CLEAN ENERGY EXPLORATION

Commission Presentation
March 17, 2025

AGENDA

- Why Clean Energy
- Technology Learning
- Future Opportunities

For Information – No Decisions

CLEAN ENERGY TECHNOLOGIES

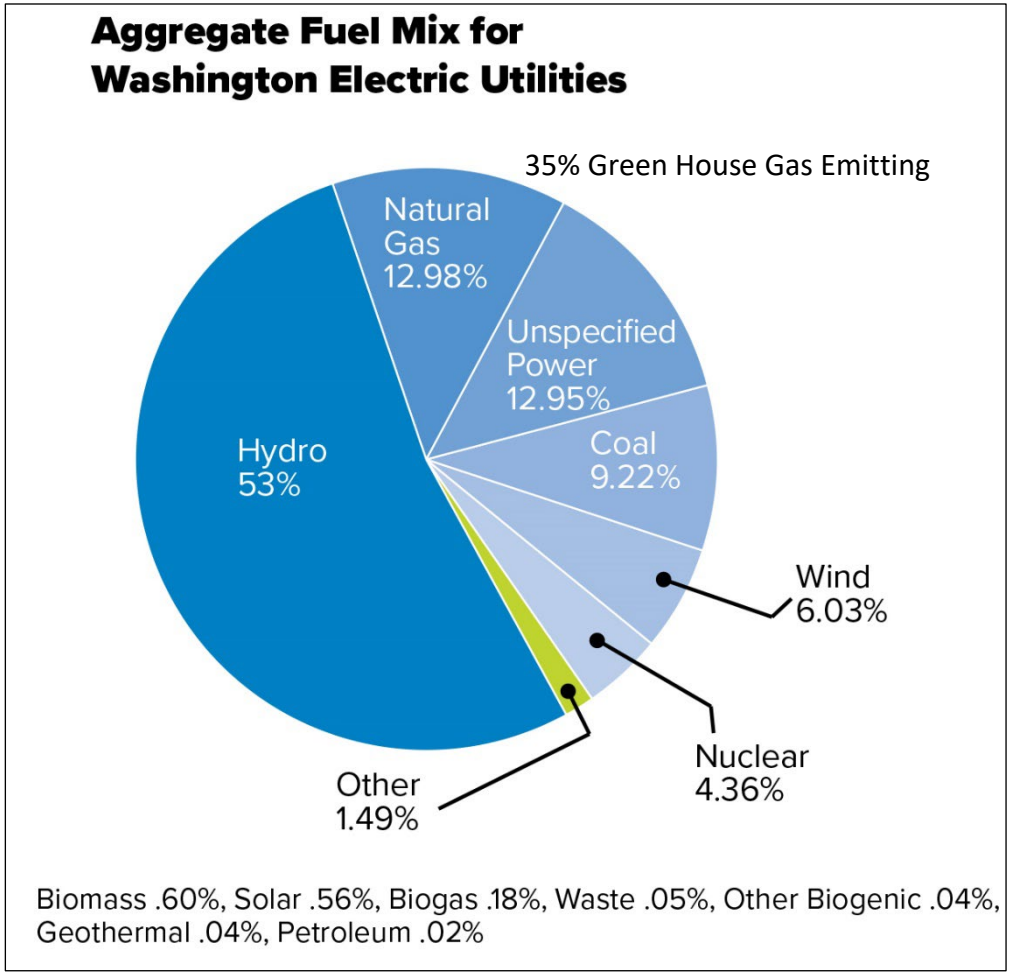
Energy Generation

- Solar
- Wind
- Geothermal
- Fission
- Fusion
- Hydro

Energy Storage

- Pumped Storage
- Gravity
- Hydrogen
- Battery
- Compressed gas

The Why



Source: WA State Dept. Commerce, 2023

CETA

Clean Energy Transformation Act - Washington State Department of Commerce **SB 5116, 2019**

In 2026 coal will no longer be allowed to serve Washington electricity customers.

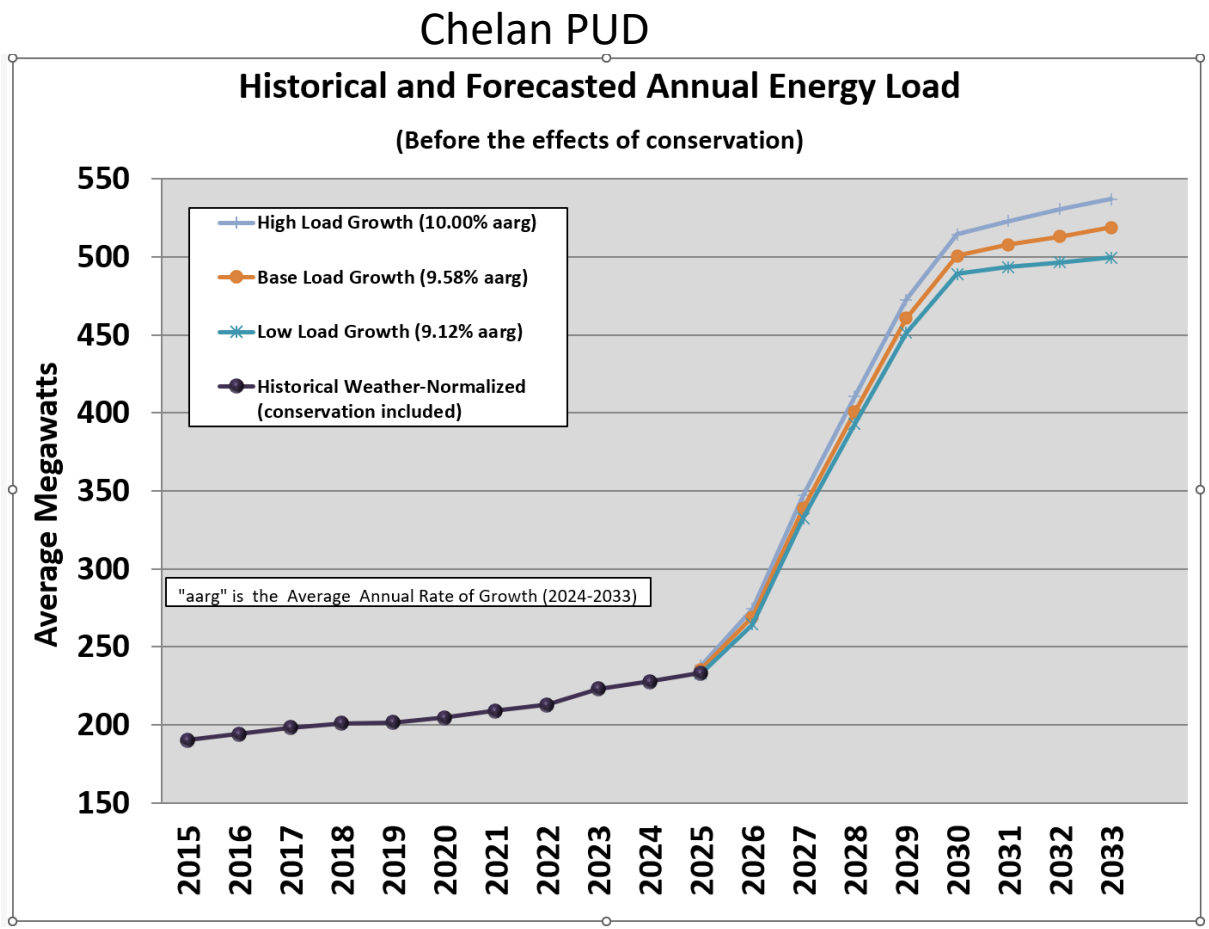
By 2030 Washington's electricity supply must be greenhouse gas neutral.

By 2045 – greenhouse gas free.

By 2050 net zero emissions from all sources – transportation, buildings, electricity, industry

P.U.D. CHELAN COUNTY

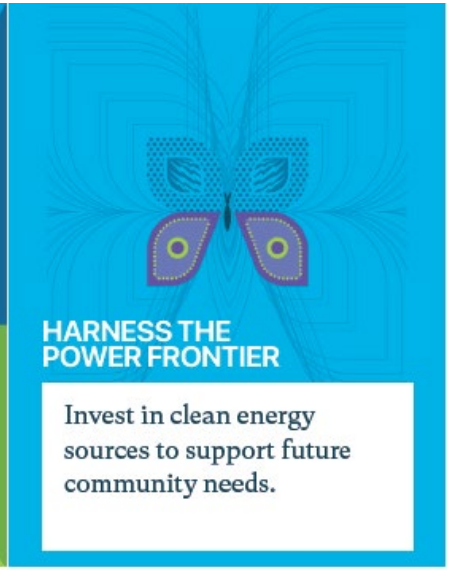
The Why



- *Large loads from data centers and industries*
- *Increasing residential and commercial loads. Chelan County Peak 585 MW Jan. 2024.*
- *Electric Vehicle Energy Demand*
- *Grant and Douglas Counties - short energy for large loads*

The Why – 2075 Vision

3 of 9 Goals



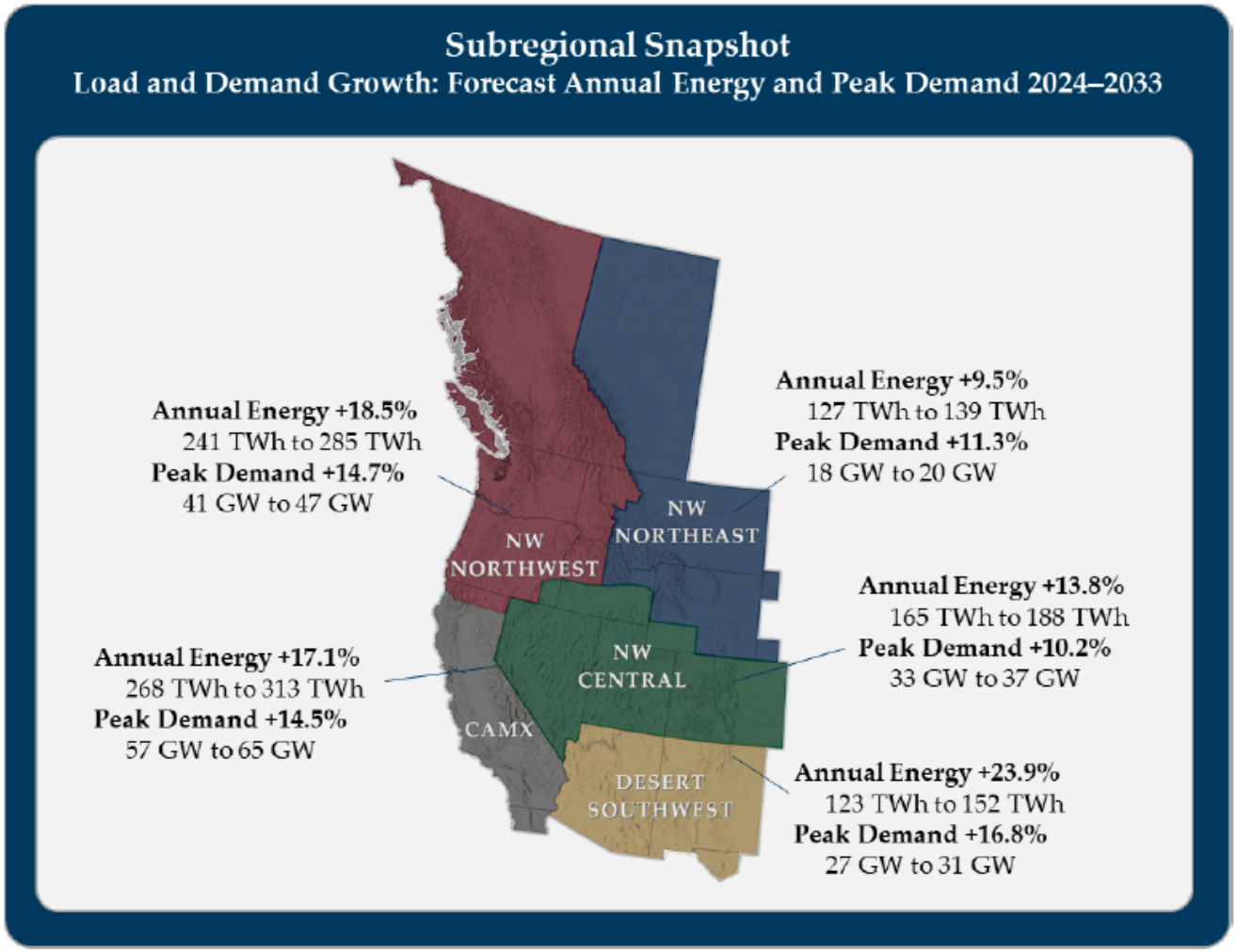
P.U.D.
CHELAN COUNTY

The Why

Resource Adequacy

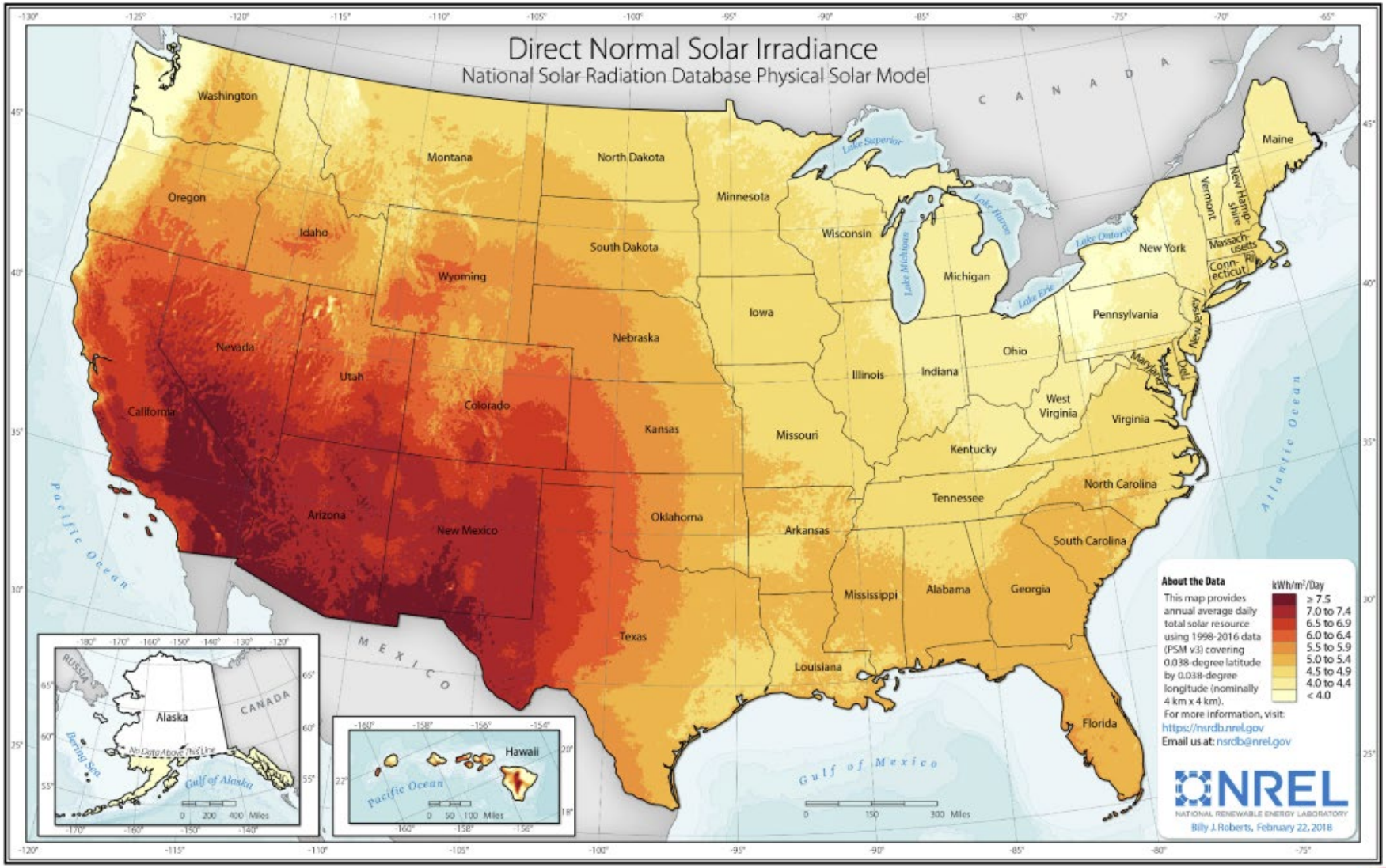
- *Future energy market requirement*
- *Requires a percentage of generating capacity to be held in reserve in case of unplanned loss of generation on the grid*
- *Reduces amount of surplus energy we can pre-sell*

The Why



Western Electric Coordinating Council released a report in November 2023, that predicts the potential for capacity shortfalls across the West after 2025.

Solar

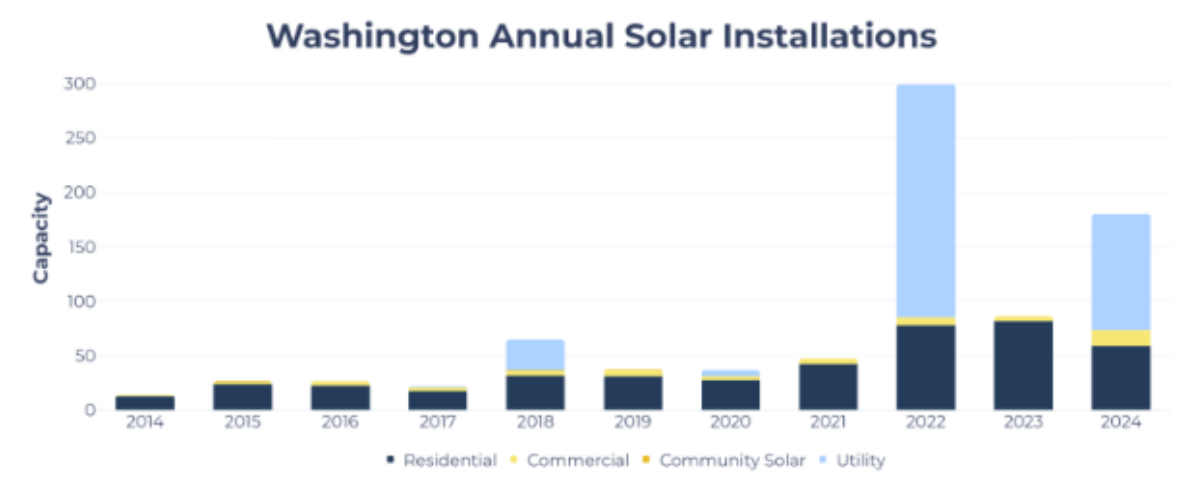

Direct Normal Solar Irradiance
National Solar Radiation Database Physical Solar Model
Washington
Oregon
California
Idaho
Nevada
Montana
Wyoming
Utah
Arizona
Colorado
New Mexico
North Dakota
South Dakota
Nebraska
Kansas
Oklahoma
Texas
Minnesota
Iowa
Missouri
Arkansas
Louisiana
Wisconsin
Illinois
Michigan
Indiana
Ohio
Kentucky
Tennessee
Mississippi
Alabama
Georgia
Florida
South Carolina
North Carolina
Virginia
West Virginia
Pennsylvania
New York
Maine
Vermont
New Hamp-shire
Massach-usetts
Conn-ecticut
R.I.
Delaware
Maryland
New Jersey
Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Lake Ontario
CANADA
MEXICO
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
Alaska
Hawaii
About the Data
This map provides annual average daily total solar resource using 1998-2016 data (PSM v3) covering 0.038-degree latitude by 0.038-degree longitude (nominally 4 km x 4 km).
For more information, visit:
https://nsrdb.nrel.gov
Email us at: nsrdb@nrel.gov
kWh/m²/Day
≥ 7.5
7.0 to 7.4
6.5 to 6.9
6.0 to 6.4
5.5 to 5.9
5.0 to 5.4
4.5 to 4.9
4.0 to 4.4
< 4.0
NREL
NATIONAL RENEWABLE ENERGY LABORATORY
Billy J. Roberts, February 22, 2018

Solar

Utility Scale In Chelan County

- RI Dam – 210 Acres, 30 MW
- Jump-off Ridge – 1000 Acres, 100 MW

Washington State Solar Overview



Data References:

SEIA/Wood Mackenzie Power & Renewables, Solar Market Insight 2024 Year-in-Review

Just The Facts

Solar Installed (MW):
865

National Ranking:
37th (34th in 2023)

Enough Solar Installed to Power:
91,134 homes

Percentage of State's Electricity from Solar:
0.99%

Solar

RI Dam Nominal 30 MW System with Battery Storage

Month \ Hour	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	0	0	0	0	0	0	0	0.0091	0.7814	1.4956	2.2099	3.0465	3.4509	2.7095	1.7319	1.128	0.2139	0	0	0	0	0	0	0
2	0	0	0	0	0	0	-8E-04	0.494	1.7071	2.5607	3.8511	4.8282	5.1869	4.1819	2.998	2.0134	1.0551	0.0639	0	0	0	0	0	0
3	0	0	0	0	0	-7E-04	0.3866	1.4754	1.9655	4.218	9.6361	11.678	12.206	10.388	9.7263	3.0652	2.9375	0.7126	0.0032	0	0	0	0	0
4	0	0	0	0	-5E-04	0.3338	5.104	13.675	14.241	20.773	23.705	22.581	21.561	20.948	20.929	18.962	14.954	4.3719	0.3989	-4E-04	0	0	0	0
5	0	0	0	0	0.0339	2.7656	11.084	19.027	20.977	23.402	23.891	22.697	24.624	25.394	23.725	22.755	20.241	11.444	1.6378	0.1011	0	0	0	0
6	0	0	0	0	0.2134	5.5606	15.049	21.249	23.117	24.854	25.397	24.718	25.061	25.866	25.695	25.411	23.996	17.154	4.592	0.386	0	0	0	0
7	0	0	0	0	0.0712	4.955	16.865	26.258	27.607	27.452	27.421	27.273	27.477	26.904	26.559	25.809	24.504	17.417	3.5975	0.2314	0	0	0	0
8	0	0	0	0	-0.001	0.6551	8.296	19.496	23.229	24.8	25.325	24.373	24.401	24.092	24.45	23.801	19.717	9.0598	0.7532	-0.002	0	0	0	0
9	0	0	0	0	0	0.0244	2.1005	4.8259	2.662	12.161	18.521	20.239	19.116	17.971	16.248	10.694	8.0653	1.2112	0.0331	0	0	0	0	0
10	0	0	0	0	0	0	0.1277	1.1251	1.6341	1.9103	2.6484	4.0415	3.6283	2.6409	1.8687	1.3242	0.6516	0.0146	0	0	0	0	0	0
11	0	0	0	0	0	0	-7E-04	0.3275	1.2536	1.5889	2.3353	2.7475	2.6697	1.9457	1.5067	0.7956	0.0299	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	-0.003	0.8615	1.843	2.6273	3.5705	3.4238	2.4396	1.753	0.7283	-0.003	0	0	0	0	0	0	0

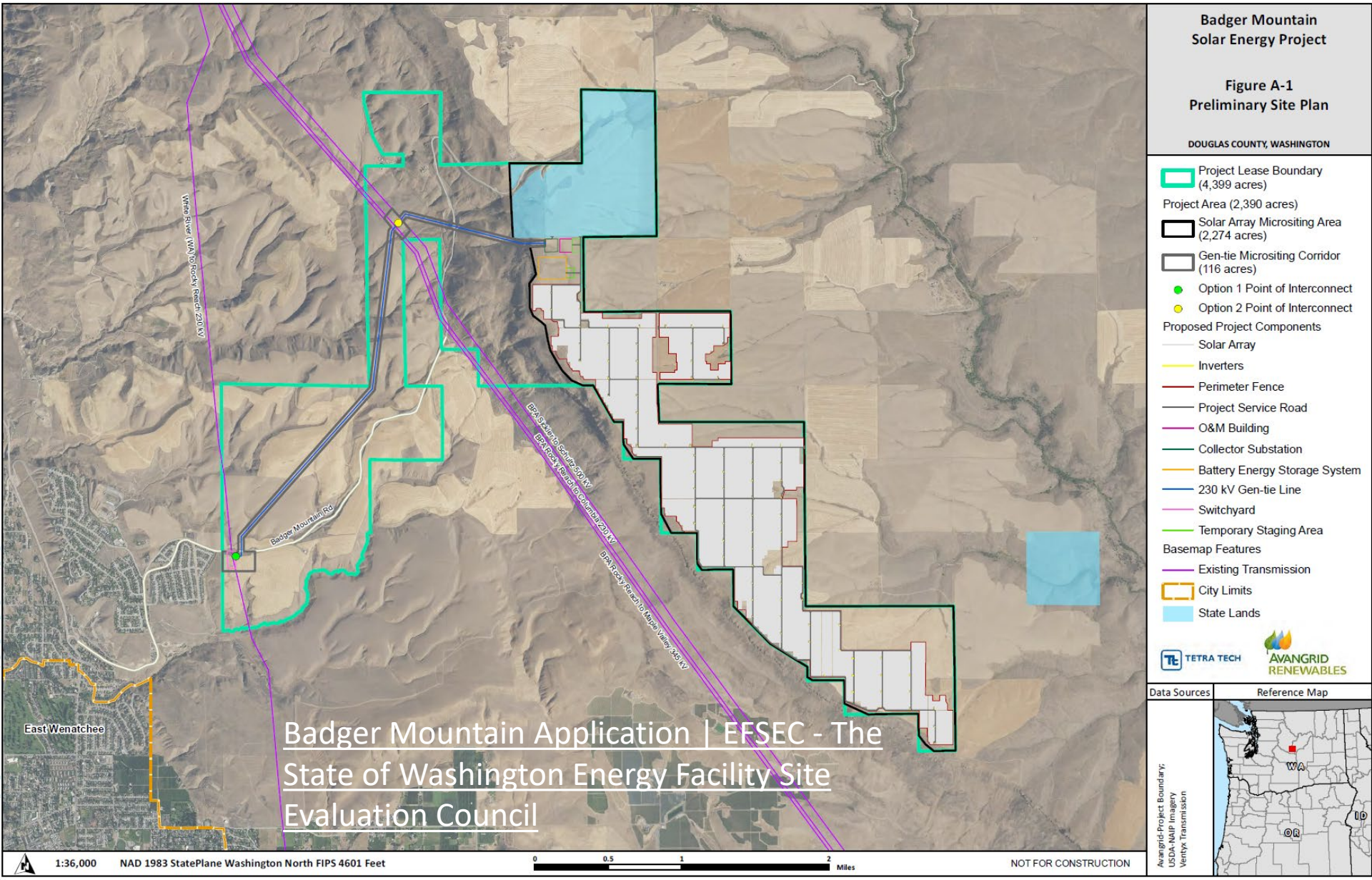
Month	Production (MW)	Seasonality
1	520.074851	1.06%
2	810.302713	1.65%
3	2120.29818	4.31%
4	6076.105401	12.36%
5	7867.746747	16.00%
6	8649.52289	17.59%
7	9622.457794	19.57%
8	7825.814501	15.92%
9	4016.16074	8.17%
10	670.083754	1.36%
11	455.994285	0.93%
12	534.47229	1.09%
Total	**49169.03415**	

Value = $2.5M/year at $50/MW

Capital Cost Est. $60M

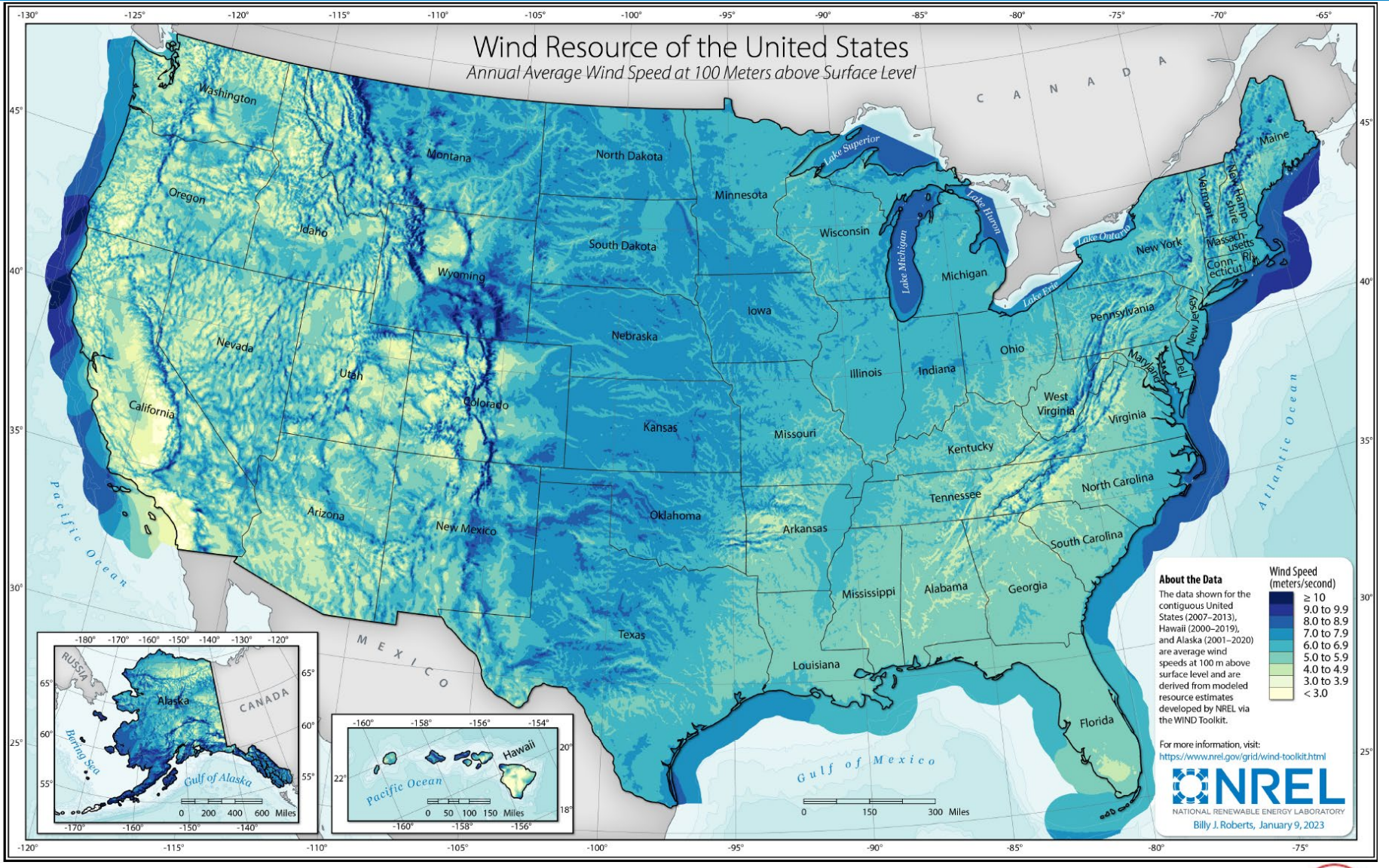
AVINGRID - BADGER MOUNTAIN SOLAR ENERGY PROJECT

2274 Acres, 200 MW



Badger Mountain Application | EFSEC - The State of Washington Energy Facility Site Evaluation Council

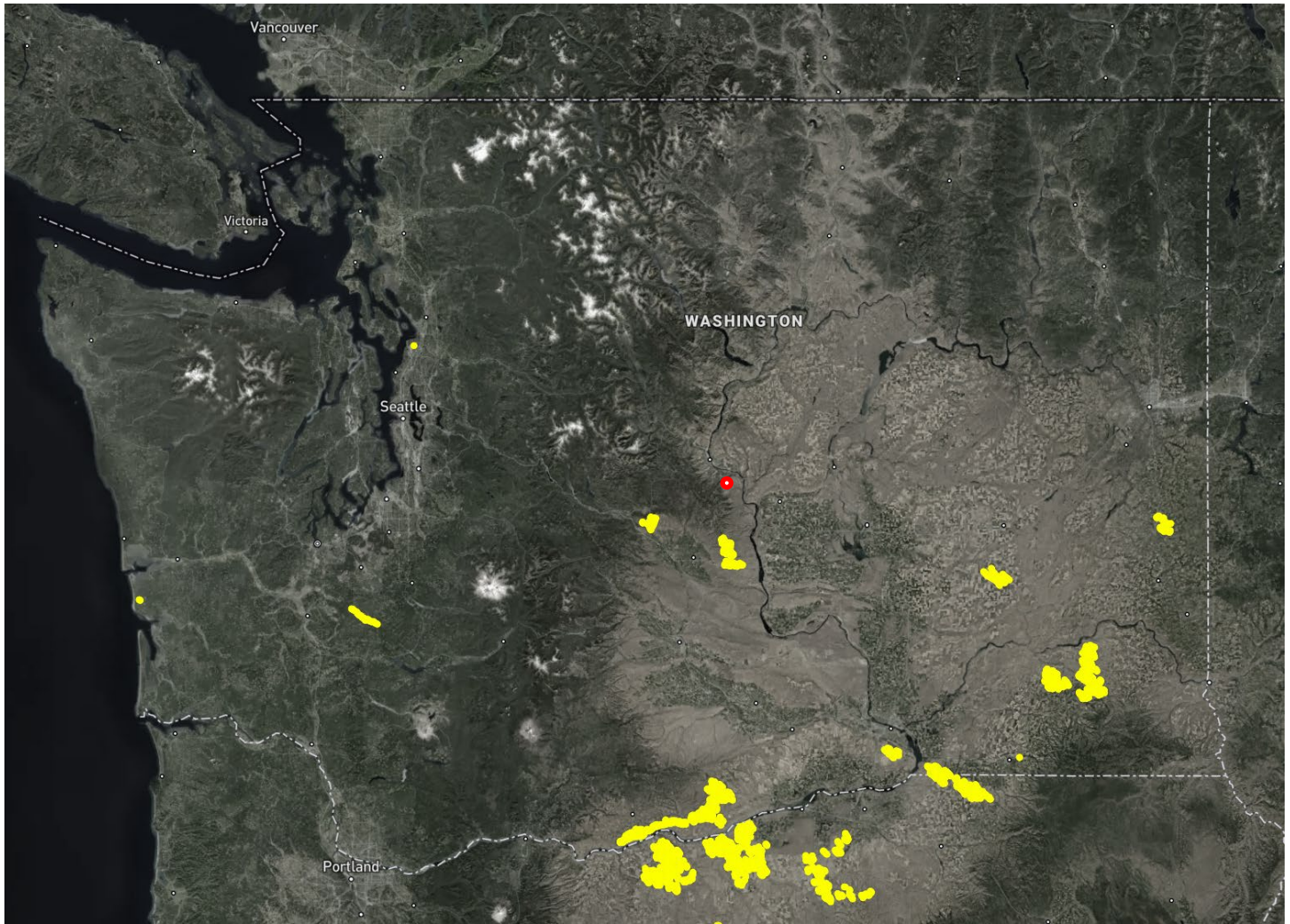
Wind


Wind Resource of the United States
Annual Average Wind Speed at 100 Meters above Surface Level
CANADA
MEXICO
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
Washington
Oregon
California
Idaho
Nevada
Montana
Wyoming
Utah
Arizona
Colorado
New Mexico
North Dakota
South Dakota
Nebraska
Kansas
Oklahoma
Texas
Minnesota
Iowa
Missouri
Arkansas
Louisiana
Wisconsin
Illinois
Michigan
Indiana
Ohio
Kentucky
Tennessee
Mississippi
Alabama
Georgia
Florida
South Carolina
North Carolina
Virginia
West Virginia
Pennsylvania
New York
Maryland
Delaware
New Jersey
Connecticut
Massachusetts
Vermont
New Hampshire
Maine
Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Lake Ontario
Alaska
Hawaii
RUSSIA
Bering Sea
Gulf of Alaska
Pacific Ocean
0 200 400 600 Miles
0 50 100 150 Miles
0 150 300 Miles
About the Data
The data shown for the contiguous United States (2007–2013), Hawaii (2000–2019), and Alaska (2001–2020) are average wind speeds at 100 m above surface level and are derived from modeled resource estimates developed by NREL via the WIND Toolkit.
For more information, visit:
https://www.nrel.gov/grid/wind-toolkit.html
Wind Speed (meters/second)
≥ 10
9.0 to 9.9
8.0 to 8.9
7.0 to 7.9
6.0 to 6.9
5.0 to 5.9
4.0 to 4.9
3.0 to 3.9
< 3.0
NREL
NATIONAL RENEWABLE ENERGY LABORATORY
Billy J. Roberts, January 9, 2023

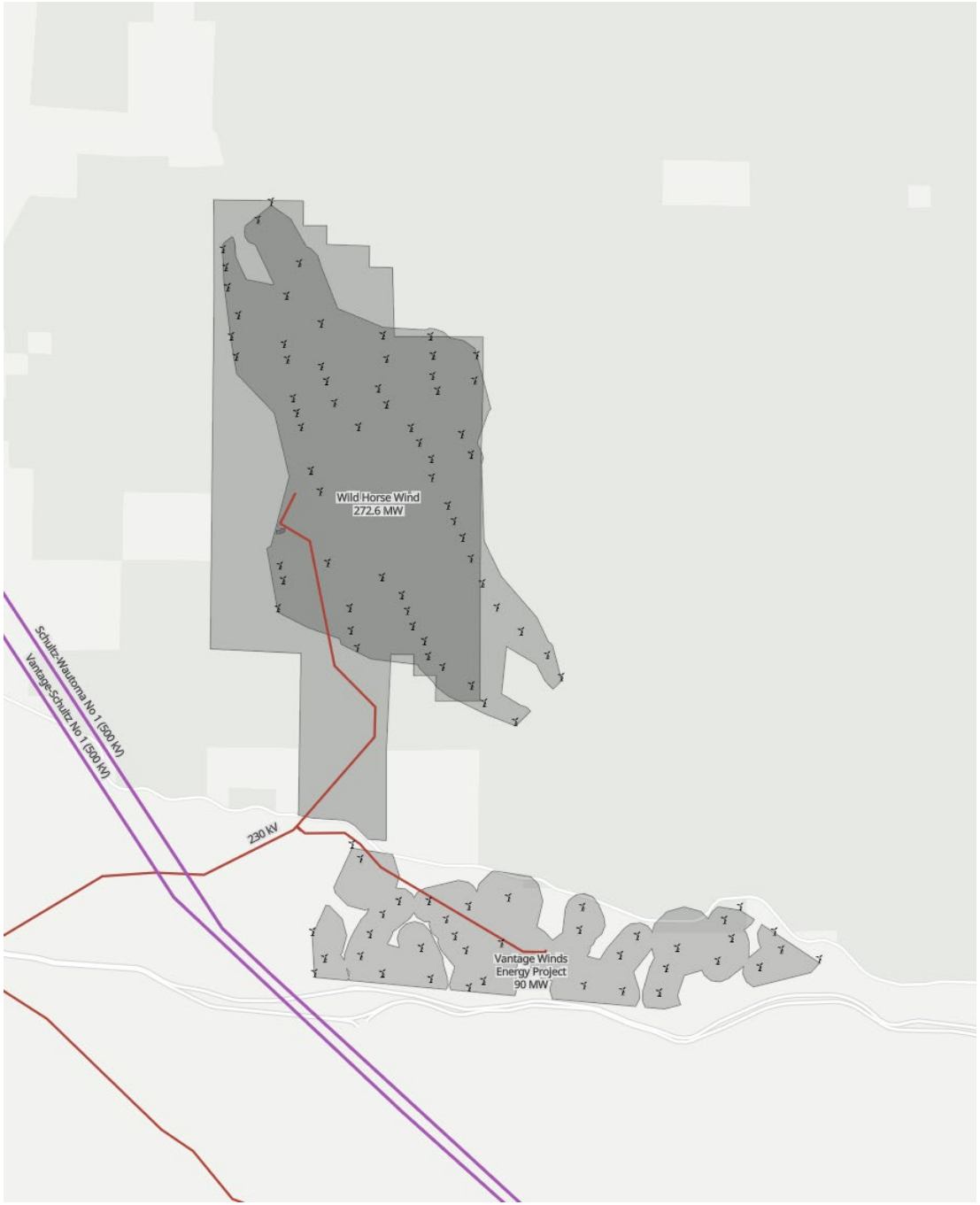
Wind

Utility Scale in Chelan County

- Jump-off Ridge 80 MW



CHELAN COUNTY P.U.D.



PSE Wild Horse Wind

11,000 ac

273 MW

149 Turbines

Online 2006

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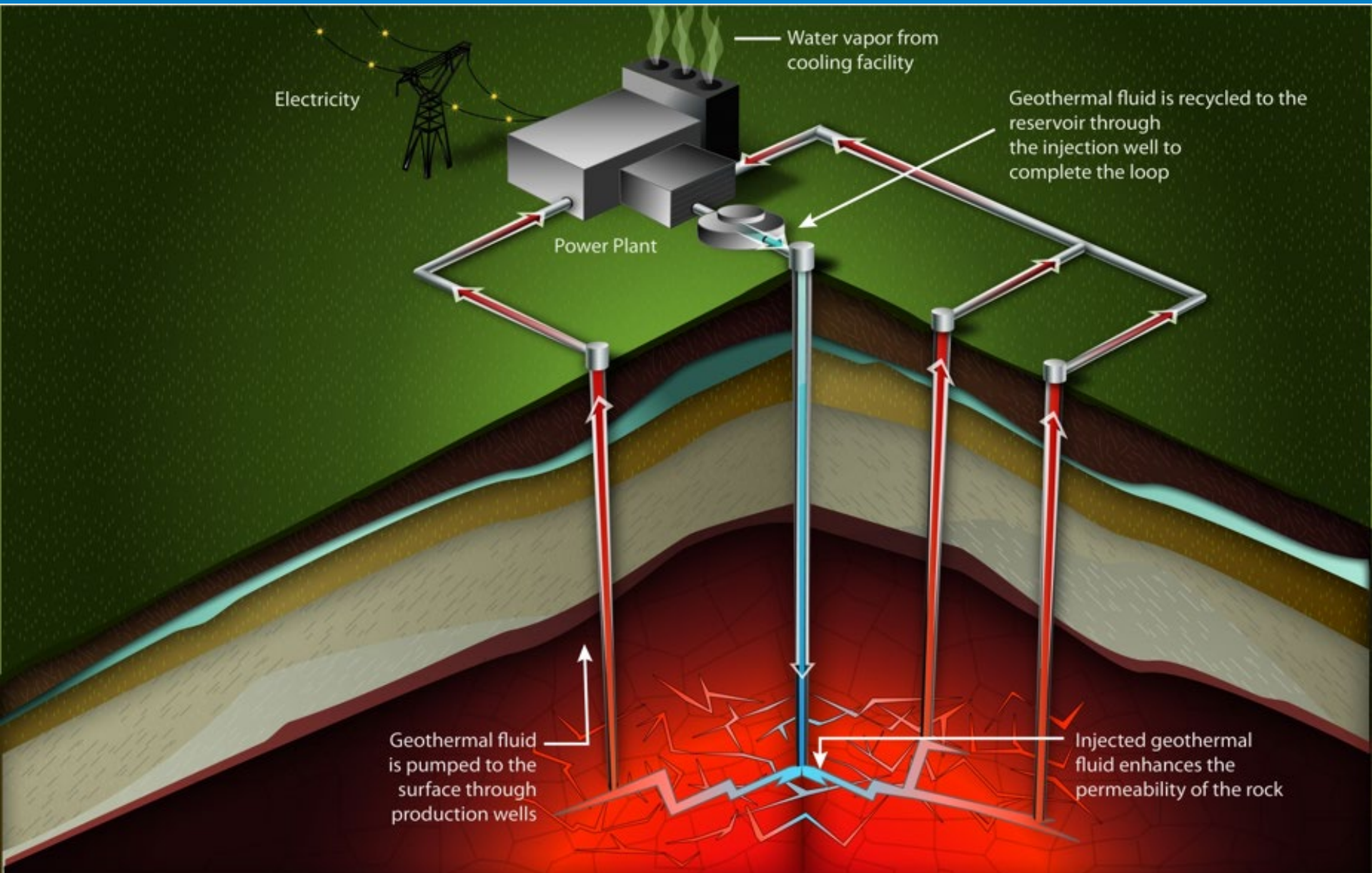
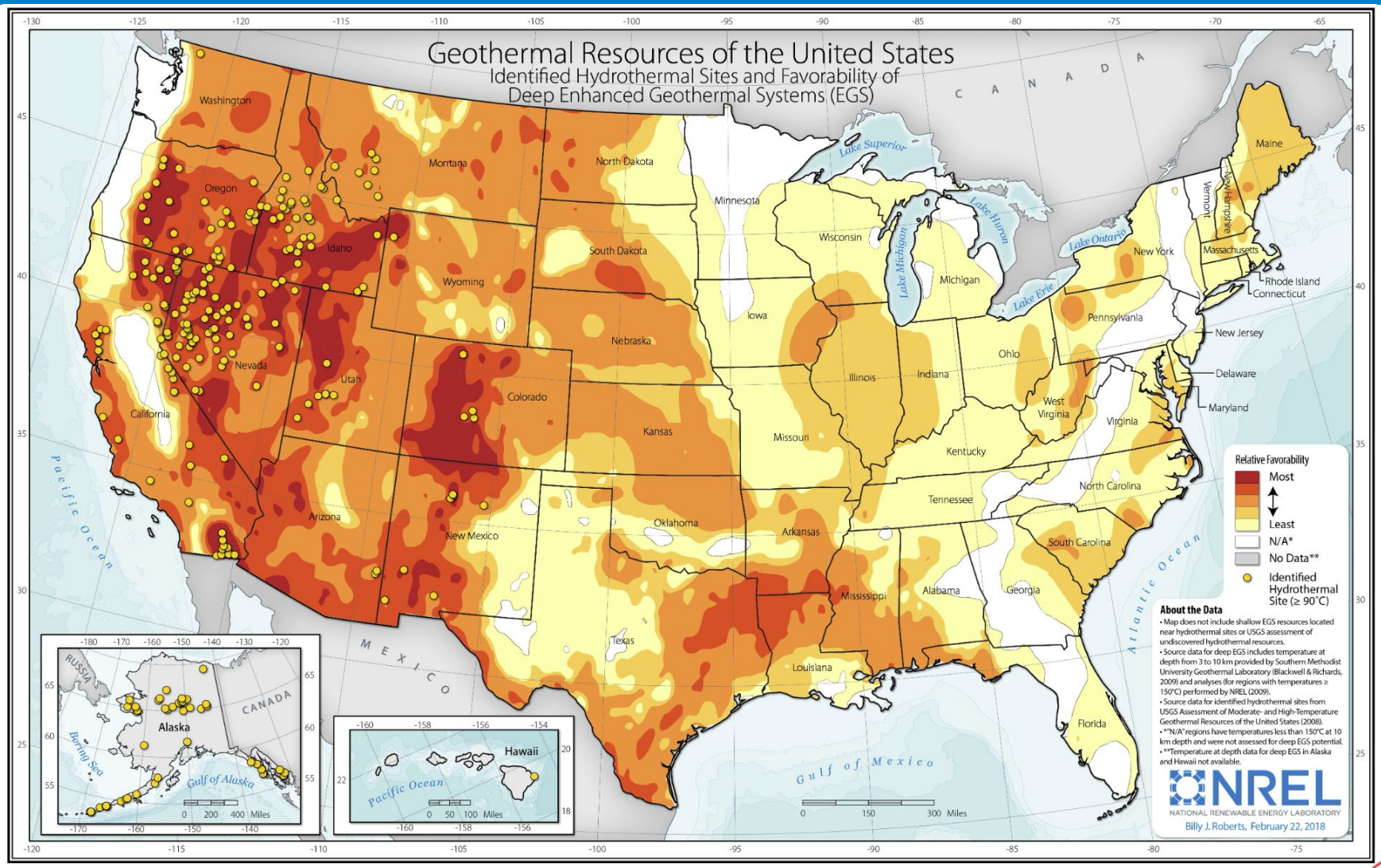
CHELAN COUNTY

Geothermal


Water vapor from cooling facility
Electricity
Geothermal fluid is recycled to the reservoir through the injection well to complete the loop
Power Plant
Geothermal fluid is pumped to the surface through production wells
Injected geothermal fluid enhances the permeability of the rock

Geothermal



Geothermal

Chelan County PUD Study

Heat Potential
- Temperature Gradients
- NA-K-Ca-Mg Geothermometry
- Quartz Geothermometry
- Thermal Spring Temperatures
- Volcanic Vent Density

Permeability Potential
- Fault Density
- Dilation Strain Rate
- Max. shear strain rate
- Horizontal Gravity Gradient
- Dike Intrusion Density

Three prominent favorable areas identified:

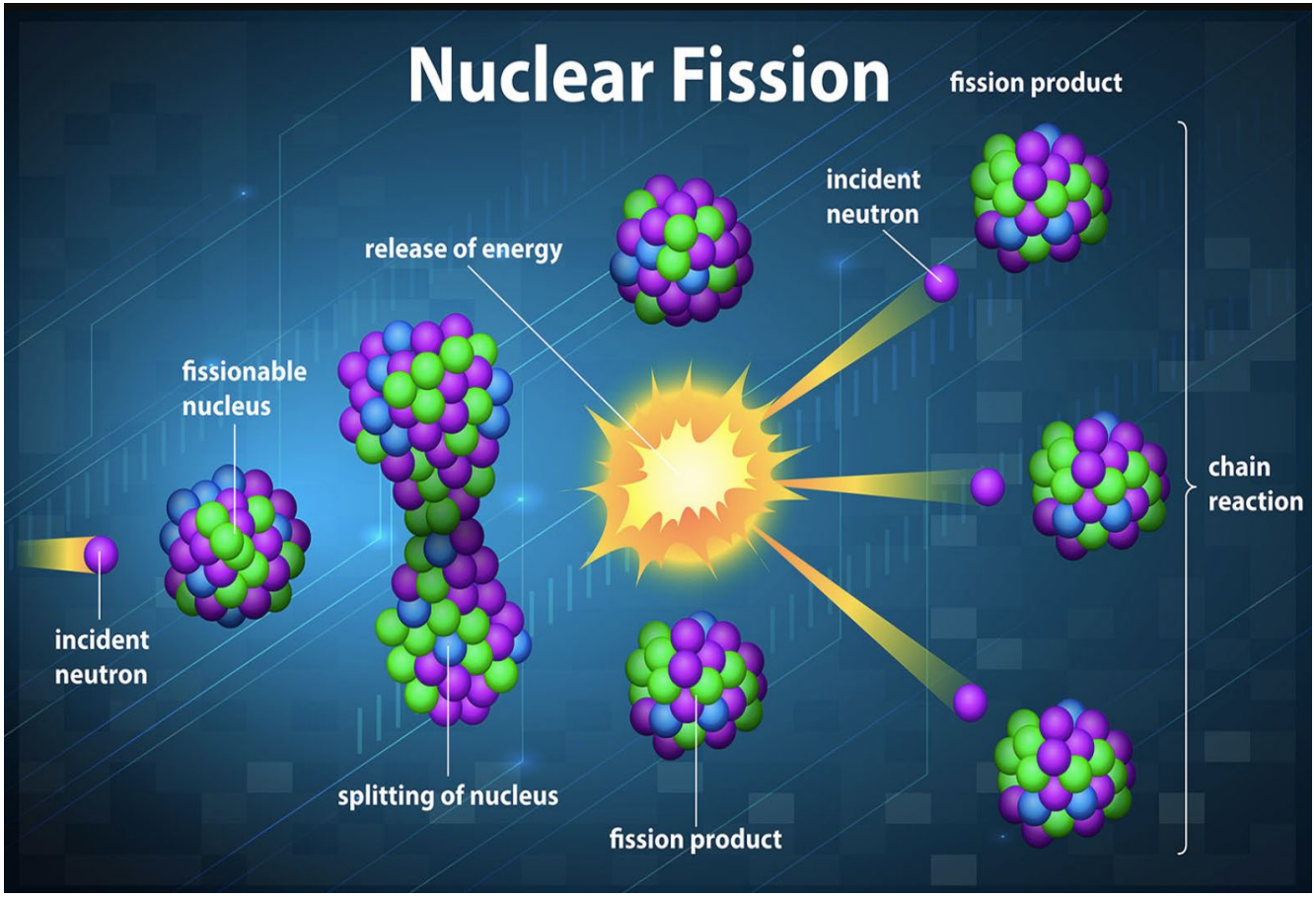
1. Glacier Peak – Stratovolcano within the Cascade volcanic arc. This area contains several hot springs and fumaroles with favorable geothermometry, elevated geothermal gradient, and young volcanic vents.

2. Straight Creek Fault – Old, large, steep fault that appears to be a conduit for several thermal springs and localized shallow elevated geothermal gradient.

3. Northern Graben Anomaly – Fault complexity at the northern end of the Chiwaukum Graben where the Entiat Fault and Leavenworth Fault interact. Some indication of elevated temperatures in nearby springs.

Fission

- Splitting the nucleus of heavy atoms to release heat to generate steam to drive a turbine-generator. This is the process used in conventional nuclear power plants.



Fission Plants U.S.

Licensed to Operate (95)

Printable Map

P.U.D. CHELAN COUNTY

Fission

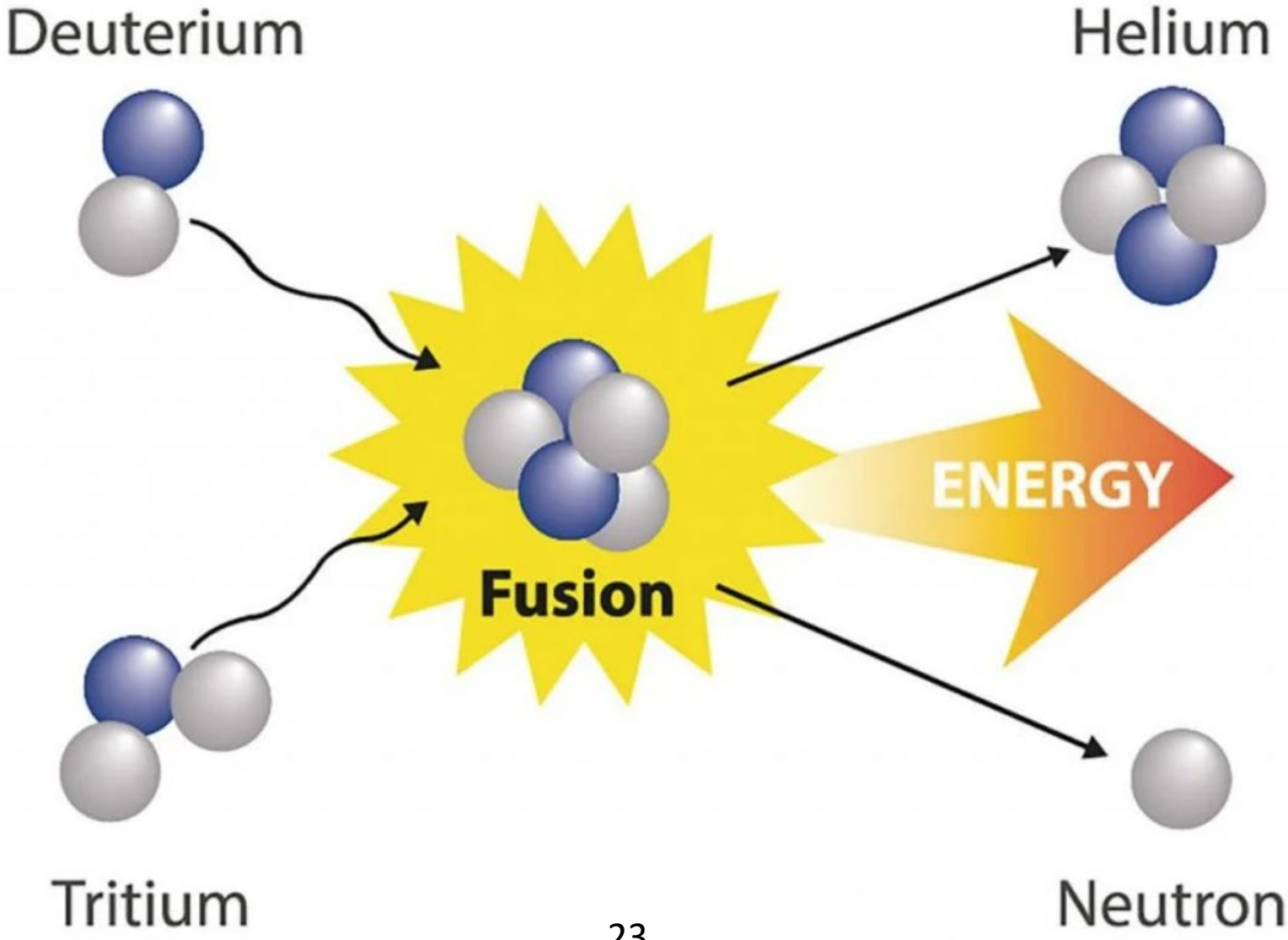
The Future:

- SMR – Small Modular Reactors. Small fission plants that can be more easily manufactured, transported and erected. Xe-100 (80 MW each).
- Oct 2024 - Energy NW, in partnership with Amazon and X-energy, working to develop a site at Hanford to produce 320 to 960 MW utilizing SMR's. Chelan is a member of Energy NW but has not opted to purchase any new SMR output.

Fusion

- A proposed form of power generation that produces electricity by combining two lighter atomic nuclei such as Hydrogen-2 (deuterium) and Hydrogen-3 (tritium) to form a heavier nucleus such as Helium, while releasing energy.
- Fusion processes include particle accelerators, high energy lasers and magnetic confinement which create intense heat and pressure (100+million degrees, 1000 Atm).

Fusion



Fusion

There are three general approaches to fusion energy

Magnetic Fusion Energy (MFE)

Low n
High τ_E

Commonwealth Fusion Systems
tokamak energy — a faster way to fusion
CTFusion — As Brilliant as the Sun
TYPE ONE ENERGY
tae TECHNOLOGIES
iter — china eu india japan korea russia usa

Magneto-Inertial Fusion (MIF)

Medium n
Medium τ_E

generalfusion
ZAP ENERGY
COMPACT FUSION SYSTEMS
Helion Energy
HYPERJET FUSION CORPORATION

Inertial Fusion Energy (IFE)

High n
Low τ_E

NIF
UR LLE
first light

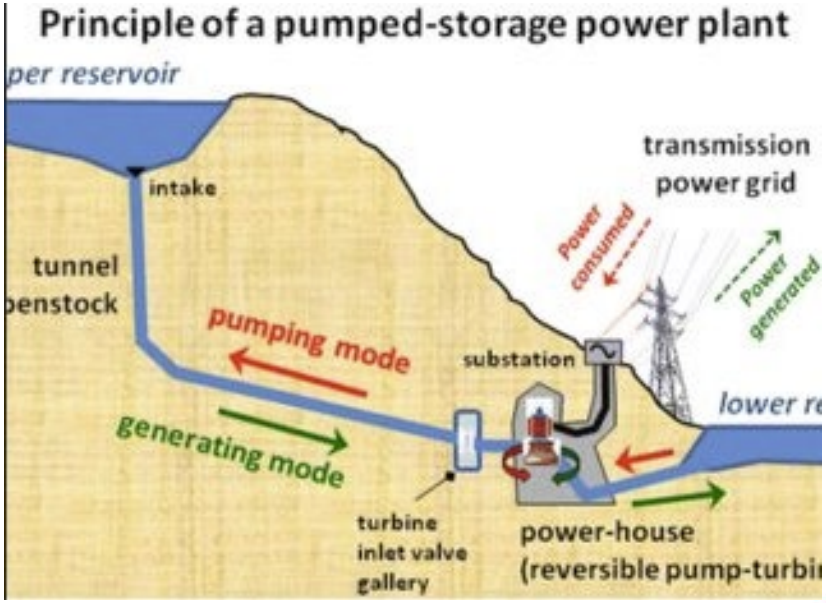
USA TODAY · 13d

TVA signs 'landmark' agreement with Type One Energy to develop nuclear fusion pilot plant

"What we're building at Bull Run is not a science project," an executive from the Knoxville-based nuclear fusion company said.

Pumped Storage

- A type of hydro-electric energy storage where water is moved with an impeller/motor to an upper reservoir and allowed to flow back down to the lower reservoir through a turbine/generator
- 42 Sites in U.S.
- 94% of U.S Storage
- 6% Battery and other



Pumped Storage - National Hydropower Association

Pumped Storage

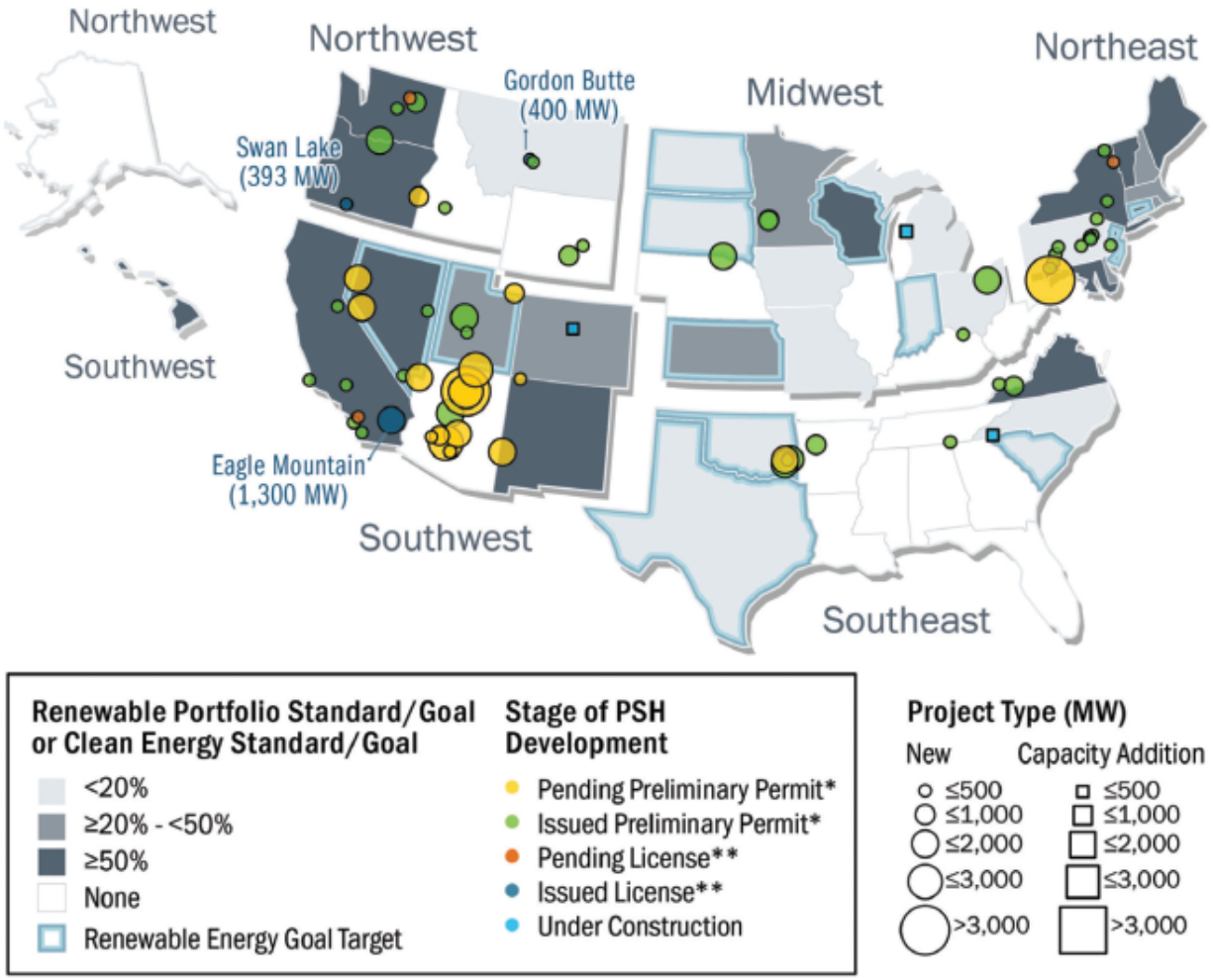


Figure 2. There are 67 new PSH projects across 21 states representing over 50 GWs of new long duration storage.

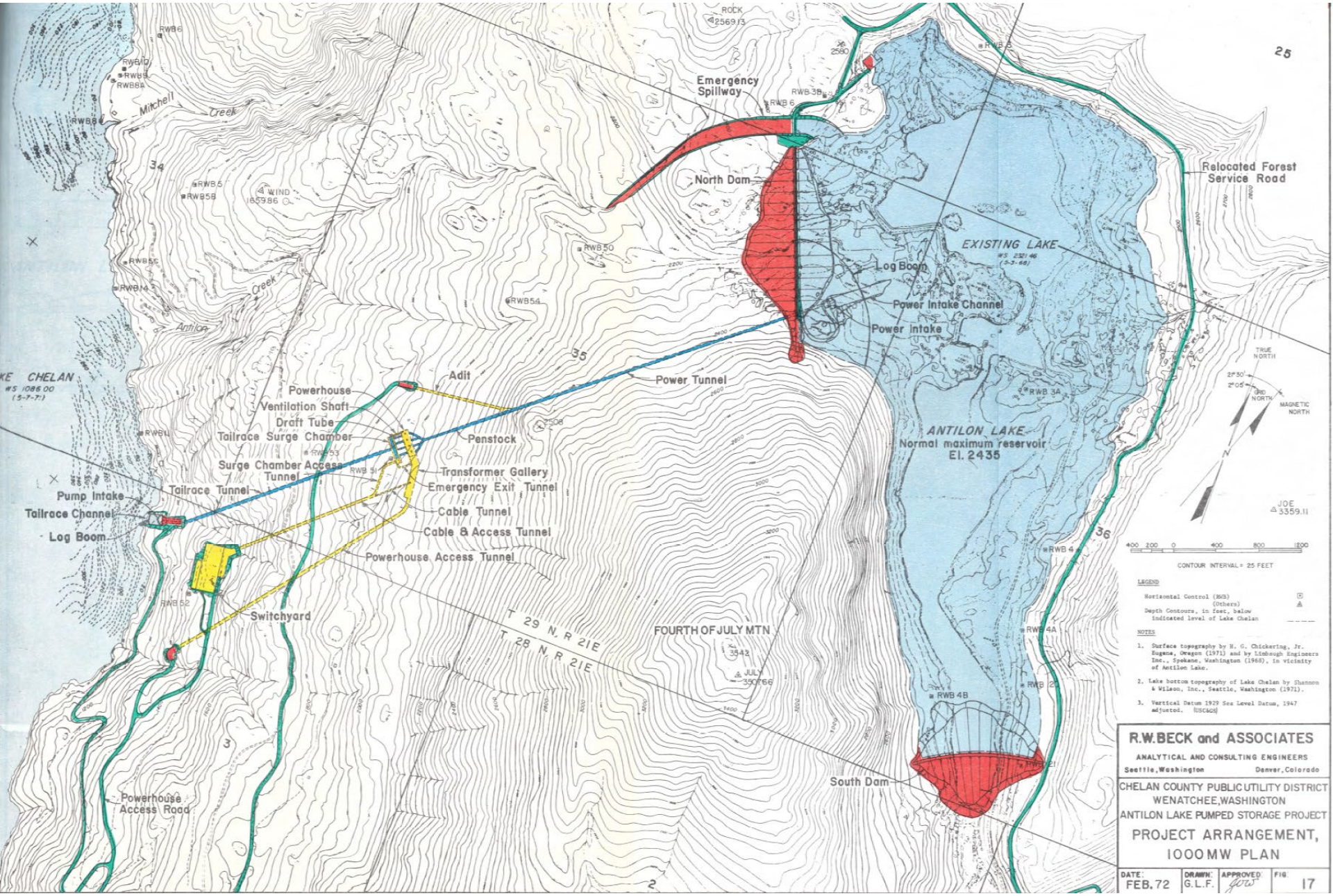
New - Goldendale Energy Storage
1200 MW for 12 Hours

P.U.D. CHELAN COUNTY

Existing Grand Coulee Pumped Storage 314 MW

Antilon Lake

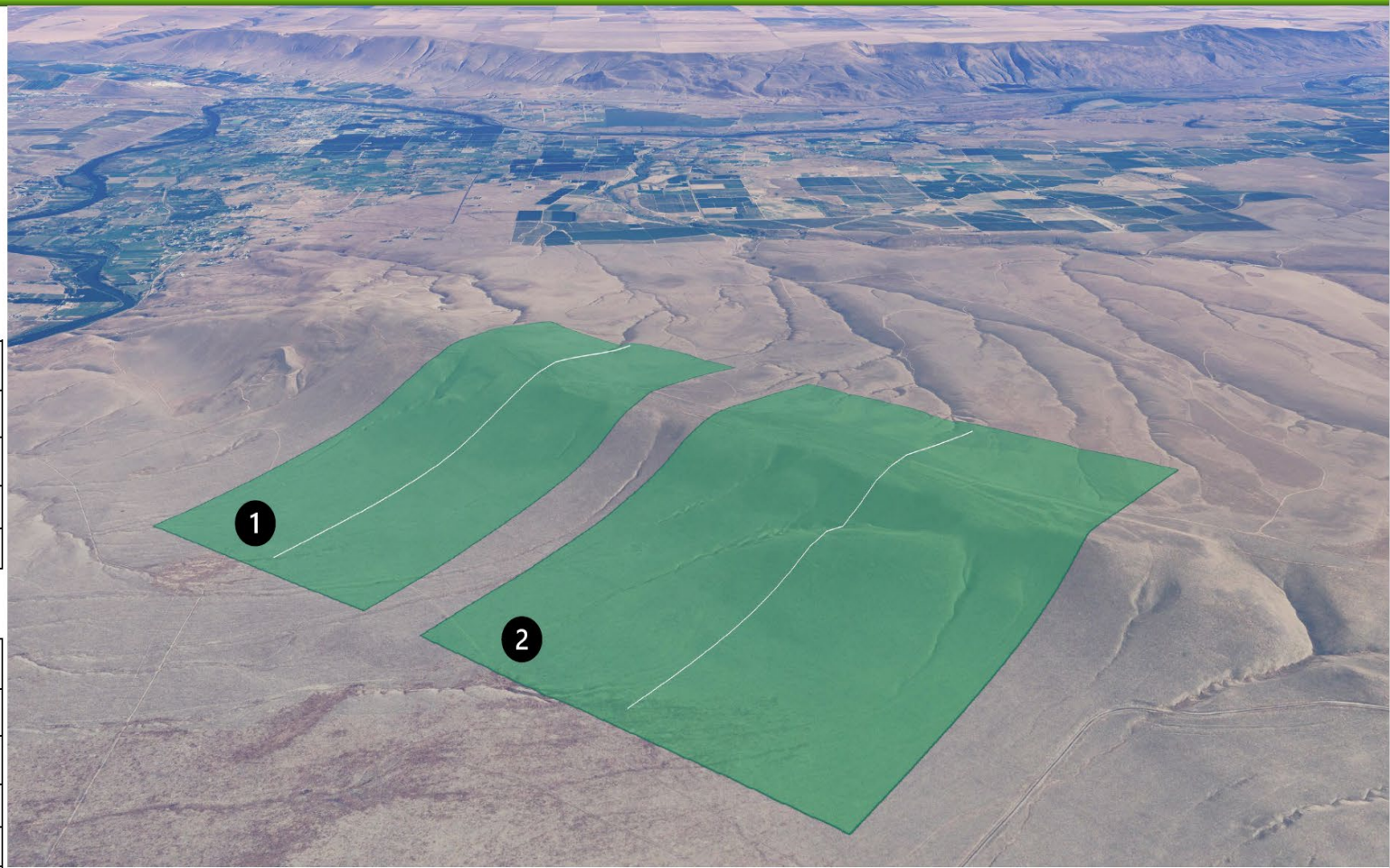
Evaluated - early 1970's and 2009.


Emergency Spillway
North Dam
Relocated Forest Service Road
EXISTING LAKE
Log Boom
Power Intake Channel
Power Intake
Adit
Power Tunnel
Powerhouse
Ventilation Shaft
Draft Tube
Tailrace Surge Chamber
Penstock
Surge Chamber Access Tunnel
Transformer Gallery
Emergency Exit Tunnel
Tailrace Tunnel
Pump Intake
Tailrace Channel
Log Boom
Cable Tunnel
Cable & Access Tunnel
Powerhouse Access Tunnel
Switchyard
Powerhouse Access Road
ANTILON LAKE
Normal maximum reservoir
El. 2435
FOURTH OF JULY MTN
South Dam
T 29 N. R 21E
T 28 N. R 21E
Mitchell Creek
Antilon Creek
CONTOUR INTERVAL = 25 FEET
R.W.BECK and ASSOCIATES
ANALYTICAL AND CONSULTING ENGINEERS
Seattle, Washington
Denver, Colorado
CHELAN COUNTY PUBLIC UTILITY DISTRICT
WENATCHEE, WASHINGTON
ANTILON LAKE PUMPED STORAGE PROJECT
PROJECT ARRANGEMENT,
1000 MW PLAN
DATE: FEB. 72
DRAWN: G.L.F.
APPROVED:
FIG. 17

Gravity Storage
Advanced Rail Energy Storage

Gravity Storage
Advanced Rail Energy Storage

Siting Flexibility: Solar Farm – Washington



1

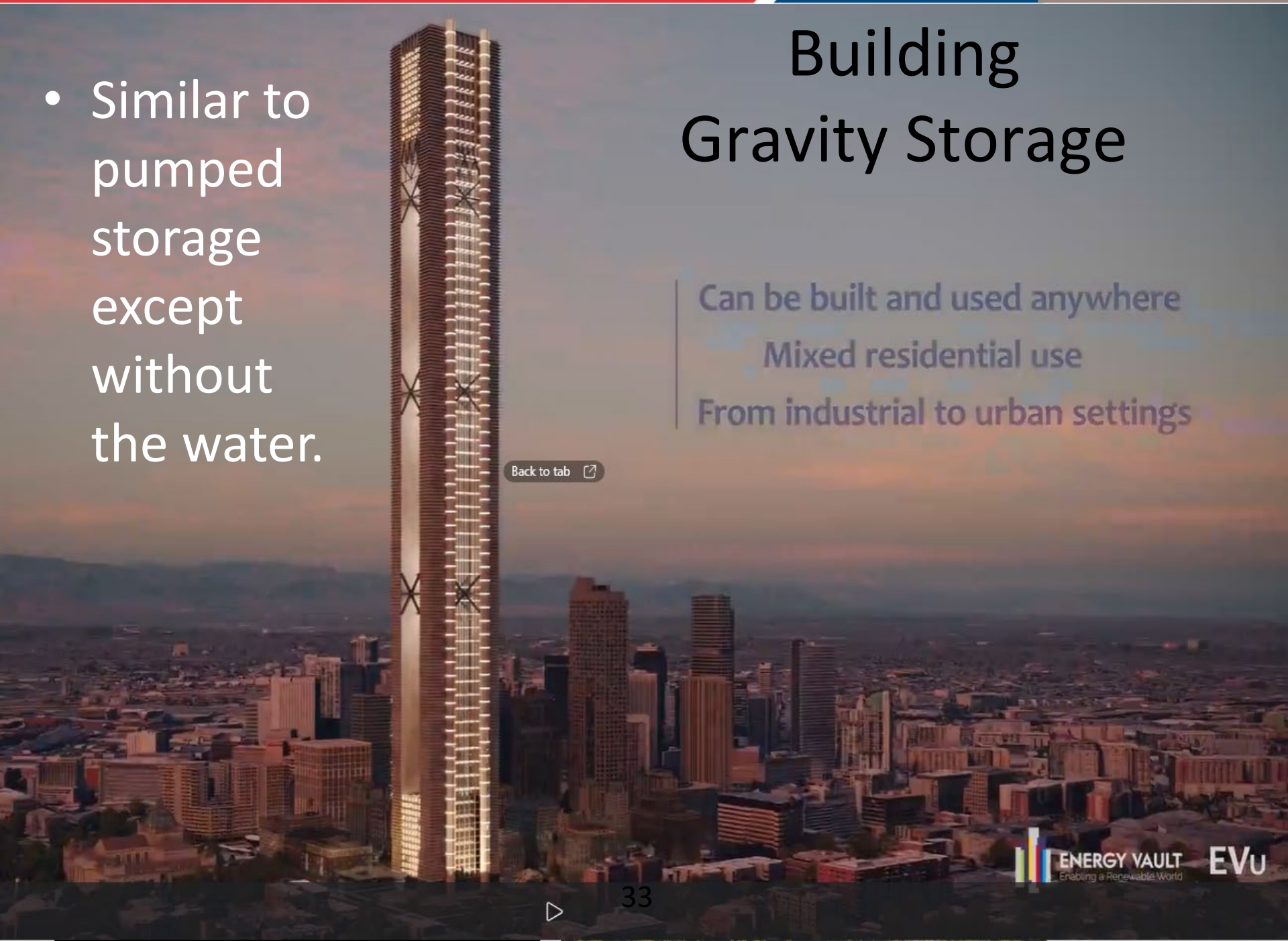
Elevation Gain (ft)	720
MW	260
Duration (hr)	10
MWh's	2600
Acres	380

2

Elevation Gain (ft)	620
MW	330
Duration (hr)	8
MWh's	2640
Acres	460

Building Gravity Storage

- Similar to pumped storage except without the water.



Gondola Gravity Storage

[Energy Vault® - G-VAULT™ - Gravity Energy Storage]

Pilot project evaluated at Jump-off.
Need property at base of the cliffs.

New Concept Pumped Storage

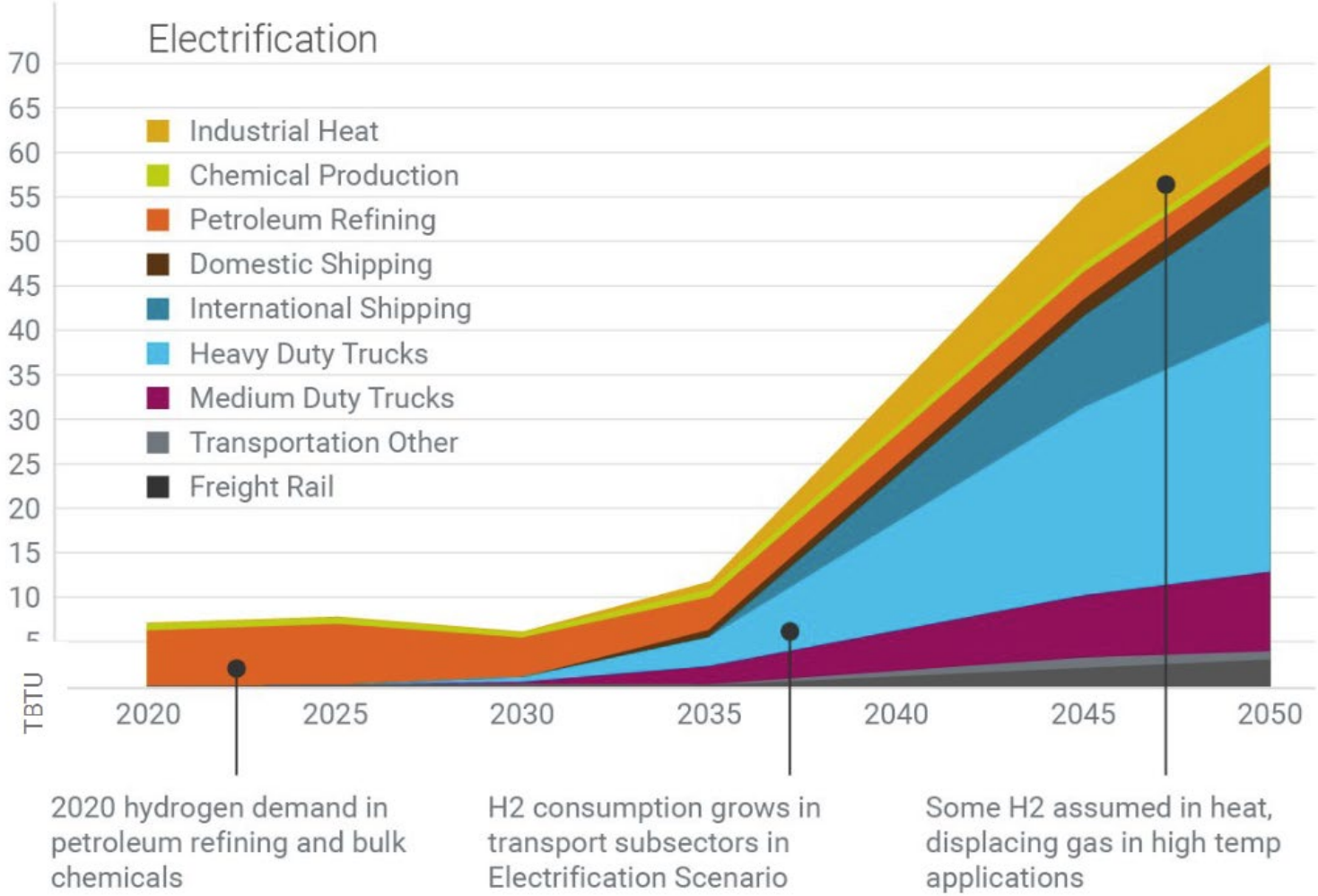
[Energy Vault® - G-VAULT™ - Gravity Energy Storage]

Electrolyzer (Hydrogen Production)

WA Hydrogen Projection

Hydrogen consumption and electricity demands - electrification scenario

WA Dept. Commerce



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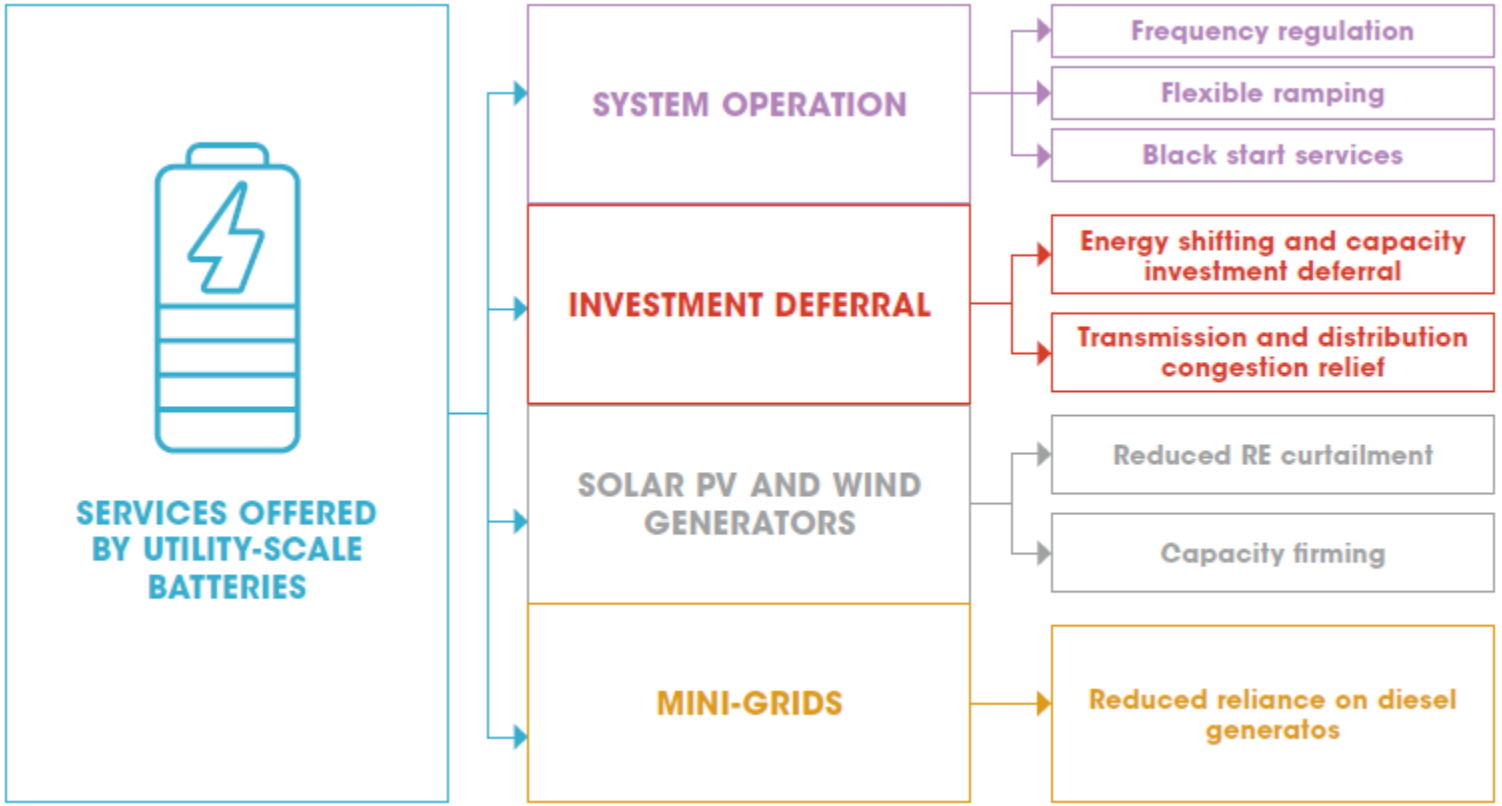
CHELAN COUNTY

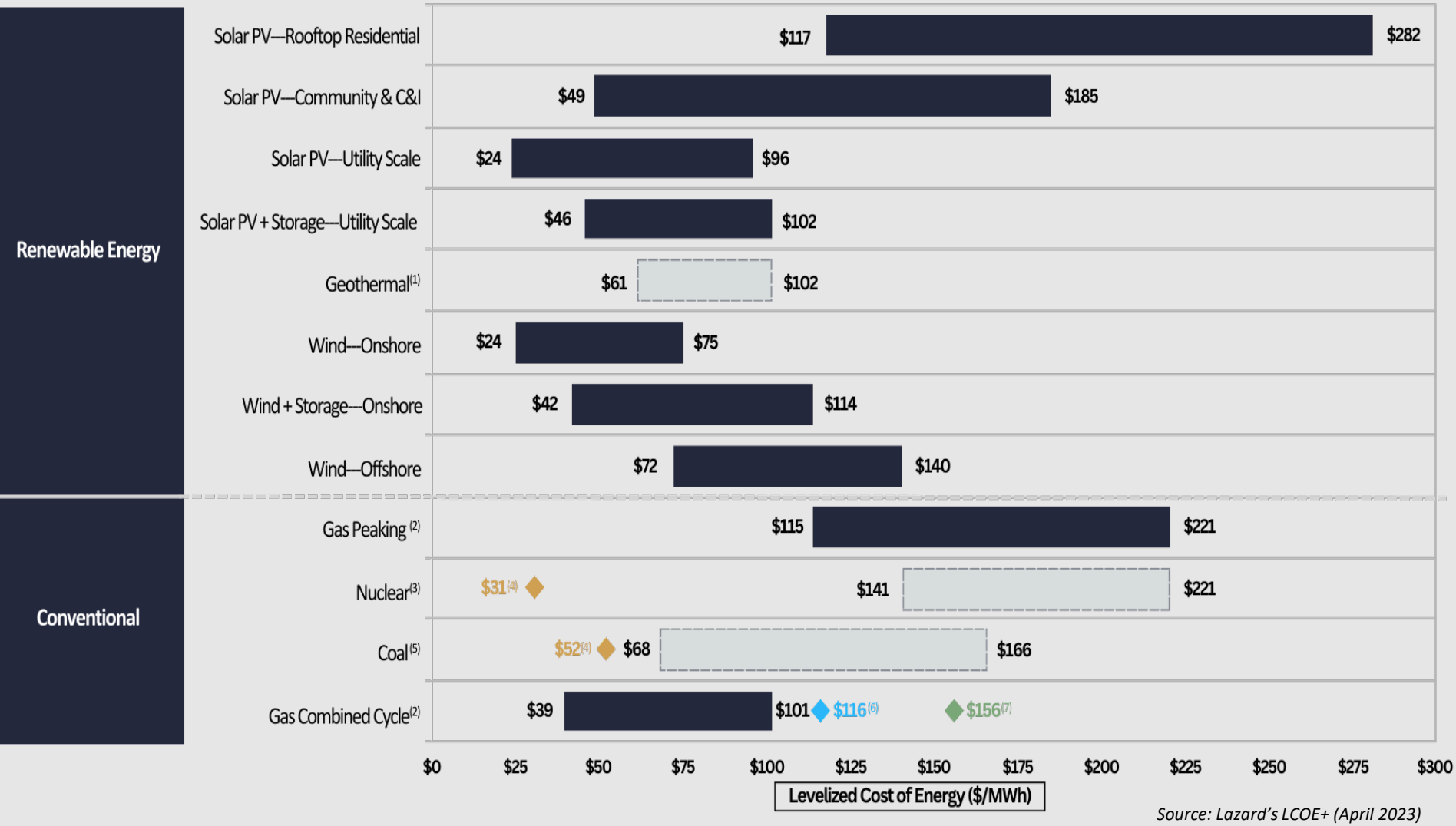
Energy Storage - Batteries



Criteria for Future Energy Generating and Storage Resources

- Safe
- Affordable
- Base Load (24/7 output)
- Flexible
- Reliable
- Sustainable
- Least impact to water resources and environment

Levelized Cost of Energy —Unsubsidized Analysis



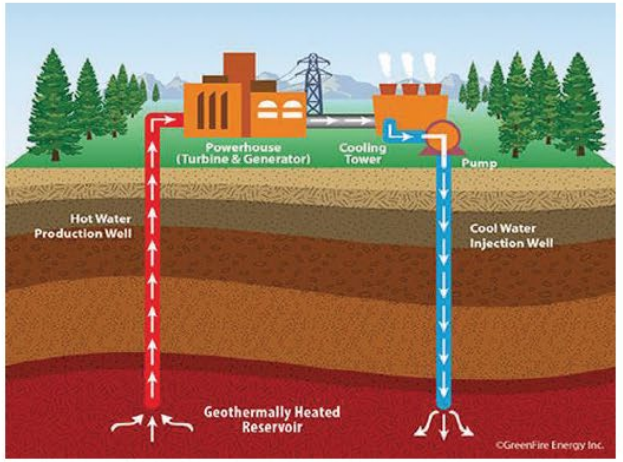
Source: Lazard's LCOE+ (April 2023)

Geothermal

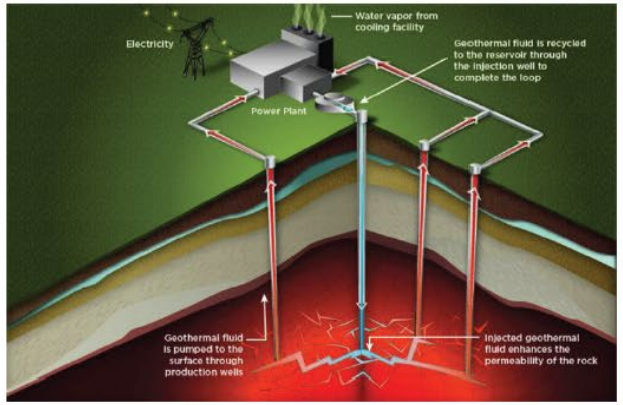
Geothermal Resource Descriptions

Two geothermal resource development options are considered in this analysis:

1. Naturally circulating Hydrothermal resources
   - Temperature <200C – Pumped wells
   - Temperatures >200C – Self flowing wells
   - Resource is the heat.
   - All produced geothermal fluids are injected to be reheated by the rock.
   - Natural permeability for fluid circulation is either from fractures or matrix permeability
2. Enhanced/Engineered Geothermal Systems (EGS)
   - Temperatures >200C
   - Reservoir is created through fracturing in either impermeable rock or enhancing fractures in low permeability rock
   - Currently EGS projects are being developed at temperatures up to 300C



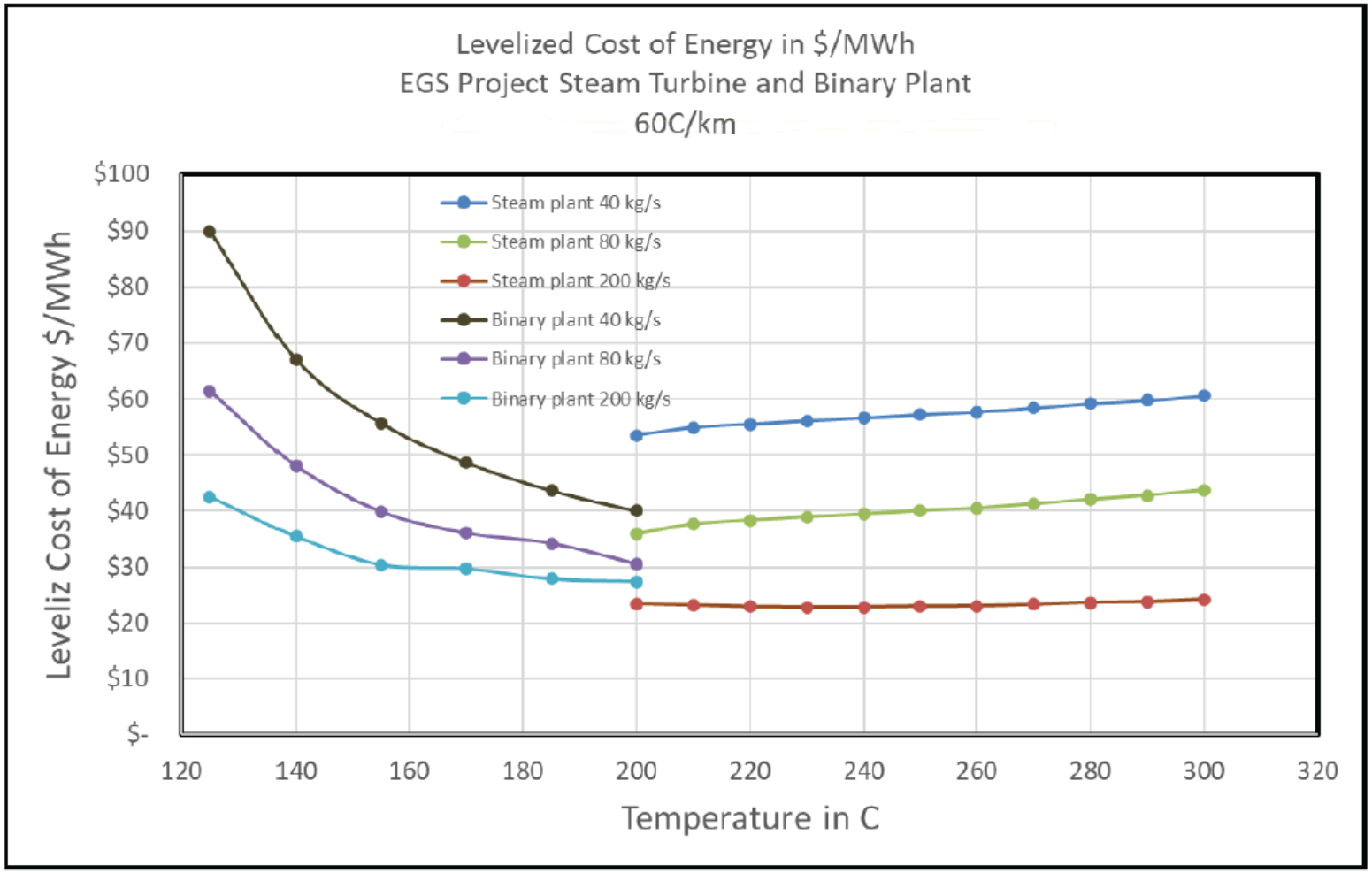
Hydrothermal Geothermal Resource



Enhanced Geothermal System (EGS)

Geothermal

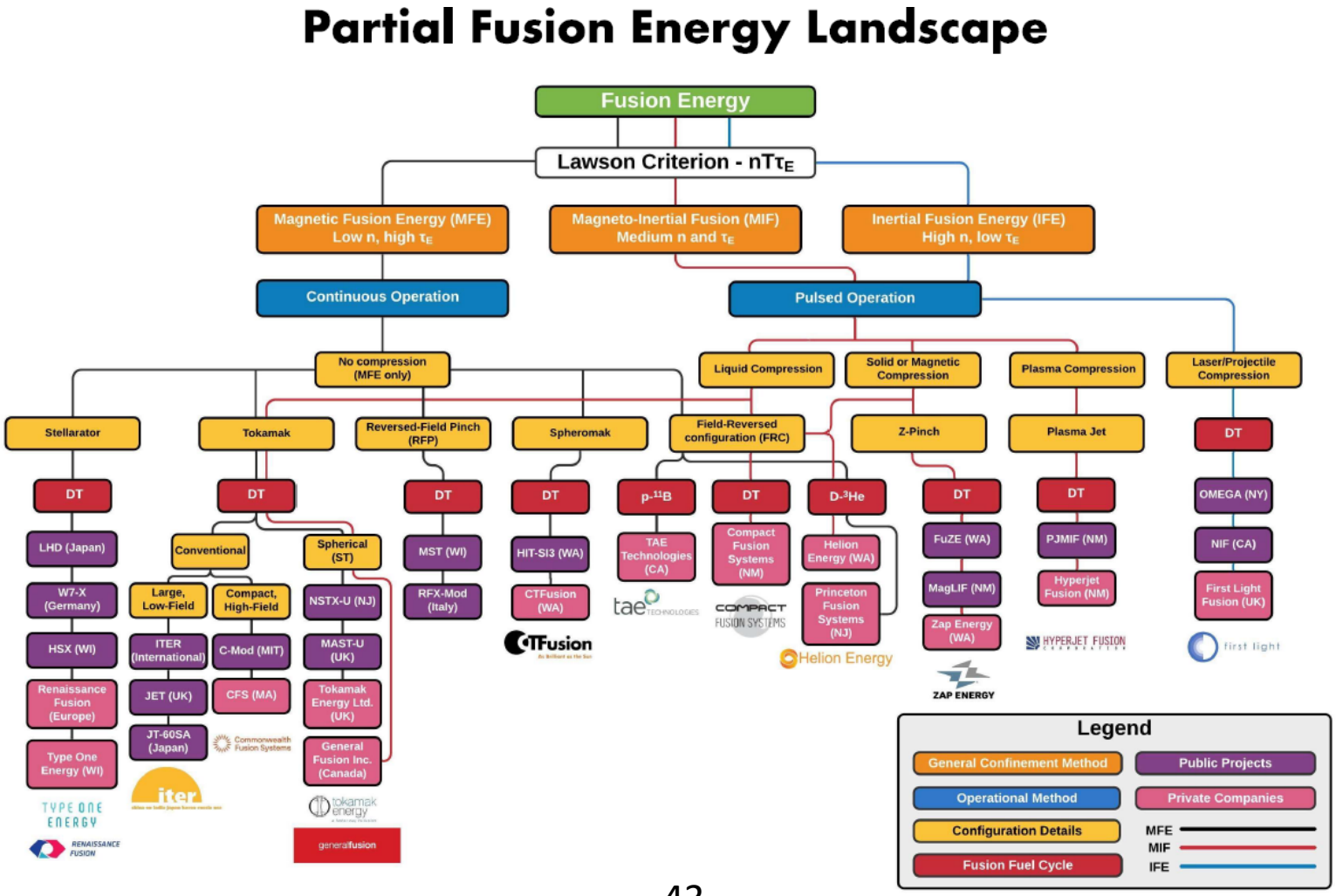
Levelized Cost of Energy



P.U.D.
ELAN COUNTY

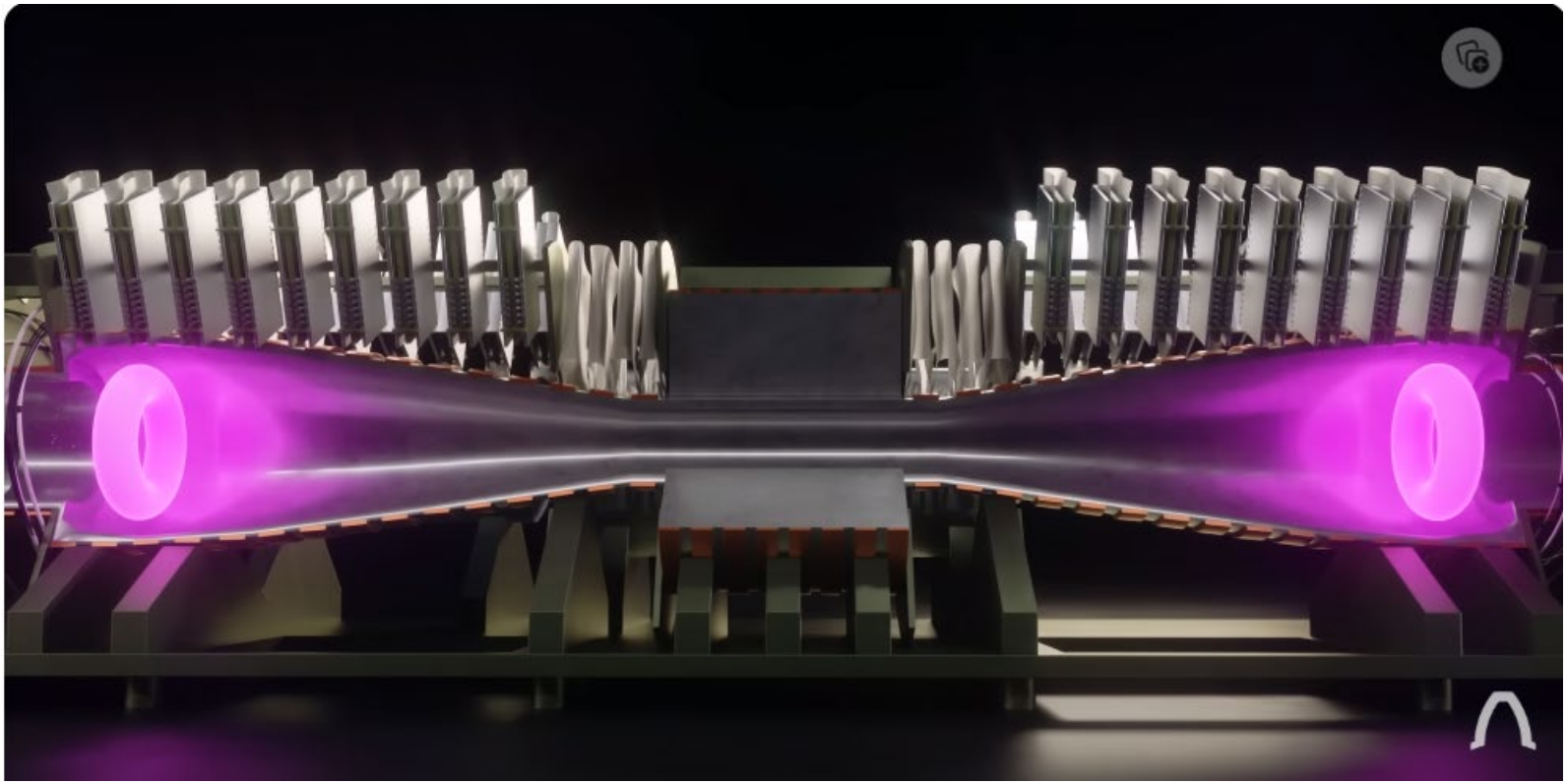
Fusion

- Monitor Technology Development



Fusion

- Evaluate with Community: Helion locating in Chelan County



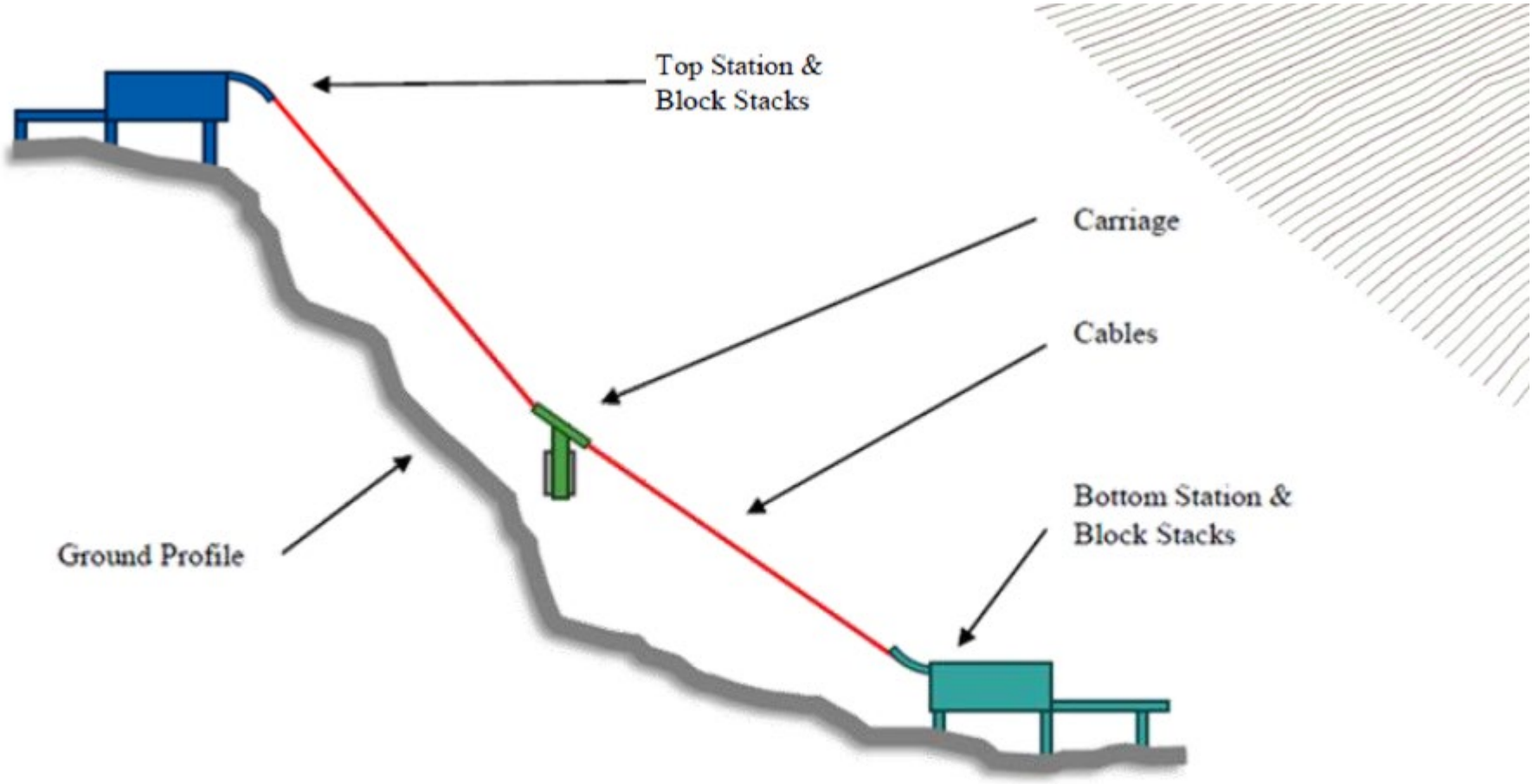
Battery Storage

Evaluating viability for:

- Minimizing use of diesel generators (Stehekin)
- System Reliability
  - PSPS, Capital Deferral
- Capacity Firming
- Resource Adequacy
- Micro-Grids

Gravity Storage

- Evaluating technology viability and costs



Summary

The District will continue to evaluate:

- Geothermal potential in Chelan County and the Mid-C
- Helion fusion generator in Malaga
- Battery storage use cases
- Monitor technology viability and cost of gravity storage (water and dry weights)

Questions?