RFI Themes Overview

Sunita Satyapal and John Litynski, DOE
Breakout Session 4: Deployment and Financing

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

Great Lakes
- Major national corridors
- Nuclear power
- 60,000+ jobs

Central U.S.
- Ample wind
- Geological storage
- Railway transport
- Nuclear resources
- >630,000 tonnes/yr CO₂ reduction

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

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

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

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

California
- Port communities
- Tribal communities
- Extensive renewables
- 8 jobs per $1M invested in H₂
Details by Region

See Backup Slides for Additional Regions
California Regional Cluster Responses

Regional resources for production and infrastructure

- >200 MT/day of gray H₂ in LA
- ~19.2 MT/year of H₂ from curtailed renewables
- >15 miles of dedicated H₂ pipeline in LA Basin
- 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 green H₂ 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
- Improves air quality in Port of LA
- ≥ 41,000 peak construction and more than 2,500 ongoing operations-skilled clean energy jobs
- Diverse racial/ethnic representation

Co-location Potential

- Co-locating hydrogen refueling stations to support MD/HDVs
Gulf Coast Regional Cluster Responses

**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 2000+ jobs for Opportunity Zones in Gulf Region, e.g., 240 new jobs for Donaldsonville, LA in “Cancer Alley” region

**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
Pacific Northwest Regional Cluster Responses

**Regional resources for production and infrastructure**
- Ample hydropower, nuclear, and wind
- 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**
- Diverse tribal and Hispanic communities
- Fugitive gas and CCS can transition current oil and gas jobs

**Co-location Potential**
- Projects on land owned by local tribe
- Estimates 8 jobs per $1m invested in H₂ infrastructure
- Projects in areas with 30%-65% non-white population
Appalachia Regional Cluster Responses

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 H₂ storage throughout

End Users, Cost, Value Proposition

- H₂ 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 CO₂/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
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**
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?
Responses related to storage, infrastructure, fossil resources by region

- Gulf Coast (Including TX & LA)
- Mountain West/ Midwest
- Northeast/Appalachia
- Southeast/Mid-Atlantic
- West Coast/Southwest

The chart shows the number of responses with Integrated Coal, Carbon, and Hydrogen (ICCM) Interests across different regions, categorized by Private Sector, Government, and Academic sectors.
Examples of Popular Terms used by Respondents

- gulf coast
- SMR
- natural gas pipeline
- electrolysis
- carbon capture
- salt cavern
- production
- carbon dioxide
- production site
- large storage volume
- storage
- CCUS
- nat gas
- carbon capture technology
- production methods
- co2 emissions
- cubic feet
- local geological formation
- natural gas infrastructure
- steam methane reforming
- natural gas storage
- solid oxide fuel
- co2 storage
- west texas
- co2 emissions
- enhanced oil recovery
- blended production methods
- tons of co2
- reversible solid oxide
- natural gas processing
Examples of Popular Terms using “Hydrogen” in Response
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Next Steps

1. Present in-depth findings through webinars and workshops

2. Organize a series of regional workshops/webinars
   - Include broad stakeholder base in each region
   - Foster communication/collaboration between respondents with common regional focus and conduct analysis & pathway studies
   - Examples of factors to consider:
     - Feedstock, end use, infrastructure, and regional diversity
     - Emissions, economic, and environmental benefit potential
     - Employment and community impact potential
     - Scalability, replicability, sustainability
Thank you!

Active on social media?
#HydrogenShot
Additional Slides
Southwest Regional Cluster Responses

**Regional resources for production and infrastructure**
- Nuclear or underutilized solar/wind power to produce H₂, 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 H₂ fueling infrastructure along heavy freight routes to/from California

**End Users, Cost, Value Proposition**
- H₂ for renewable export to California
- Fuel cell electric buses in Las Vegas region and heavy-duty freight vehicles
- H₂ 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 H₂ 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 H₂ production, fueling stations, and heavy-duty vehicle manufacture
New England Regional Cluster Responses

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 H₂ to produce methane
• H₂ + HCl from wastewater or seawater treatment
• Cross-border cooperative projects with Canada

End Users, Cost, Value Proposition
• Blending of H₂ in MA, NH; with ultimate conversion of NG to 100% H₂ turbine – ~500 tons/yr H₂
• 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 H₂) -32k tons/year
• Replacing diesel fishing vessels with H₂ - ~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 H₂ to methanol for simple storage and transport
Great Lakes Regional Cluster Responses

Regional resources for production and infrastructure
- Limited infrastructure, production potential is from coal, nuclear plants
- Some access to 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
- Ohio has non-attainment areas for air pollution
- 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
Central US Regional Cluster Responses

Regional resources for production and infrastructure

- Ample wind and moderate solar for H₂ production
- Coal resources; uranium ore and plans for nuclear H₂ projects; NH₃ production
- CNG infrastructure in WY and UT can support transition to H₂
- Numerous saline formations, salt caverns, and depleted oil fields for potential storage

End Users, Cost, Value Proposition

- Low-carbon ammonia and ammonium nitrate for and fertilizer markets
- H₂ 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 H₂

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
Alaska and Hawaii Regional Cluster Responses

**Regional resources for production and infrastructure**
- Geothermal, wind, biomass, solar and atmospheric water generation, landfill methane, solid municipal waste, and green waste to H₂
- 100 kW ocean thermal energy electrolyzer under development
- Existing H₂ station, pipelines for storage; distribution by trailers and trucks

**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 H₂ would save 86,000 tonnes/year

**End Users, Cost, Value Proposition**
- Local and public transit, back up power with large scale hydrogen storage for natural disasters in HI
- Export liquid H₂ from geothermal plant with expected cost $3.00-3.35/kg in HI
- Potential for H₂ fueled fishing vessels on Alaskan coast

**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