ENERGY NORTHWEST

Next Generation Nuclear
The Key to a Clean Energy Future

Greg Cullen, Vice President, Energy Services and Development

Energy Northwest

CMBG Annual Meeting

July 11-13, 2022

Energy Northwest

A not-for-profit Municipal Corporation

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

100% Clean Generating Portfolio

Nine Canyon Wind Project (96 MW)

Columbia Generating Station (1,207 MW)

Horn Rapids Solar, Storage & Training Project (4 MW)

White Bluffs Solar Station (38 KW)

Portland Hydroelectric Project (37.5 MW)

Tieton Hydroelectric Project (15 MW)

Packwood Lake Hydroelectric Project (27 MW)

Stone Creek Hydroelectric Project (12 MW)

Ruby Flats Solar Project (150 MW)

Transition in the Northwest Power Industry

Focus on carbon reduction

Increasing capacity challenges

Bonneville Power Administration contracts

West Coast Carbon & Climate Policies

Washington's Clean Energy Transformation Act (CETA)

- Zero Coal by 2025
- Carbon neutral by 2030
- Carbon-free by 2045

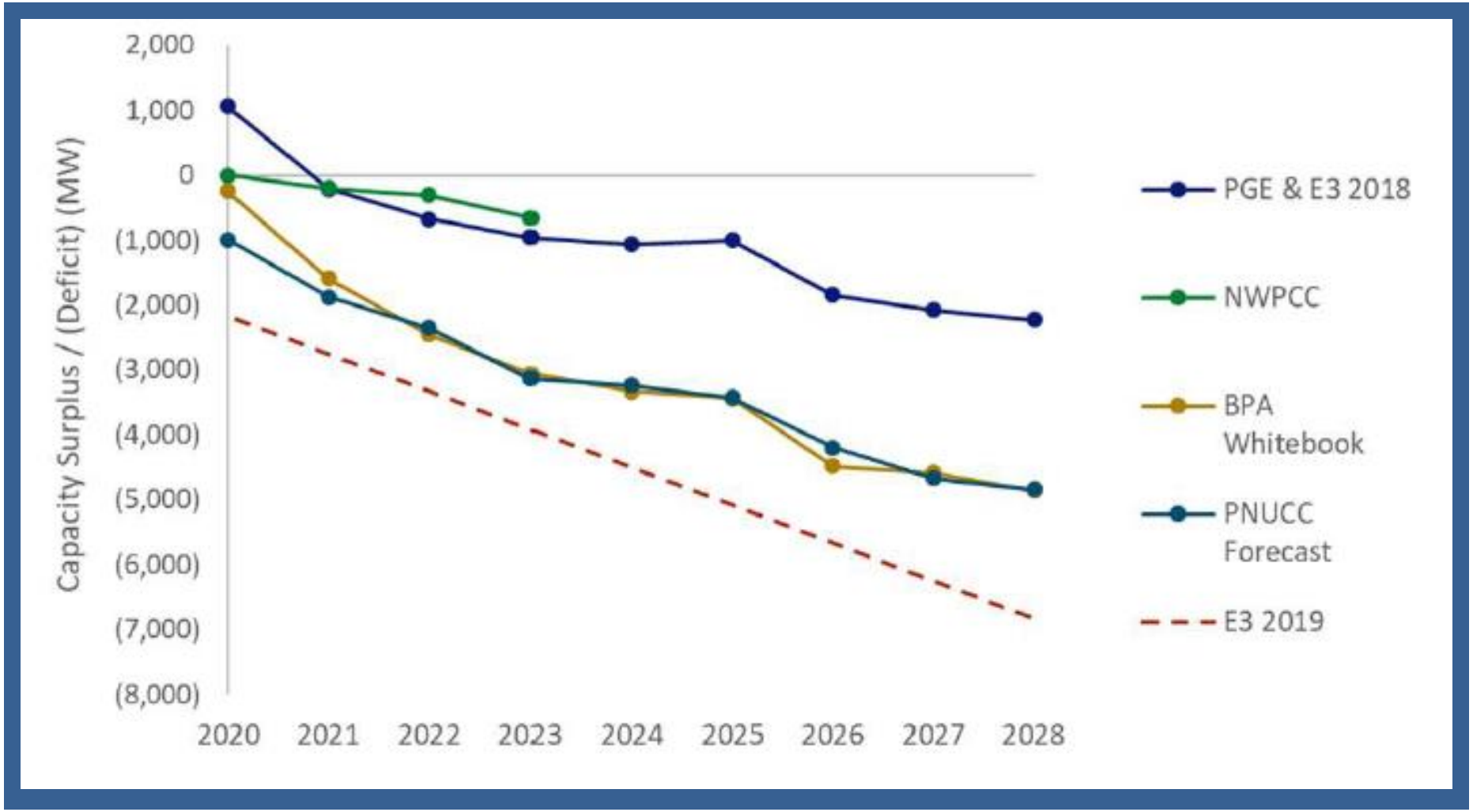
Oregon Clean Energy Standard (H.B. 2021)

- Requires utilities to reduce emissions by 80% from a baseline amount by 2030, 90% by 2035 and 100% by 2040
- 50% of electricity must come from renewable resources

California Renewable Portfolio Standard/Clean Energy Standard

- RPS is increased to 50% by 2025 and 60% by 2030
- 100% carbon-free electricity by 2045

NW Capacity Surplus/ Deficit in Recent Studies



Resource Adequacy in the Pacific Northwest

Serving Load Reliably under a Changing Resource Mix

January 2019

Arne Olson, Sr. Partner
Zach Ming, Managing Consultant

2018 Load and Resource Balance

	2018
Load (GW)	
Peak Load	43
PRM (%)	*12%*
PRM	5
Total Load Requirement	48

Resources / Effective Capacity (GW)	
Coal	11
Gas	12
Bio/Geo	1
Imports	3
Nuclear	1
DR	0.3
Hydro	18
Wind	0.5
Solar	0.2
Storage	0
Total Supply	47

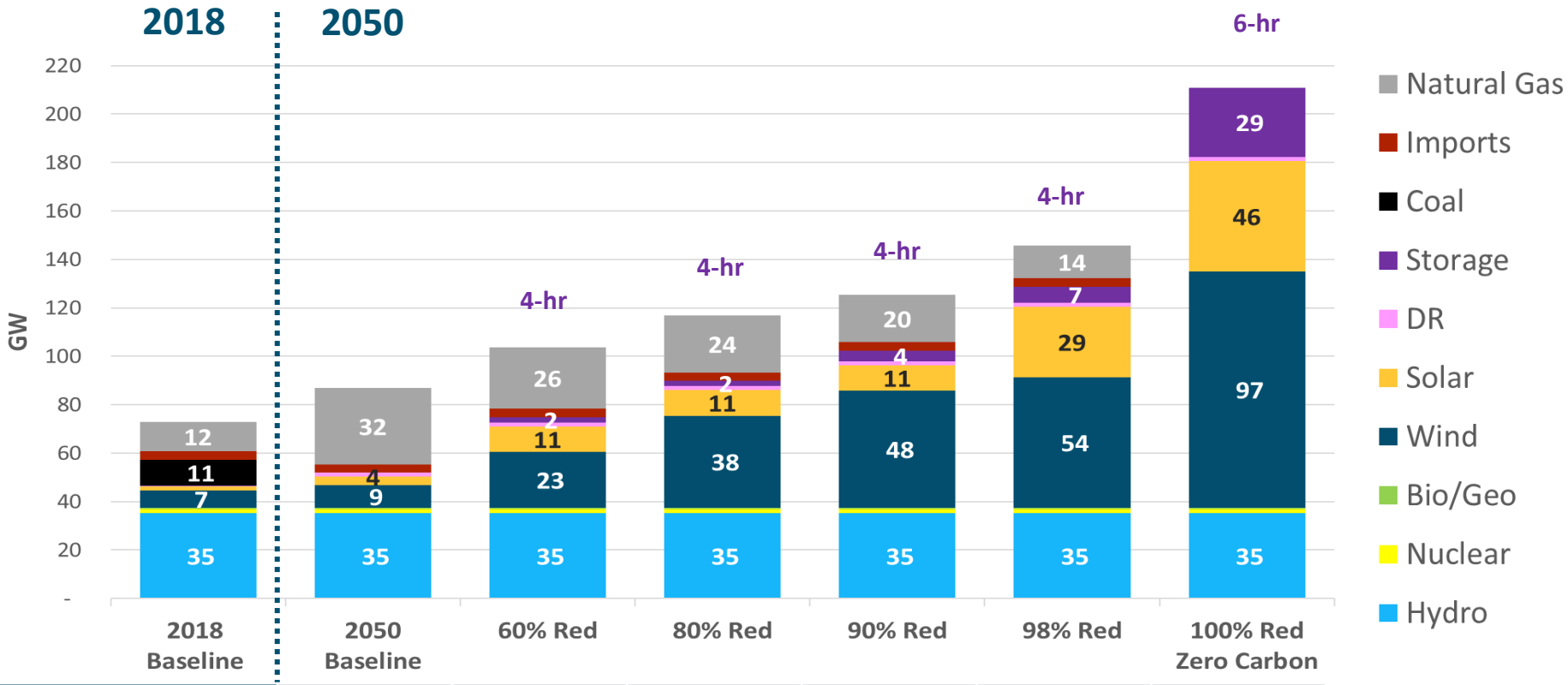
Wind and solar contribute little effective capacity with ELCC* of 7% and 12%

Nameplate Capacity (GW)	ELCC* (%)	Capacity Factor (%)
35	*53%*	*44%*
7.1	*7%*	*26%*
1.6	*12%*	*27%*

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

Scenario Summary

2050 Resource Use

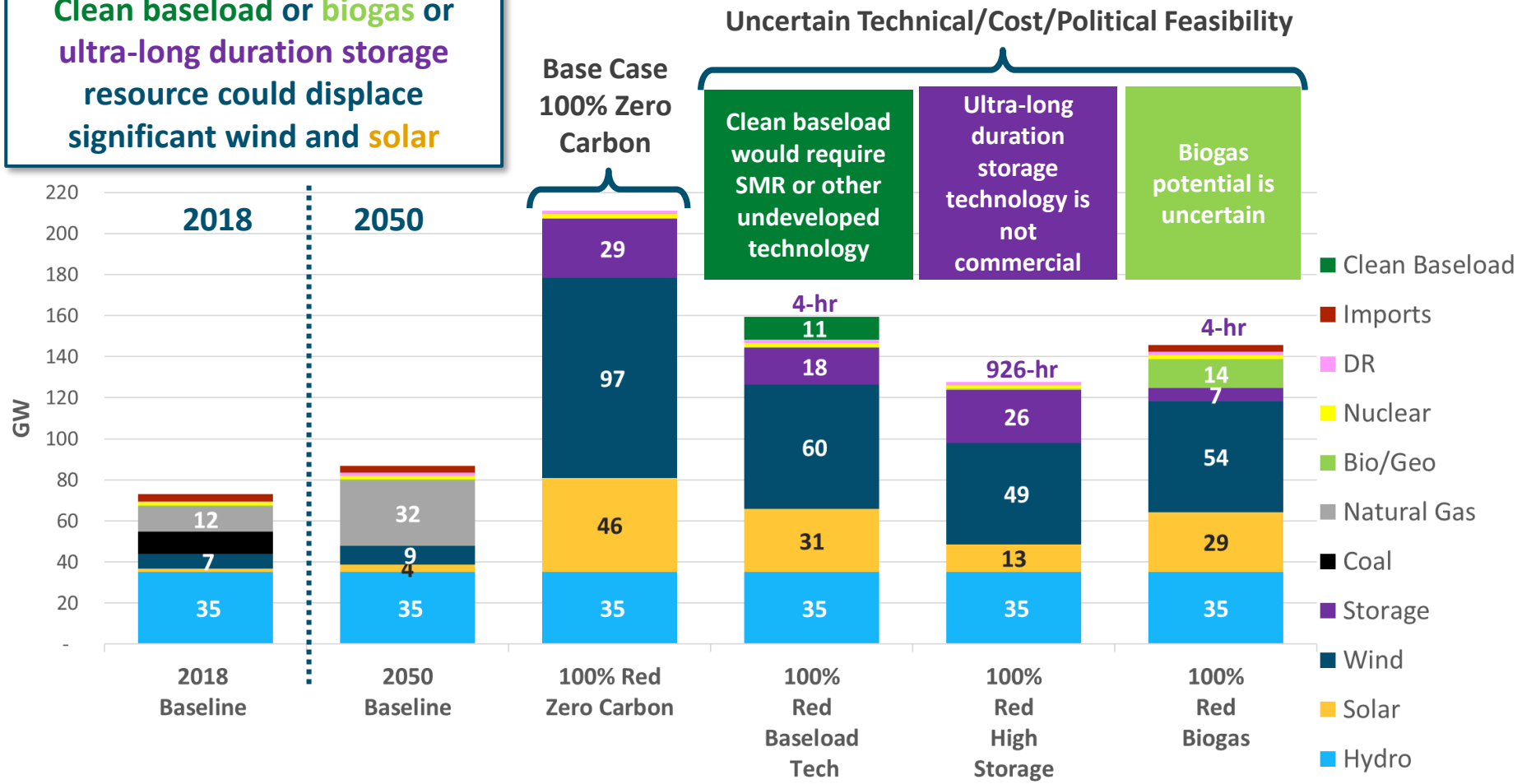


	2018 Baseline	2050 Baseline	60% Red	80% Red	90% Red	98% Red	100% Red Zero Carbon
Renewable Capacity (GW)	13	34	49	59	83	143
Annual Renewable Curtailment (%)	Low	Low	4%	10%	21%	47%
Gas Capacity (GW)	32	26	24	20	14	0
Gas Capacity Factor (%)	46%	27%	16%	9%	3%	0%

[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

100% Reduction- Portfolio Alternatives in 2050

Clean baseload or biogas or ultra-long duration storage resource could displace significant wind and solar



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

ENERGY NORTHWEST

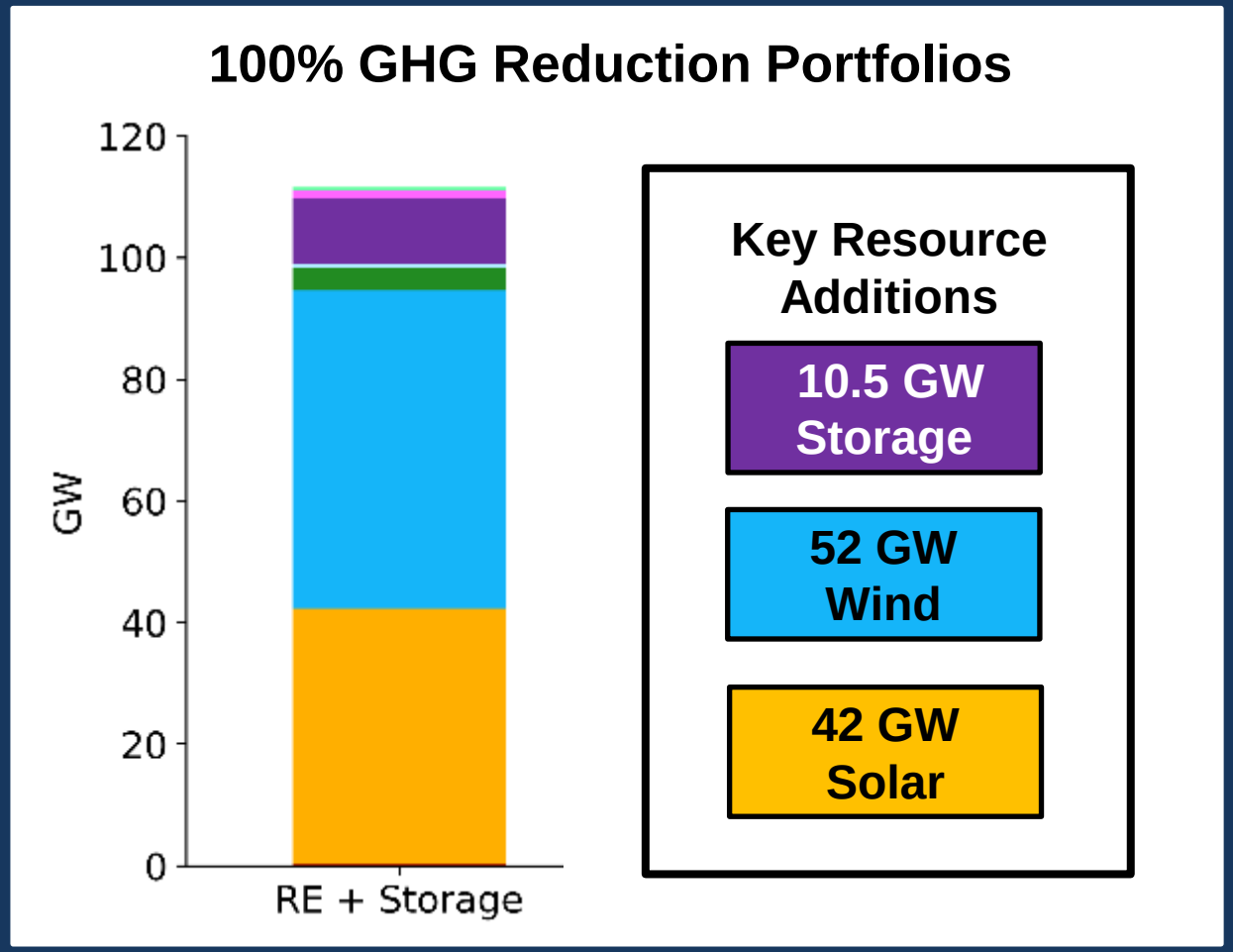
Energy+Environmental Economics

Pacific Northwest Zero-Emitting Resources Study

Dan Aas, Managing Consultant
Oluwafemi Sawyerr, Consultant
Clea Kolster, Consultant
Patrick O'Neill, Consultant
Arne Olson, Senior Partner

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

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



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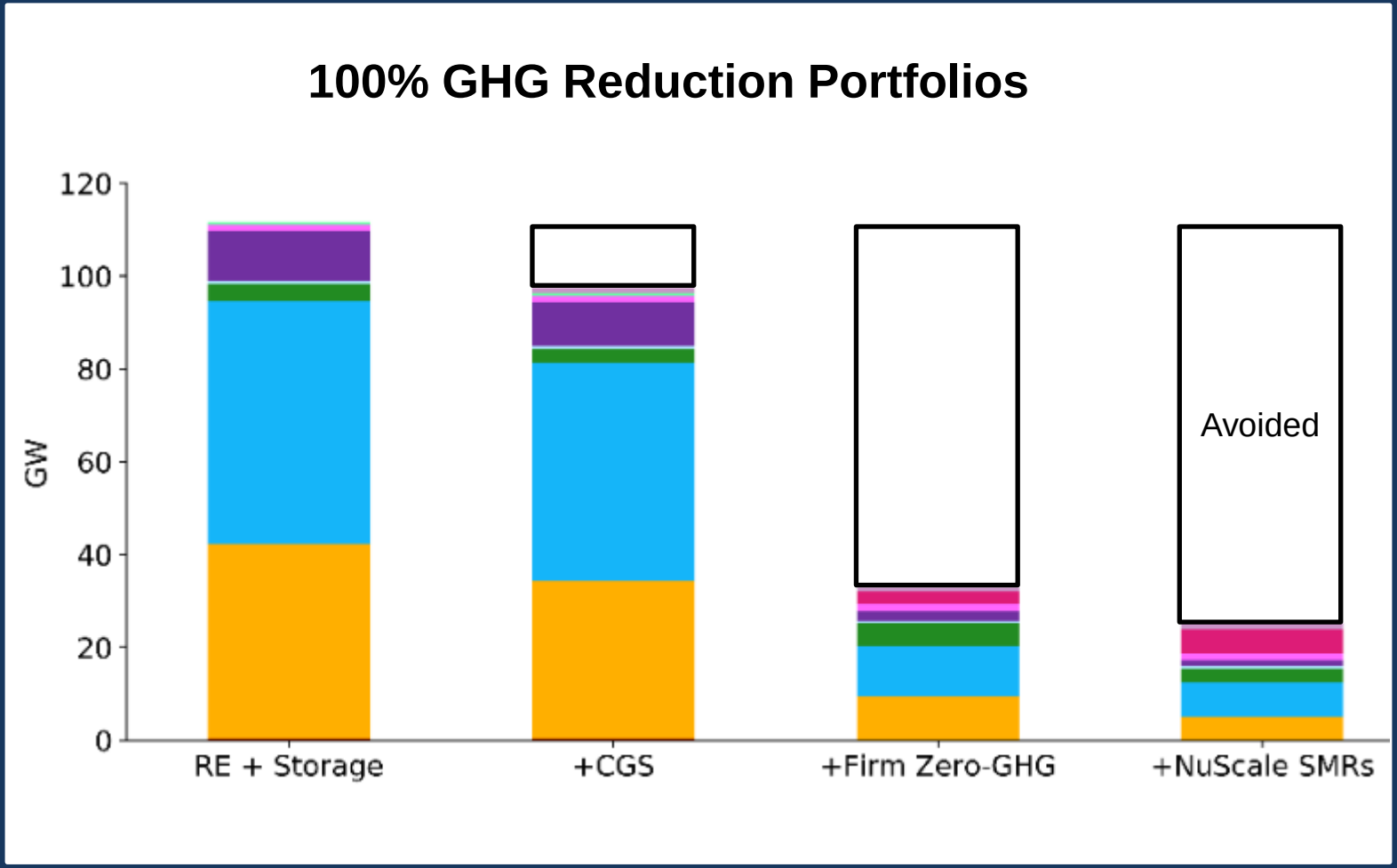


Adding	Avoids
+1.2 GW CGS	-9.5 GW Storage
+5.3 GW SMRs	-44.8 GW Wind
	-37 GW Solar
+6.5 GW Firm	-91 GW Non-firm

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

Optimal Resource Mix under CETA

Wind & Solar
(w/ storage)

Hydro

Existing Nuclear
(Columbia)

New Nuclear

Supporting Studies

Previous Studies

- **Organisation for Economic Co-operation and Development**
  The Costs of Decarbonisation: *System Costs with High Shares of Nuclear and Renewables*
- **Massachusetts Institute of Technology (MIT) study**
  The Future of Nuclear Energy in a Carbon-Constrained World
- **Pacific Northwest National Laboratory (PNNL)**
  Siting Advanced Reactors in the Pacific Northwest
- **United Nations Economic Commission for Europe**
  Nuclear Power Technology Brief
- **New Nuclear Watch Institute (NNWI)**
  Energy Security in the Age of Net-Zero Ambitions & the System Value of Nuclear Power

The math is simple – higher production rates produces lower per unit costs

(Lazard Data v13.0 95% CapFac $25 LO $65 CO2 Penalty)

SMR LCOE	Solar LCOE	Wind LCOE	CCNG LCOE
$58-63/MWh	4 times the cost	5 times the cost	3 times the cost
	Eastern WA	Eastern WA	

High Capacity-Factors Matter

Major Developments in 2020

Deploying New Nuclear Technologies

Advanced Reactor Demonstration Program (ARDP)

- January 2020 – Congress appropriates $160M for two advanced reactor demo projects
- May 2020 – DOE issue Funding Opportunity Announcement
- August 2020 – EN named in two applications to DOE for ARDP project funding
- October 2020 – EN named in both awards by DOE for ARDP project funding

ARDP: a federal 50/50 cost-share for 2 commercial projects

energy

U.S. DEPARTMENT OF ENERGY

TerraPower

Federal Funding for New Nuclear Demonstration Projects

UAMPS Carbon Free Power Project (NuScale)

Versatile Test Reactor Sodium Fast Reactor (TerraPower/GEH)

Advanced Reactor Demonstration Program (ARDP)

ARDP Demonstration Project 1

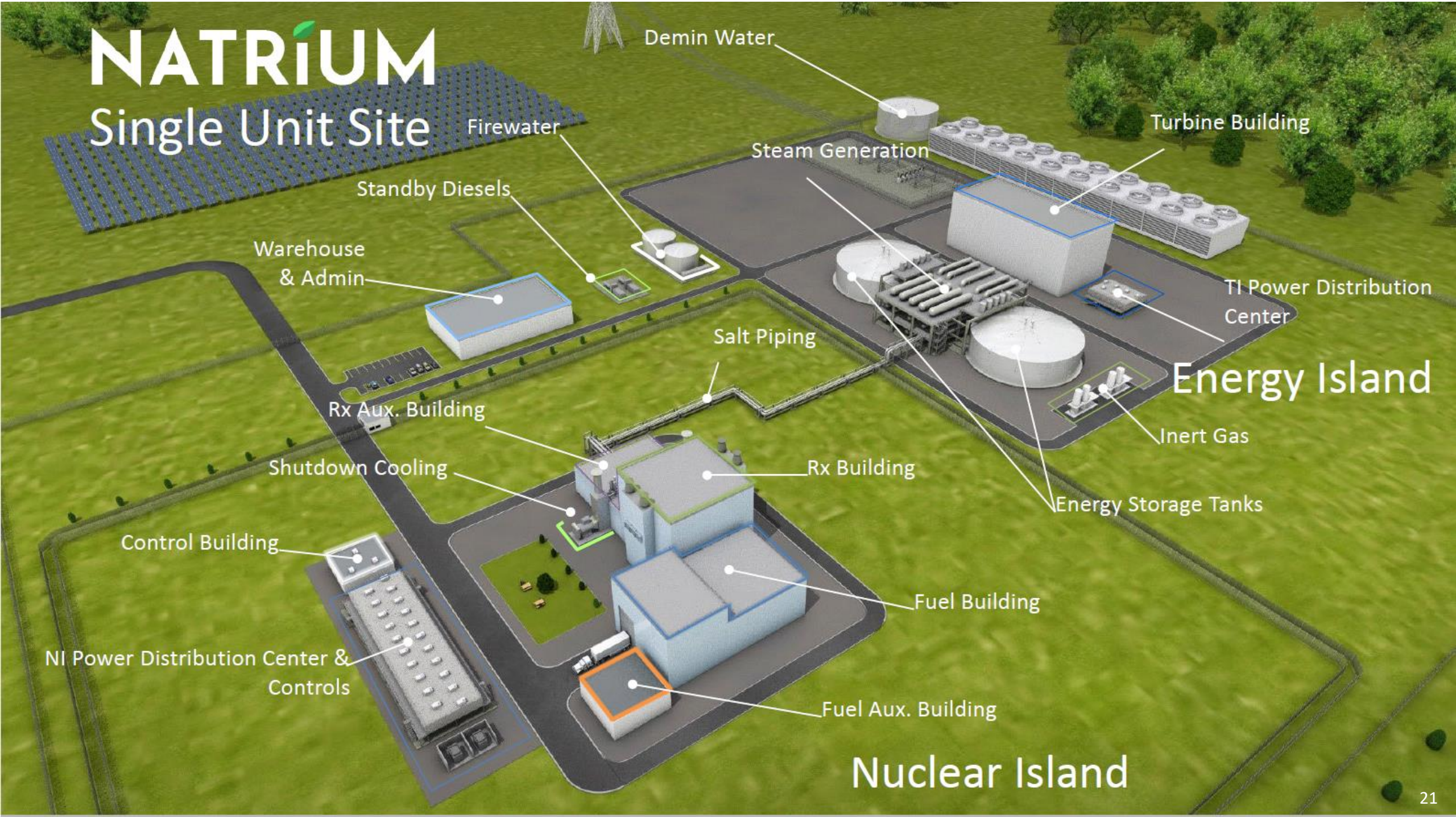
(TerraPower/GEH)

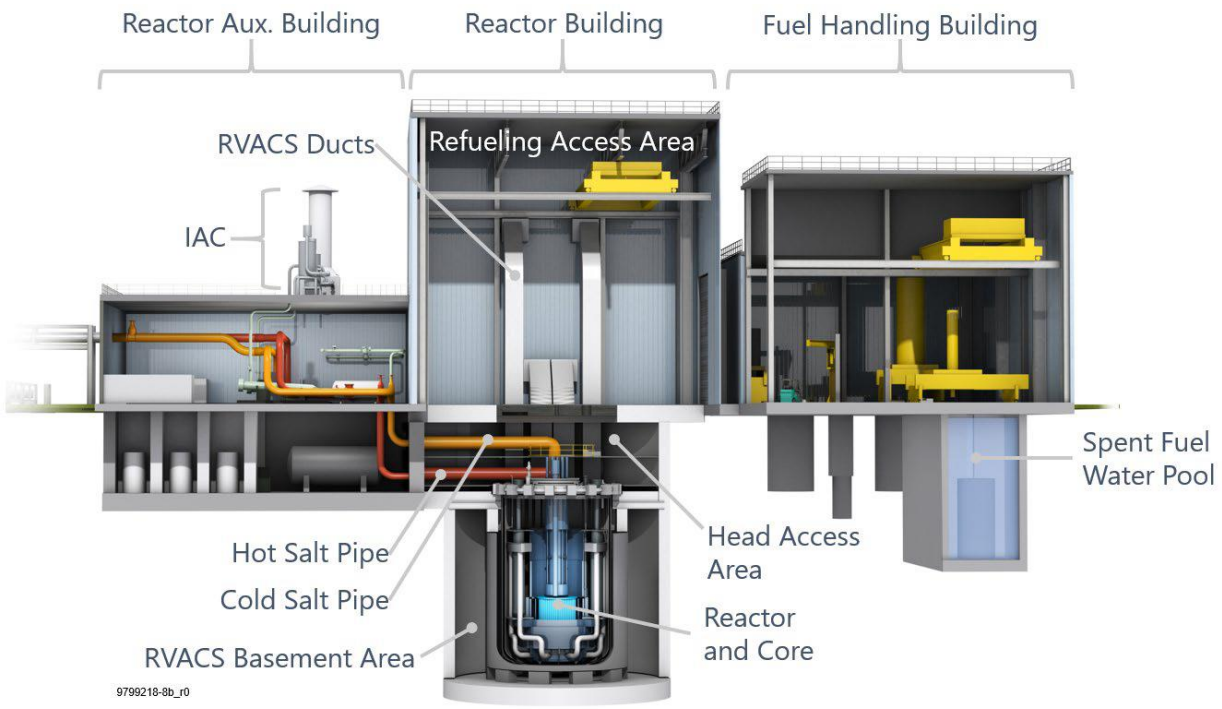
ARDP Demonstration Project 2

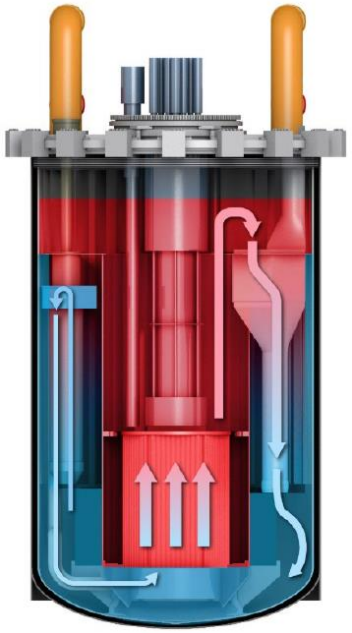
(X-energy)

TerraPower/GE Hitachi – Natrium

- Single reactor facility utilizing sodium cooled fast reactor technology
- Total reactor output around 340 MW, with optional salt storage capability to complement renewables and support net generation of 500 MW
- Planned siting location is at a retiring coal plant site in Wyoming
- PacifiCorp is expected to be owner


NATRiUM
Single Unit Site
Demin Water
Firewater
Turbine Building
Steam Generation
Standby Diesels
Warehouse
& Admin
TI Power Distribution
Center
Salt Piping
Energy Island
Rx Aux. Building
Inert Gas
Shutdown Cooling
Rx Building
Energy Storage Tanks
Control Building
Fuel Building
NI Power Distribution Center &
Controls
Fuel Aux. Building
Nuclear Island

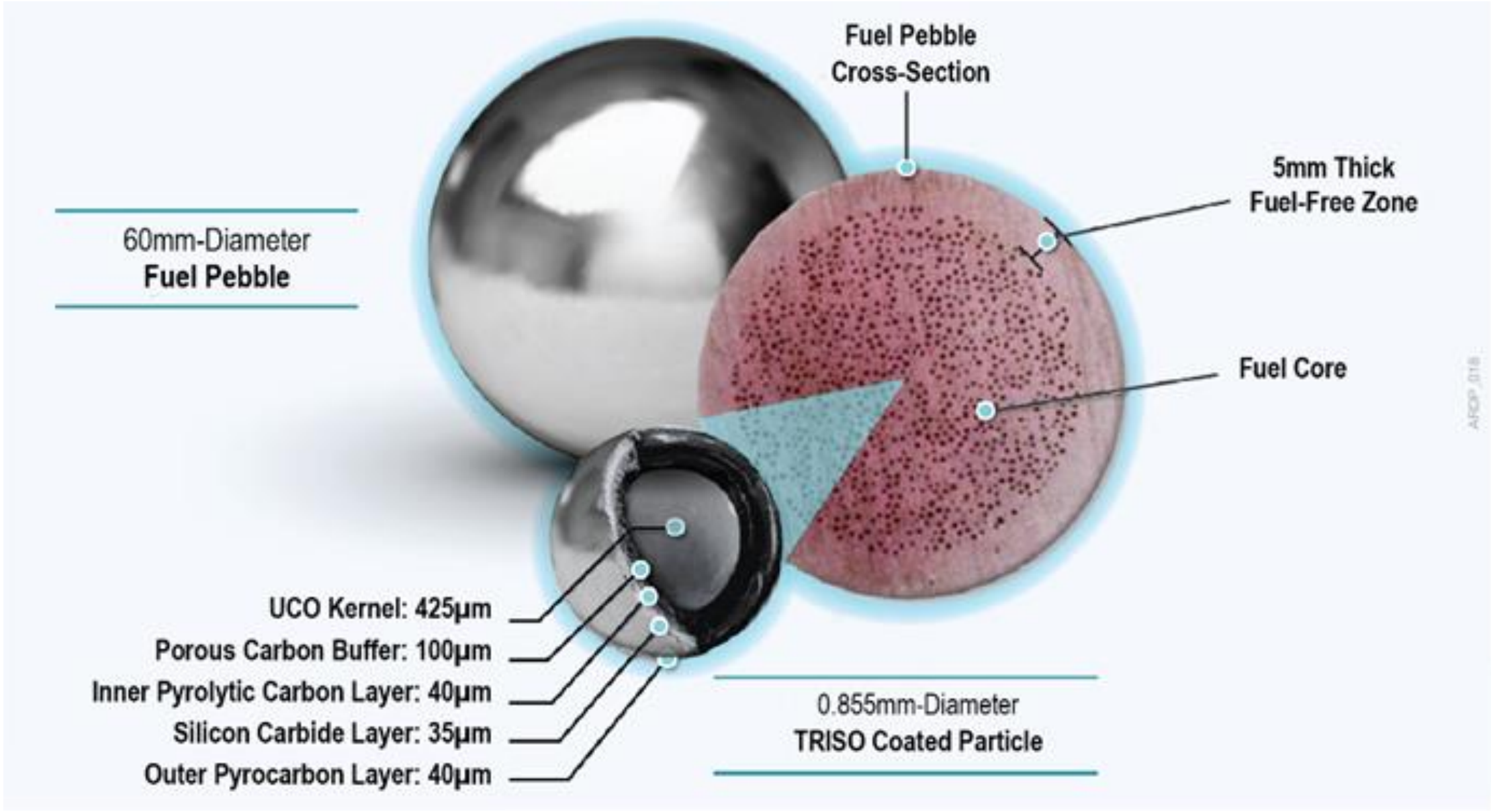


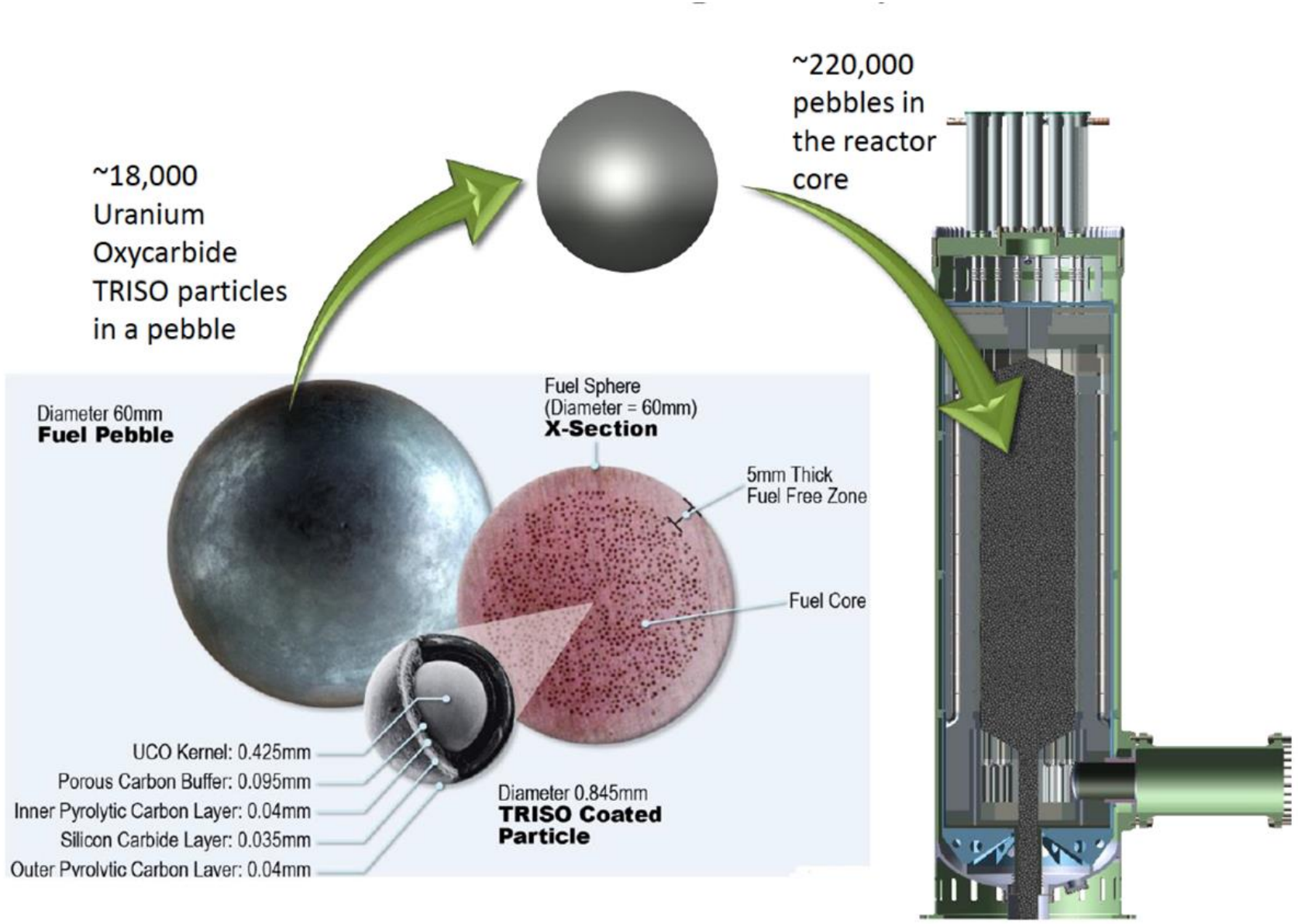


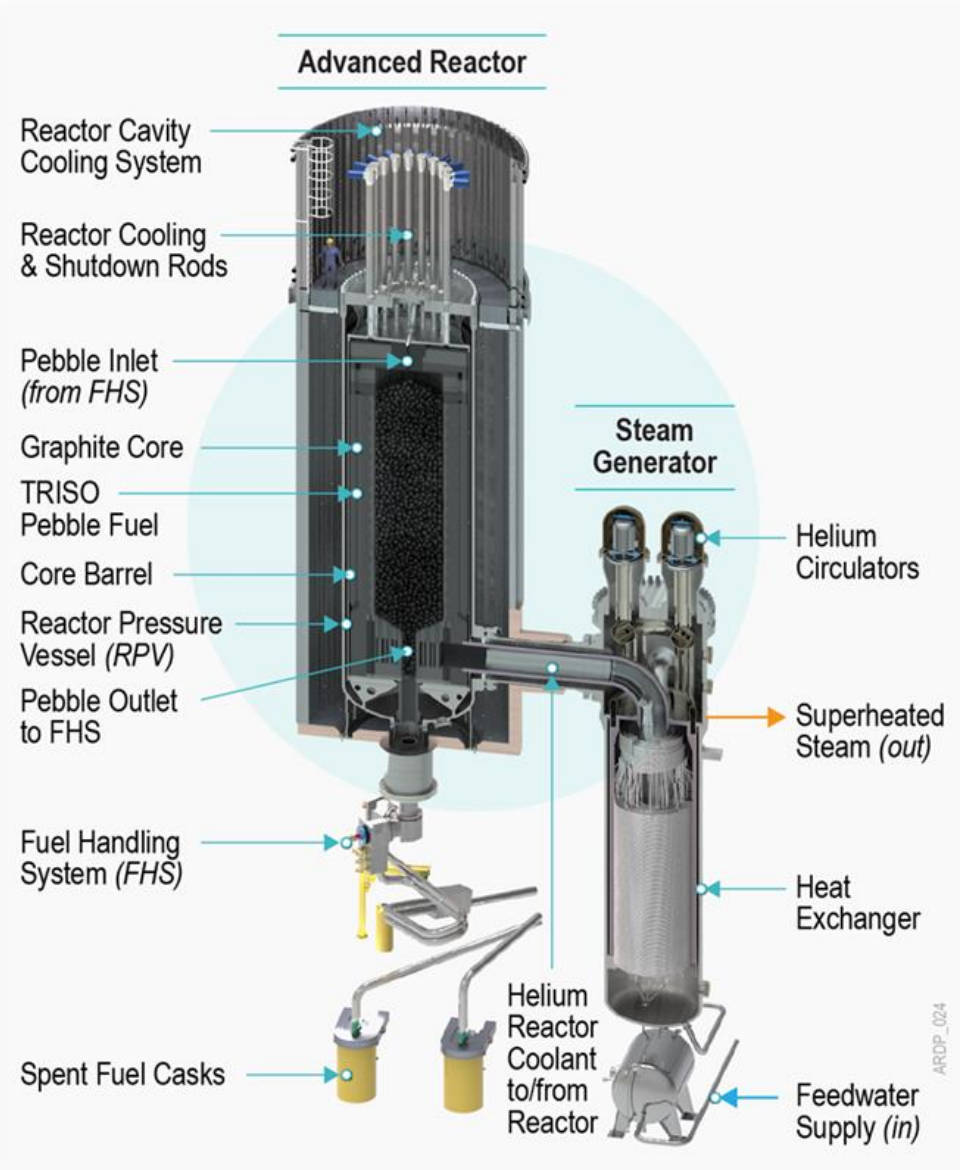
Liquid Sodium Coolant

X-energy – Xe-100

- Four reactor facility utilizing high temperature gas (Helium) reactor technology
- Total generation around 320 MW (80 MW/reactor plant)
- Planned siting location is in Grant County
- Current plan is Energy Northwest as technical consultant and operator
- Member Public Utility District (Grant County PUD) providing anchor partnership and likely owner


Fuel Pebble
Cross-Section
5mm Thick
Fuel-Free Zone
60mm-Diameter
Fuel Pebble
Fuel Core
UCO Kernel: 425µm
Porous Carbon Buffer: 100µm
Inner Pyrolytic Carbon Layer: 40µm
Silicon Carbide Layer: 35µm
Outer Pyrocarbon Layer: 40µm
0.855mm-Diameter
TRISO Coated Particle

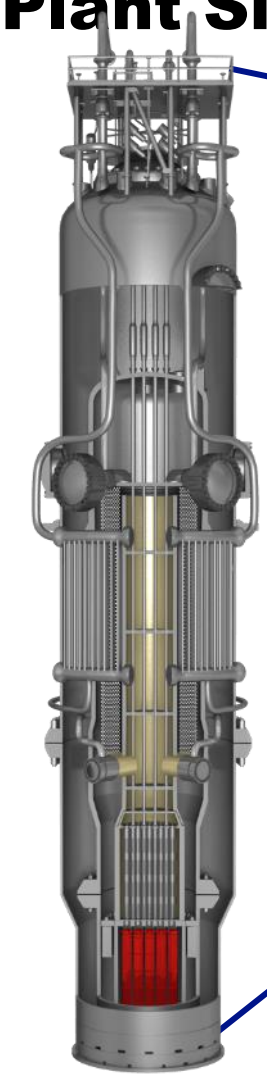

~18,000
Uranium
Oxycarbide
TRISO particles
in a pebble
~220,000
pebbles in
the reactor
core
Diameter 60mm
Fuel Pebble
Fuel Sphere
(Diameter = 60mm)
X-Section
5mm Thick
Fuel Free Zone
Fuel Core
UCO Kernel: 0.425mm
Porous Carbon Buffer: 0.095mm
Inner Pyrolytic Carbon Layer: 0.04mm
Silicon Carbide Layer: 0.035mm
Outer Pyrolytic Carbon Layer: 0.04mm
Diameter 0.845mm
TRISO Coated
Particle

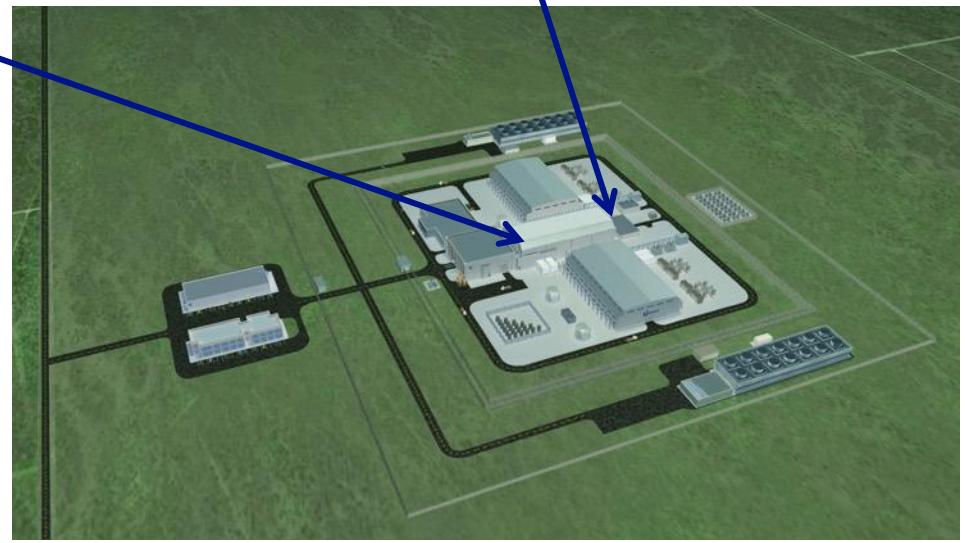

Advanced Reactor
Reactor Cavity Cooling System
Reactor Cooling & Shutdown Rods
Pebble Inlet (from FHS)
Graphite Core
TRISO Pebble Fuel
Core Barrel
Reactor Pressure Vessel (RPV)
Pebble Outlet to FHS
Fuel Handling System (FHS)
Spent Fuel Casks
Steam Generator
Helium Circulators
Superheated Steam (out)
Heat Exchanger
Helium Reactor Coolant to/from Reactor
Feedwater Supply (in)
ARDP_024

NuScale

- Current design:
  - 12-module reactor building; 50 MW per module
  - Total generation around 600 MW
  - Design certified by Nuclear Regulatory Commission
- Proposed new design:
  - 6-module reactor building; 77 MW per module
  - Total generation around 462 MW
  - Requires design approval by NRC (expected by 2024)
  - Plant will be sited on Idaho National Lab site
  - Utah Associated Municipal Power System (UAMPS) will be owner

NuScale Plant Site Overview





Real Option for Utilities

- ✓ Federal funding to reduce first-of-a-kind costs and risks
- ✓ Nuclear production tax credit in place
- ✓ Viable technologies building upon decades of work
- ✓ Advancements in safety and design resulting in lower costs
- ✓ Modular and innovative construction techniques to improve constructability
- ✓ Designed for flexible operation
- ✓ Cost-competitive resource option
- ✓ First deployments expected by 2030

Configuration Management for new nuclear

Goals for New Nuclear

- This is our opportunity!
  - Learn from and build on the past
  - Fix our frustrations
  - Do it better this time around
- Operations must be cost-effective
- Licensing and operational requirements must reflect advancements in safety
- On-time, on-budget licensing and construction must be proven
- The commercial nuclear industry must continue our legacy of cooperation to make the future a reality

Goals for New Nuclear

- Visionary ideas for the next generation of plants
  - Begin with the end in mind
  - Technology-based fleets and standardization
  - Centralized fleet services
  - Optimized staffing
  - Leverage technology
  - Right-sized regulation and oversight
  - Very few safety-related systems and components
  - Expect, plan for, and design for flexible operation
  - Expandable configurations

What Should CMBG Do?

- Reach out to and engage with developers
- Look toward creation of a square hole
  (Plan for an entirely different model)
- Engage with NRC, NEI, EPRI, and INPO on new models
- Question everything

Questions