

Sustainability Criteria for Hydrogen Deployments

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DOE Hydrogen Program
2023 Annual Merit Review and Peer Evaluation Meeting

Project ID: SA188

Project Goal: Provide guidance on improving existing methods to quantify and characterize sustainability benefits of hydrogen projects

Vision

Create a framework with which to characterize quantifiable sustainability metrics for hydrogen supply chain projects

What

- Identify existing sustainability metrics such as GHG emissions and air quality standards by EPA, sustainable development goals by the UN, and life cycle assessments
- Assess gaps in existing sustainability metrics as applicable to hydrogen supply chain projects
- Propose guidance to improve existing sustainability metrics

How

- Review existing literature on hydrogen or energy supply chain infrastructure
- Identify expert practitioners with experience in developing and monitoring sustainability ratings to seek guidance and input on improving sustainability metrics
- Conduct case studies on hydrogen projects in collaboration with experts

Why

- Hydrogen infrastructure development is growing. Aside from GHG emissions standards, there are few mature frameworks for quantifying and rating sustainability of such projects
- Providing a framework for rating the sustainability of a hydrogen infrastructure project can guide investment decisions and ensure projects are a net benefit to all stakeholders

Overview

Timeline and Budget

- Project Start Date: September 1, 2022
- FY22 DOE Funding (if applicable): \$200,000
- FY23 Planned DOE Funding (if applicable): \$130,000
- Total DOE Funds Received to Date^{**}: \$200,000
 - ** Since the project started

Barriers and Targets

1. Identify gaps in literature and existing sustainability rating systems that are applicable to hydrogen projects
2. Address these gaps by improving existing frameworks for quantifiable sustainability metrics
3. Apply this framework to at least two case studies to assess the appropriateness and impact of such sustainability metrics.

Partners

- Mark Chung, PI NREL
- Mission Innovation via Department of State
- HFTO, DOE

Potential Impact

Driving Factor

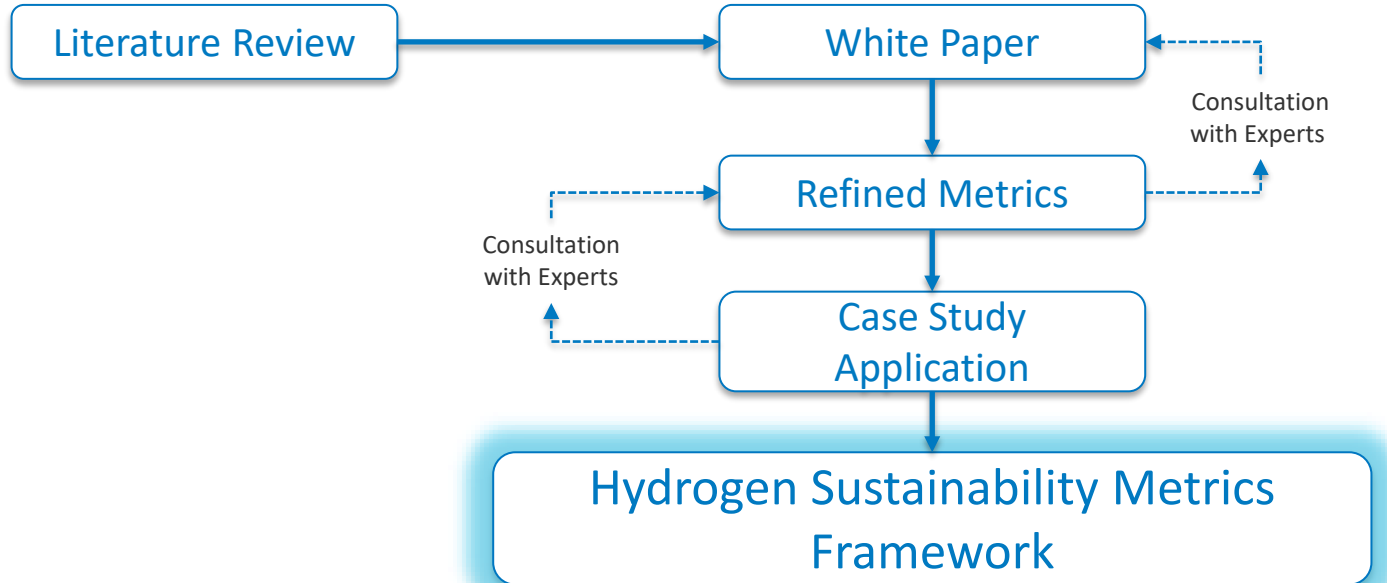
The Inflation Reduction Act and Bipartisan Infrastructure Law are unleashing billions of federal dollars into clean hydrogen technologies over the next decade, resulting in significant growth across the supply chain (production, transmission, storage, end use). Evaluating sustainability of hydrogen will be necessary to accommodate this growth.

The Impact

Improving the framework for assessing sustainability of hydrogen projects is not only needed to measure sustainability of a project, but also to better inform future investments in the hydrogen supply chain. This project will not only refine the standard economic and environmental metrics of hydrogen sustainability but will also include a social metric assessment to provide a holistic approach to sustainability.

Approach

To ensure a comprehensive framework with quantitative metrics is developed, independent research will be supplemented with feedback from industry experts with experience across consulting, creating, and measuring of metrics in the sustainability field

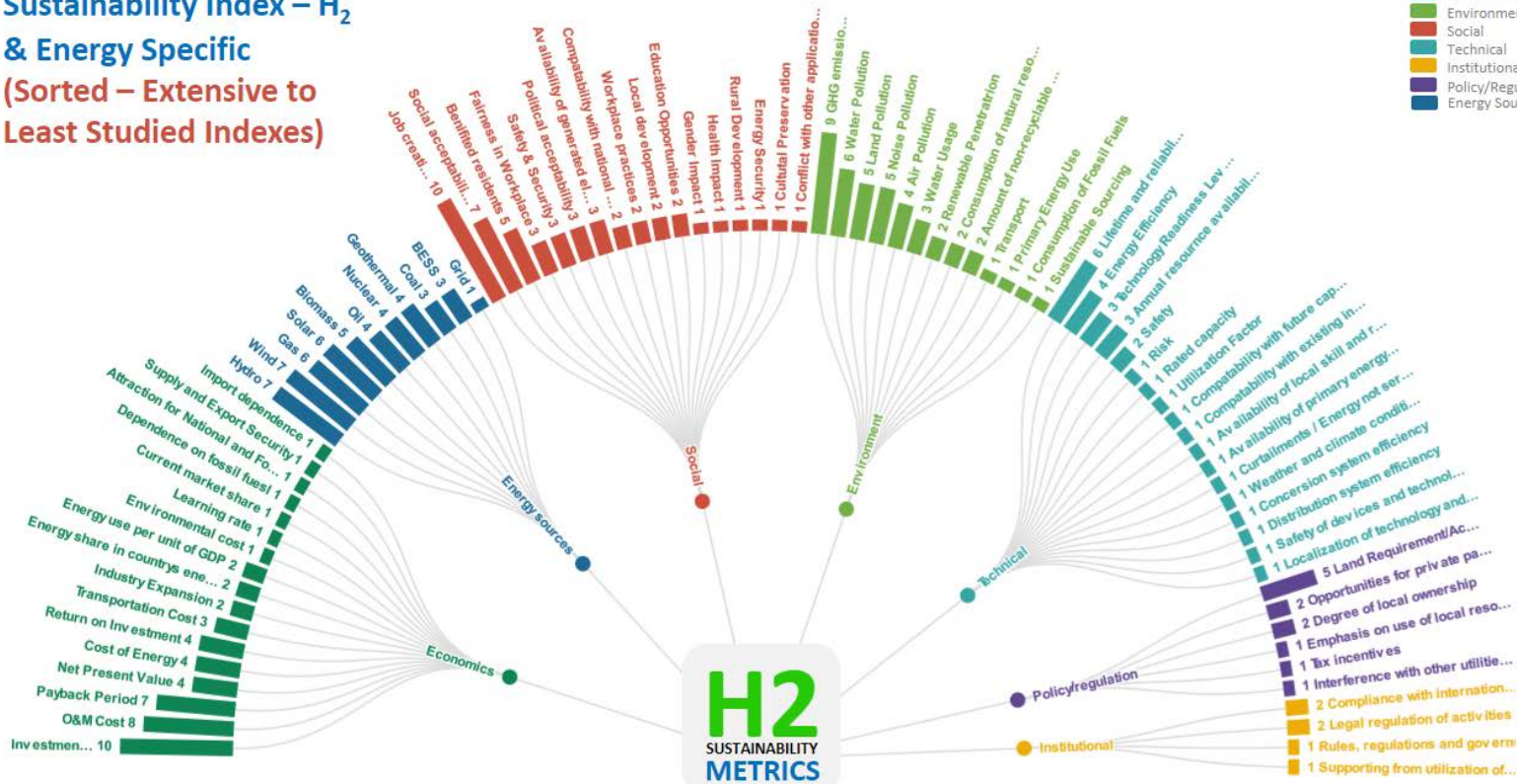


Accomplishments and Progress (1/6): A brief literature survey on H₂ sustainability

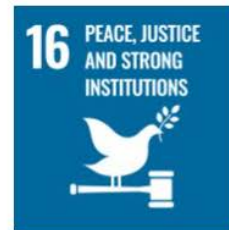
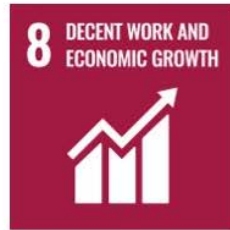
metrics used in literature finds a heavy focus on economics, energy resources, and environment.

Available Literature On Sustainability Index – H₂ & Energy Specific (Sorted – Extensive to Least Studied Indexes)

- Legend
- Economics
 - Environment
 - Social
 - Technical
 - Institutional
 - Policy/Regulation
 - Energy Source



Accomplishments and Progress (2/6): The UN's Sustainable Development Goals brings a diverse set of additional sustainability metrics to consider, specifically social factors.



Accomplishments and Progress (3/6): The UN's SDG metrics emphasize *social* and *environmental* aspects, providing a unique lens through which to view sustainability

The Sustainable Development Goals – Subcategories (General)

Goal	SI Category	Major Category	Sub-Category
Goal 1	Social	No Poverty	Access to basic services
Goal 1	Social	No Poverty	Local disaster risk reduction
Goal 1	Social	No Poverty	Domestic resources to poverty reduction programs
Goal 1	Social	No Poverty	Government spending on essential services
Goal 1	Social	No Poverty	Pro-poor public spending
Goal 2	Environmental	Zero Hunger	Local breeds at risk of extinction
Goal 3	Social	Good Health and Well Being	Mortality rate from unsafe water, sanitation, hygiene (WASH)
Goal 3	Social	Good Health and Well Being	Health emergency preparedness
Goal 4	Social	Quality Education	Information and communications technology (ICT) skills
Goal 4	Social	Quality Education	Education on sustainable development and global citizenship
Goal 5	Social	Gender Equality	Legal frameworks for gender equality and non-discrimination
Goal 6	Social	Clean water & Sanitation	Safe drinking water
Goal 6	Environmental	Clean water & Sanitation	Improve water quality, wastewater treatment and safe reuse
Goal 6	Environmental	Clean water & Sanitation	Ambient water quality
Goal 6	Environmental	Clean water & Sanitation	Water use efficiency
Goal 6	Environmental	Clean water & Sanitation	Levels of freshwater stress
Goal 6	Environmental	Clean water & Sanitation	Integrated water management
Goal 6	Environmental	Clean water & Sanitation	Protect and restore water-related ecosystems
Goal 7	Social	Affordable and Clean Energy	Access to electricity
Goal 7	Social	Affordable and Clean Energy	Access to clean fuels for cooking
Goal 7	Environmental	Affordable and Clean Energy	Renewable energy
Goal 7	Environmental	Affordable and Clean Energy	Energy efficiency
Goal 7	Environmental	Affordable and Clean Energy	Access and investments in clean energy
Goal 8	Environmental	Decent Work and Economic Growth	Material footprint
Goal 8	Environmental	Decent Work and Economic Growth	Domestic material consumption
Goal 8	Social	Decent Work and Economic Growth	Unemployment rate
Goal 8	Social	Decent Work and Economic Growth	Youth employment, education and training
Goal 8	Social	Decent Work and Economic Growth	Child labour
Goal 8	Social	Decent Work and Economic Growth	Occupational injuries
Goal 8	Social	Decent Work and Economic Growth	Access to financial services
Goal 8	Social	Decent Work and Economic Growth	Youth employment strategy
Goal 9	Social	Industry Innovation and Infrastructure	Road access for rural populations
Goal 9	Social	Industry Innovation and Infrastructure	Manufacturing value
Goal 9	Environmental	Industry Innovation and Infrastructure	CO2 emissions per unit value added

Legend

■ Economics
 ■ Environment
 ■ Social

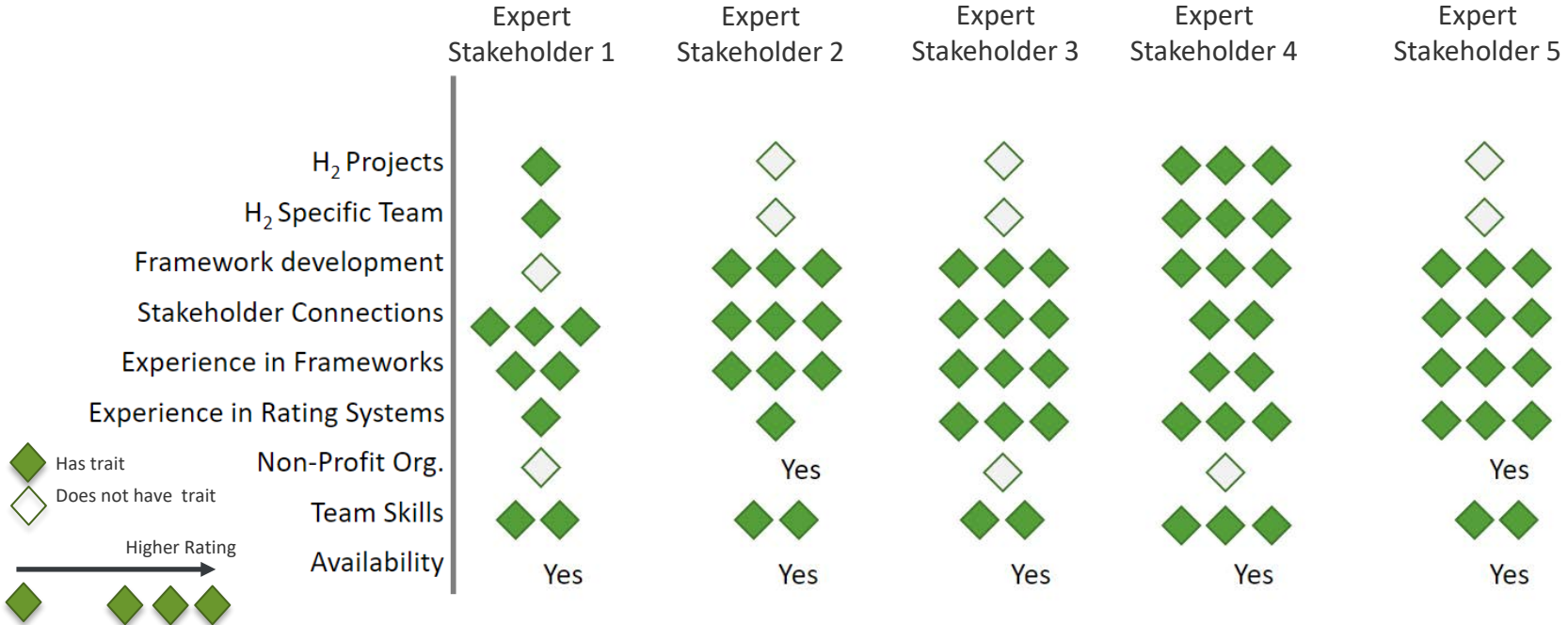
Goal	SI Category	Major Category	Sub-Category
Goal 9	Social	Industry Innovation and Infrastructure	Research and Development (R&D) spending
Goal 9	Social	Industry Innovation and Infrastructure	Researchers per million inhabitants
Goal 10	Social	Reduced Inequalities	Policies for greater equality
Goal 11	Social	Sustainable Cities and Communities	Public transport access
Goal 11	Environmental	Sustainable Cities and Communities	Solid waste management
Goal 11	Environmental	Sustainable Cities and Communities	Urban air pollution
Goal 11	Social	Sustainable Cities and Communities	Open spaces in cities
Goal 11	Environmental	Sustainable Cities and Communities	Sustainable and resilient buildings in least developed countries
Goal 12	Environmental	Responsible consumption and Production	Sustainable consumption and production action plans
Goal 12	Environmental	Responsible consumption and Production	Material footprint
Goal 12	Environmental	Responsible consumption and Production	Domestic material consumption
Goal 12	Environmental	Responsible consumption and Production	International agreements on hazardous waste
Goal 12	Environmental	Responsible consumption and Production	Hazardous waste generation
Goal 12	Environmental	Responsible consumption and Production	Recycling rates
Goal 12	Social	Responsible consumption and Production	National sustainable procurement plans
Goal 12	Social	Responsible consumption and Production	Understanding of sustainable lifestyles
Goal 12	Social	Responsible consumption and Production	Support for developing countries' capacity for sustainable production
Goal 12	Social	Responsible consumption and Production	Monitoring sustainable tourism
Goal 12	Economical	Responsible consumption and Production	Removing fossil fuel subsidies
Goal 13	Environmental	Climate action	Education on climate change
Goal 14	Environmental	Life below water	Reduce marine pollution
Goal 14	Environmental	Life below water	Protect and restore ecosystems
Goal 14	Environmental	Life below water	Reduce ocean acidification
Goal 16	Social	Peace, Justice and Strong Institution	Public access to information
Goal 16	Social	Peace, Justice and Strong Institution	Public discrimination
Goal 17	Environmental	Partnership for the Goals	Sustainable technologies in developing countries

Accomplishments and Progress (4/6): An overview of existing ratings systems by region show less coverage for infrastructure and community vs. buildings

	Buildings	Infrastructure	Community
	Office, healthcare, educational, commercial, retail, science & technology	Roads, bridges, pipelines, railways, airports, dams, levees, landfills, water treatment systems	New neighborhood development, urban revitalization projects
Africa	Green Africa Building Standards, EDGE, LEED		
South Africa	Green Star SA, EDGE, LEED		
Asia	EDGE, LEED		
China	China 3 Star, GBAS, EDGE, LEED, WELL		
Hongkong	Beam	HK BEAM Plus-Infrastructure, CEEQUAL International	HK BEAM - District Tool
India	EDGE, LEED India, GRIHA, WELL		IGBC Green Townships, GRIHA
Japan	CASBEE, WELL		CASBEE
Singapore	BCA Green Mark, WELL	BCA Green Mark	
Australia/New Zealand	Green Star, NABERS, WELL	Infrastructure Sustainability (IS), Greenroads	Green Star Communities
Europe	BREEAM, LEED, Living Building Challenge, WELL	CEEQUAL	BREEAM for Communities
France	HQE, Living Building Challenge, WELL	CEEQUAL International	BREEAM for Communities
Germany	DGNB, WELL	CEEQUAL International	BREEAM for Communities, DGNB
United Kingdom	BREEAM, Living Building Challenge, WELL	CEEQUAL	BREEAM for Communities
North America	LEED, Living Building Challenge	Envision	
Canada	BREEAM, BOMA BEST, Green Globes, LEED, Living Building Challenge, WELL	Envision, Greenroads	LEED ND
United States	BOMA 360 Performance Program, ENERGY STAR, Fitwel, Green Globes, LEED, Living Building Challenge, TRUE, WELL	Envision, INVEST, Greenroads	LEED ND, SITES, STAR Communities
South America	EDGE, LEED, Living Building Challenge, WELL		
Middle East	EDGE, LEED	CEEQUAL International, Envision	
Abu Dhabi	Estidama - Pearl Building Rating System	CEEQUAL International	Estidama - Community Rating System
United Arab Emirates	LEED, Green Key, WELL	CEEQUAL International	

Accomplishments and Progress (5/6): NREL has shortlisted a group of select, diverse industry experts to collaborate with on building a hydrogen sustainability framework.

To ensure a diverse set of stakeholders are represented, NREL reached out to 23 companies seeking expert assistance. Of those that responded with interest, NREL shortlisted 5 and conducted in-depth interviews and is now in the final stages of selecting a group of experts.



Accomplishments and Progress (6/6): Response to Previous Year Reviewers' Comments

- This is a new project was not reviewed at the previous AMR

Collaboration and Coordination

- Key Project Partnerships include:
 - Soon to be identified experts from industry
 - Support from the German Agency for International Cooperation (GIZ). GIZ is open to sharing information and insights to further shared objectives in hydrogen sustainability.

Remaining Challenges and Barriers

- Case study identification may present challenges as there may be a lack of sufficient data to apply hydrogen sustainability metrics
- Social impacts may be difficult to capture in metrics either due to lack of data or ability to measure

Proposed Future Work

- **FY23 Proposed Work:**
 - Complete white paper that outlines current sustainability metrics that are widely used and improve existing and/or identifies new metrics that could be adopted into a holistic sustainability framework
 - Solicit feedback from expert groups on white paper and proposed metrics
 - Refine the framework further after expert feedback
- **FY24 Proposed Work:**
 - Finalize metrics to be used in the proposed sustainability framework
 - Collaborate with experts on applying these metrics to one or more case studies. These case studies will assess viability of proposed metrics.
 - Publish a journal article on the proposed metrics and applicability in the case studies assessed

Summary

- NREL is contributing to the field of hydrogen sustainability metrics in collaboration with Mission Innovation, Department of State, Department of Energy, and numerous experts
- Identifying and quantifying gaps in sustainability metrics is essential to support Department of Energy funding for hydrogen supply chain projects and will help guide private investment towards highly impactful projects
- Economic and environmental metrics are commonly found in literature, but more research is warranted to refine existing metrics and to identify additional metrics beyond economic and environmental dimensions that drive impactful investment decisions

Thank You

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Technical Backup and Additional Information

Technology Transfer Activities

- There is no known patent, licensing, or potential licensing information associated with this project.