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energy & experience

# *Using Renewable Energy from the Cook Inlet to create an eFuels Export Market*

*REAP Speaker Series*

May 1st , 2024

David Clarke, Engineering Director

# The Creation of an eFuels Export Market

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- Offshore wind resource in the Cook Inlet
- Potential markets for renewable power and the challenges of intermittency
- The importance of large-scale hydrogen storage
- Nikiski today and tomorrow
- Next steps

# US wind resources

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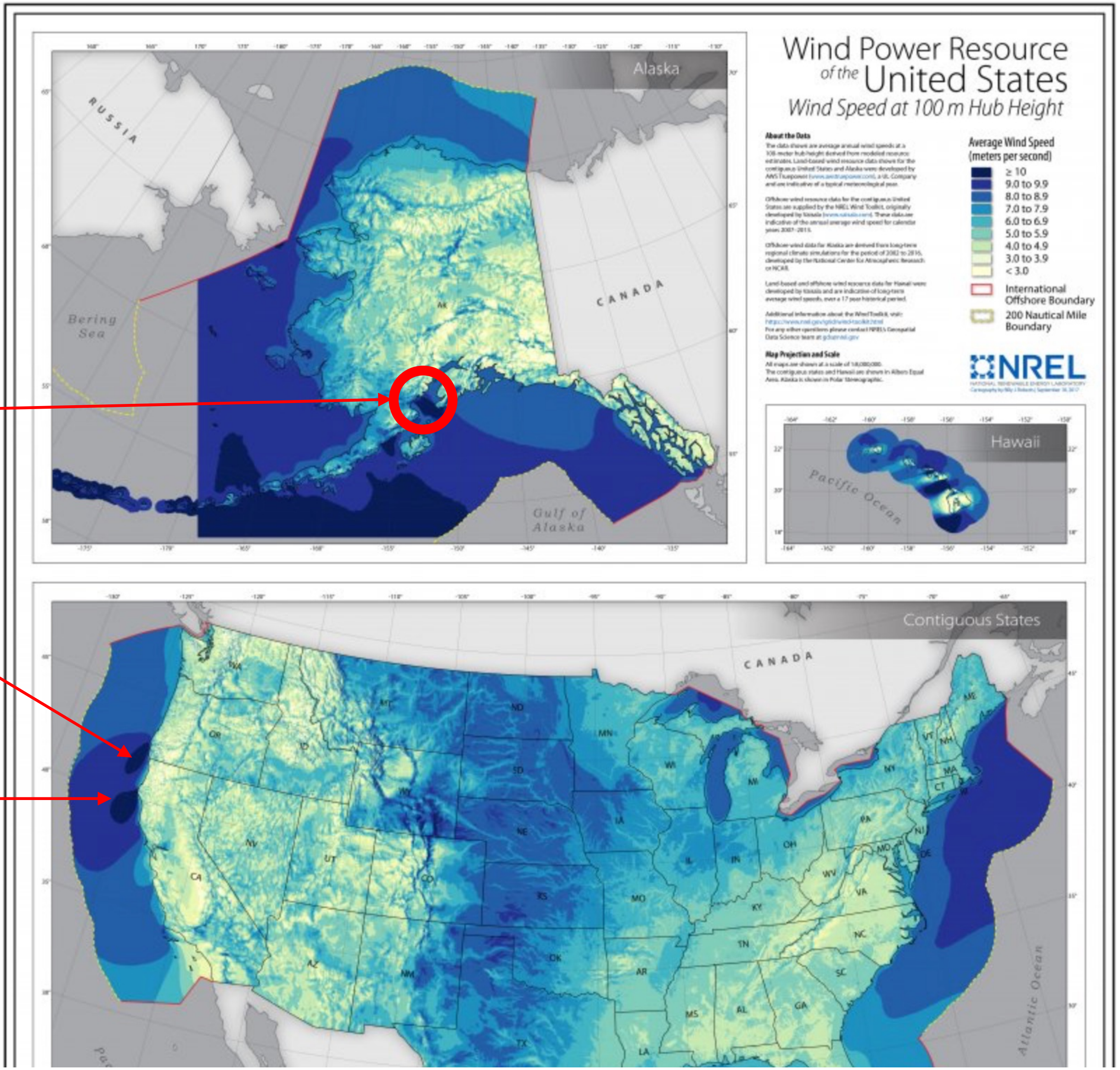
Lower Cook Inlet

Del Norte
Humboldt
Cape Mendocino

Morro Bay
Diablo Canyon




## Cook Inlet

- one of only four offshore US locations with average wind speeds > 10 m/s
- only such area
  - with water depth < 60 m
  - in an energy community
- > 60% gross capacity factor *
  - high power prices (US #2)



* NREL 2023

# Cook Inlet wind

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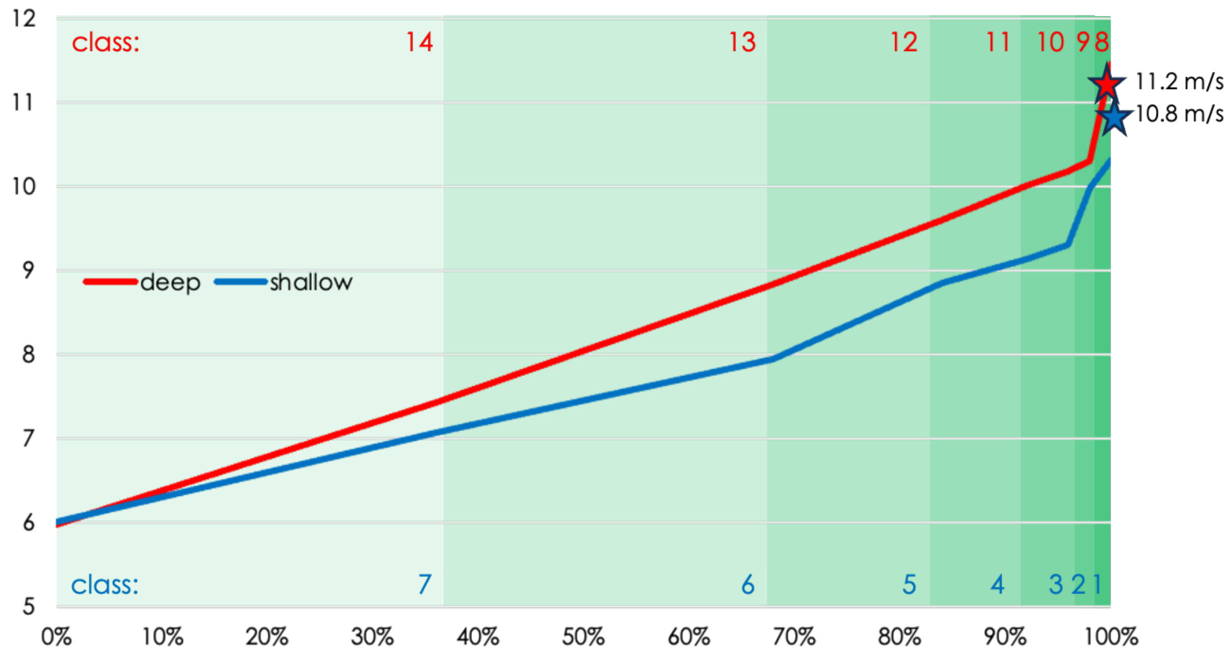
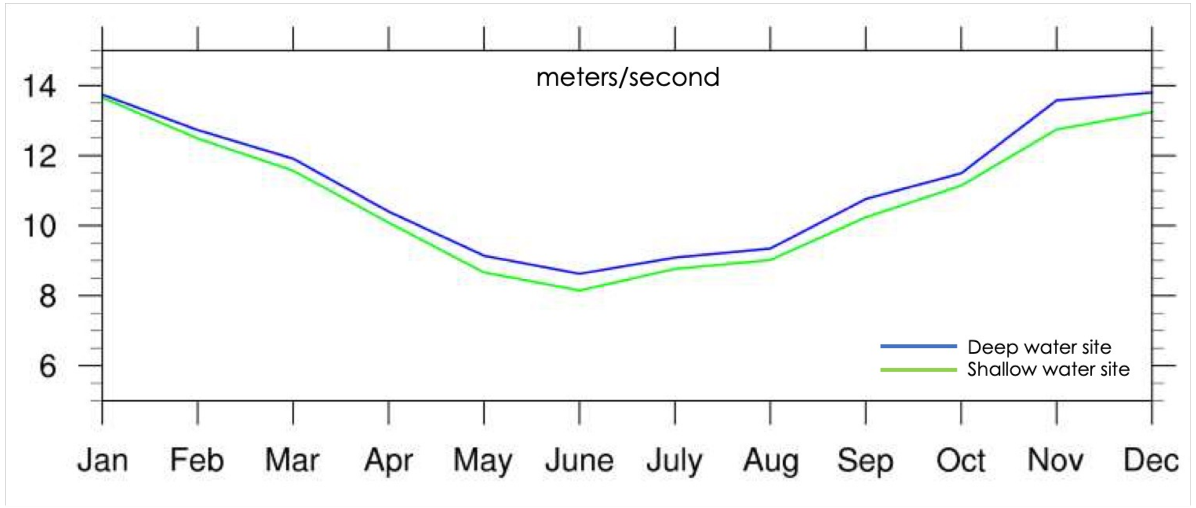
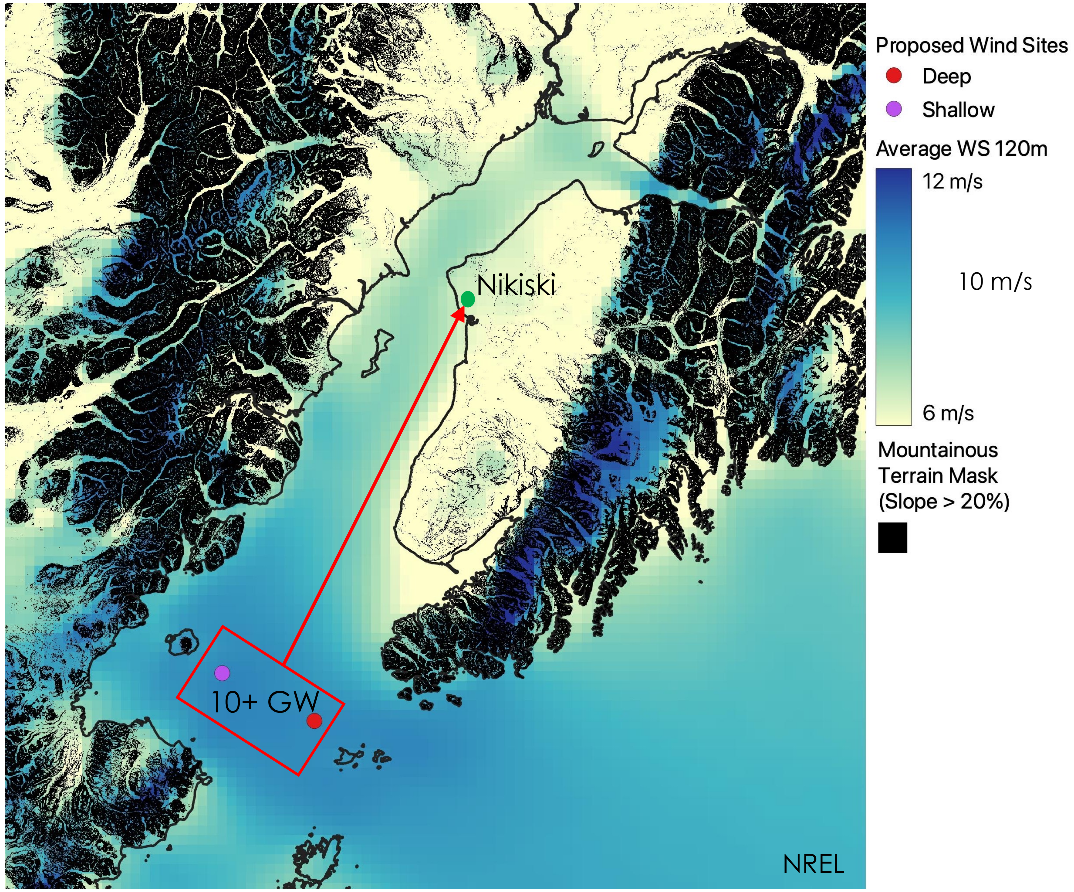
US wind resources (m/s, 2023 ATB)



# Lower Cook Inlet - the "Perfect" location to capture winds from all directions

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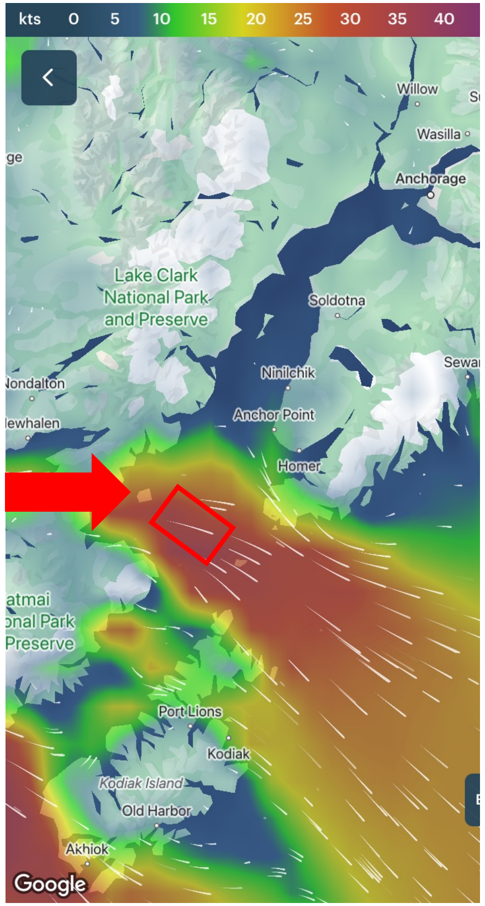


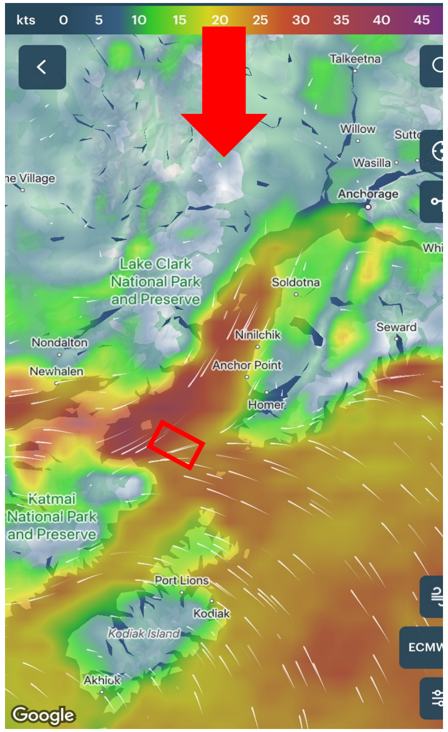


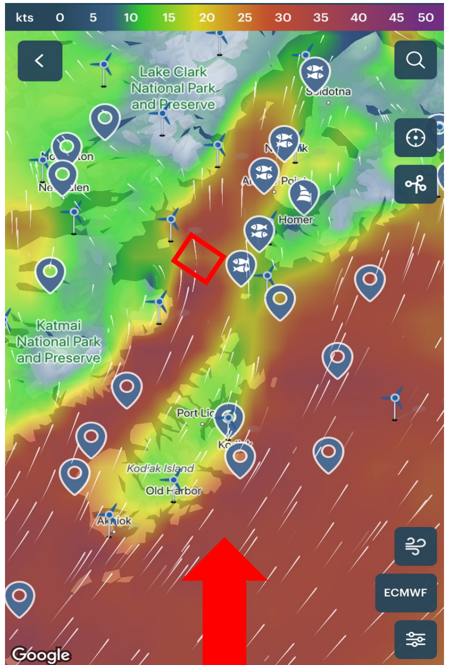


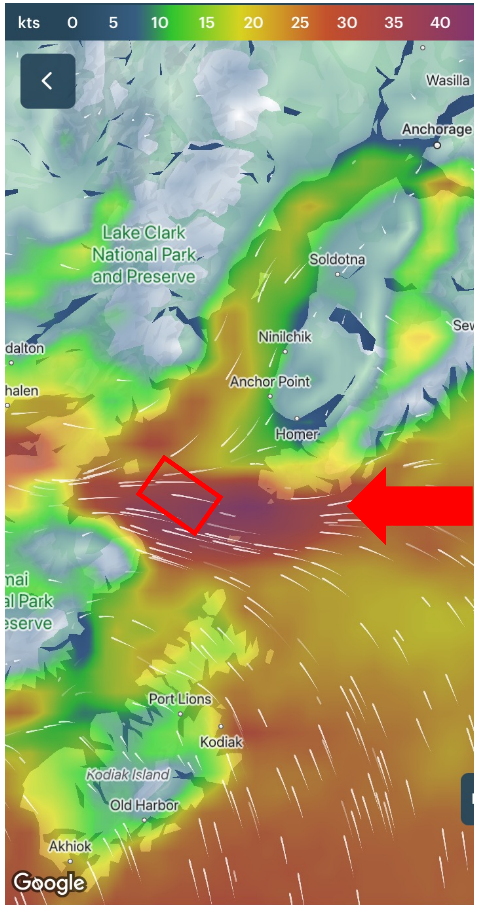

# Cook Inlet wind

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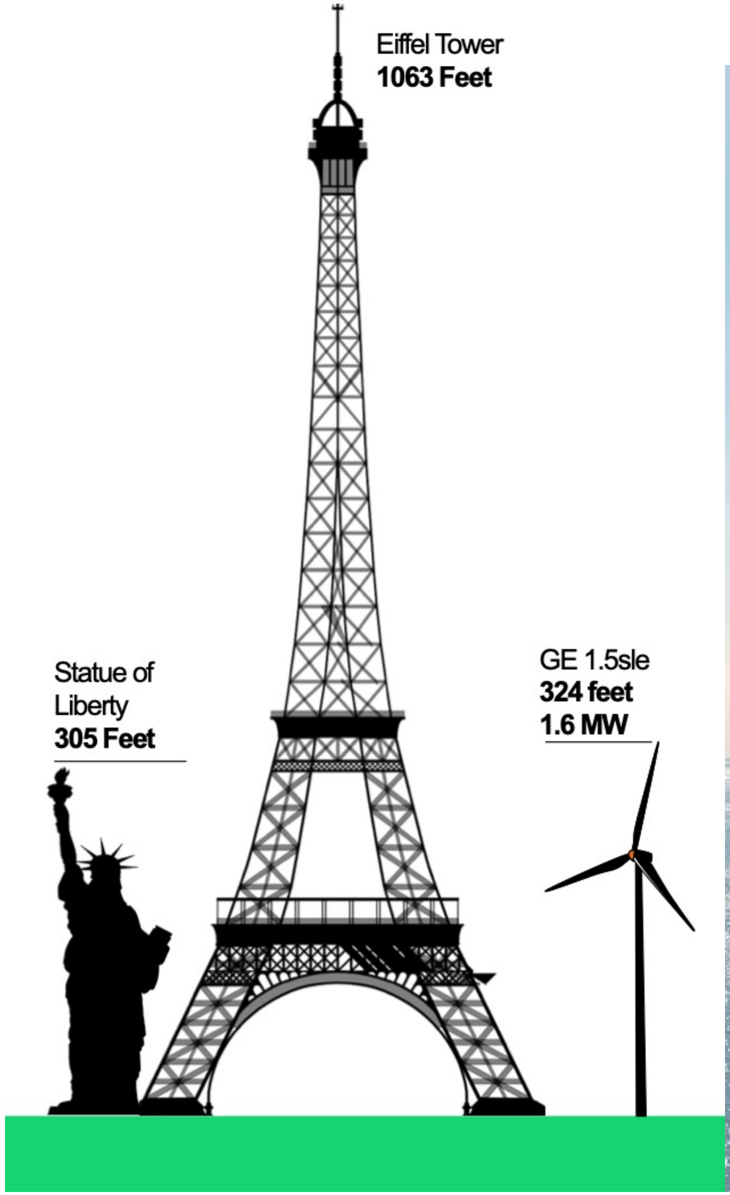


- 15 MW capacity
- 64% capacity factor
- 79 GWh/yr output

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a 12 MW Haliade-X offshore wind nacelle

current standard is 15 MW

each blade is 107m (351ft) long

WTIV Charybdis – 1st US flagged vessel


Kincardine 5 x 9.5 MW wind farm, offshore Aberdeen, Scotland

# Cook Inlet Wind-Hydrogen Hub

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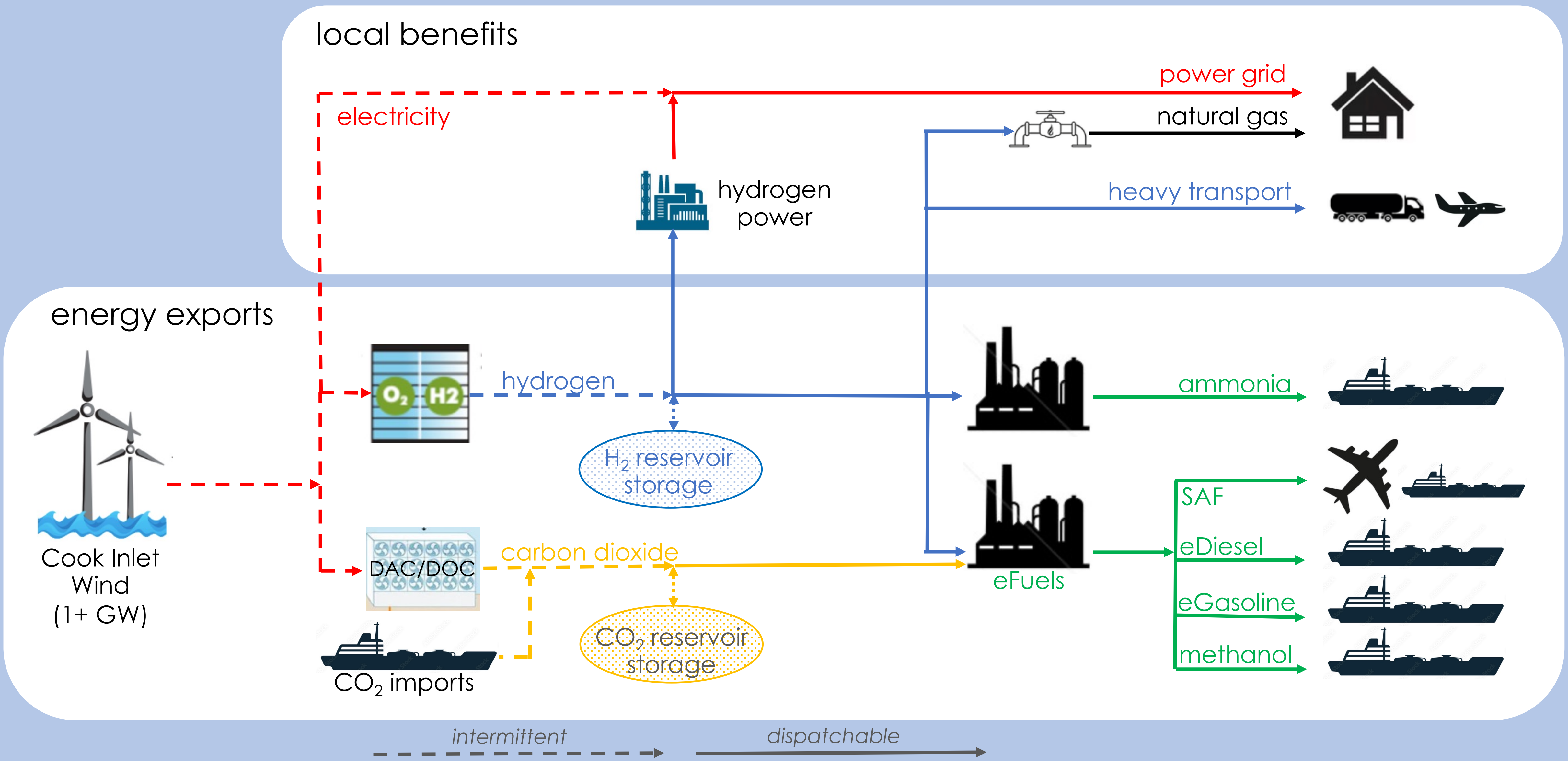
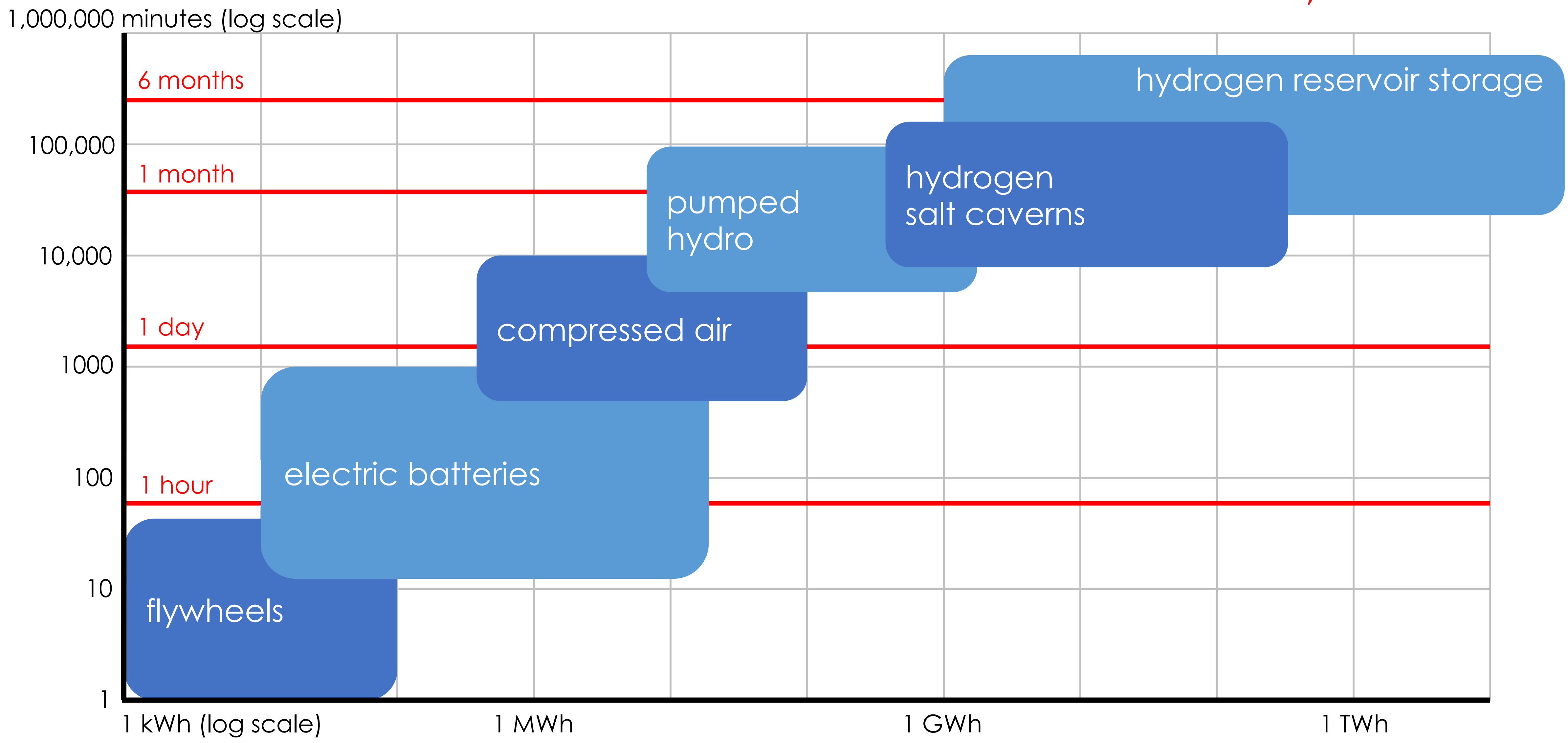


# energy storage technologies



DOE/NETL-2022/3236

SHASTA
Subsurface Hydrogen Assessment, Storage, and Technology Acceleration

# Subsurface Hydrogen and Natural Gas Storage: State of Knowledge and Research Recommendations Report

*SHASTA: Subsurface Hydrogen Assessment, Storage, and Technology Acceleration Project*

April 2022


***Prepared for the U.S. Department of Energy, Office of Fossil Energy and Carbon Management by:***

**National Energy Technology Laboratory:** Angela Goodman, Barbara Kutchko, Greg Lackey, Djuna Gulliver, Brian Strazisar, Kara Tinker, Ruishu Wright, Foad Haeri

**Pacific Northwest National Laboratory:** Nicolas Huerta, Seunghwan Baek, Christopher Bagwell, Julia De Toledo Camargo, Gerad Freeman, Wenbin Kuang, Joshua Torgeson

**Lawrence Livermore National Laboratory:** Joshua White, Thomas A. Buscheck, Nicola Castelletto, Megan Smith


U.S. DEPARTMENT OF ENERGY | Fossil Energy and Carbon Management

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SAND2023-1724049
PNNL-35058

SHASTA
Subsurface Hydrogen Assessment, Storage, and Technology Acceleration

# Local-Scale Framework for Techno-Economic Analysis of Subsurface Hydrogen Storage

*SHASTA: Subsurface Hydrogen Assessment, Storage, and Technology Acceleration Project*

September 2023


***Prepared for the U.S. Department of Energy, Office of Fossil Energy and Carbon Management by:***

**Sandia National Laboratories:** Shruti Khadka Mishra

**Pacific Northwest National Laboratory:** Sumitrra Ganguli, Gerad Freeman, Malcolm Moncheur de Rieudotte, Nicolas Huerta


U.S. DEPARTMENT OF ENERGY | Fossil Energy and Carbon Management

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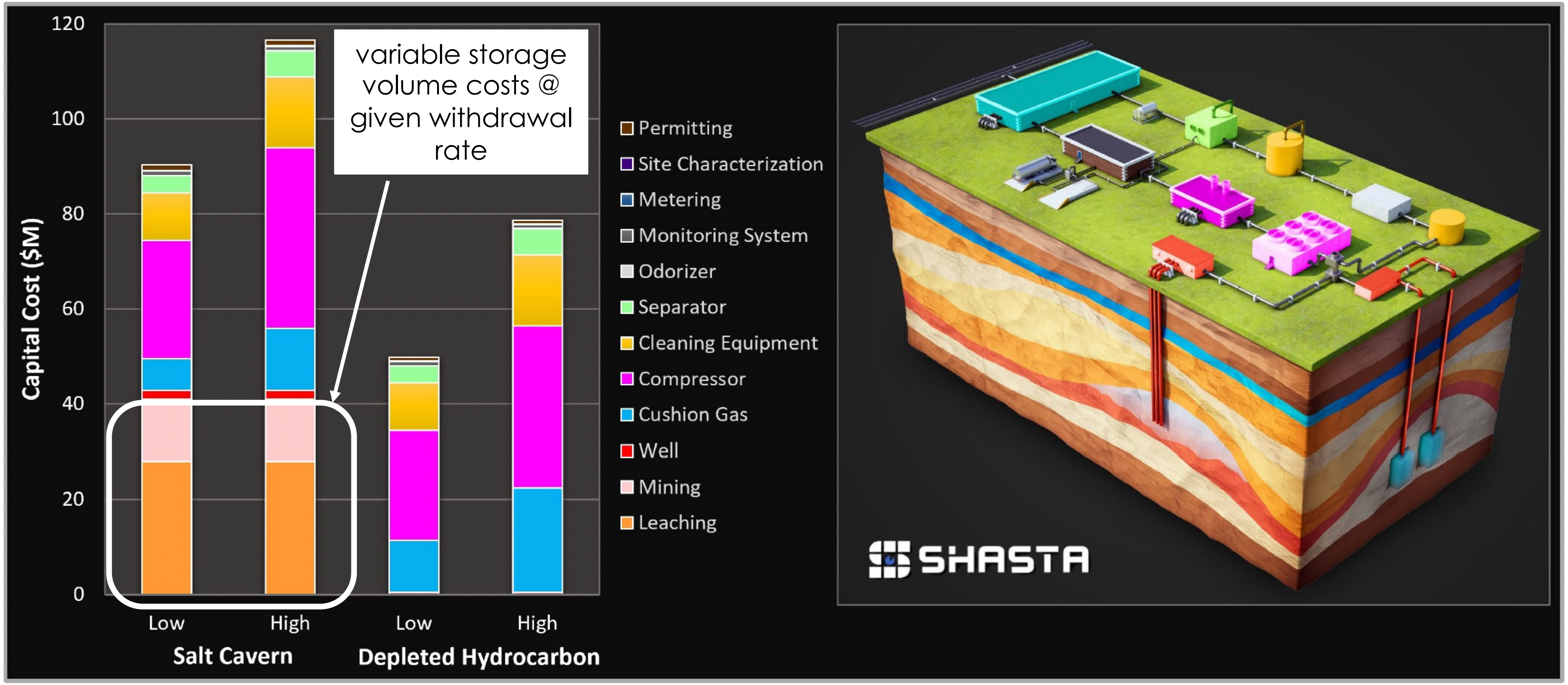
# natural gas reservoirs vs. salt caverns



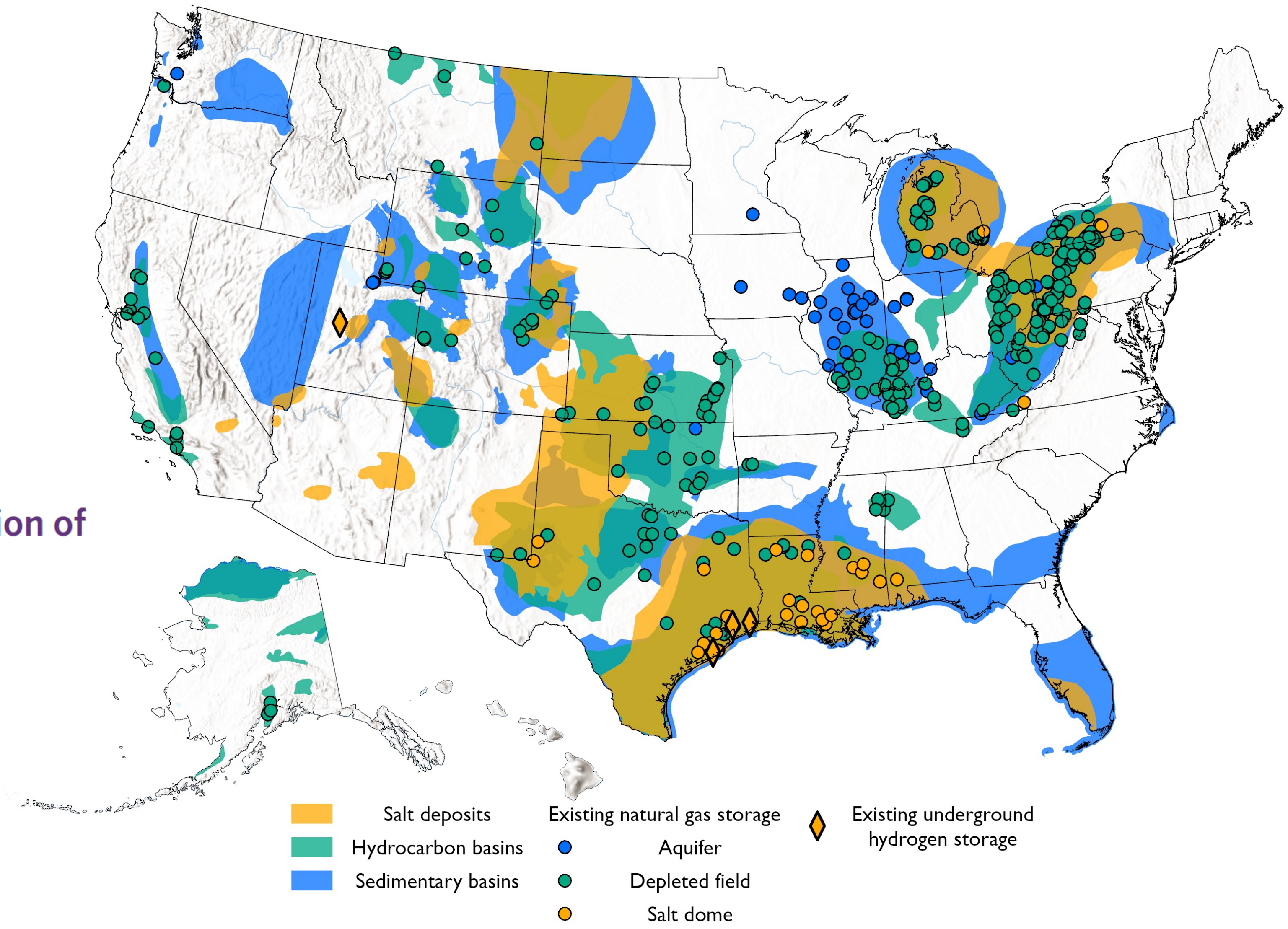

Share of capital costs for site development, well, cavern, and equipment for a 20-MMcf single-well UHS facility with no additional pipeline construction required. Capital costs are connected to surface and subsurface system components roughly by color coding.

# Geologic Storage Opportunities

## US Department of Energy Announces Selection of Seven Clean Hydrogen Hubs

November 06, 2023

Potential Hydrogen Storage Reservoirs




Leon Hibbard, Pacific Northwest National Laboratory; Nicolas Huerta, Pacific Northwest National Laboratory; Gregory Lackey, National Energy Technology Laboratory, Clean Hydrogen Hubs and Geologic Storage Shapefiles, 1/17/2024, https://edx.netl.doe.gov/dataset/clean-hydrogen-hubs-and-geologic-storage-shapefiles

PNNL-SA-196651

# Geologic Storage Opportunities

## US Department of Energy Announces Selection of Seven Clean Hydrogen Hubs

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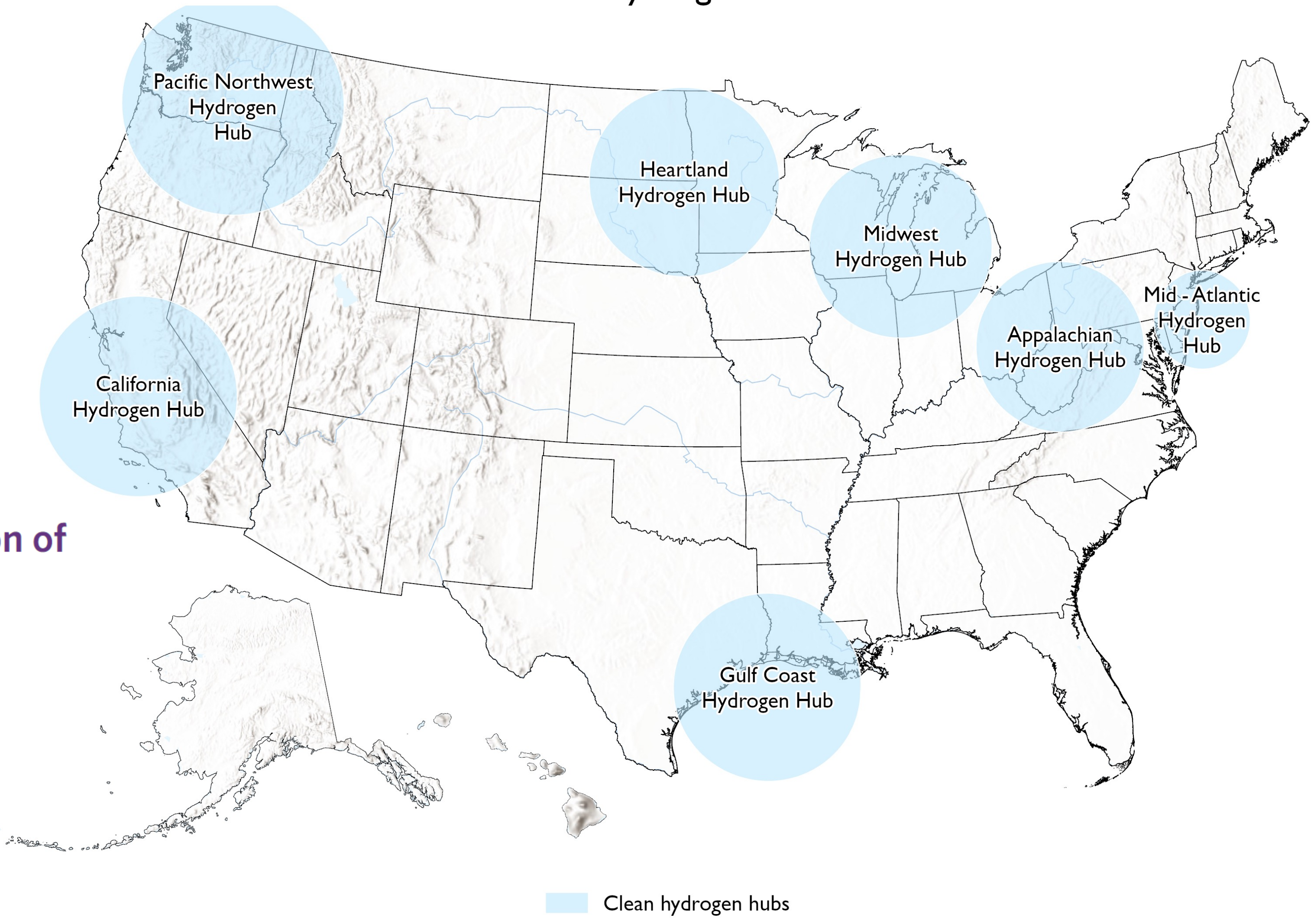
Clean Hydrogen Hubs




Leon Hibbard, Pacific Northwest National Laboratory; Nicolas Huerta, Pacific Northwest National Laboratory; Gregory Lackey, National Energy Technology Laboratory, Clean Hydrogen Hubs and Geologic Storage Shapefiles, 1/17/2024, https://edx.netl.doe.gov/dataset/clean-hydrogen-hubs-and-geologic-storage-shapefiles

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# Geologic Storage Case Studies

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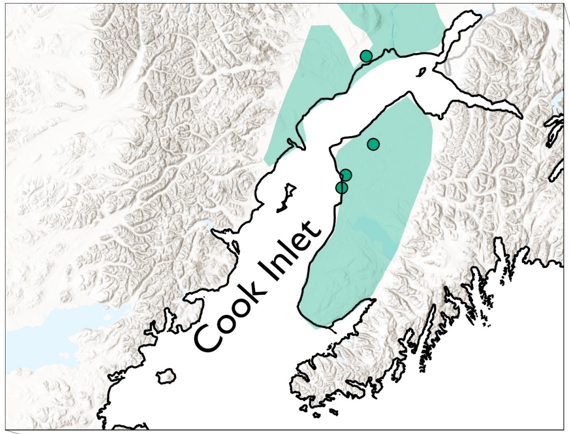
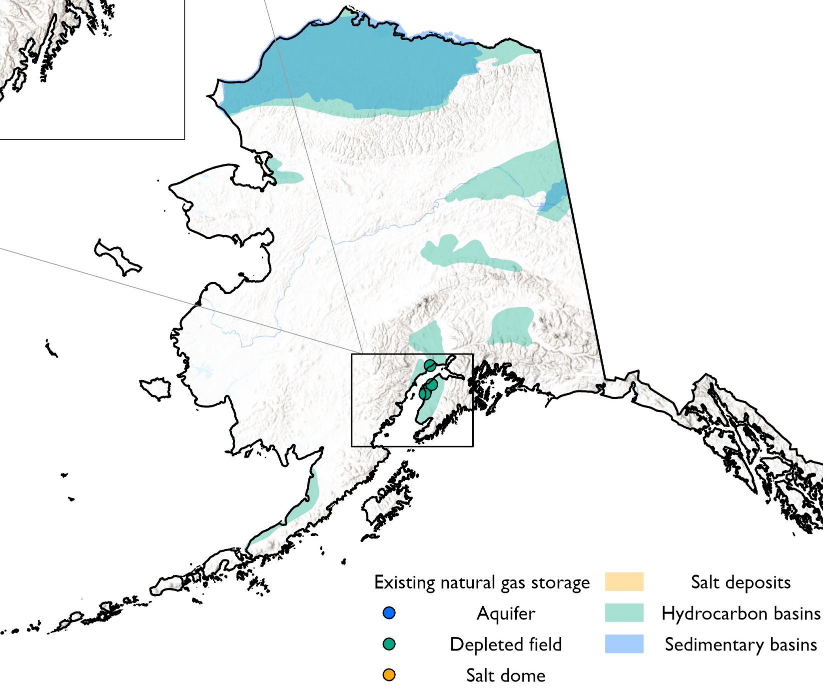
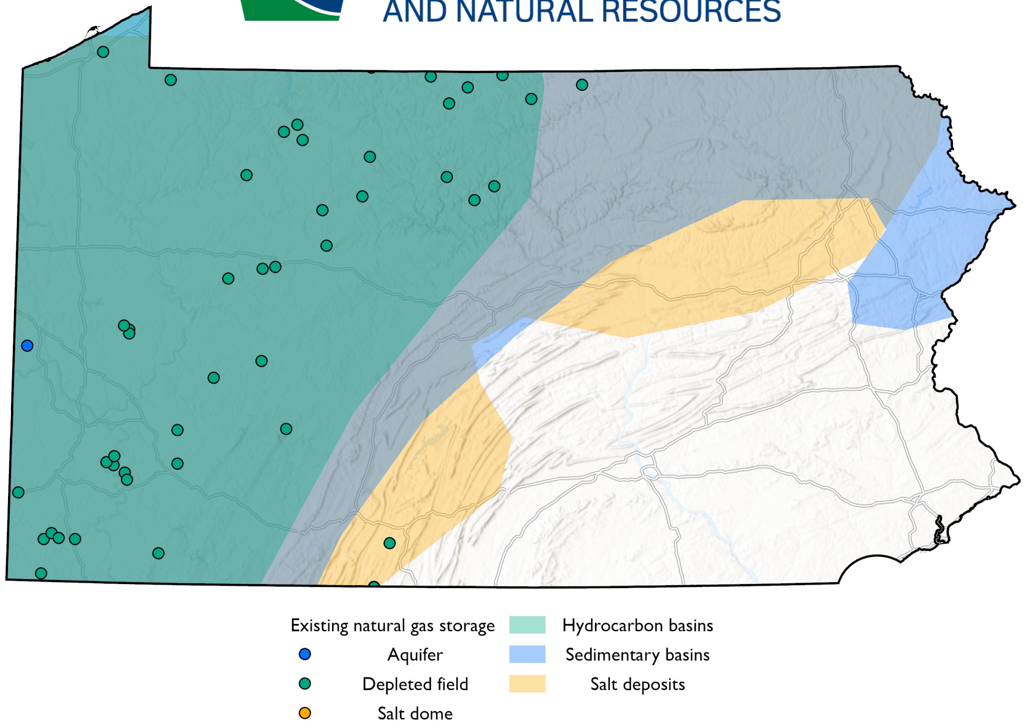



**92** hydrocarbon pools, **4** natural gas storage pools, **5** main producing formations

pennsylvania
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES




**1,295** conventional hydrocarbon pools, **51** natural gas storage pools, ~ **10** major producing formations ( > 1 % total production)

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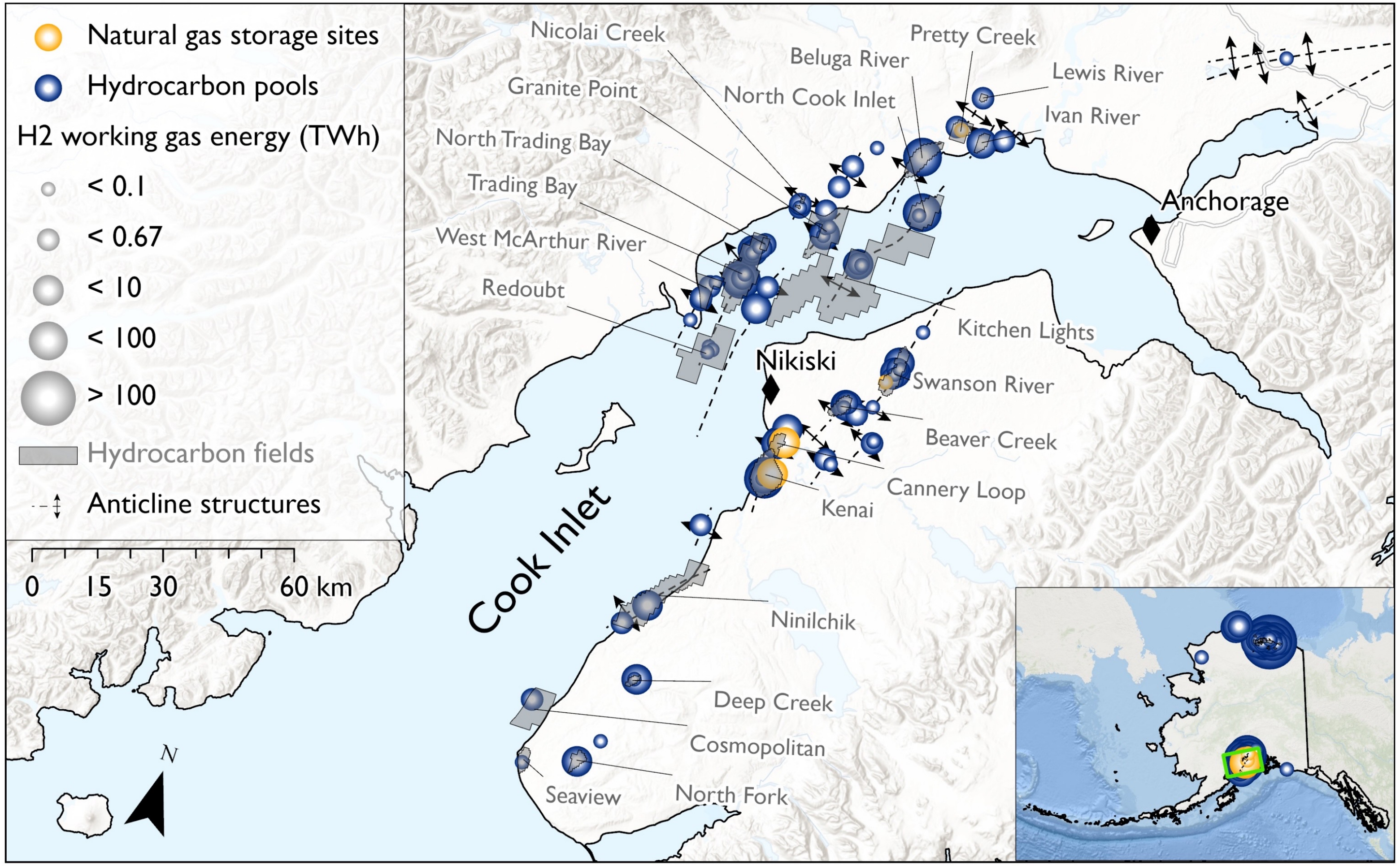
# Cook Inlet, Alaska

1. Storage volume
2. Physical and chemical suitability




**286 TWh $H_2$ working gas** in Cook Inlet

**29 hydrocarbon pools** and **two natural gas storage pools** could meet a theoretical $H_2$ storage demand

**48 pools** are currently unused

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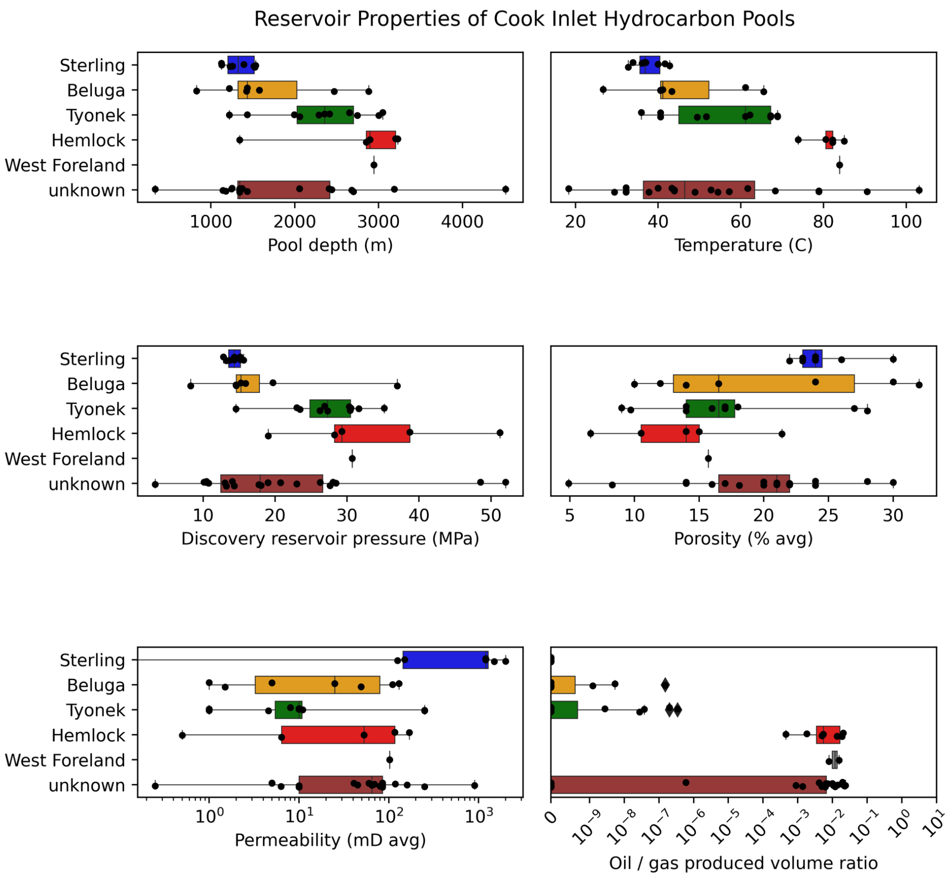
# Cook Inlet, Alaska




1. Storage volume
2. Physical and chemical suitability

Some formations exhibit **higher temperatures and pressures, better porosity and permeability, and lower oil saturations**

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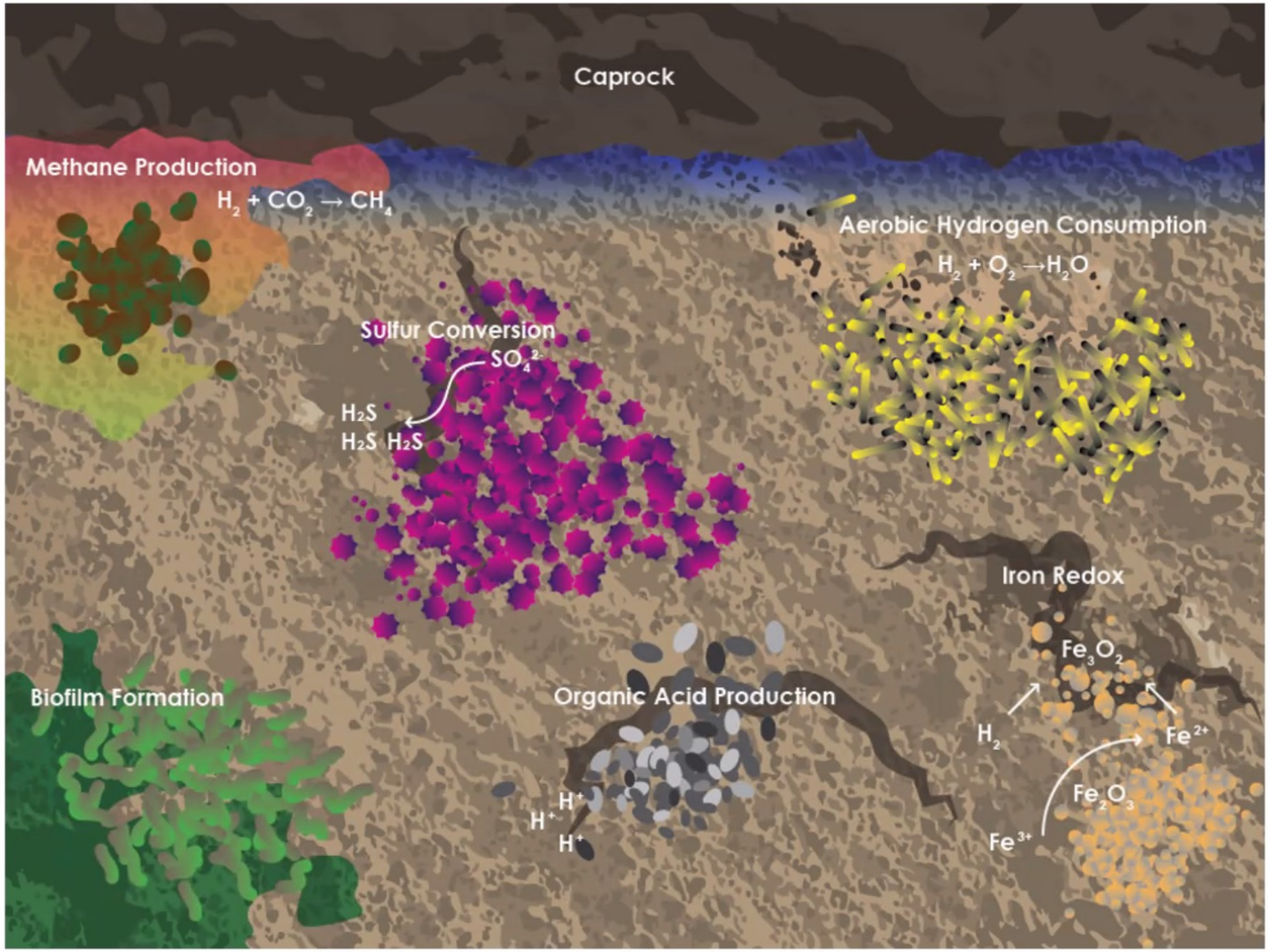
# Microbial Interactions

**Large-scale hydrogen storage will not be possible without the delineation of expected microbial activity**




<u>Microbial activity can affect subsurface energy storage through:</u>

- Methanogenesis
- Hydrogen Sulfide Production
- Acid Production
- Microbiological Corrosion Pathways

<u>Industry has documented microbial impacts on energy storage systems:</u>

- Gaz de France found methanogens consumed 50% of stored hydrogen gas.
- Gaz de France documented challenges from microbially produced $H_2S$.
- Czech Republic gas storage fields reported consumption of stored $H_2$ coupled to $H_2S$ production

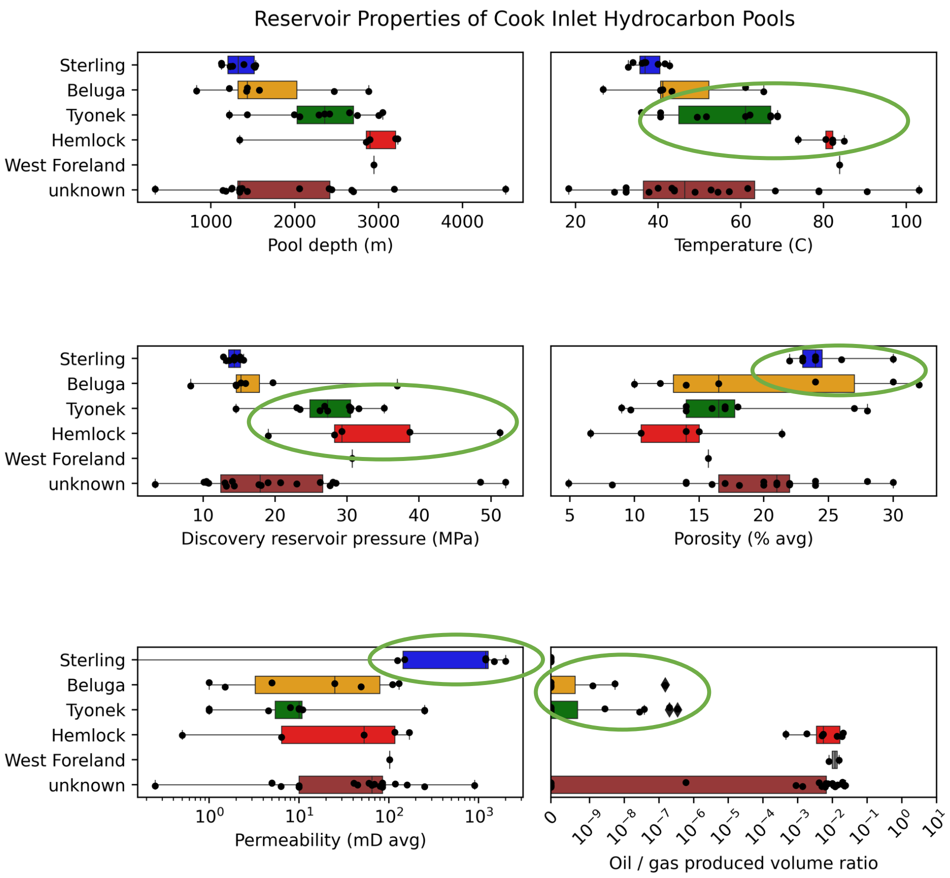
Before hydrogen can be safely and securely stored in underground reservoirs, the effect of gas injection on the naturally occurring microbial community and the associated change in chemistry needs to be assessed.

SHASTA

# Cook Inlet, Alaska

= potentially favorable

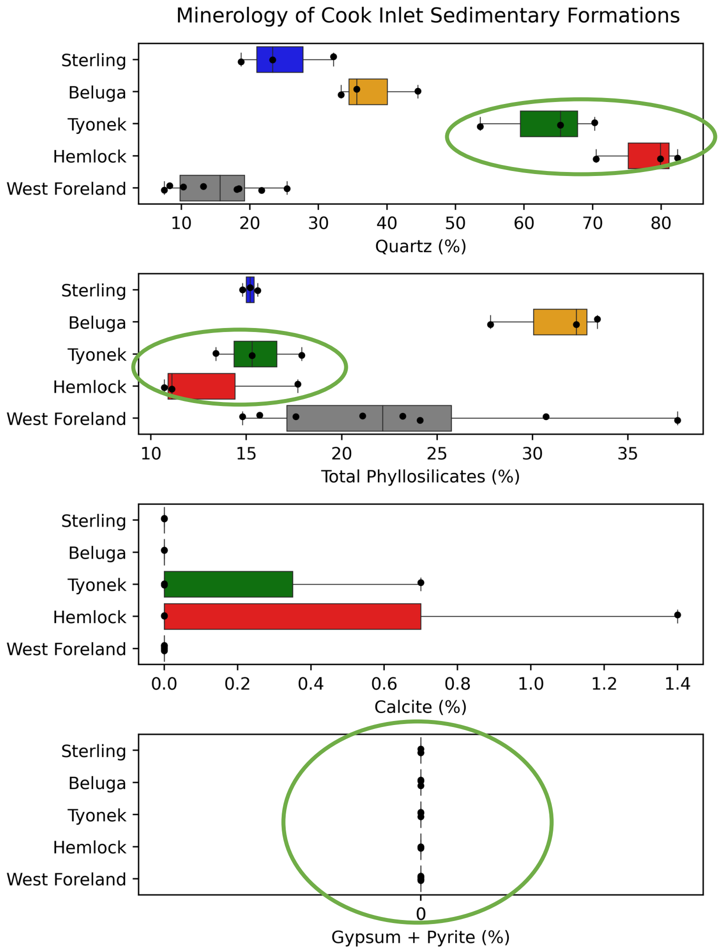
1. Storage volume
2. Physical and chemical suitability




Some formations exhibit **higher temperatures and pressures, better porosity and permeability, and lower oil saturations**

Some formations are <u>relatively</u> **quartz-rich** and **clay poor**

**All exhibit low calcite and no gypsum or pyrite**

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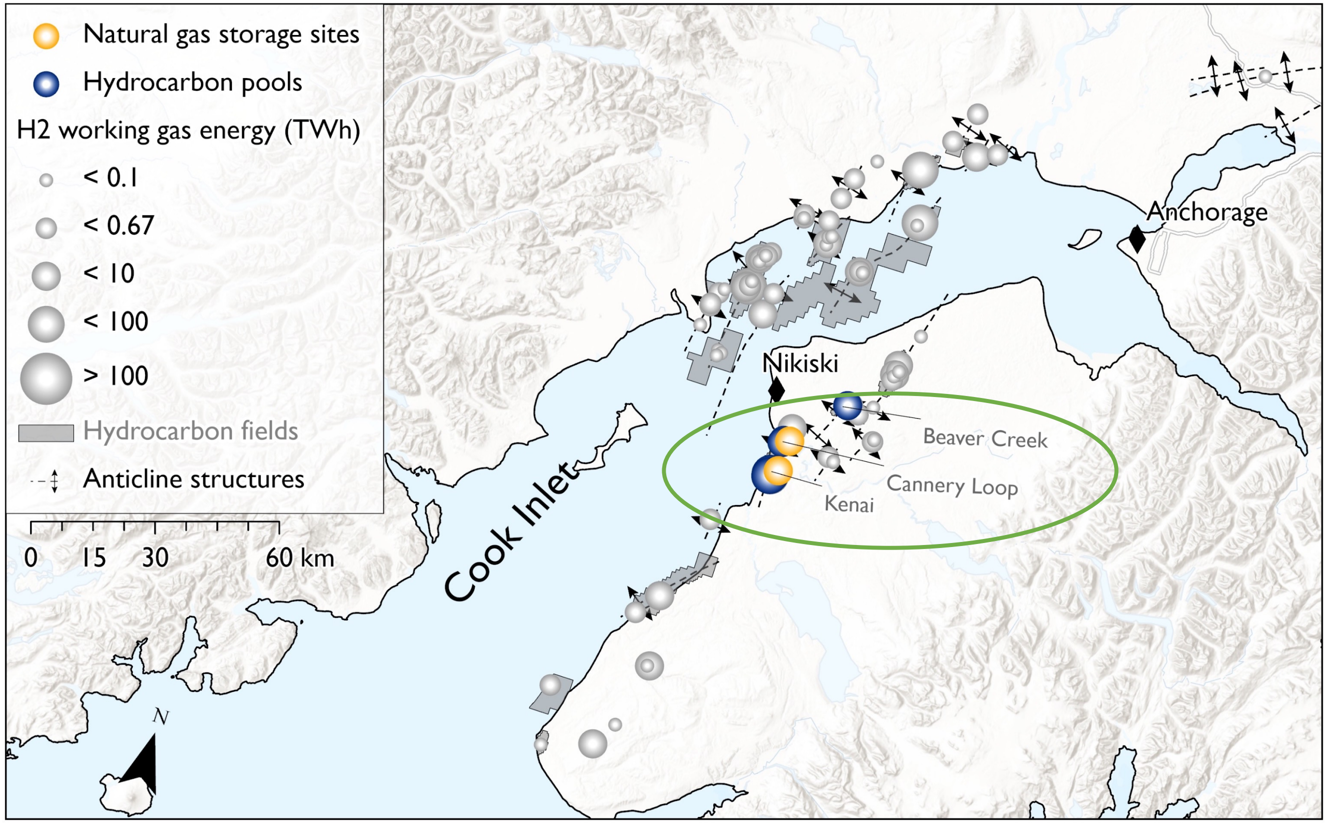
# Cook Inlet, Alaska

- **Seven** out of 92 pools offer available and adequate storage volumes and potentially favorable characteristics for hydrogen storage

- Next steps are site characterization and development




Submitted to *Applied Energy*

Underground Hydrogen Storage Resource Assessment for the Cook Inlet, Alaska

Leon Hibbard[a,*], Joshua A. White[b], David G. Clarke[d], Simon Harrison[d], Angela Goodman[e], Franek Hasiuk[c], Richard A. Schultz[f], Nicolas Huerta[a]

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# Nikiski today – oil & gas hub

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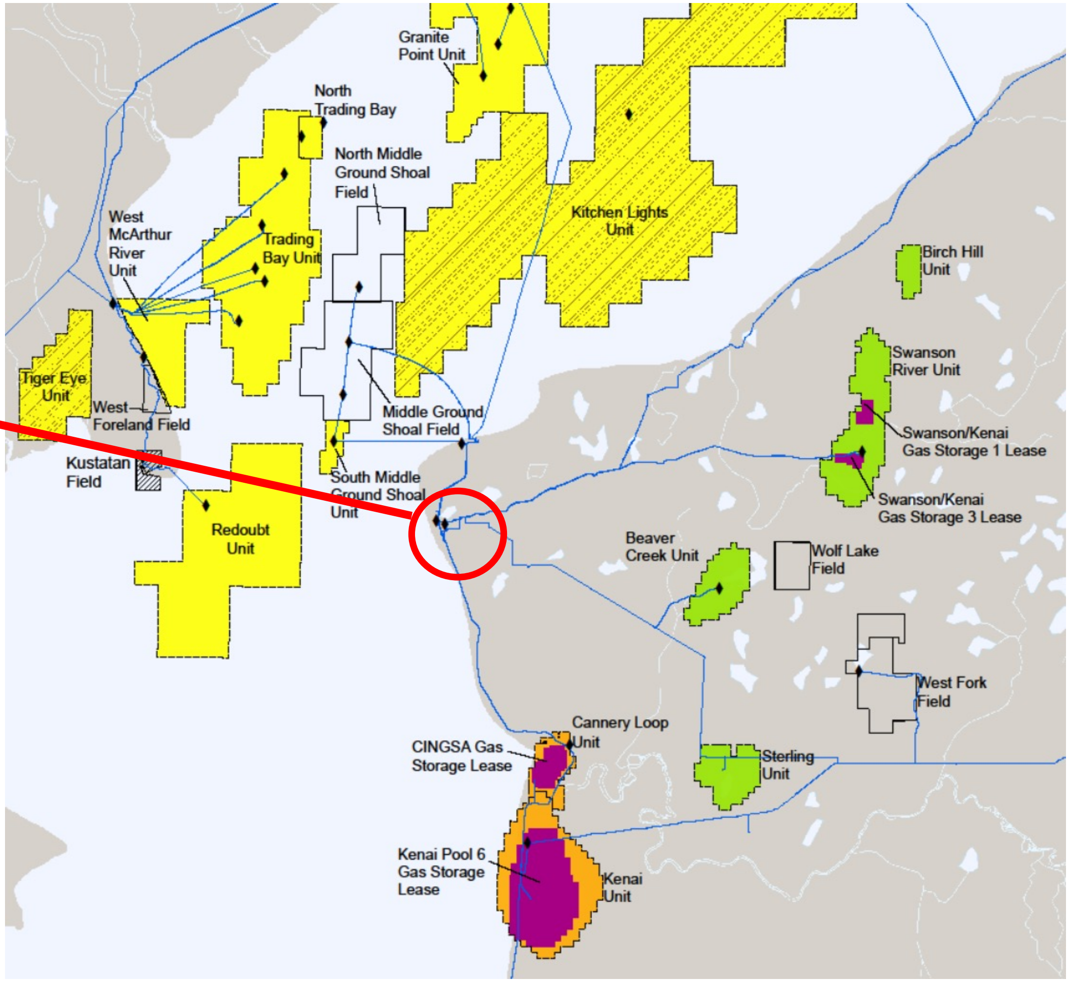
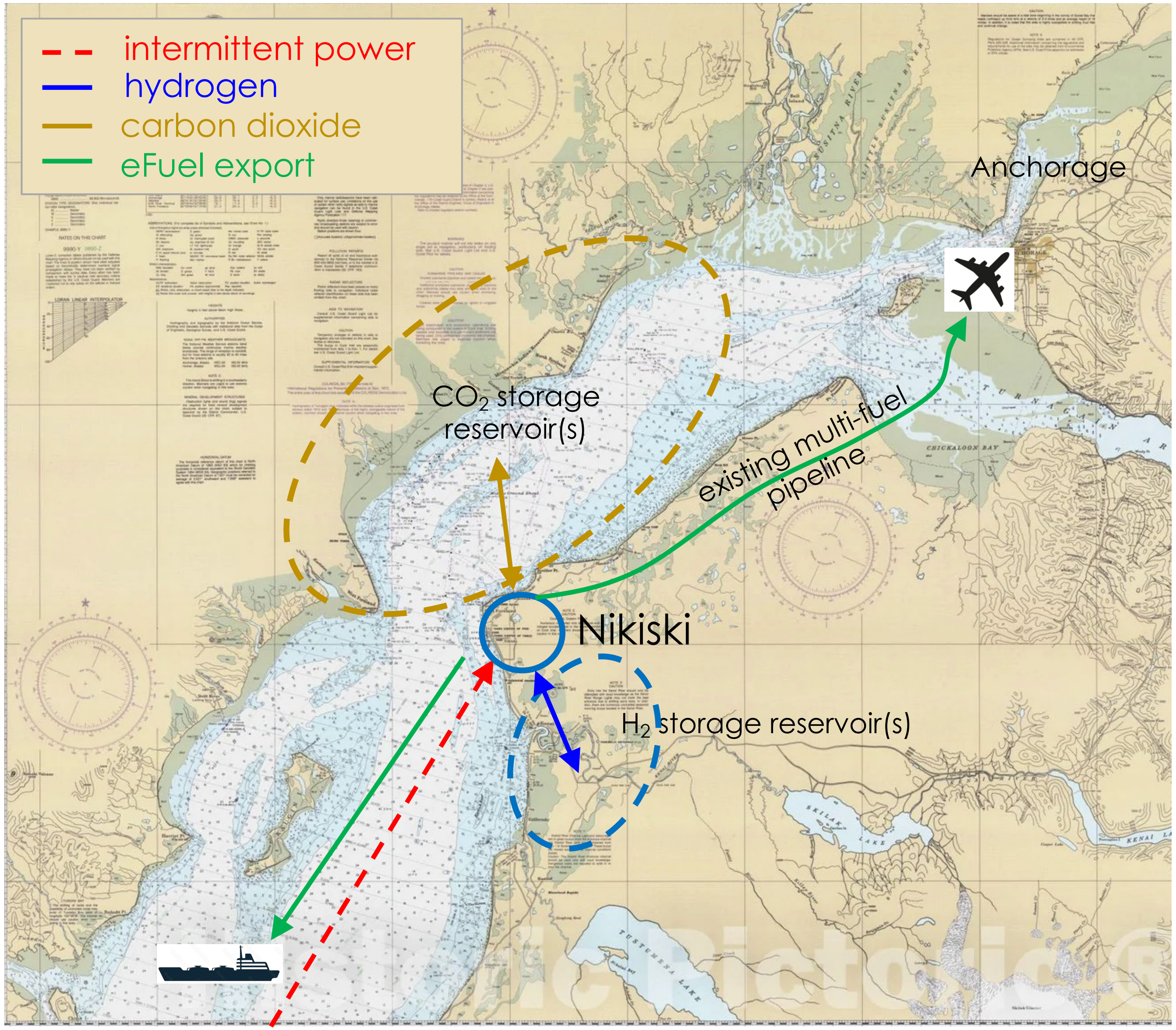



- oil & gas production operations
- underground natural gas storage
- deep-water port
- refinery
- LNG & ammonia plants (mothballed)

# Nikiski tomorrow



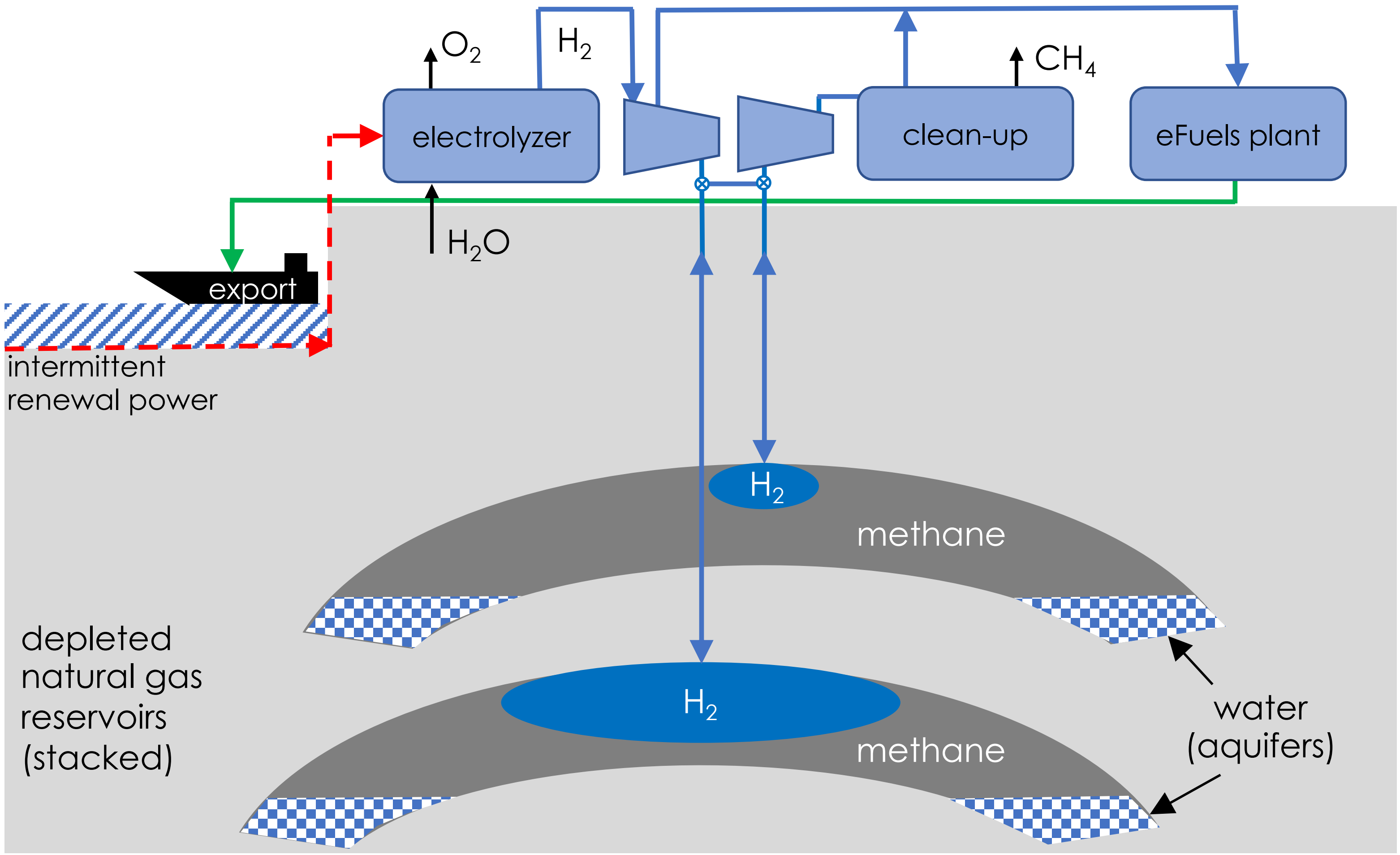

## core activities

- offshore wind power
- hydrogen electrolysis
- hydrogen reservoir storage
- $CO_2$ direct air/ocean capture
- reservoir $CO_2$ storage
- green fuels production
- green fuels export

## other activities

- $CO_2$ import & sequestration
- geothermal & tidal power
- in-state power supply
  - residential/commercial
  - industrial (mines, etc.)

# hydrogen reservoir storage




characteristics

- ultra-long duration (> 6 mth)
- ultra-high capacity (> 1 TWh)
- meteorological storage
- inter-seasonal storage
- cost ∝ withdrawal rate
- cost NOT-∝ storage capacity
- capacity ∝ reservoir size
- low cost (~$0.45/kg gross)
- low cost (~$0.15/kg net*)

* AMP estimate using offshore wind power with 64% capacity factor

# Hydrogen storage pilot

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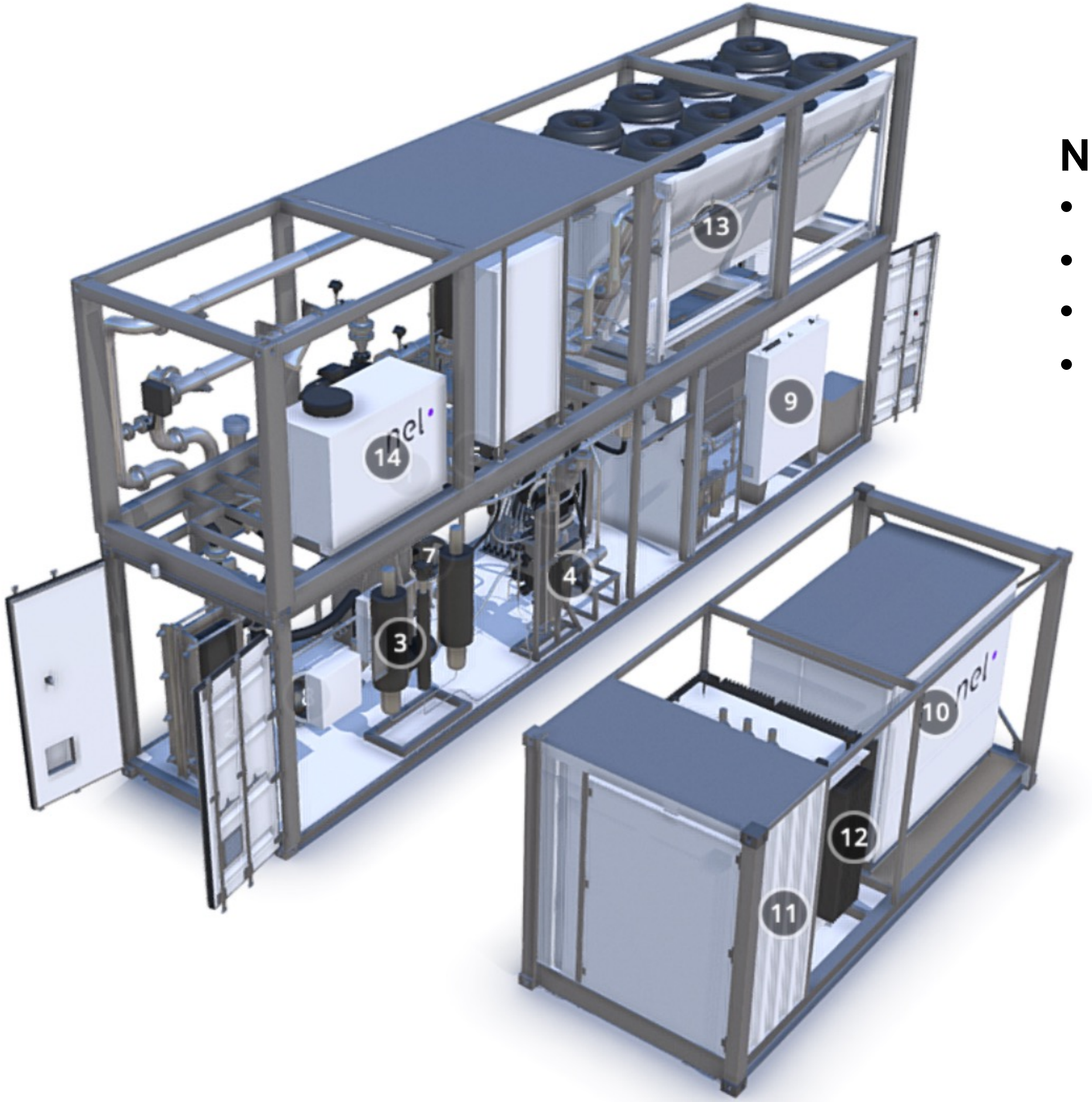


**NEL Model MC500 PEM Electrolyzer**

- Power requirement – 2.5 MW
- Production volume – 18,704 scf/h (0.45 mmscf/d)
- Production mass – 1.062 t/d
- Delivery pressure – 30 barg (435 psig)

# way forward

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## science project
DOE sponsored, SHASTA operated ($7M to date)

- feasibility study (2022-23) ✅
- Cook Inlet & other studies (2023-25) ✅
- national studies, funding delays, citations, papers ……

"good science"

### Phase 1
- local context ✅
- business strategy ✅

### Phase 2
select reservoir, prepare test
- project management
- well & reservoir sampling
- leasing & permitting
- commercial agreements
- engineering design
- ~2 years, ~$5M

information

"nimble engineering"

### Phase 3
pre-commercial pilot test
- project management
- drill & complete well(s)
- design & construct facility
- 2-years injection & withdrawal cycling
- post-test well & reservoir sampling
- ~5 years, ~$25-35M

2024 → FID by → 2027 → commercial by → 2030

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for wind power …
for hydrogen storage …
for green fuels


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