Is There A Role For Nuclear Power In The Pacific Northwest Now And Into The Future?

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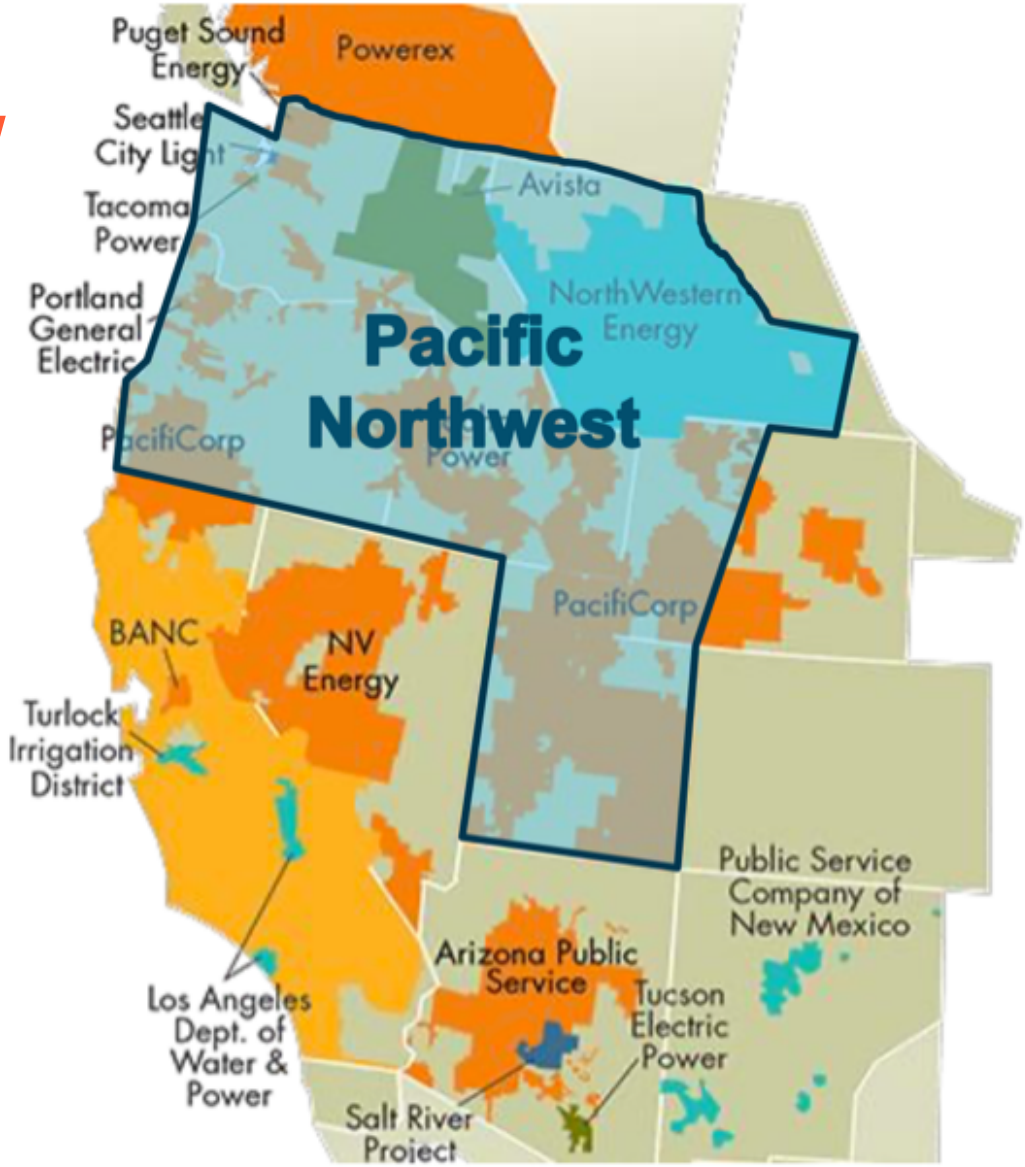
The Pacific Northwest faces a significant power generation capacity shortfall

Near-term (today-2025): the Pacific Northwest faces a near-term capacity shortfall of up to 7 GW

Mid-term (2025-2030): capacity need grows to as much as 10 GW

This was recently highlighted in the June heatwave where Washington and Oregon came extremely close to having rolling blackouts.

For similar reasons, California and Texas are having rolling blackouts during extreme weather, both heat and cold.



Power Grid Reliability Concerns

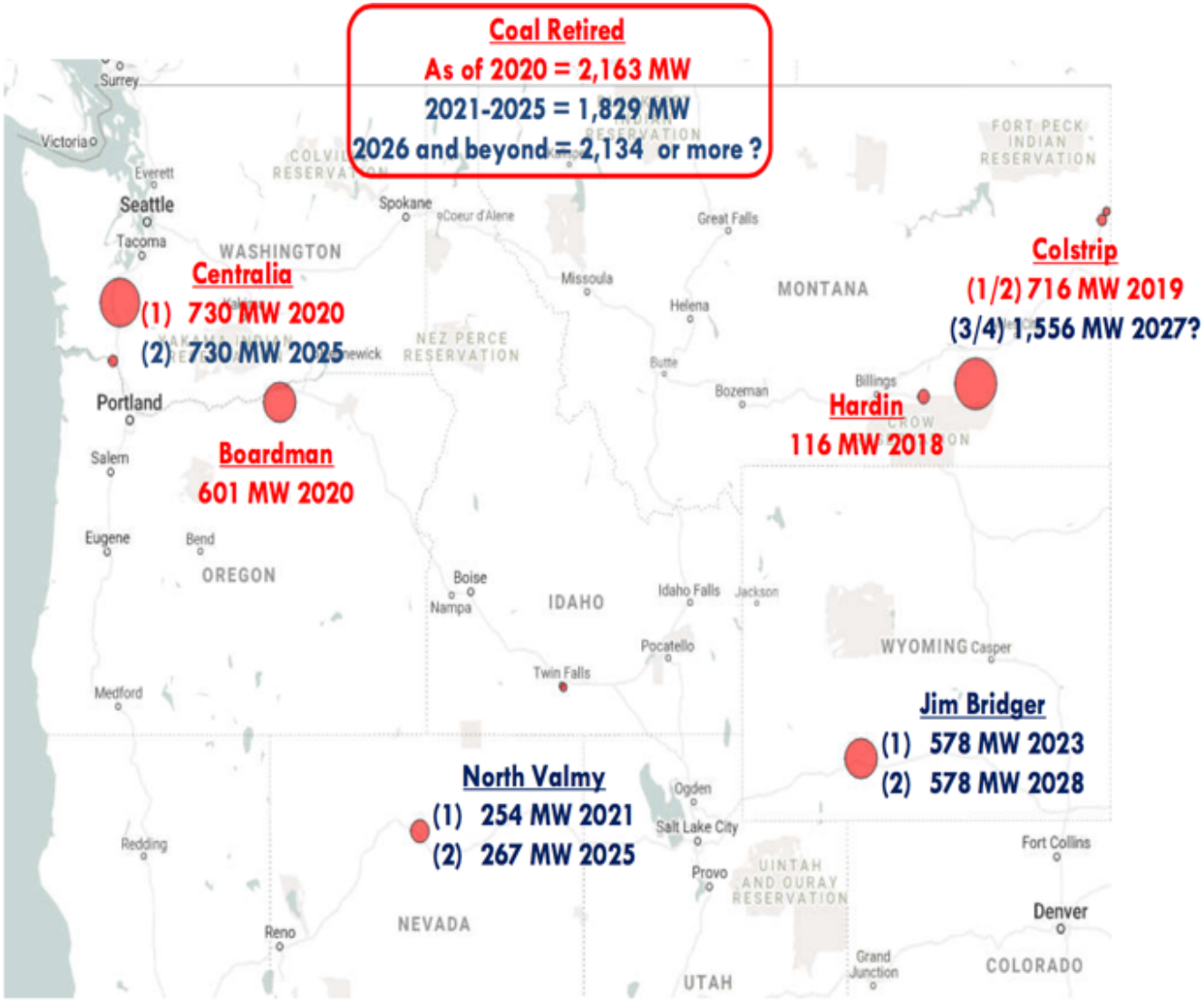
The Washington State Legislature passed the Clean Energy Transformation Act (CETA) in 2019 which requires that all utilities eliminate coal by 2025 and provide carbon neutral electricity by 2030.

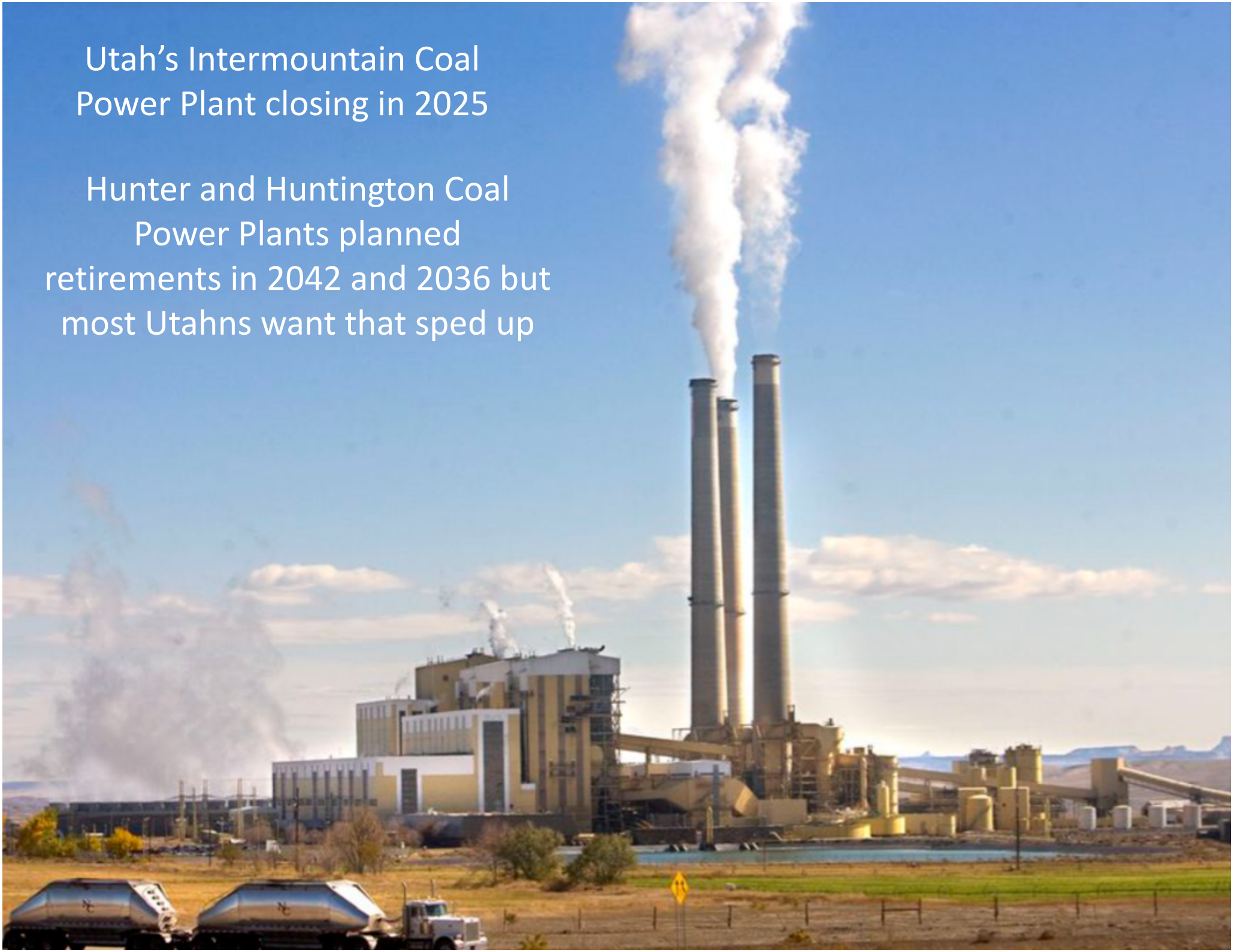
Many stakeholders, utility officials and industry leaders warned that losing baseload sources like coal would increase the probability of brownouts and blackouts if demand increased, a likely occurrence by 2030.

Coal-Fired Power Plant Retirements in the PNW

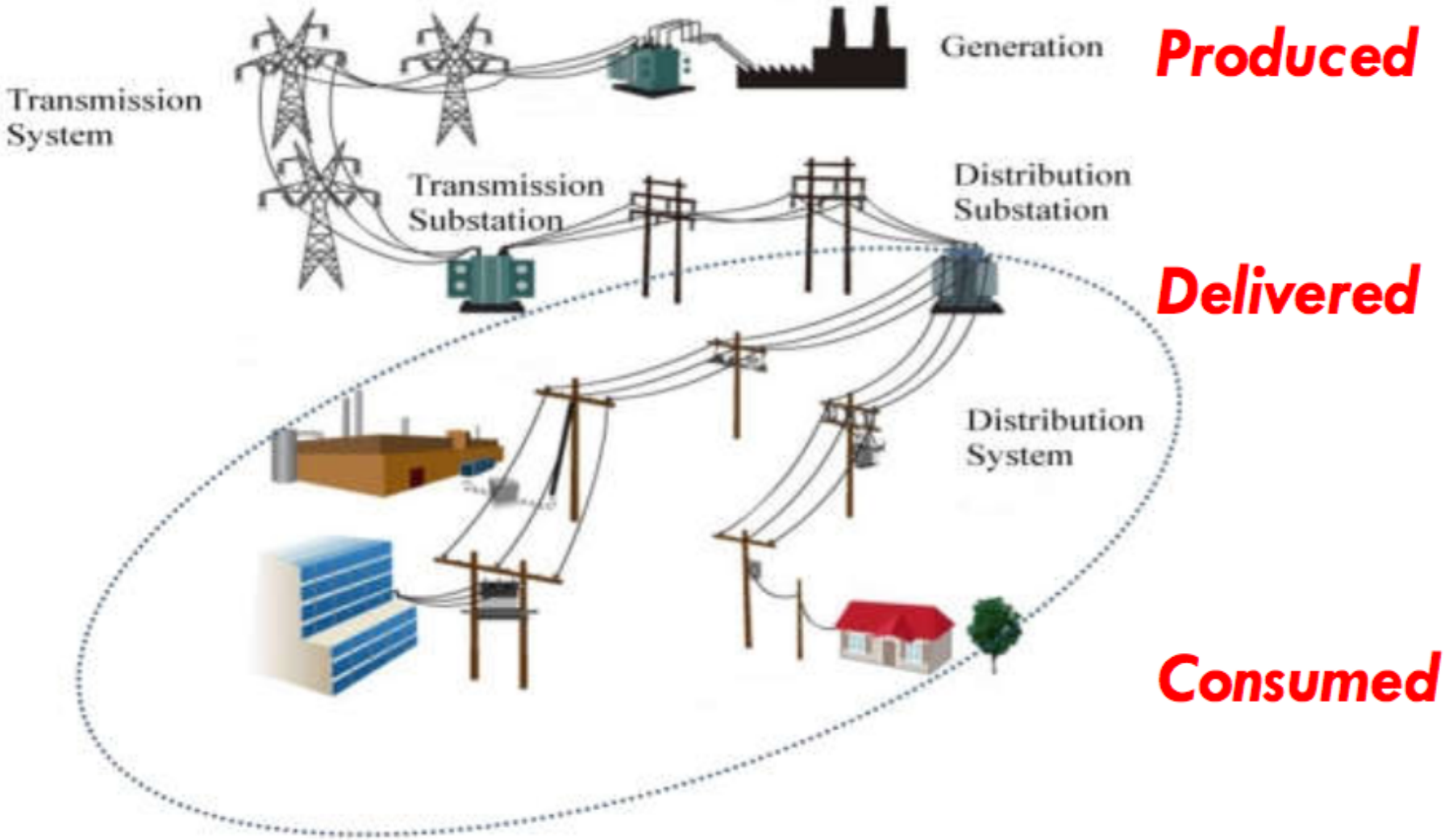
Plant Name	Capacity (MW) [1]	Retirement Year [2]
Hardin	116	2018
Colstrip (1) & (2)	716	2019
Centralia (1)	730	2020
Boardman	601	2020
North Valmy (1)	254	2021
Jim Bridger (1)	578	2023
Centralia Generation (2)	730	2025
North Valmy (2)	267	2025
Colstrip (3) & (4)	1,556	2027 (?)
Jim Bridger (2)	578	2028
TOTAL	6,126	

Notes:
(1) https://www.nwcouncil.org/energy/energy-topics/power-supply/map-of-power-generation-in-the-northwest
(2) Northwest Power and Conservation Council Pacific Northwest Power Supply Adequacy Assessment for 2024 (Assessment Update Figure 2)




Utah's Intermountain Coal Power Plant closing in 2025
Hunter and Huntington Coal Power Plants planned retirements in 2042 and 2036 but most Utahns want that sped up

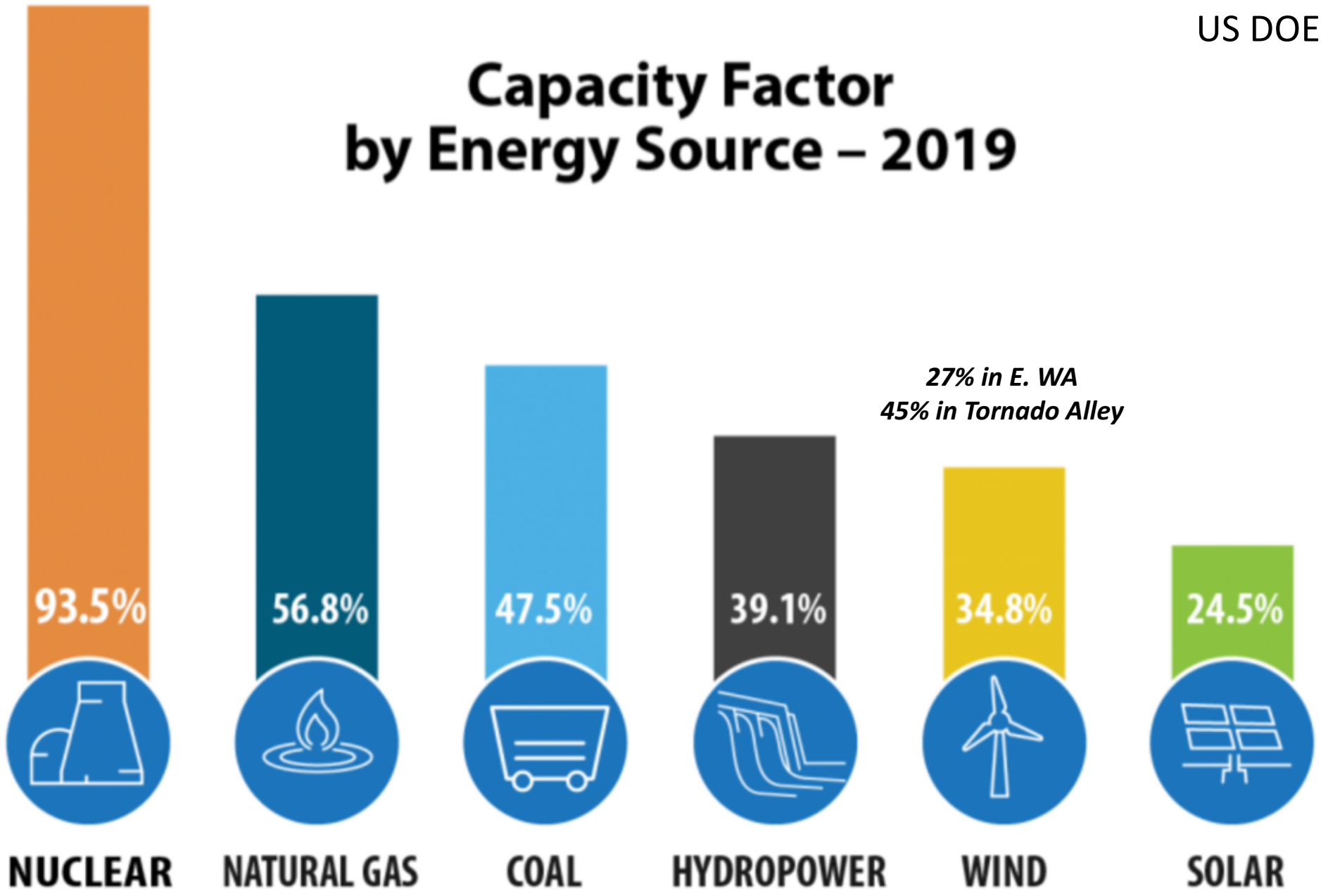
Electricity is Simultaneously…



Nuclear: 8,196,210 MWh/yr x 80 years = 655,696,800 MWh

Wind: 2,366,820 MWh/yr x 25 years = 59,170,500 MWh

US DOE



Load-following or Buffering of Intermittency

With the need for the grid to be completely balanced, and with the intermittent capacity of wind and solar, there has to be firm back-up generation that can be fired up quickly, in minutes to hours, when needed or else blackouts will occur, as occurred recently in Texas and California

- usually natural gas is used, or coal in China, Germany and parts of the mid-west and Texas
- in the Pacific Northwest, eastern Canada and parts of China hydro is used
- pumped hydro storage is used where available, it represents 97% of global storage, batteries are still negligible
- new gravitational potential energy storage shows promise, like pumped hydro
- new Small Modular Reactors are specifically designed for load-following

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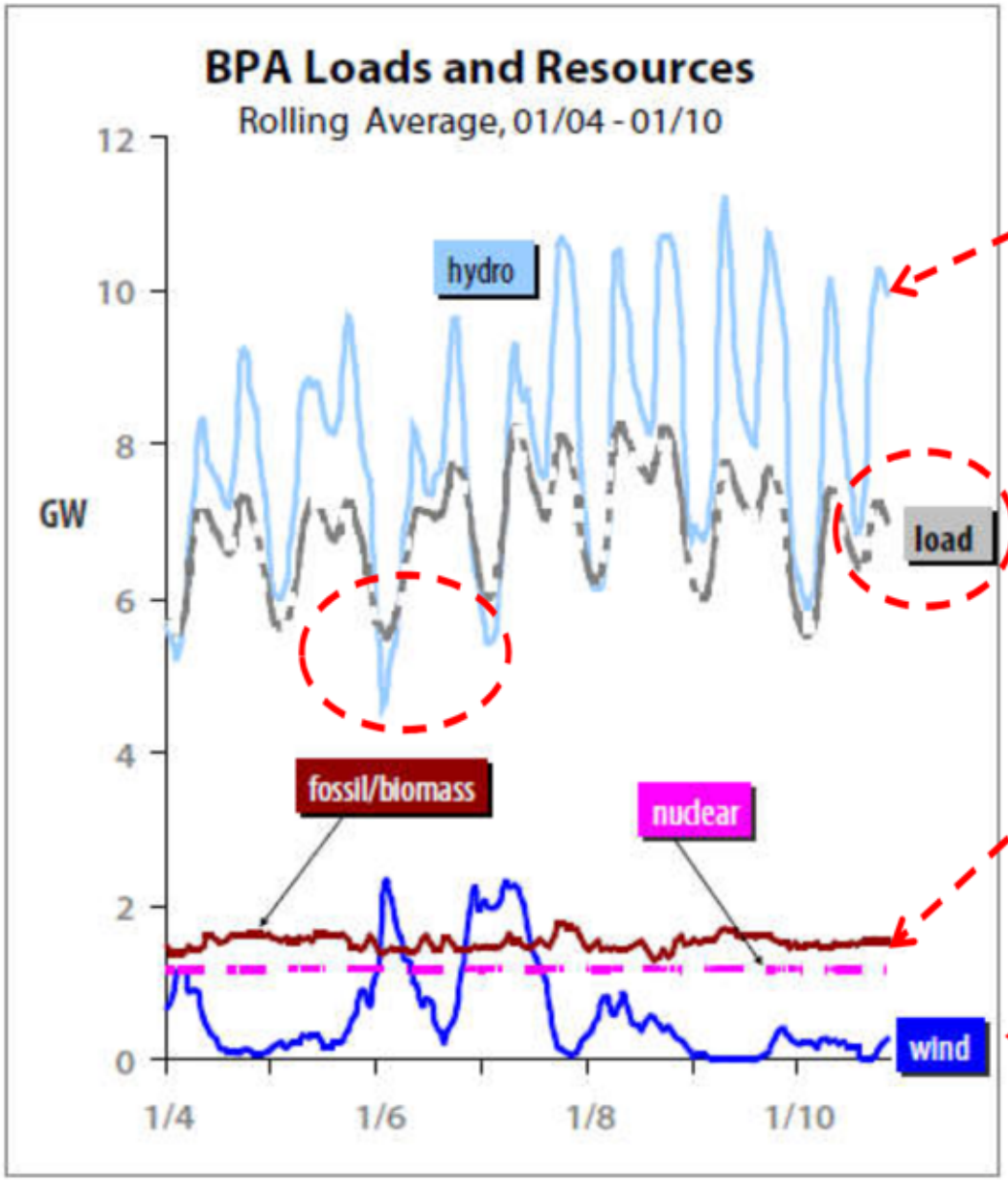
- in the Pacific Northwest where hydro is used to buffer

    - during droughts and heat waves the PNW is in danger. The heat wave here of last June put stress on the system to near the point of failure. BPA said it was lucky they didn't have to implement rolling blackouts, specifically because of the lower four Snake River Dams

Load Balancing in the Pacific Northwest

- it's all about hydro



Hydro-Generation Follows Load
Maintains Demand (Load)
& Supply (Generation Resource) Balance

Thermal Plants Produce
Steady Generation

Wind Displaces Hydro in this Case
(Effectively Negative Load)

The Northwest Power Pool considers an outage risk of <5% to be safe, but they warn that the state faces a 26% probability of an outage from insufficient generation to meet an increased load by 2025.

That increased load-to-generation ratio will come from the loss of coal plants, a slow increase in population and an expected large increase in electric vehicle use, eventually requiring an additional 10 billion kWh/year, the amount generated by our nuclear power plant here in Richland, a full SMR set or two gas plants.

The Problem with Wind

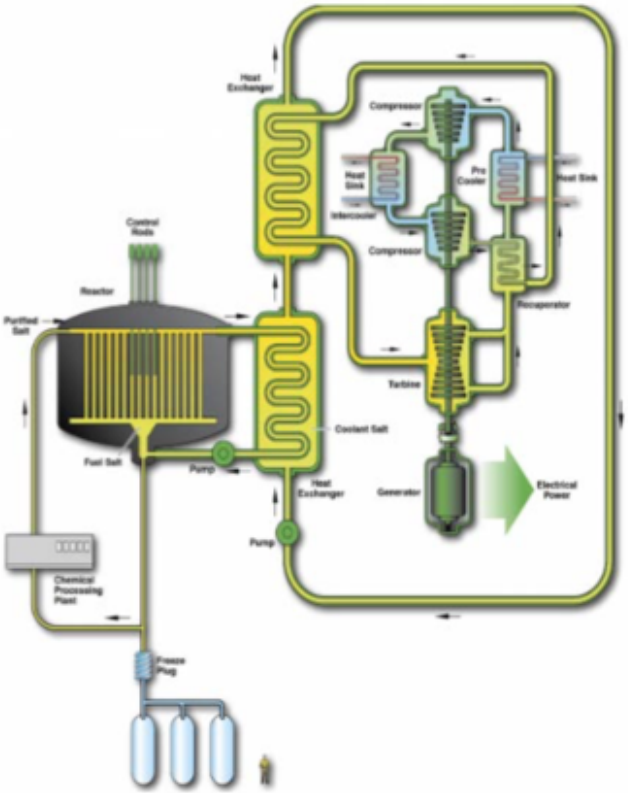
On an annual basis, wind power plants generally generate energy equivalent to about 30% of what they would if the wind blew constantly and the generators were producing at their maximum nameplate rating.

By comparison, our nuclear plant generates over 95% of its maximum nameplate rating year after year.

According to the most recent E3 Northwest Resource Adequacy study, the effective capacity contribution of Washington's 7,100 MW of wind power was determined to be only 7% of its nameplate capacity, that is, only 500 MW of wind power, out of 7,100 MW, can be expected to show up on the coldest or warmest days in the region.

NRC Applications and Pre-Applications for Advanced Nuclear Reactors and Small Modular Reactors

- NuScale – 60 MWe SMR x 12 modules
- Holtec SMR-160 – 160 MWe SMR
- GEH BWRX-300 – 300 MWe SMR
- Oklo Aurora – 1.5 MWe fast reactor
- X-energy – 80 MWe high-temperature gas reactor
- Kairos Power – 140 MWe molten salt cooled with TRISO fuel
- Terrestrial Energy – 200 MWe liquid fuel molten salt reactor
- TerraPower – molten salt fast reactor
- Westinghouse – 200 kWe to 5 MWe
- General Atomics – gas cooled fast reactor



ARDP Demonstration Awards

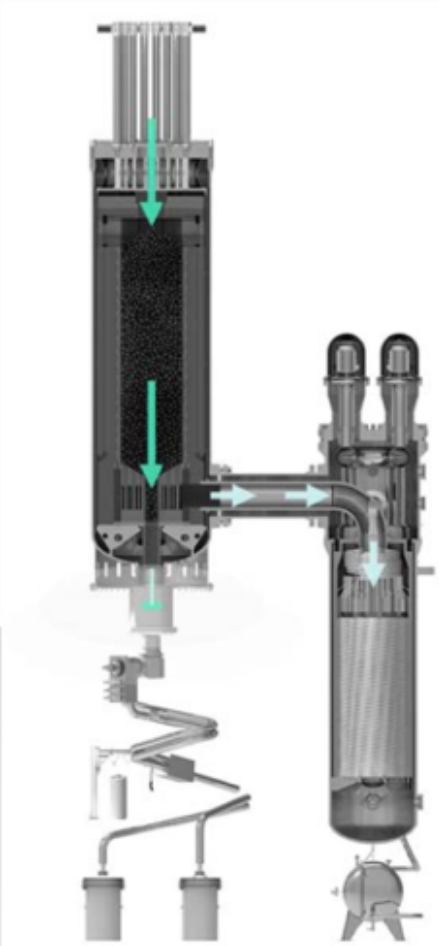
- TerraPower Natrium Reactor
  - Liquid sodium fast reactor - 345 MWe
  - Metallic fuel
  - Molten salt thermal storage for peaking to 500 MWe

- Looking to build on the sites of existing coal plants in WY or CO to show how easy it is to replace them and use existing infrastructure

ARDP Demonstration Awards

- X-energy Xe-100
  - Pebble bed Helium cooled gas reactor – 80 MWe
  - Four reactors
  - TRISO fuel

TRISO Fuel Pebble Cutaway



- To be built on Energy Northwest's site in Richland under their existing license and permits

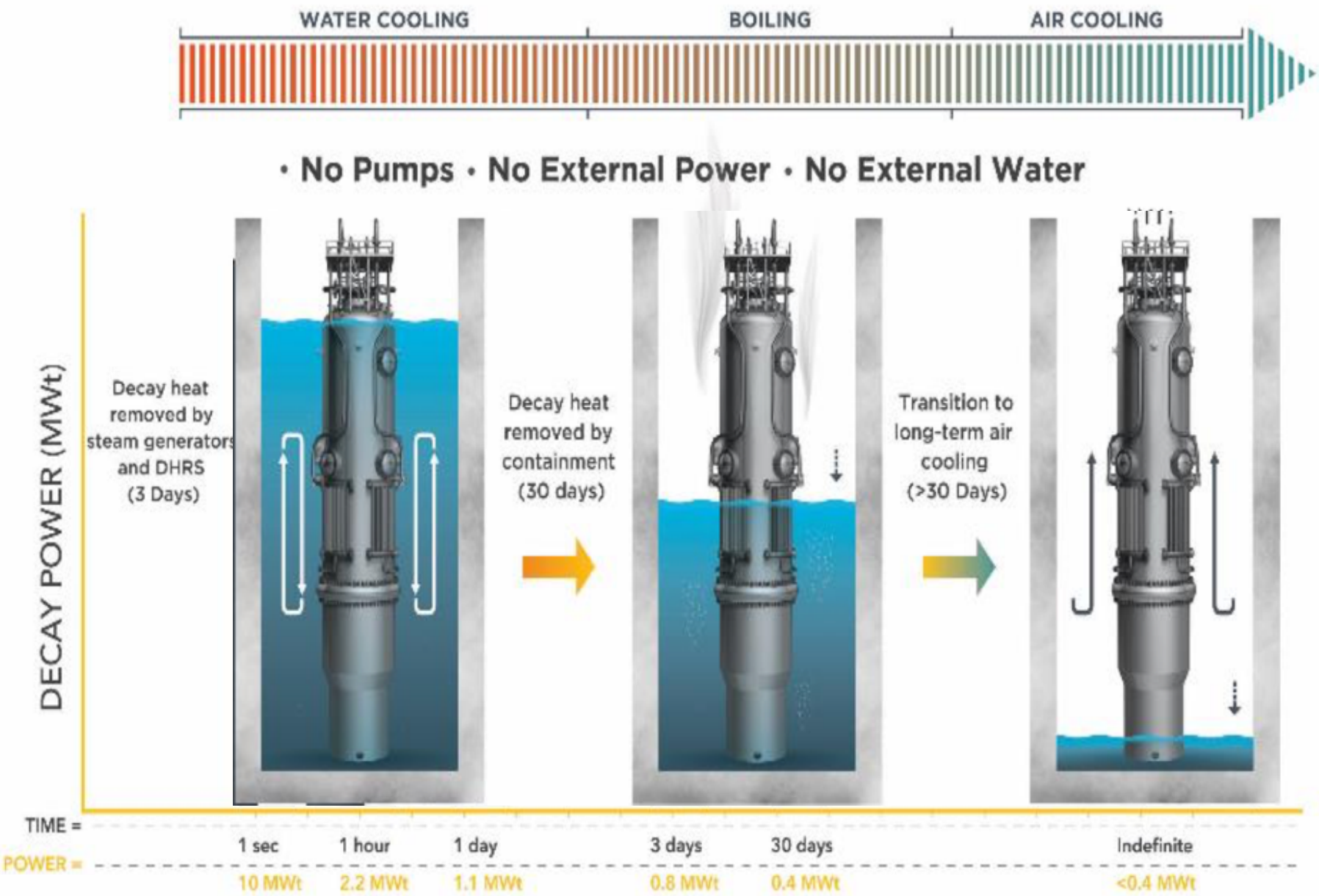
UAMPS

- Utah Associated Municipal Power Systems (UAMPS) plans to construct and operate a NuScale reactor at Idaho National Lab around 2029

- Primarily to load-follow their new wind farms

- DOE approved $1.4 billion multi-year cost share in October 2020 for UAMPS

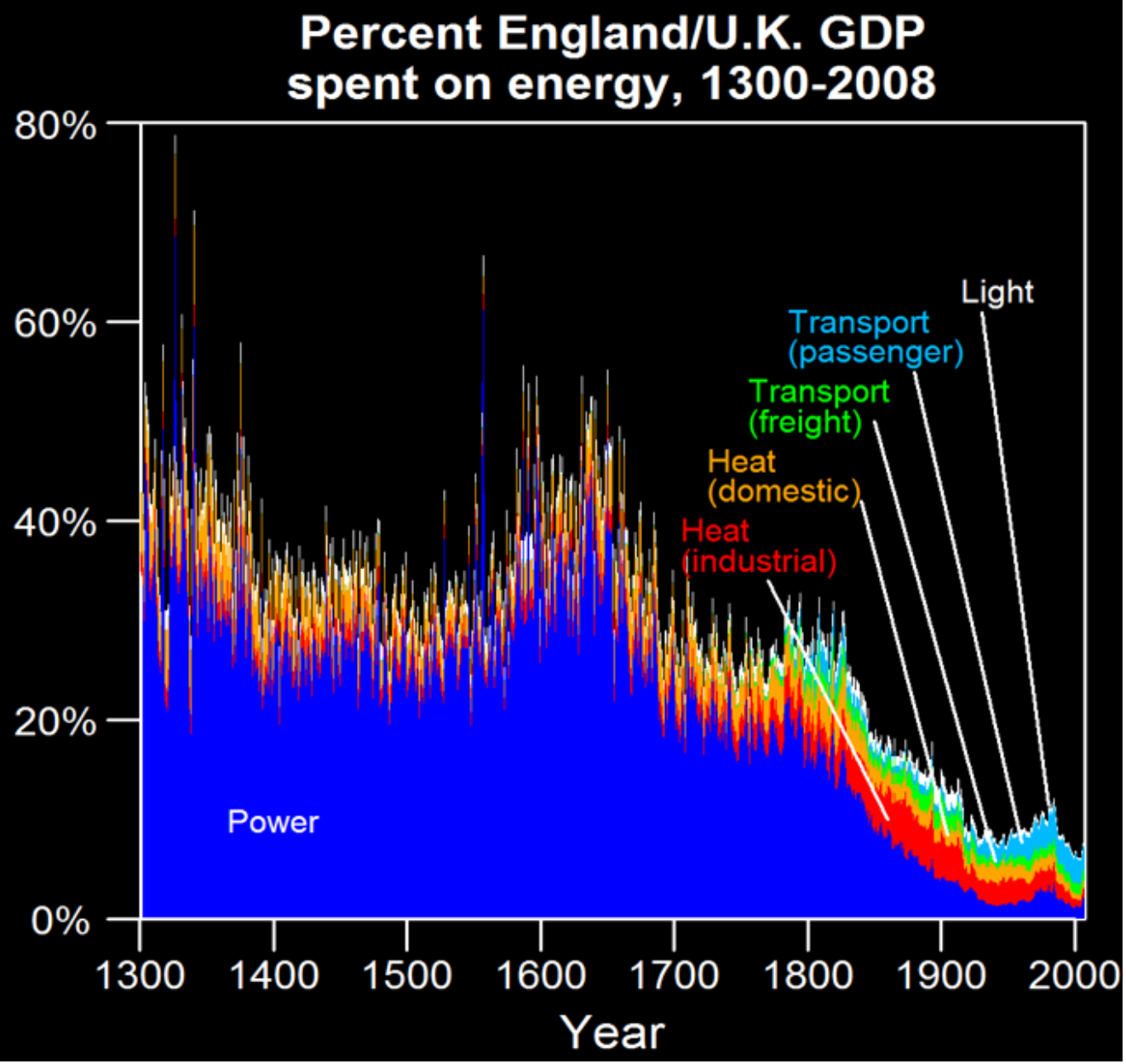
SMRs cannot melt down - small means high SA/V ratio – heat bleeds off quickly



Energy has never been cheaper than it is now

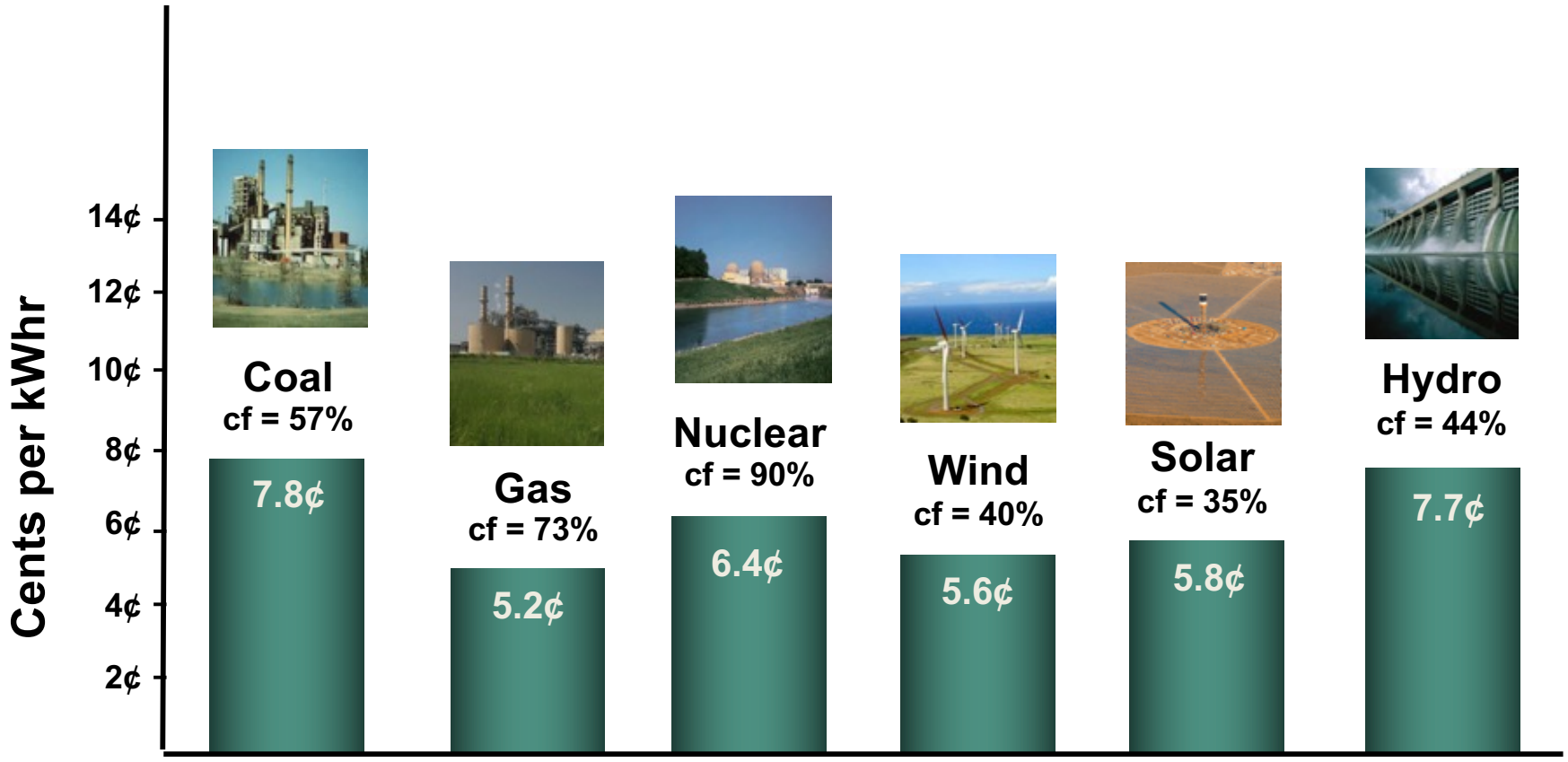
Spending on energy did not fall below 20% of GDP until the middle of the 1800's - the beginning of the fossil fuel age

In the preindustrial era, food was fuel for power as well as for life



Courtesy of Carey King, UT Austin

How Much Will A New Energy Mix Cost?



Levelized Costs per kWhr
(Northwest Integrated Resource Plan)

The problem is that LCOE does not capture indirect costs which are large for renewables and small for nuclear and gas

IHS Markit conducted an analysis of renewable energy costs that accounted for regional wind capacity and solar intensity, and full integration costs (adjusting for the all-in costs of firming (load-following), integration with battery storage, transmission requirements and renewable integration).

According to the IHS study, all-in, going-forward cost of power is

- 4.5¢/kWh for existing nuclear
- 5.9¢/kWh for new gas, 7.7¢for new gas net-zero (if that's even an option)
- 6.9¢/kWh for new nuclear
- 8.9¢/kWh for wind (includes tax-payer subsidy)
- 9.8¢/kWh for solar (includes tax-payer subsidy)

Remember that tax-payer subsidies do not reduce costs, they just shift costs from the ratepayers to the tax-payers.

It matters where you put power plants

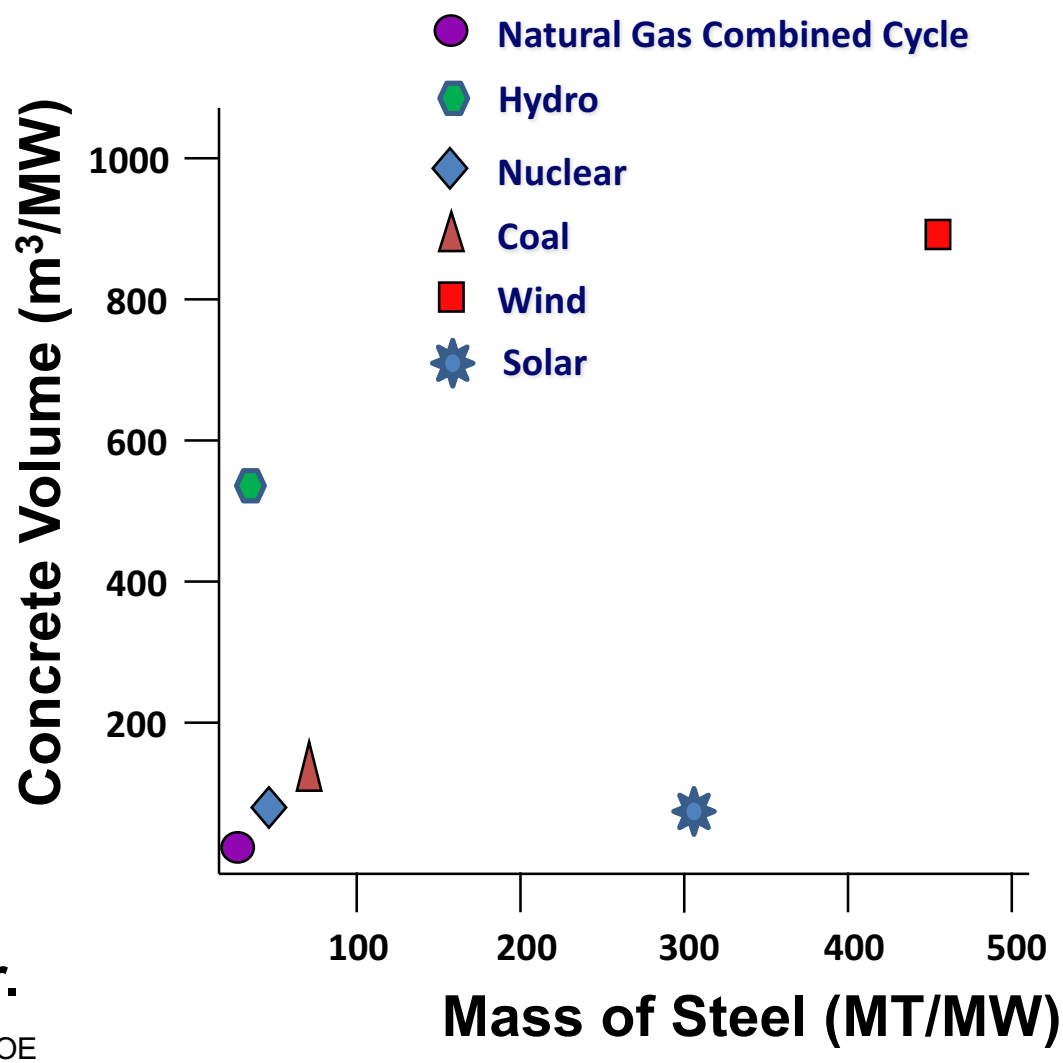
Mundane Logistical Hurdles Rarely Discussed

Concrete + steel + copper are > 98% of construction inputs, and become more expensive in a carbon-constrained economy

What determines the cost of power?

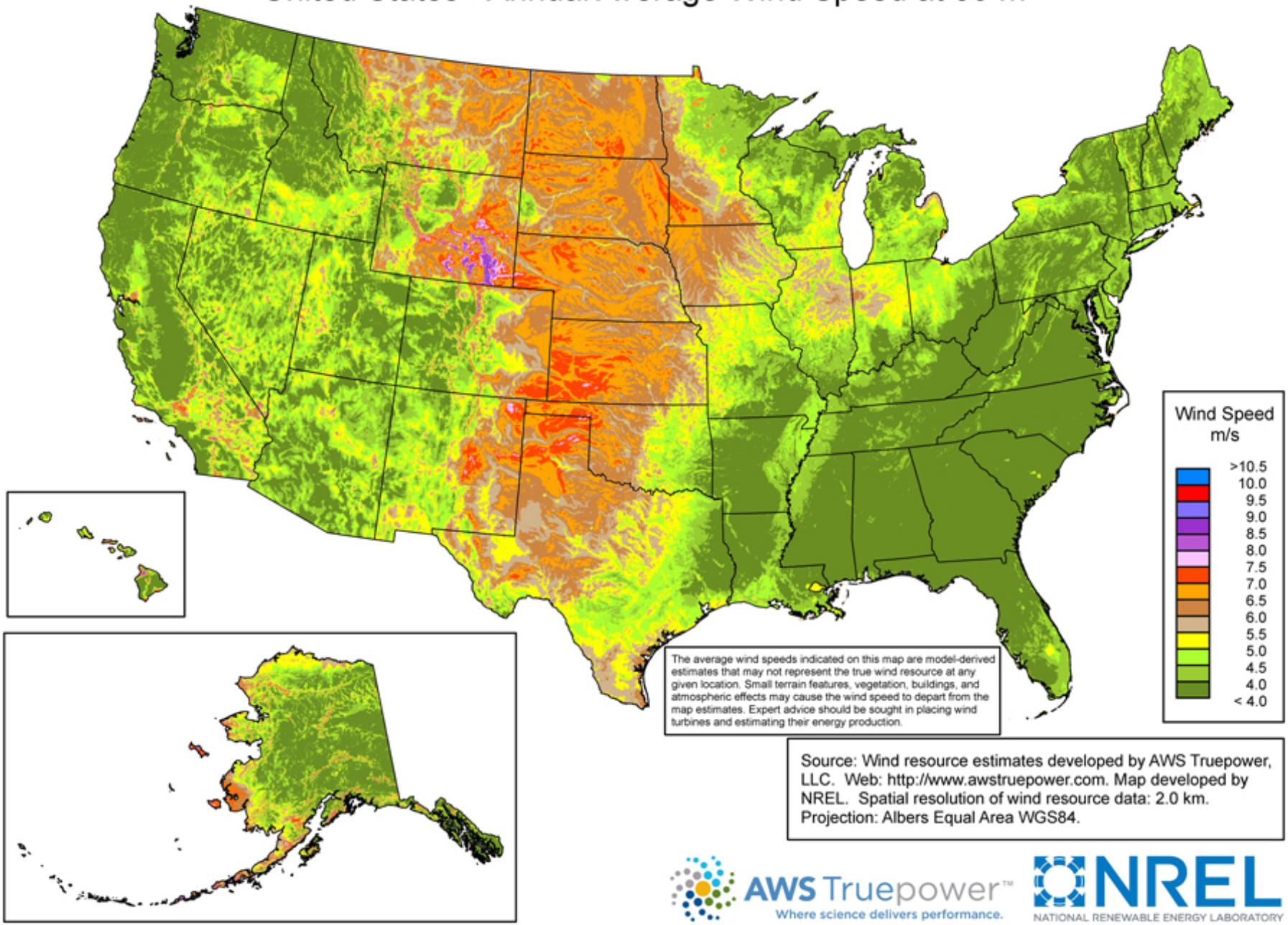
- the price of oil
- the price of natural gas
- the price of steel
- the price of concrete
- the price of copper and rare metals like Li

The most sensitive to these prices is wind energy, followed by coal, then gas. The least affected is nuclear.



data from Per Peterson, Berkeley and DOE

United States - Annual Average Wind Speed at 30 m



The average wind speeds indicated on this map are model-derived estimates that may not represent the true wind resource at any given location. Small terrain features, vegetation, buildings, and atmospheric effects may cause the wind speed to depart from the map estimates. Expert advice should be sought in placing wind turbines and estimating their energy production.

Source: Wind resource estimates developed by AWS Truepower, LLC. Web: http://www.awstruepower.com. Map developed by NREL. Spatial resolution of wind resource data: 2.0 km. Projection: Albers Equal Area WGS84.

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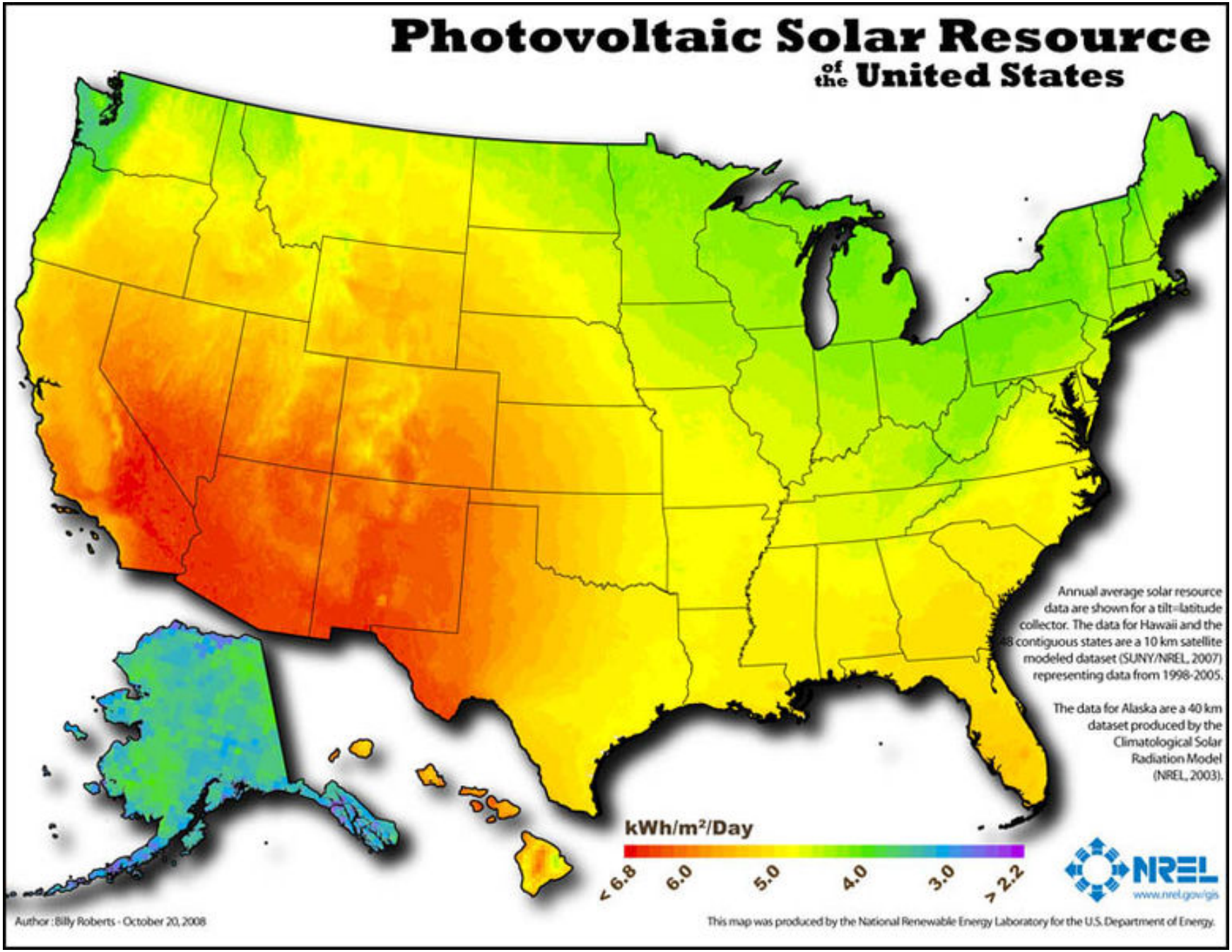
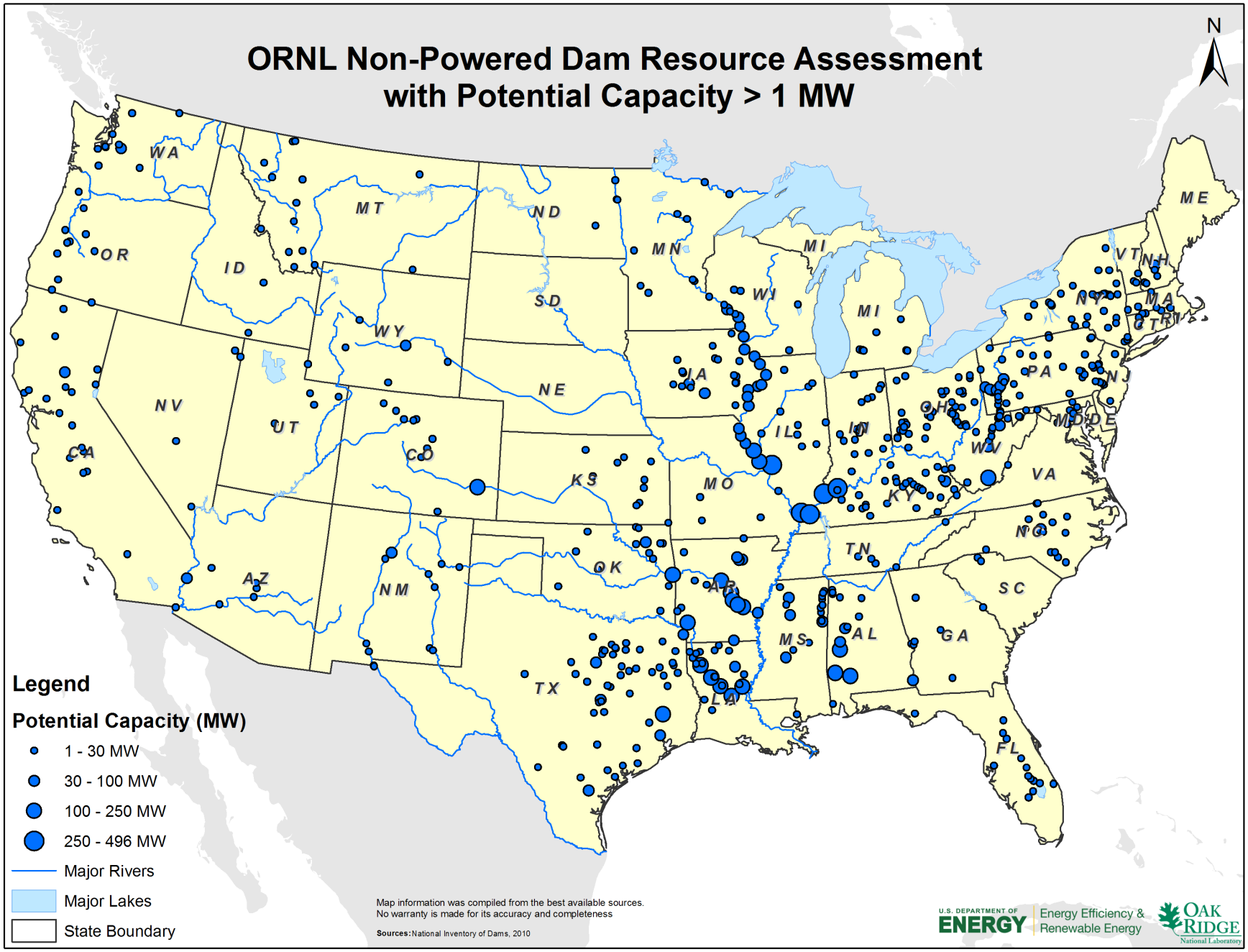
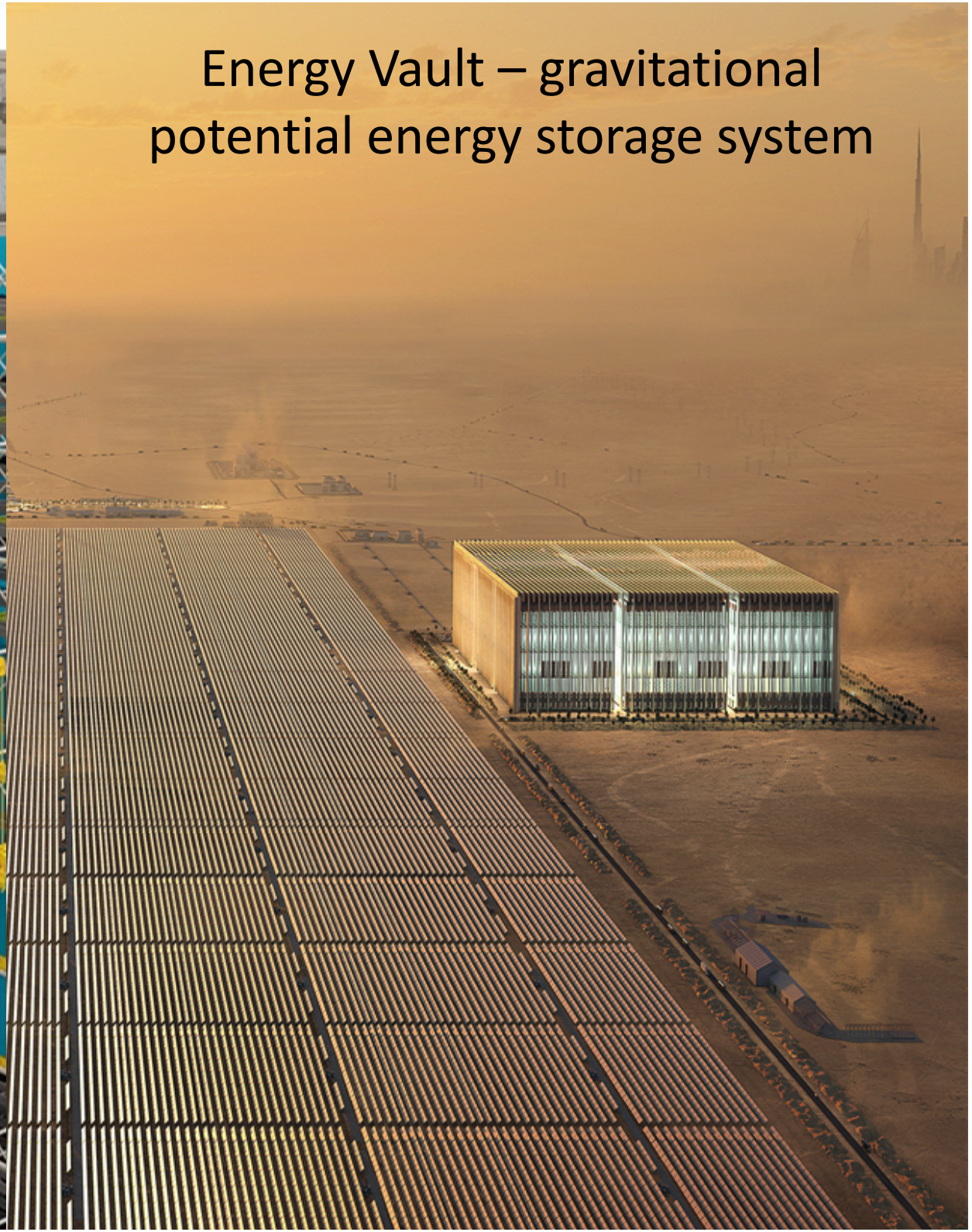

Photovoltaic Solar Resource
of the United States
Annual average solar resource data are shown for a tilt=latitude collector. The data for Hawaii and the 48 contiguous states are a 10 km satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2005.
The data for Alaska are a 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003).
kWh/m²/Day
< 6.8
6.0
5.0
4.0
3.0
> 2.2
NREL
www.nrel.gov/gis
Author : Billy Roberts - October 20, 2008
This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.

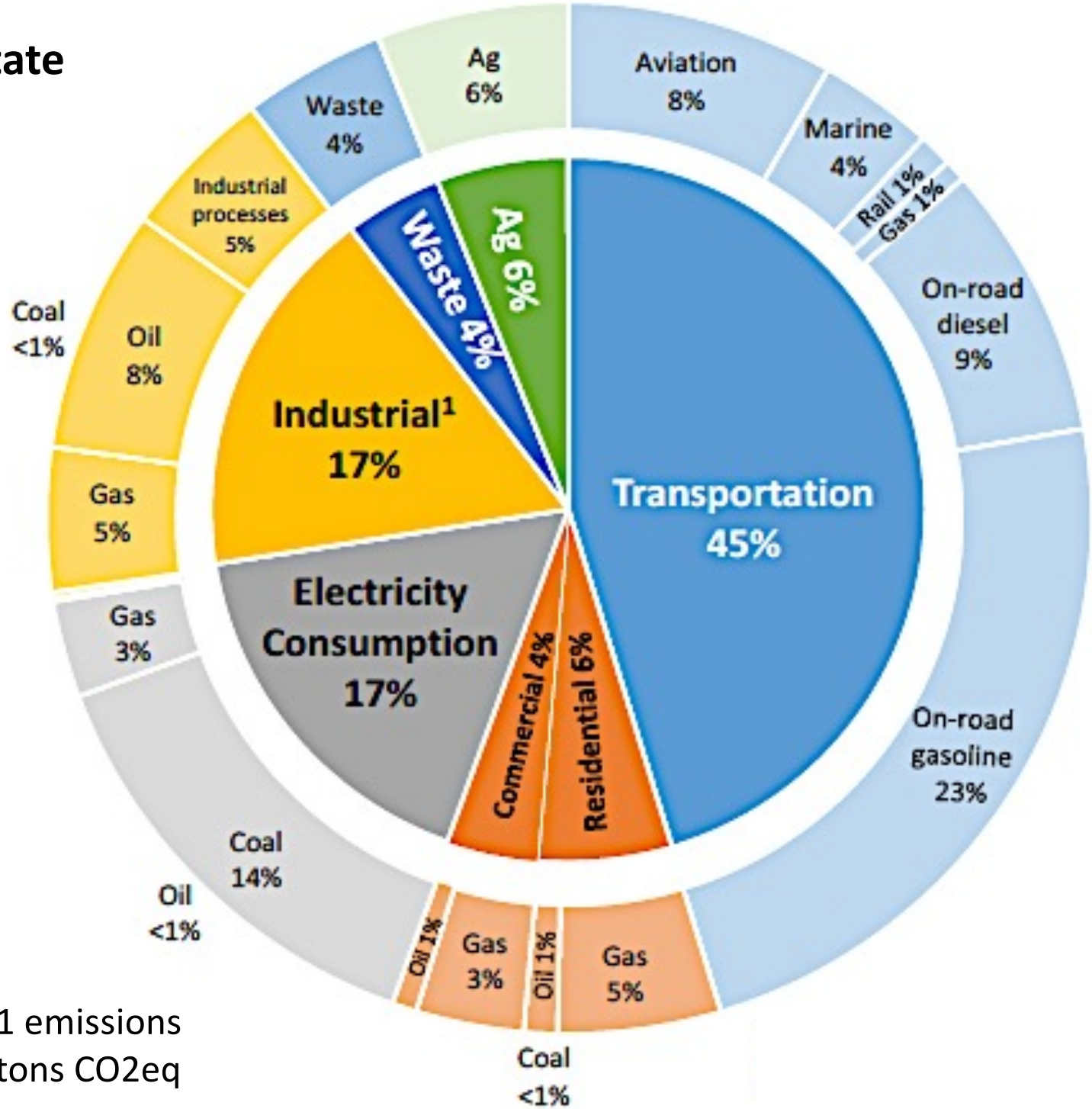
DOE/ORNL: 12 GW at over 54,000 sites - Only 3% of our 80,000 dams generate power, mostly owned by the Army Corps - 8 GW in top 100 sites





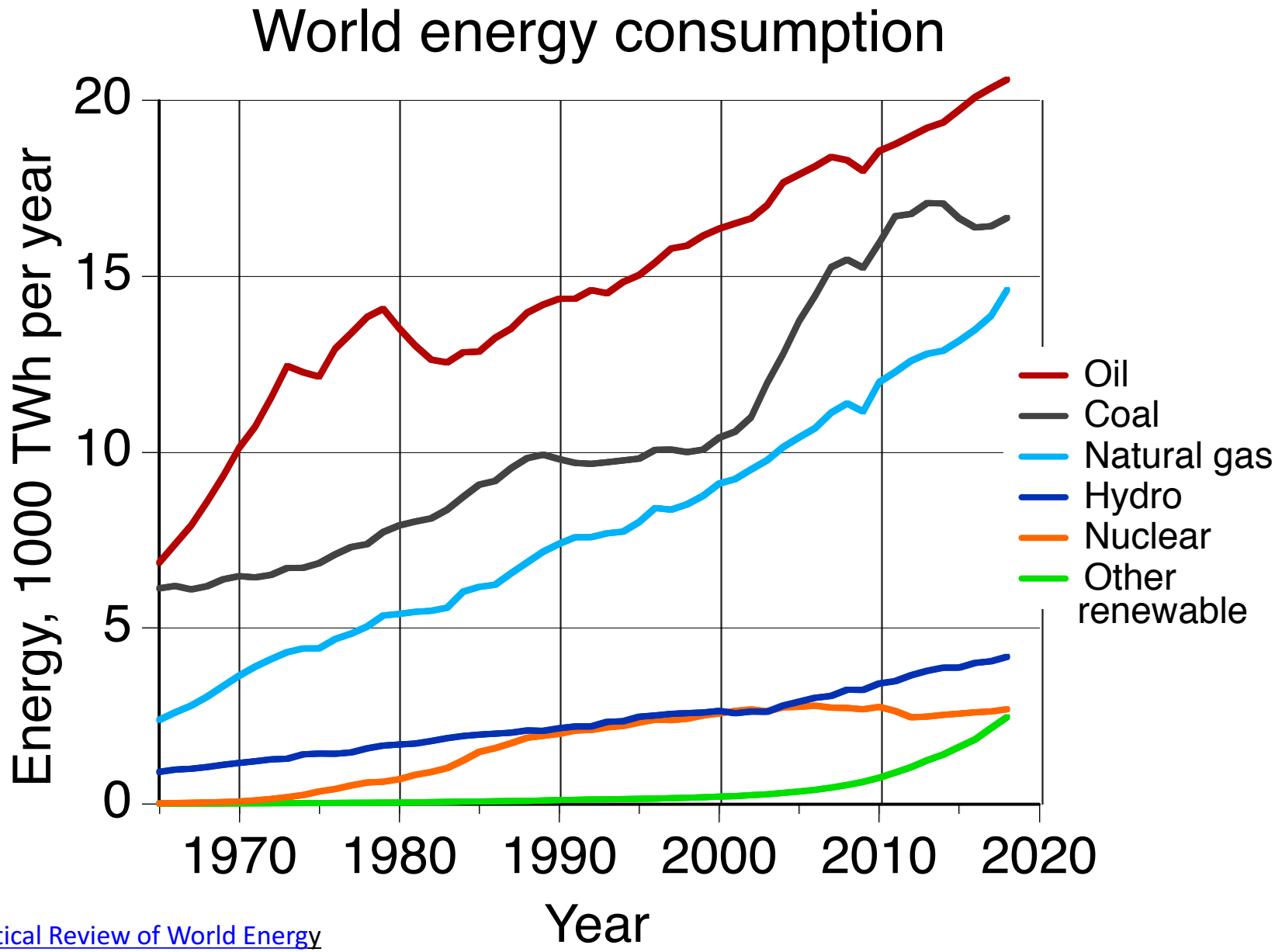
Energy Vault – gravitational potential energy storage system

Washington State
Carbon emissions
by sector



Total projected 2021 emissions
= 91 million metric tons CO2eq

What are the fastest growing energy sources in the world?



BP Statistical Review of World Energy