The #H2IQ Hour

Welcome!

The #H2IQ Webinar will start shortly

Active on social media? Use #H2IQ for posts about this webinar

Learn more about the DOE Hydrogen Program

www.hydrogen.energy.gov

The #H2IQ Hour

Today's Topic:

DOE Update on Hydrogen Shot, RFI Results, and Summary of Hydrogen Provisions in the Bipartisan Infrastructure Law

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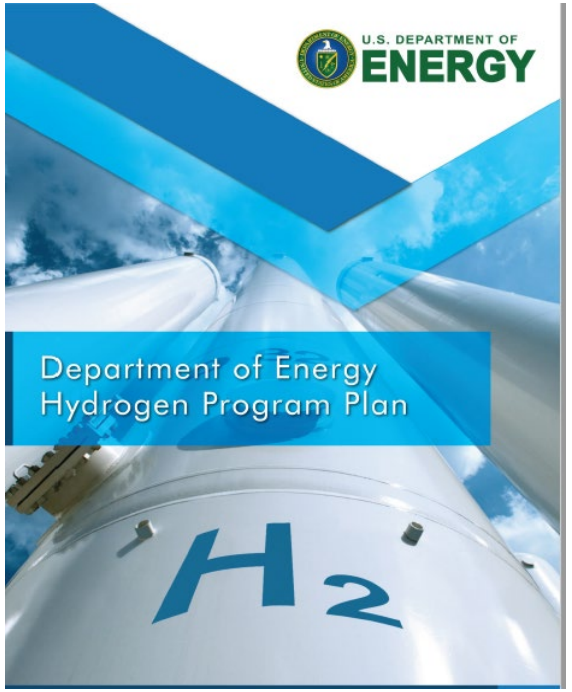
December 8, 2021

Agenda

1) DOE Hydrogen Program Background
2) Feedback from DOE Hydrogen Shot Request for Information (RFI)
3) Provisions in Bipartisan Infrastructure Law (BIL)
   - National Hydrogen Strategy and Roadmap
   - Clean Hydrogen Production Qualifications
   - Hydrogen Hubs
   - Electrolysis, Manufacturing, and Recycling RD&D
4) H2 Matchmaker
5) Summary and Next Steps

The U.S. DOE Hydrogen Program

Hydrogen is one part of a broad portfolio of activities



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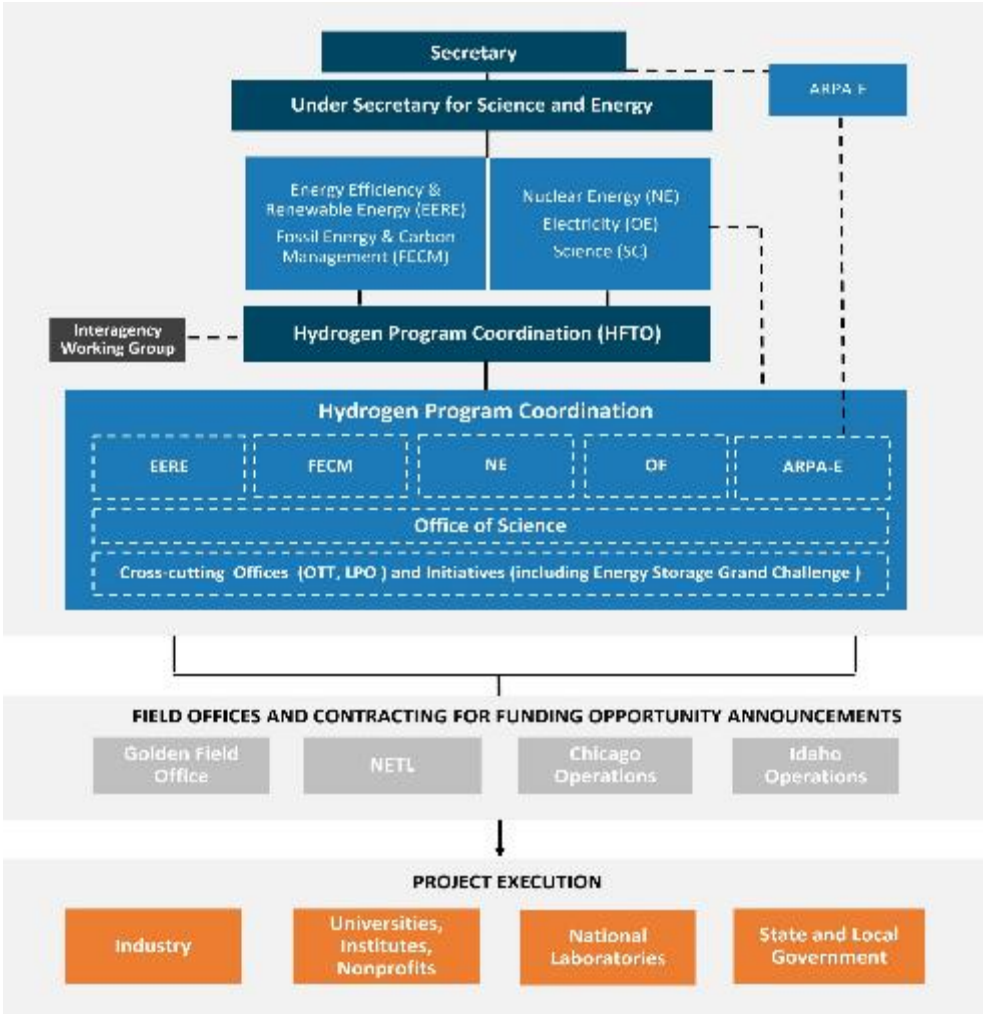


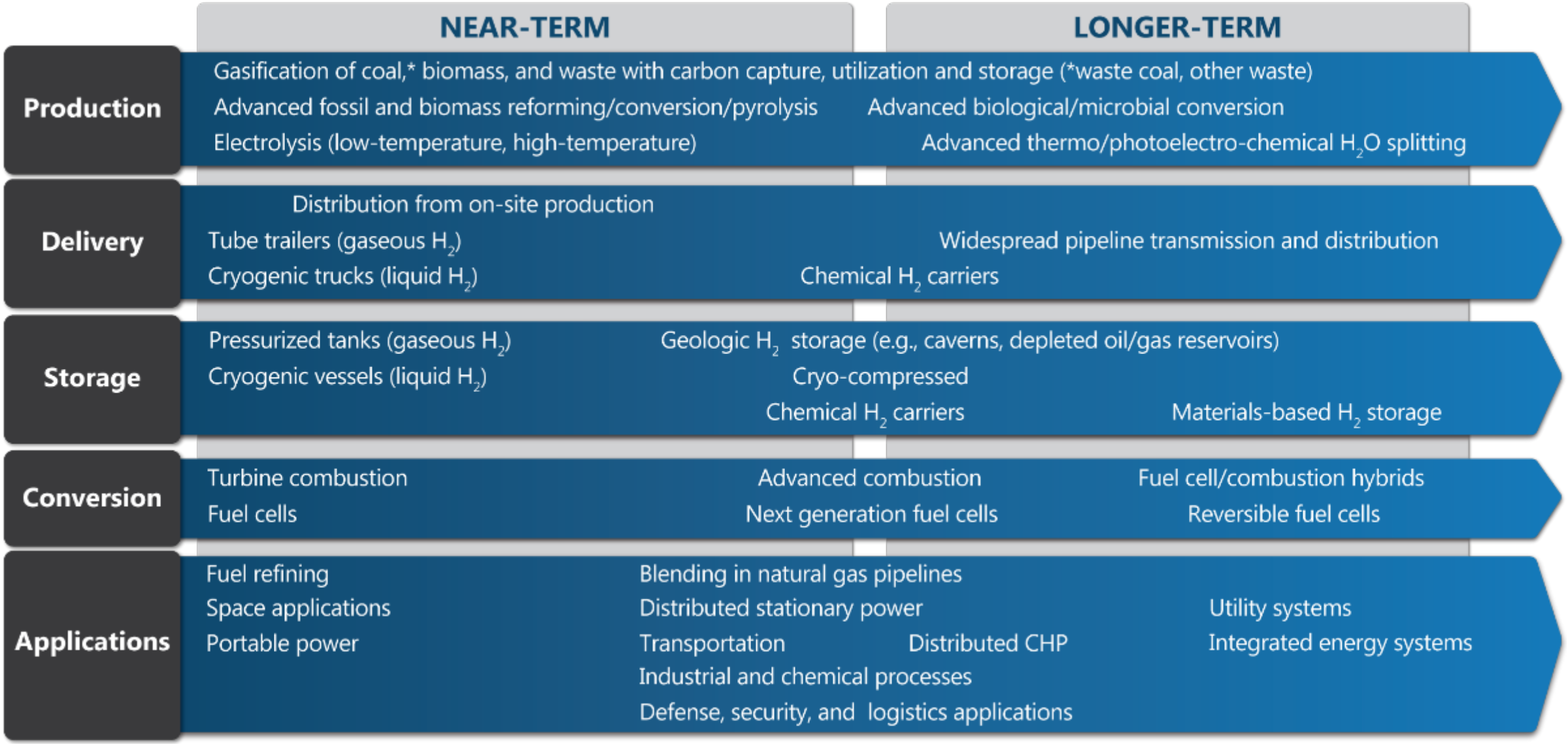
Coordinated across all relevant DOE Offices. Interagency Working Group coordinates across Agencies.

Priorities

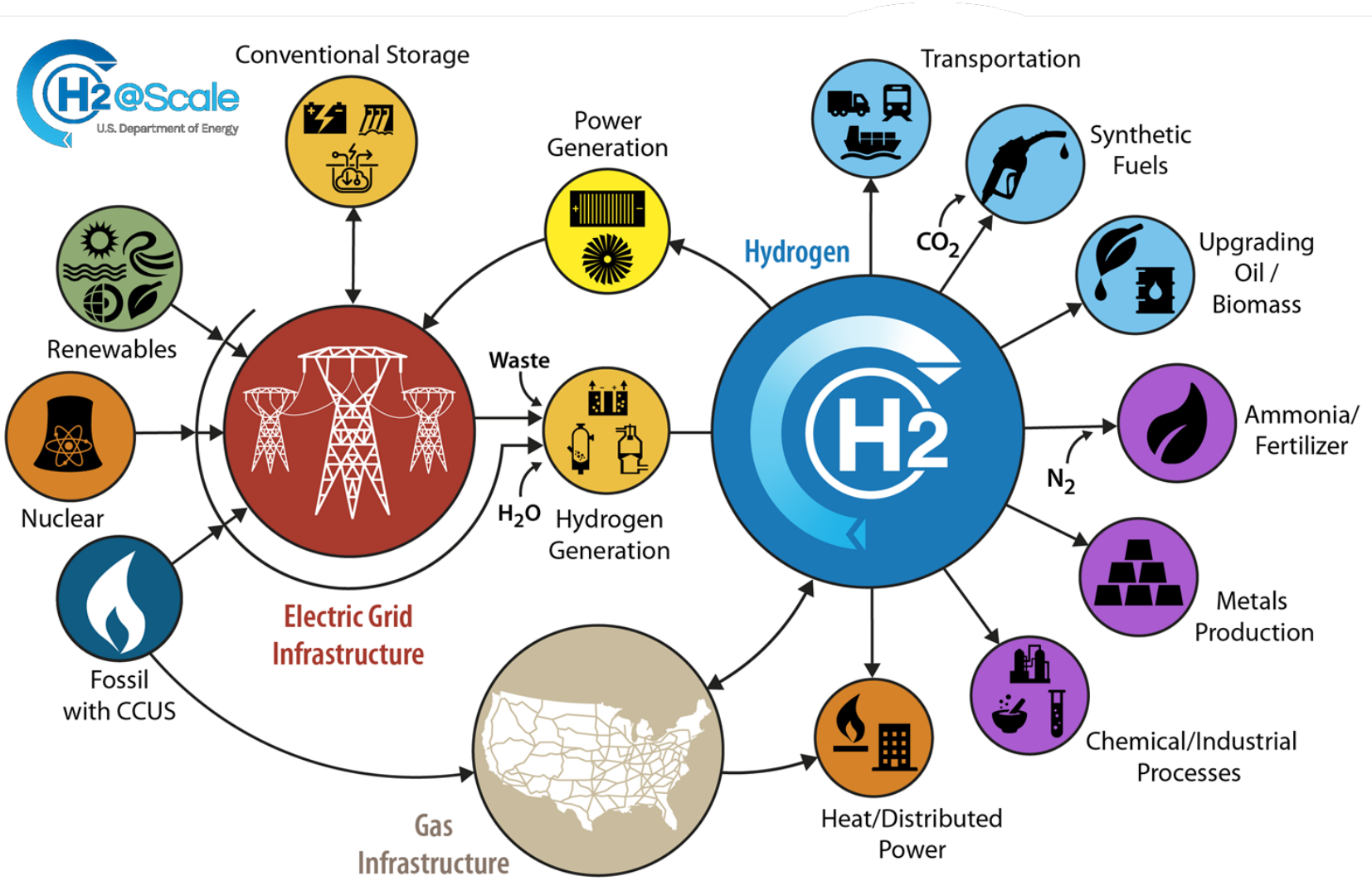
1. **Low cost, clean hydrogen**
2. **Low cost, efficient, safe hydrogen delivery and storage**
3. **Enable end use applications at scale for impact**

Workforce development, safety, codes, standards, and Environmental Justice priorities

Hydrogen Program Areas of Focus across Multiple Offices



H2@Scale: Enabler for Deep Decarbonization across Sectors and Jobs



Key Opportunities

- **Industry and Chemicals**
  Steel, ammonia, cement, syn fuels (e.g., aviation), exports
- **Transportation**
  Trucks, marine, buses, etc.
- **Power and Energy Storage**
  Long duration storage, NG blending, turbines, fuel cells

U.S. Snapshot

- 10 MMT of H_2/yr produced today with scenarios for 2-5X growth.
- +10 MMT H_2 would ~ double today's solar or wind deployment
- Potential for 700K jobs, $140B by 2030

Energy Earthshots and Hydrogen Shot Launch

"…I've asked the Secretary of Energy to speed the development of critical technologies to tackle the climate crisis. No single technology is the answer on its own because every sector requires innovation to meet this moment."

President Joseph R. Biden
April 23, 2021

Launch of Hydrogen Energy Earthshot
First of the Energy Earthshots: $1 for 1 kg clean H2 in 1 decade
June 7, 2021
at DOE Hydrogen Program Annual Merit Review

Secretary Jennifer Granholm
June 7, 2021

Hydrogen Energy Earthshot

“Hydrogen Shot”

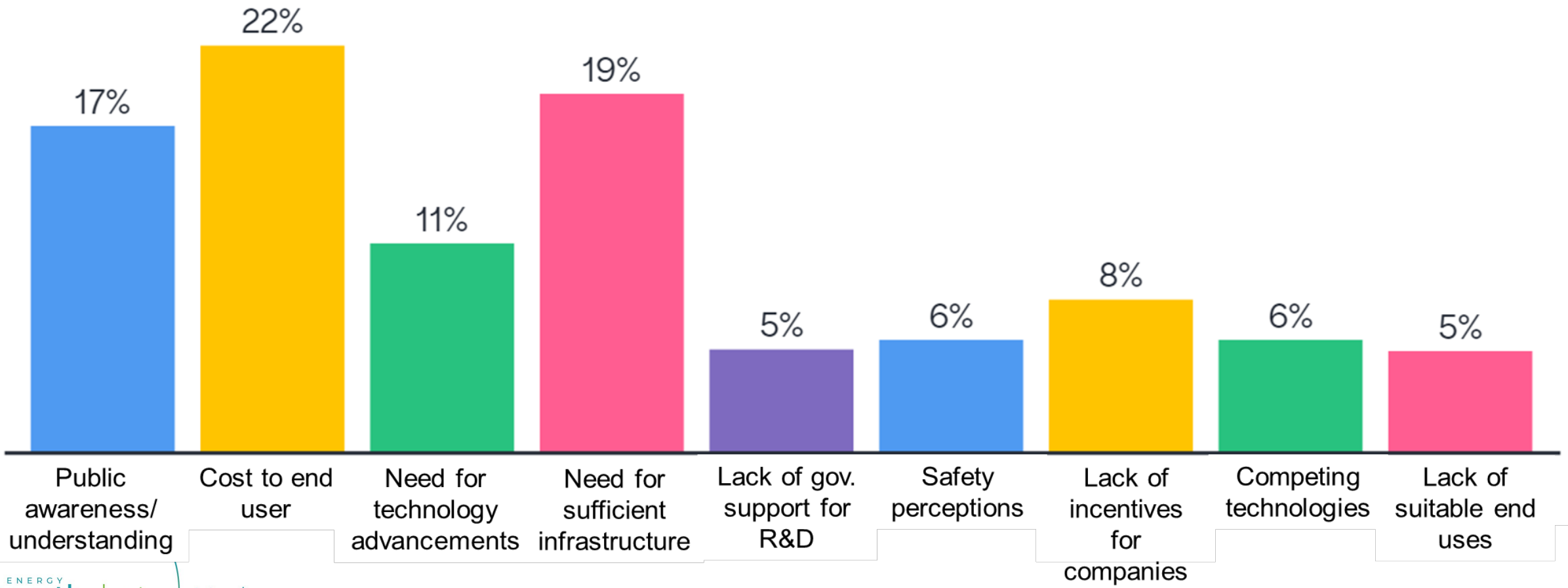
“1 1 1”
$1 for 1 kg clean hydrogen in 1 decade

Launched June 7, 2021
Summit Aug 31-Sept 1, 2021

DOE Hydrogen Shot Summit Stakeholder Feedback

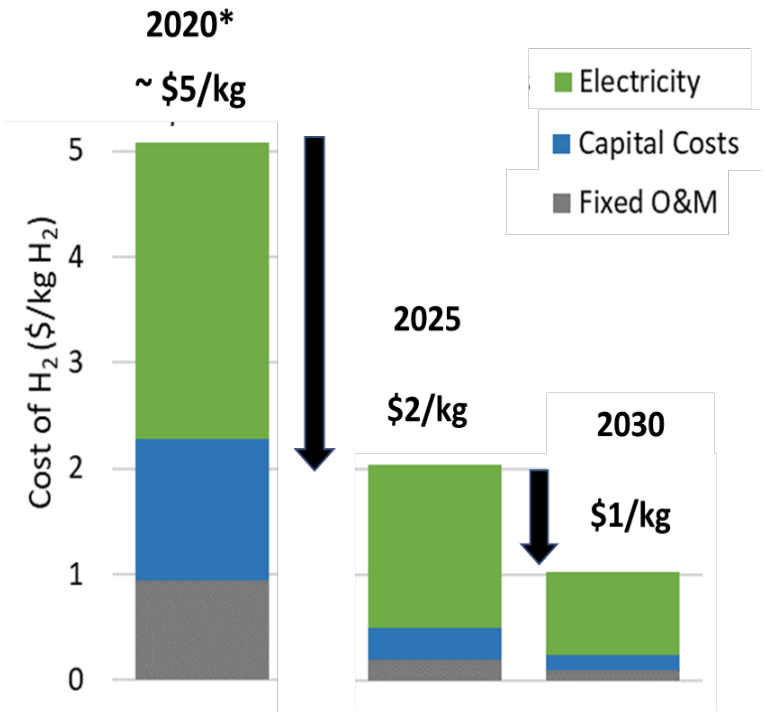
4,900+ total registrants, 3,200+ participants in Plenary, 33 countries + USA

Responses to: What are the greatest barriers preventing public acceptance of widespread H_2 in the US?



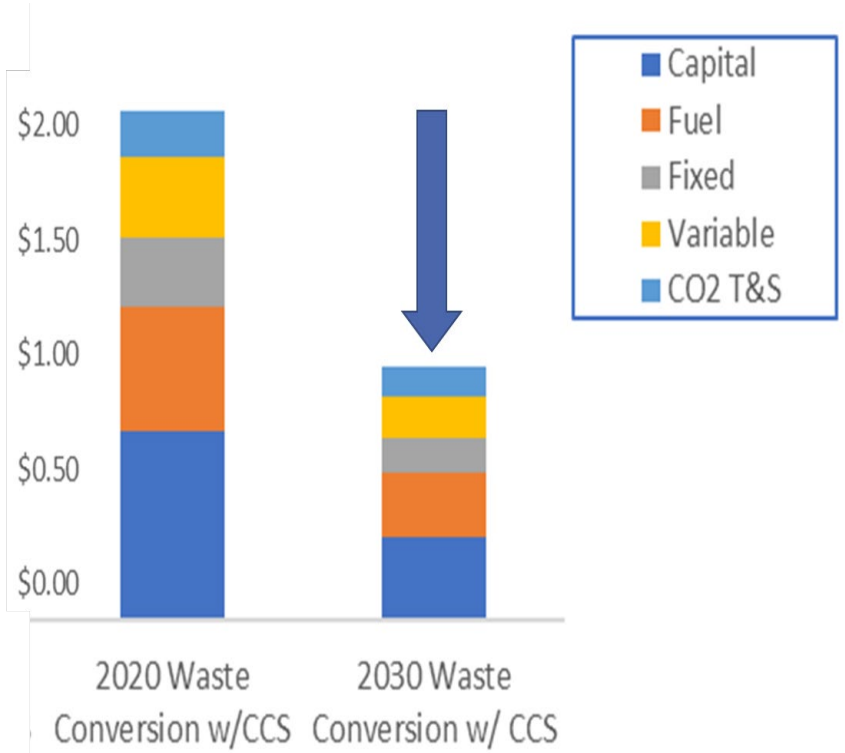
All pathways with potential for "1 1 1" being assessed

H_2 from Electrolysis



- Reduce electricity cost, improve efficiency and utilization
- Reduce capital cost >80%; operating & maintenance cost >90%

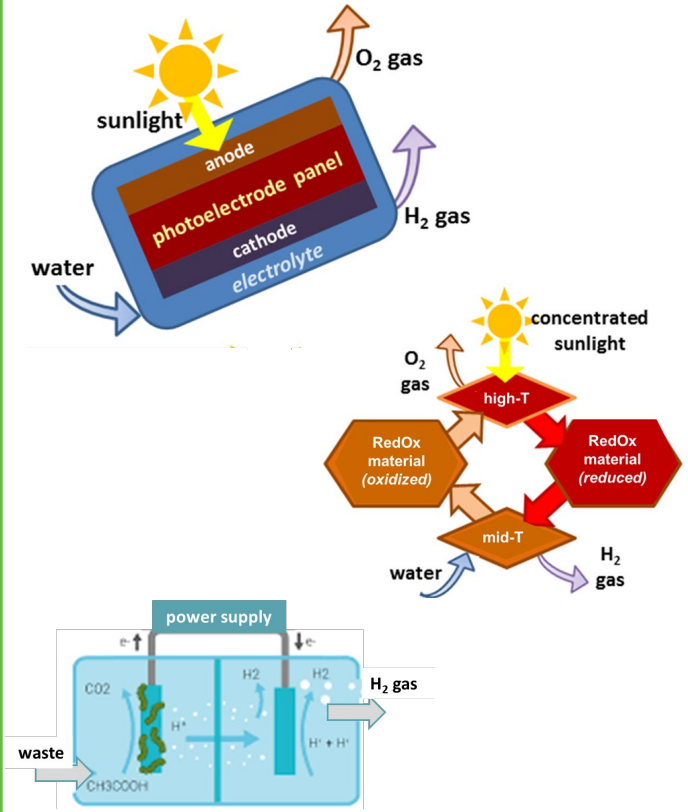
H_2 from Waste Conversion + CCS



* Waste coal, plastics, biomass residuals, municipal solid waste (MSW), and biogas

- Reforming, pyrolysis, air separation, catalysts, CCS, upstream emissions

Advanced Pathways

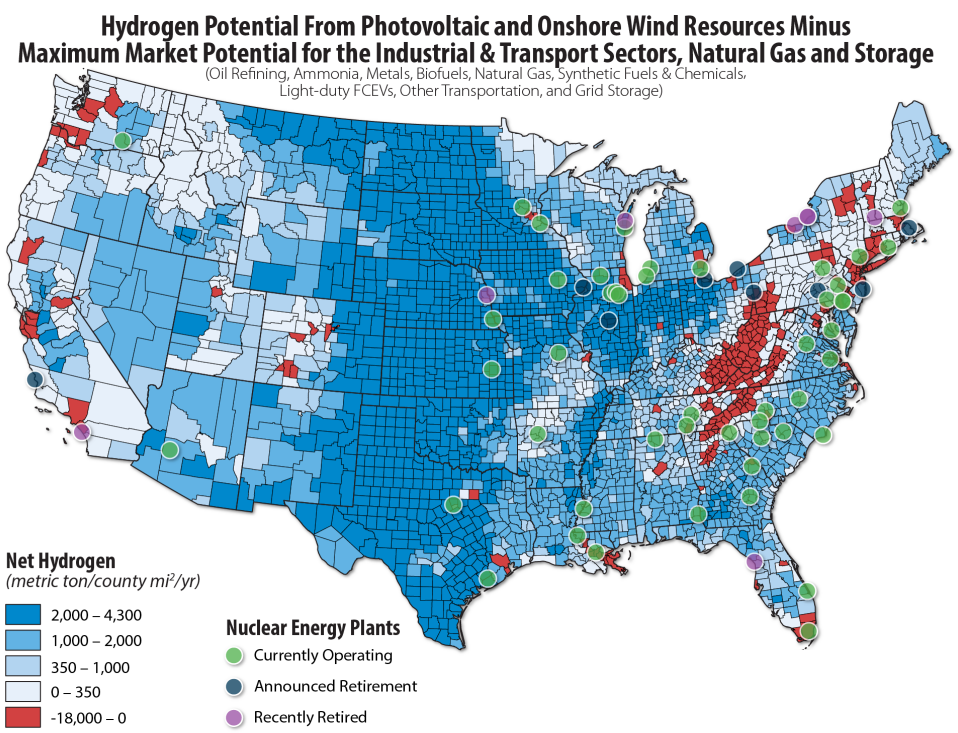


- Photelectrochemical (PEC), thermochemical, biological, etc.

*2020 Baseline: PEM (Polymer Electrolyte Membrane) low volume capital cost ~$1,500/kW, electricity at $50/MWh. Pathways to targets include capital cost < $300/kW by 2025, < $150/kW by 2030 (at scale). Assumes $50/MWh in 2020, $30/MWh in 2025, $20/MWh in 2030

Stakeholder Engagement and Request for Information (RFI)

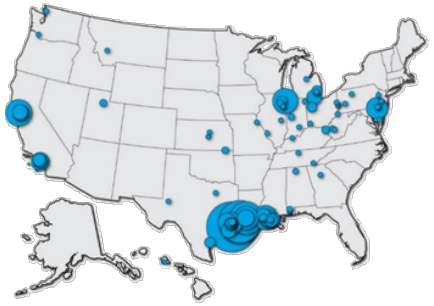
Renewables



Red: Regions where projected industrial & transportation demand exceeds local supply.

Regional and national analyses planned – stay tuned to Hydrogen Shot and www.hydrogen.energy.gov

Natural Gas (SMR)



CCS

DOE Request of Information covered key themes:

- Production, Resources, Infrastructure
- End Users, Cost, Value Proposition
- Co-location potential
- Emissions Reduction Potential
- DEI, Jobs, EJ
- Science & Innovation Needs and Challenges

DEI: Diversity, Equity and Inclusion
EJ: Environmental Justice

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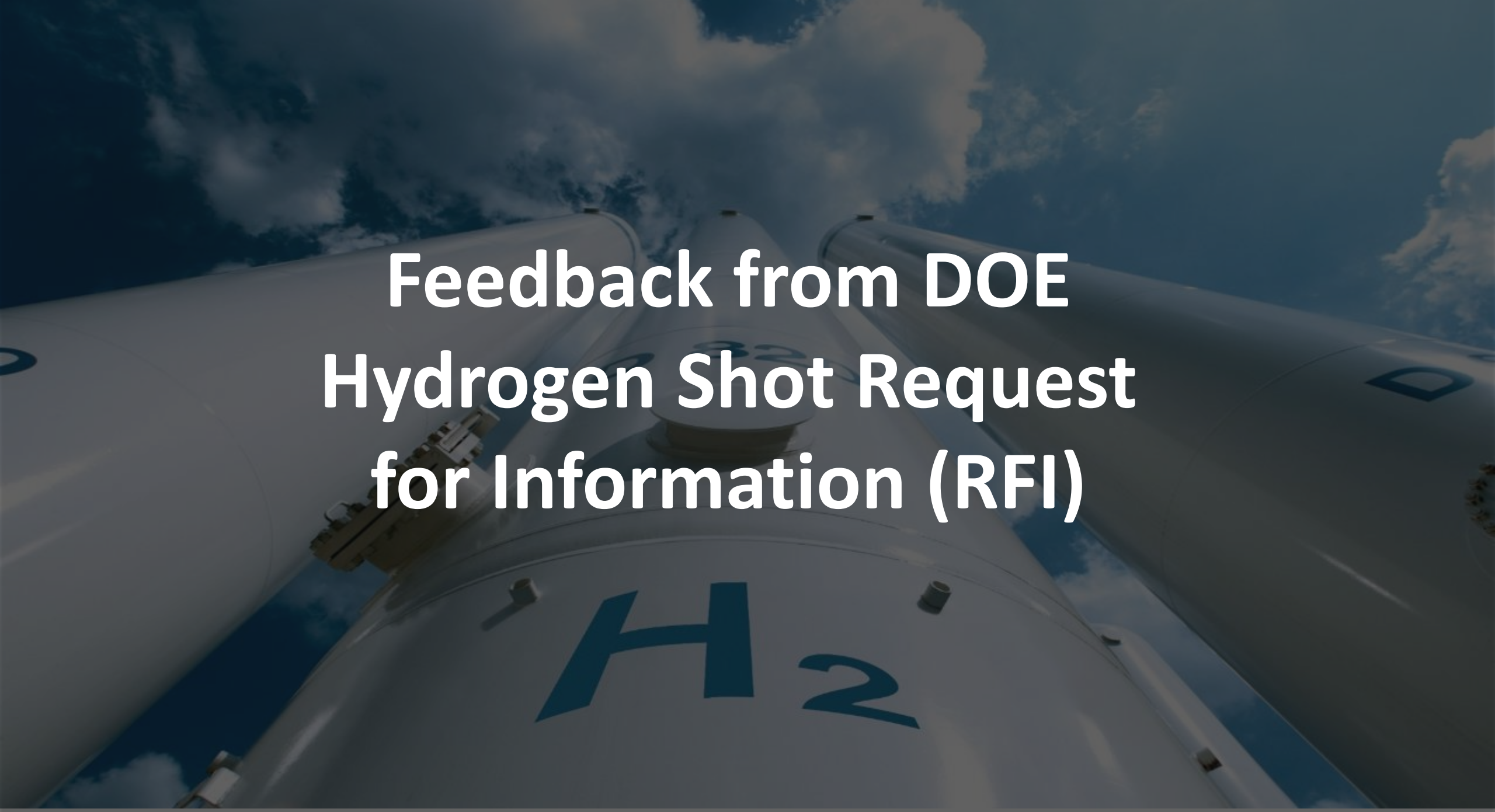
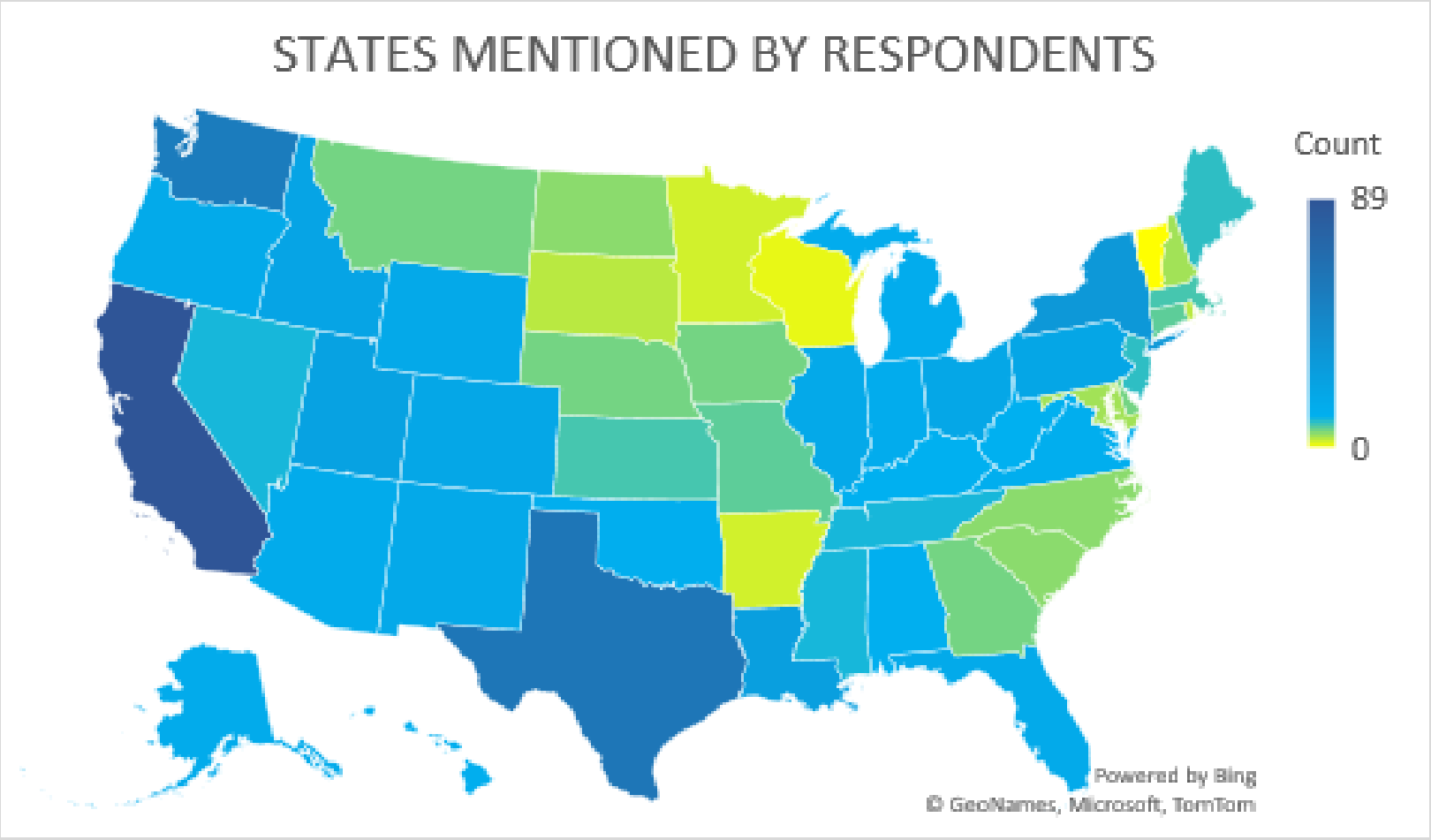


Feedback from DOE Hydrogen Shot Request for Information (RFI)

RFI: Snapshot of Responses

Includes regional, EJ, tribal, investor, and industry perspectives



Over 200 RFI responses described diverse resources, end-uses and impact potential in various regions

RFI Findings: Regional clusters and geographic factors

Pacific Northwest

- *Port communities*
- *Tribal communities*
- *Extensive renewables*
- *8 jobs per $1M invested in H2*

California

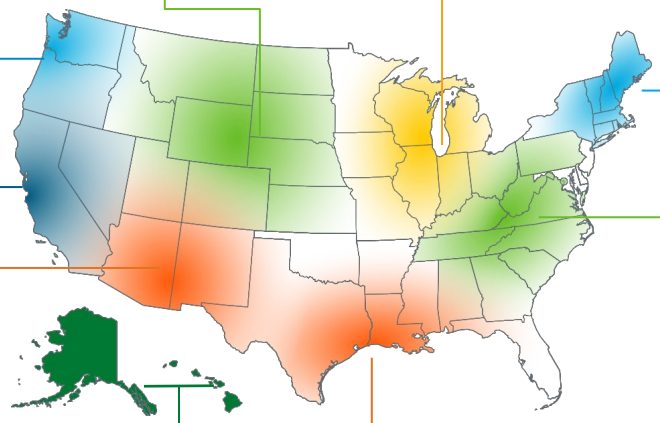
- *Diverse populations*
- *Extensive infrastructure*
- *Emissions regulations*
- *40,000+ jobs*

Southwest

- *Tribal and Hispanic communities*
- *Underutilized solar*
- *Nuclear power*
- *Up to 2B tonnes/yr emission reduction potential*

Central U.S.

- *Ample wind*
- *Geological storage*
- *Railway transport*
- *Nuclear resources*
- *>630,000 tonnes/yr CO2 reduction*



Alaska and Hawaii

- *Extensive renewables – geothermal, solar, ocean*
- *Backup power*
- *Isolated communities*
- *86,000 tonnes/yr emission reduction*

Great Lakes

- *Major national corridors* • *Nuclear power* • *60,000+ jobs*

New England

- *Offshore wind*
- *Fishing communities*
- *Backup power and winter heating*
- *~120K tons CO2/year reduction*

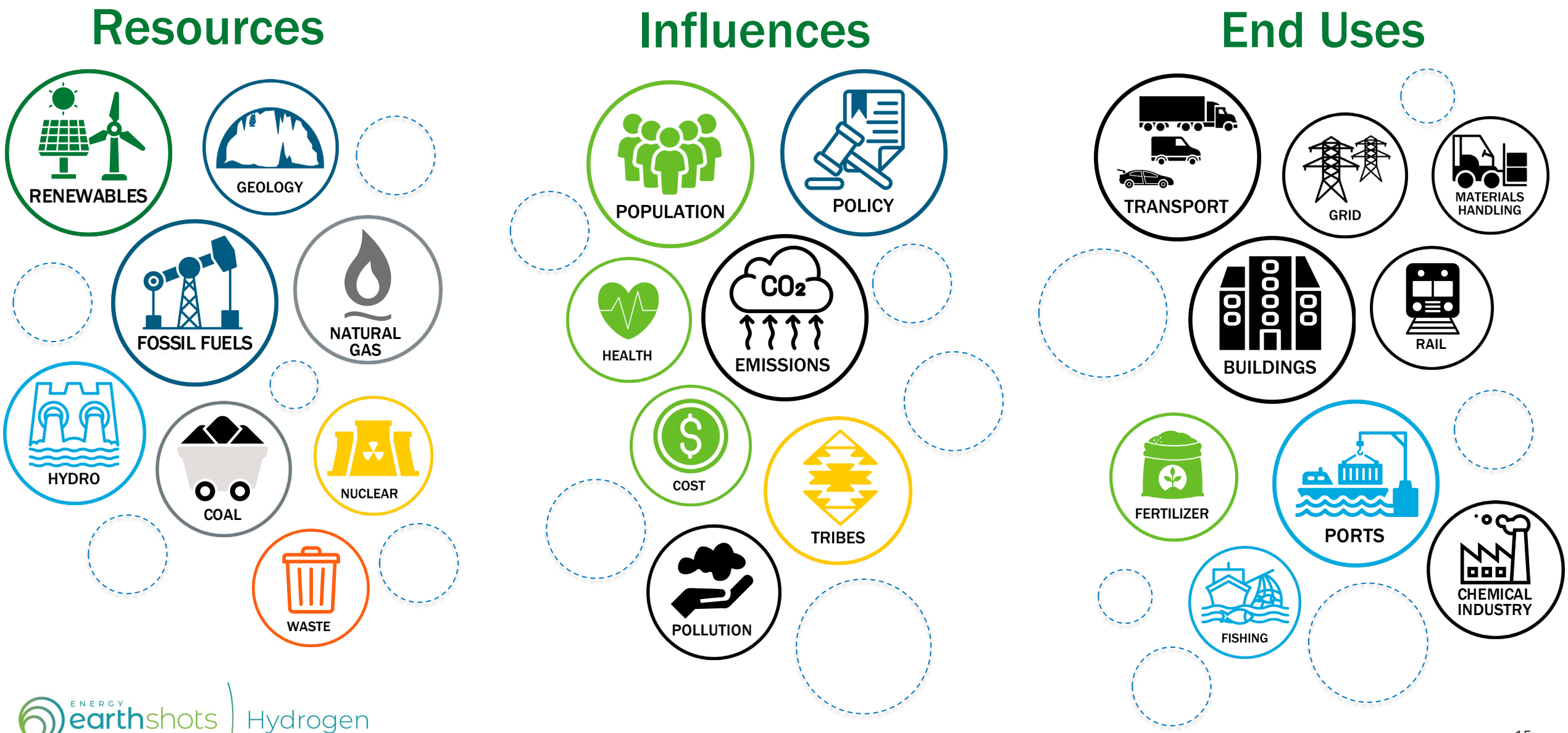
Appalachia

- *Retiring fossil plants*
- *Mining, refining transferable skills*
- *Carbon capture and sequestration*
- *70,000 tons/yr H2 production*

Gulf Coast

- *Existing infrastructure*
- *Multiple opportunity zones*
- *Renewable resources*
- *1,000s of jobs*
- *Chemical industry*

Distinct Considerations for Each Region



California Regional Cluster – RFI Regional Highlights

Most populous
Largest economy
3rd largest by area

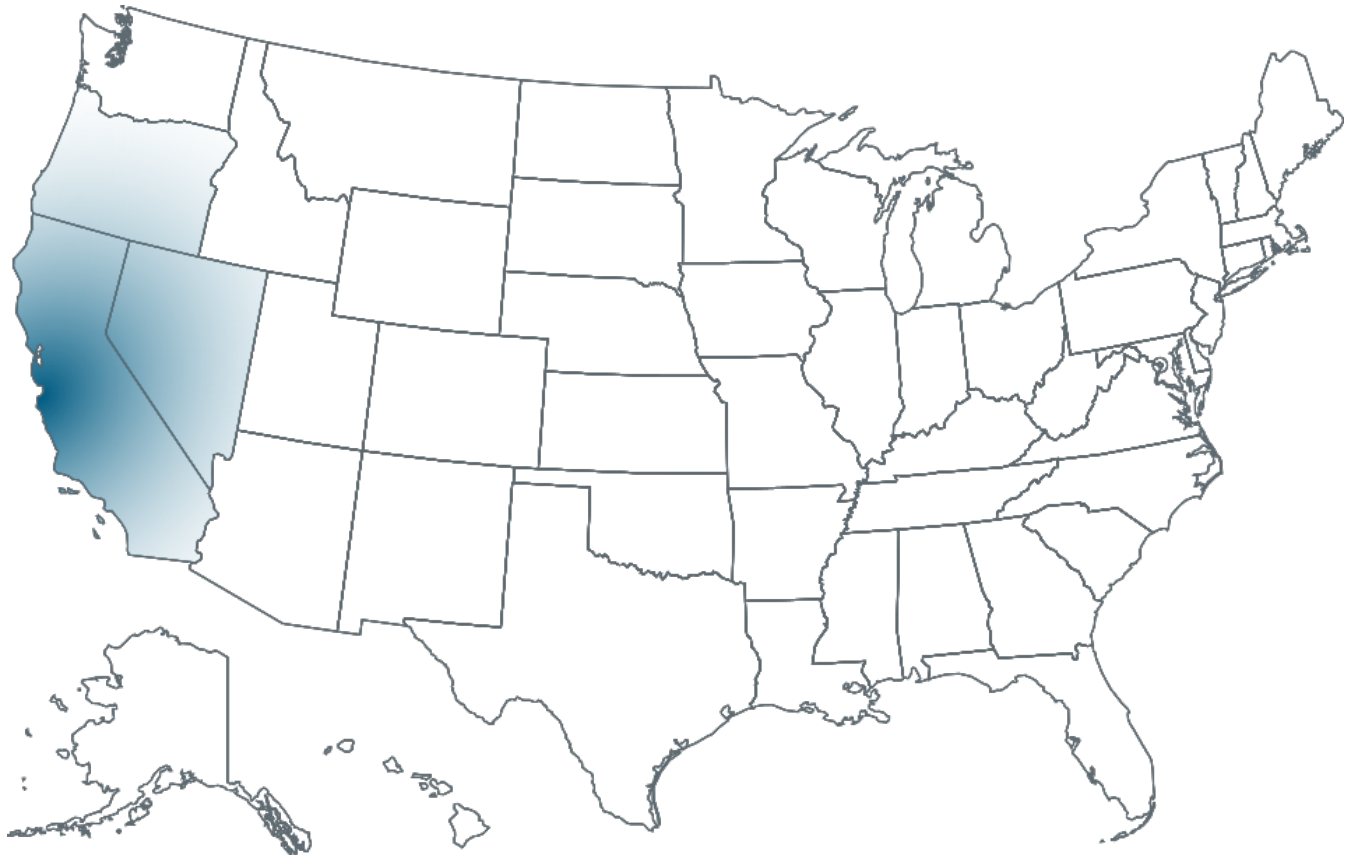
Largest share of state energy consumption

>340 million
miles

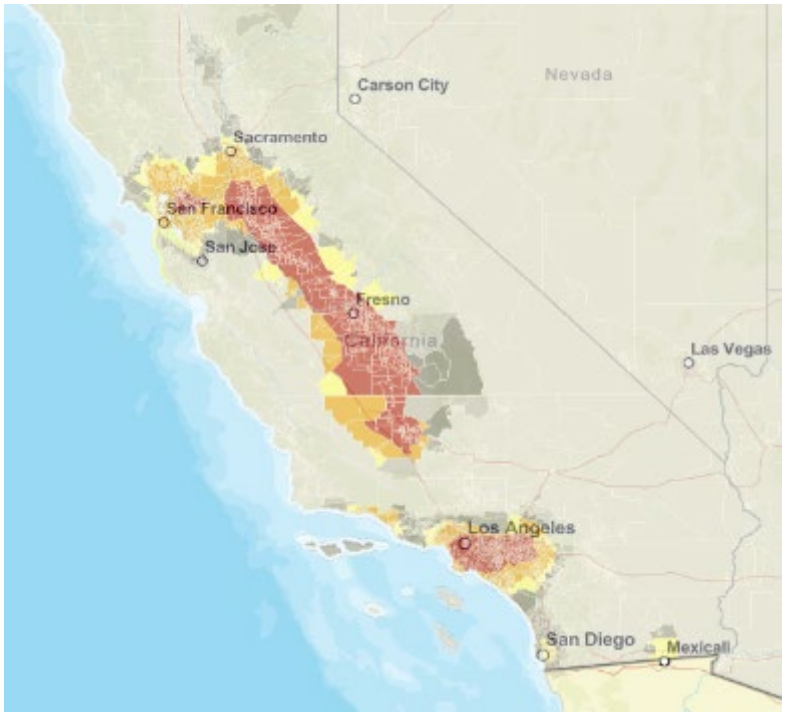
3,073 trillion
BTUs

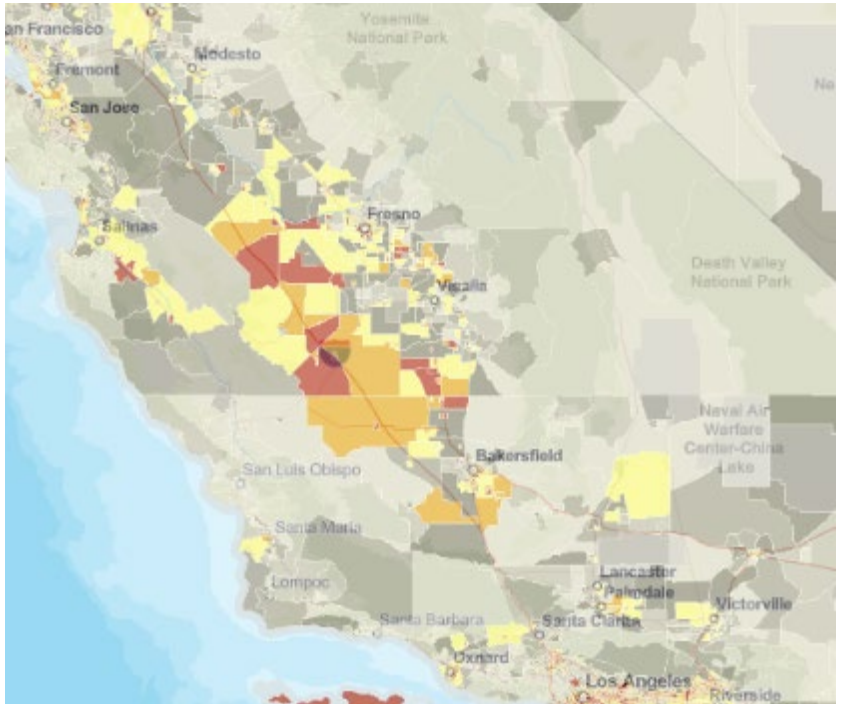
11%
of gasoline

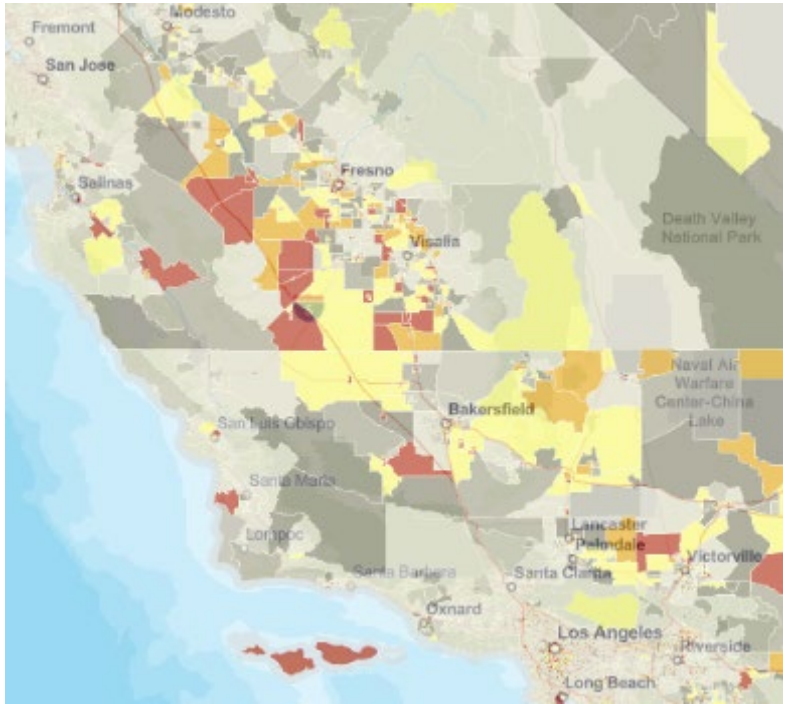
(EIA.gov)



California Regional Cluster – Regional Highlights







Air Quality
- 95-100 percentile
- 90-95 percentile
- 80-90 percentile

Percent People of Color
- 95-100 percentile
- 90-95 percentile
- 80-90 percentile

Percent Low Income
- 95-100 percentile
- 90-95 percentile
- 80-90 percentile

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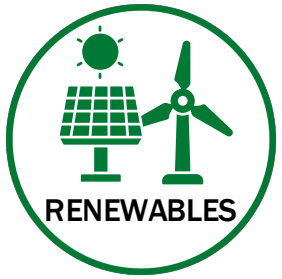
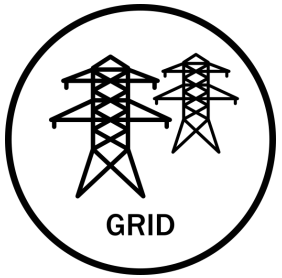
EPA Environmental Justice Screening and Mapping Tool https://ejscreen.epa.gov/mapper/

California Regional Cluster – RFI Regional Highlights



Wind
Solar
Geothermal



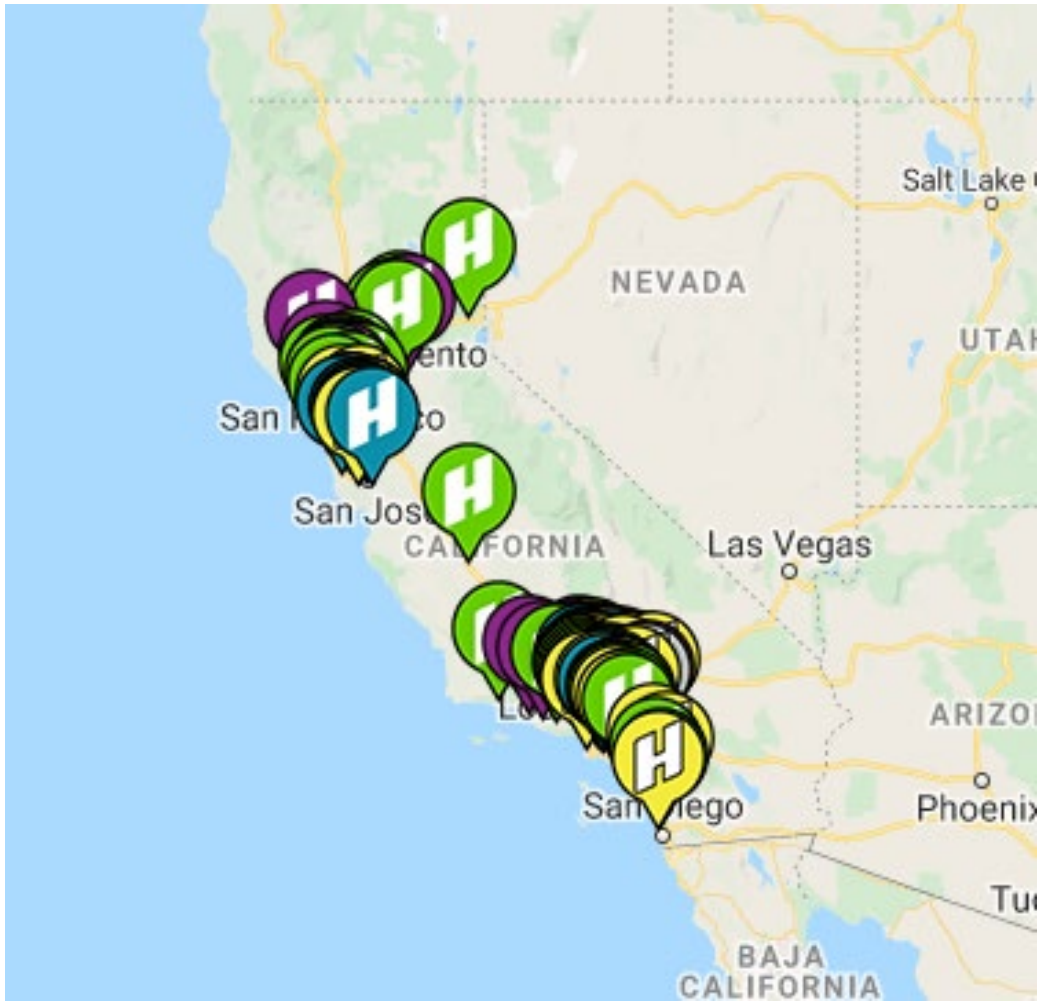
Opportunities for regional grids

Emissions-free by 2045

48

hydrogen fueling stations available

Source: California Fuel Cell Partnership



Source: California Fuel Cell Partnership. https://cafcp.org/stationmap

California Regional Cluster – RFI Response Highlights

WASTE

Waste to clean hydrogen

NATURAL GAS

4 stations under consideration for repowering

GEOLOGY

Cavern storage in UT and NV

TRANSPORT

Multiple end users for transportation

TRIBES

Collaboration with tribal nations in the Southwest

California Regional Cluster – RFI Response Highlights

Regional resources for production and infrastructure

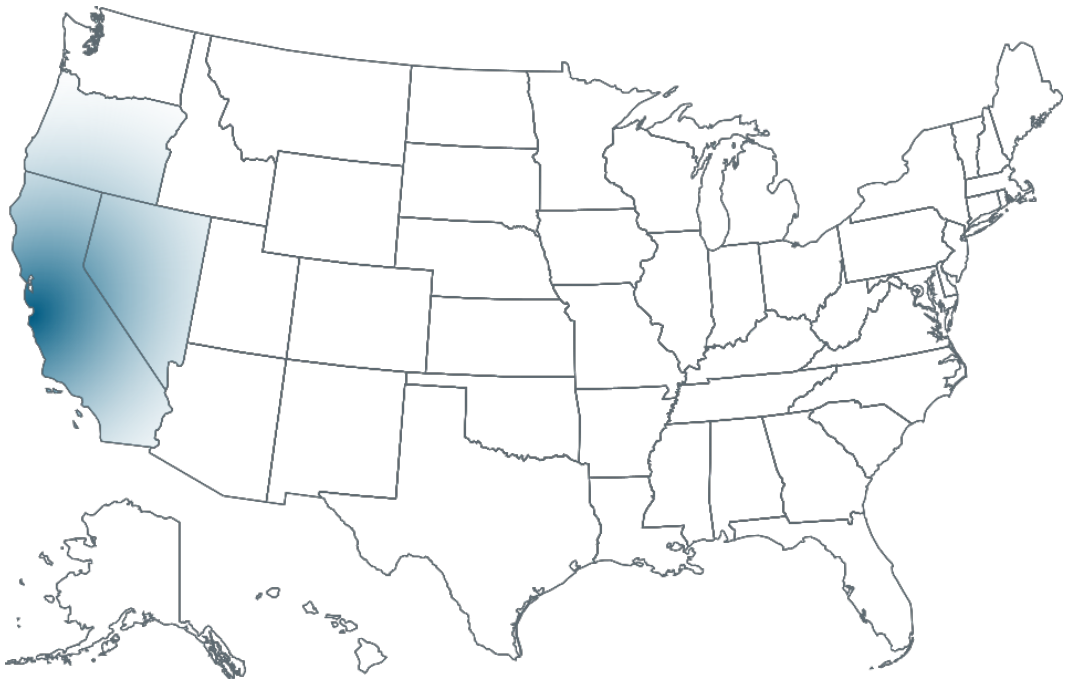
- >15 miles of dedicated H2 pipeline in LA Basin
- >200 MT/day of gray H2 in Los Angeles
- ~19.2 MT/year of clean H2 via electrolyzers from curtailed renewable energy
- 5 power stations to use H2: Scattergood (~800 MW), Haynes (~1580 MW), Valley (~600 MW), Harbor (~450 MW) and Intermountain Power Plant (840 MW)
- Potential natural reservoirs: Pleasant Creek Storage field (2.3 BCF) and Los Medanos Storage field (17.9 BCF)

Emissions Reduction Potential

- ~0.2 MMT CO2eq/year – 1.3 MMT CO2eq/year for each project

End Users, Cost, Value Proposition

- Proposed unit cost of clean H2 from electrolysis in LA basin at $1.50/kg
- CAPEX per project $48-$86M and OPEX of $20-$63M/year, depending on location
- Blending H2 with natural gas, LDVs, HDVs, stationary power, aviation, ports, forklifts, industrial (steel) applications



DEI, Jobs, EJ

- Demonstration projects, and unpaid training programs
- Improve air quality in Port of LA
- ≥ 41,000 peak construction and more than 2,500 ongoing operations skilled clean energy jobs
- Diverse racial representation in Richmond and Port Arthur

Co-location Potential

- Co-locating hydrogen refueling stations to support MD/HDVs

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Pacific Northwest Regional Cluster – RFI Regional Highlights

PORTS

Large container ports and ferry systems

RENEWABLES

Hydropower and wind resources

HYDRO

Electrolyzer installations at dams

30%

US CO2 emissions from coastal vessels

3%

Global CO2 emissions from ocean vessels

POLICY

Support for hydrogen in the long term

TRIBES

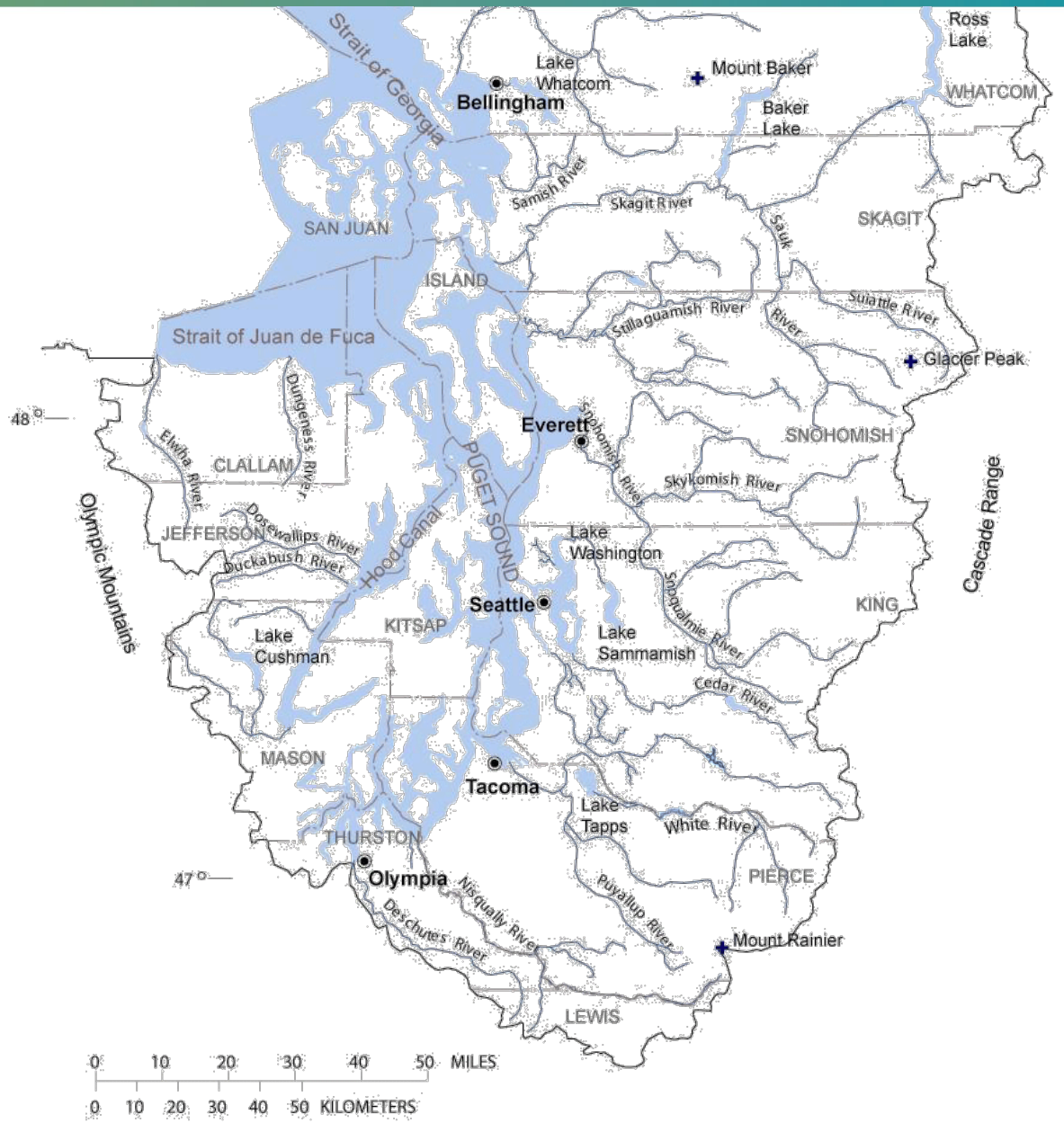
29 recognized tribes in WA and 9 in OR

Pacific Northwest Regional Cluster – RFI Regional Highlights

Diesel exhaust pollution in Puget Sound and Duwamish Valley

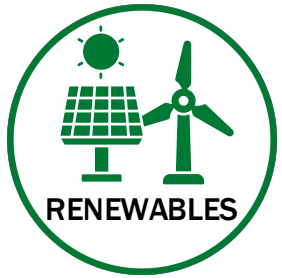
Negative health outcomes and decreased life expectancy

Lands of the Puyallup Tribe of Indians



Pacific Northwest Regional Cluster – Regional Highlights

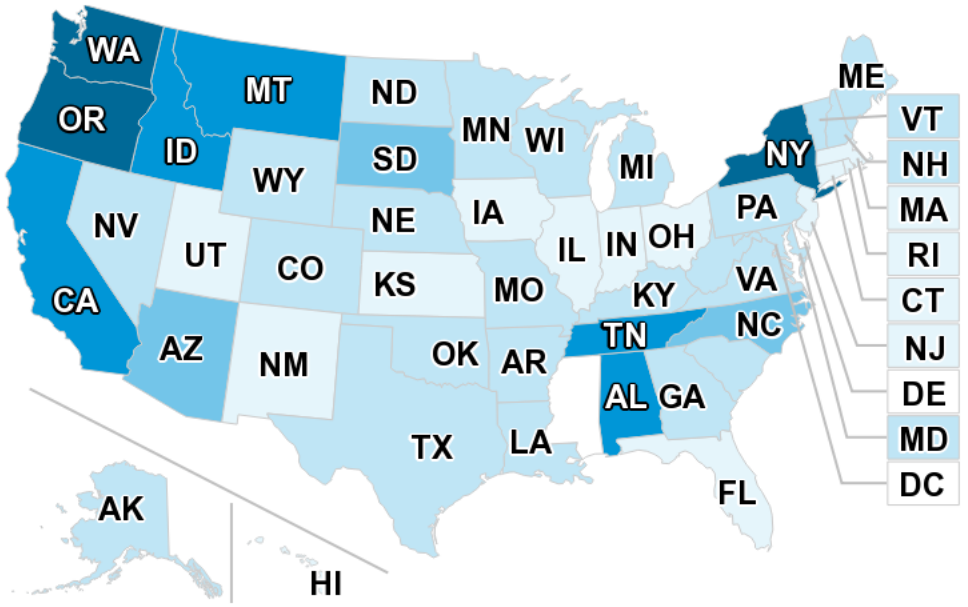
Generate most hydroelectricity in the country



Other renewables include solar and wind

Nuclear power also available in the region

Hydroelectricity generation by state in 2020



billion kilowatthours

= 0 | 1 - 1,000 | 1,000 - 5,000 | 5,000 - 10,000 | 10,000 - 30,000 | > 30,000

Note: Includes utility-scale conventional hydropower.
Source: U.S. Energy Information Administration, *Electric Power Monthly*, Table 1.10.B, February 2021, preliminary data

eia

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Pacific Northwest Regional Cluster – RFI Regional Highlights

HYDRO

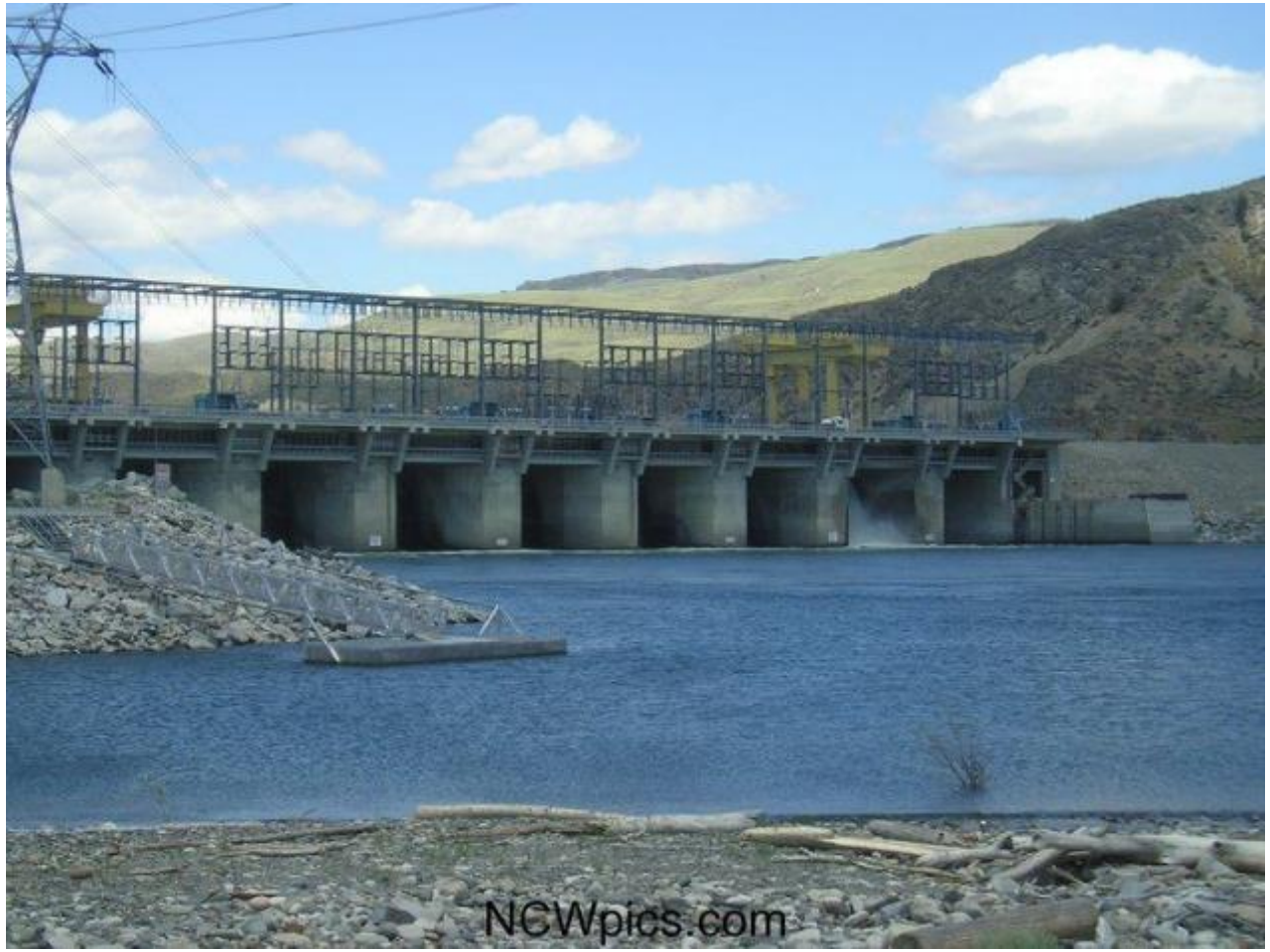
Electrolyzer installation at dam site

POLICY

First tariffs for electrofuels and flexibility in electrolytic loads in WA

POLICY

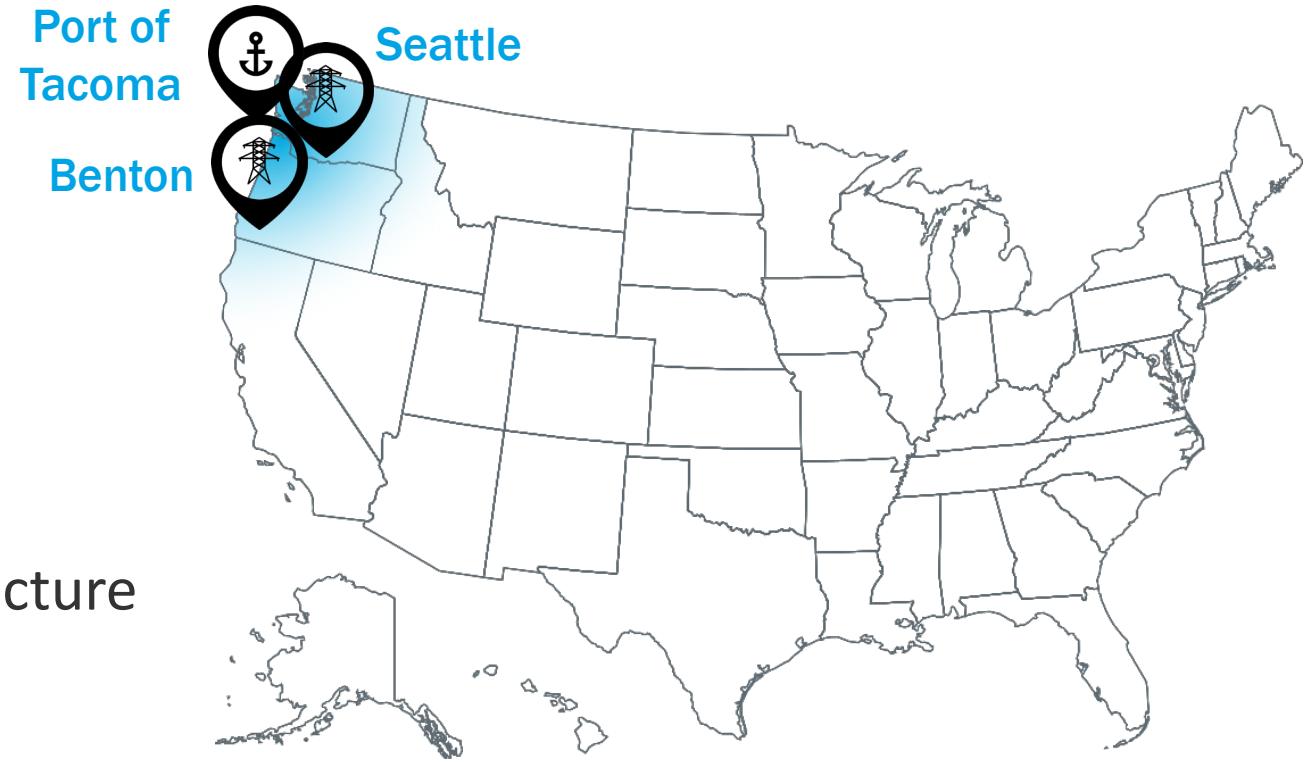
Senate Bill 333 for study of potential use of hydrogen in OR



Pacific Northwest Regional Cluster – RFI Response Highlights

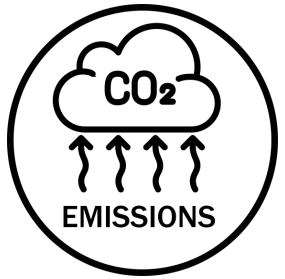
18
TWh/year excess renewable power

558
million kg H2 production/year



1-5 years
Ferries, tugs, harbor craft
Shoreside storage/infrastructure
Cargo handling

3-8 years
Zero emission fishing fleet
Ocean going vessels
Port infrastructure



Emissions reductions in impacted areas

Reductions in particulate matter

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Pacific Northwest Regional Cluster – RFI Response Highlights

Regional resources for production and infrastructure

- Ample hydropower, nuclear, and wind
- 558M kg H2/year from excess renewable power
- Sites: Port of Tacoma, Richland, Boardman, Centralia
- Production of 20 – 400 tons/day, 3-4 H2 fueling stations funded and planned in WA in the next year
- High-capacity electrical infrastructure - up to 100 MW electrolyzer complexes

End Users, Cost, Value Proposition

- Estimated $3.50-$18/kg production cost
- CAPEX/project between $12.5-100M and OPEX ~$200K
- Portable and back-up power, data centers, oil refining and port cargo handling, chemicals, FCEVs

Emissions Reduction Potential

- 35% emissions reduction and up to 75% reduction when CCS is used
- 15,000 - 92,000 tons of CO2 reduction potential per year

DEI, Jobs, EJ

- Fugitive gas and CCS can transition current oil and gas jobs
- Projects on land owned by local tribe
- Projects in areas with 30%-65% non-white population

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Central US Regional Cluster – RFI Regional Highlights

POPULATION

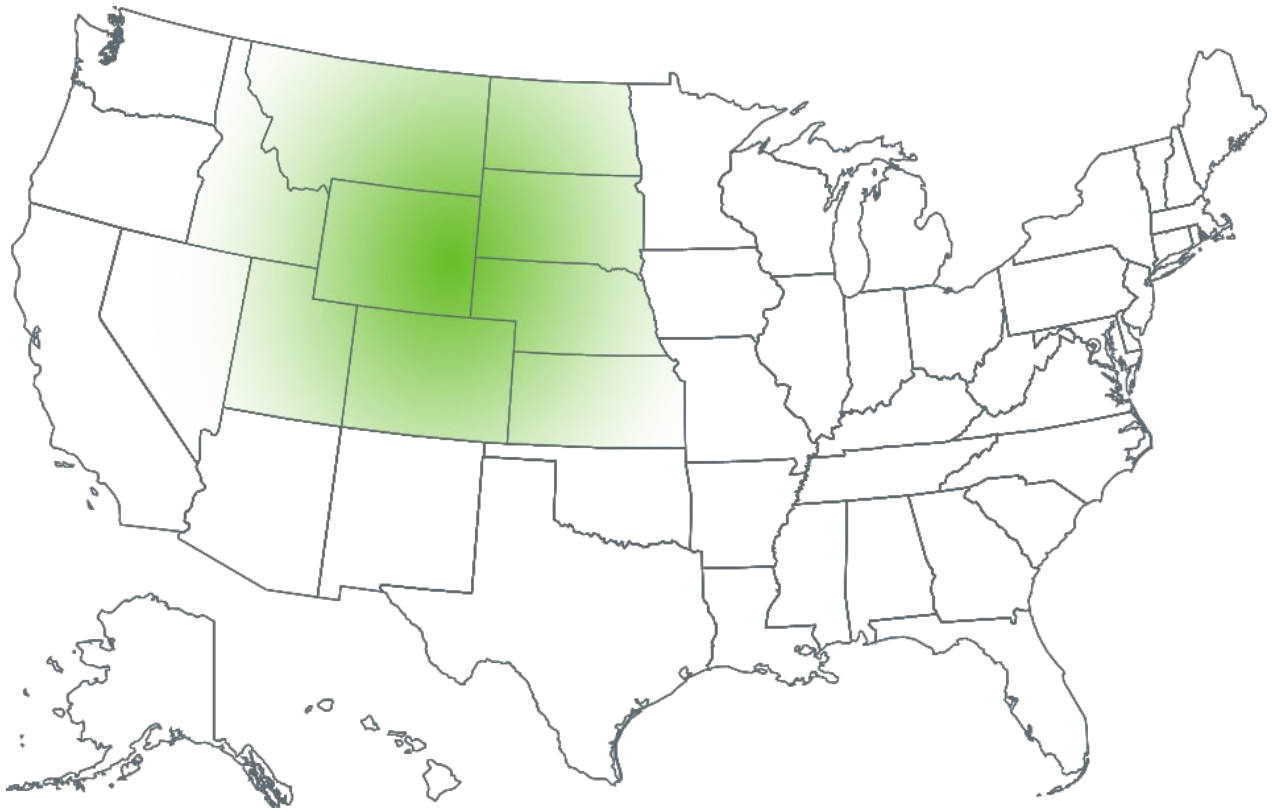
Part of EIA Western coal region

Alaska	Montana	Utah
Arizona	New Mexico	Washington
Colorado	North Dakota	Wyoming

~55%

U.S. coal production

(EIA.gov)



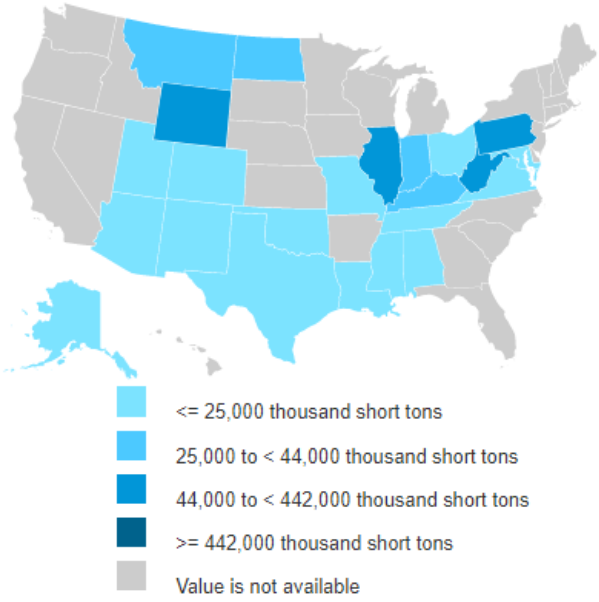
Central Regional Cluster – Regional Highlights

Highest coal-producing state of WY

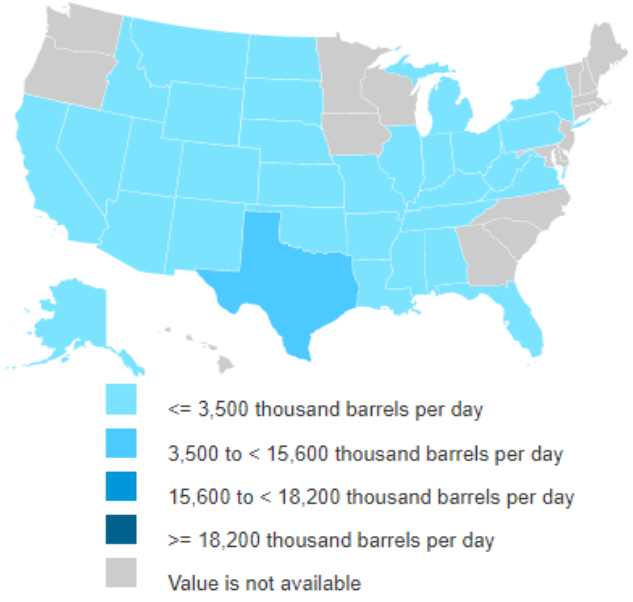
High natural gas and crude oil

Production fields on tribal lands

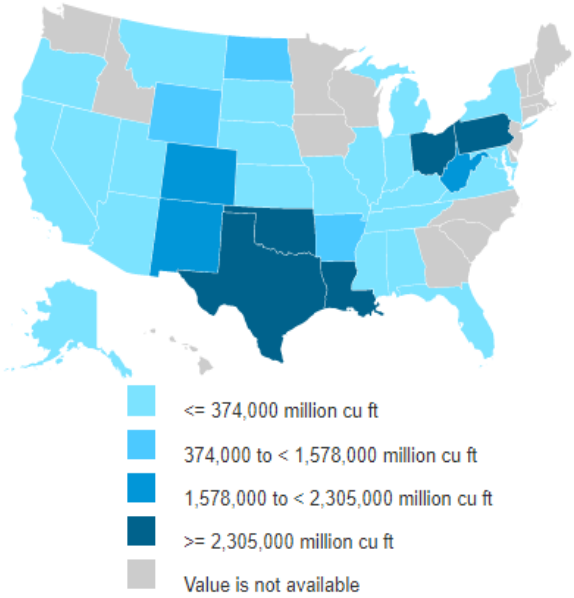
Coal Production, 2019



Crude Oil Production, June 2021



Natural Gas Marketed Production, 2019



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Map Source: EIA

Central Regional Cluster – Regional Highlights

TRIBES

Wind River Reservation

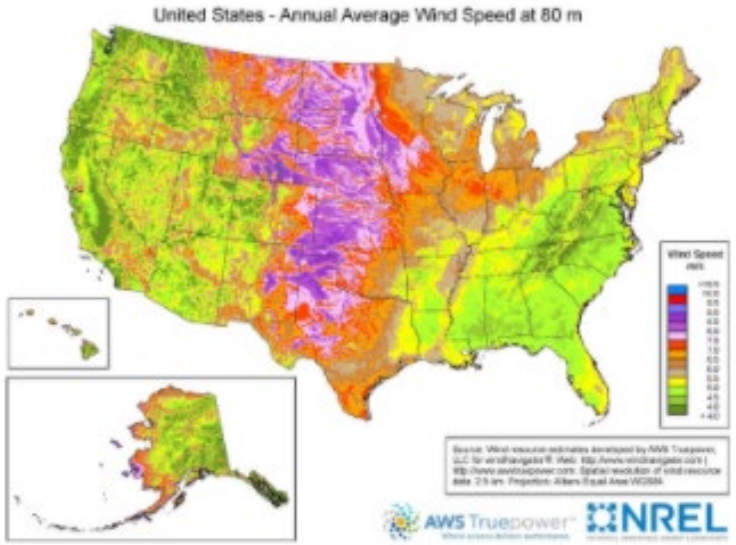
RENEWABLES

Potential for increased wind energy

POPULATION

Transition to renewables to create jobs

Average Wind Speed

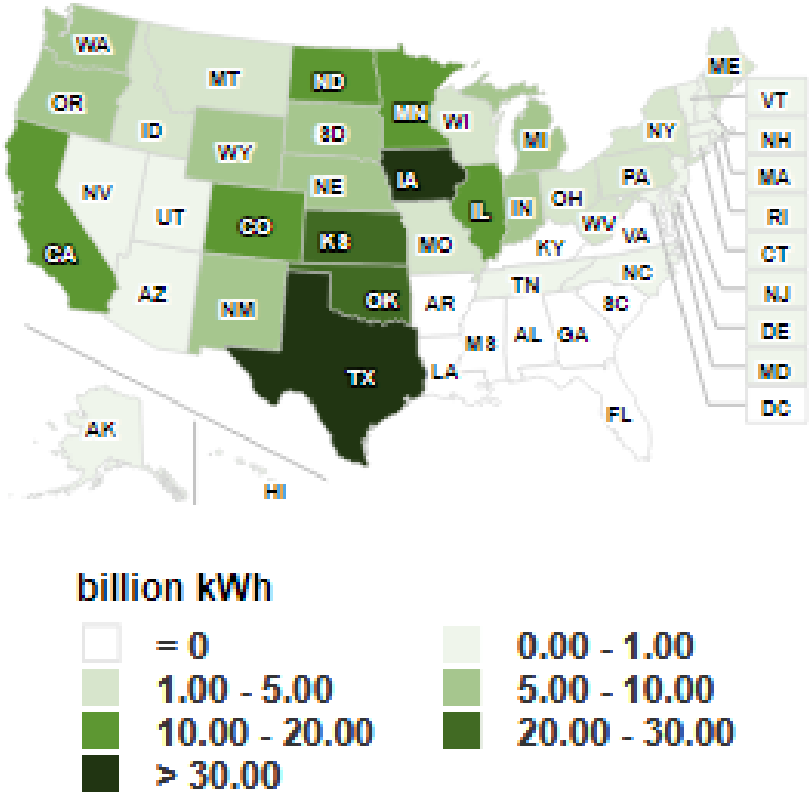


Map of U.S. wind resources

Source: National Renewable Energy Laboratory, U.S. Department of Energy (public domain)

Utility-scale Wind Electricity

U.S. utility-scale wind electricity generation by state, 2020



Source: U.S. Energy Information Administration, *Electric Power Monthly*, Table 1.14.B, February 2021, preliminary data

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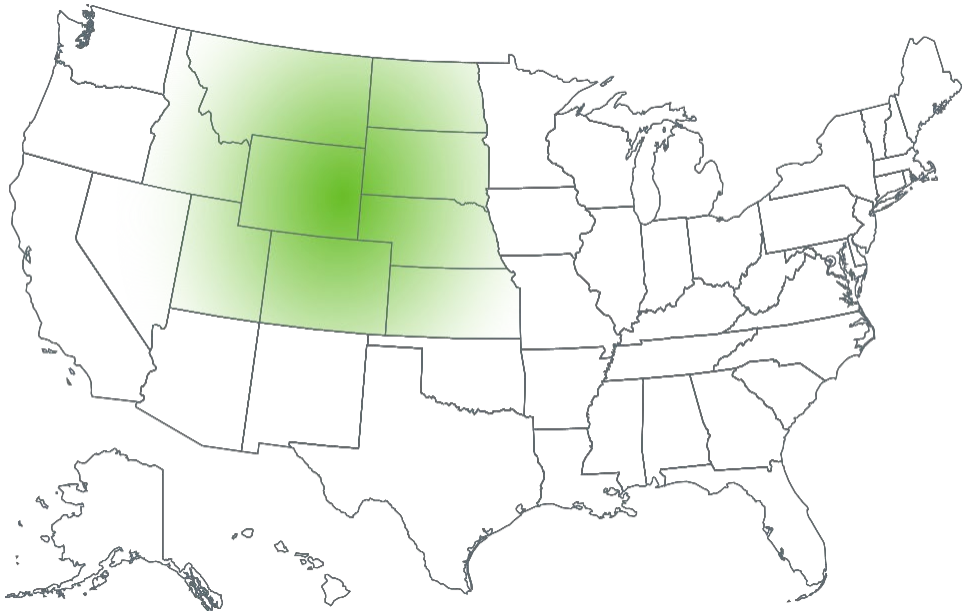
Central Regional Cluster – RFI Response Highlights

RENEWABLES

Ample wind and moderate solar



NATURAL GAS

Natural gas resources and infrastructure

COAL

Coal resources with CCS

RAIL

Extensive railway infrastructure

FERTILIZER

Low-carbon ammonia ammonium nitrate

GEOLOGY

Saline formations, caverns and depleted oil fields

NUCLEAR

Uranium ore for nuclear power

Central Regional Cluster – RFI Response Highlights

Regional resources for production and infrastructure

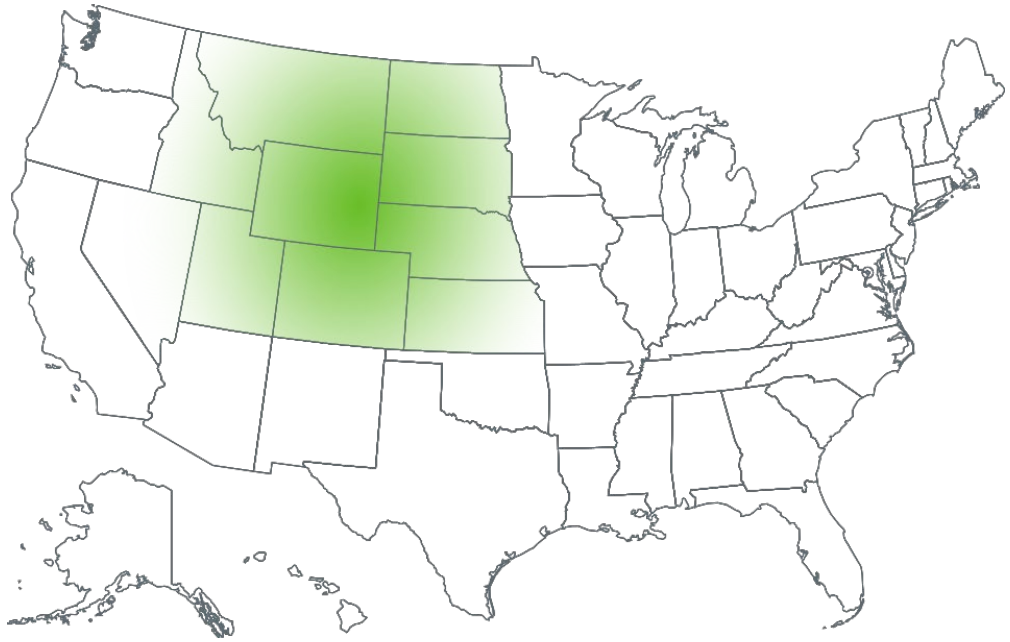
- Ample wind and moderate solar for H_2 production
- Coal resources; uranium ore and plans for nuclear H_2 projects; NH_3 production
- CNG infrastructure in WY and UT can support transition to H_2
- Numerous saline formations, salt caverns, and depleted oil fields for potential storage

Emissions Reduction Potential

- Emissions reduction dependent on effective CCS implementation

End Users, Cost, Value Proposition

- Low-carbon ammonia and ammonium nitrate for and fertilizer markets
- H_2 for hydrotreating for low-sulfur road fuels
- Conversion of over-the-road motor coaches to FCEV
- Montana, North Dakota, and other refineries using SMR could transition to renewable H_2



DEI, Jobs, EJ

- Economically distressed Northern Rocky Mountain and Yellowstone communities; crude oil and NG-producing Wind River Basin Reservation in need of transition
- Projects to create thousands of jobs in construction, installation, and operation

Co-location Potential

- Carbon sequestration sites and rail access points
- Nuclear plant in ID, new nuclear plants at retired coal locations
- Hydropower plants e.g., Missouri River

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Southwest Regional Cluster – Regional Highlights

POPULATION

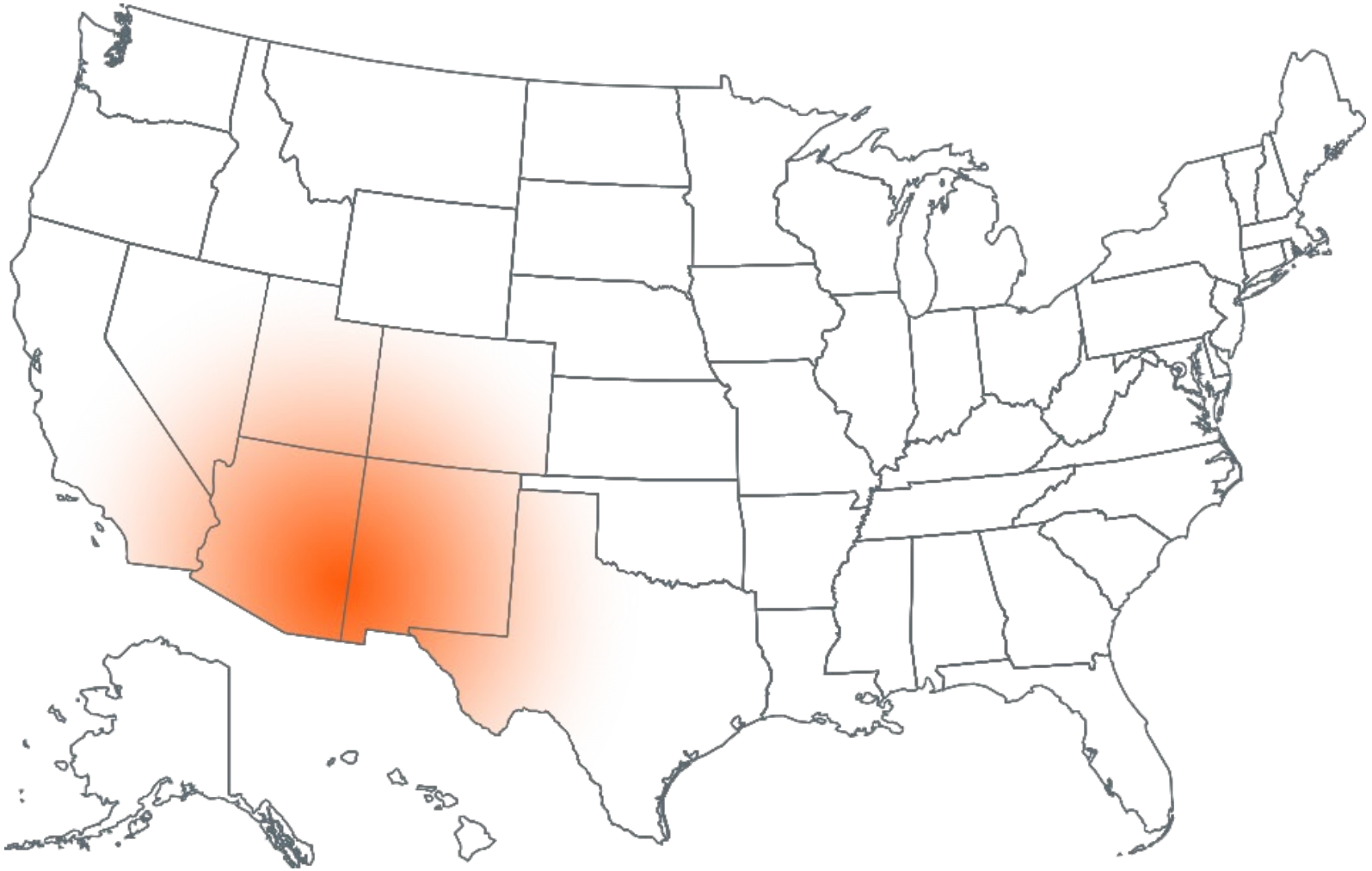
Part of the Western coal region

FOSSIL FUELS

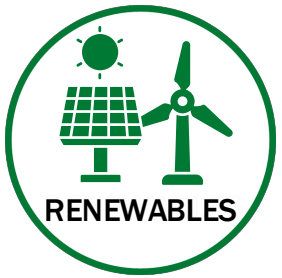
High natural gas and crude oil

TRIBES

Many tribal communities in the region



Southwest Regional Cluster – RFI and Regional Highlights

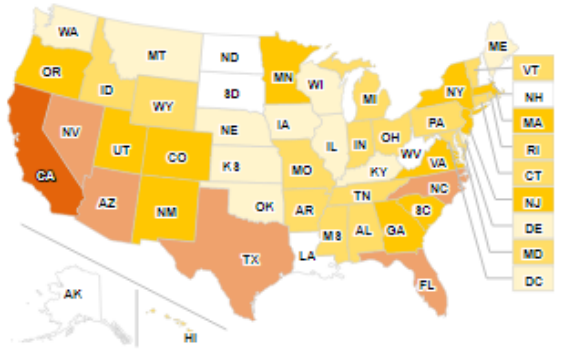


Major existing solar production

Existing hydrogen from fugitive methane

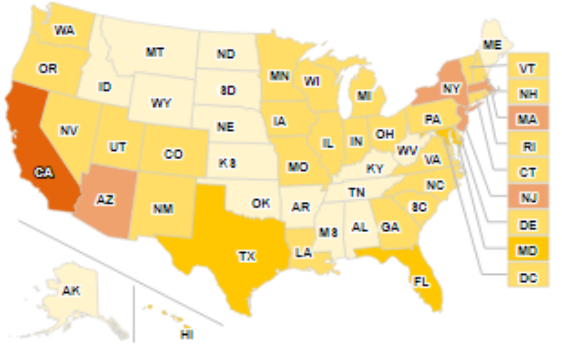
Job opportunities for tribal and Hispanic communities

Utility-scale Solar Electricity Generation

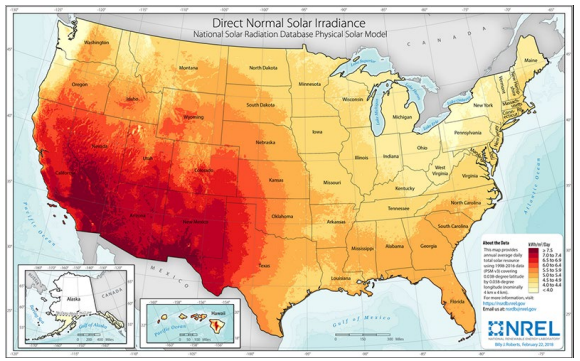


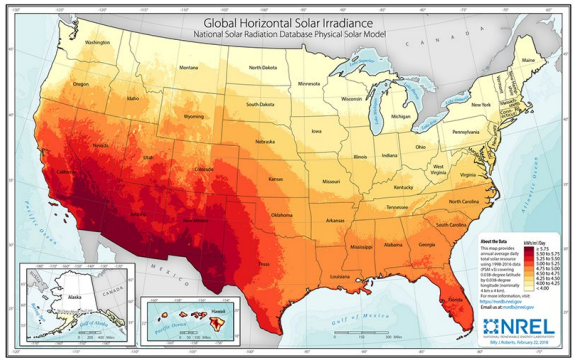
eia Source: U.S. Energy Information Administration, *Electric Power Monthly*, February 2021, preliminary data

Small-scale Solar Electricity Generation



eia Source: U.S. Energy Information Administration, *Electric Power Monthly*, February 2021, preliminary data





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Southwest Regional Cluster – RFI Response Highlights

RENEWABLES

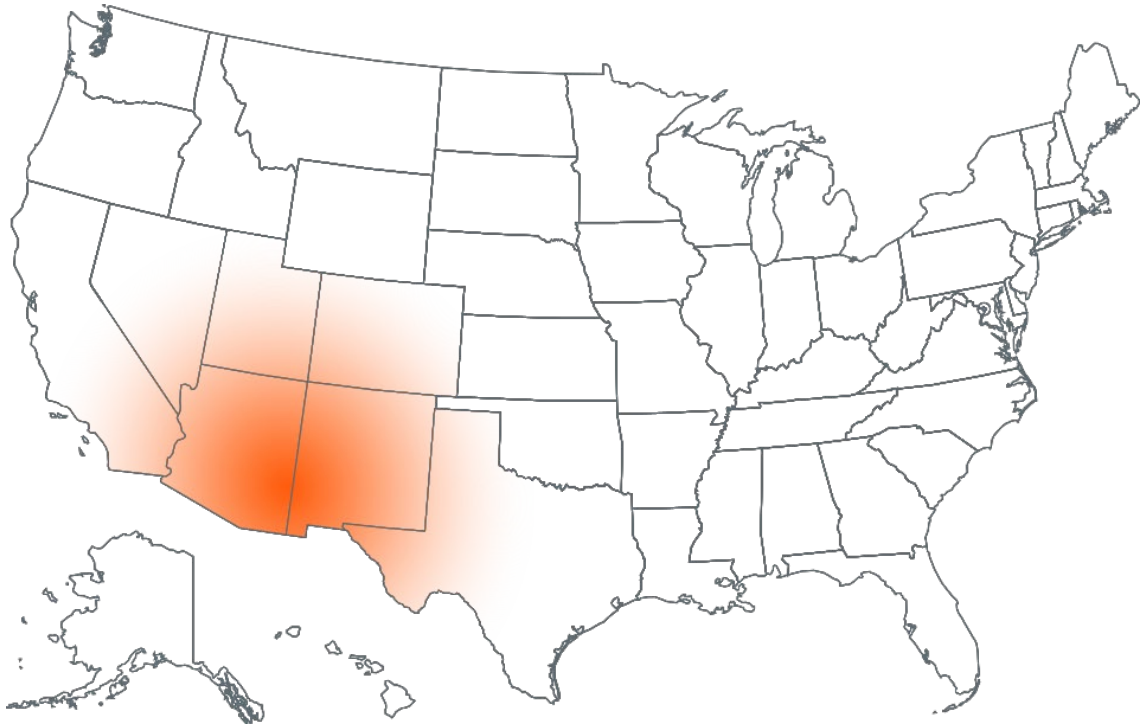
Underutilized solar and wind

NATURAL GAS

Renewable natural gas from waste, and fugitive gas

NATURAL GAS

Hydrogen blending with natural gas



TRANSPORT

Expanding refueling structure to CA

GRID

Primary or backup power at remote posts

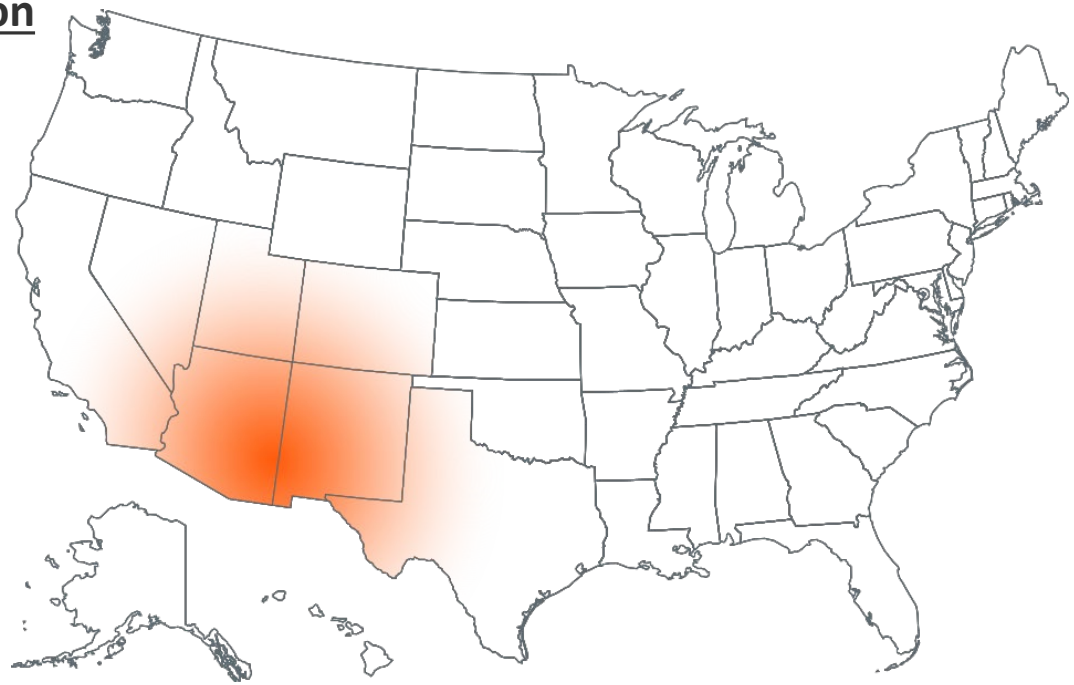
Southwest Regional Cluster - RFI Response Highlights

Regional resources for production and infrastructure

- Nuclear or underutilized solar/wind power to produce H_2, salt deposits and abandoned potash mines for storage
- Renewable NG from farming and landfills, fugitive gas from shale oil
- Interstate natural gas pipelines as candidates for blending
- Growing H_2 fueling infrastructure along heavy freight routes to/from California

End Users, Cost, Value Proposition

- H_2 for renewable export to California
- Fuel cell electric buses in Las Vegas region and heavy-duty freight vehicles
- H_2 turbine power generation to supply power to grid
- Primary or backup power at remote posts, e.g., US Border Patrol



Emissions Reduction Potential

- Fugitive gas to H_2 with CCS over current diesel and gasoline nearly 2B tonnes/year decrease in emissions possible

DEI, Jobs, EJ

- Diverse tribal and Hispanic communities
- Fugitive gas and CCS can transition current oil and gas jobs

Co-location Potential

- Enhanced oil refining, nuclear plants, and connections to current NG pipelines
- Plans for cooperative H_2 production, fueling stations, and heavy-duty vehicle manufacture

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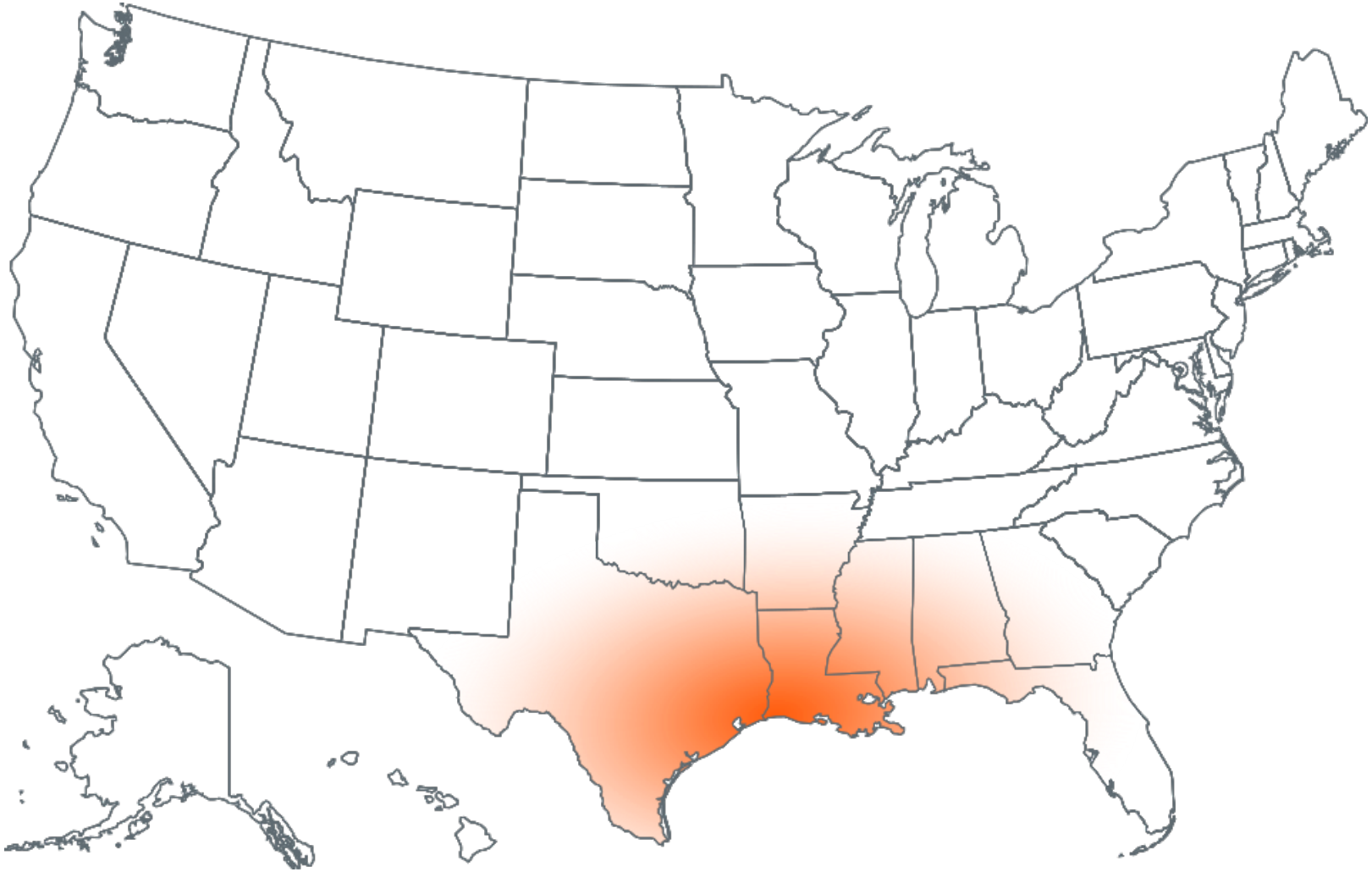
Gulf Coast Regional Cluster – Regional and RFI Highlights

POPULATION

Region includes portions of Mississippi, Alabama, Texas, Louisiana, and Florida

POPULATION

Multiple disadvantaged cities



Gulf Coast Regional Cluster – Regional and RFI Highlights

FOSSIL FUELS

High natural gas and petroleum refining

47%

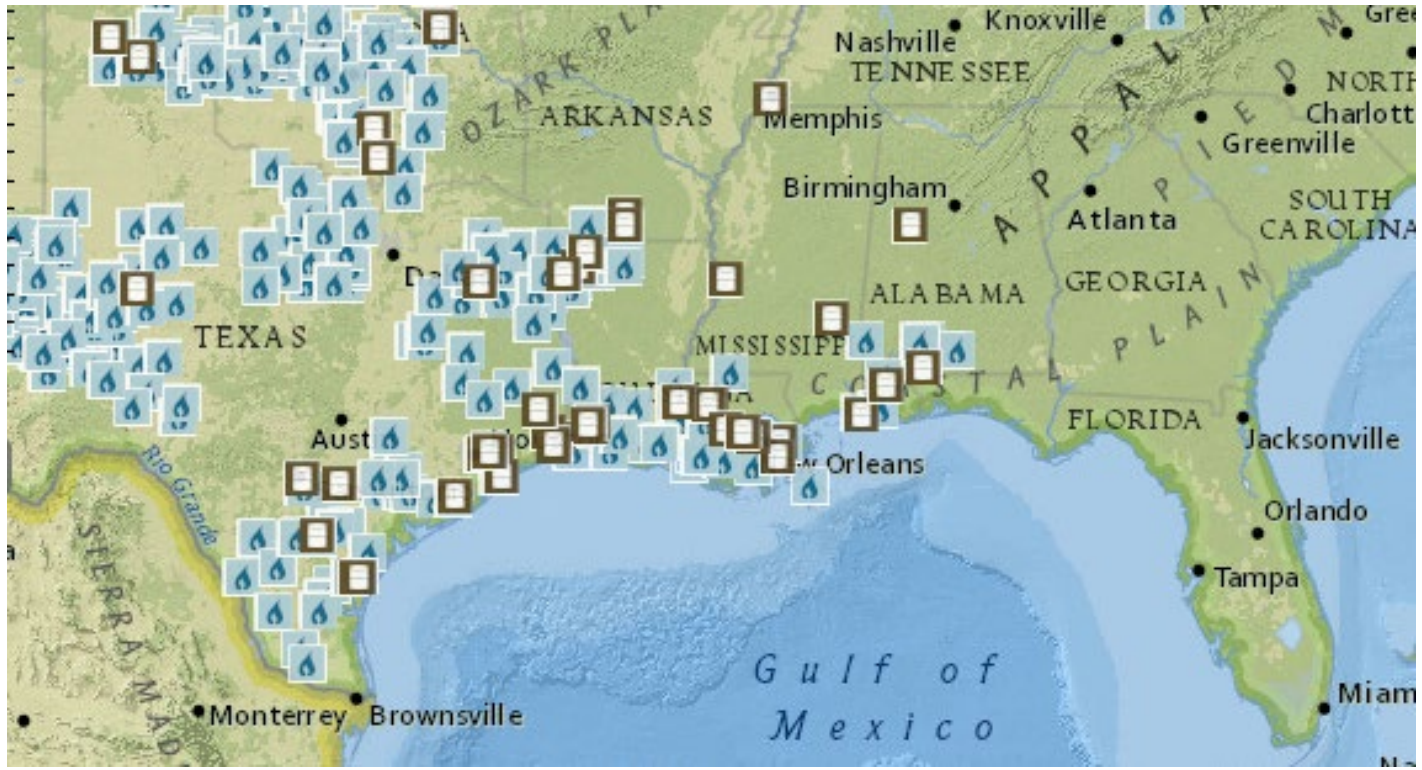
U.S. petroleum refining capacity

51%

U.S. natural gas processing capacity

(EIA.gov)

Natural Gas Processing Plant **Petroleum Refinery**



Oil/Gas Refining and Processing in the Gulf Region (EIA.gov)

Gulf Coast Regional Cluster – Regional and RFI Highlights

90%
total U.S. hydrogen pipeline

>1,400
miles of hydrogen pipeline

(Texas Railroad Commission and Pipeline and Hazardous Materials Safety Administration, 2020)

>20
hydrogen plants

1 billion scf
2,408 tonnes
of hydrogen daily

(Gas Processing News)

Existing Gulf Coast Hydrogen Pipelines
(Texas Railroad Commission and Pipeline and Hazardous Materials Safety Administration, 2020)

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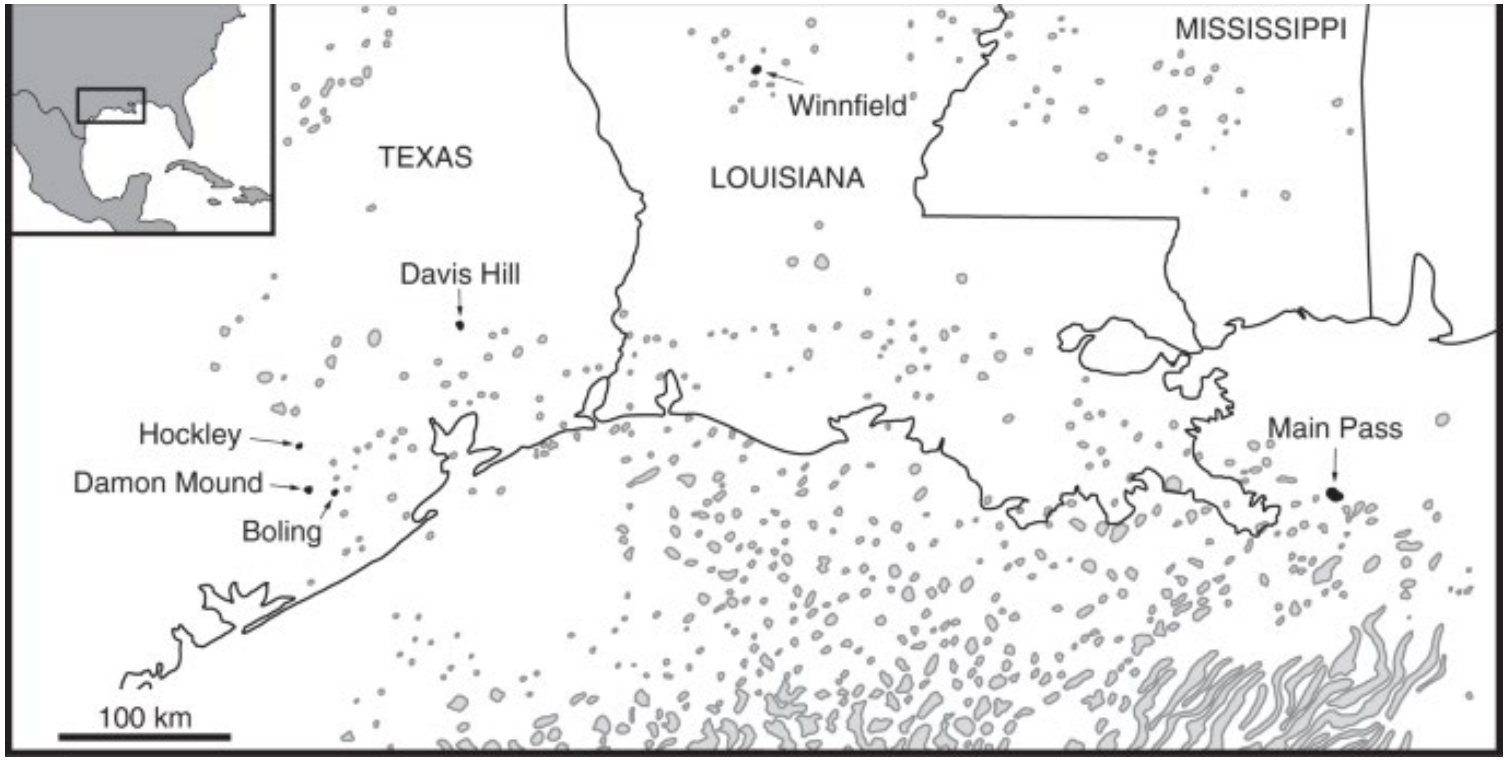
Gulf Coast Regional Cluster – Regional Highlights

GEOLOGY

Three existing hydrogen storage caverns in TX

GEOLOGY

Potential for CCS and additional hydrogen storage



Distribution of Northern Gulf of Mexico Basin Salt Structures

Caesar, K.H., Kyle, J.R., Lyons, T.W. et al. Carbonate formation in salt dome cap rocks by microbial anaerobic oxidation of methane. *Nat Commun* 10, 808 (2019).

Gulf Coast Regional Cluster – RFI Response Highlights

Examples from RFI Responses:

>1.2 billion scf

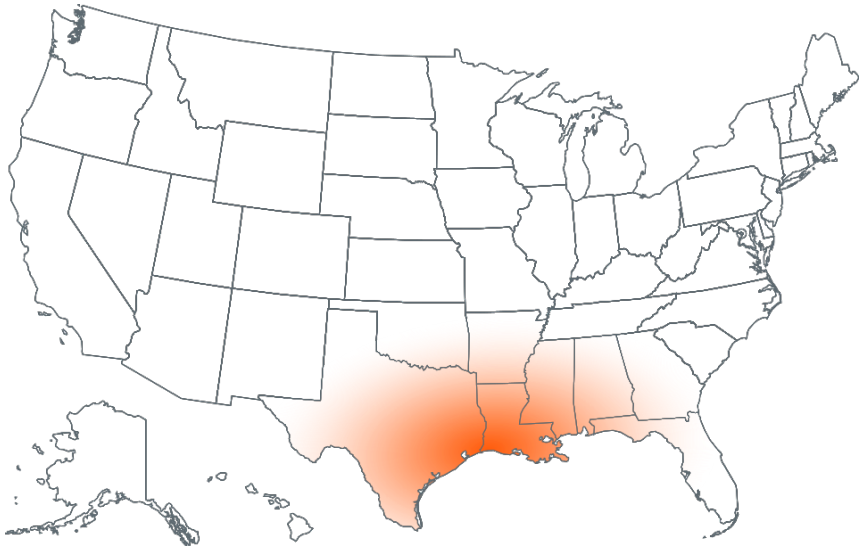
2,846 tonnes

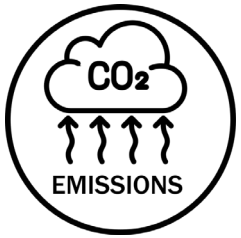
per day of hydrogen production potential

80 billion scf

18,970 tonnes

per day of hydrogen from SMR





Emissions reductions in impacted areas

Industry to support agriculture

Metallic ore refining and processing

Creation of jobs in opportunity zones

Oil refining and processing

CCS and additional hydrogen storage

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Gulf Coast Regional Cluster – RFI Response Highlights

End Users, Cost, Value Proposition

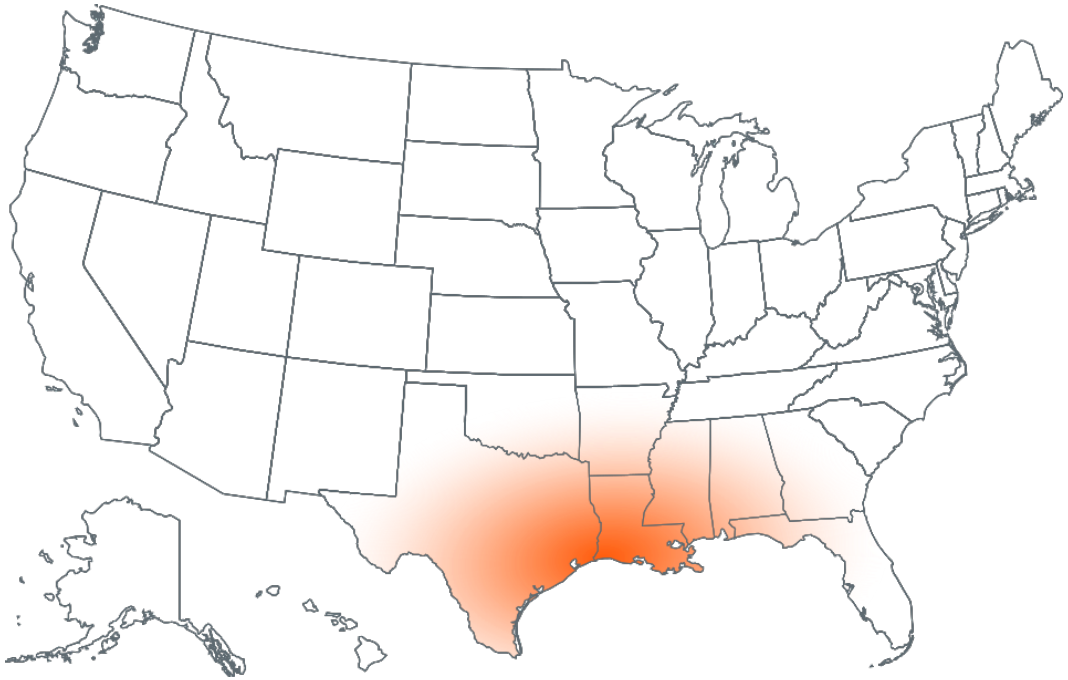
- Current: ~ 50 SMR petrochemical/refining plants producing ~3.6 MT/year of H2
- Future: city transit, industrial forklifts, phosphate industry supporting agricultural sector, green ammonia for marine fuel
- Oil refining and processing, ammonia and methanol production, metallic ore production, food processing, industrial use

Regional resources for production and infrastructure

- Legacy oil and gas wells, reclaimed water sites, natural gas pipelines, saline aquifer, salt domes and caverns

DEI, Jobs, EJ

- Creation of 2,000+ jobs for Opportunity Zones in Gulf Region, e.g., 240 new jobs for Donaldsonville, LA



Emissions Reduction Potential

- Geologic storage accessibility could accommodate >1B tonnes/year in emissions

Co-Location Potential

- Large electricity capacity, electrolysis and SMR capability with inland marine shipping
- Storage in salt caverns and depleted oil fields

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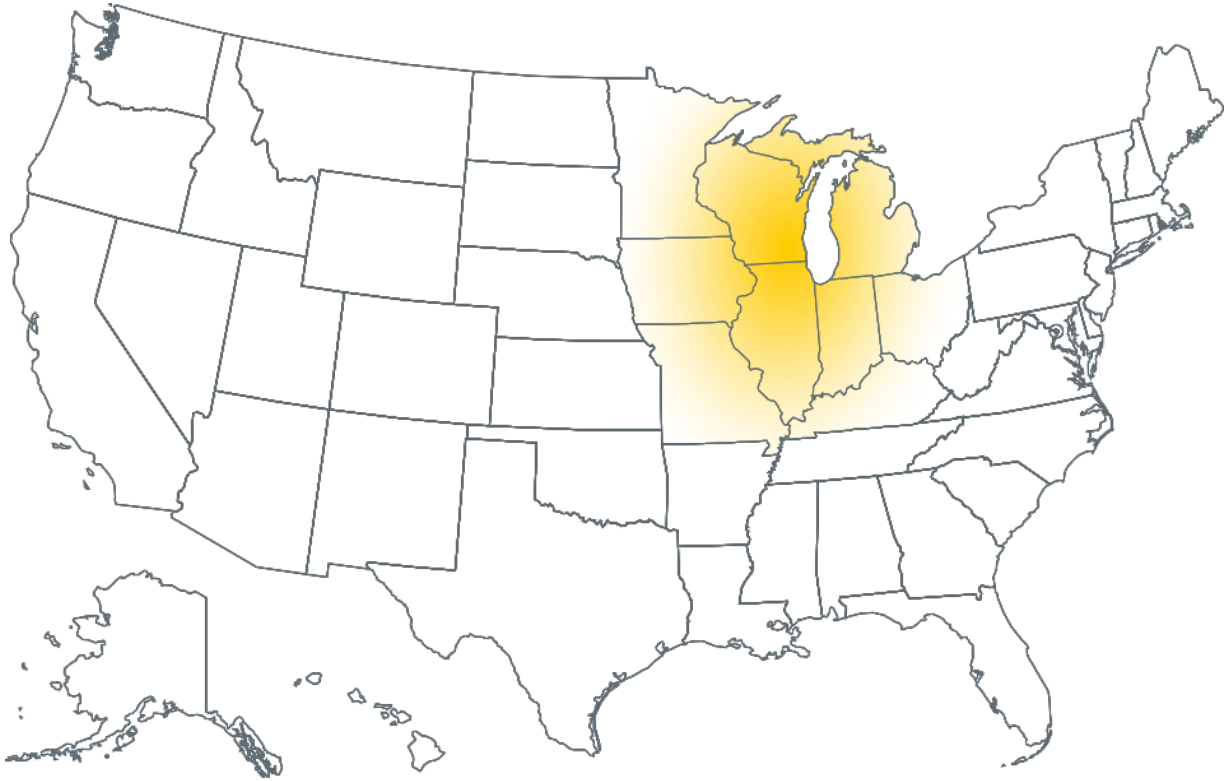
Great Lakes Regional Cluster – Regional and RFI Highlights

POPULATION

North midwestern states

PORTS

Cargo shipping center for several industries



84%
freshwater surface of North America

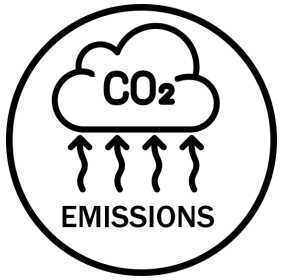
200 million
tons of cargo shipped annually

(Council of the Great Lakes Region, 2017)

Great Lakes Regional Cluster – Regional and RFI Highlights

Most nuclear plants of any region

Major trade corridors



Increased emissions vs average

11

Nuclear plants in Illinois

(EIA.gov)

Nuclear Power Plants

Nuclear Power Plants in the Great Lakes Region (EIA.gov)

Great Lakes Regional Cluster – Regional Highlights

POPULATION

Gary, Detroit, Cleveland and Dayton

POPULATION

Multiple environmental justice indices

HUD Opportunity Zones

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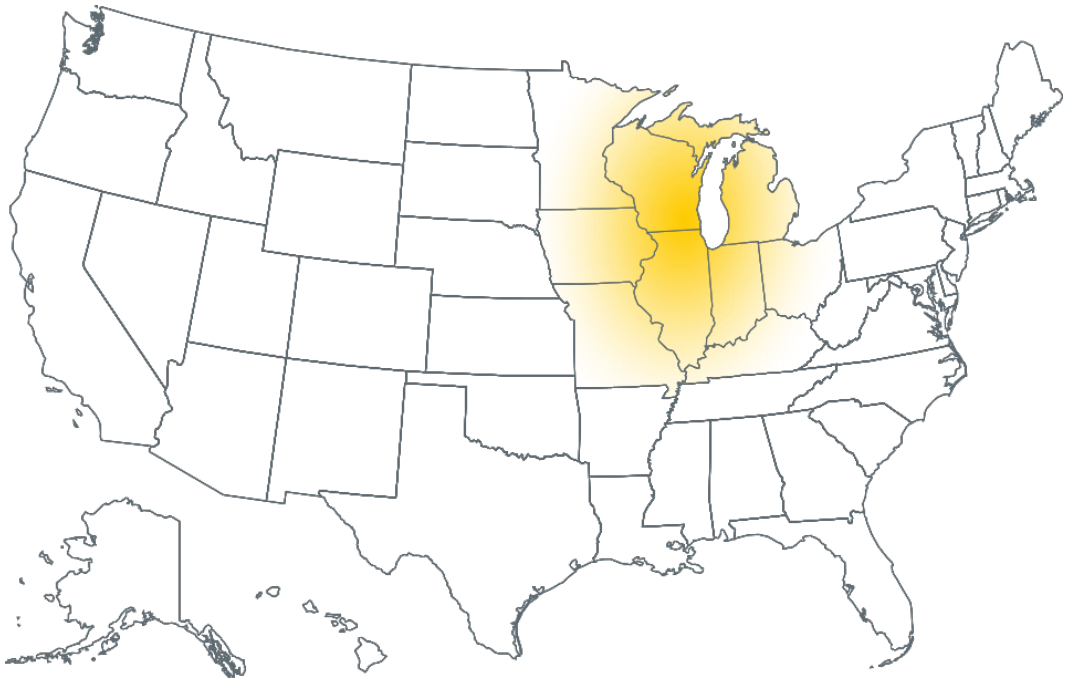
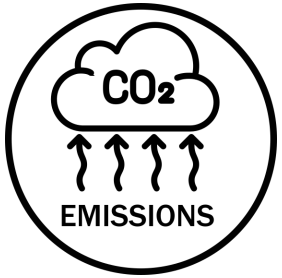
Great Lakes Regional Cluster – RFI Response Highlights

Co-location at nuclear power plants

Saline caverns and depleted oil and gas fields



Deactivated coal plant jobs



Non-attainment areas benefit from CCUS

Steel, cement, and chemical industry

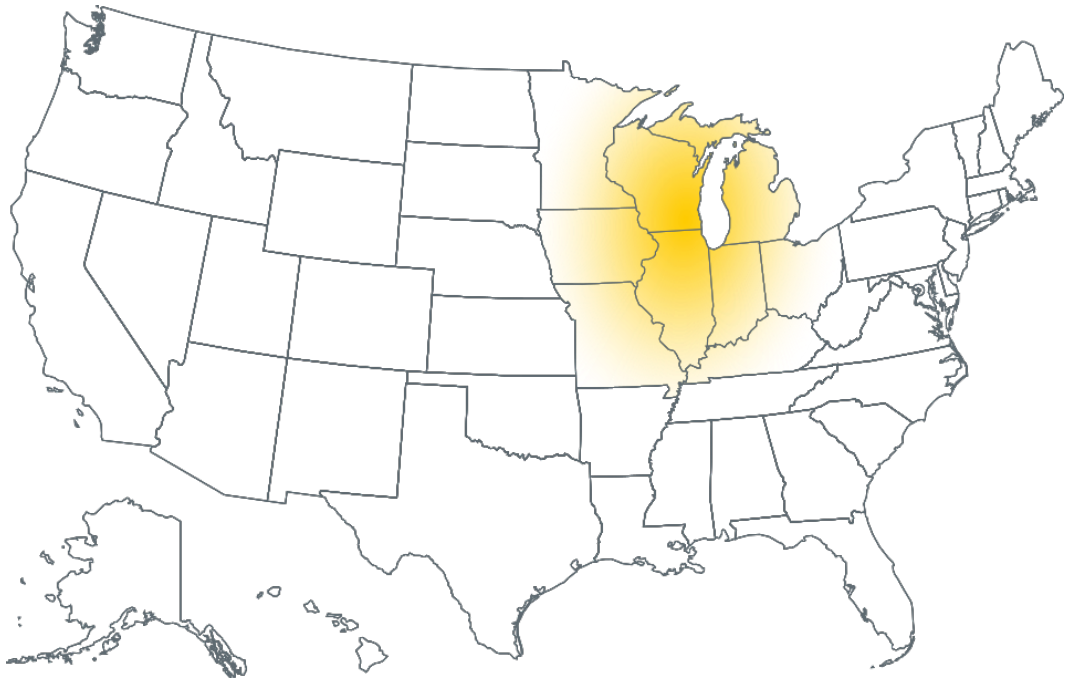
Great Lakes Regional Cluster – RFI Response Highlights

Regional resources for production and infrastructure

- Limited infrastructure, production potential is from coal, nuclear plants, depleted oil and gas fields, salt caverns
- NG pipelines available but limited H2 storage potential

End Users, Cost, Value Proposition

- Long haul truck corridors motivate refueling structures
- Steel, cement, and chemical plants are dominant end users



Emissions Reduction Potential

- ~20 MMT CO_2eq/yr
- Air quality improvement is a great benefit considering industrial plants

DEI, Jobs, EJ

- Estimated 60k+ jobs created
- Gary, Detroit, Cleveland, and Dayton are top 100 disadvantaged communities and opportunity zones with multiple EJ indices

Co-location Potential

- Nuclear plants near transportation arteries, warehouses, and distribution facilities

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Appalachia Regional Cluster – Regional Highlights

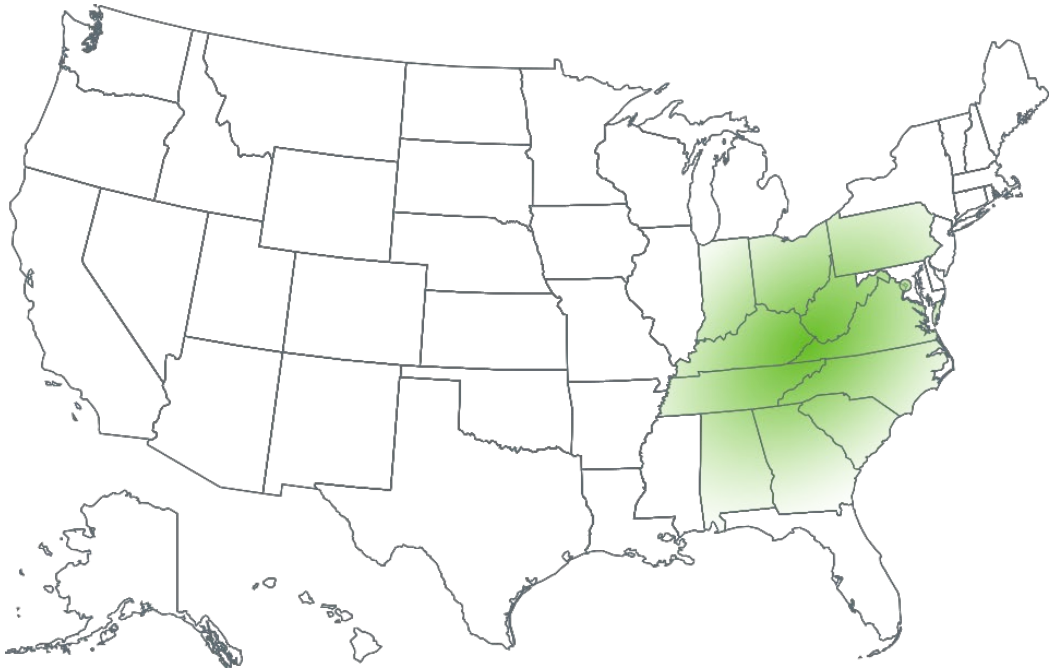
POPULATION

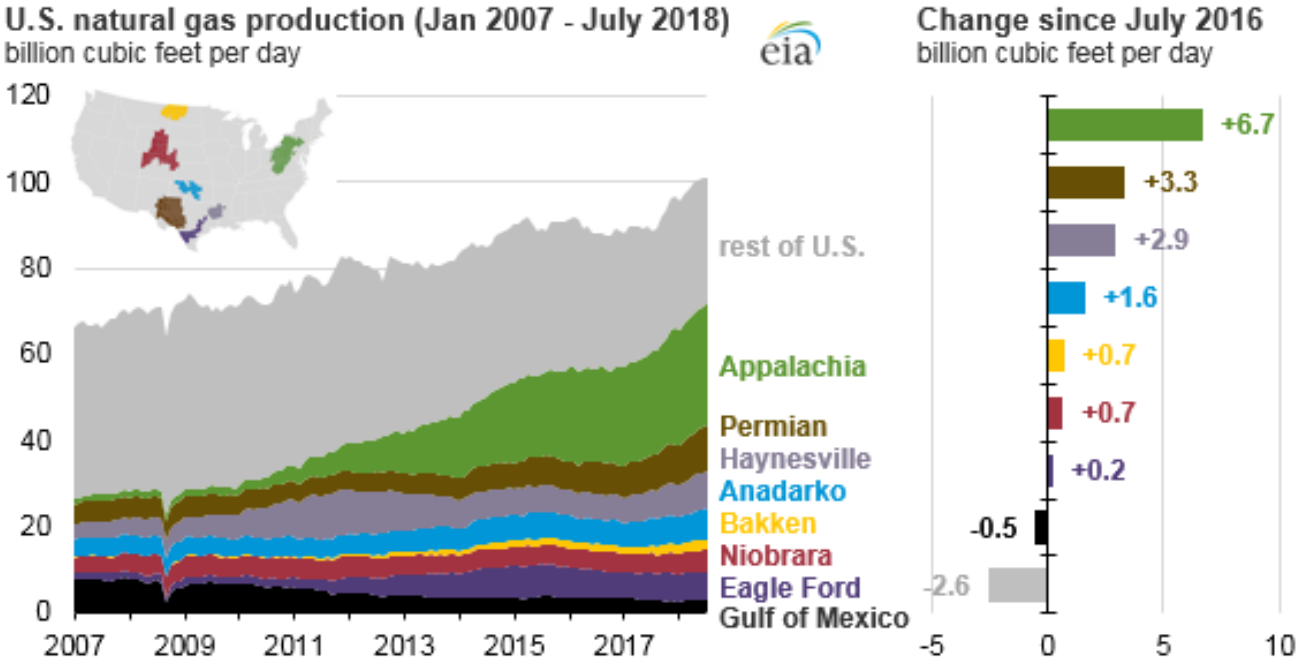
Spans southern NY to Northern MS

206,000
square miles
26 million
residents
(Appalachian Regional Commission)

NATURAL GAS

Grown to single largest natural gas producer





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Appalachia Regional Cluster – Regional and RFI Highlights

COAL

Historically a major coal producer

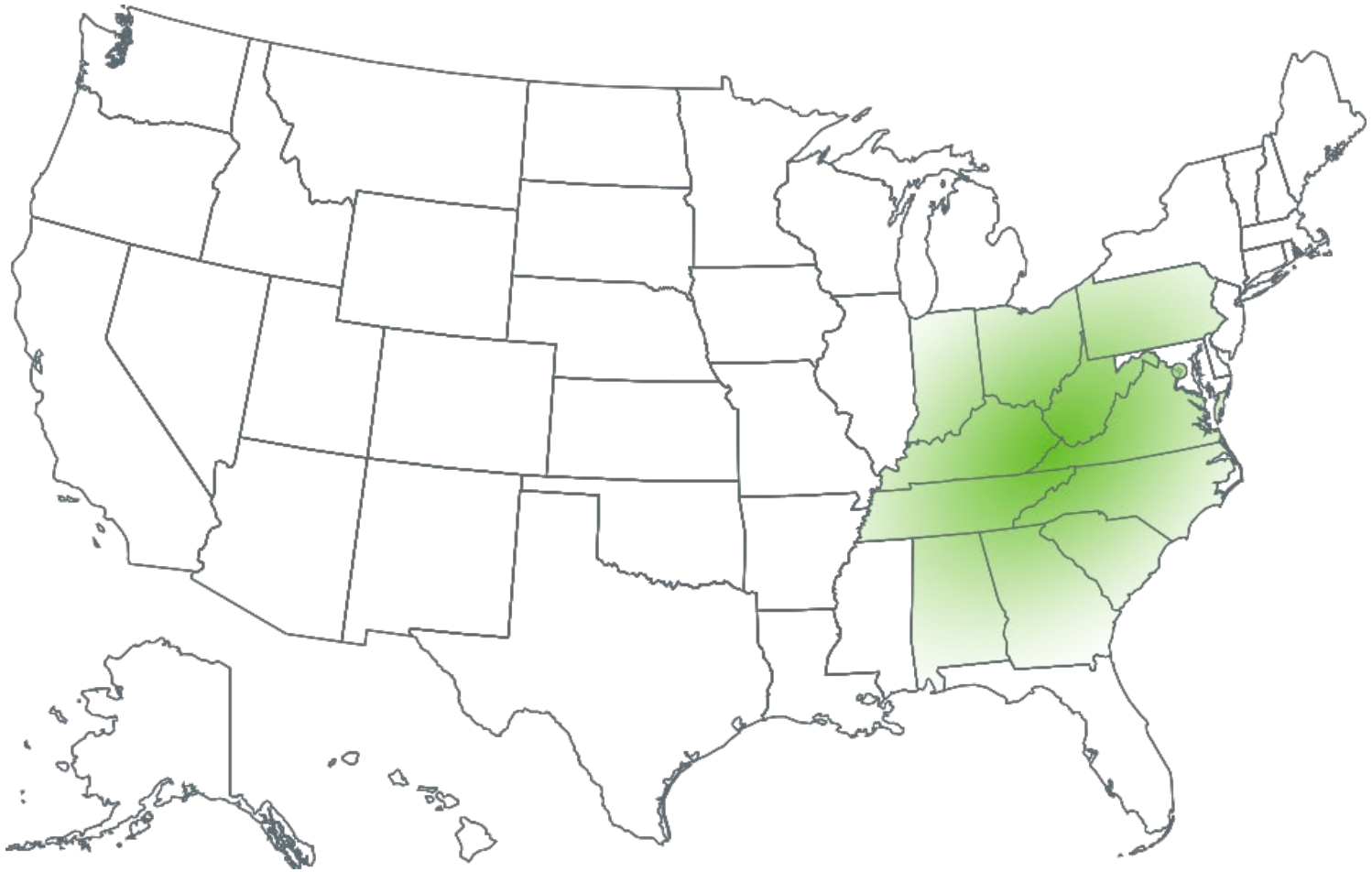
65%

reduction in coal production

2,000

jobs lost per mine closure

(Appalachian Regional Commission, EIA.gov)



POPULATION

High STEM graduation but low retention

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Appalachia Regional Cluster – RFI Response Highlights*

NATURAL GAS

Clean hydrogen with advanced CCS

GEOLOGY

Salt, limestone, and sandstone formations

MATERIALS HANDLING

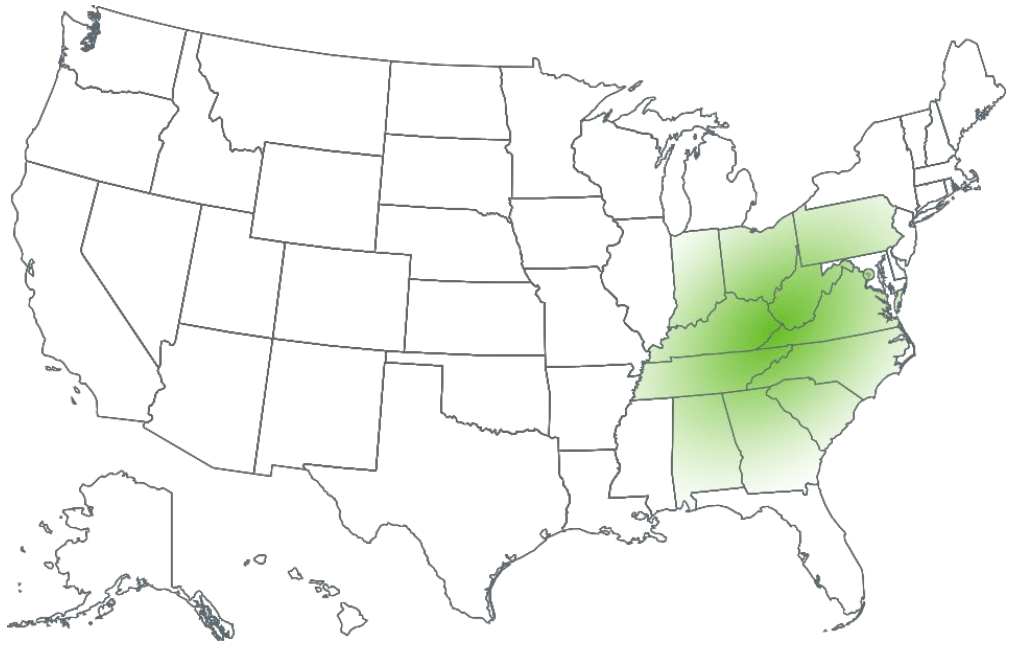
Fuel cell forklifts at distribution hubs

0.9

MT CO2/year reduction

1-4

MT additional CO2/year reduction



10

Distribution centers

900,000

kg H2/year for fuel cell forklifts

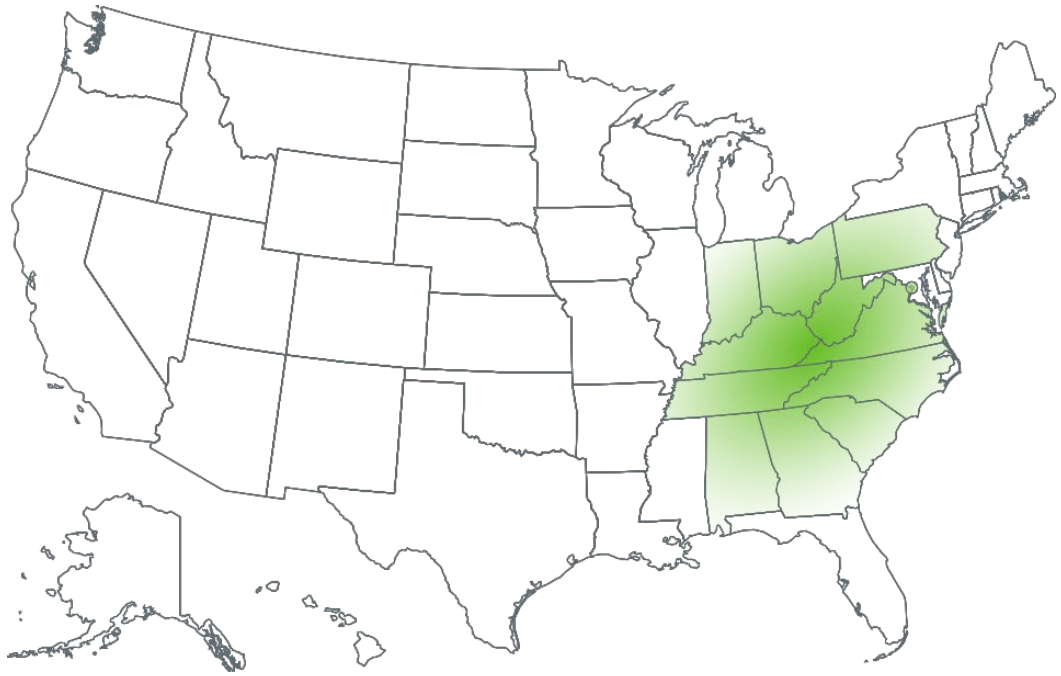
Appalachia Regional Cluster - RFI Response Highlights

Regional resources for production and infrastructure

- Overlap with Great Lakes region, especially Western OH
- Primarily fossil resources with CCS, with future transition to renewables
- Access to significant NG and saline storage of CCS
- Salt, limestone, and sandstone formations for potential CCS or H_2 storage throughout

End Users, Cost, Value Proposition

- H_2 for power generation, industry, backup power
- Steel, cement, and chemical industries; decarbonizing refining facilities
- Need for policy incentives to address cost premium versus traditional fossil



Emissions Reduction Potential

- 0.9 MT CO_2/year with NG reforming + 1-4 MT with additional CCS in a single project
- Decarbonization of current processes and possible negative emissions

DEI, Jobs, EJ

- Many distressed communities based on unemployment rates, per capita market income, and poverty rates.
- Coal industry employment in that period has declined 54% in 15 years
- High dependence on mining as a portion of overall economic activity, e.g., one mine closure lost 2000 jobs

Co-location Potential

- Nuclear plants near transportation arteries, warehouses, and distribution facilities
- Wastewater treatment, ammonia production
- Environmental, architectural, archaeological studies completed; active work site for powerplant and other facility developments

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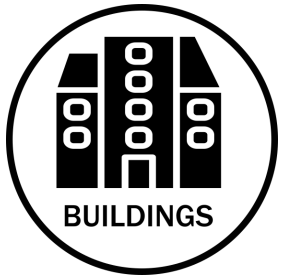
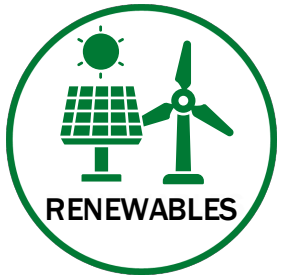
New England Regional Cluster – Regional and RFI Highlights

Northeast states and parts of NY

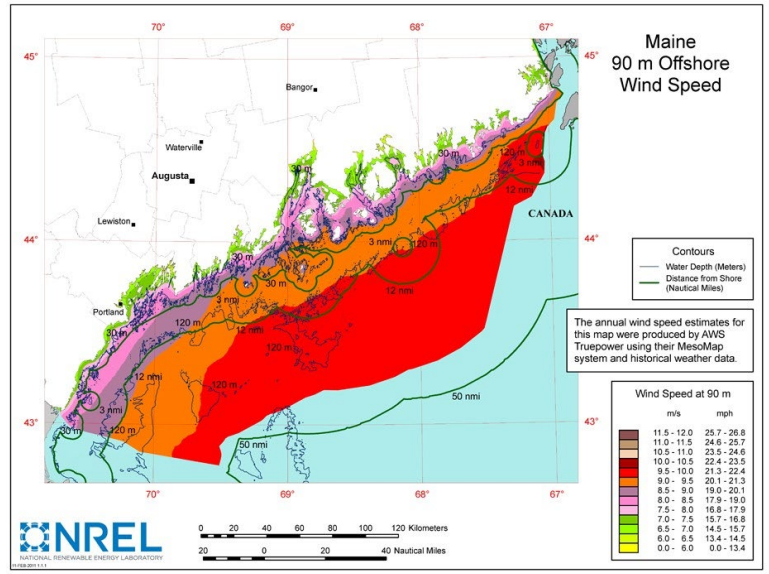


Multifamily rental homes

Aquaculture and fishing economies



World-class offshore wind resources



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New England Regional Cluster – RFI Response Highlights

MANUFACTURING

Existing hydrogen off-takers

NATURAL GAS

Blending hydrogen in natural gas

BIOMASS/ WASTE

Wood to renewable methane

FISHING

Retrofitting fishing vessels for methanol

RENEWABLES

Floating offshore wind for hydrogen

120,000

Tons of CO_2 saved

Image: Lobster Institute, University of Maine

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New England Regional Cluster - RFI Response Highlights

Regional resources for production and infrastructure

- Gulf of Maine has high renewables (hydropower, solar, and wind – significant potential for offshore)
- Wood chip/waste pyrolysis + renewable H_2 to produce methane
- H_2 + HCl from wastewater or seawater treatment
- Cross-border cooperative projects with Canada

End Users, Cost, Value Proposition

- Blending of H_2 in MA, NH; with ultimate conversion of NG to 100% H_2 turbine – ~500 tons/yr H_2
- Backup power – e.g., 2020 Tropical Storm Isaias left 2.5M people in NY w/o power; winter storms –need heating
- Replace fuel oil for home heating
- Commercial fishing vessels (e.g., Maine)

Emissions Reduction Potential

- Wood to methane (with renewable H_2) -32k tons/year
- Replacing diesel fishing vessels with H_2 - ~120k tons CO2/year

DEI, Jobs, EJ

- Many communities are not readily accessible by major highways or pipeline
- Offshore floating wind installations would create thousands of new jobs

Co-location Potential

- Wastewater treatment facilities + dynamic heat production
- Renewable H_2 to methanol for simple storage and transport

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Alaska and Hawaii Regional Cluster –Regional Highlights (Hawaii)

POPULATION

Geographically unique energy infrastructure

RENEWABLES

Abundant renewable resources

COST

Expensive electricity due to petroleum dependence

TRANSPORT

High adoption of electric vehicles

POLICY

100% renewable electricity by 2045

~21%

Electricity from renewables

(EIA.gov)

Alaska and Hawaii Regional Cluster – Regional Highlights (Alaska)

Remote and rural communities

Reliance on diesel in remote areas

50% renewable/ alternative energy sources by 2025

15%

Electricity from petroleum

30%

Electricity from renewables

(EIA.gov)

Prior efforts on renewable hydrogen

U.S. DEPARTMENT OF ENERGY
ARCTIC ENERGY OFFICE

Alaska and Hawaii Regional Cluster – RFI Response Highlights

RENEWABLES

Growing renewable hydrogen production in HI

RENEWABLES

Ocean thermal and geothermal production in HI

PUBLIC TRANSPORT

Fuel cell bus fleets in HI

BIOMASS/ WASTE

Bio-energy plant with reforestation

TRIBES

Remote tribal communities in Alaska

Alaska and Hawaii Regional Cluster - RFI Response Highlights

Regional resources for production and infrastructure

- Geothermal, wind, biomass, solar and atmospheric water generation, landfill methane, solid municipal waste, and green waste to H_2
- 100 kW ocean thermal energy electrolyzer under development
- Existing H_2 station, pipelines for storage; distribution by trailers and trucks

End Users, Cost, Value Proposition

- Local and public transit, back up power with large scale hydrogen storage for natural disasters in HI
- Export liquid H_2 from geothermal plant with expected cost $3.00-3.35/kg in HI
- Potential for H_2 fueled fishing vessels on Alaskan coast

Emissions Reduction Potential

- Carbon capture from the atmosphere to produce kerosene under investigation in HI
- Goal to transform island in HI to zero emissions by 2030; converting public transit to H_2 would save 86,000 tonnes/year

DEI, Jobs, EJ

- Estimated 877 jobs for Oahu, which lags in economic and population health, and prosperity vs State and nation
- Bus assembly facilities on island will maintain 75% of capital within community

Co-location Potential

- Bio-energy plant with reforestation and tree farming in HI
- Assembly facilities with subassembly shops and recycling facilities, training centers, purity testing facilities, and maintenance and calibration centers
- Nuclear plant in AK

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Example: Deep Dive on Fossil + CCS Responses

A. How many responses involved fossil resources (coal, NG) – 92 of 195

B. How many involve any type of gasification or high temperature thermal conversion (any fuel) – 59 of 195

C. Provide a breakdown of interest by region – See Summary in Slide

D. Identify any trends in what is suggested for R&D needs; any specific technology areas?
   - Improving the Reforming Process
   - More research on possible Hydrogen storage (both Geologic & On-Site)
   - More research on CCS. CCUS, and Cryogenic Carbon Capture (CCC) to make more economic

E. How many showed interest in Geologic Hydrogen Storage or CCUS? – 53 of 195

Deep Dive: Responses on Specific Qs

A total of 92 out of 195 were found to have interest in categories below:

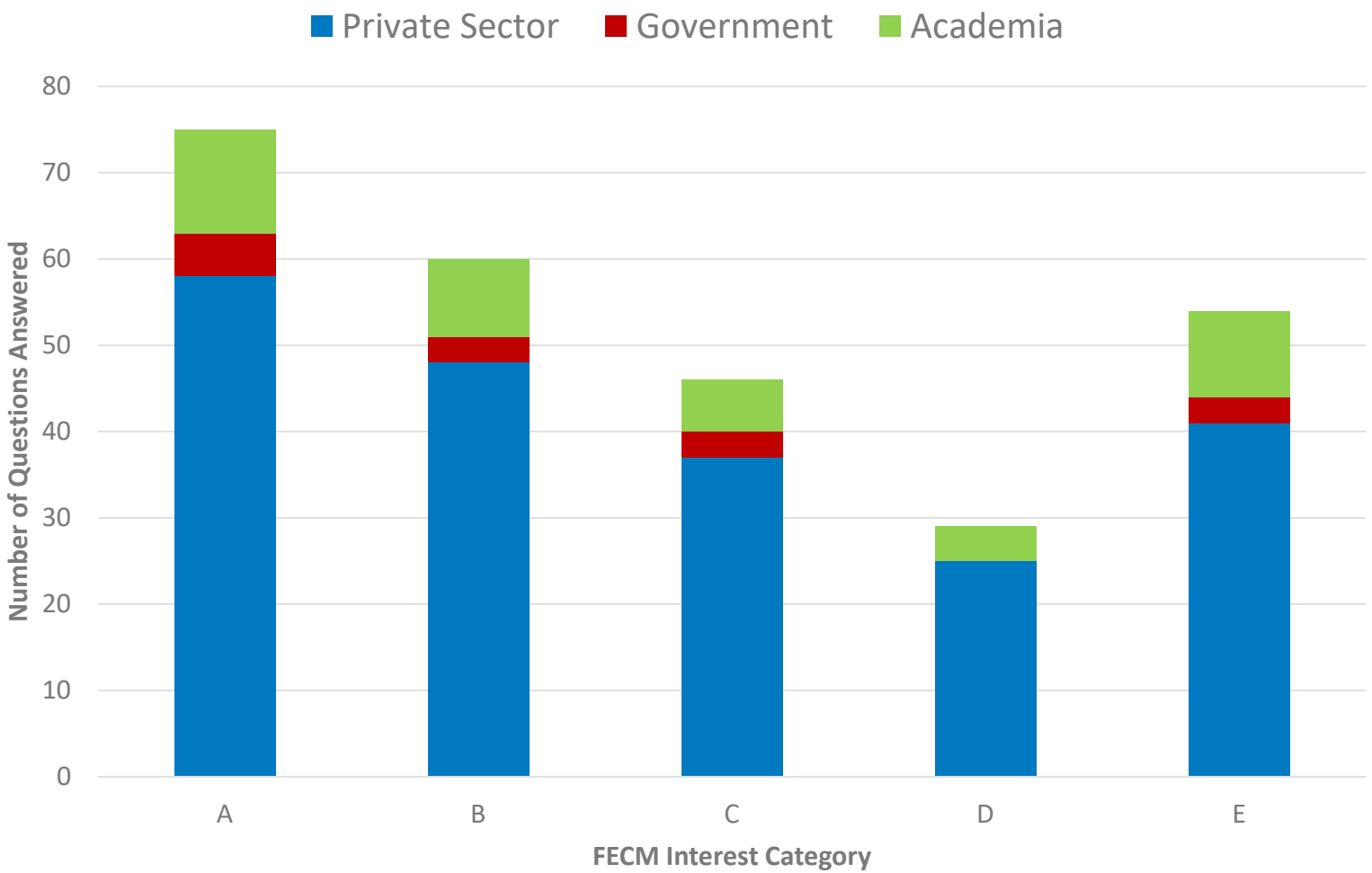
A. How many responses involved fossil fuel (coal, NG)

B. How many involve any type of gasification or high temperature thermal conversion (any fuel)

C. Provide a breakdown of interest by region (related to fossil, large storage, infrastructure)

D. Identify any trends in what is suggested for R&D needs; any specific technology areas?

E. Any discussion of Geologic Hydrogen Storage or CCUS?



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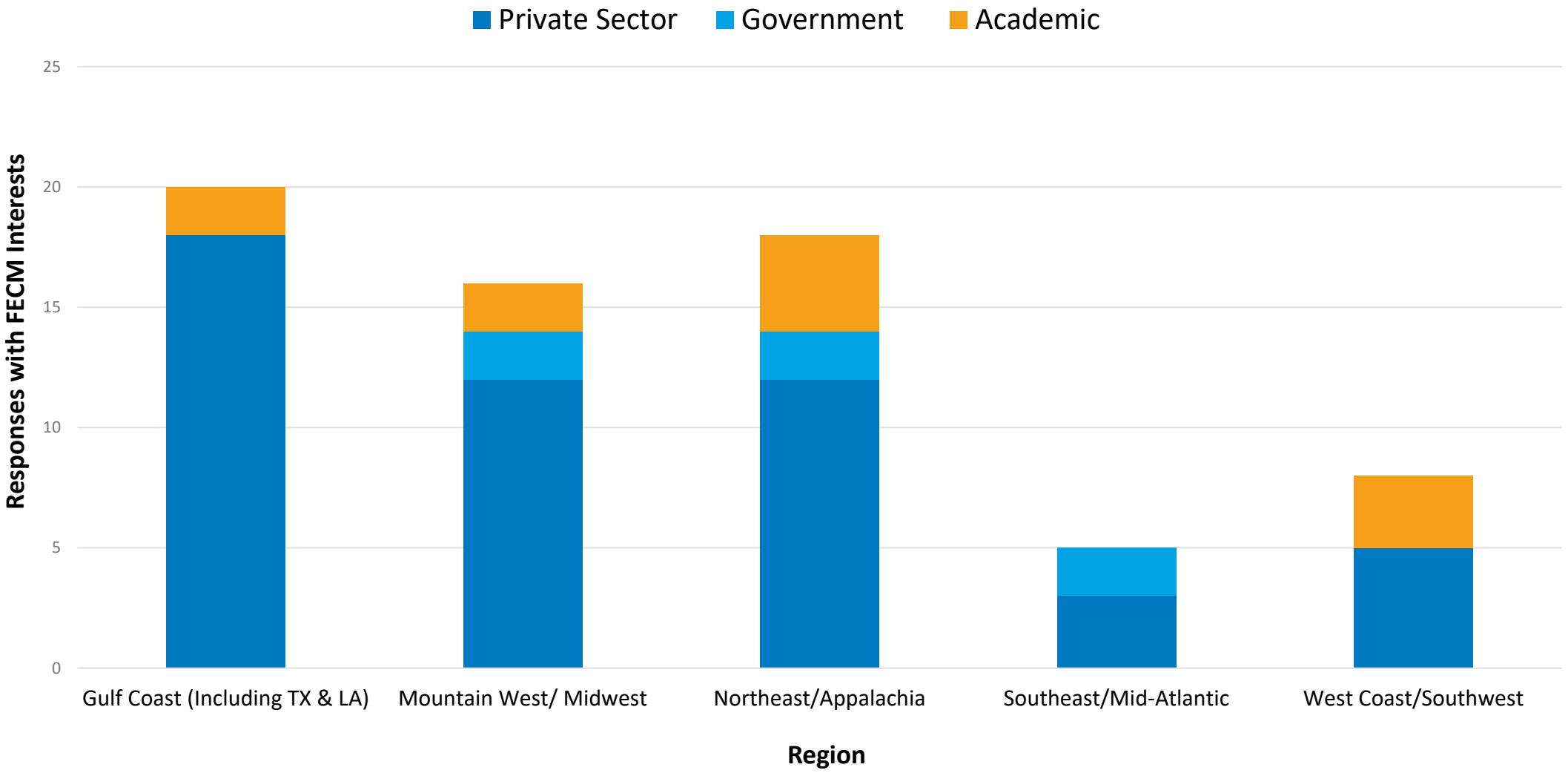
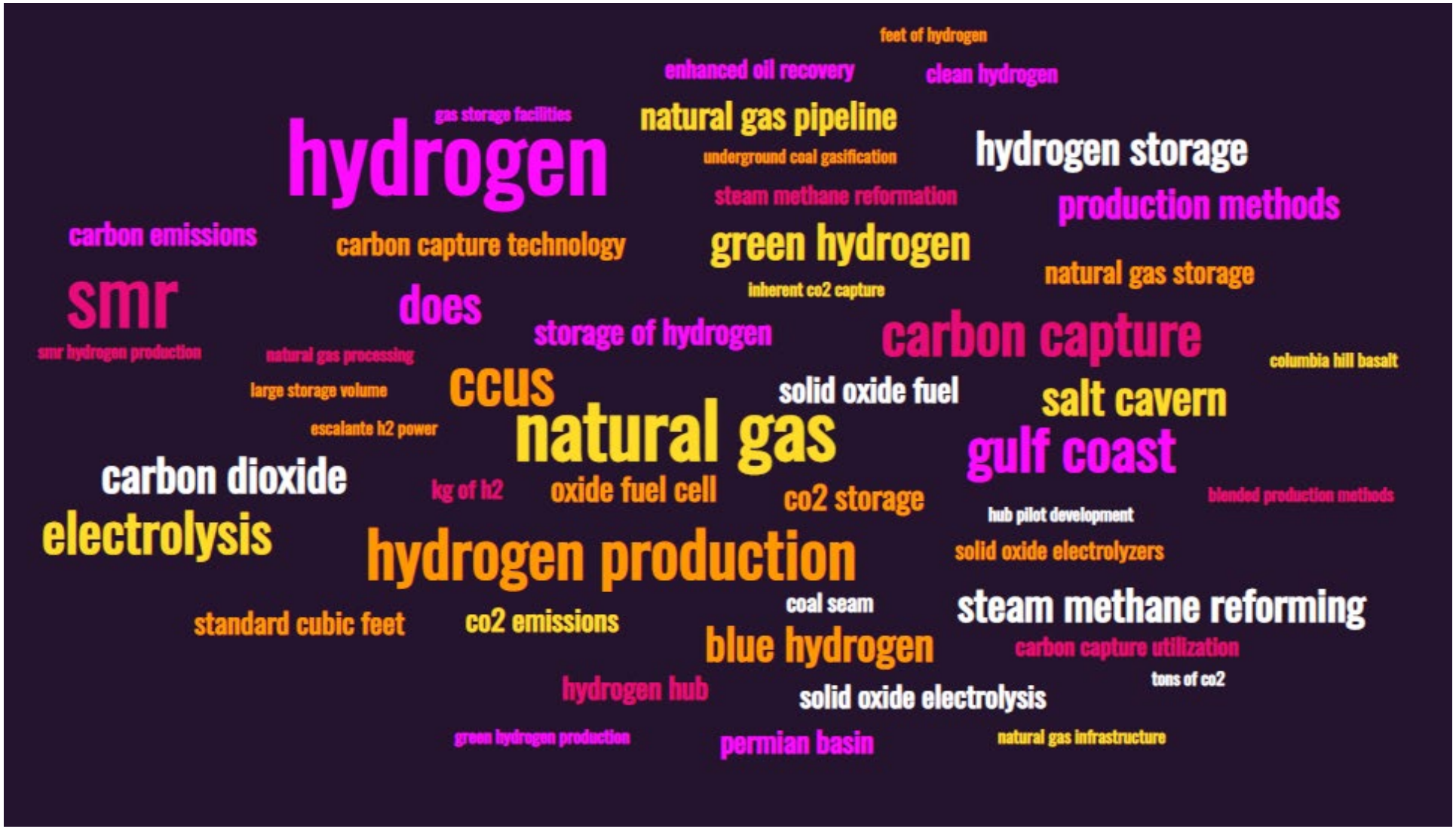
Responses related to storage, infrastructure, fossil resources by region

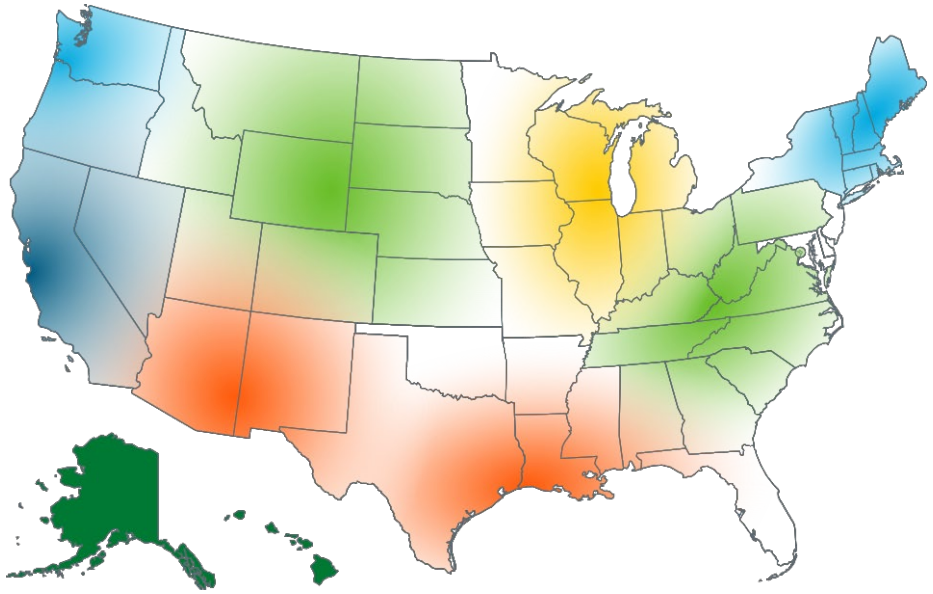


ENERGY earthshots U.S. DEPARTMENT OF ENERGY | Hydrogen

Examples of Popular Terms using “Hydrogen” in Response



Summary - RFI



- Numerous opportunities for growing hydrogen economy across the US
- Early regional deployment needs can be supported by current infrastructure highlighted in RFI responses
- Additional regional and national analysis under way

We gratefully acknowledge the RFI Team

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Opportunities through the Bipartisan Infrastructure Law

Bipartisan Infrastructure Law - Hydrogen Highlights

- **Covers $9.5B** for clean hydrogen:
  - $8B for at least four regional clean hydrogen hubs
  - $1B for electrolysis research, development and demonstration
  - $500M for clean hydrogen technology manufacturing and recycling R&D

President Biden Signs the Bipartisan Infrastructure Bill on November 15, 2021.
Photo Credit: Kenny Holston/Getty Images

- **Aligns with Hydrogen Shot priorities by directing work to reduce the cost of clean hydrogen to $2 per kilogram by 2026**
- **Requires developing a National Hydrogen Strategy and Roadmap**

Hydrogen Sections of the BIL Covered in this Webinar

Sec. 40314. Additional Clean Hydrogen Programs, which amends EPACT 2005 to include:

- Sec. 813. Regional Clean Hydrogen Hubs
  - $8,000,000,000 for the period of fiscal years 2022 through 2026
- Sec. 814. National Clean Hydrogen Strategy and Roadmap
- Sec. 815. Clean Hydrogen Manufacturing and Recycling
  - $500,000,000 for the period of fiscal years 2022 through 2026
- Sec. 816. Clean Hydrogen Electrolysis Program
  - $1,000,000,000 for the period of fiscal years 2022 through 2026

Sec. 40315. Clean Hydrogen Production Qualifications

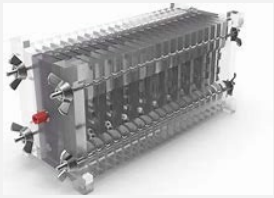
BIL Hydrogen Provisions cover Range of RDD&D

Manufacturing RD&D across H_2 and fuel cell technologies

Raw Materials → Processed Materials → Subcomponents → End Product

Includes end of life (EOL) & recycling RD&D

Sec. 40314 (EPACT Sec 815): Clean Hydrogen Manufacturing & Recycling **$0.5 Billion over 5 years**

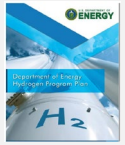


Electrolysis RD&D: BIL Includes RD&D across multiple electrolysis technologies, compression, storage, drying, integrated systems, etc.

Sec. 40314 (EPACT Sec 816): Clean Hydrogen Electrolysis Program; **$1 Billion over 5 years. Goal $2/kg by 2026**

Regional Clean H_2 Hubs: At least 4 Hubs, geographic diversity, includes renewables, fossil + CCS, nuclear, for clean hydrogen production, multiple end use applications

Sec. 40314 (EPACT Sec 813): Regional Clean Hydrogen Hubs; **$8 Billion over 5 years**



National Hydrogen Strategy and Roadmap: Within 180 days
Clean Hydrogen Standard: 2 kg CO_2e/kg H_2, update within 5 yrs

Sec. 40314 (EPACT Sec 814: Strategy & Roadmap and **Sec. 40315 (EPACT Sec 822)**: Clean Hydrogen Production Qualifications)

Sec. 40314 (EPACT Sec. 814): National Clean Hydrogen Strategy and Roadmap

(a) DEVELOPMENT.—

(1) IN GENERAL.—In carrying out the programs established under sections 805 and 813, the Secretary, in consultation with the heads of relevant offices of the Department, shall develop a technologically and economically feasible national strategy and roadmap to facilitate widescale production, processing, delivery, storage, and use of clean hydrogen.

(2) INCLUSIONS.—The national clean hydrogen strategy and roadmap developed under paragraph (1) shall focus on—

(A) establishing a standard of hydrogen production that achieves the standard developed under section 822(a), including interim goals towards meeting that standard;

(B) (i) clean hydrogen production and use from natural gas, coal, renewable energy sources, nuclear energy, and biomass; and

(ii) identifying potential barriers, pathways, and opportunities, including Federal policy needs, to transition to a clean hydrogen economy;

National Clean Hydrogen Strategy and Roadmap - continued

(C) identifying—

(i) economic opportunities for the production, processing, transport, storage, and use of clean hydrogen that exist in the major shale natural gas-producing regions of the United States;

(ii) economic opportunities for the production, processing, transport, storage, and use of clean hydrogen that exist for merchant nuclear power plants operating in deregulated markets; and

(iii) environmental risks associated with potential deployment of clean hydrogen technologies in those regions, and ways to mitigate those risks;

(D) approaches, including substrategies, that reflect geographic diversity across the country, to advance clean hydrogen based on resources, industry sectors, environmental benefits, and economic impacts in regional economies;

(E) identifying opportunities to use, and barriers to using, existing infrastructure, including all components of the natural gas infrastructure system, the carbon dioxide pipeline infrastructure system, end-use local distribution networks, end-use power generators, LNG terminals, industrial users of natural gas, and residential and commercial consumers of natural gas, for clean hydrogen deployment;

National Clean Hydrogen Strategy and Roadmap - continued

(F) identifying the needs for and barriers and pathways to developing clean hydrogen hubs (including, where appropriate, clean hydrogen hubs coupled with carbon capture, utilization, and storage hubs) that—

(i) are regionally dispersed across the United States and can leverage natural gas to the maximum extent practicable;

(ii) can demonstrate the efficient production, processing, delivery, and use of clean hydrogen;

(iii) include transportation corridors and modes of transportation, including transportation of clean hydrogen by pipeline and rail and through ports; and

(iv) where appropriate, could serve as joint clean hydrogen and carbon capture, utilization, and storage hubs;

(G) prioritizing activities that improve the ability of the Department to develop tools to model, analyze, and optimize single-input, multiple-output integrated hybrid energy systems and multiple-input, multiple-output integrated hybrid energy systems that maximize efficiency in providing hydrogen, high-value heat, electricity, and chemical synthesis services;

National Clean Hydrogen Strategy and Roadmap - continued

(H) identifying the appropriate points of interaction between and among Federal agencies involved in the production, processing, delivery, storage, and use of clean hydrogen and clarifying the responsibilities of those Federal agencies, and potential regulatory obstacles and recommendations for modifications, in order to support the deployment of clean hydrogen; and

(I) identifying geographic zones or regions in which clean hydrogen technologies could efficiently and economically be introduced in order to transition existing infrastructure to rely on clean hydrogen, in support of decarbonizing all relevant sectors of the economy.

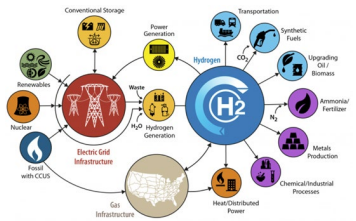
(b) REPORTS TO CONGRESS.—

(1) IN GENERAL.—Not later than 180 days after the date of enactment of the Infrastructure Investment and Jobs Act, the Secretary shall submit to Congress the clean hydrogen strategy and roadmap developed under subsection (a).

(2) UPDATES.—The Secretary shall submit to Congress updates to the clean hydrogen strategy and roadmap under paragraph (1) not less frequently than once every 3 years after the date on which the Secretary initially submits the report and roadmap.

National Strategy and Roadmap

Utilize DOE H2 Program Plan Industry Roadmap H2@Scale and regional analysis



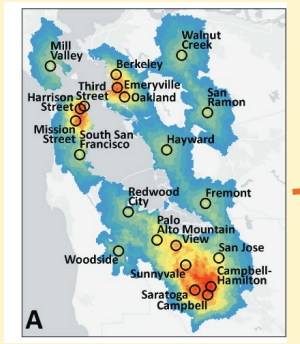
Stakeholder Engagement & Listening Sessions	National and regional coalitions, industry, states, labs, etc.	EJ, tribal and broad community engagement
Analysis: Policies, Decarbonization Scenarios, Jobs, etc.	Global roadmap assessments; updates of H2@Scale and industry analysis	Scenario analysis to meet Administration priorities
Interagency and State Government Coordination	Interagency coordination and strategy development	Iterations based on stakeholder feedback

Deliver to Congress by May 15 2022

Supply, Demand, and Infrastructure Analysis

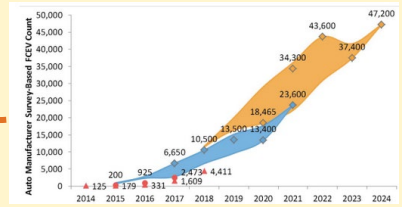
- National Roadmap process to be implemented over time to improve decision making
  - Updates every 3 years per statute
- National planning tools integrated with local and regional plans, policies, tools
- Will focus on actions

Infrastructure Planning & Coordination Process

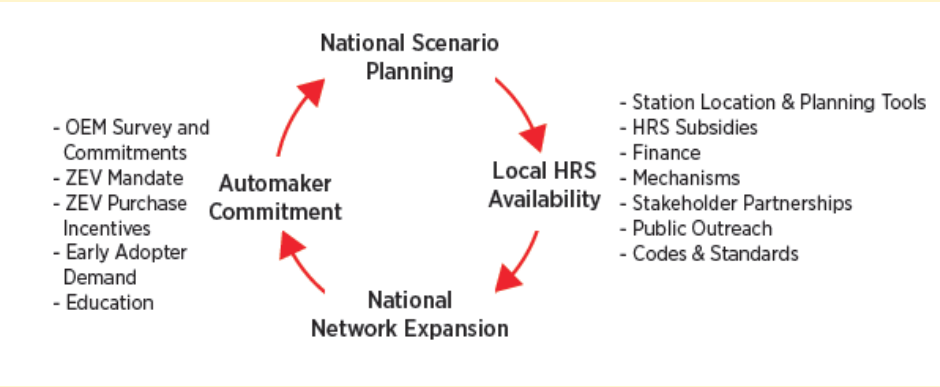


Station Coverage

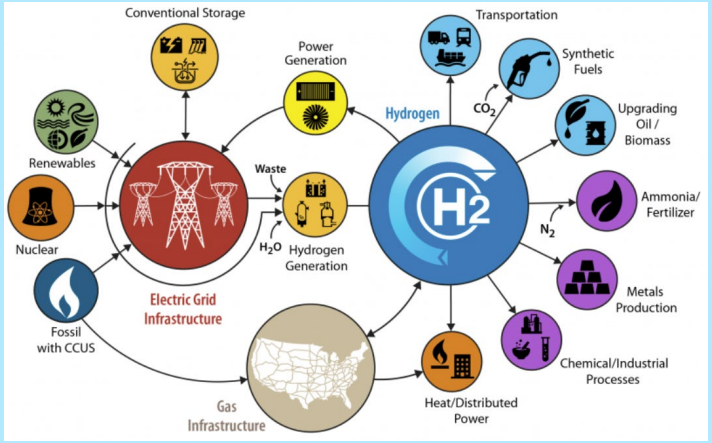
Annual Survey

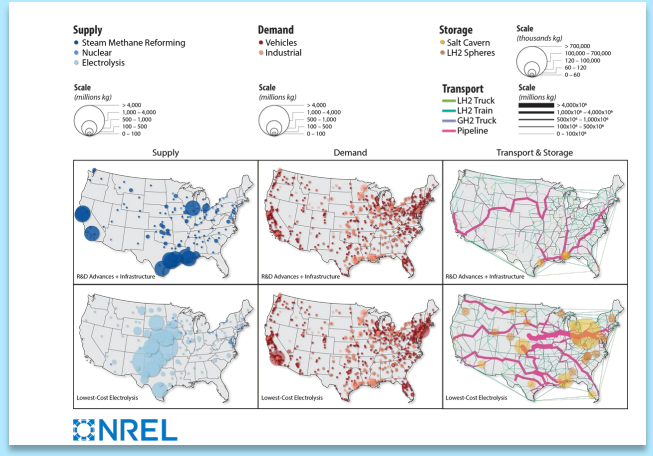


Example by CARB

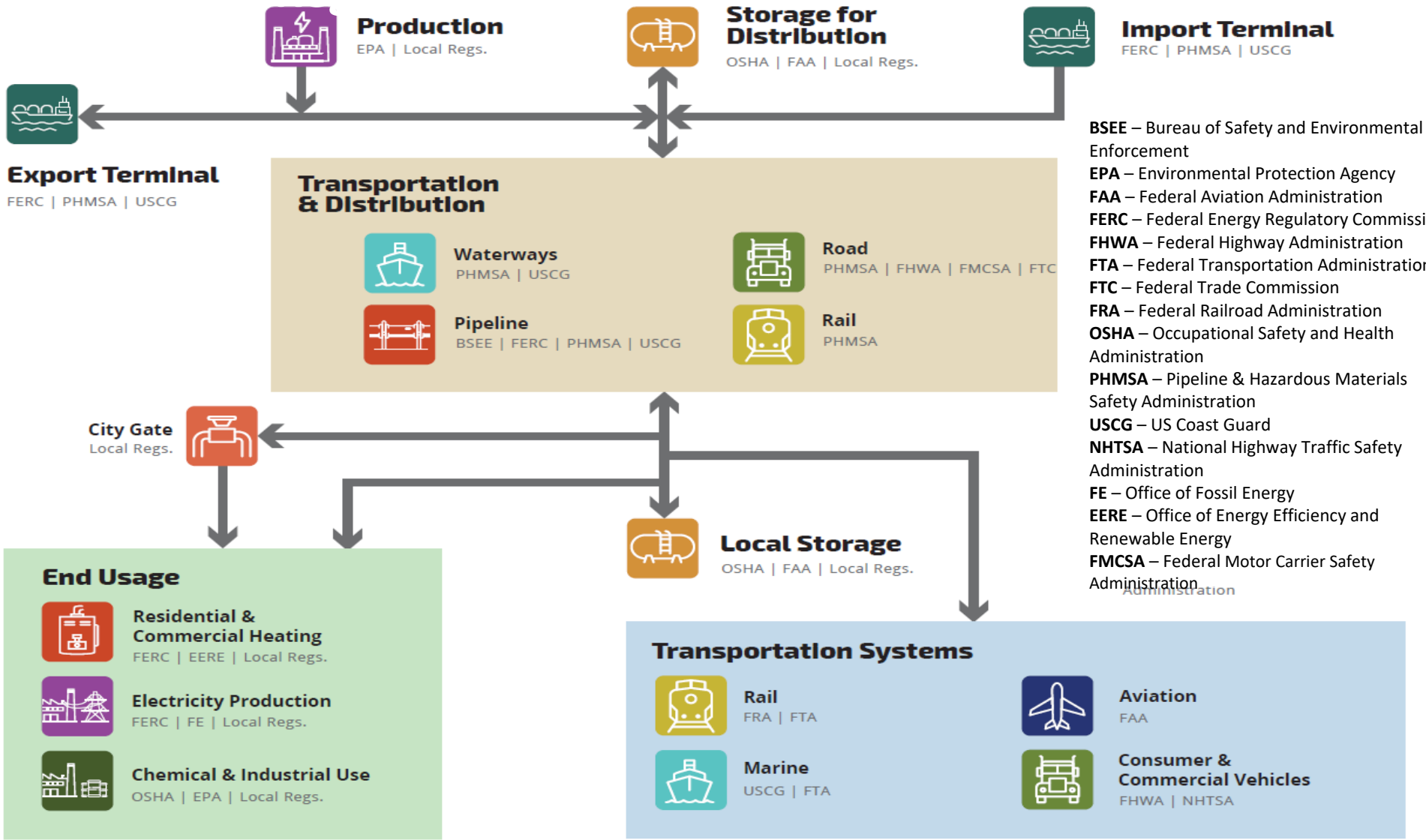


Hub Infrastructure Planning & Coordination Process





Example: Developed Federal Regulatory Map & Identified Gaps



BSEE – Bureau of Safety and Environmental Enforcement
EPA – Environmental Protection Agency
FAA – Federal Aviation Administration
FERC – Federal Energy Regulatory Commission
FHWA – Federal Highway Administration
FTA – Federal Transportation Administration
FTC – Federal Trade Commission
FRA – Federal Railroad Administration
OSHA – Occupational Safety and Health Administration
PHMSA – Pipeline & Hazardous Materials Safety Administration
USCG – US Coast Guard
NHTSA – National Highway Traffic Safety Administration
FE – Office of Fossil Energy
EERE – Office of Energy Efficiency and Renewable Energy
FMCSA – Federal Motor Carrier Safety Administration

Gaps Identified

- **FERC for pipeline transmission, electricity production, and heating**
- **FHWA for bridges and tunnels**
- **FRA, USCG, and FAA for rail, maritime, and aviation use**

Final Report Available:
energy.sandia.gov/wp-content/uploads/2021/03/H2-Regulatory-Map-Report_SAND2021-2955.pdf

Sec 40315 (EPACT Sec. 822): Clean Hydrogen Production Qualifications

(a) IN GENERAL.—Not later than 180 days after the date of enactment of the Infrastructure Investment and Jobs Act, the Secretary, in consultation with the Administrator of the Environmental Protection Agency and after taking into account input from industry and other stakeholders, as determined by the Secretary, shall develop an initial standard for the carbon intensity of clean hydrogen production that shall apply to activities carried out under this title.

(b) REQUIREMENTS.—

(1) IN GENERAL.—The standard developed under subsection (a) shall—

(A) support clean hydrogen production from each source described in section 805(e)(2);

(B) define the term 'clean hydrogen' to mean **hydrogen produced with a carbon intensity equal to or less than 2 kilograms of carbon dioxide-equivalent produced at the site of production per kilogram of hydrogen produced;** and

(C) take into consideration technological and economic feasibility.

Clean Hydrogen Production Qualifications - continued

(2) ADJUSTMENT.—Not later than the date that is 5 years after the date on which the Secretary develops the standard under subsection (a), the Secretary, in consultation with the Administrator of the Environmental Protection Agency and after taking into account input from industry and other stakeholders, as determined by the Secretary, shall—

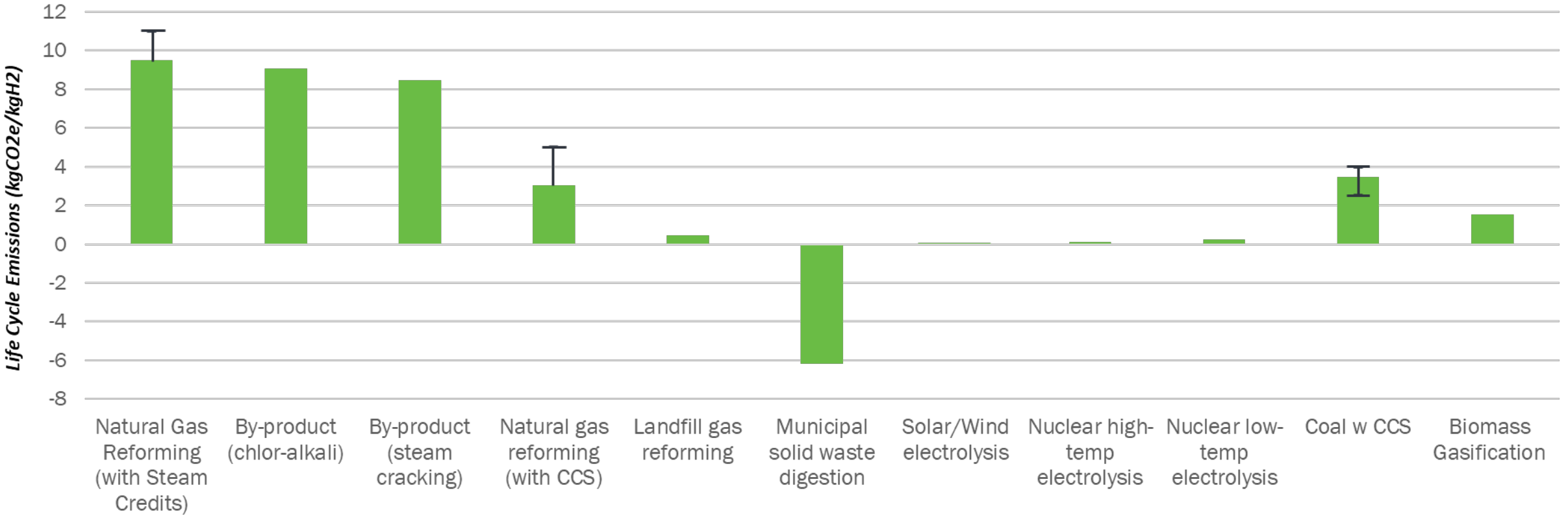
(A) determine whether the definition of clean hydrogen required under paragraph (1)(B) should be adjusted below the standard described in that paragraph; and

(B) if the Secretary determines the adjustment described in subparagraph (A) is appropriate, carry out the adjustment.

Sec. 40313: Goals include "to demonstrate a standard of clean hydrogen production in the transportation, utility, industrial, commercial, and residential sectors by 2040."

GREET GHG Emissions

Identifies life cycle GHG emission from multiple hydrogen pathways



Ranges shown reflect potential variability in upstream leak rates, CCS efficiency, and capture rates. Baseline assumes 90% capture.

Source: Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies Model 2021, https://greet.es.anl.gov/

For more information, see GREET documentation or the October H2IQHr: https://www.energy.gov/eere/fuelcells/2021-hydrogen-and-fuel-cell-technologies-office-webinar-archives#date10282021

Sec 40314 (EPACT Sec. 813): Regional Clean Hydrogen Hubs

(a) DEFINITION OF REGIONAL CLEAN HYDROGEN HUB.—In this section, the term ‘regional clean hydrogen hub’ means a network of clean hydrogen producers, potential clean hydrogen consumers, and connective infrastructure located in close proximity.

(b) ESTABLISHMENT OF PROGRAM.—The Secretary shall establish a program to support the development of at **least 4 regional clean hydrogen hubs** that—

(1) demonstrably aid the achievement of the clean hydrogen production standard developed under section 822(a);

(2) demonstrate the production, processing, delivery, storage, and end-use of clean hydrogen; and

(3) can be developed into a national clean hydrogen network to facilitate a clean hydrogen economy.

Definition and Emphasis for Hydrogen Hubs

Hub Definition: ***a network of clean hydrogen producers, potential clean hydrogen consumers, and connective infrastructure located in close proximity.***

Purpose:

1. Demonstrably aid the achievement of the **clean hydrogen production standard**;

Metrics & Measurement

2 kg CO_2/kg H_2

2. Demonstrate the **production, processing, delivery, storage, and end-use** of **clean** hydrogen;

All components needed and must be clean H_2

3. Can be **developed into a national clean hydrogen network** to facilitate a clean hydrogen economy.

Solicitation and Selection of Regional Clean Hydrogen Hubs

(c) SELECTION OF REGIONAL CLEAN HYDROGEN HUBS.—

(1) SOLICITATION OF PROPOSALS.—Not later than 180 days after the date of enactment of the Infrastructure Investment and Jobs Act, the Secretary shall solicit proposals for regional clean hydrogen hubs.

(2) SELECTION OF HUBS.—Not later than 1 year after the deadline for the submission of proposals under paragraph (1), the Secretary shall select at least 4 regional clean hydrogen hubs to be developed under subsection (b).

(3) CRITERIA.—The Secretary shall select regional clean hydrogen hubs under paragraph (2) using the following criteria:

Selection of Regional Clean Hydrogen Hubs – continued

(3) CRITERIA.—The Secretary shall select regional clean hydrogen hubs under paragraph (2) using the following criteria:

(A) FEEDSTOCK DIVERSITY.—To the maximum extent practicable—

(i) at least 1 regional clean hydrogen hub shall demonstrate the production of clean hydrogen from fossil fuels;

(ii) at least 1 regional clean hydrogen hub shall demonstrate the production of clean hydrogen from renewable energy; and

(iii) at least 1 regional clean hydrogen hub shall demonstrate the production of clean hydrogen from nuclear energy.

Selection of Regional Clean Hydrogen Hubs – continued

(B) END-USE DIVERSITY.—To the maximum extent practicable—

(i) at least 1 regional clean hydrogen hub shall demonstrate the end-use of clean hydrogen in the electric power generation sector;

(ii) at least 1 regional clean hydrogen hub shall demonstrate the end-use of clean hydrogen in the industrial sector;

(iii) at least 1 regional clean hydrogen hub shall demonstrate the end-use of clean hydrogen in the residential and commercial heating sector; and

(iv) at least 1 regional clean hydrogen hub shall demonstrate the end-use of clean hydrogen in the transportation sector.

(C) GEOGRAPHIC DIVERSITY.—To the maximum extent practicable, each regional clean hydrogen hub—

(i) shall be located in a different region of the United States; and

(ii) shall use energy resources that are abundant in that region.

Selection of Regional Clean Hydrogen Hubs – continued

(D) HUBS IN NATURAL GAS-PRODUCING REGIONS.—To the maximum extent practicable, at least 2 regional clean hydrogen hubs shall be located in the regions of the United States with the greatest natural gas resources.

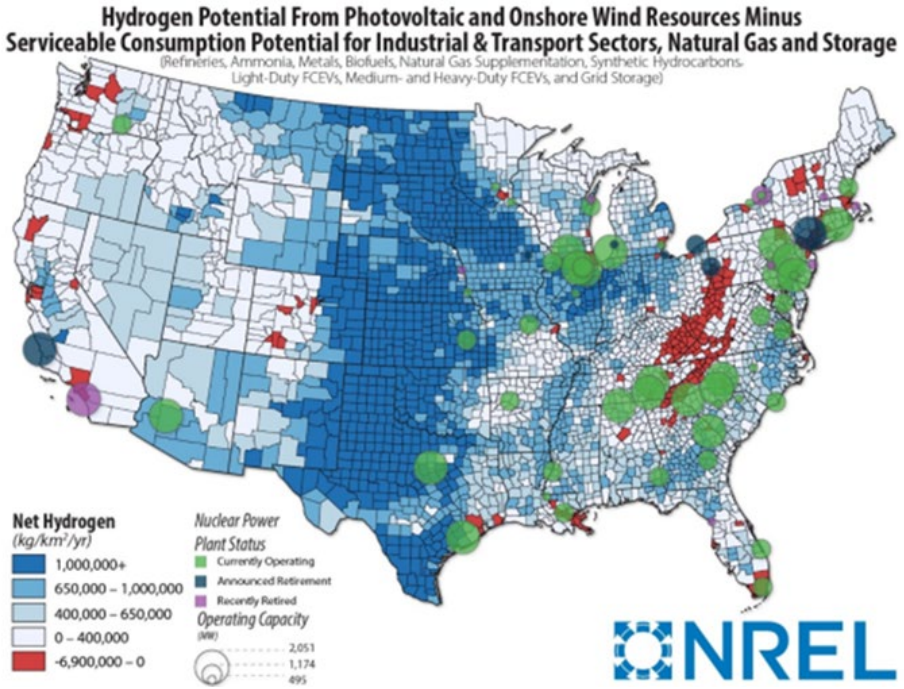
(E) EMPLOYMENT.—The Secretary **shall give priority to regional clean hydrogen hubs that are likely to create opportunities for skilled training and long-term employment to the greatest number of residents of the region.**

(F) ADDITIONAL CRITERIA.—The Secretary may take into consideration other criteria that, in the judgment of the Secretary, are necessary or appropriate to carry out this title

(4) FUNDING OF REGIONAL CLEAN HYDROGEN HUBS.—The Secretary may make grants to each regional clean hydrogen hub selected under paragraph (2) to accelerate commercialization of, and demonstrate the production, processing, delivery, storage, and end-use of, clean hydrogen.

$8,000,000,000 for the period of fiscal years 2022 through 2026.

H2@Scale Analysis of Hydrogen Supply and Demand



Most regions have sufficient resources to meet even aggressive increase in hydrogen demand

3 analysis reports completed in 2020-2021:

- Determined **regional technical potential** of hydrogen supply. [1]
- Assessed **price points and market potential** for hydrogen in 8 sectors. [2]
- Assessed **growth potential for hydrogen supply and demand** in 5 scenarios. [3]

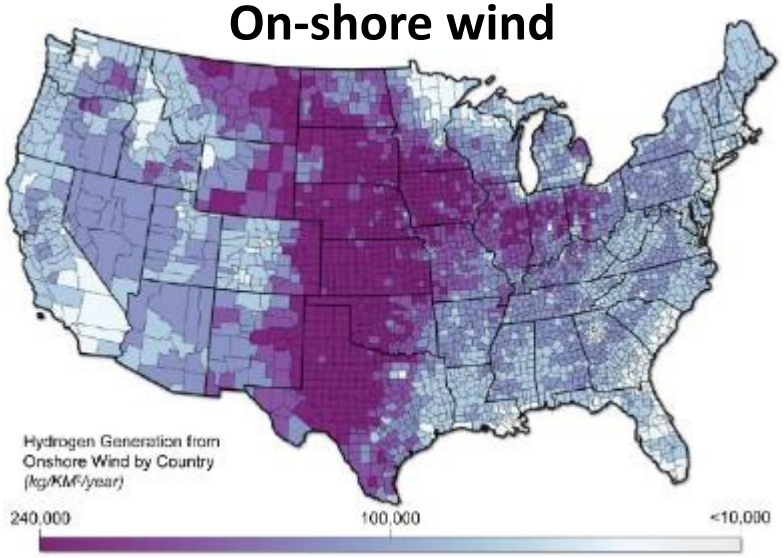
DOE supported models enable GHG emission analysis for hydrogen pathways:

- **Life Cycle Analysis (LCA) informs** annual updates to Argonne National Laboratory's Greenhouse gases, Regulated Emissions, and Energy Use in Technologies **(GREET) model**[4]
- **Updates to Global Change Analysis Model** (GCAM, Pacific Northwest National Laboratory, University of Maryland) underway to **simulate hydrogen demand** given drivers for decarbonization

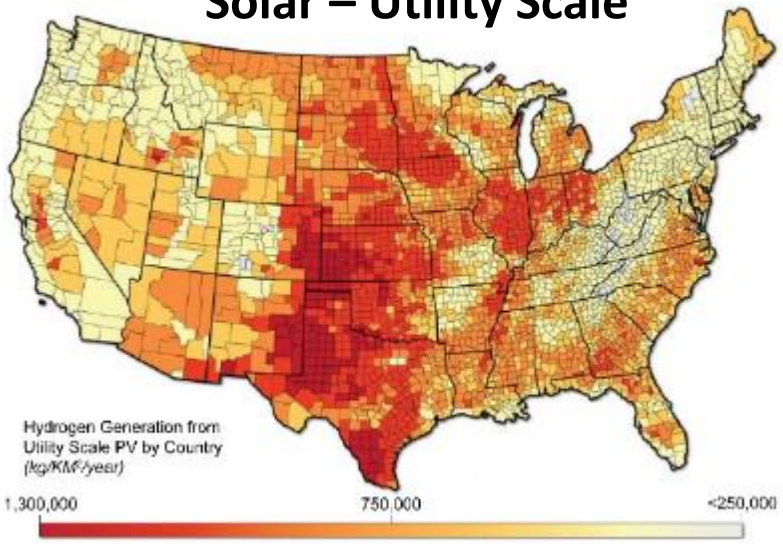
1. https://www.nrel.gov/docs/fy20osti/77198.pdf
2. https://greet.es.anl.gov/publication-us_future_h2
3. https://www.nrel.gov/docs/fy21osti/77610.pdf
4. https://greet.es.anl.gov/greet.models

Examples of Resource Analysis

On-shore wind



Solar – Utility Scale



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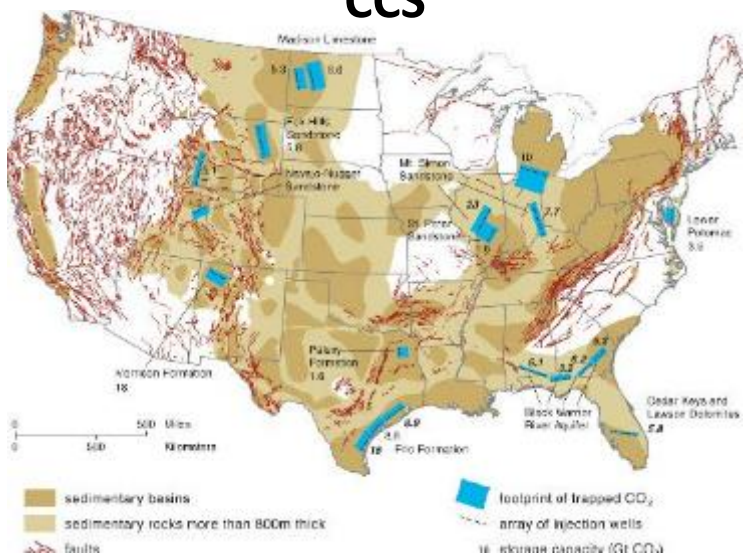
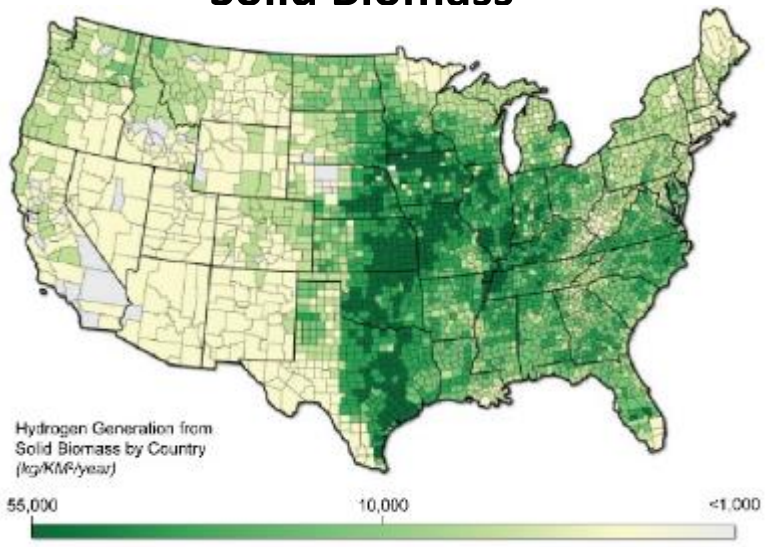
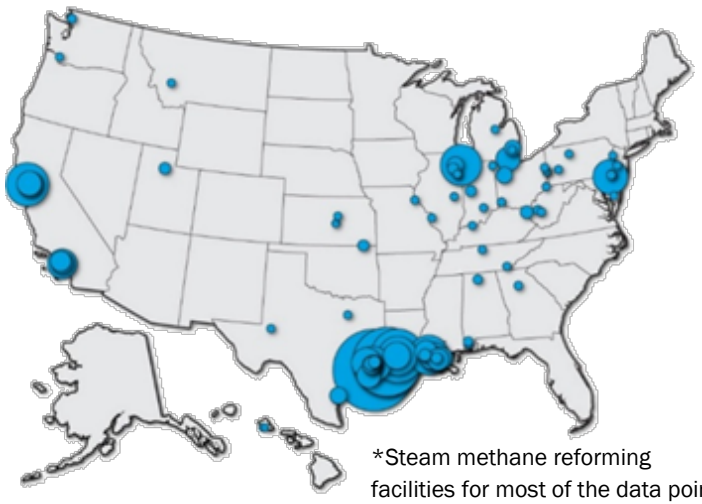


Solid Biomass



Nuclear

Natural Gas*



*Steam methane reforming facilities for most of the data points.

Sec 40314 (EPACT Sec. 816): Clean Hydrogen Electrolysis Program

(a) DEFINITIONS.—In this section:

(1) ELECTROLYSIS.—The term ‘electrolysis’ means a process that uses electricity to split water into hydrogen and oxygen.

(2) ELECTROLYZER.—The term ‘electrolyzer’ means a system that produces hydrogen using electrolysis.

(3) PROGRAM.—The term ‘program’ means the program established under subsection (b).

(b) ESTABLISHMENT.—Not later than 90 days after the date of enactment of the Infrastructure Investment and Jobs Act, the Secretary shall establish a research, development, demonstration, commercialization, and deployment program for purposes of commercialization to improve the efficiency, increase the durability, and reduce the cost of producing clean hydrogen using electrolyzers.

Clean Hydrogen Electrolysis Program – continued

(c) GOALS.—The goals of the program are—

(1) to reduce the cost of hydrogen produced using electrolyzers to less than $2 per kilogram of hydrogen by 2026; and

(2) any other goals the Secretary determines are appropriate.

(d) DEMONSTRATION PROJECTS.—In carrying out the program, the Secretary shall fund demonstration projects—

(1) to demonstrate technologies that produce clean hydrogen using electrolyzers; and

(2) to validate information on the cost, efficiency, durability, and feasibility of commercial deployment of the technologies described in paragraph (1).

Clean Hydrogen Electrolysis Program – continued

(e) FOCUS.—The program shall focus on research relating to, and the development, demonstration, and deployment of—

(1) low-temperature electrolyzers, including liquid-alkaline electrolyzers, membrane-based electrolyzers, and other advanced electrolyzers, capable of converting intermittent sources of electric power to clean hydrogen with enhanced efficiency and durability;

(2) high-temperature electrolyzers that combine electricity and heat to improve the efficiency of clean hydrogen production;

(3) advanced reversible fuel cells that combine the functionality of an electrolyzer and a fuel cell;

(4) new highly active, selective, and durable electrolyzer catalysts and electro-catalysts that—

(A) greatly reduce or eliminate the need for platinum group metals; and

(B) enable electrolysis of complex mixtures with impurities, including seawater;

(5) modular electrolyzers for distributed energy systems and the bulk-power system (as defined in section 215(a) of the Federal Power Act (16 U.S.C. 824o(a)));

Clean Hydrogen Electrolysis Program – continued

(6) low-cost membranes or electrolytes and separation materials that are durable in the presence of impurities or seawater;

(7) improved component design and material integration, including with respect to electrodes, porous transport layers and bipolar plates, and balance-of-system components, to allow for scale-up and domestic manufacturing of electrolyzers at a high volume;

(8) clean hydrogen storage technologies;

(9) technologies that integrate hydrogen production with—

(A) clean hydrogen compression and drying technologies;

(B) clean hydrogen storage; and

(C) transportation or stationary systems; and

(10) integrated systems that combine hydrogen production with renewable power or nuclear power generation technologies, including hybrid systems with hydrogen storage.

$1,000,000,000 for the period of fiscal years 2022 through 2026

Sec 40314 (EPACT Sec. 815): Clean Hydrogen Manufacturing and Recycling

(2) PRIORITY.—In awarding grants or entering into contracts, cooperative agreements, or other agreements under paragraph (1), the Secretary, to the maximum extent practicable, shall give priority to clean hydrogen equipment manufacturing projects that—

(A) increase efficiency and cost-effectiveness in

(i) the manufacturing process; and

(ii) the use of resources, including existing energy infrastructure;

(B) support domestic supply chains for materials and components;

(C) identify and incorporate nonhazardous alternative materials for components and devices;

(D) operate in partnership with tribal energy development organizations, Indian Tribes, Tribal organizations, Native Hawaiian community-based organizations, or territories.

(E) are located in economically distressed areas of the major natural gas-producing regions

Clean Hydrogen Manufacturing and Recycling – continued

(1) Research, development, and demonstration projects to create innovative and practical approaches to increase the reuse and recycling of clean hydrogen technologies, including by—

(A) increasing the efficiency and cost-effectiveness of the recovery of raw materials from clean hydrogen technology components and systems, including enabling technologies such as electrolyzers and fuel cells;

(B) minimizing environmental impacts from the recovery and disposal processes;

(C) addressing any barriers to the research, development, demonstration, and commercialization of technologies and processes for the disassembly and recycling of devices used for clean hydrogen production, processing, delivery, storage, and use;

(D) developing alternative materials, designs, manufacturing processes, and other aspects of clean hydrogen technologies;

(E) developing alternative disassembly and resource recovery processes that enable efficient, cost-effective, and environmentally responsible disassembly of, and resource recovery from, clean hydrogen technologies; and

(F) developing strategies to increase consumer acceptance of, and participation in, the recycling of fuel cells.

$500,000,000 for the period of fiscal years 2022 through 2026

BIL – Language on Targets

"No later than 180 days after the date of enactment of the Infrastructure Investment and Jobs Act, the Secretary shall establish targets for the program to address near-term (up to 2 years), mid-term (up to 7 years), and long-term (up to 15 years) challenges to the advancement of clean hydrogen systems and technologies."

H_2 Matchmaker Tool

H_2 Matchmaker:
A Voluntary Tool to Facilitate Hub Formation

U.S. DEPARTMENT OF ENERGY

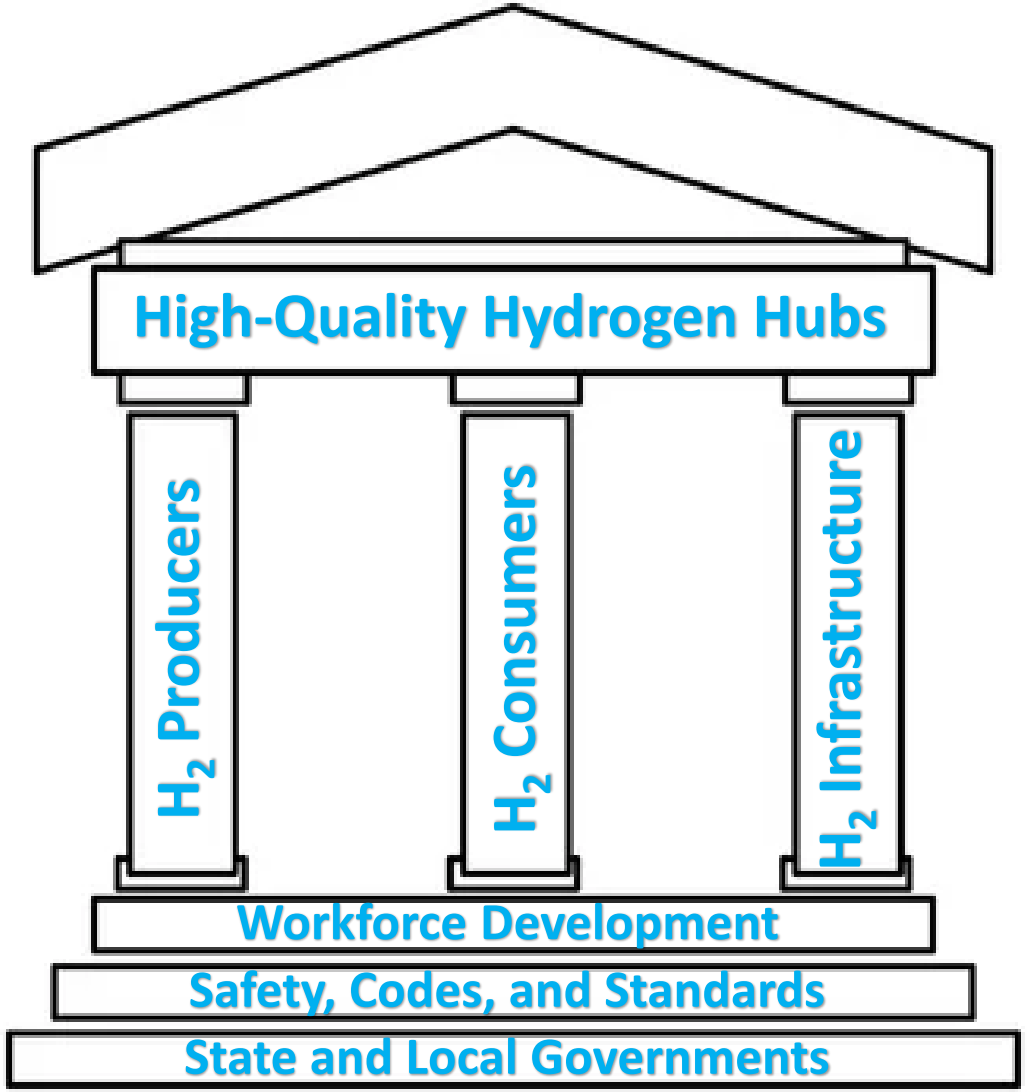
Vision

An interactive online map and database containing self reported hydrogen producers, consumers, infrastructure operators, and other stakeholders.

Objectives

- Assist with the formation of high-quality teams for hydrogen hubs and provide broader hydrogen stakeholder tracking and support for future efforts
- Increase regional hydrogen project awareness and opportunities for technology developers and suppliers
- Foster partnerships and catalyze investments and deployment of hydrogen production, storage, and distribution infrastructure by region
- Promote regional business development opportunities by providing hydrogen supply and demand maps for current and planned projects

Scope And Process



Example Stakeholders

H_2 Producers & Source

- Renewables
- Fossil Fuels (+CCS)
- Nuclear

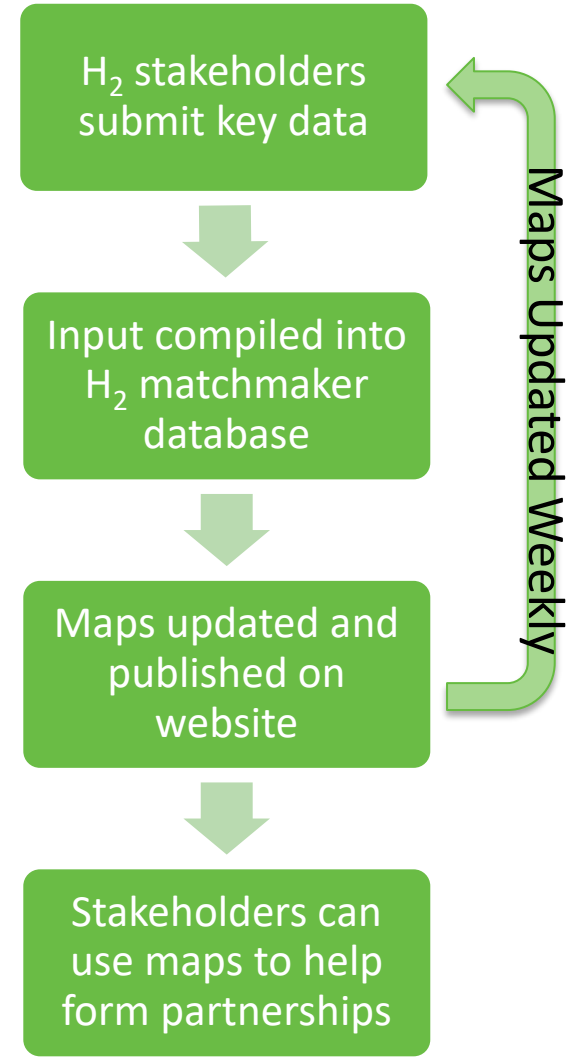
H_2 Consumers

- Electrical power production
- Industrial use
- Residential and commercial heating
- Transportation

H_2 Infrastructure Operators

- H_2 bulk storage
- H_2 compatible pipelines
- Fueling Stations
- H_2 delivery solutions

Matchmaker Process

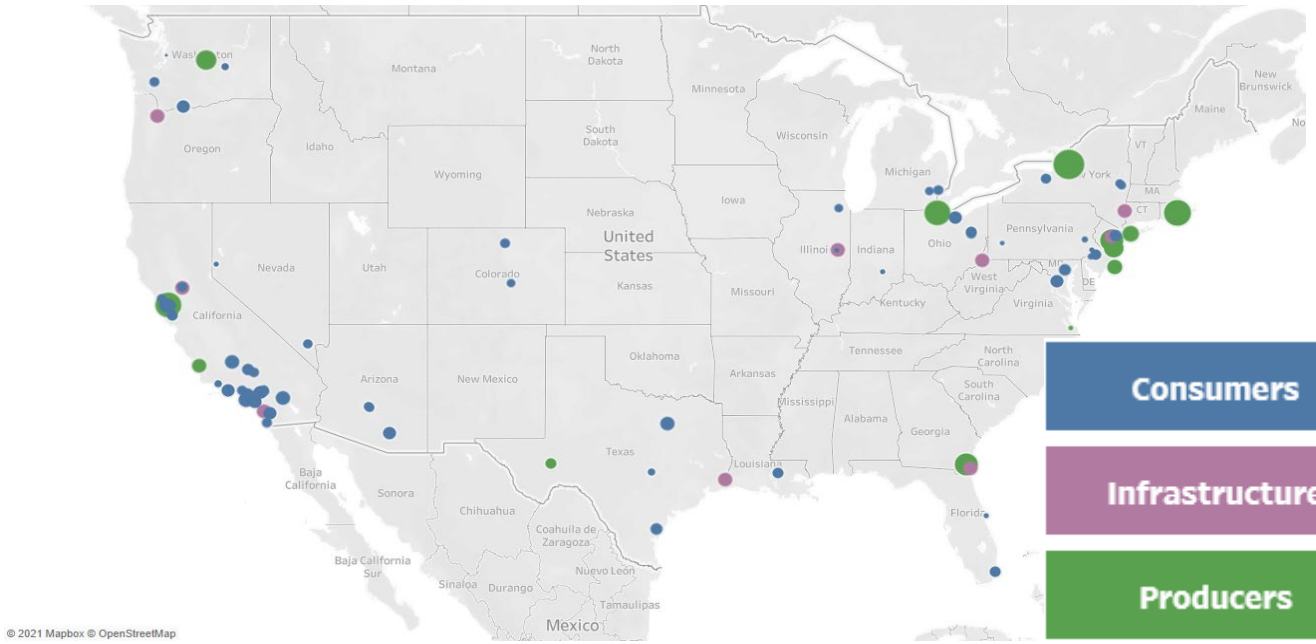


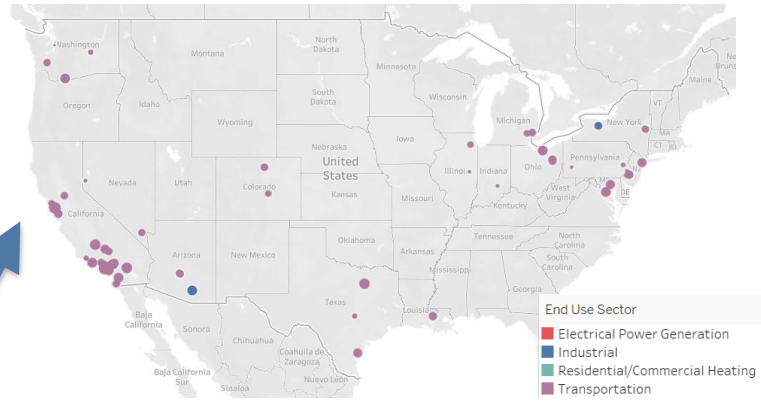
Interactive Maps

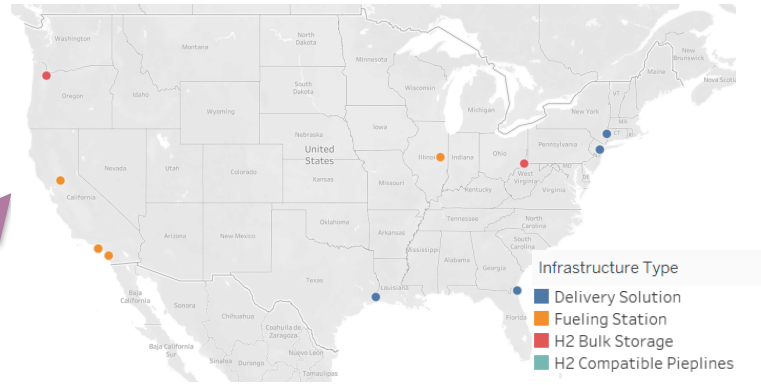
Information submitted by stakeholders will be compiled into interactive maps which will overlay:

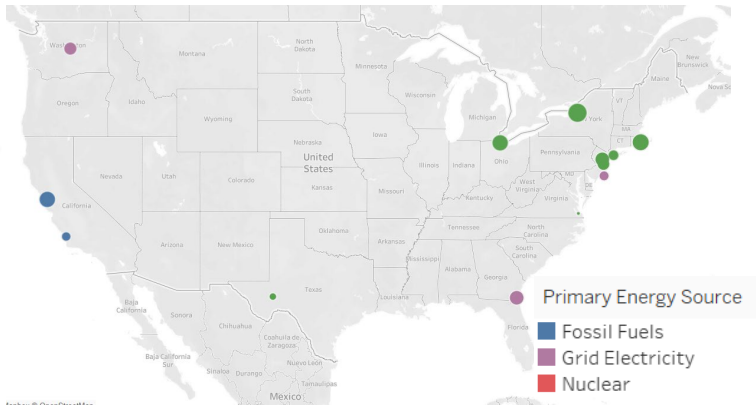
- Hydrogen producers
- Infrastructure providers
- Hydrogen consumers
- Supporting Stakeholders

Example Data for Illustrative Purposes Only



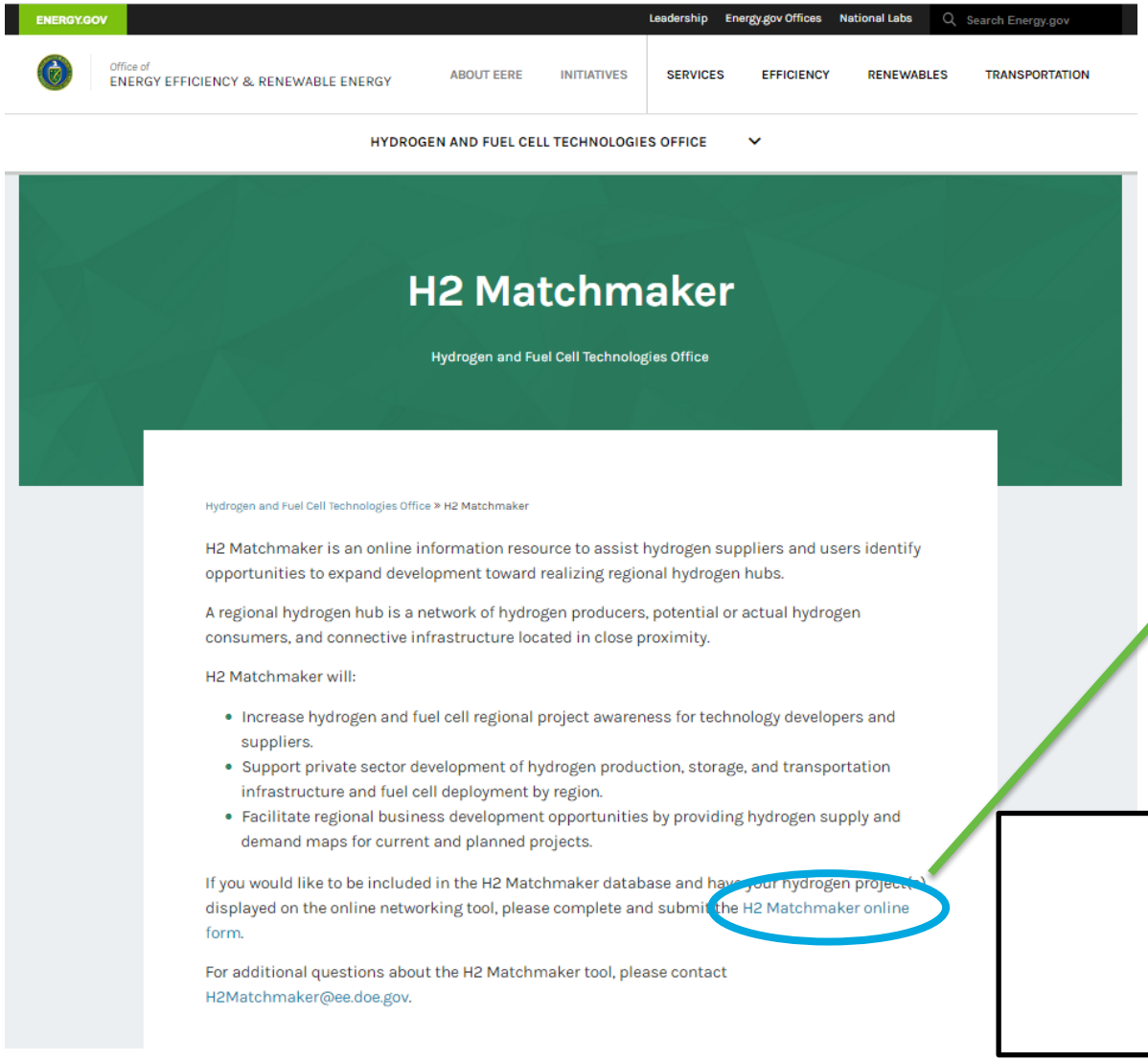


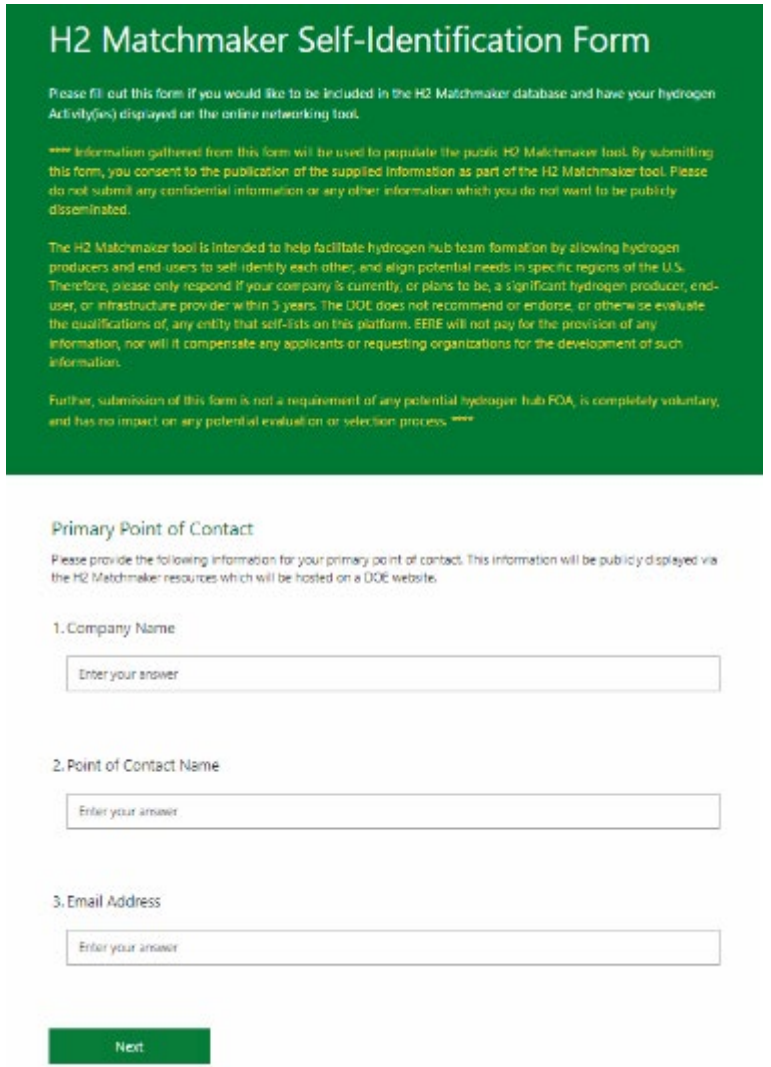




Website and Input Form

https://www.energy.gov/eere/fuelcells/h2-matchmaker





Rollout Timeline

U.S. DEPARTMENT OF ENERGY

December 2021	January 2022	February 2022
Input Form Launched	H2 Matchmaker Database Published, "Beta Testing"	Interactive Maps Published
https://www.energy.gov/eere/fuelcells/h2-matchmaker	Provides early access to companies that have self-identified	Full access to the interactive maps and company listing

Please email any questions to H2Matchmaker@ee.doe.gov

Disclaimers

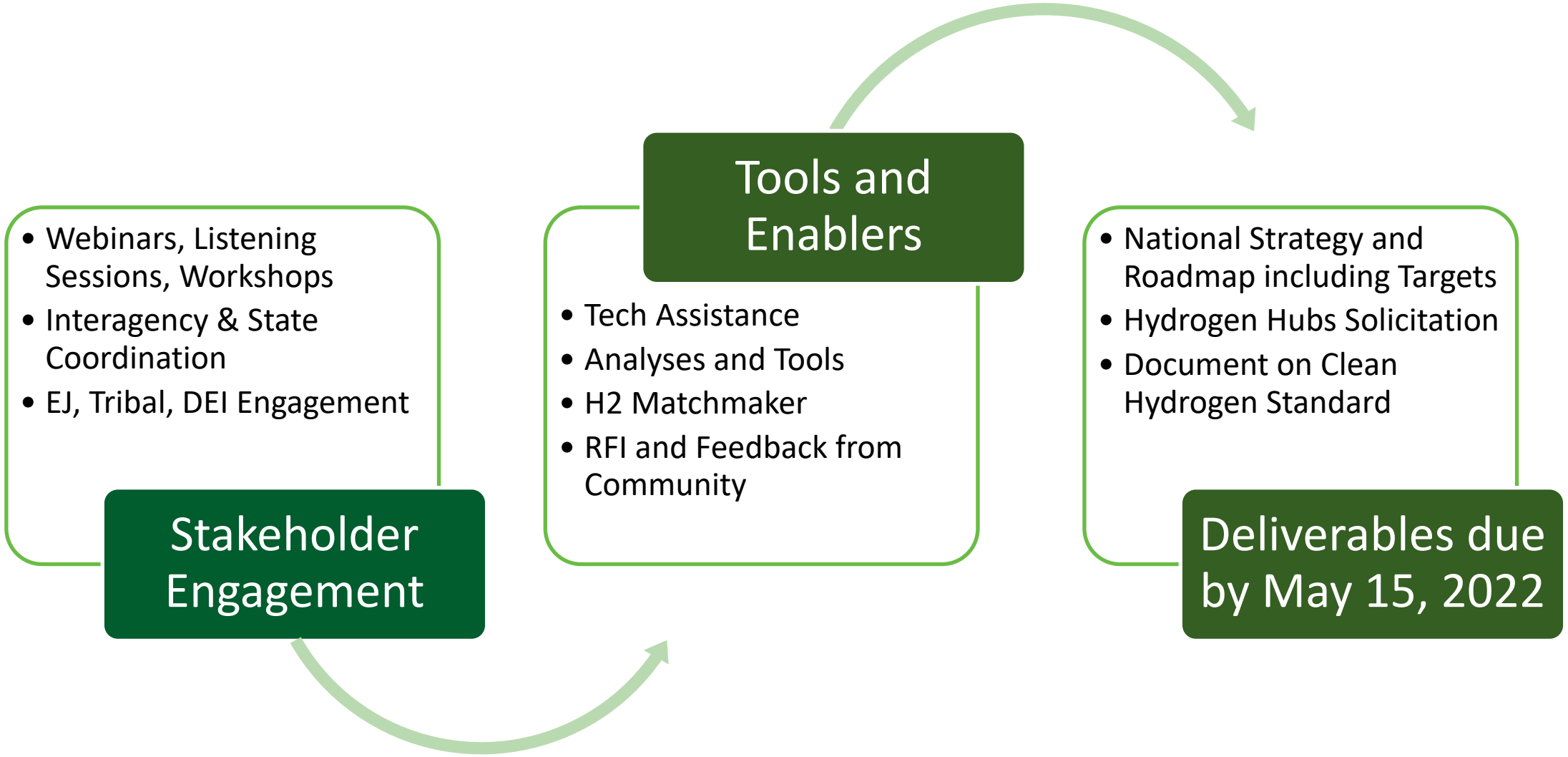
- Information gathered from this form will be used to populate the public H2 Matchmaker tool. By submitting this form, you consent to the publication of the supplied information as part of the H2 Matchmaker tool. Please do not submit any confidential information or any other information which you do not want to be publicly disseminated.

- The H2 Matchmaker tool is intended to help facilitate hydrogen hub team formation by allowing hydrogen producers and end-users to self-identify each other and align potential needs in specific regions of the U.S. Therefore, please only respond if your company is currently, or plans to be, a significant hydrogen producer, end-user, or infrastructure provider within 5 years. The DOE does not recommend, endorse, or otherwise evaluate the qualifications of any entity that self-lists on this platform. DOE will not pay for the provision of any information, nor will it compensate any applicants or requesting organizations for the development of such information.

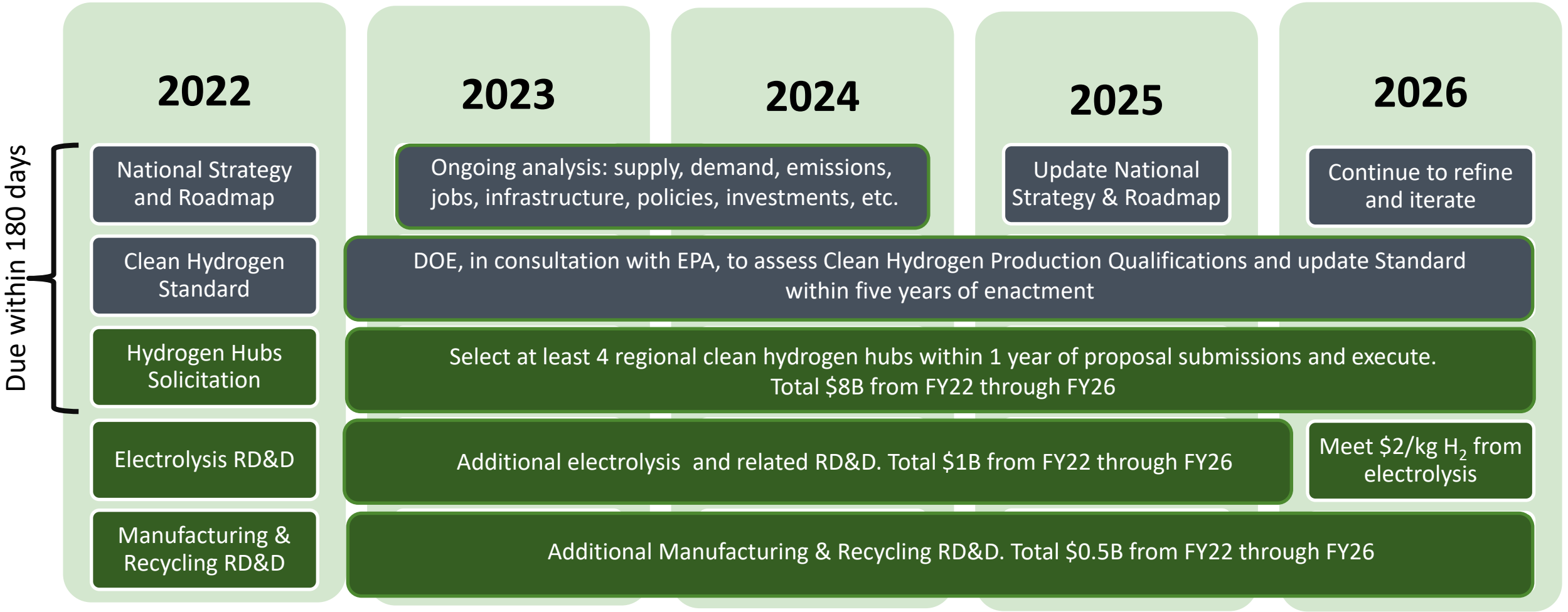
- Further, submission of this form is completely voluntary and the information submitted will be available to the public. By submitting information for inclusion in the H2 Matchmaker tool, the submitter consents to public disclosure of any information submitted. Submitting this form is not a requirement of any potential hydrogen hub FOA, and has no impact on any potential FOA evaluation or selection process.

Summary and Next Steps

Examples of Hydrogen Activities

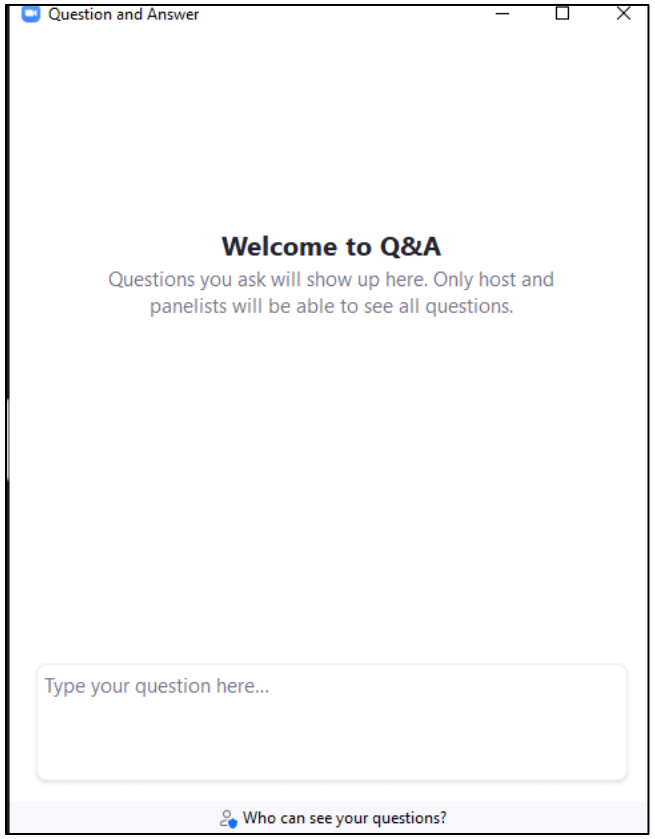


Timeline for Key Hydrogen Provisions



The #H2IQ Hour Q&A

Please type your questions into the **Q&A Box**



The #H2IQ Hour

Thank you for your participation!

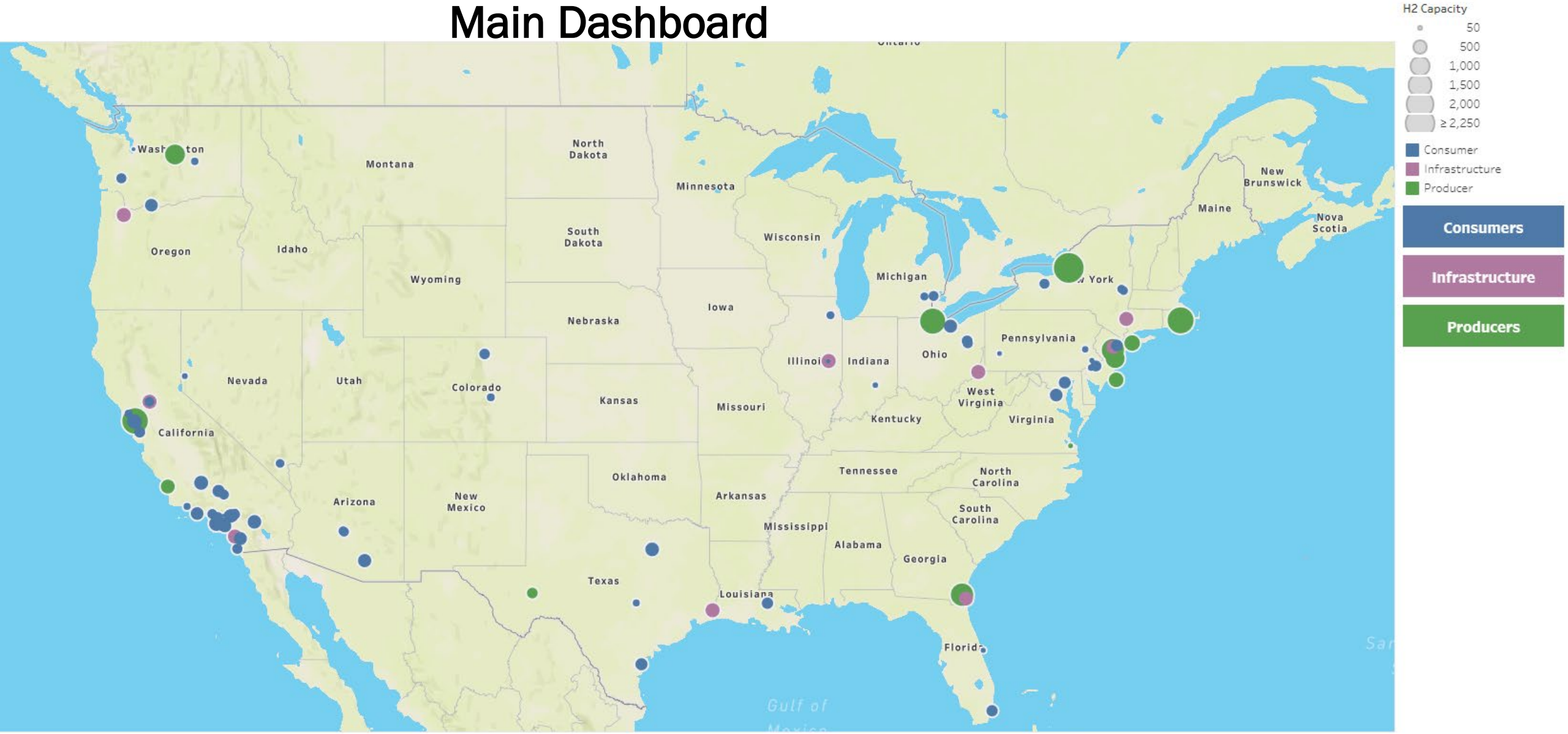
Learn more:
hydrogen.energy.gov

Sign up to receive hydrogen and fuel cell updates
www.energy.gov/eere/fuelcells/fuel-cell-technologies-office-newsletter

Example Maps

U.S. DEPARTMENT OF ENERGY

Main Dashboard



Example Maps

H2 Consumer Dashboard