Colorado H2 Roadmap and Clean Hydrogen Hubs Indian Energy Minerals 2022 Webinar Series

June 2022

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CO AND FED POLICIES AND ACTIONS SET STAGE

- House Bill 19-1261-*Climate Action Plan to Reduce Pollution* with targets for reducing statewide GHG pollution 26% by 2025, 50% by 2030 and 90% by 2050 from 2005 levels;

- Development of a GHG Roadmap to ensure progress towards these targets which found that low-carbon fuels such as hydrogen are essential after 2030 and need to start ramping up between 2025 and 2030;

- Development of the *Opportunities of Low-Carbon Hydrogen in Colorado Roadmap* which identified the actions the state could take to develop a hydrogen economy and called for us to undertake pilots and develop a H2 Hub;

CO AND FED POLICIES AND ACTIONS SET STAGE

- The 2021 Federal Infrastructure Investment and Jobs Act (IIJA) allocated $8 billion in funding for four or more regional hydrogen hubs (one month after we released or H2 plan calling for the development of hubs)

- Western Inter-States Hydrogen Hub MOU- Feb 23, 2022- between Colorado, Wyoming, New Mexico and Utah- establishes a framework for coordinating and developing a hub in response to the opportunity in the IIJA

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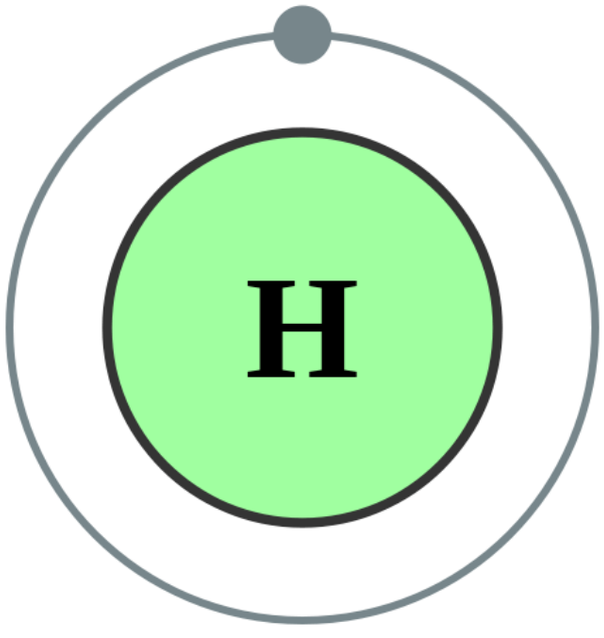
Colorado Low-Carbon Hydrogen Roadmap 2021

Project Objective: a Colorado Low-Carbon Hydrogen Roadmap that is based upon:

- Definition of low-carbon hydrogen for Colorado;
- State of the hydrogen market in world, US and Colorado;
- Opportunities for hydrogen in Colorado;
- Steps Colorado could take to overcome barriers to build a hydrogen economy and;
- Economic potential of a Colorado hydrogen economy.

Final deliverable: Roadmap for the next 15-year period with:

- Key Success Factors
- Recommended Actions
- Production and Investment Targets



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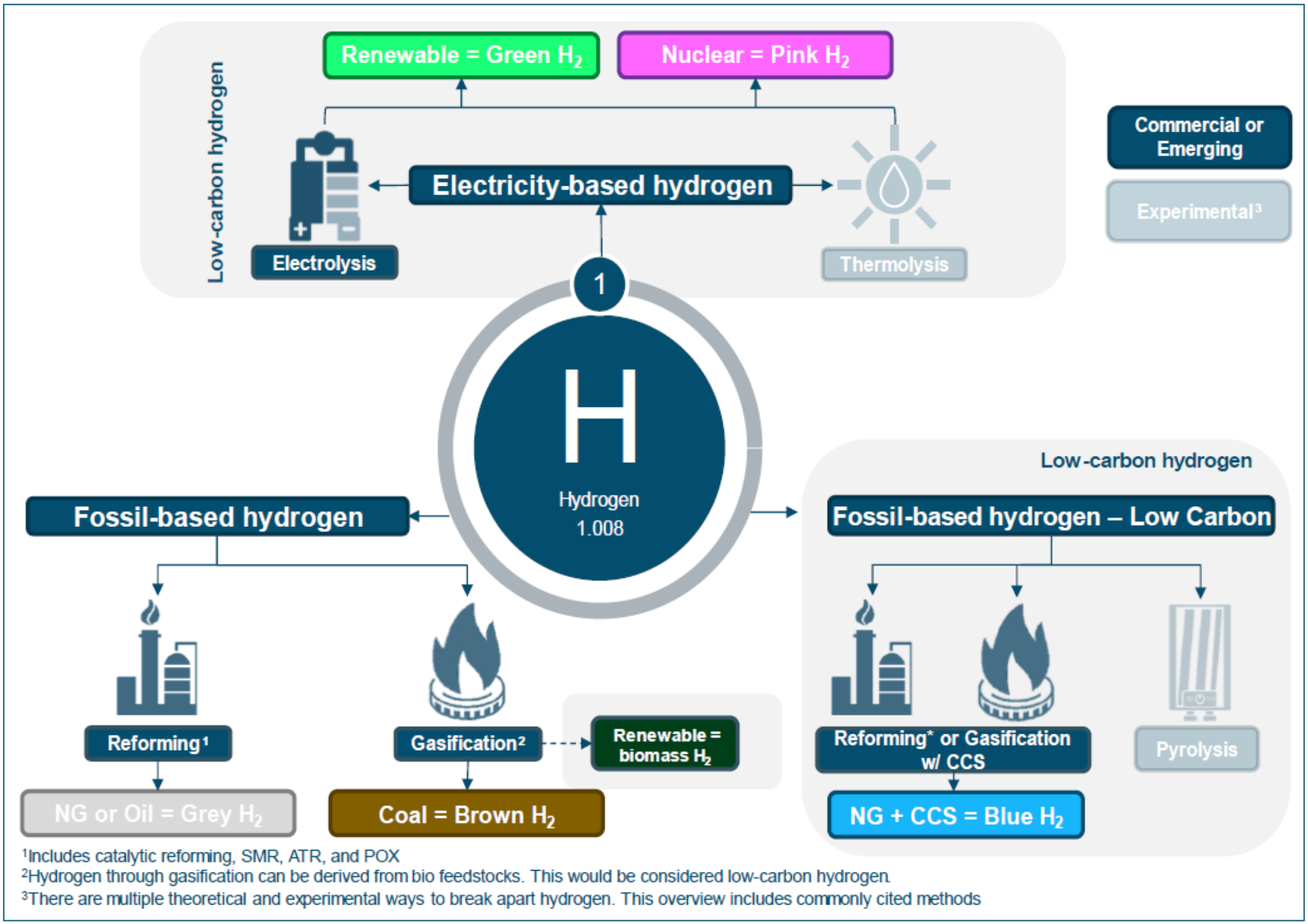
What is Low-Carbon Hydrogen?



[1]Includes catalytic reforming, SMR, ATR, and POX
[2]Hydrogen through gasification can be derived from bio feedstocks. This would be considered low-carbon hydrogen.
[3]There are multiple theoretical and experimental ways to break apart hydrogen. This overview includes commonly cited methods

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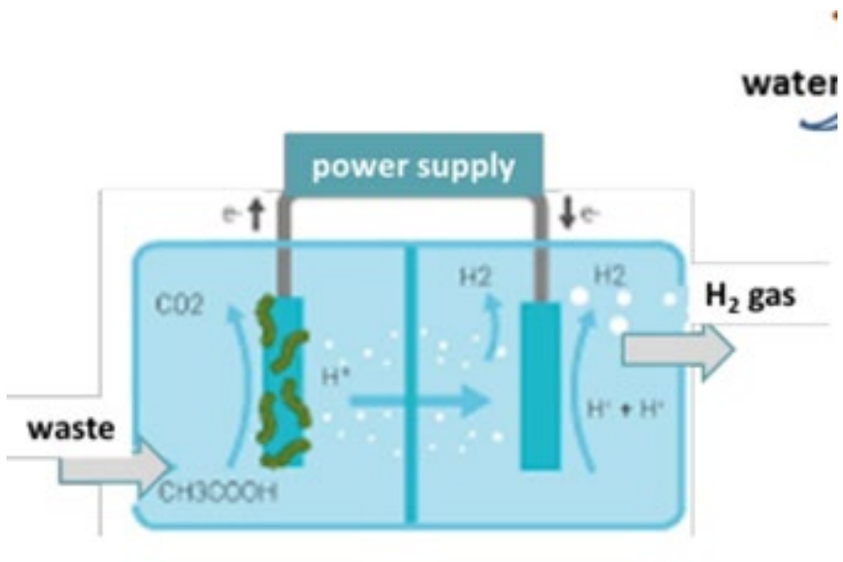
What is Low-Carbon Hydrogen?

Defined in the roadmap as:

-Hydrogen produced with significantly reduced life-cycle GHG emission compared to existing hydrogen production and encompasses both:

-Green hydrogen from renewable electricity and,

-Blue hydrogen produced from fossil-based source with Carbon Capture and Storage



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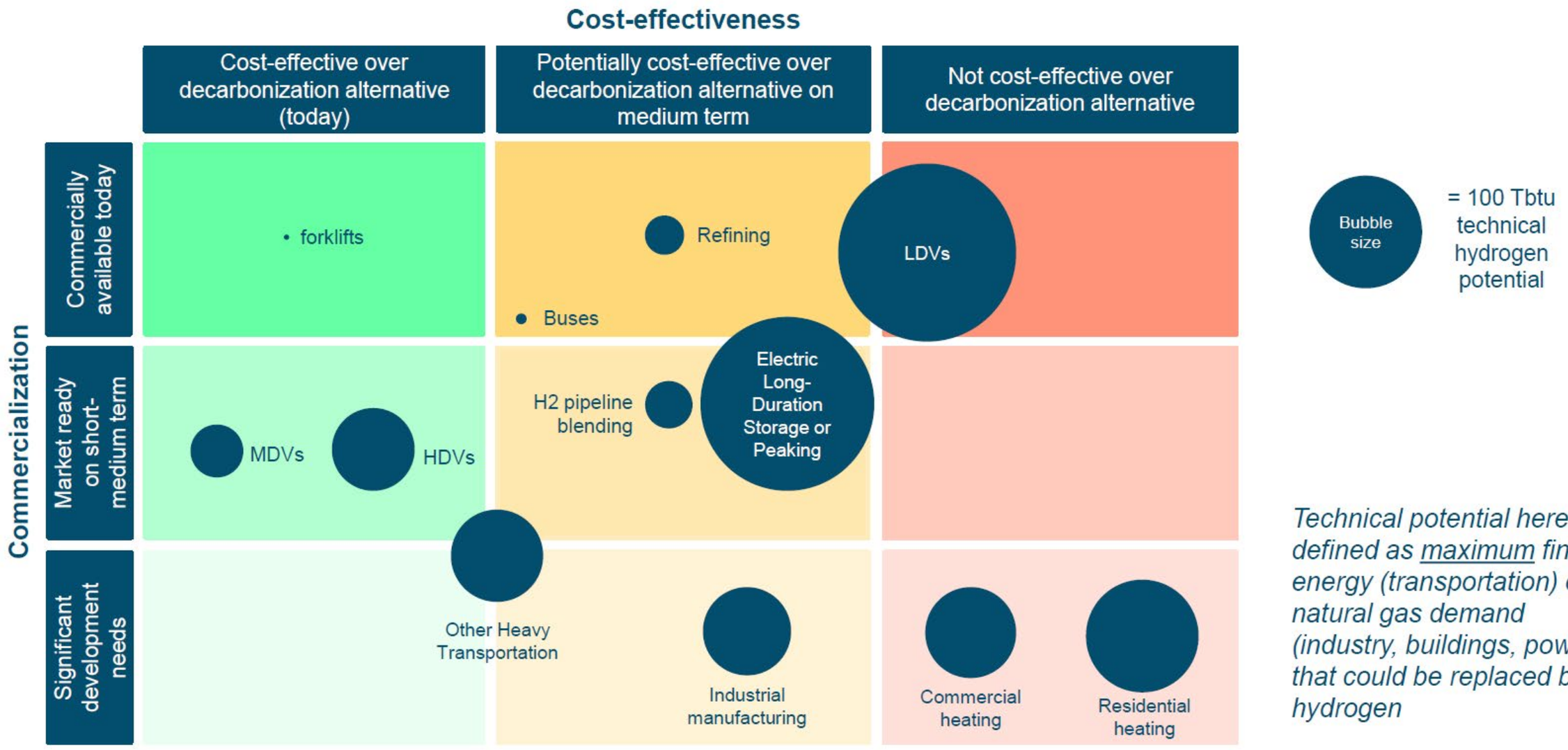
Opportunities for hydrogen by end-use application

Conceptual overview of mid-term (2030) hydrogen potential in Colorado



Technical potential here defined as <u>maximum</u> final energy (transportation) or natural gas demand (industry, buildings, power) that could be replaced by hydrogen

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Most Promising H2 Applications in CO

Short term (0-5 years):

-Medium and heavy duty vehicle sector -Where some use cases are already cost-effective over other decarbonization alternatives such as Battery Electric Vehicles (BEVs)

Medium Term (5-10 years)

-Electric Sector –especially as emission targets increase and the need for long duration storage increases

-Hydrogen could replace natural gas use for electric peaking generation

-High-temperature industrial processes

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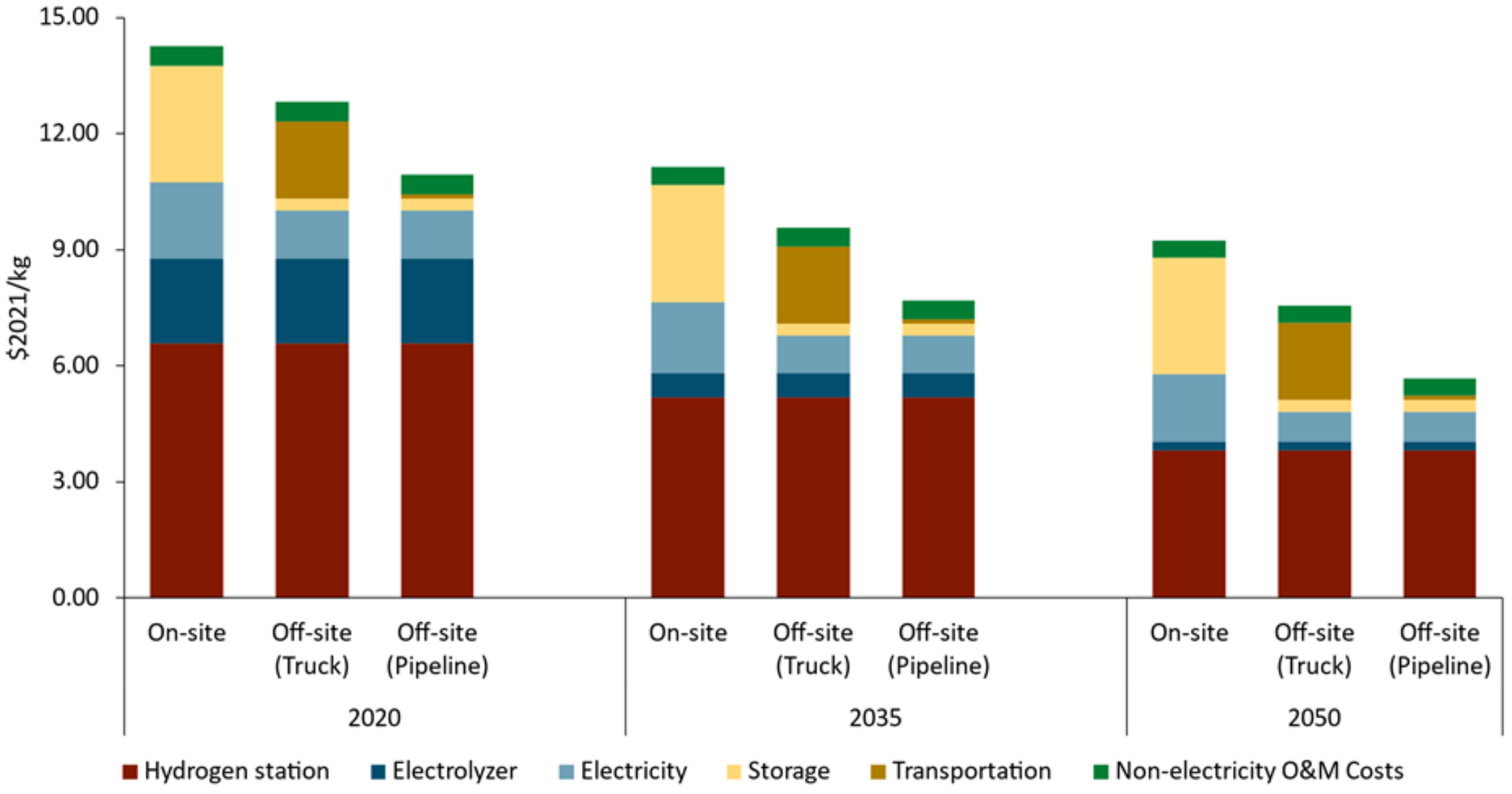
Estimated hydrogen refueling costs in CO



By 2030 the study finds H2 would need to be $6-8/kg to be cost competitive with diesel

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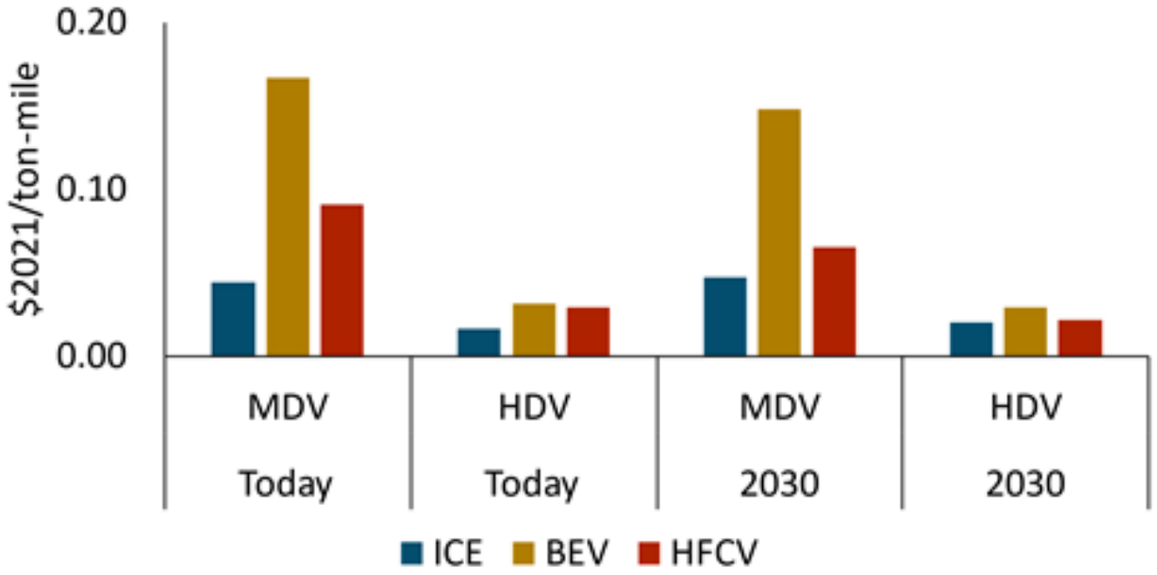
-Pump prices using off-site hydrogen production remain the more cost-effective option compared to on-site production, both now and in the future,

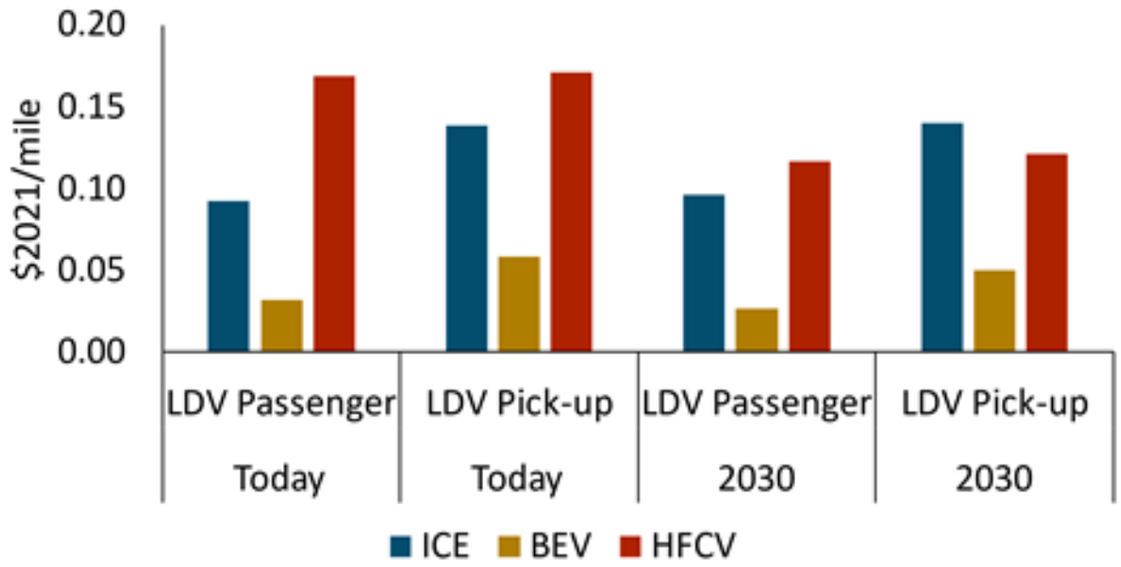
-Because, electrolyzers using electricity from the grid may have higher electricity prices than using off-grid electricity (like excess solar and wind)

-However, off-site production, especially by pipeline, requires more advanced infrastructure that is likely to become viable only at scale.

-Pump prices across all scenarios are expected to decline as electrolyzer costs decline and station cost economics improve with scale and higher utilization rates.

Operational Costs for HFCEV vs alternatives





-In the HDV segment, hydrogen is shown to be a cost-effective solution compared to electric vehicles, both now and in the future, on a per weight basis.

-Because, HD-EVs are projected to have a significantly lower carrying capacity than a diesel or HFCEV. Most public roadways have an 80,000lb weight limit for vehicles, the greater unladen weight of electric trucks, due to onboard batteries, is a competitive disadvantage because it results in lower cargo capacity and therefore higher costs per ton of cargo shipped.

- In the LDV segment, the study estimates that BEVs will remain a more operationally cost-effective option both today and in the next decade as a result of significantly better fuel economies and lower fuel costs than equivalent LDV FCEVs.

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Recommended Actions

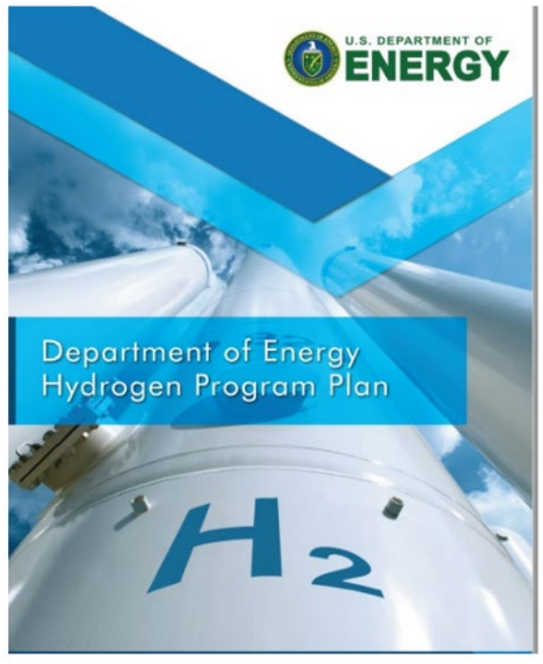
The Roadmap suggests the following actions:

- Develop a hydrogen plan
  - Contain renewable hydrogen production target
    - Based upon scenario modeling in Roadmap of 45,000 (growth scenario)-85,000 (transformative scenario) metric tons requiring capital investments of $310 (growth scenario) - $1,200 (transformative scenario) million
  - Contain target for development of vehicle refueling stations potentially in centralized areas or hubs
    - Based upon scenario modeling for 4,000-20,000 MHDV H2 vehicles on the road by 2030, between 30 (growth scenario) to 150 (transformative scenario) stations would be required with an investment between $66 - $330 million
- Investigate market interest and feasibility of regional early-development hydrogen hubs
- Develop pilot projects on the use of hydrogen in the power sector
- Develop pilots related to blending of hydrogen in existing gas infrastructure
- Issue a Request for Information to potential hydrogen market participants to assess the feasibility of developing pilots and/or geographically-based hydrogen hubs in the state

Hubs in 2021 Infrastructure Investment and Jobs Act (IIJA)

- Allocates $8 billion for four or more regional hydrogen hubs

- Purpose – To develop a robust clean hydrogen supply chain and workforce by prioritizing clean hydrogen demonstration projects in major shale gas regions and establishing regional clean hydrogen hubs
  - Definition of Regional Clean Hydrogen Hub (RCHH) - a network of clean hydrogen producers, potential clean hydrogen consumers and connective infrastructure located in close proximity



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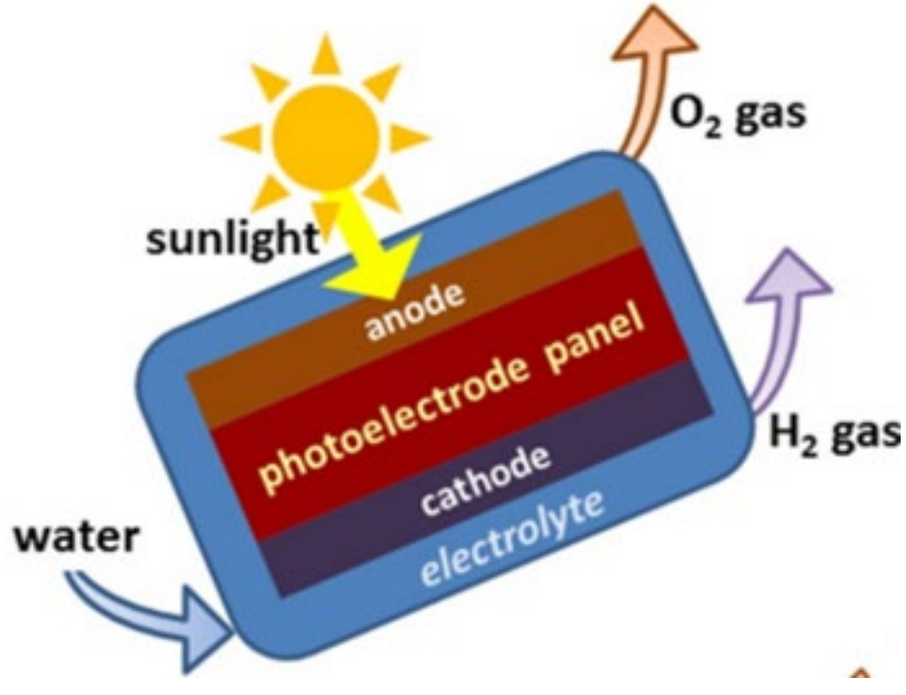
Hubs in 2021 Infrastructure Investment and Jobs Act (IIJA)

- Directs the US Department of Energy to manage Hydrogen Hub programming and to provide more guidance on definitions and funding

- Clean Hydrogen Definition - 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 (essentially allows green and blue hydrogen)



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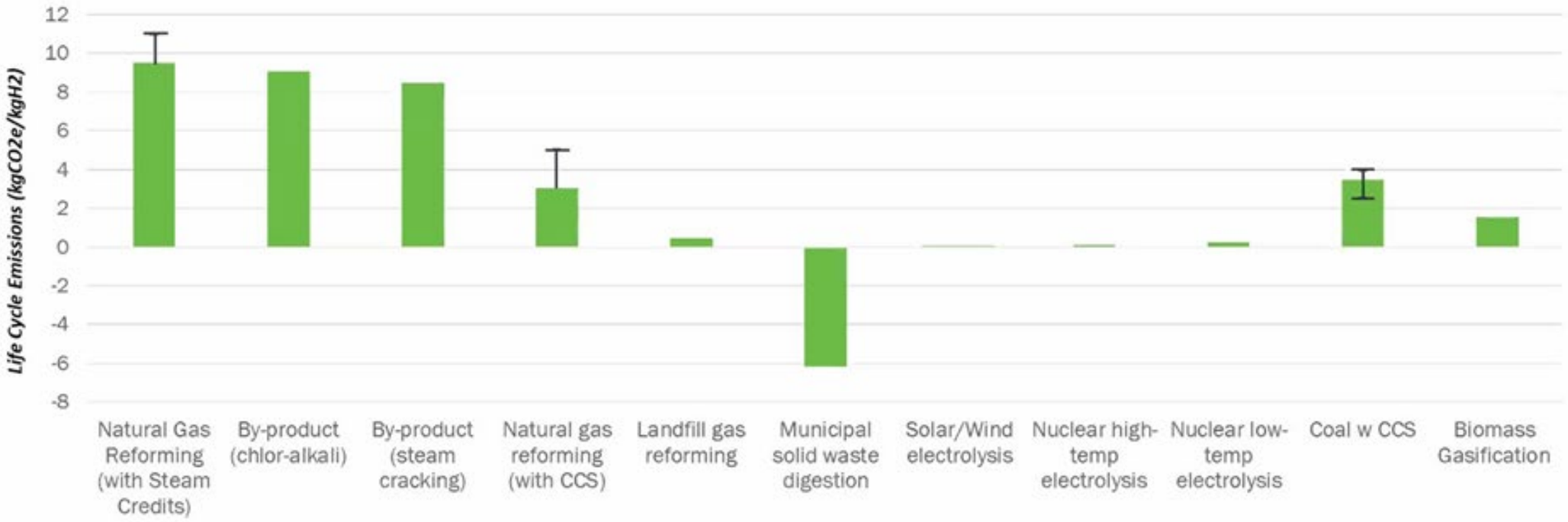
Hubs in 2021 Infrastructure Investment and Jobs Act (IIJA)

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

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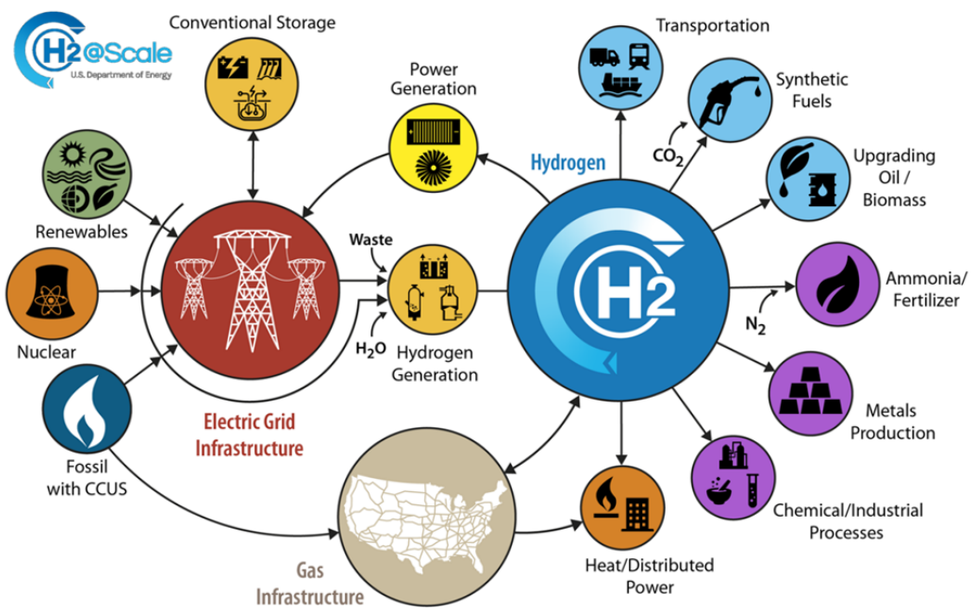
Hubs in 2021 Infrastructure Investment and Jobs Act (IIJA)

Meet the following criteria:

- Feedstock (at least 1 for each): fossil fuels, renewable energy, nuclear energy
- End use (at least 1 for each): electric power generation sector, industrial sector, residential commercial heating sector and transportation sector.
- Geographic diversity: located in different regions and use energy resources abundant in that region. At least 2 RCHH shall be located in regions with the greatest natural gas resources.
- Employment: provide opportunities for skilled training and long-term employment to the greatest number of residents of the region.



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H2 Hubs in 2021 Infrastructure Investment and Jobs Act (IIJA)

- Solicitation of proposals: the DOE Secretary shall establish a program and solicit proposals, **within 180 days of enactment** (updated recently to Aug/Sep 2022), to support the development of at least 4 Regional Clean Hydrogen Hubs that:
  - Demonstrates production, processing, delivery, storage and end use
  - Can be developed into a national clean hydrogen network
  - Proposals should emphasize our diversity, equity, inclusion, jobs and environmental justice

- Selection of Hubs - The Secretary shall select at least 4 RCHH not later than 1 year after the deadline for the submission of proposals

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SO…

- Colorado found itself very well-positioned to seriously consider this opportunity due to the very recent completion of it's Low Carbon Hydrogen Roadmap
  - Decided to pursue this opportunity rather than develop a Colorado focused plan as the roadmap suggested

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Western Inter-States Hydrogen Hub (WISHH)

- In February of 2022 the state of Colorado, New Mexico, Utah and Wyoming signed an Memorandum of Understanding (MOU) to coordinate, develop and manage a regional clean energy hub.

- The states agree to work together exclusively to compete for a portion of the $8 billion in the IIJA region.

- The states recently collaborated with the Colorado research Collaboratory (CSU, CU, School of Mines, NREL) Univ. of Wyoming, Sandia and Los Alamos National Labs on a response to a DOE Request for Information to provide input into design of the Clean Hydrogen Hub Funding Opportunity Announcement (FOA)

- While the states wait for that FOA they are organizing and having some preliminary discussions with utilities and industry.

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H2 Hubs Notice of Intent June 2022

-Last week the DOE released a Notice of Intent (NOI) announcing that they will intend to issue a Funding Opportunity Announcement for the H2 Hubs in Sep/Oct of 2022

-Interested applicant will likely be required to submit a concept paper. The DOE will then review and either discourage or encourage a full application.

-Principles of equity and justice and the expansion of high-paying, secure and safe union jobs will be important aspects of H2 Hub selection.

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What About the Inclusion of Tribal Groups?

- Applicant teams are encouraged to maximize meaningful, early engagement with stakeholders, including Tribal communities, to address environmental justice and workforce or other economic concerns and opportunities, including through the use of Community Benefits Agreements or similar structured partnerships. Tribal communities could be part of a team.

- For more information, the NOI can be found here: https://oced-exchange.energy.gov/Default.aspx#FoaId4e674498-618c-4f1a-9013-1a1ce56e5bd3

- The WISHH states are very interested in collaborating with tribal groups and welcome inquiries and information on points of contact

- You can find information about other possible collaborators on DOE's H2 Matchmaker: https://www.energy.gov/eere/fuelcells/h2-matchmaker

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DOE Process Description

☆ Initial Application

◇ Go/No-Go Decisions

	Application	Phase 1: Detailed Plan	Phase 2: Develop, Permit, Finance	Phase 3: Install, Integrate, Construct	Phase 4: Ramp-Up & Operate
	Pre - DOE funding	**Up to $10M DOE Funding , Non-Federal Cost Share ≥ 50%, 12-18 Months**	**TBD DOE Funding, Non-Federal Cost Share ≥ 50%, 2-3 Years**	**TBD DOE Funding, Non-Federal Cost Share ≥ 50%, 2-4 Years**	**TBD DOE Funding, Non-Federal Cost Share ≥ 50%, 2-4 Years**
Engineering, Procurement, Construction, Operations	• Conceptual Design • Technical Readiness • Project Schedule • Total Project Cost Estimate	• Engineering & Design Documents • Technical Maturation Plans • Integrated Project Schedules	• Mature Engineering & Design • Technical Risk Management • Execution ready schedule & cost estimate, PM Tools • Operations Plan	• Ongoing execution reporting • Interim Go/No-Go reviews	• Ongoing performance Reporting • Technical risk updates, tracking • Final TPC accounting
Business Development & Management	• Business Strategy • Team Description • Workforce Plan • Finance Plan • Market potential analysis	• Project Management Plan • Risk Management Plan • Financial modelling • Site selection	• Finalized project structure, management, financing • Ongoing risk management • Final legal, workforce, procurement agreements • Feedstock & Offtake Plans	• Ongoing execution reporting • Ongoing risk management	• Updated financial analyses • Revised growth plans • Updated Risk Management
Permitting & Safety	• Safety history/culture description • Regulatory approval timeline overview	• Initial Hydrogen Safety Plan (HSP) & Site Safety Plan • Physical, Information, Cyber Security Plans • Environmental & Regulatory preparations	• Execution ready HSP and security plans • Permits & approvals in place for construction	• Ongoing permit, environmental, safety reporting • Permits & approvals in place for operations	• Ongoing permit, safety, and security reporting
Community Engagement & Impacts	• Initial Equity Plan addressing community engagement, Justice40, community consent or benefits agreements, job quality, workers rights, etc.	• Stakeholder engagement and Community Consent or Benefits Agreement drafts	• Finalized Equity Plan, Agreements • Community development targets identified, tracking plans	• Ongoing reporting on Equity Plan activities	• Revised community engagement plans for operations • Ongoing reporting and evaluation
Technical Data & Analysis	• Lifecycle Analysis • Techno-economic Analyses	• Project Production Model • Updated Lifecycle and Technoeconomic Analysis	• Final Lifecycle & Technoeconomic Analyses • V&V and Project Completion Testing Plans	• Periodic analyses updates • V&V data collection • Project completion testing and performance ramp V&V	• Validated performance model • Finalize lifecycle and technoeconomic analyses • Dissemination of analyses, lessons learned

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Contact information for the WISHH

Colorado

https://energyoffice.colorado.gov/climate-energy/western-inter-states-hydrogen-hub

Contact: maria.eisemann@state.co.us

New Mexico

Brian Schath, New Mexico Environment Department: Brian.Schath@state.nm.us

Utah

Bailey Toolson, Utah Office of Energy Development: btoolson@utah.gov

Wyoming

Anja Bendel, Wyoming Energy Authority: anja.bendel@wyo.gov

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Thank you!

Maria DiBiase Eisemann
Senior Transportation Policy Analyst
Colorado Energy Office
Maria.eisemann@state.co.us

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