Carbon Intensity of Hydrogen

Enabling an Accelerated and Affordable Clean Hydrogen Future
DOE-GTI Virtual Workshop
September 28, 2021

Shannon Angielski
Principal, Van Ness Feldman
Carbon Utilization Research Council (CURC)

**Equipment Suppliers**
- General Electric
- Mitsubishi Heavy Industries America, Inc. (MHIA)

**Labor Unions**
- International Brotherhood of Boilermakers
- International Brotherhood of Electrical Workers

**Producers**
- Consol Energy
- Lignite Energy Council
- Occidental Petroleum
- Peabody Energy

**Technology Developers**
- Bloom Energy
- Bright Energy
- ION Engineering
- Jupiter Oxygen Corporation
- NET Power

**Research Organizations**
- Battelle
- Electric Power Research Institute (EPRI)
- Gas Technology Institute
- University of North Dakota Energy & Environmental Research Center

**State Organizations**
- Kansas State Geological Survey
- Southern States Energy Board
- Wyoming Infrastructure Authority

**Trade Associations**
- American Coal Council
- American Coalition for Clean Coal Electricity (ACCCE)
- Edison Electric Institute (EEI)
- National Rural Electric Cooperative Association (NRECA)

**Universities**
- Lehigh University
- Ohio State University
- Pennsylvania State University
- Southern Illinois University
- University of Illinois/PRI
- University of Kentucky/CAER
- University of Texas – Austin
- University of Wyoming
- West Virginia University

**Utilities**
- Basin Electric Power Cooperative
- Duke Energy Services
- Minnkota Power Cooperative
- Nebraska Public Power District
- Southern Company
- Tri-State Generation & Transmission Association

**NGOs**
- ClearPath Action
- EnergyBlue Project

Orange = Steering Committee Members
UNIQUE MISSION
With a global focus on reducing emissions from fossil fuel utilization, CURC’s nonpartisan, technology-driven mission ensures the long-term value of fossil energy resources in an increasingly carbon-constrained world.

CONSENSUS DRIVEN & TECHNICALLY INFORMED
CURC brings technology developers and end users together. Our recommendations represent the consensus of our membership, including cutting-edge technical experts from a diverse set of interests in power generation.

SKILLED FACILITATORS
CURC is an established facilitator and trusted authority on advanced fossil energy technologies. We maintain productive working relationships with Members of Congress and the Department of Energy, and these entities turn to CURC for the most recent, fact-driven expertise and recommendations on federal policies affecting technology.

PIONEERING RESEARCH & GLOBAL COLLABORATION
CURC collaborates with world-class U.S. and international research organizations, and has been a driving force behind the crafting and passage of federal legislation, creating financial incentives for fossil fuel technology development and Funding for research programs at the U.S. Department of Energy.

CURC.NET
<table>
<thead>
<tr>
<th>174 Power Global</th>
<th>Engie</th>
<th>ONE Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Gas Association</td>
<td>Gas Technology Institute</td>
<td>Sempra Energy</td>
</tr>
<tr>
<td>American Public Gas Association</td>
<td>GE Gas Power</td>
<td>Siemens Energy</td>
</tr>
<tr>
<td>Bayotech</td>
<td>Int’l Brotherhood of Boilermakers</td>
<td>Southern Company</td>
</tr>
<tr>
<td>bp</td>
<td>Int’l Brotherhood of Electrical Workers</td>
<td>Tennessee Valley Authority</td>
</tr>
<tr>
<td>California Fuel Cell Partnership</td>
<td>INGAA</td>
<td>U. of Wyoming School of Energy Resources</td>
</tr>
<tr>
<td>Chevron</td>
<td>LanzaTech</td>
<td>UND Energy &amp; Environmental Research Center</td>
</tr>
<tr>
<td>ClearPath Action</td>
<td>Linde</td>
<td>Voice of the Arctic Inupiat</td>
</tr>
<tr>
<td>Duke Energy</td>
<td>Nikola</td>
<td>Wabash Valley Resources</td>
</tr>
<tr>
<td>EN Engineering</td>
<td>North America’s Building Trades Union</td>
<td>Williams Companies</td>
</tr>
<tr>
<td>Energy Infrastructure Council</td>
<td>North Slope Borough</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nuclear Energy Institute</td>
<td></td>
</tr>
</tbody>
</table>
CHFC Foundational Principles

(1) Clean hydrogen is a critical pathway to achieve U.S. decarbonization objectives.
(2) Investments in the full value chain of clean hydrogen production, transport and delivery, storage and use, as well as the infrastructure across multiple sectors, will be necessary to scale clean hydrogen in the U.S.
(3) Policies designed to stimulate clean hydrogen production and use throughout the U.S. economy should be fuel agnostic and technology neutral, and focus on the carbon intensity of CO₂ hydrogen production method.
(4) Skilled labor and the use of existing infrastructure are essential to the deployment of clean hydrogen throughout our economy.
Carbon Intensity of Hydrogen

- What is the baseline – Steam Methane Reforming?
- What will be the acceptable low carbon intensity for hydrogen produced from fossil fuels?
  - Tax legislation starting at 40%-50% GHG reduction from SMR
  - RD&D legislation starting with a carbon intensity of 2 kg/CO2 per kg/H2
- What are the boundaries for calculating carbon intensity?
- What methodology is being used in other countries?
Boundary Considerations

- Upstream including raw materials input to point of production
- Upstream to point of end use
- Upstream to use of product
The term “lifecycle greenhouse gas emissions” means the aggregate quantity of greenhouse gas emissions (including direct emissions and significant indirect emissions such as significant emissions from land use changes), as determined by the Administrator, related to the full fuel lifecycle, including all stages of fuel and feedstock production and distribution, from feedstock generation or extraction through the distribution and delivery and use of the finished fuel to the ultimate consumer, where the mass values for all greenhouse gases are adjusted to account for their relative global warming potential.
Key Upstream Issues for Hydrogen Production

- Water acquisition and transport
- Natural gas (or other fossil fuel) production and transport
- Biomass production and transport
- Production of raw materials for solar panels, wind turbines, nuclear materials, electrolyzers
- Manufacture of solar panels, wind turbines, nuclear components, and electrolyzers, and transport to point of production
- Renewable energy credits considered an “offset”?
- CO₂ sequestered in accordance with 45Q be subtracted from process emissions?
Key Downstream Issues for Hydrogen Production

- Liquefaction and compression – should this be point of production or downstream?
- Delivery methods to point of end use:
  - Trucking
  - Pipeline
  - Rail
- End use emissions?
  - GHG emissions of hydrogen are being evaluated by ENGOs and deemed to have some lifetime emission associated with it
Carbon Intensity of Fossil with CCS

- Legislation pending in Congress for hydrogen production tax credit requires use of the CAA RFS to determine the carbon intensity of the hydrogen, and ties the GHG reduction to the value of the tax credit.

- The tax credit is valued at $3.00 per kg of clean hydrogen and pro-rated for percentage reduction of GHGs from steam methane reforming without capture.

<table>
<thead>
<tr>
<th>Lifecycle GHG Emission</th>
<th>PTC $Value per kg (% of credit)</th>
<th>ITC % Value (% of credit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>95 - 100%</td>
<td>$3.00 (100%)</td>
<td>30% (100%)</td>
</tr>
<tr>
<td>85 – 95%</td>
<td>$1.02 (34%)</td>
<td>10.2% (34%)</td>
</tr>
<tr>
<td>75 – 85 %</td>
<td>$0.75 (25%)</td>
<td>7.5% (25%)</td>
</tr>
<tr>
<td>50 - 75%</td>
<td>$0.60 (20%)</td>
<td>6% (20%)</td>
</tr>
</tbody>
</table>
Questions . . .

Contact information

Shannon Angielski, Principal, Governmental Issues
sma@vnf.com
(202) 492-3443 (mobile)

www.vnrf.com
www.curc.net
www.cleanh2.org