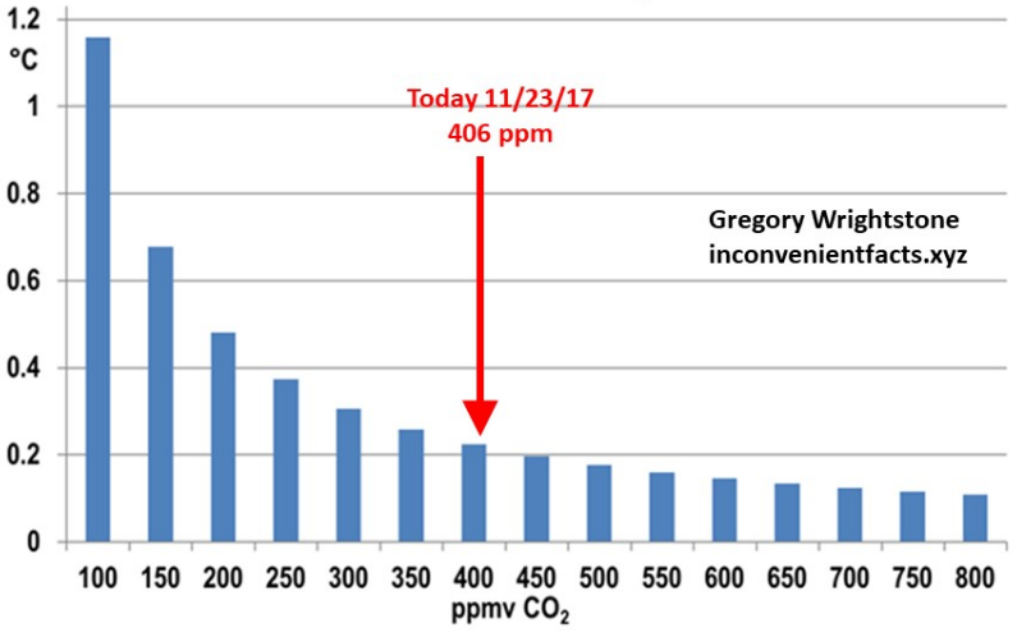
Steven Koonin
University Professor, New York University,
Senior Fellow at the Hoover Institution

FOSSIL FUELS AND GREENHOUSE GASES (GHGs) CLIMATE SCIENCE

April 2024

Each additional increase of CO_2 in the atmosphere causes a smaller and smaller change in "radiative forcing," or in temperature.

Figure I-3: Less global warming for each additional 50 parts-per-million-by-volume of CO_2 concentration



(Graph calculated using IPCC's formula $\Delta T_0 = \frac{5.35}{3.2} ln \frac{C}{C_0}$;
AR3, Ch. 6.1. Courtesy Monckton 2017)

Global CO_2 Emissions – Things to Consider (Climate Models)

"…models do not work, and bear no rational relationship to the reality they purport to represent."

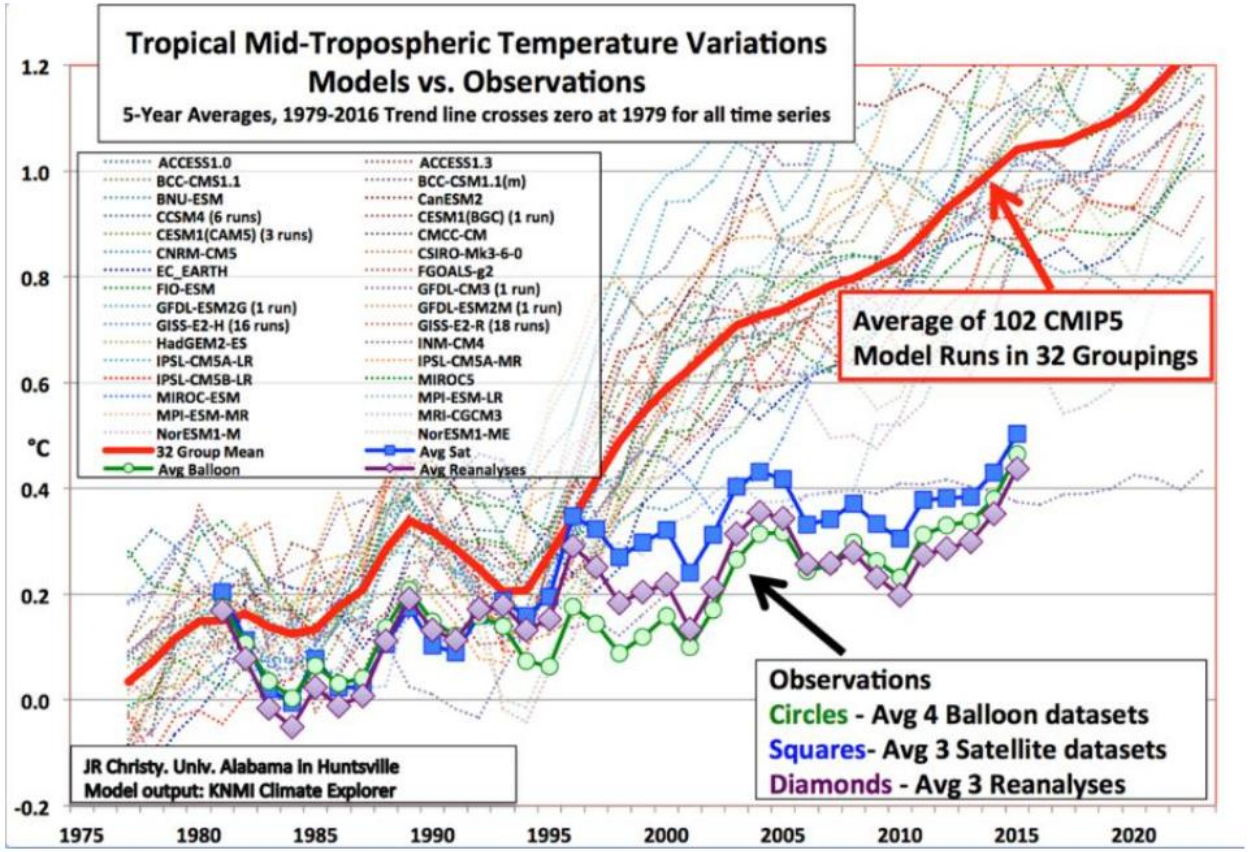
Richard Lindzen
Professor of Earth, Atmospheric, and Planetary Sciences, Emeritus
Massachusetts Institute of Technology

William Happer
Professor of Physics, Emeritus Princeton University

Steven Koonin
University Professor, New York University,
Senior Fellow at the Hoover Institution

FOSSIL FUELS AND GREENHOUSE GASES (GHGs) CLIMATE SCIENCE

April 2024



Global CO_2 Emissions – Things to Consider (Heat Waves)

Richard Lindzen
Professor of Earth, Atmospheric, and Planetary Sciences, Emeritus
Massachusetts Institute of Technology

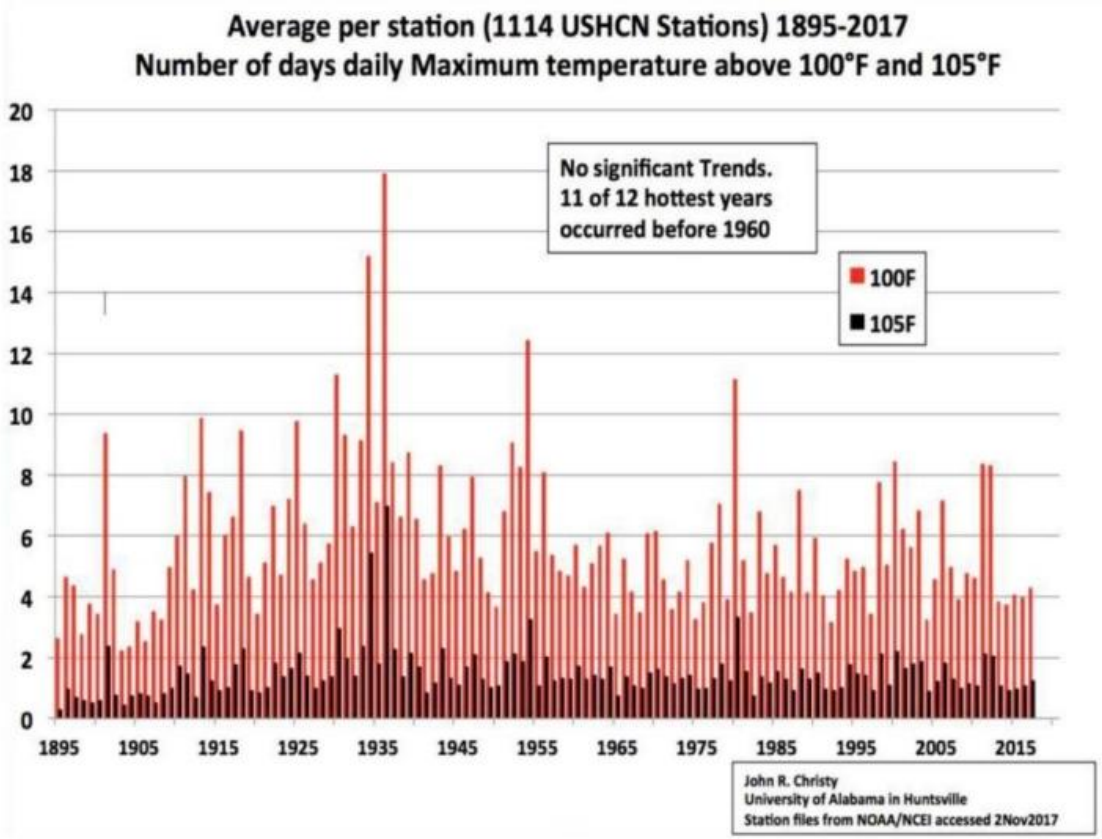
William Happer
Professor of Physics, Emeritus Princeton University

Steven Koonin
University Professor, New York University,
Senior Fellow at the Hoover Institution

FOSSIL FUELS AND GREENHOUSE GASES (GHGs) CLIMATE SCIENCE

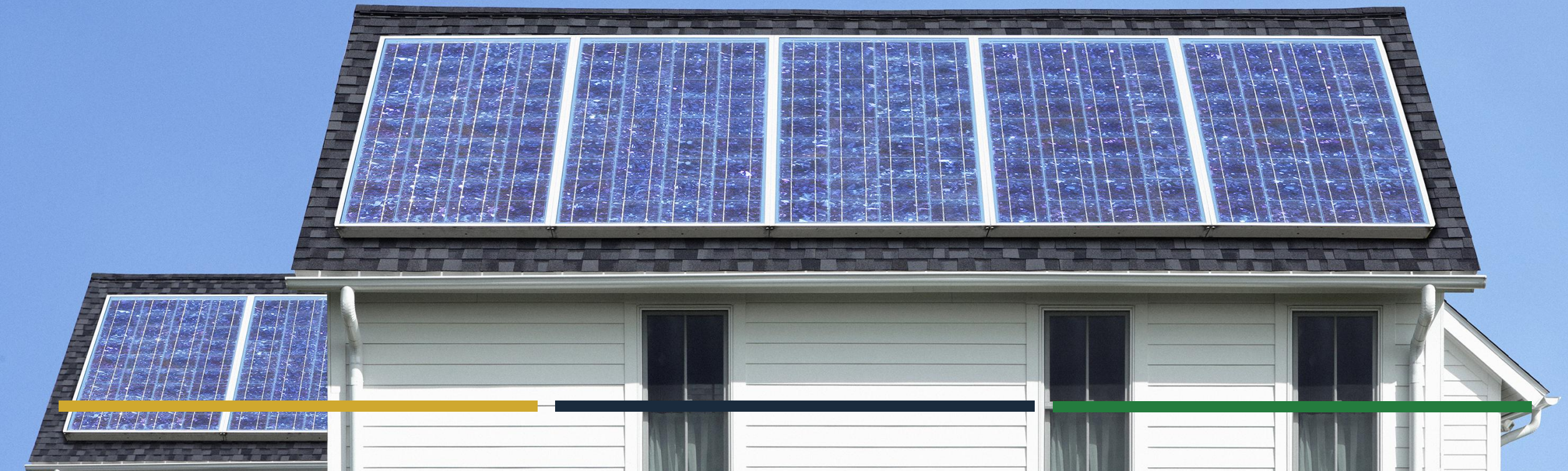
April 2024

The annual number of high temperature records set shows no significant trend over the past century, nor over the past 40 years.



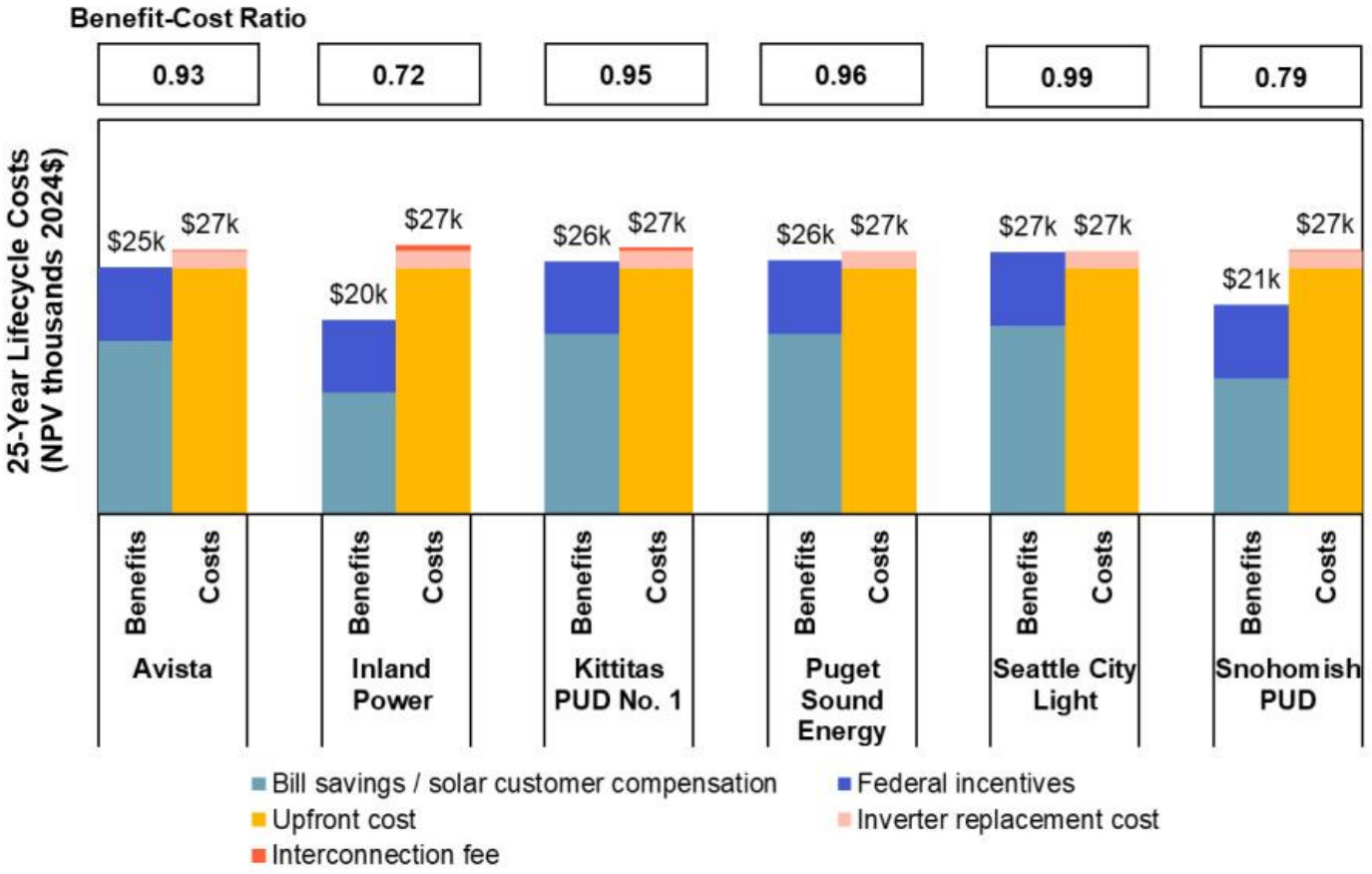
Rooftop Solar

Rooftop Solar

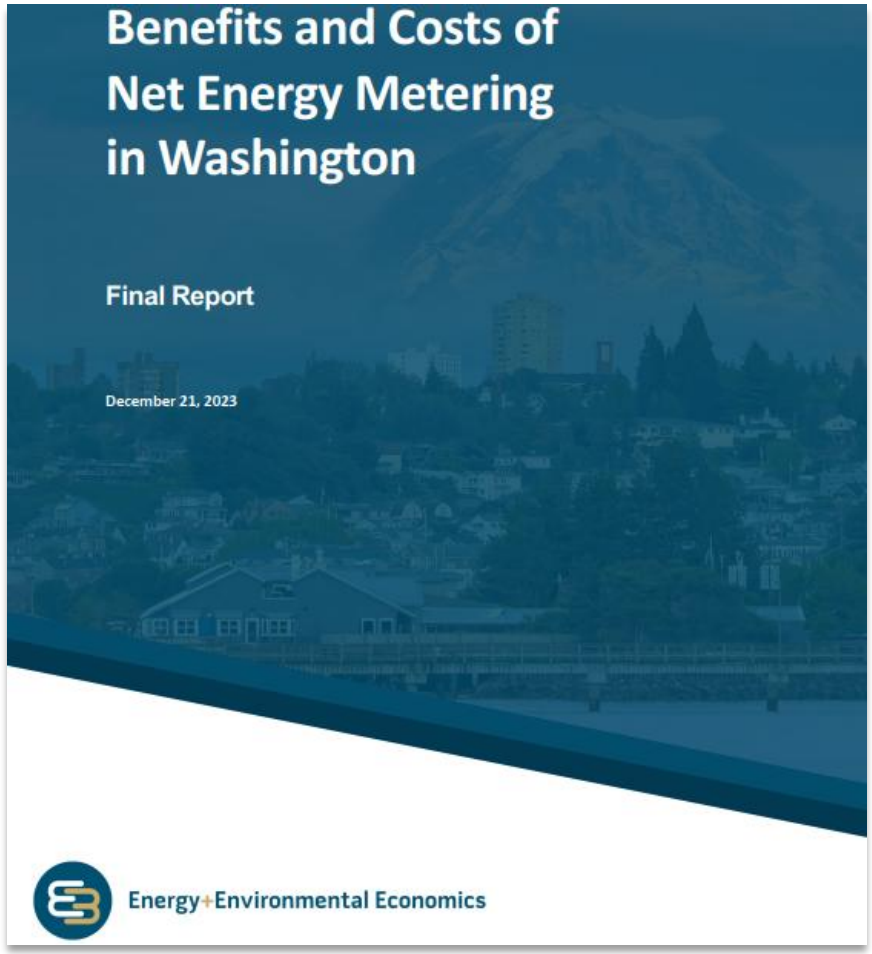


Rooftop Solar – Break Even Analysis

Figure 1. Participant Cost Test (PCT) by Utility for an Example 7 kW-AC System



Washington Public Utility Districts Association



Rooftop Solar – Break Even Analysis

- Benton PUD started collecting cost data in Jan 2023
  - Average reported cost per watt (DC) is $4.96 or ≈ $5 per watt (AC)

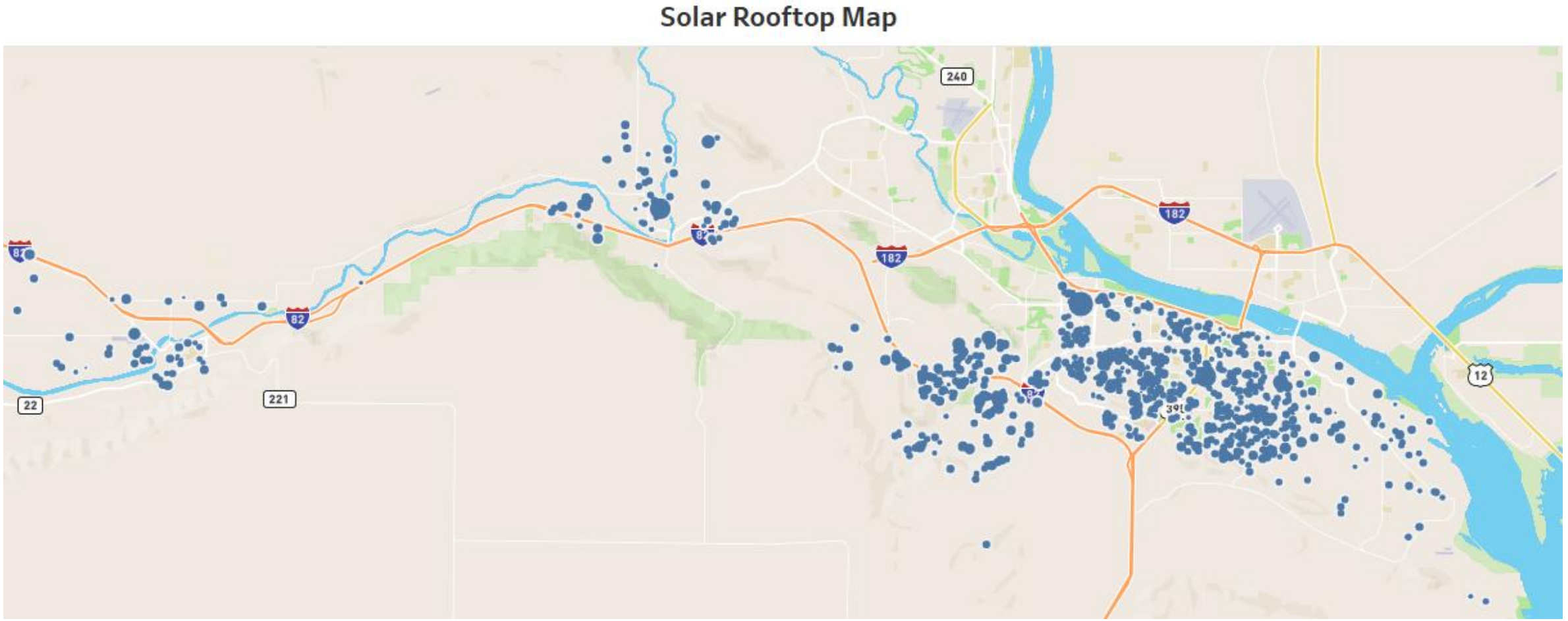
- 12 KW would offset average annual residential home energy (kWh) charges

- What planet are we on financially speaking?
  - 12 KW system x $5 per KW (AC) = $60,000 up-front system cost
  - Average residential power bill is $126 per month or $1,512 per year
  - System cost equivalent to over 40 years of annual electricity bills at current rates

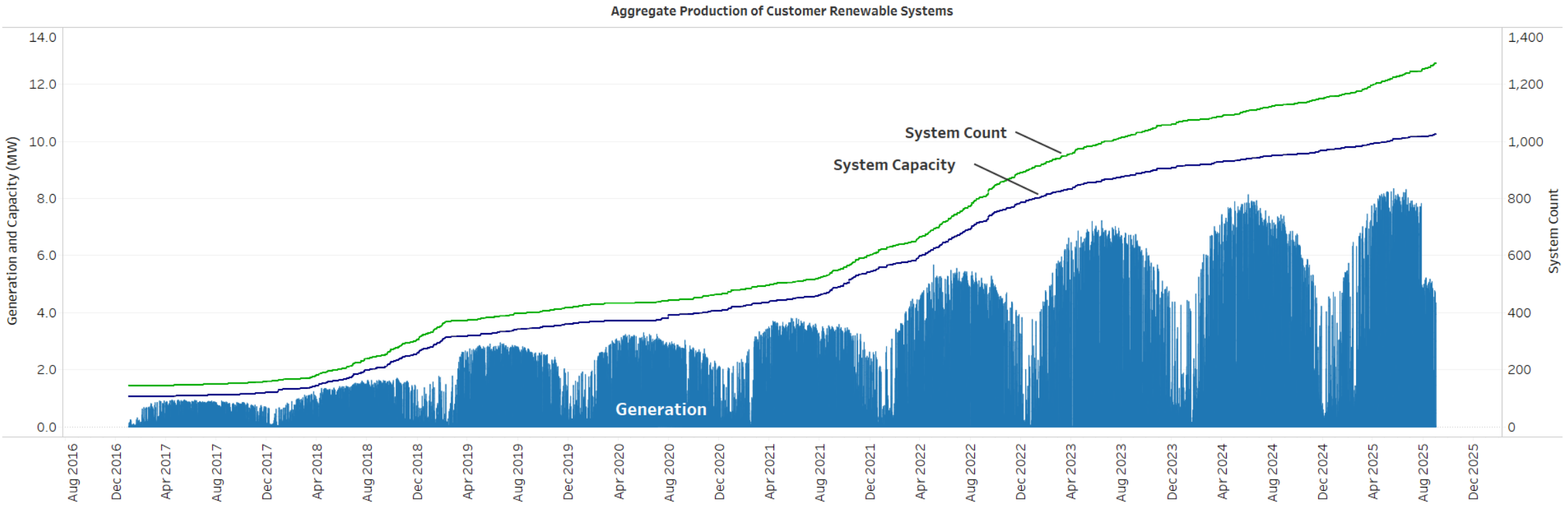
- Federal Investment Tax Credits for Homeowners currently 30% thru December 31, 2025
  - Applies to customer with tax liability

- For most residential rooftop solar systems, you can avoid paying state and local sales tax on both equipment and installation under current Washington law (through December 31, 2029).

Rooftop Solar – Benton PUD Customer Solar



Rooftop Solar – Benton PUD Customer Solar



End Date Time
1/1/2017 — 9/1/2025

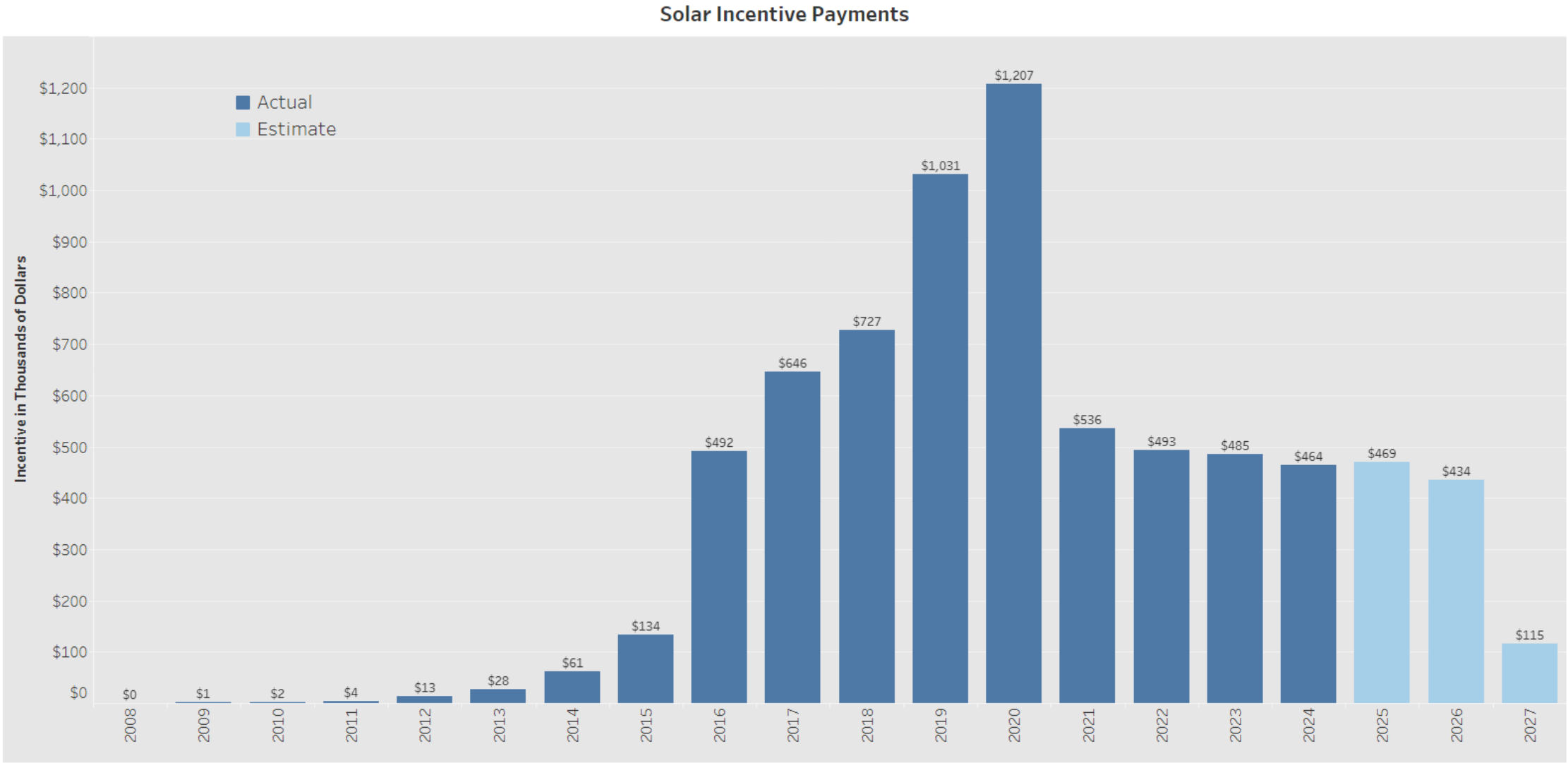
Maximums (Based on End Date Range)	
Highest System Count	1,274
System Capacity (MW)	10.25
Highest Production (MW)	8.35
Mean Production (MW)	0.86
Capacity Factor	0.16

Rooftop Solar – Washington State Incentives

Customer-generated power applicable rates	Base rate (0.15) multiplied by applicable factor, equals incentive payment rate
Solar modules manufactured in Washington **Factor: 2.4** (two and four-tenths)	$0.36
Stirling converter manufactured in Washington **Factor: 2.4** (two and four-tenths)	$0.36
Solar or wind generating equipment with an inverter manufactured in Washington **Factor: 1.2** (one and two-tenths)	$0.18
Both solar modules and inverter manufactured in Washington **Factor: (2.4 + 1.2)** = 3.6 (three and six-tenths)	$0.54
Anaerobic digester or other solar equipment or wind generator equipped with blades manufactured in Washington **Factor: 1.0** (one)	$0.15
Wind generator equipped with both blades and inverter manufactured in Washington **Factor: (1.0 + 1.2)** = 2.2 (two and two-tenths)	$0.33
All other electricity produced by wind **Factor: 0.8** (eight-tenths)	$0.12

- ✓ ***Washington State Renewable Energy Cost-Recovery Incentive Program Established in 2013 for Customer-Owned Generation***
- ✓ ***Some of the most generous tax subsidies in the U.S.***
- ✓ ***Program terminated February 14, 2019, after reaching funding limit***

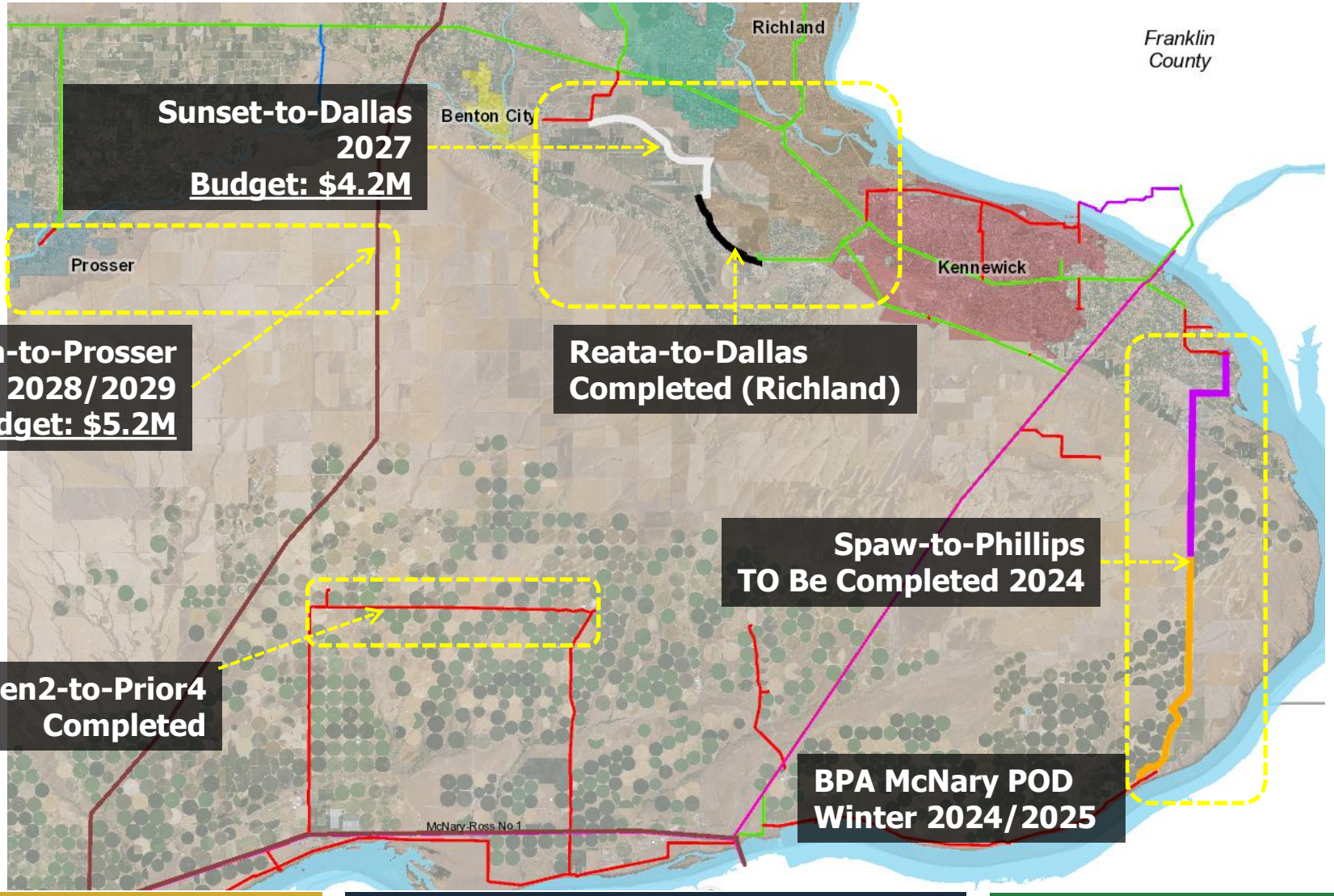
Rooftop Solar – Benton PUD Solar Incentive Payments



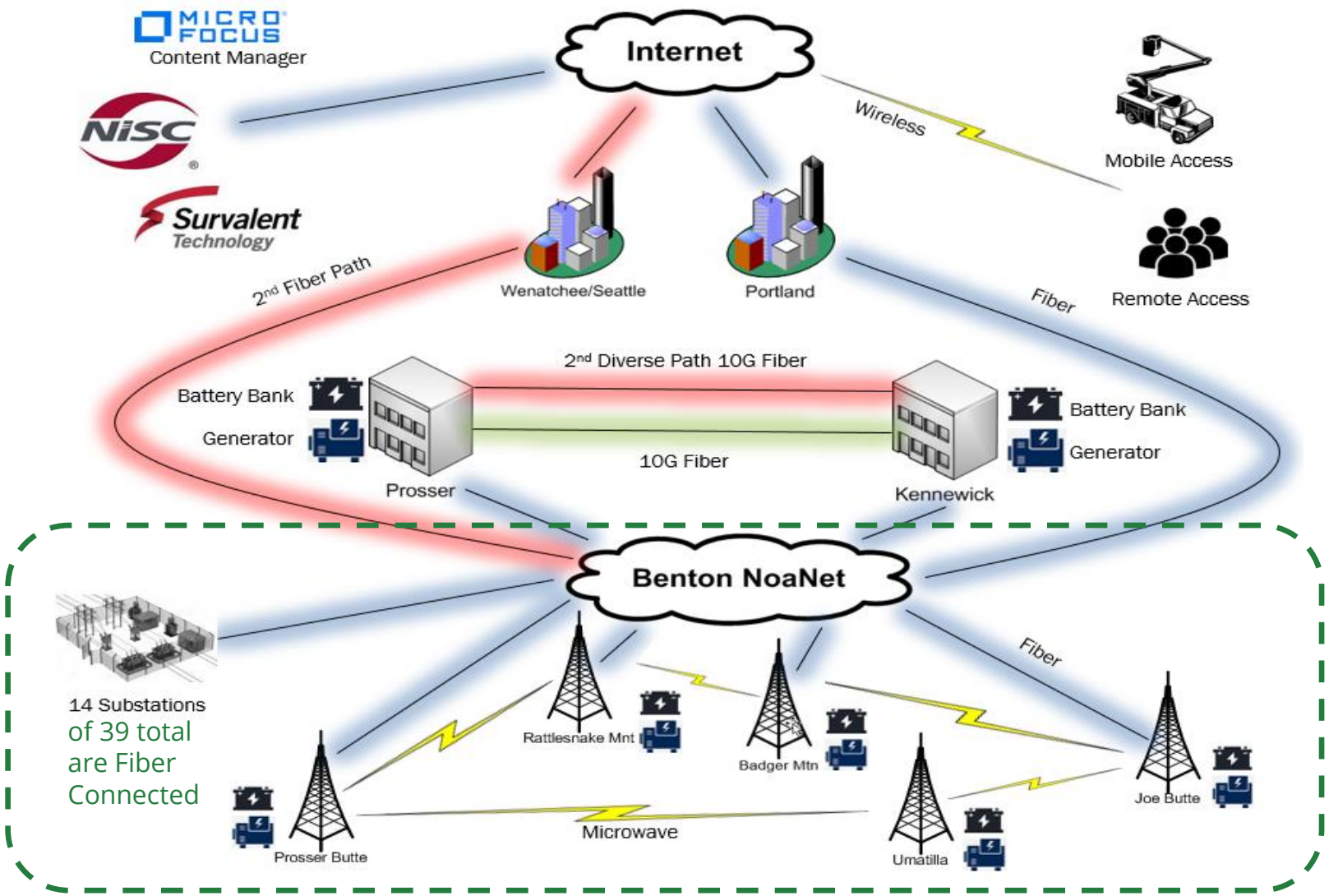
21st Century Grid

21st Century Grid

Transmission Reliability Improvement Projects

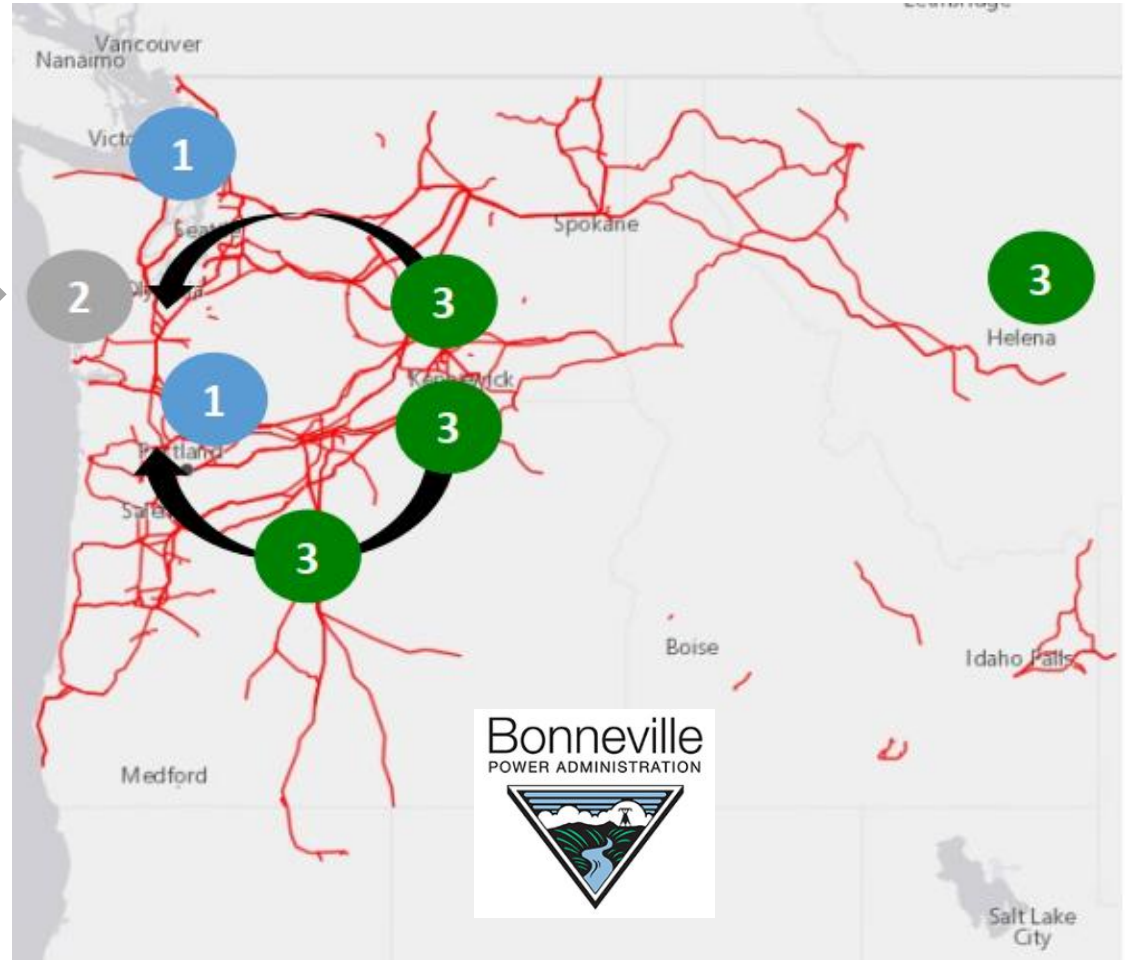


Next Generation SCADA: Communications



BPA Transmission: *What "We" want BPA to Do*

"The Evolving Grid Update on the State of Transmission"



The following factors:

1. Load growth in Portland and Seattle – driven by high tech industry, transportation and building electrification
2. Reduced operation of 4.5 GW of carbon emitting generators on the west side along the I5 corridor
3. Replacement wind and solar resources are located east of the Cascades

Will increase flows on cross-Cascades transmission paths and throughout the load centers

Source: BPA April 2023 Presentation "The Evolving Grid Update on the State of Transmission"

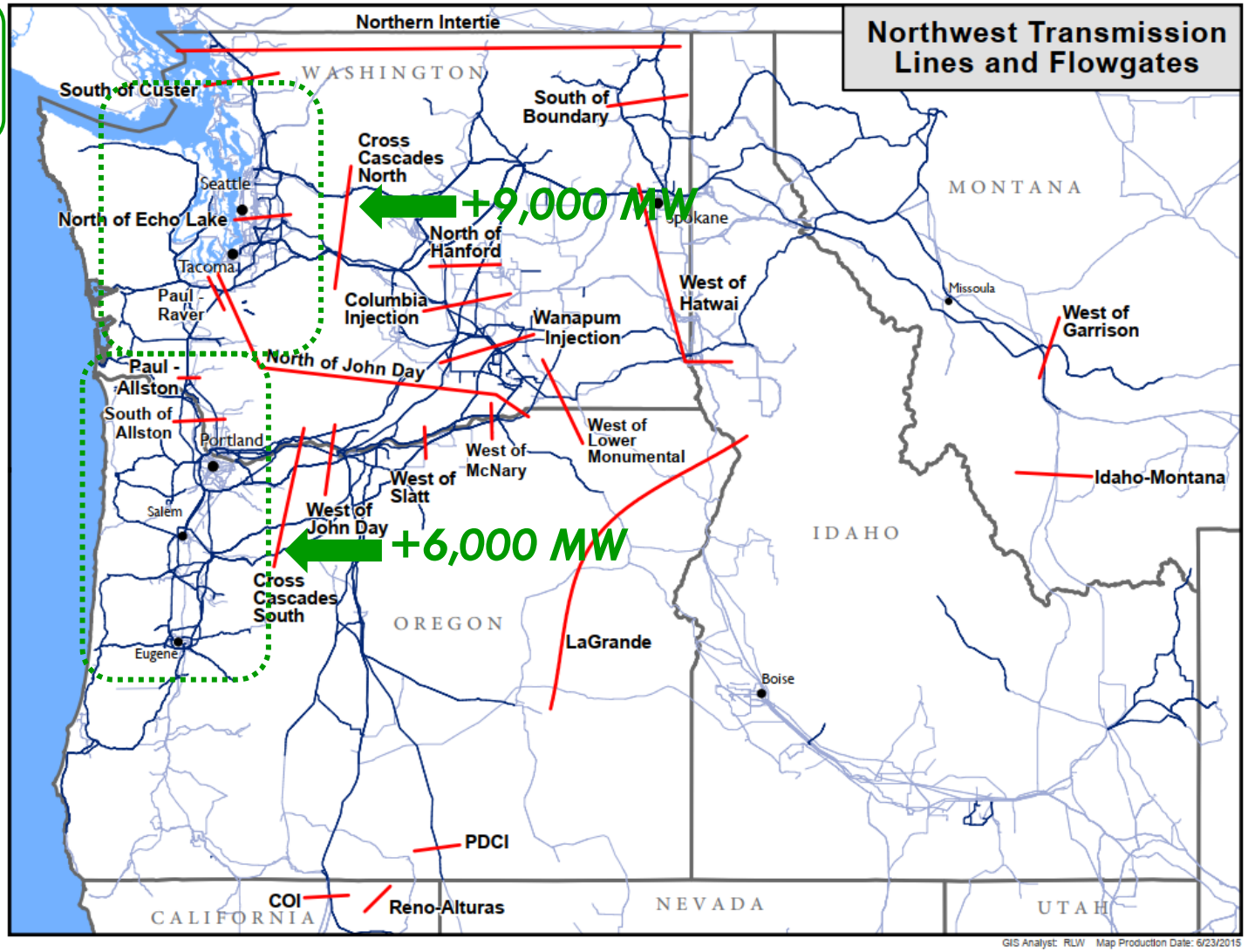
BPA Transmission: *East-to-West Flowgates*

Total West Peak Load = 21,000 MW
(62% of Northwest)

Seattle/West
11,000 MW

Portland/Vancouver/West
10,000 MW

East-to-West Flowgates = +15,000 MW
(74% of West Load Served from East)

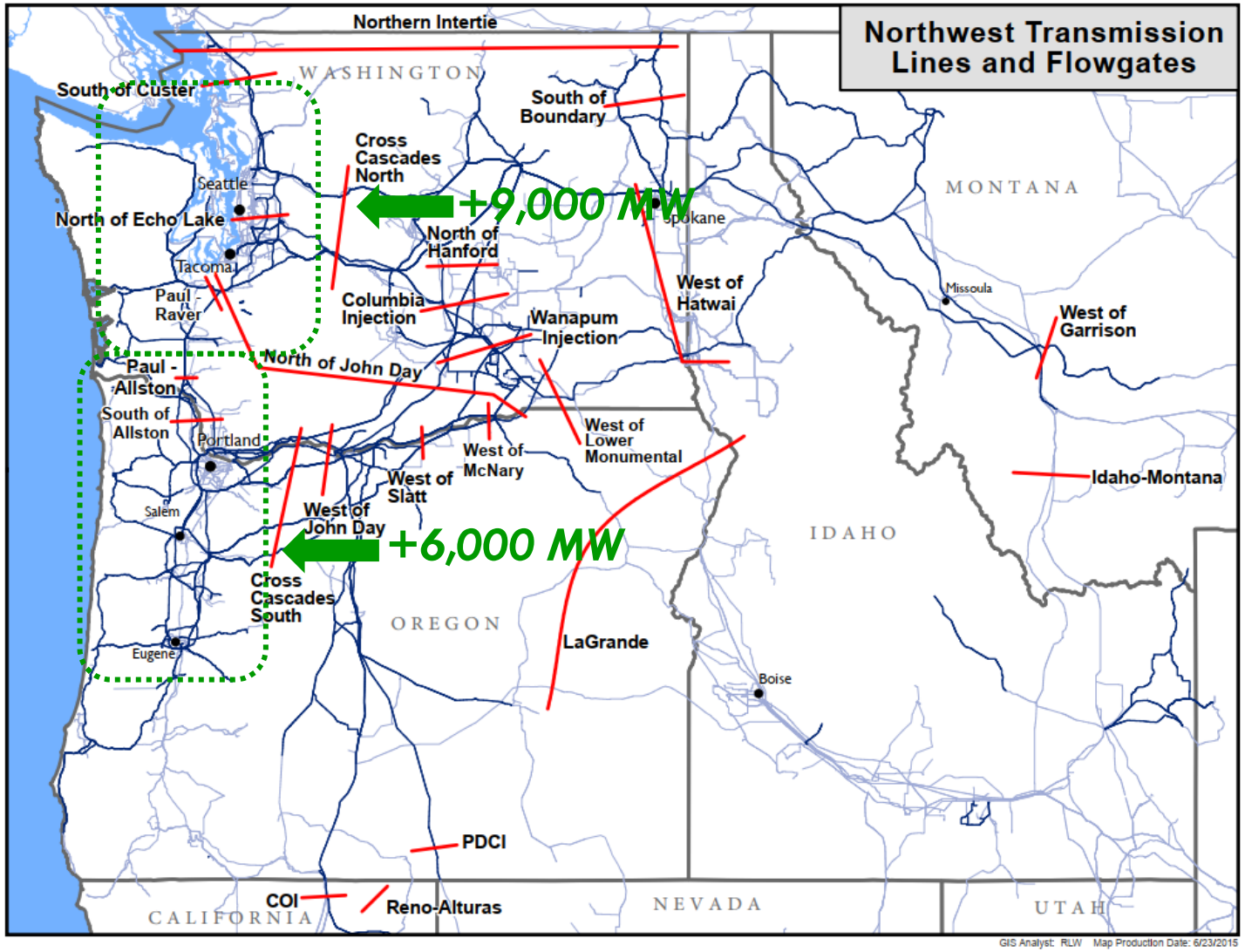


BPA Transmission: *Cascades Bottleneck*

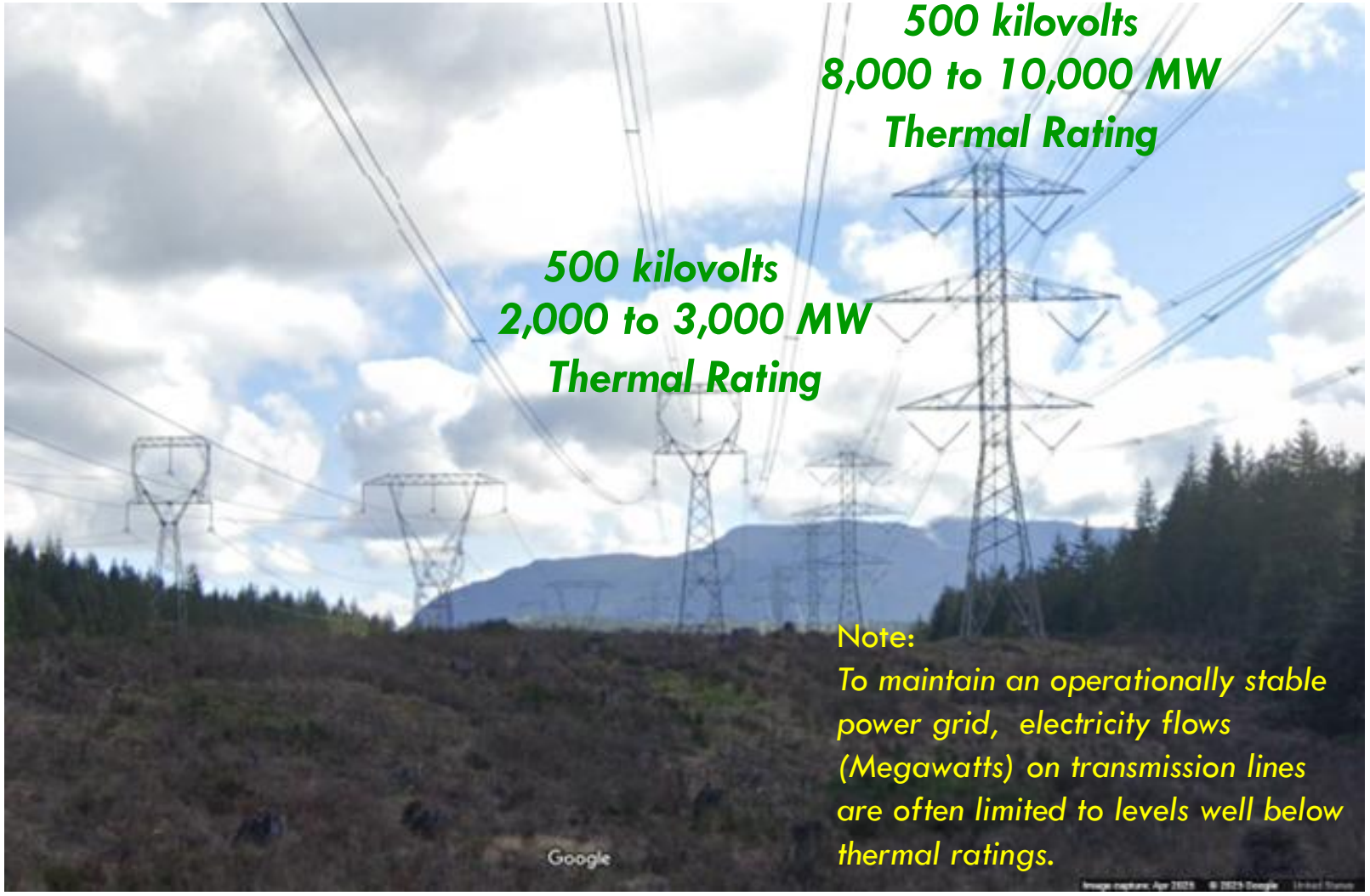
WA & OR Policies Double Demand & Reduce/Eliminate Natural Gas

- ✓ *Feasible Capacity in existing ROW?*
- ✓ *How much New ROW & Where?*

Kirsten Strough/Yakima Basin/Flickr



Transmission Lines: *Anatomy & Megawatts*



3-Phase AC Apparent Power

$$S = \sqrt{3} \times V \times I \; [\cos\varnothing + j \sin\varnothing]$$

$V \times I$ [cosØ + j sinØ] = ***Megawatts (MW)***

How to Double Power (MW)

Double Voltage (V) - pressure

- *increase insulator length*
- *tower height & width*
- *right-of-way width*

Double Current (I) - flow

- *increase conductor (cable) size*
- *cost & weight*
- *tower size & strength*