Future of Energy 101

Emerging Clean Energy Technologies

OEDA FALL CONFERENCE 2022

The Clean Energy Future

Clean Energy Generation

Energy Storage

Transmission or Other Transport

Fast Moving Energy Transition

Clean Energy creates Economic

Opportunities for Oregon

Ways to think about new energy projects

WHAT INFRASTRUCTURE DOES THE PROJECT NEED?

WHO'S BEHIND THE PROJECT AND WHAT'S THEIR FINANCIAL PICTURE?

WHO IS THE END USER OF THE OUTPUT?

WHAT ARE THE LOCAL BENEFITS OF THE PROJECT?

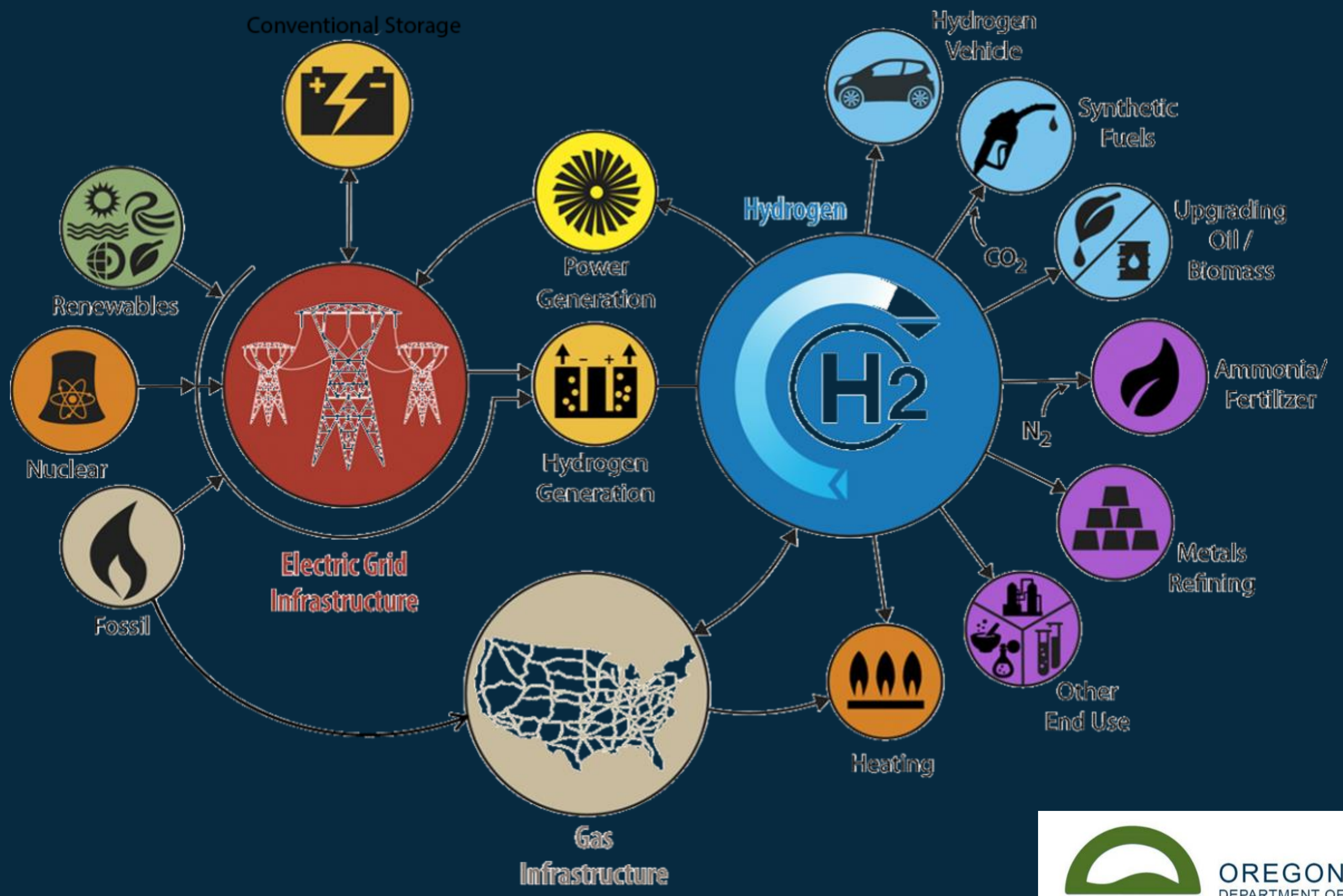
Oregon Department of **ENERGY**

ODOE RH2 Study

Stakeholder Workshop #1

Rebecca Smith

November 16, 2021



OREGON DEPARTMENT OF ENERGY

Leading Oregon to a safe, equitable, clean, and sustainable energy future.

Our Mission

The Oregon Department of Energy helps Oregonians make informed decisions and maintain a resilient and affordable energy system. We advance solutions to shape an equitable clean energy transition, protect the environment and public health, and responsibly balance energy needs and impacts for current and future generations.

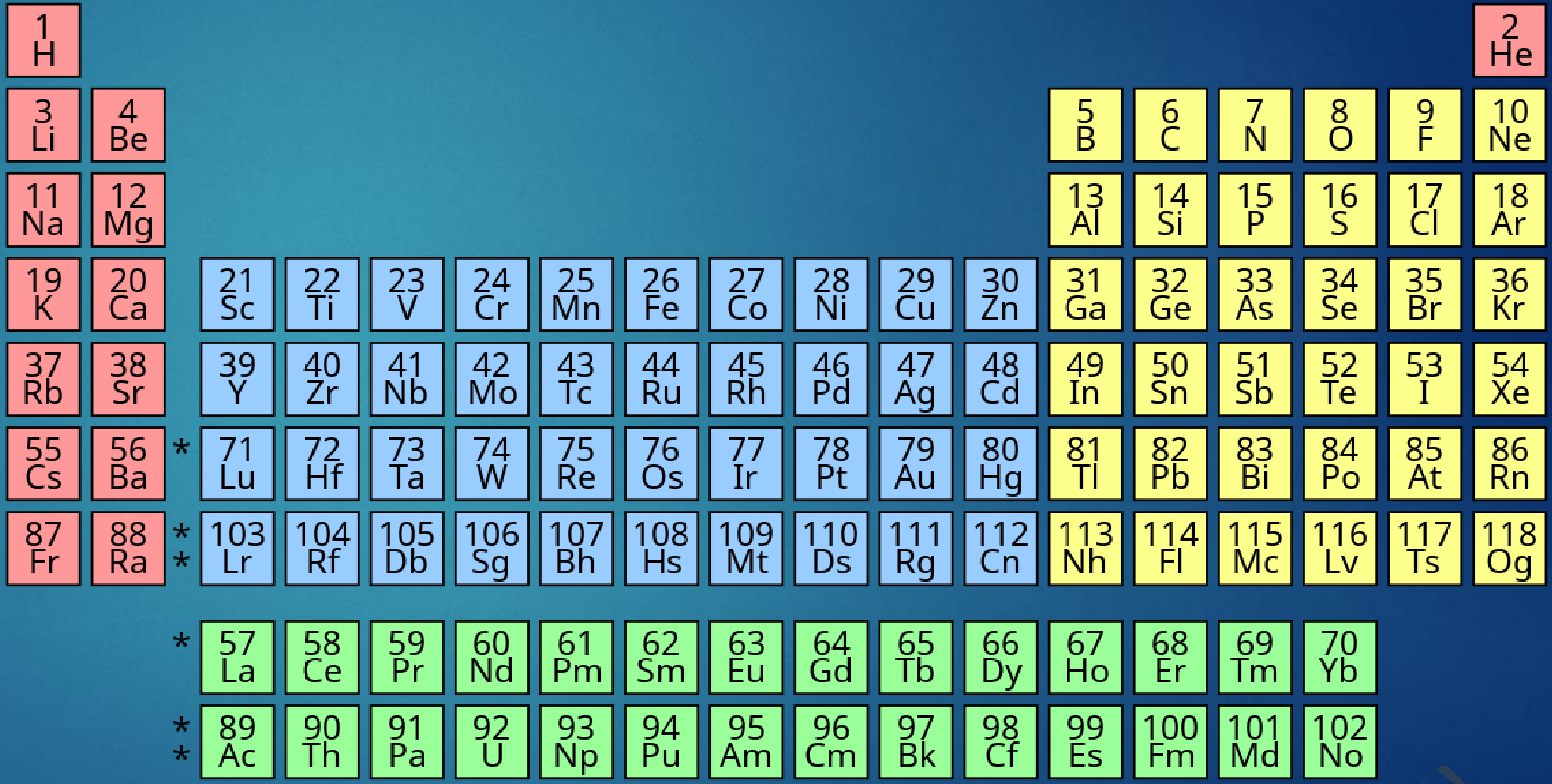
What We Do

On behalf of Oregonians across the state, the Oregon Department of Energy achieves its mission by providing:

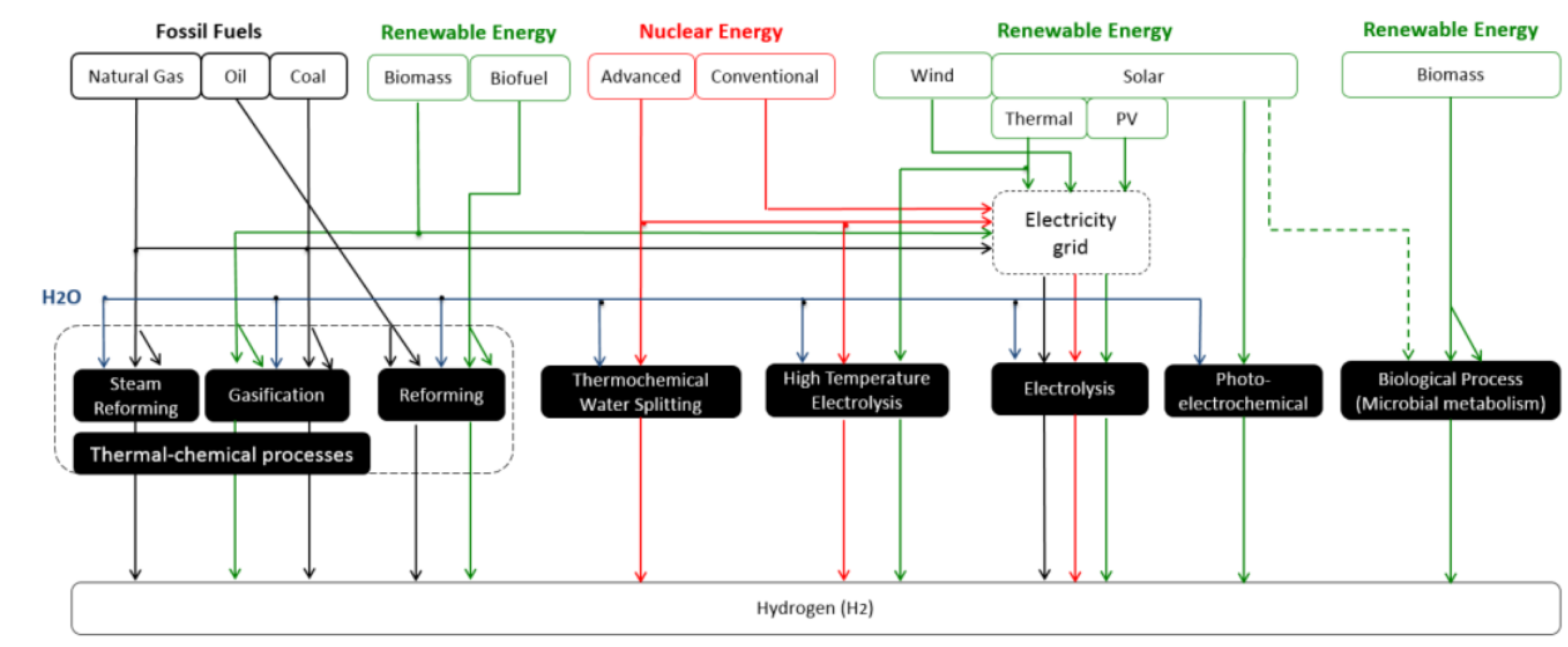
- A Central Repository of Energy Data, Information, and Analysis
- A Venue for Problem-Solving Oregon's Energy Challenges
- Energy Education and Technical Assistance
- Regulation and Oversight
- Energy Programs and Activities

WHAT IS HYDROGEN?

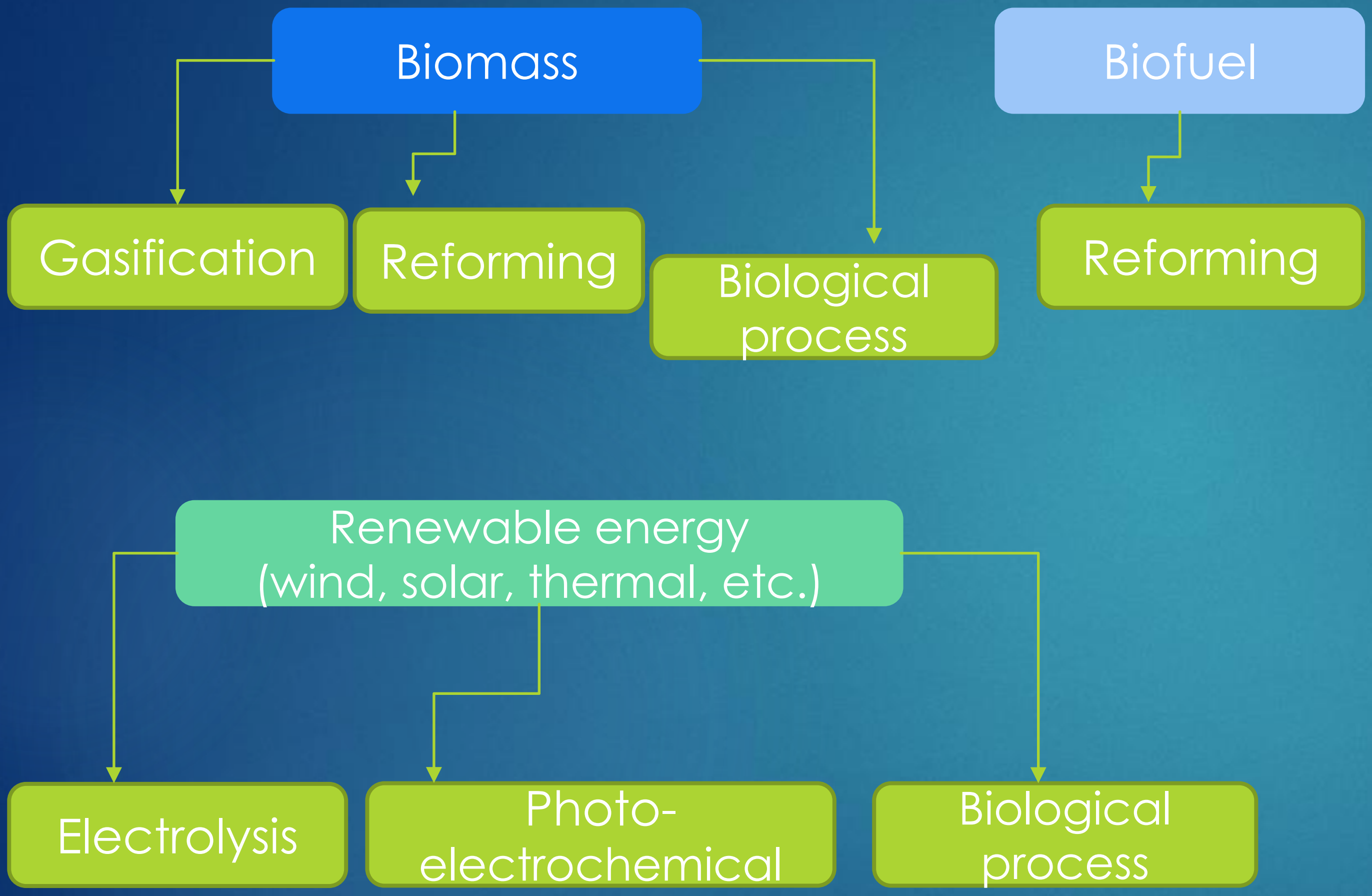
- Lightest element
- Most abundant element in universe
- States include gas and liquid
- Lowest density of all gases



PATHWAYS FOR PRODUCING H2



RENEWABLE PATHWAYS FOR RH2



Reforming: Steam reformation uses high-temperature steam with a catalyst to produce hydrogen from a source of methane, such as natural gas, biogas, ethanol, etc. Very established process.

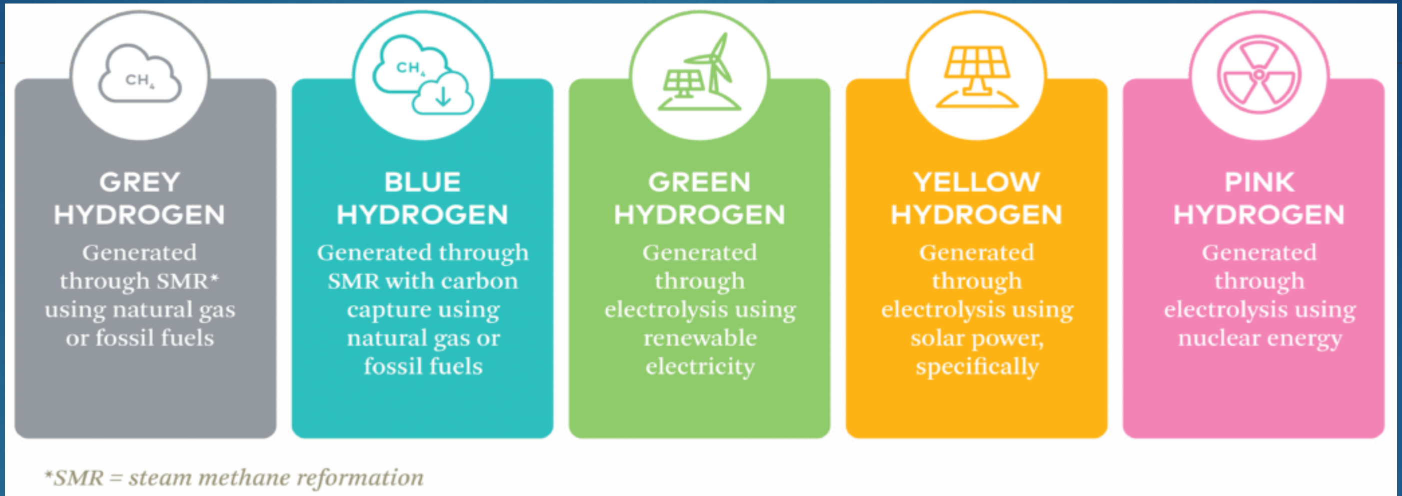
Gasification: Process involving heat, steam, and oxygen to convert biomass to hydrogen and other products. Very established process.

Biological processes: These can include fermentation of biomass to produce RH2 as a byproduct. Emerging process.

Photo-electrochemical: Using sunlight to directly split water into hydrogen and oxygen. Emerging process.

Electrolysis: Renewable electricity is used to split water into hydrogen and oxygen using an electrolyzer. Very established process.

CATEGORIZING HYDROGEN

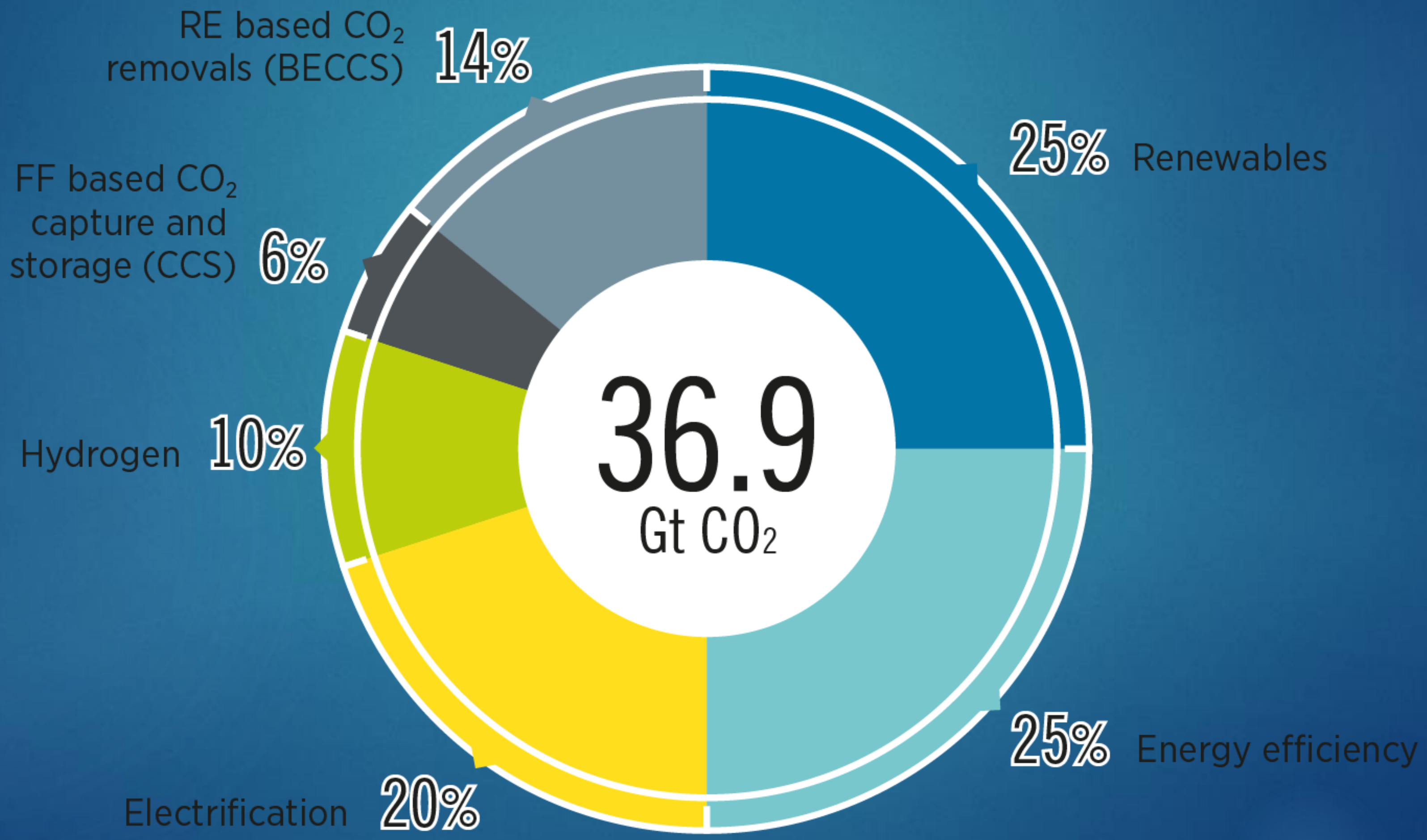


Source: 3 Degrees Inc.

- Industry moving away from color categorization of hydrogen.
- IIJA defines "**clean** hydrogen" with a carbon intensity at the site of production.
- Clean fuel standards use lifecycle emissions, not just those from production.
- Bottom line – industry moving toward measure of "clean" based on CI, not on whether feedstock is considered "renewable."

WHY THE INTEREST IN HYDROGEN?

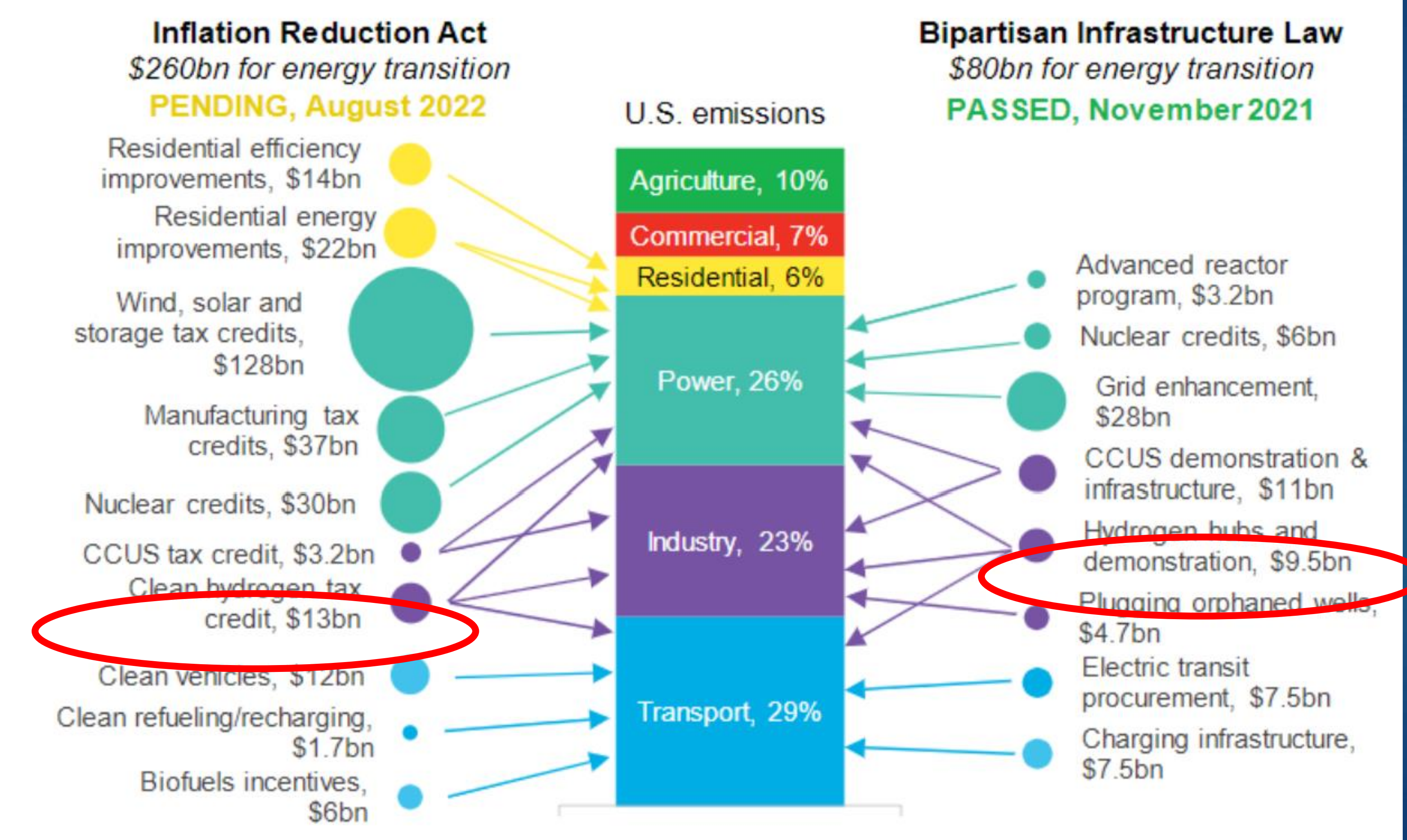
Reducing GHG Emissions Through Six Technological Avenues



Source: IRENA World Energy Transitions 2022

WHY THE INTEREST IN HYDROGEN?

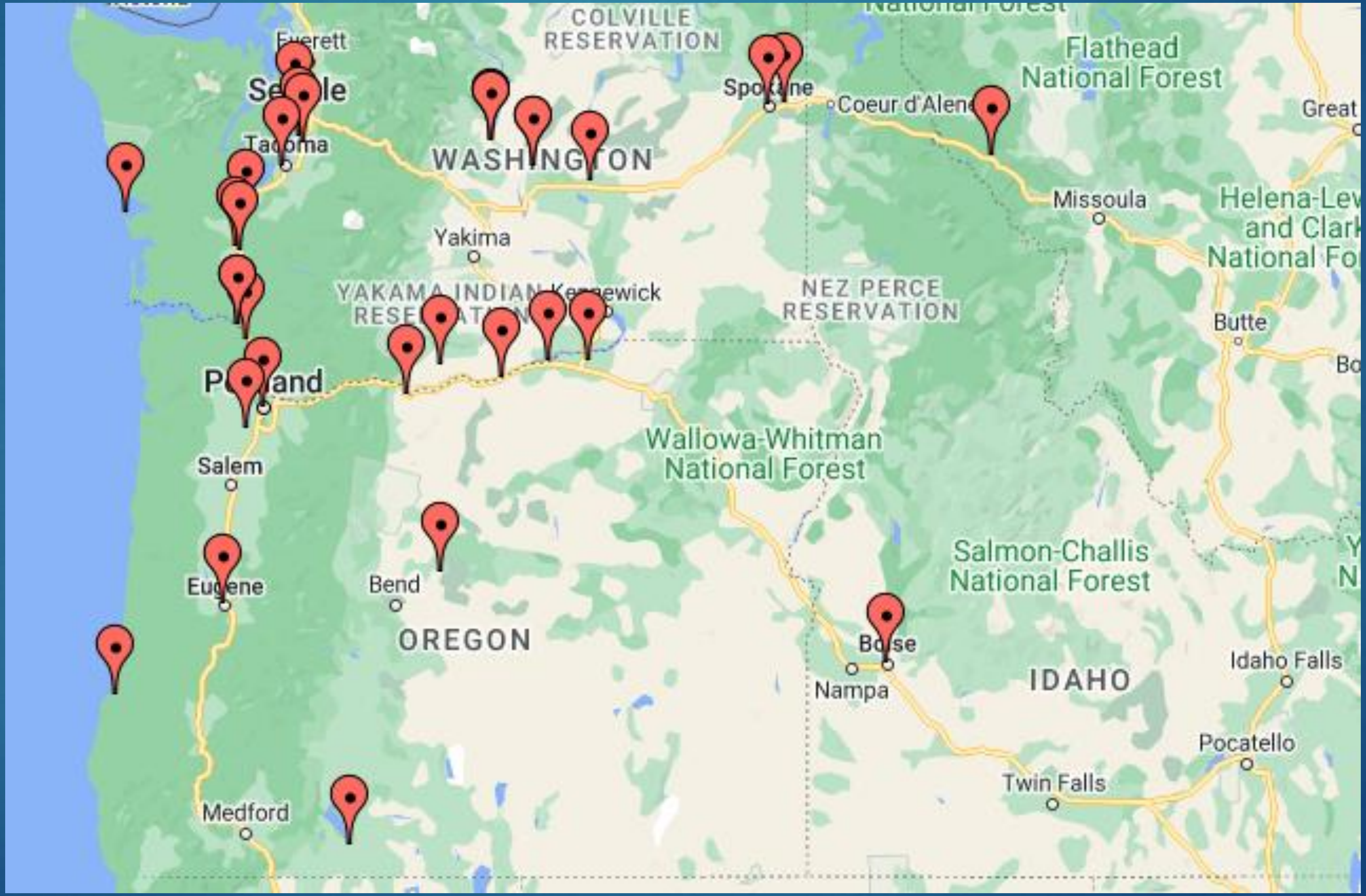
Energy Transition Spending in Recent Federal Legislation



Source: BNEF "US Climate Bill Changes the Game for Two Key Sectors," 2022

WHERE WILL WE SEE H2 PROJECTS IN OREGON?

Proposed and Planned Hydrogen Projects in the PNW



Source: Renewable Hydrogen Association

WHAT KIND OF H2 PROJECTS TO EXPECT?

Production

- Electrolyzers
- SMR with CCS
- Methane pyrolysis

Delivery

- Via truck
- Injected into NG pipeline
- Dedicated H2 pipeline

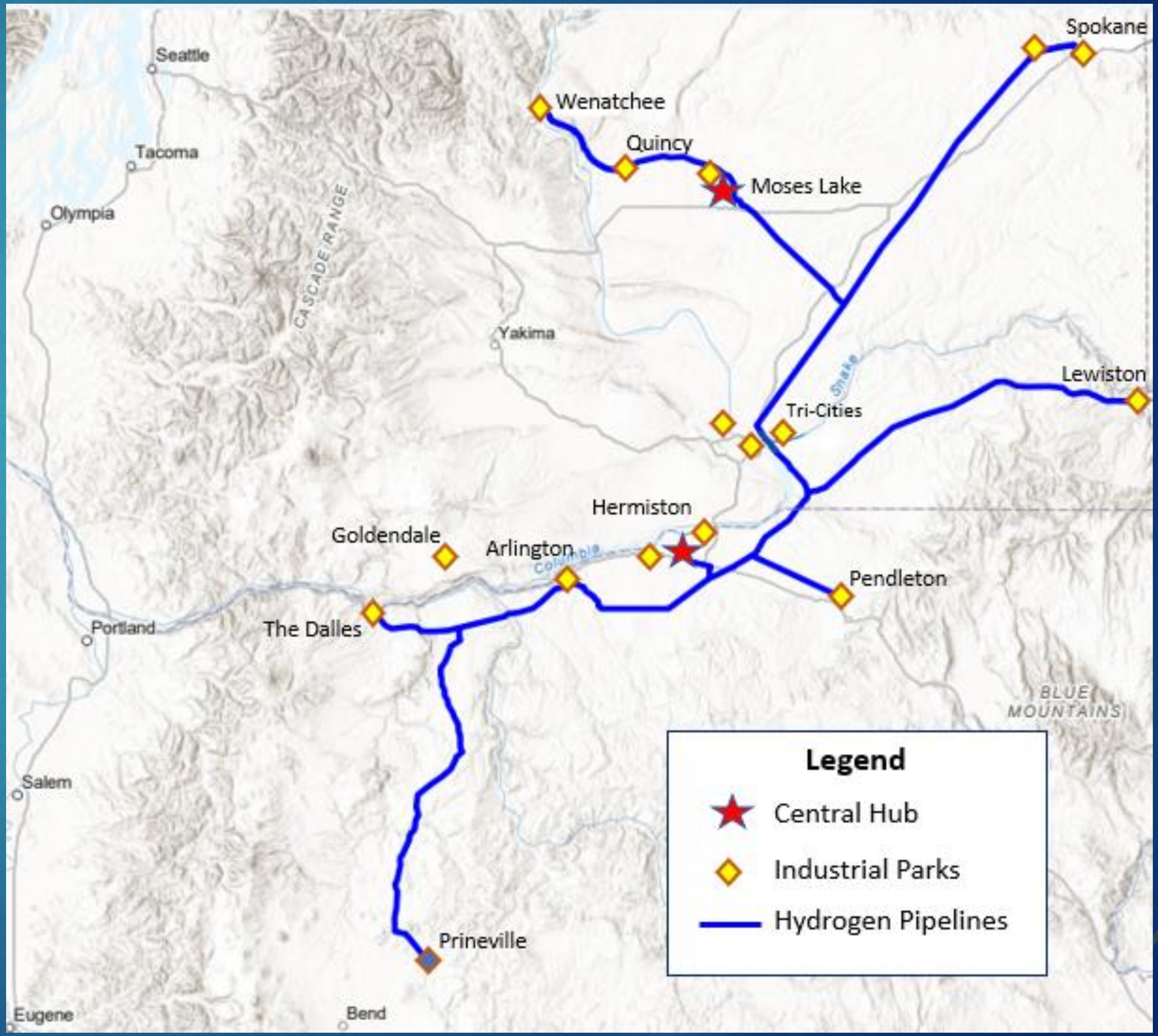
Consumption

- Fueling stations
- Industry
- Back-up power with fuel cells
- Export

EXAMPLE PROJECT: OBSIDIAN RENEWABLES

Obsidian Renewables Pacific NW H2 Hub

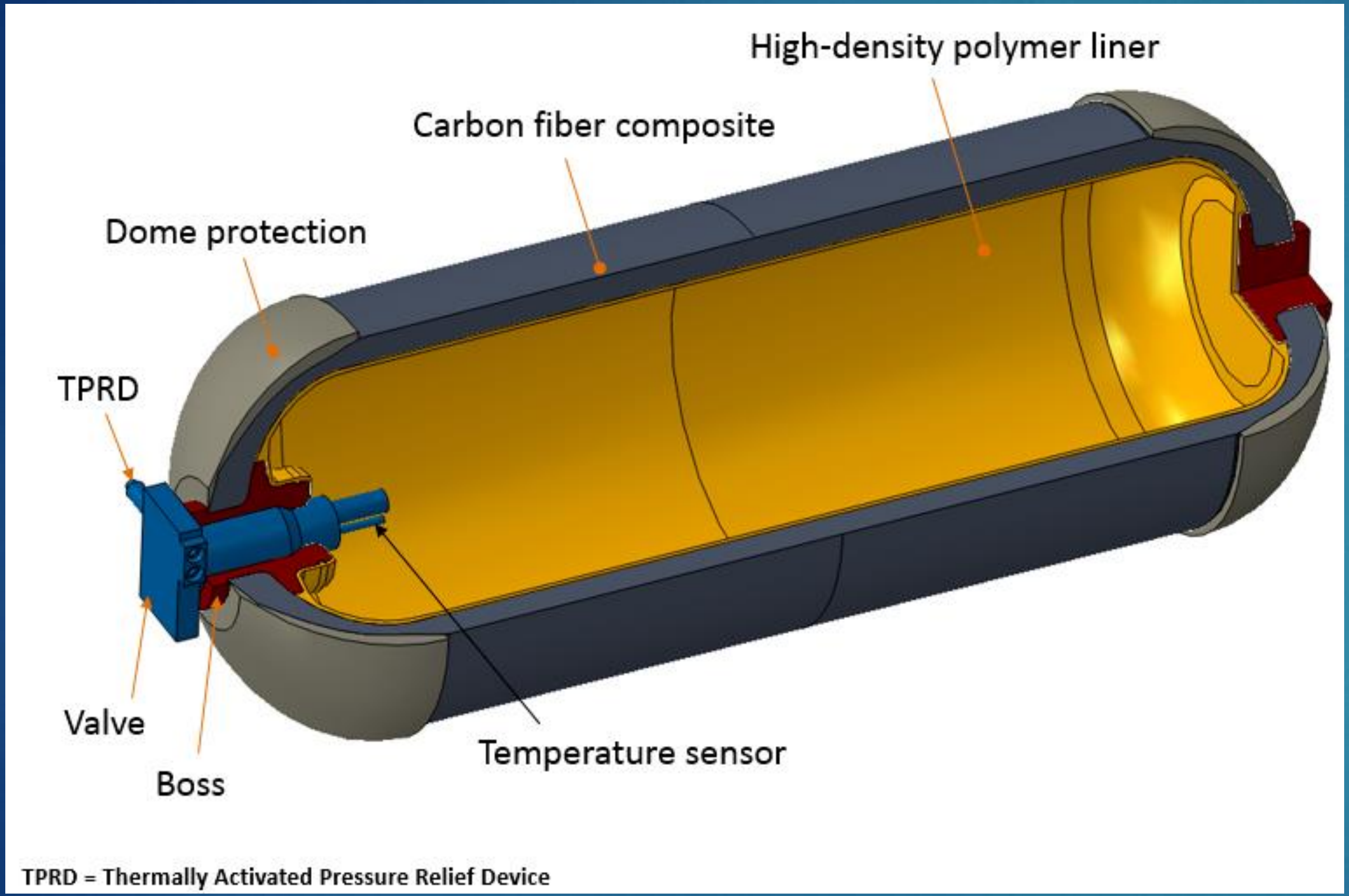
- Produce renewable hydrogen from wind and solar power.
- Industrial parks to include end uses such as nitrogen/ammonia fertilizer plant.
- Other H2 customers could include companies with large data centers replacing back-up diesel generators with H2 fuel cells, and commercial transportation.
- Longer-term plans for hydrogen pipelines.



COMMON CONCERNS WITH H2

- Safety
- Costs
- Potential to prolong use of fossil fuels
- NOx emissions from combustion
- Water use

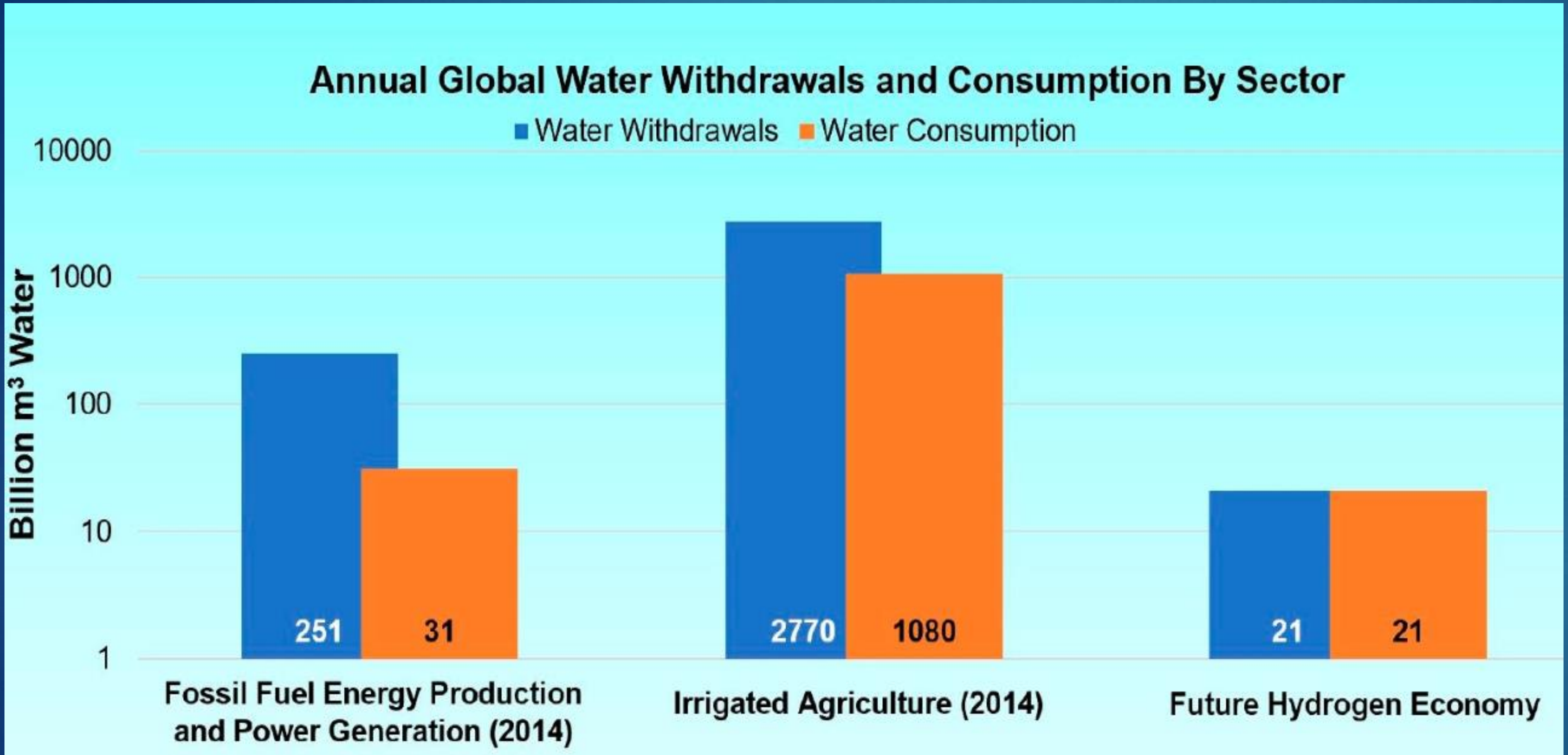
SAFE USE OF HYDROGEN



Source: H. S. Roh and R. K. Ahluwalia, Argonne National Laboratory (ANL), U.S.

Safety issues	Safety practices
Ignition	Leak sensors
Materials degradation	Tank testing codes and standards
Leakage	Continued R&D
Indirect GHG	Rigorous training

RENEWABLE HYDROGEN WATER USAGE



Source: "Does the Green Hydrogen Economy Have a Water Problem?" in ACS Energy Letters 2021.

- Minimum water requirement for producing H2 from electrolysis is 9 kg of water for every 1 kg of H2 produced.
- This does not account for the process of water de-mineralization needed.

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(503) 931-3340

Trillium Lake, Mt. Hood

OEDA
Future of Fuels

Chris Kroeker/Nina Carlson

October 10, 2022

Destination Zero

The pathway to our vision of carbon neutral

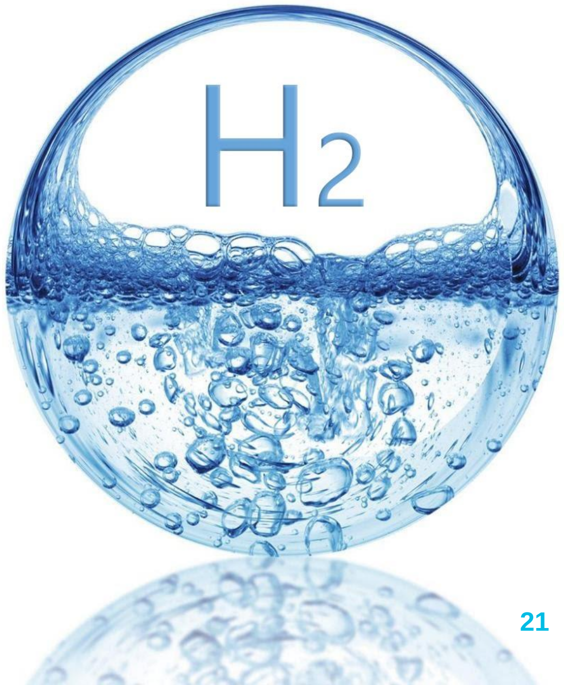
A decarbonized network:

- Deep energy efficiency
- Renewable natural gas
- Renewable hydrogen
- Blended and dedicated hydrogen systems

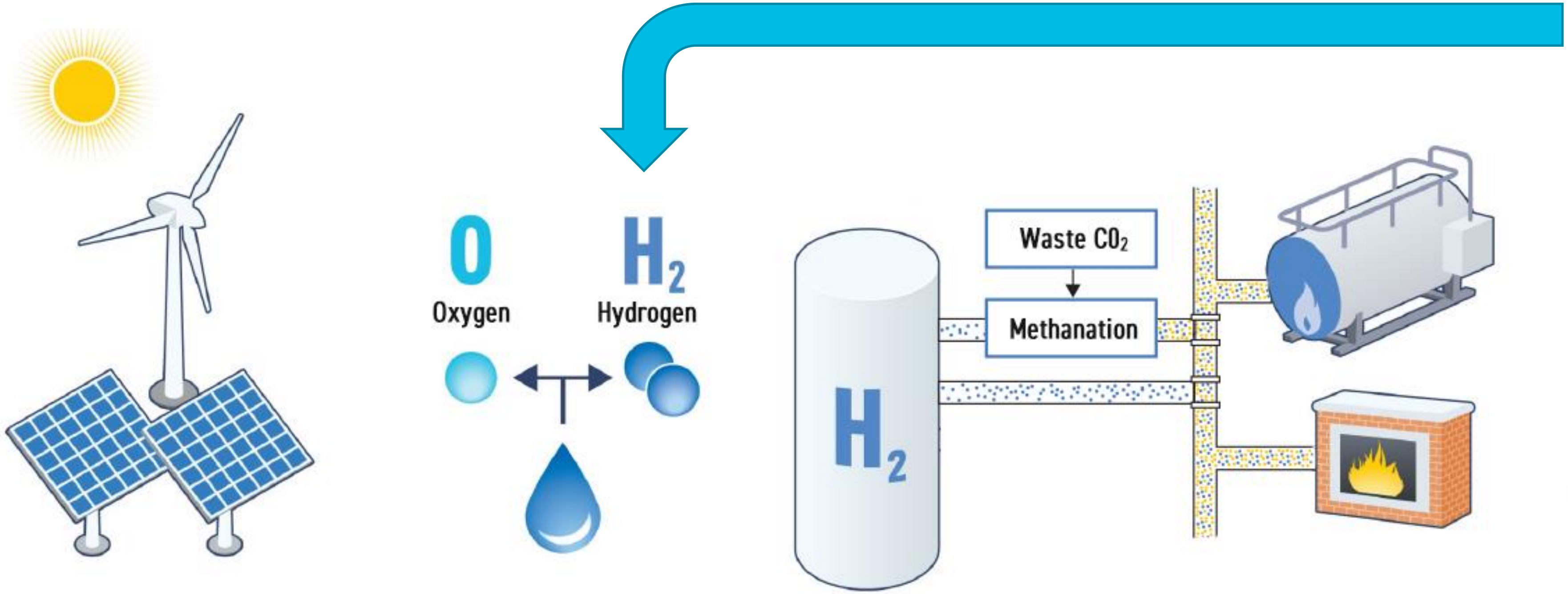
Renewable Natural Gas
Dedicated Hydrogen
Waste CO2
Renewable Electricity

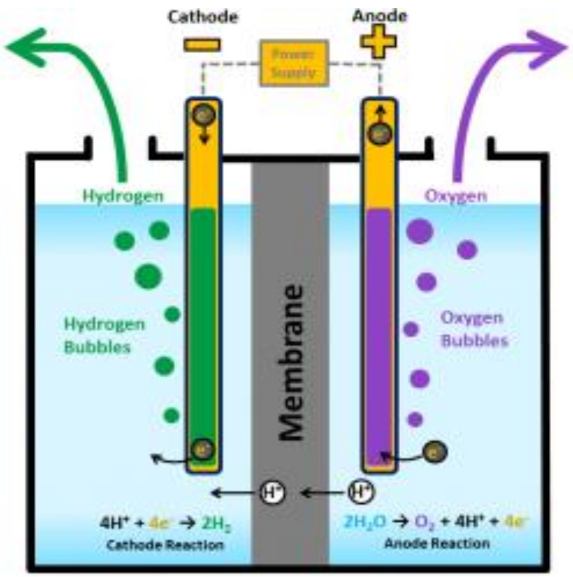
Hydrogen Benefits

Needed as key component of carbon-free future	No reasonable pathway to decarbonizing without hydrogen
Fits into current gas operations	Distribution | Storage | Customer Appliances
Numerous sources	Electricity | Biomass | Natural gas
Pathway to decarbonize hard to decarbonize sectors	Aviation, transportation, industry, marine



Electrolysis / Power to Gas / Green H_2





Source: DOE

Wind and solar energy that can't be stored

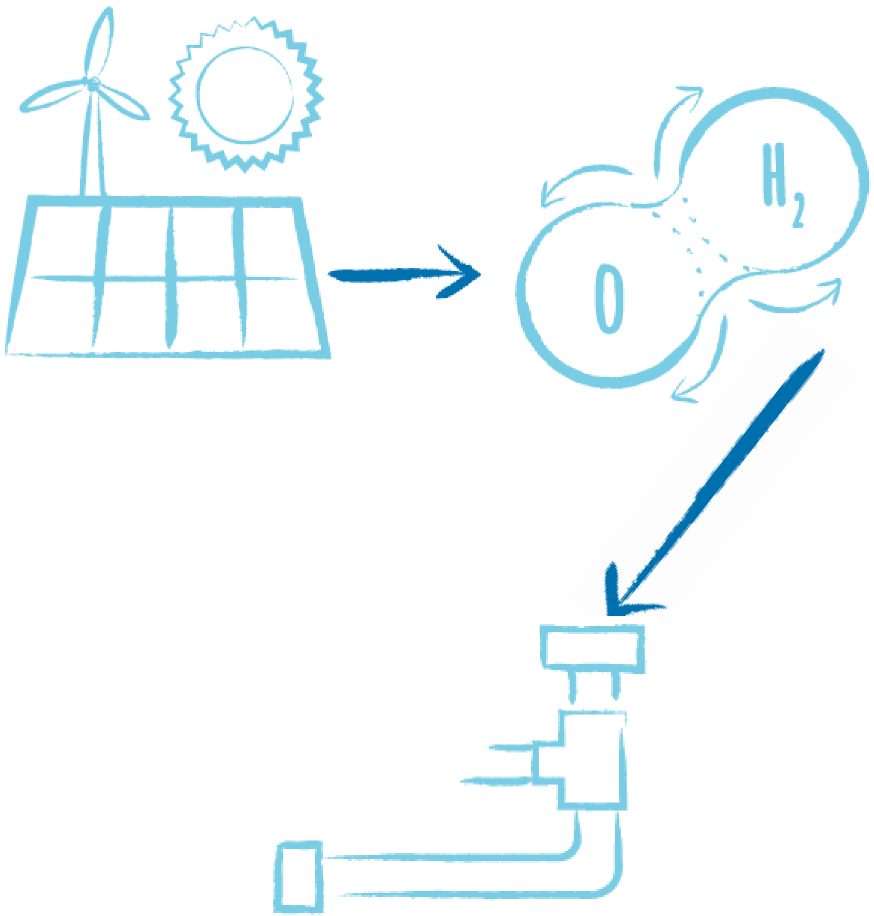
Goes through electrolysis which splits the molecule

Can be blended as hydrogen directly into the pipeline or combined with waste carbon to create renewable natural gas

Can be used immediately or stored seasonally for future use

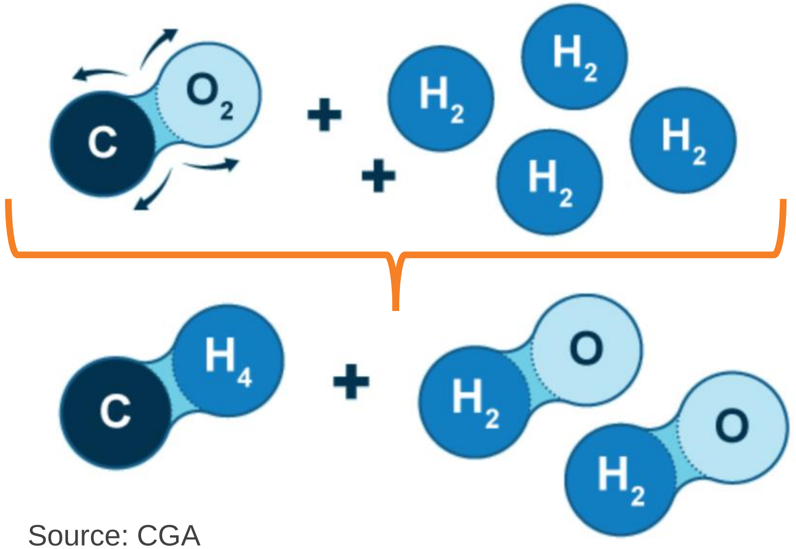
Green Hydrogen

- Takes advantage of curtailed renewables
- Provides grid benefits (ancillary services & energy storage) to lower rates
- Simple messaging
- Lower capital cost to methanated hydrogen
- Limitations
    - Blend % limits (system and appliance compatibility)
    - Small scale
    - No transmission injection options



Methanated Green Hydrogen

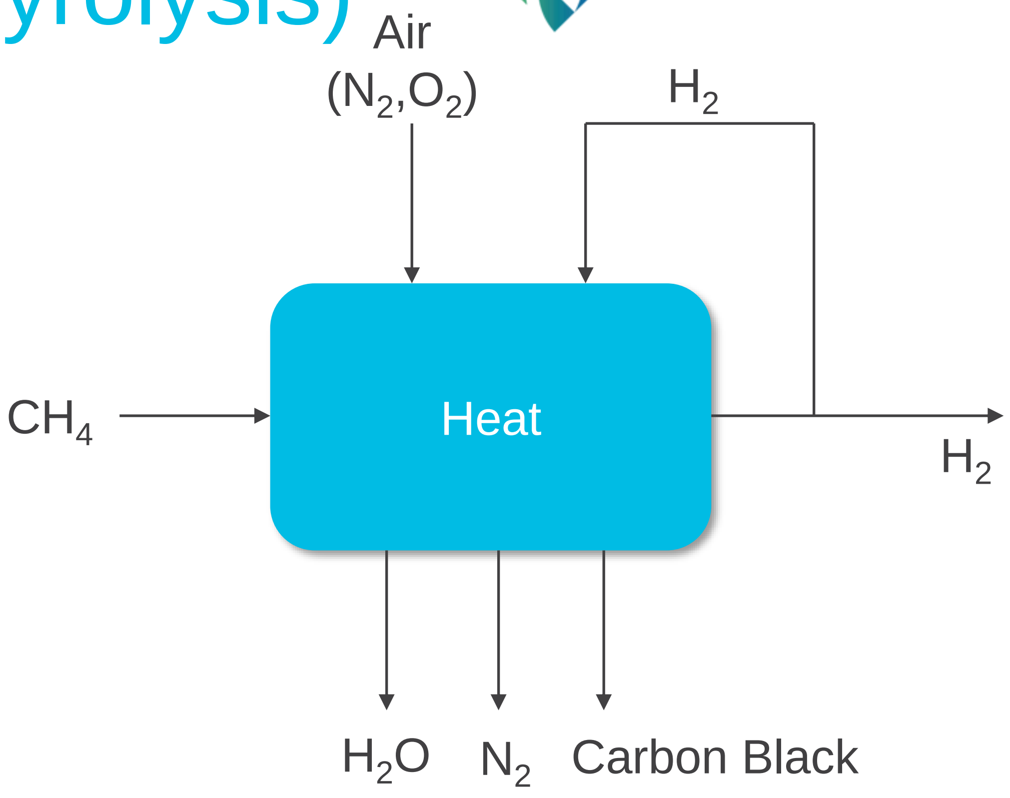
- Identical generation as previously described
- Similar costs to green hydrogen even with lower efficiency
  - Enables high electrolyzer utilization
  - Enables large scale production plants
- No blending % limit (system and appliance compatibility)
- No system energy delivery loss
- Need steady and low-cost supply of CO_2
- Complicated messaging



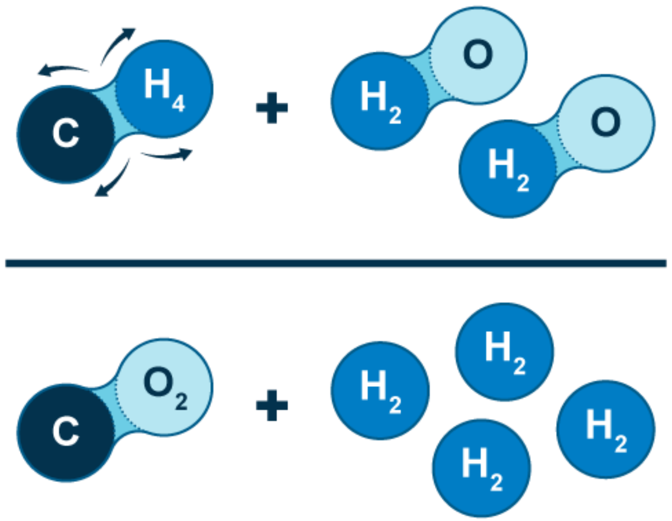
Source: CGA

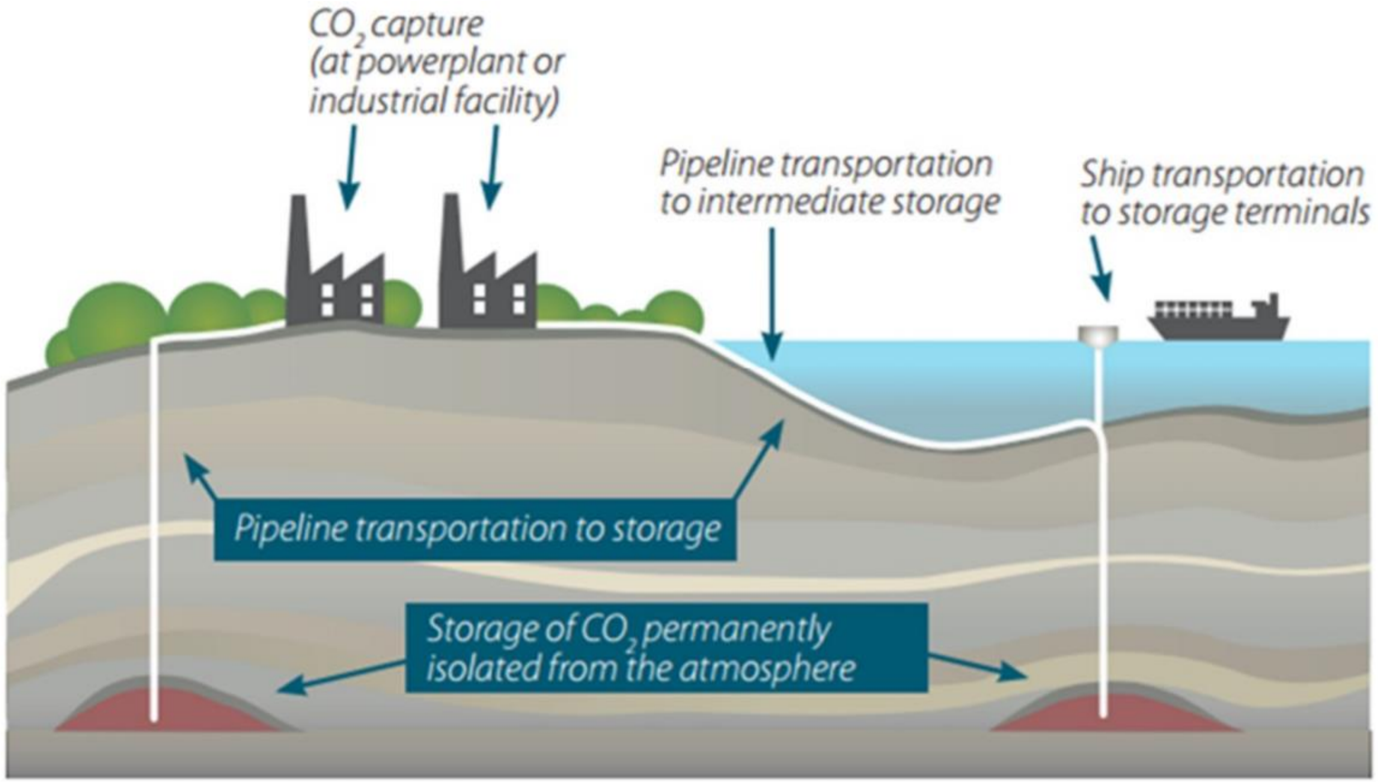
Turquoise Hydrogen (Methane Pyrolysis)

- Uses natural gas to produce hydrogen and solid carbon
- Very low emissions
- Low cost
- Distributed hydrogen generation
- Leverages existing infrastructure
- Produces valuable commodity
- Trial 2023



Blue Hydrogen: Methane Reforming + CCUS*

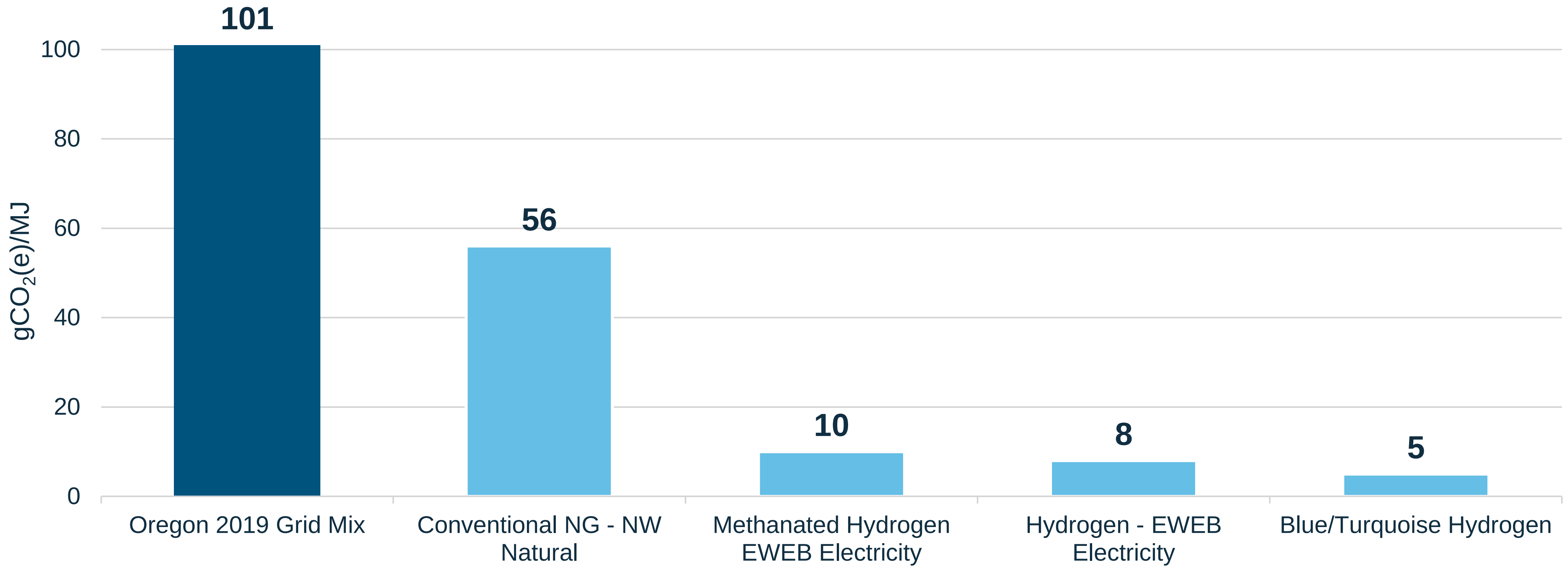




Source: Piyush Choudhary

*Carbon Capture, Utilization, and Sequestration

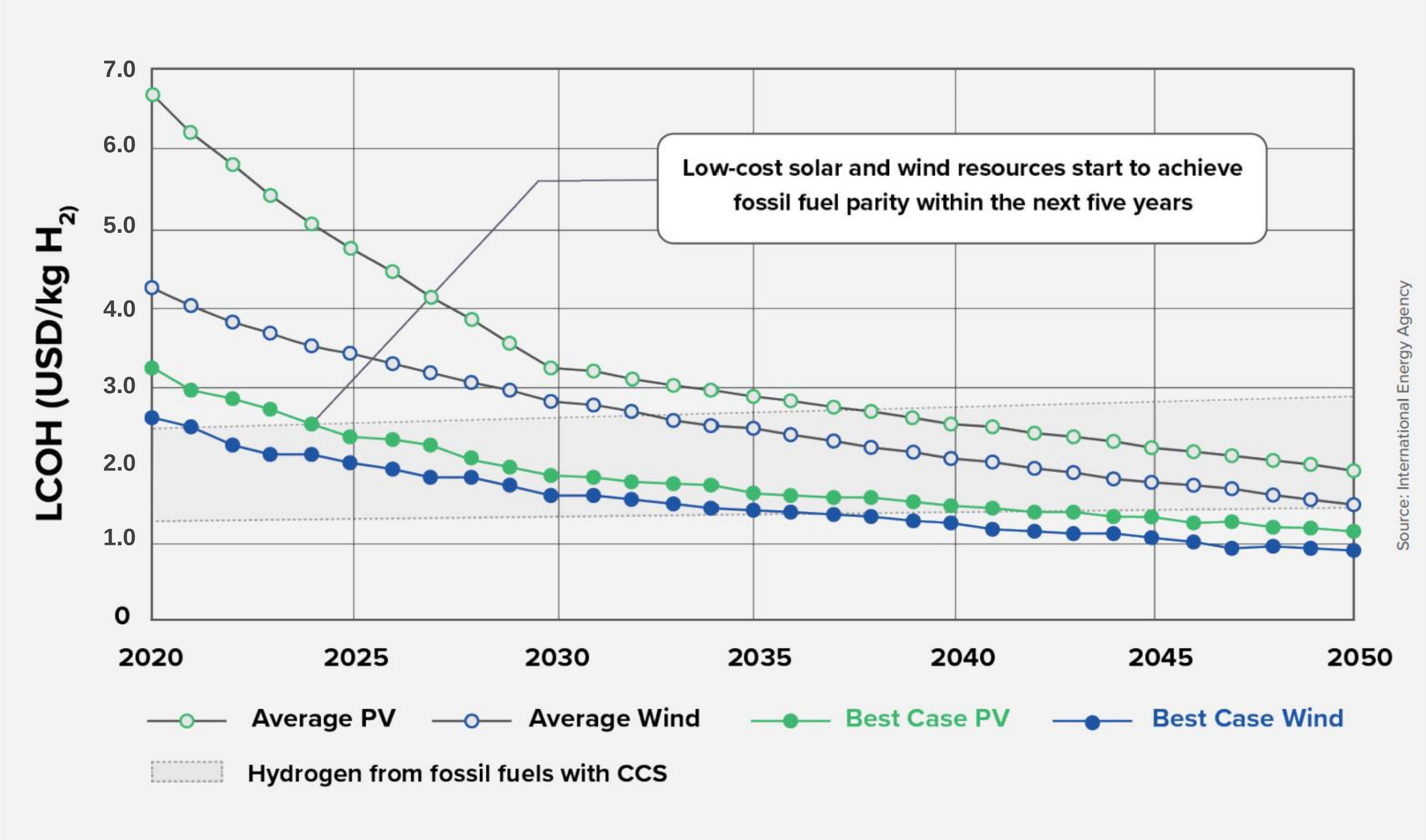
Carbon Intensities of Energy Sources



Estimates using power to gas efficiencies, Oregon DEQ, & California LCFS data

Hydrogen Cost Forecast

Levelized Cost of Hydrogen Forecast



[1]Wood Mackenzie, 2019, The Future for Green Hydrogen

Chart: Global Stationary Fuel Cell Market: 2019 Research Radar - ResearchAndMarkets.com." Business Wire, 1 Nov. 2019, www.businesswire.com/news/home/20191101005281/en/Global-Stationary-Fuel-Cell-Market-2019-Research

Inflation Reduction Act (IRA)

- Hydrogen Production Tax Credit (PTC)
  - Based on carbon intensity ($0.60/kg base credit, 5x if prevailing wages & apprenticeship requirements met):
    - 0.45kgCO_2/kgH_2: 100% ($3.00/kg or $22/MMBtu)
    - 0.45-1.5kgCO_2/kgH_2: 33.4% ($1.00/kg or $7.43/MMBtu)
    - 1.5-2.5kgCO_2/kgH_2: 25% ($0.75/kg or $5.57/MMBtu)
    - 2.5-4.0kgCO_2/kgH_2: 20% ($0.60/kg or $4.46/MMBtu)
- Energy storage investment tax credit (ITC): 30%
- Cannot combine 45Q and 45V tax credits (CO_2 sequestration and hydrogen respectively)
- 45Q tax credit increased to $85/tonne from $50 and $130 for Direct Air Capture

Hydrogen Activities at NW Natural

NW Natural®

5% Blending at Sherwood

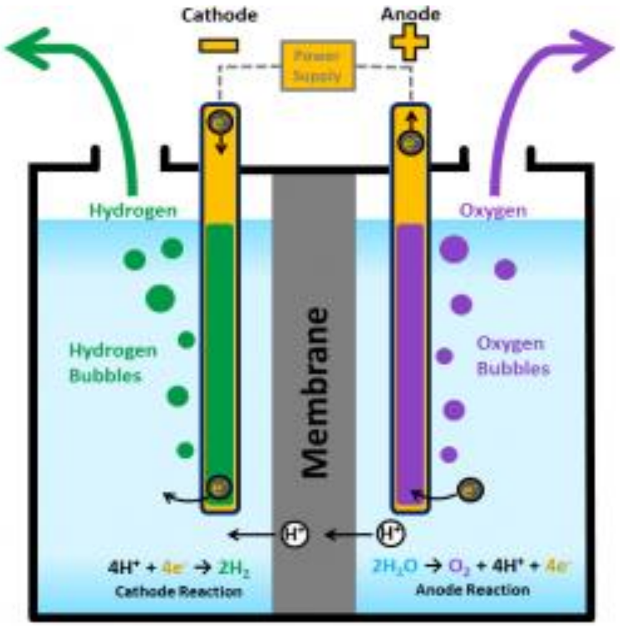
- Equipment check ✓
- Training town injection ✓
- Sherwood building(s)

System blending

- Customer trials ←
- System-wide injection
- Hydrogen hub

EWEB Blending Project Description

- 1 MW Plant (provisions for 2MW)
- Electrolyzer type: Assuming PEM
- Estimated utilization: 90%
- Production of 4,300MMBtu of renewable hydrogen for 20 years
- Electricity:
  - Provided by EWEB
  - Mix of low-carbon sources (BPA blend: large hydro, wind, nuclear)
- Estimated CO_2 emissions reduction: ≈200 MTCO_2(e) per year



Source: DOE

Location of Hydrogen Electrolyzer Project EWEB West Eugene Campus

Summary

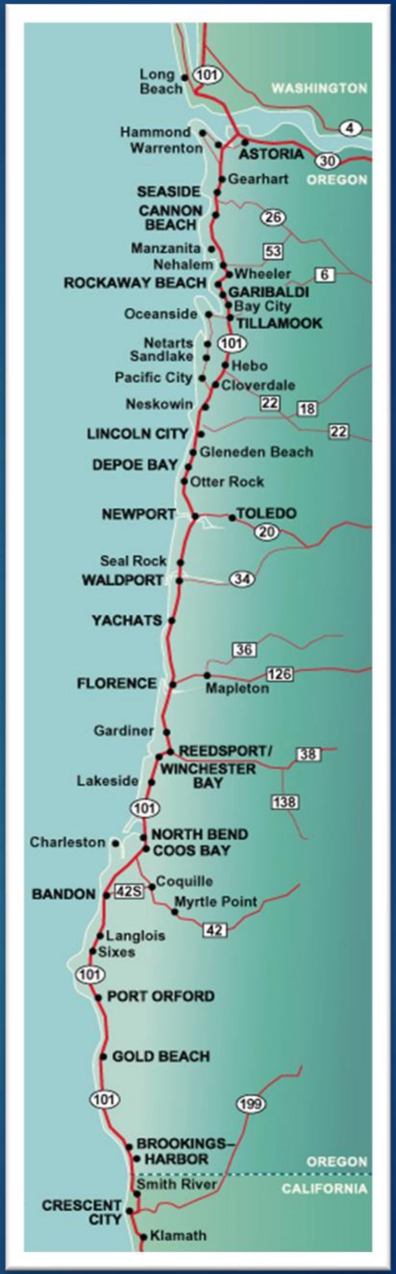
- Hydrogen provides a relatively low-cost mechanism for decarbonizing the natural gas grid
- Provides molecules that fill in gaps around RNG supplies
- Hydrogen can play a significant role in a decarbonized PNW:
    - Low-cost, low-carbon energy supply for thermal generation (blue/turquoise)
    - Low-cost, long-duration renewable energy storage (green/methanated)
    - Can help relieve transmission congestion (hydrogen pipelines/blending)
    - New markets for electric and gas utilities alike
- Will lead to deeper sector coupling
- Hydrogen will increasingly be used to deliver energy in the region

Thank you.

Oregon Ocean Energy: Carpe vim et pecuniam

Presentation to the Oregon Economic Development Association

October 10, 2022

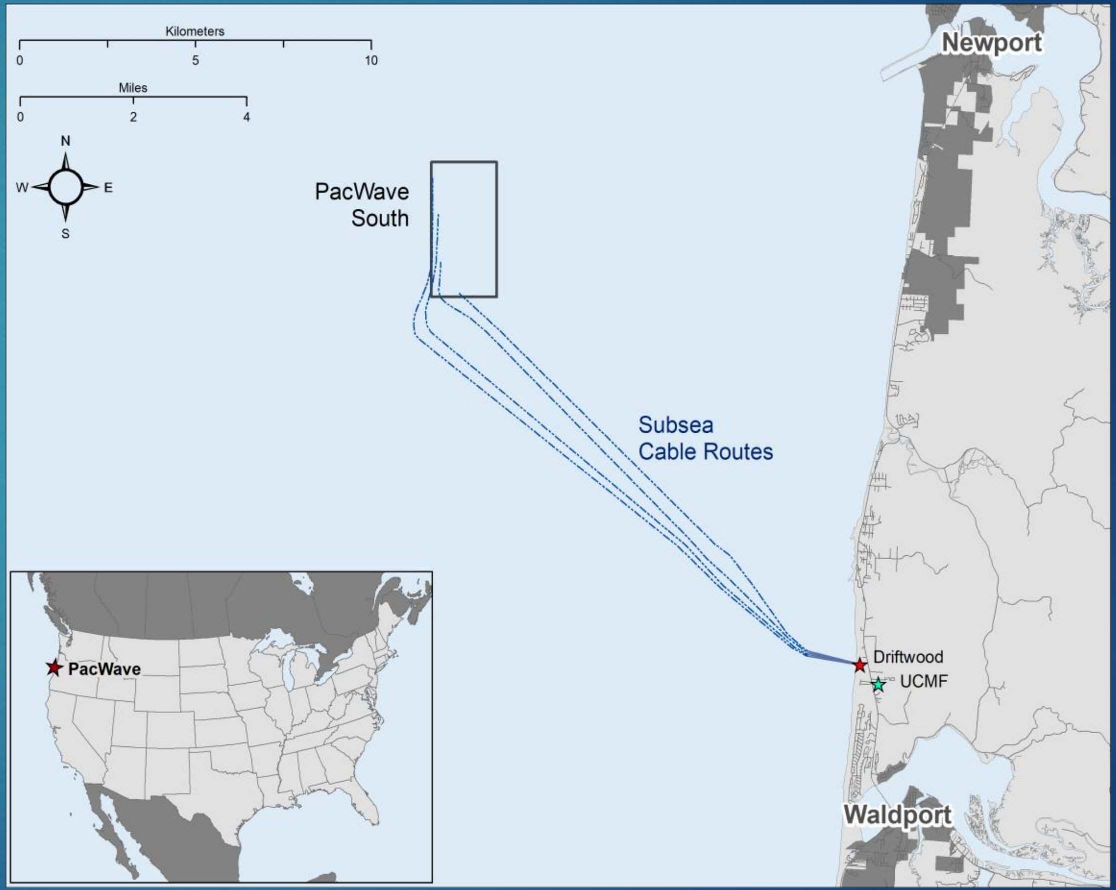


poet

PACIFIC OCEAN ENERGY TRUST

PacWave South Project Overview

- Test site is 7 miles from shore
- ~10 miles from Newport
- Four test berths
- Four subsea power & data cables
- Up to 20 MW and 20 devices
- Cable landing at Driftwood Beach State Recreation Site
- Cables run to a Utility Connection & Monitoring Facility (UCMF)
- Connection to Central Lincoln PUD




Contingency marker buoy
Recovery Lift Line Can
Acoustic pinger


ENTERPRISE


OceanEnergy Wave Buoy

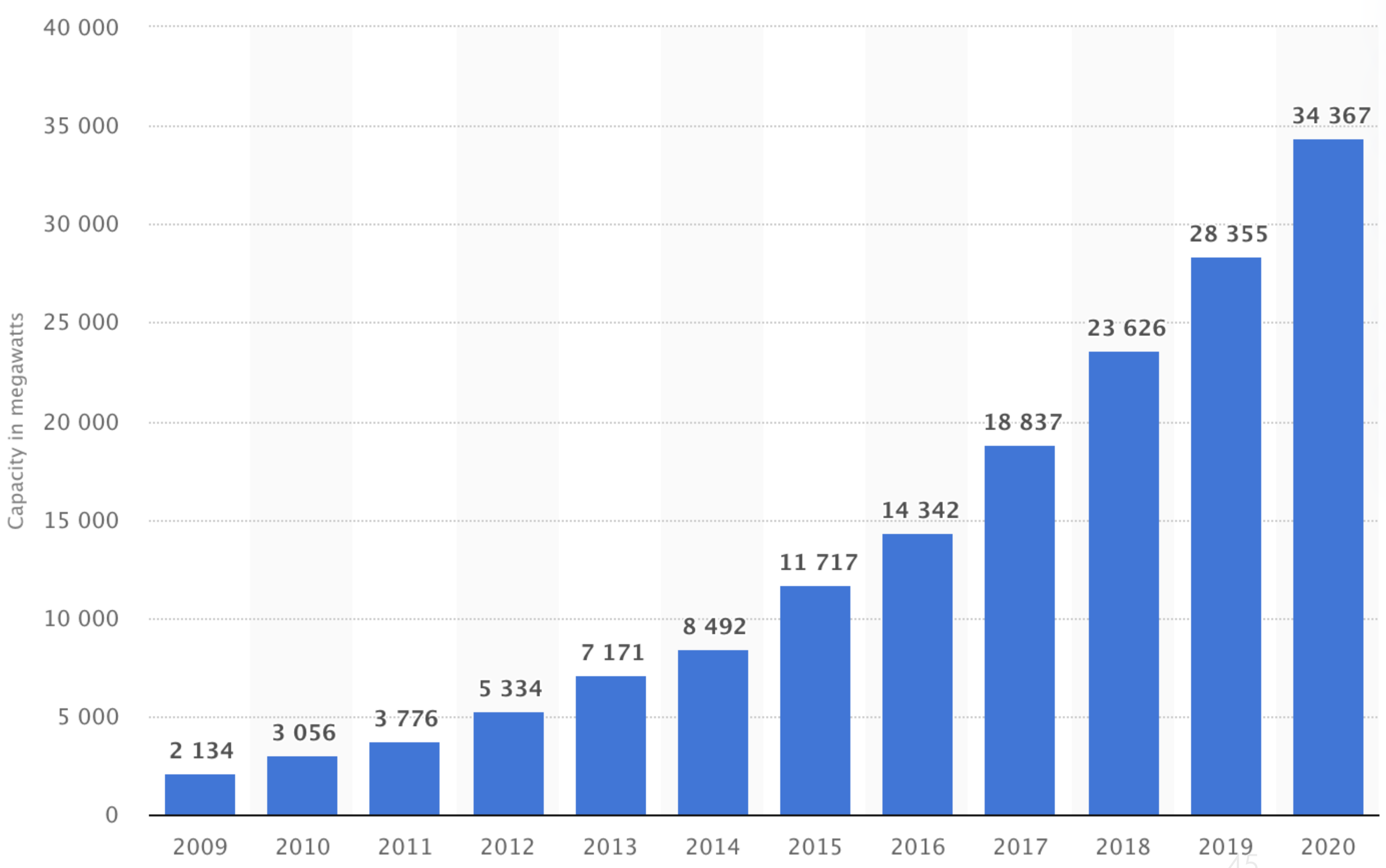
Hydrokinetic Baseload Solutions from Rivers and Tides

RivGen device on mooring prior to submerging

- Project partnership with tribal community of Igiugig, Alaska
- Includes two RivGen® devices, smart grid controls and battery energy storage. Estimated to reduce community diesel use 60% to 90%.

Deployed in Kvichak River

Floating Offshore Wind



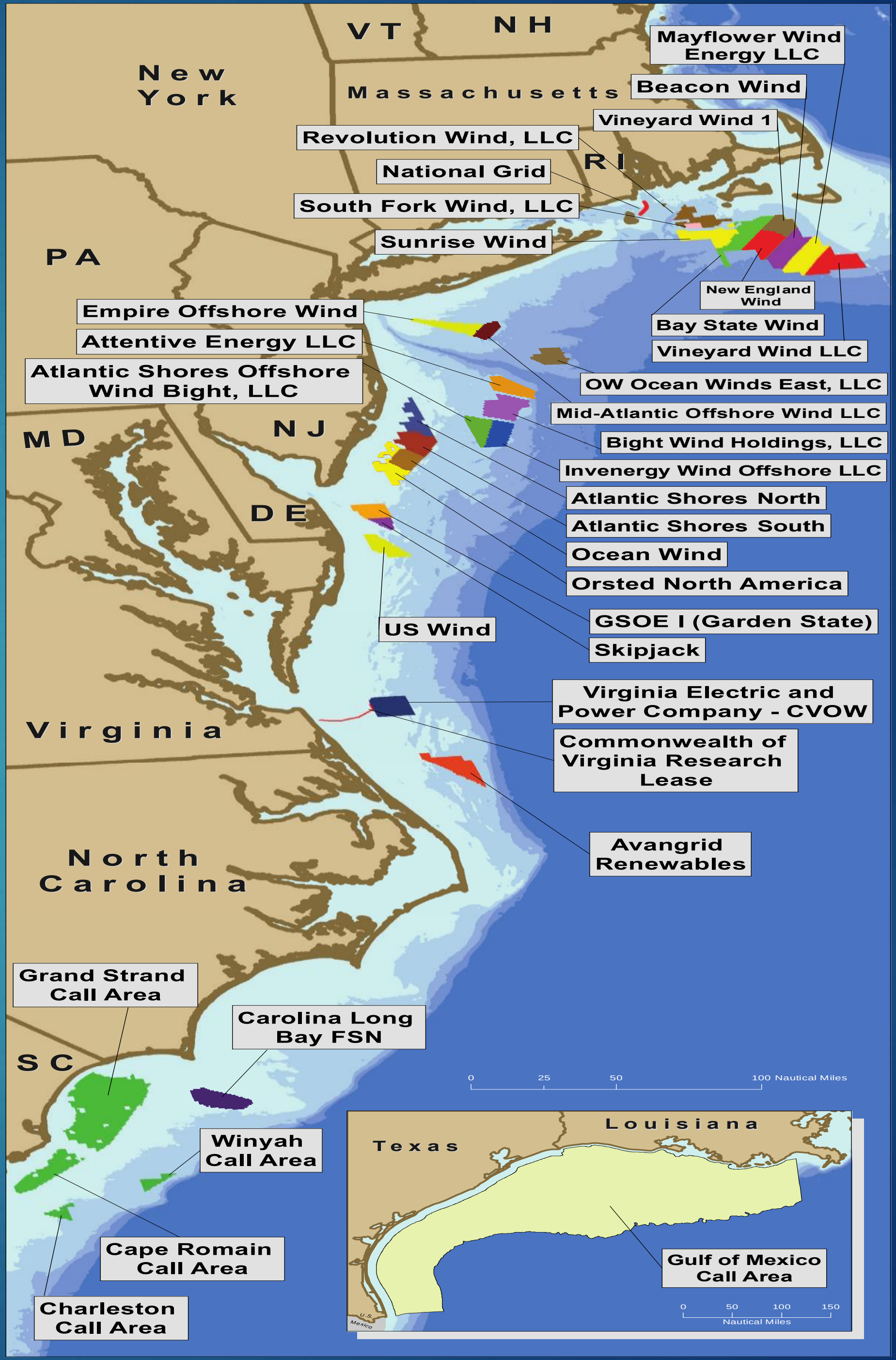
Additional Information

Show source

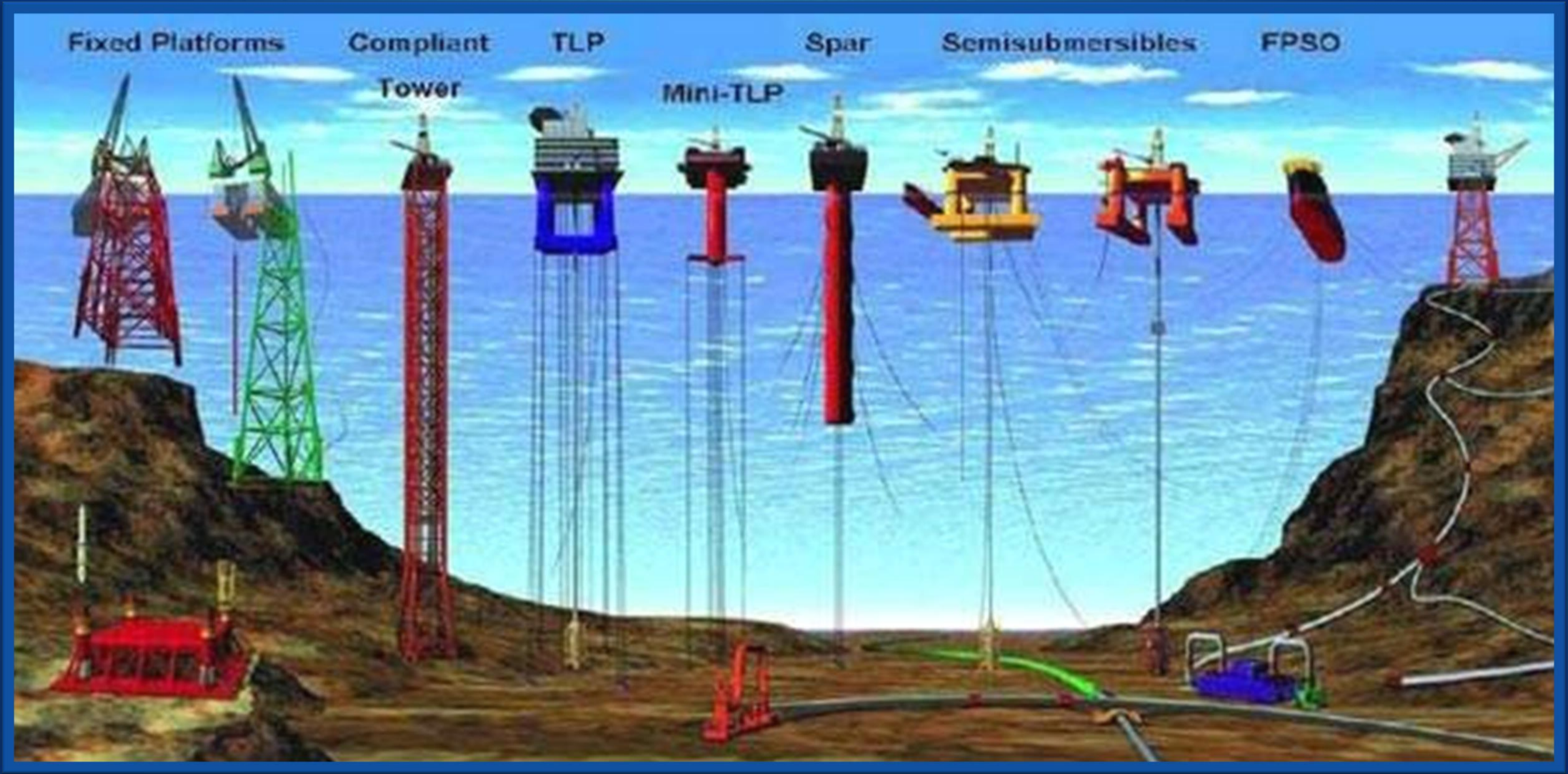
STATE OF THE GLOBAL SECTOR

- Worldwide – approximately 55.6 GW
  - Europe has dominated, but China is growing
- Growth rate is accelerating - 846 GW - pipeline of offshore wind energy projects which are operational, under construction, consented, or being planned
- Cost for OSW continues to decline
  - 75 Percent reduction in costs since 2014
    - Below CFD price in Europe
    - Cost of capital – lower risk
    - Scale of production
    - Standardization


Oregon State University PacWave South Research Lease
Oregon Call Area Coos Bay
Oregon
Oregon Call Area Brookings
Humboldt WEA
California
Morro Bay WEA
0 20 40 80 Nautical Miles
Oahu North Call Area
Oahu South Call Area
Hawaii
0 25 50 100 Nautical Miles
Bathymetry meters
Deeper than -90
-60 to -90
-45 to -60
-30 to -45
Shallower than -30

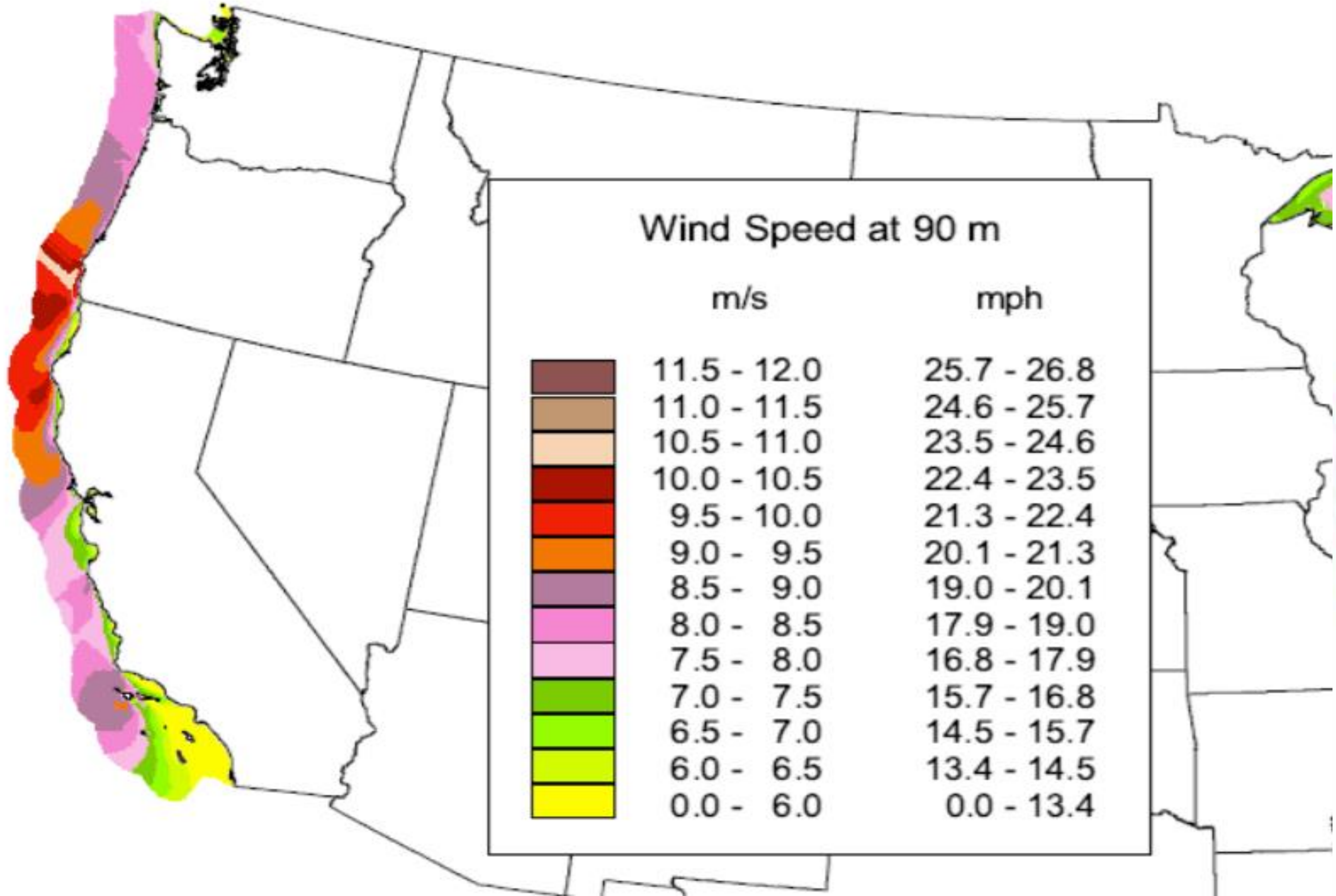

VT
NH
New York
Massachusetts
Mayflower Wind Energy LLC
Beacon Wind
Vineyard Wind 1
Revolution Wind, LLC
National Grid
RI
South Fork Wind, LLC
Sunrise Wind
PA
New England Wind
Bay State Wind
Vineyard Wind LLC
Empire Offshore Wind
Attentive Energy LLC
Atlantic Shores Offshore Wind Bight, LLC
OW Ocean Winds East, LLC
Mid-Atlantic Offshore Wind LLC
Bight Wind Holdings, LLC
Invenergy Wind Offshore LLC
MD
NJ
Atlantic Shores North
Atlantic Shores South
DE
Ocean Wind
Orsted North America
GSOE I (Garden State)
US Wind
Skipjack
Virginia Electric and Power Company - CVOW
Virginia
Commonwealth of Virginia Research Lease
Avangrid Renewables
North Carolina
Grand Strand Call Area
Carolina Long Bay FSN
SC
0 25 50 100 Nautical Miles
Winyah Call Area
Texas
Louisiana
Cape Romain Call Area
Gulf of Mexico Call Area
Charleston Call Area
0 50 100 150 Nautical Miles

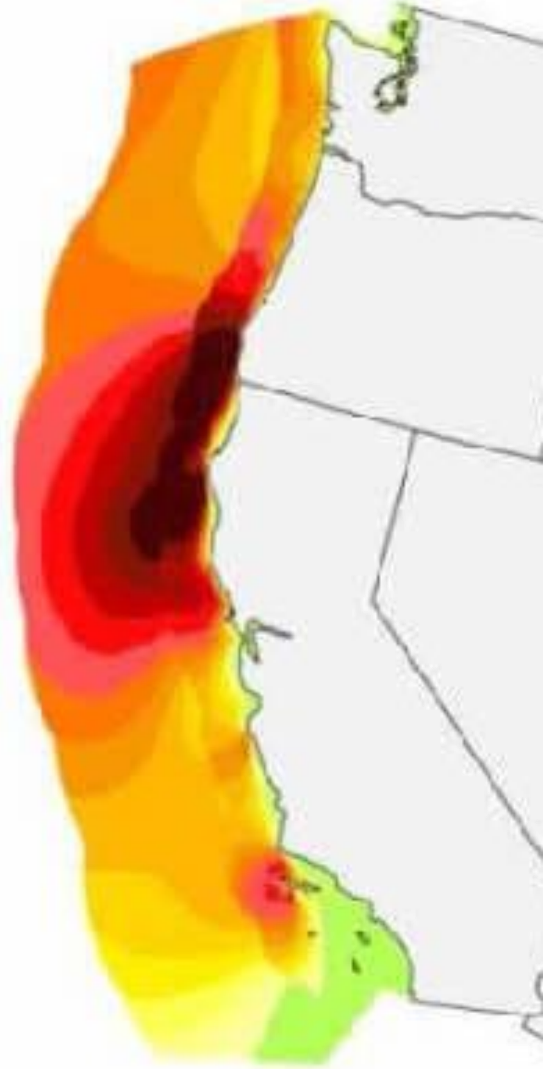

WF1


Fixed Platforms
Compliant
Tower
TLP
Mini-TLP
Spar
Semisubmersibles
FPSO


Spar
Semi-Submersible
Tension
Leg
Platform

Offshore Wind Resource



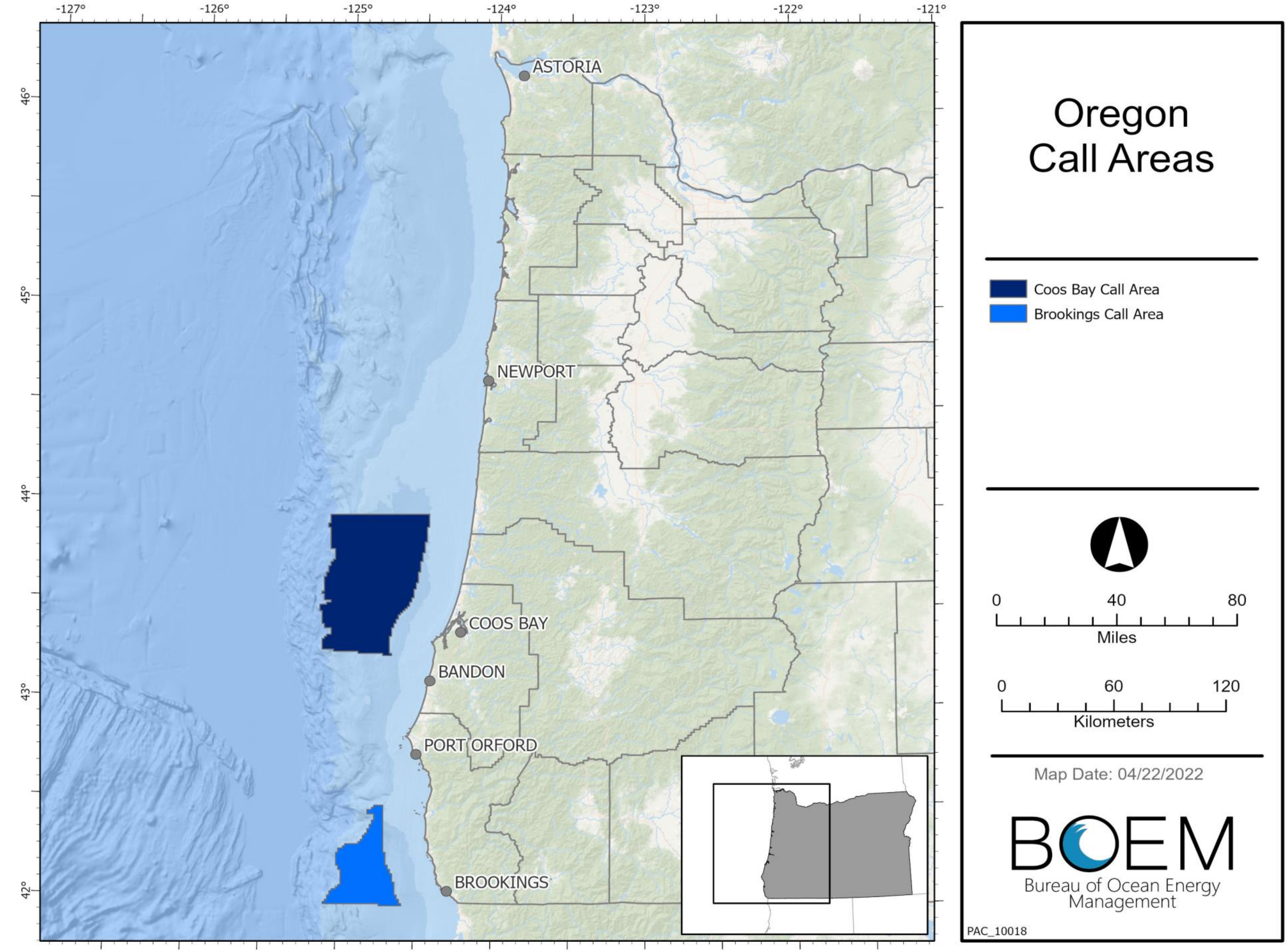


Floating OSW– What's the Opportunity?

- Enormous Wind Resource – World Class
- High Capacity Factors > 60%
  - Function of Height and Distance from Shore
  - Ever larger turbines – currently at 15 MW!!!!
- Leverages Steeply Descending Cost Curve of OSW
- Shoreside Construction Lowers Cost
- No Special Purpose Vessels – No 3x – 5x cost premium
- Grid benefits beyond electrons
- Close to Populations/Load Centers
- Improved Resilience
- West Side Generation – Non-wires solutions to transmission
- Complimentarity with existing generation and Load
- Enormous Economic development

Oregon

- BOEM Taskforce initiated - Means the state has agreed to engage with BOEM and execute a process for identifying potential OSW area
- Draft Call Areas identified February 25
  - Coos Bay
  - Brookings
- BOEM Call for Information and Nominations Closed June 28
- Next Step – Wind energy Areas, then leasing
- Major studies of transmission and grid benefits underway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ASTORIA
NEWPORT
COOS BAY
BANDON
PORT ORFORD
BROOKINGS
Oregon
Call Areas
Coos Bay Call Area
Brookings Call Area
0
40
80
Miles
0
60
120
Kilometers
Map Date: 04/22/2022
BOEM
Bureau of Ocean Energy Management
PAC_10018

Floating OSW Issues

- State Leadership – or lack thereof
- Commercial Fishing Opposition
- Transmission
- Port Infrastructure
- Supply Chain
- Workforce Development

Economics

- USC Schwarzenegger institute – *California's Offshore Wind Electricity Opportunity*
  - "Job gains of the development of 10 GW OSW by 2040 estimated to be a total of 97,000 to 195,000 job-years through 2040 for the construction of the wind facilities and another 4,000 to 4,500 annual operation and maintenance jobs, which translates into an additional 120,000 to 180,000 job-years of employment."

Economics – con't

Table VIB. Economic Impacts of Capital Expenditures for the Deployment of 3 GW of Offshore Wind in California between 2020 and 2030

Impact Indicator	Category	Lower RPC	Higher RPC
Employment (job-years)	Wind farms	22,049	42,923
	Transmission upgrades	5,247	11,210
	Total	27,296	54,133
GDP (million 2019$)	Wind farms	2,818	5,391
	Transmission upgrades	629	1,342
	Total	3,447	6,733
Gross Output (million 2019$)	Wind farms	5,987	11,160
	Transmission upgrades	996	2,113
	Total	6,983	13,272
Personal Income (million 2019$)	Wind farms	2,642	5,062
	Transmission upgrades	600	1,280
	Total	3,241	6,342

FINAL OBSERVATIONS

- Understand the opportunity
- Do the math
- Provide state leadership
- Maximize the benefits
- Momento California

- Jason Busch
- Executive Director
- Pacific Ocean Energy Trust
- jbusch@pacificoceanenergy.org

Oregon Department of **ENERGY**

Floating Offshore Wind Overview

OEDA Fall Conference

Jason Sierman
October 10, 2022

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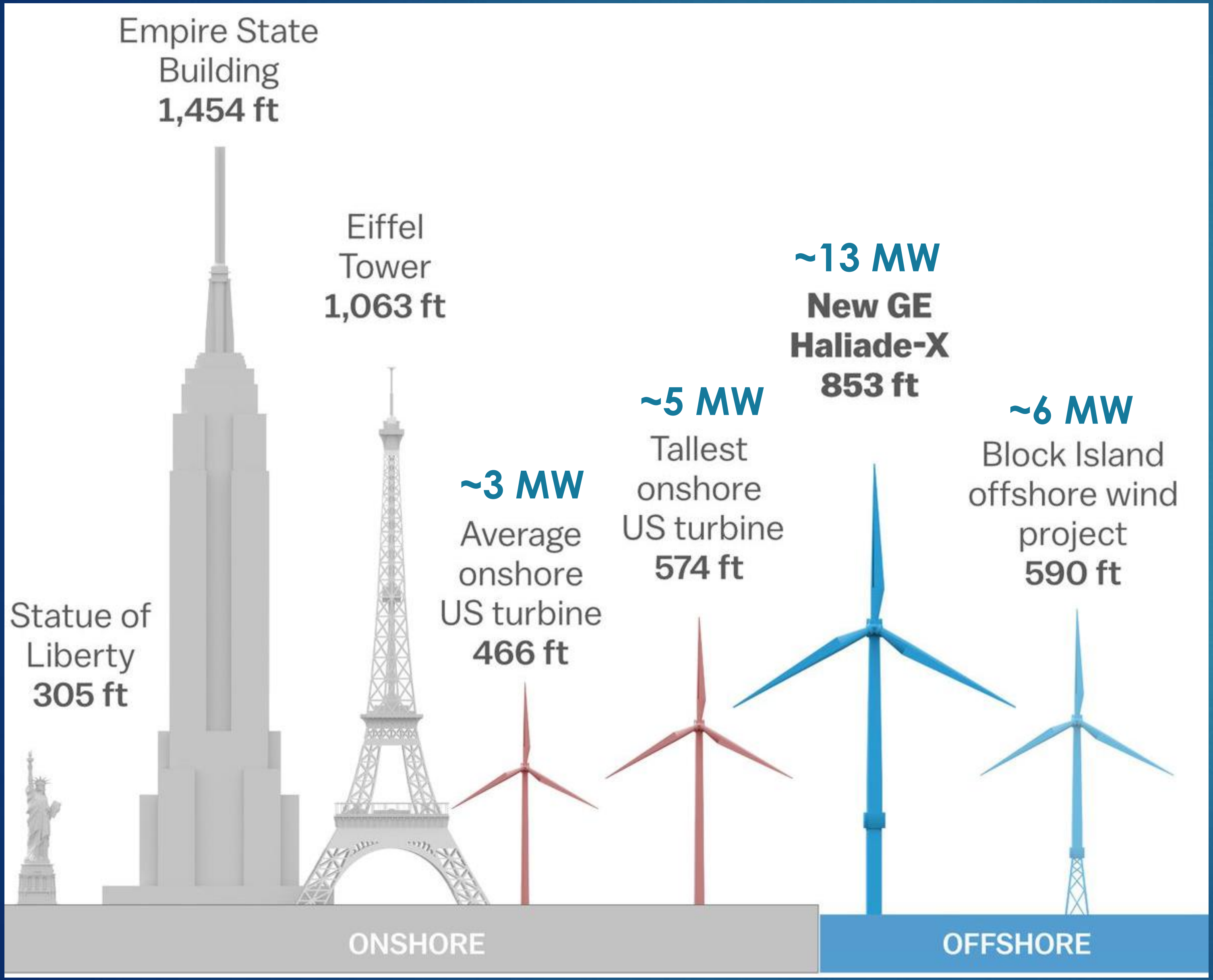
What is Offshore Wind?



It's BIG!

But Why?

- Open ocean allows larger scales
- Economies of scale drive lower production costs

What does this Mean?

- Energy costs go down

What is Floating Offshore Wind (FOSW)?

1 Bigger

\+

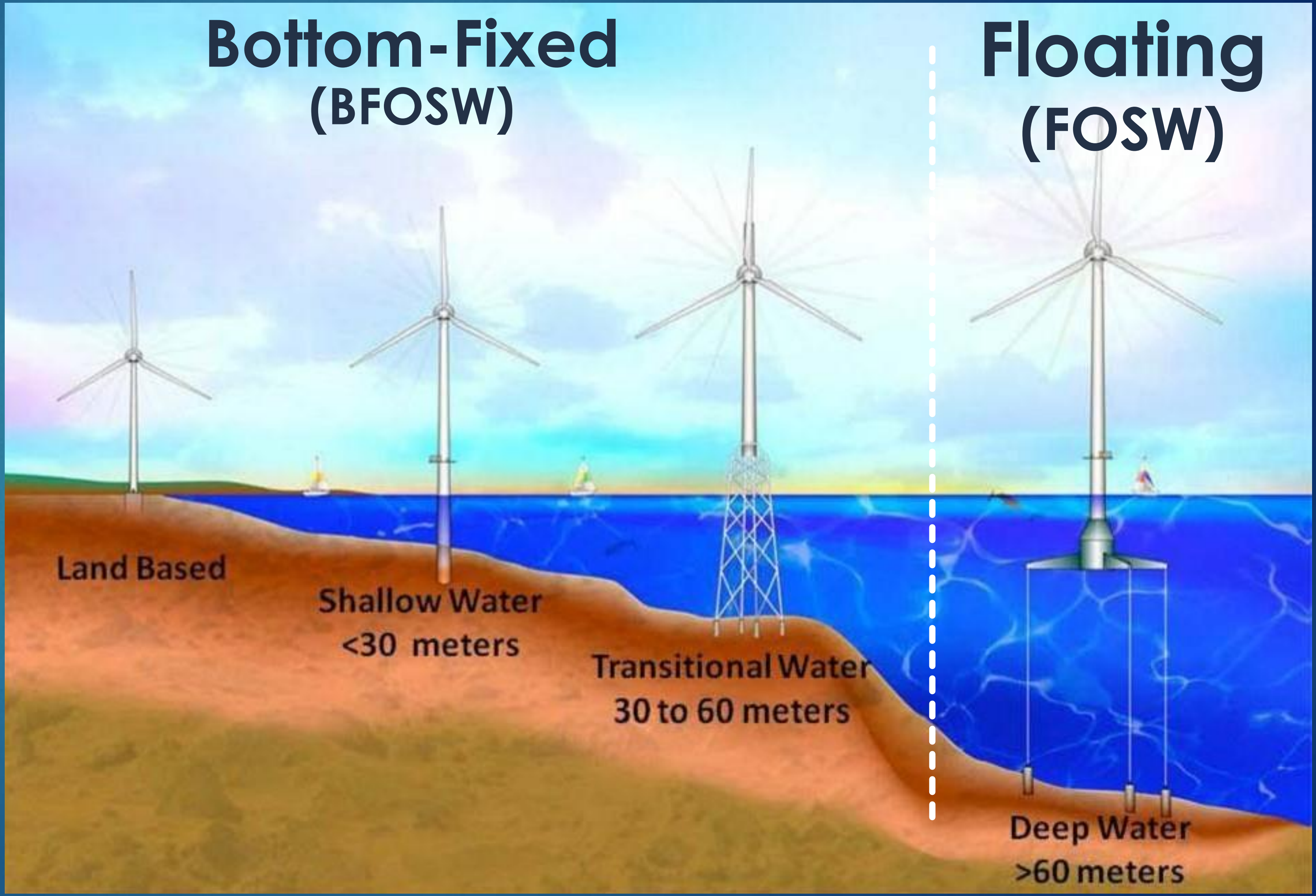
2 Stronger Winds

\+

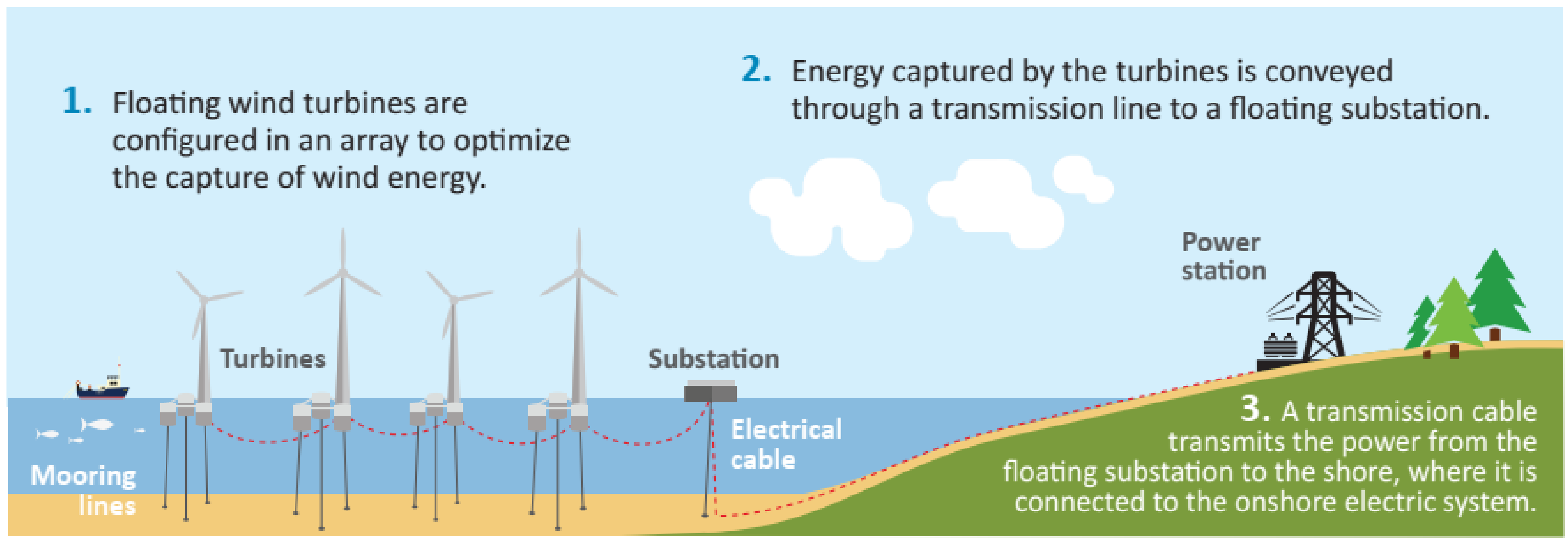
3 More Consistent

=

more wind energy further out at sea



How Does FOSW Work?



Installation Requires Offshore & Onshore Transmission Infrastructure

[Link to National Geographic Video](#) on World's First Floating Offshore Wind facility in Scotland

ODOE Floating Offshore Wind Study

- Report Issued Sept. 15, 2022
- Summary of Key Findings
  - Key Potential Benefits
  - Key Potential Challenges
- Summary of Opportunities for Future Study and Engagement

https://www.oregon.gov/energy/energy-oregon/Pages/fosw.aspx

HIGHEST-LEVEL KEY FINDINGS

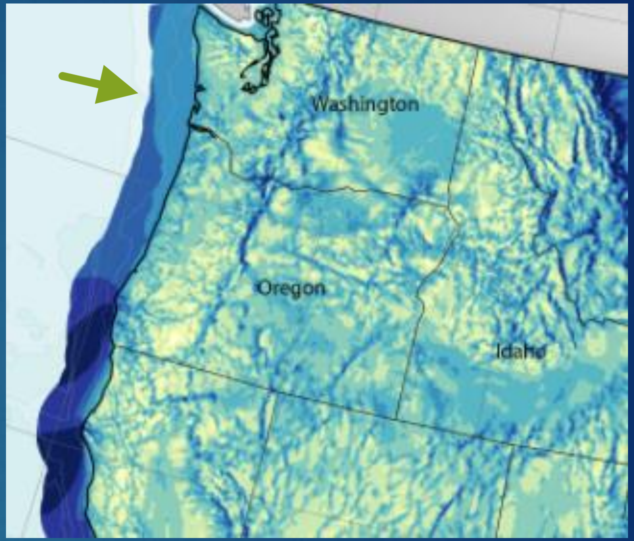
- **2050 Clean Targets - 100s of gigawatts (GWs)** of new renewables are necessary across the West to achieve policy goals.

- **Oregon has outstanding offshore wind resources - strong & consistent.**
  - Ocean depth requires **floating** offshore wind technology.
  - Emerging tech, global deployments total ~0.1 GW (100 MW).

- **FOSW and supporting transmission can have potential effects on ocean users and the environment.**

- **FOSW is a unique renewable technology because it requires:**
  - GW-scale for commercial development.
  - Floating platforms.
  - Port upgrades.
  - Transmission upgrades.
    - New offshore & expanded onshore transmission.

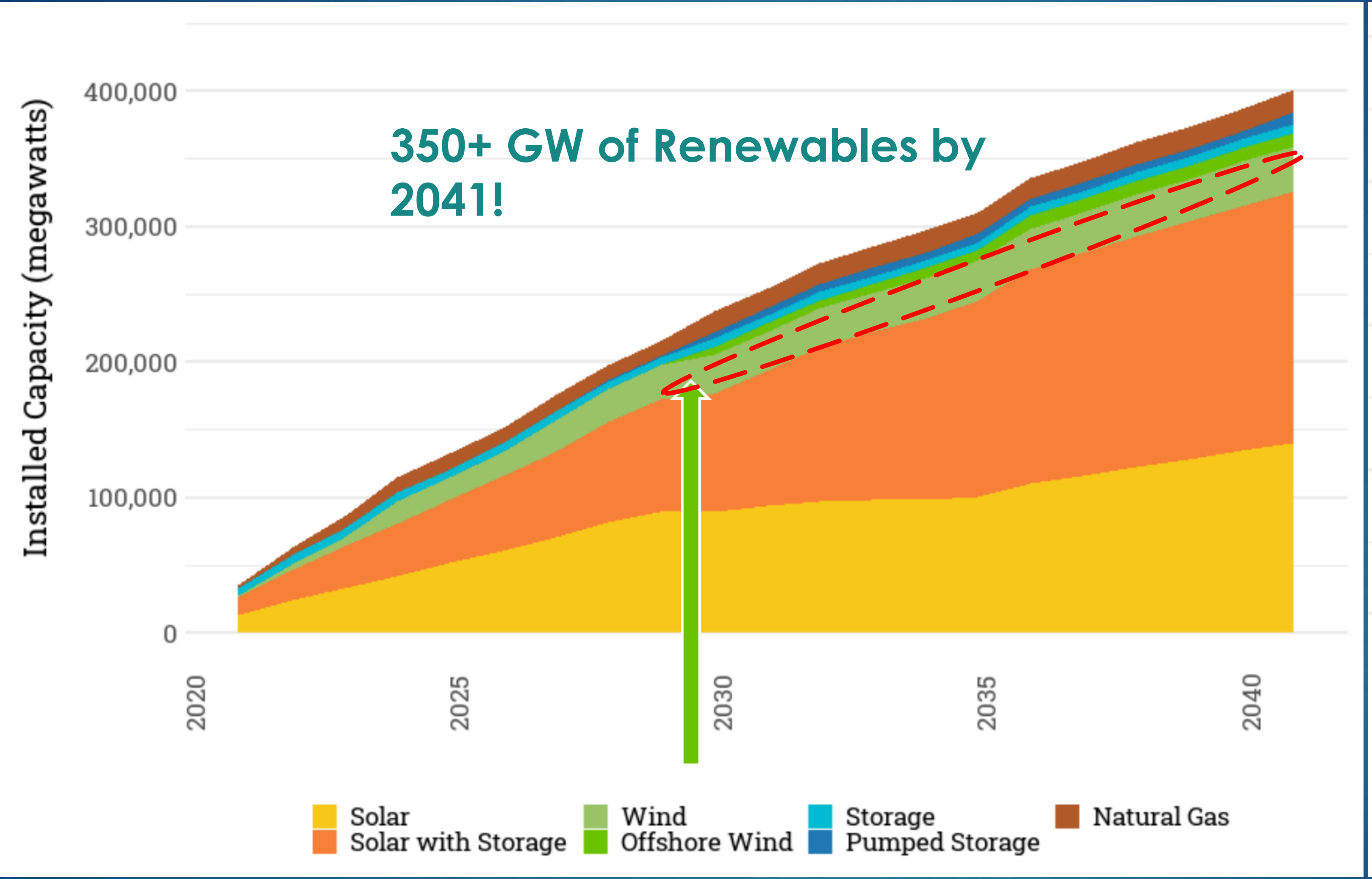
Annual – Average Wind Speed



Potential Effects

Source

FOSW Context



THE 2021 NORTHWEST POWER PLAN

FOR A SECURE & AFFORDABLE ENERGY FUTURE

Source

West-wide Projection: Baseline projection for what will be required across western states to meet clean energy targets

Diversity is least cost, least risk.

Source: Draft 2021 Plan , p. 6-45

Can It All Get Built In Time? Where?

Oregon – 100% Clean Electricity by 2040

Clean Electricity Targets for Oregon

- 80% by 2030,
- 90% by 2035,
- 100% by 2040.

Applies to Oregon's IOUs and ESSs*

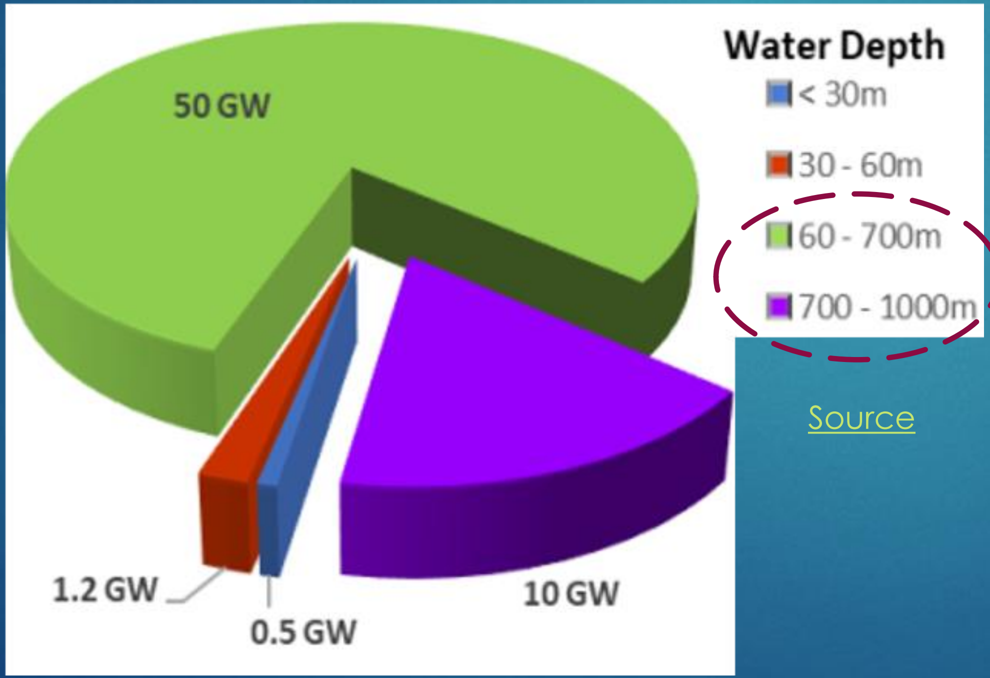
*IOUs = Investor-Owned Utilities; ESSs = Electricity Service Suppliers.

POTENTIAL BENEFITS

Scale of FOSW can help achieve mid-century clean energy targets.

- Dozens of GWs could be deployed if potential effects can be avoided and mitigated.

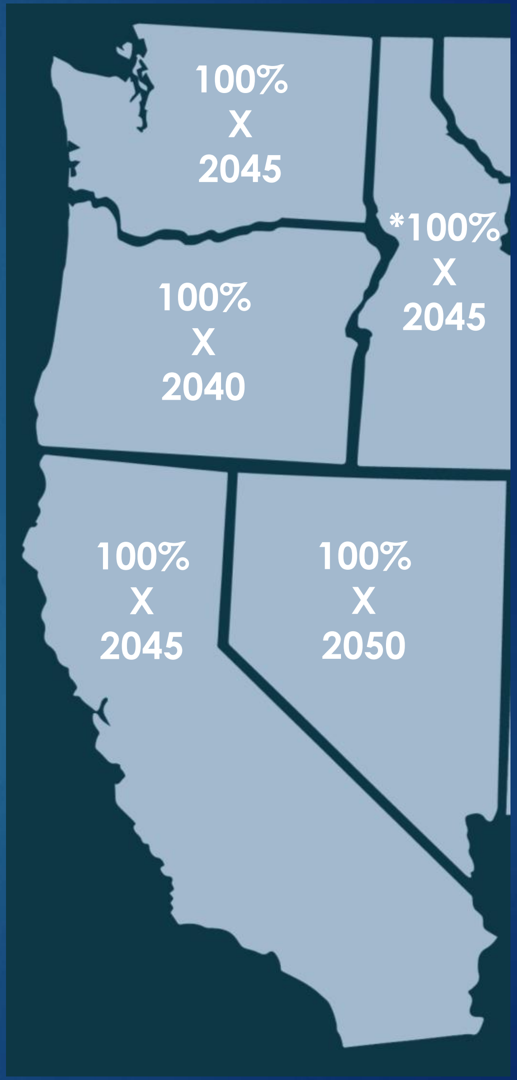
Technical Resource Capacity – 62 GW



Oregon Call Area Depths

Source

Regional States w/ 100% Clean Energy Targets



*Idaho Power & Avista Targets

POTENTIAL BENEFITS

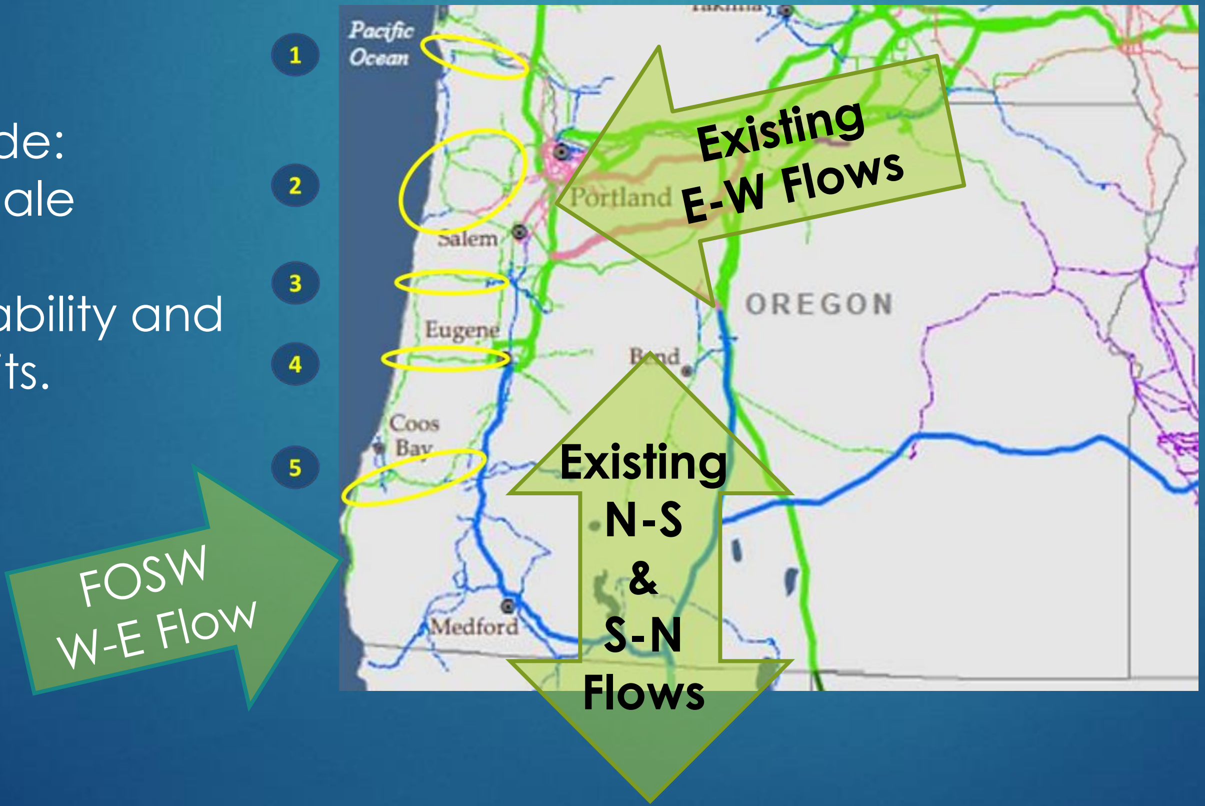
FOSW at the grid's western edge can bolster the reliability & resilience of both the coastal and regional power grid.

Coastal power systems currently served by **distant** generation.

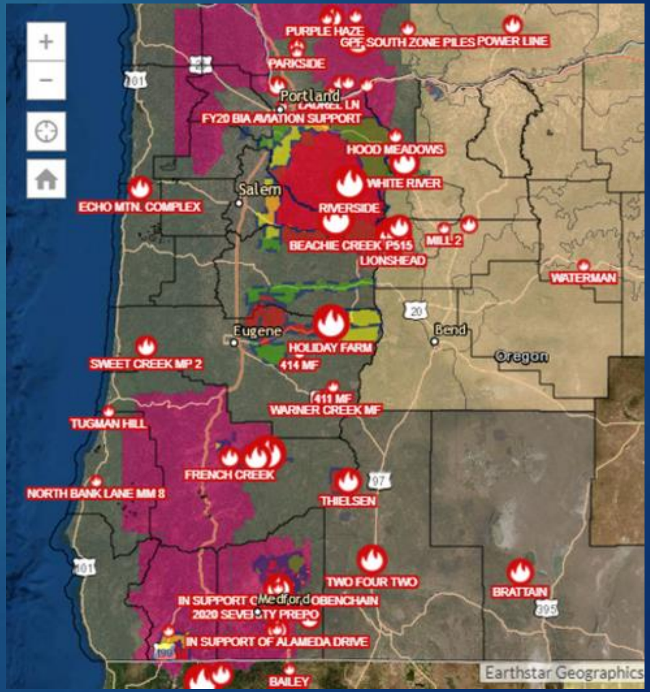
FOSW could provide:

- **Coastal** large-scale generation.
- Transmission reliability and resilience benefits.

Oregon's predominant power flows



Wildfire Snapshot from Oregon RAPTOR at 7 a.m. Friday, Sept. 11, 2020



POTENTIAL BENEFITS

Economic Development: FOSW could bring direct, indirect, and induced economic benefits for coastal Oregon, other Oregon areas, and neighboring West Coast states.

- Potential adverse impacts to existing coastal economies (fishing, seafood, recreation & tourism industries, etc.)
- Further study needed to assess net economic effects.

ENERGY NEWS NETWORK

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NORTHEAST

Massachusetts grants focus on equity in offshore wind workforce development

The Massachusetts Clean Energy Center has awarded $1.6 million in grants to eight offshore wind workforce training programs aimed at reducing specific obstacles for people of color and low-income people.

by Sarah Shemkus
August 3, 2021

- **Equity:** New jobs in **underemployed coastal communities**; and reduced emissions that disproportionately impact **disadvantaged communities**.

Source

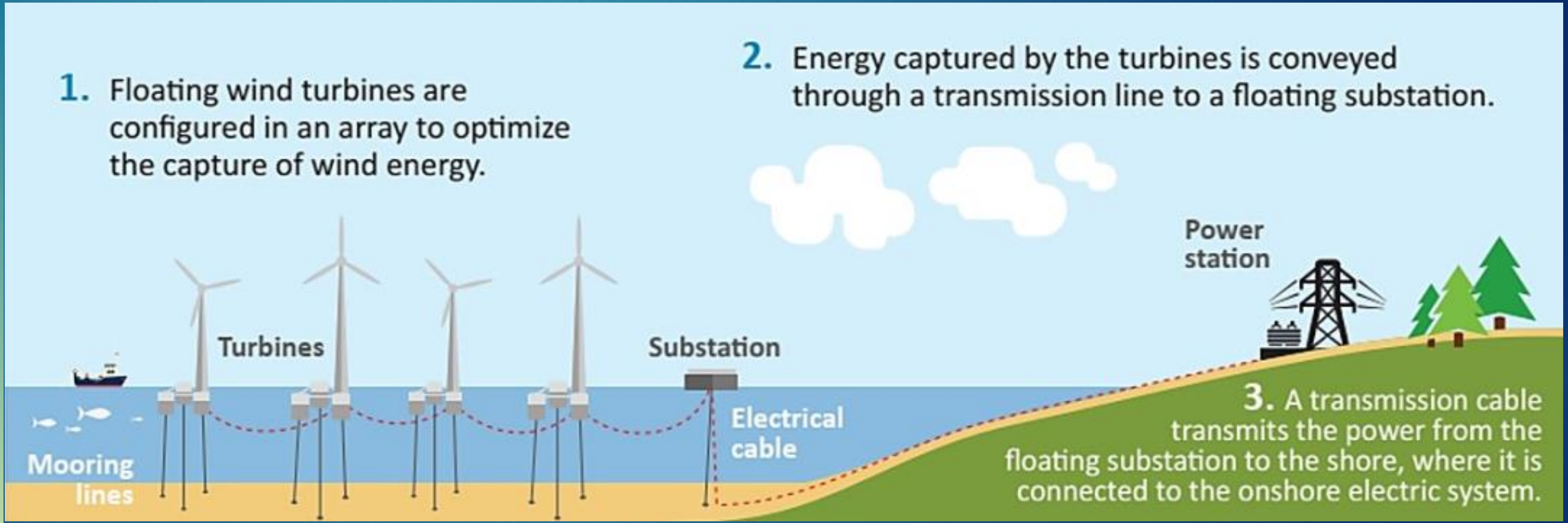
POTENTIAL CHALLENGES

Avoiding & mitigating effects from FOSW on **coastal communities, existing industries, the environment, and cultural resources** could be a significant challenge.

Examples - potential impacts to: Fishing, Shipping, Military, Tribes, Coastal Citizens, Tourists, Others

Examples - potential impacts to:

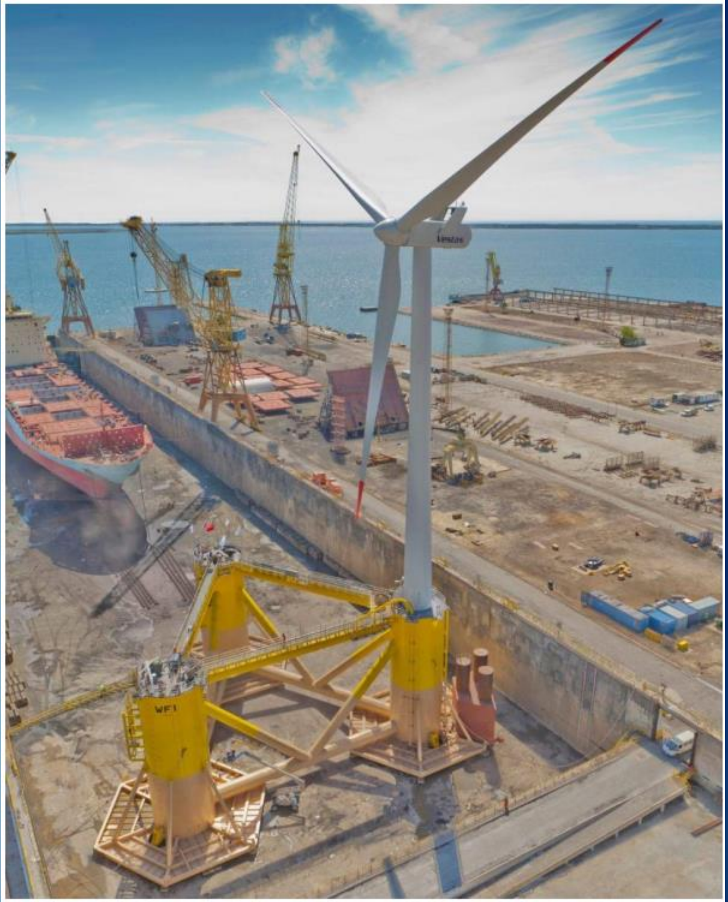
- **Local & migratory fish & wildlife**
  - Marine & land-based species
  - Birds
  - Others
- **Sensitive habitats**
  - Marine
  - Seafloor
  - Estuary
  - Land-based
  - Others



POTENTIAL CHALLENGES

Floating Platforms & Major Infrastructure Upgrades

- **FOSW has tremendous upfront capital costs and is in a nascent stage of global development.**
    - **Floating Platforms:** Need for novel floating platforms, and new facilities to fabricate them, add significant capital costs.
    - **Port Upgrades:** Need for costly upgrades to Oregon ports.
    - **Transmission Expansion:** Need for costly new offshore transmission and expanded onshore transmission.



Source: BOEM Port Study, 2016

POTENTIAL CHALLENGES

GW-scales likely necessary to attract investment are likely too large for near-term demand from Oregon offtakers alone.

- **Cooperation Not Formalized:** Oregon lacks a collective, state-wide planning process and is not part of a Regional Transmission Organization (RTO).
- **Fragmented Planning:** Bi-lateral markets make cooperative offtake challenging.
- **Voluntary Cooperation:** Multiple offtakers in bi-lateral markets is possible if utilities are flexible and cooperative in planning and procurement activities.

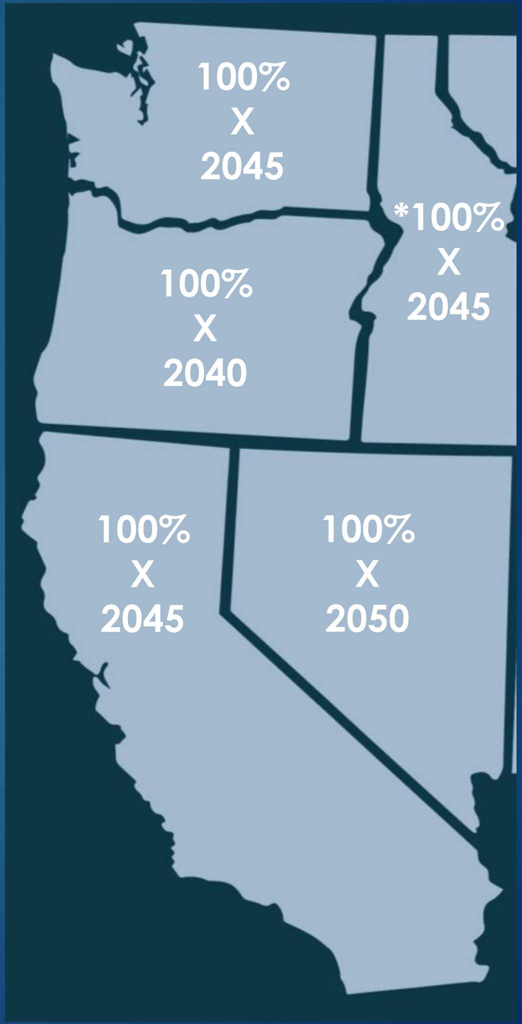
Source

PIECING IT ALL TOGETHER

Opportunities for Future Study and Engagement

- **Additional Technical Studies Across Many Topics**
- **Comprehensive State Strategy & Planning**
    - Tailored for Oregon and informed by similar planning in other states.
- **Broad and Robust Engagement & Input**
    - All interested parties - the public, local communities, Tribes, fishing and other coastal industries, interest groups, utilities, and state, regional, and federal entities.
- **Expanded Regional Collaboration**
    - To optimize opportunities for FOSW that best avoids and minimizes cumulative effects.

Regional States w/ 100% Clean Energy Targets



*Idaho Power & Avista Targets

Thank You!

Contact information:
Jason.Sierman@energy.oregon.gov

Photo by Scottish Government

Circling back to our questions…

WHAT INFRASTRUCTURE DOES THE PROJECT NEED?

WHO’S BEHIND THE PROJECT AND WHAT’S THEIR FINANCIAL PICTURE?

WHO IS THE END USER OF THE OUTPUT?

WHAT ARE THE LOCAL BENEFITS OF THE PROJECT?

PGE

Questions?

THANK YOU!!

PGE