OPEN **HYDROGEN** INITIATIVE

Rosa Dominguez-Faus, Ph.D.
Sr. Mgr. LCA at GTI Energy

GTI ENERGY

NATIONAL ENERGY TECHNOLOGY LABORATORY

S&P Global Commodity Insights

1r Congreso de Hidrógeno y Eficiencia Energética

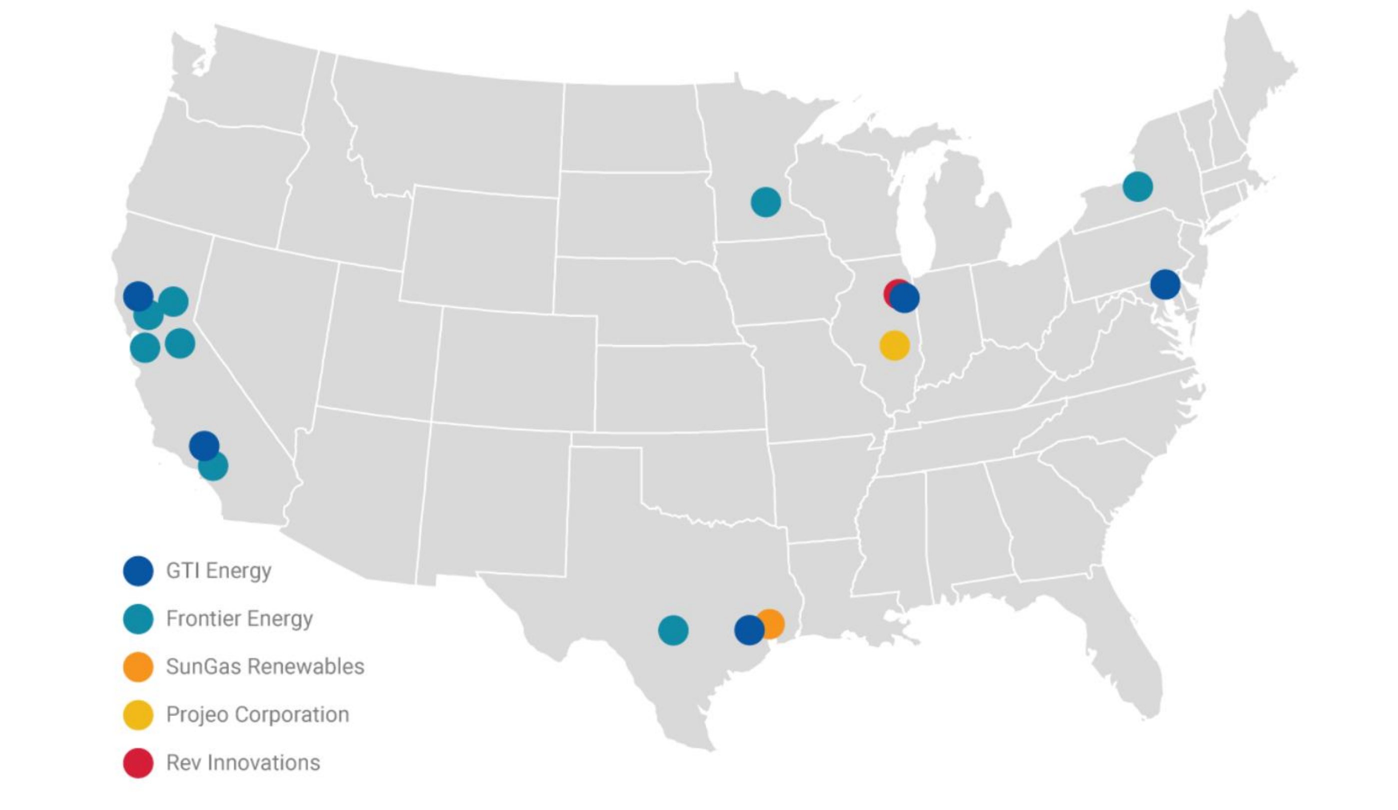
ANDI | NATURGAS| Cartagena, Colombia | 19-20 de octubre de 2023

Que es GTI Energy?

Contact: OHI@gti.energy

OPEN HYDROGEN INITIATIVE

What is GTI Energy?



- **Not-for-profit R&D** organization in the liguids/gases space
- Mission driven for **low carbon, low cost** energy transition, **leverage existing infrastructure** and knowledge resources.
- 75 years **legacy**
- **GRI founded in 1976** in response to the Federal Power Commission (FPC) encouraging increased gas research and development (R&D).
- **IGT founded in 1941** to train graduate engineers, in affiliation with the Illinois Institute of Technology (IIT)
- GRI/IGT merge and become **GTI in 2000**
- Name changes to **GTI Energy in 2022**
- **400+ Employees**
- Mostly **Engineers and PhDs**
- Recognized for **rigor and technical expertise**

Working with utilities to address critical challenges

A Highly Collaborative Organization

Leveraging expertise and funding to address common challenges and opportunities for utilities

OTD Operations Technology Development

UTD Utilization Technology Development

ETP Emerging Technology Program

LCRI LOW-CARBON RESOURCES INITIATIVE

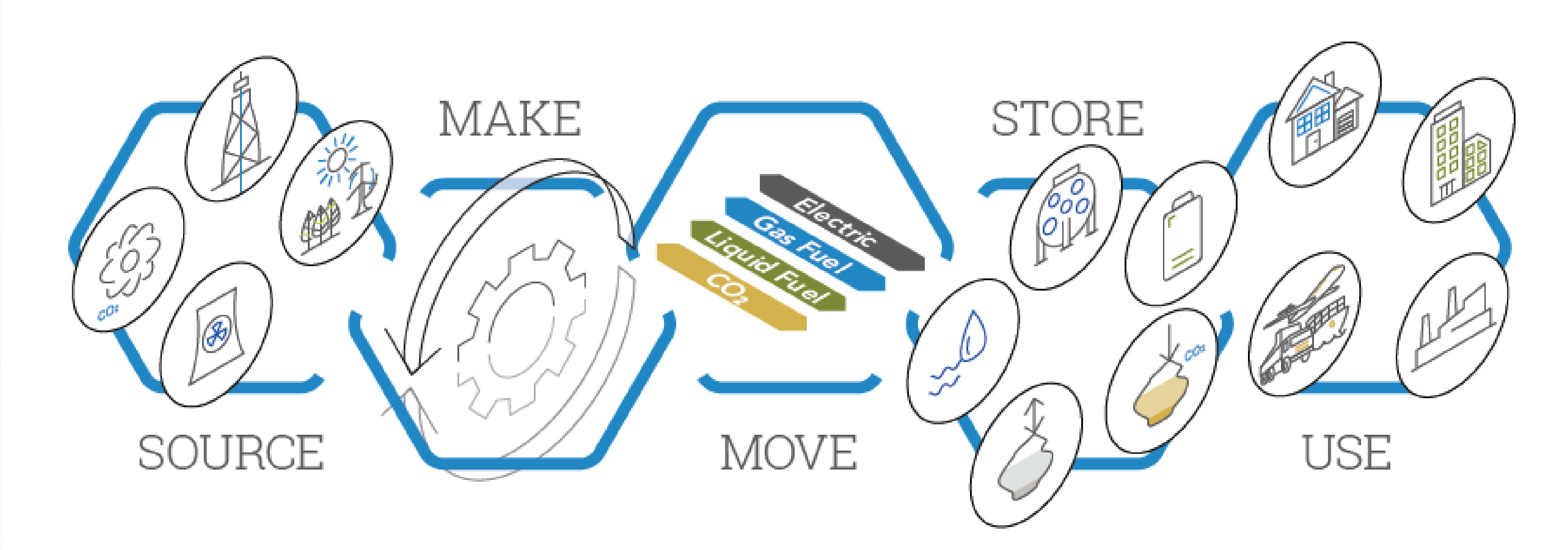
VERITAS

OPEN HYDROGEN INITIATIVE

Hydrogen Technology Center

Creating Low Cost, Low Carbon Energy Systems through Integrated Hydrogen Solutions

OPEN **HYDROGEN** INITIATIVE



Kristine Wiley
VP Low Carbon Solutions

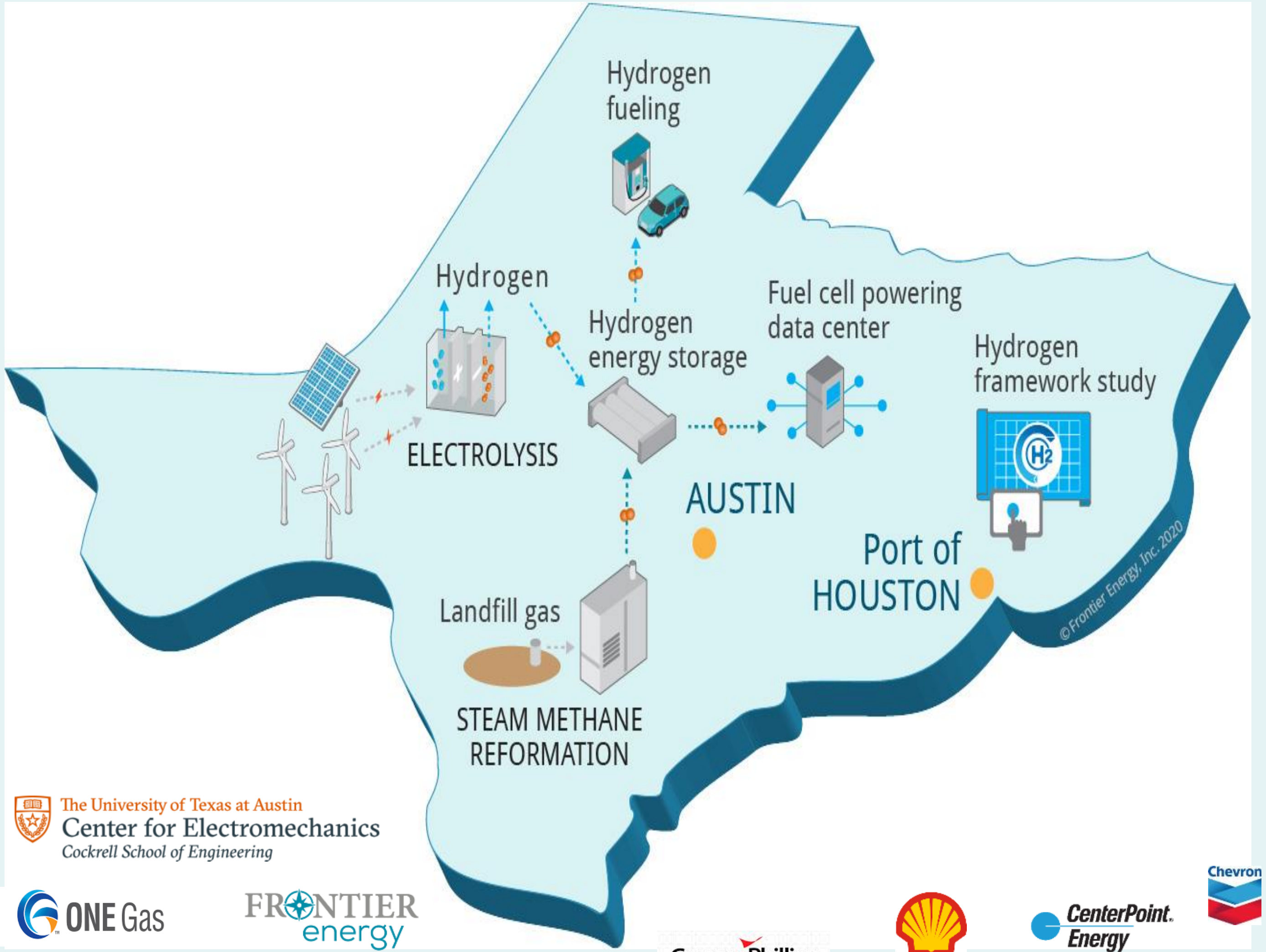
Contact: OHI@gti.energy

Hydrogen Hubs

OPEN HYDROGEN INITIATIVE

Contact: *OHI@gti.energy*

H2@Scale TX Demo



~100% renewable H_2 generation

- 75 kg/day SMR: GTI, OneH2, ONE Gas, Waste Management
- 20 kg/day PEM electrolyzer in H70 SimpleFuel: MHI, SoCalGas, TACC
  - Emulated wind and solar power through UT CEM microgrid

Large scale, industry H_2 user

- 100kW fuel cell powering Texas Advanced Computing Center

Vehicle refueling

- Published SAE J2601-4 fueling of 7-10 Toyota Mirai's
- Drones included

Sobre el Hydrogeno

Contact: OHI@gti.energy

Current uses of H2

OPEN HYDROGEN INITIATIVE

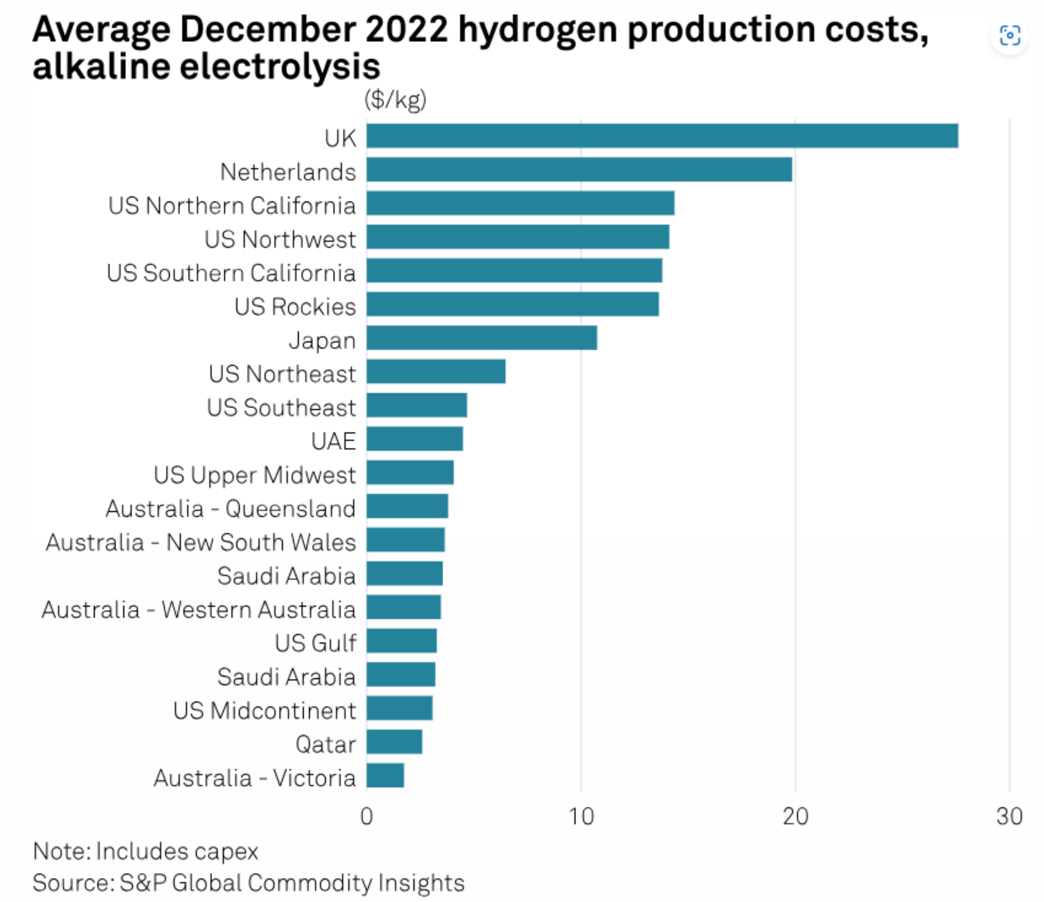
- Petroleum Refining
- Ammonia Production
- Methanol Production
- Electronics and Semiconductor Industry
- Metal Production
- Food Industry
- Rocket Propulsion
- Chemical Manufacturing
- Glass Industry
- Energy Storage
- Power Generation

Current sources of H2

- Natural Gas Reforming (Steam Methane Reforming - SMR)
- Partial Oxidation (POX) of Natural Gas
- Autothermal Reforming (ATR)
- Methane Pyrolysis
- Coal Gasification
- Biomass Gasification
- Electrolysis
- Biological Production
- Geologic Hydrogen

Production Costs

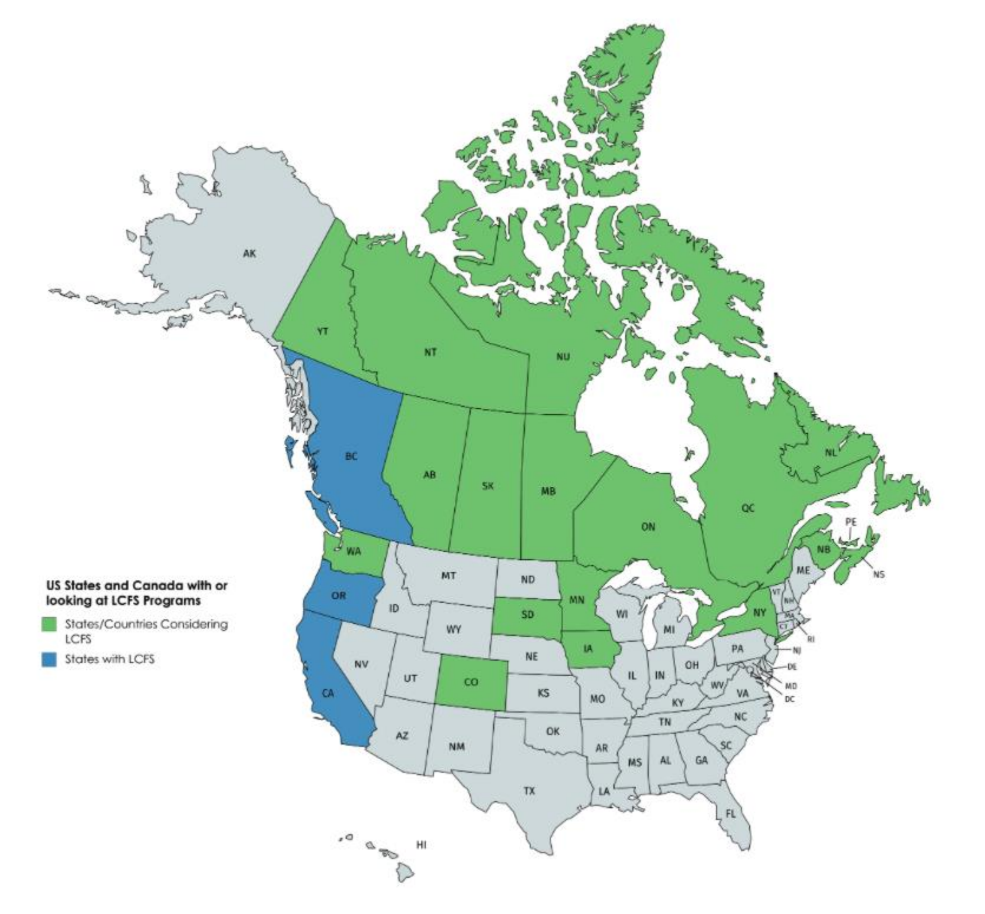
- Hydrogen production via unabated (no CCS) SRM for US Gulf Coast was the cheapest globally for December 2022 at **$1.27/kg.**
- Southern California alkaline electrolysis more than doubled over November, averaging **$13.79/kg in December**.
- UK PEM electrolysis remained the most expensive production pathway globally, averaging **$32.41/kg**, up over 30% on the month.



Source: S&P Global Insights. Cold December boosts hydrogen production costs, as market price indications emerge

A plethora of Incentives inversely proportional to the Carbon Intensity of Hydrogen

OPEN HYDROGEN INITIATIVE

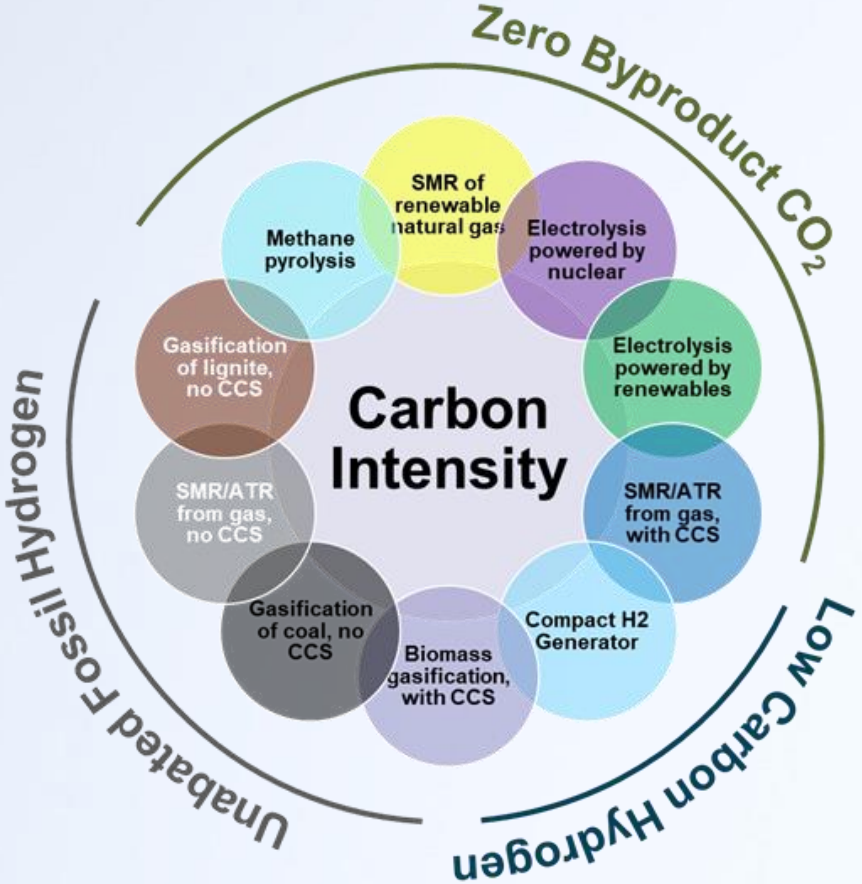


- LCFS
- IRA (45V, 45Q, 45B, 45Z)
- RED II
- Others

Contact: OHI@gti.energy

CI of H_2 production has significant variability among ‘colors’

OPEN **HYDROGEN** INITIATIVE



Risks of Reliance on the Color Wheel Include:

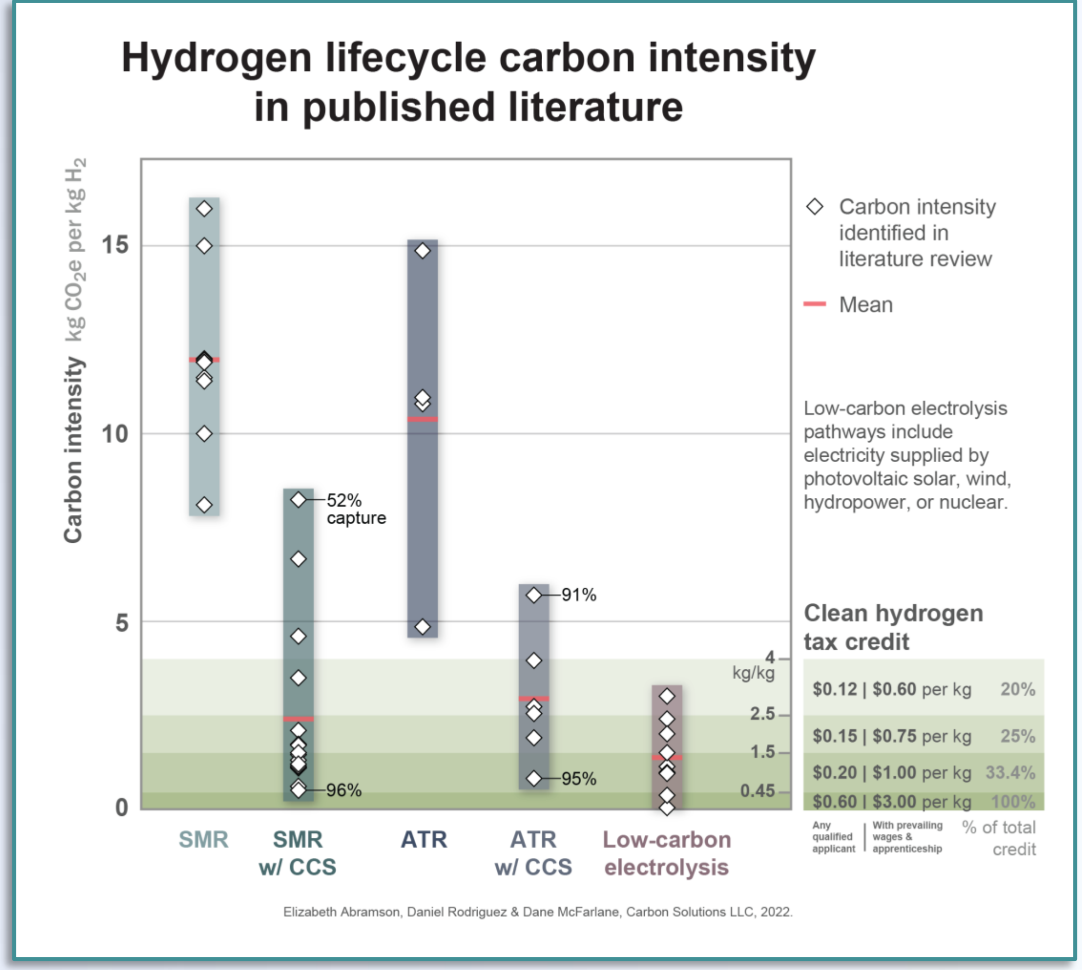
- Fracture hydrogen markets along color boundaries
- Stifle innovation by boxing out alternatives
- Lack of standardization and transparency around color nomenclature
- Deeply inaccurate

Source: Carbon Solutions

OPEN HYDROGEN INITIATIVE

CI of H_2 production has significant variability among 'colors'

OPEN HYDROGEN INITIATIVE



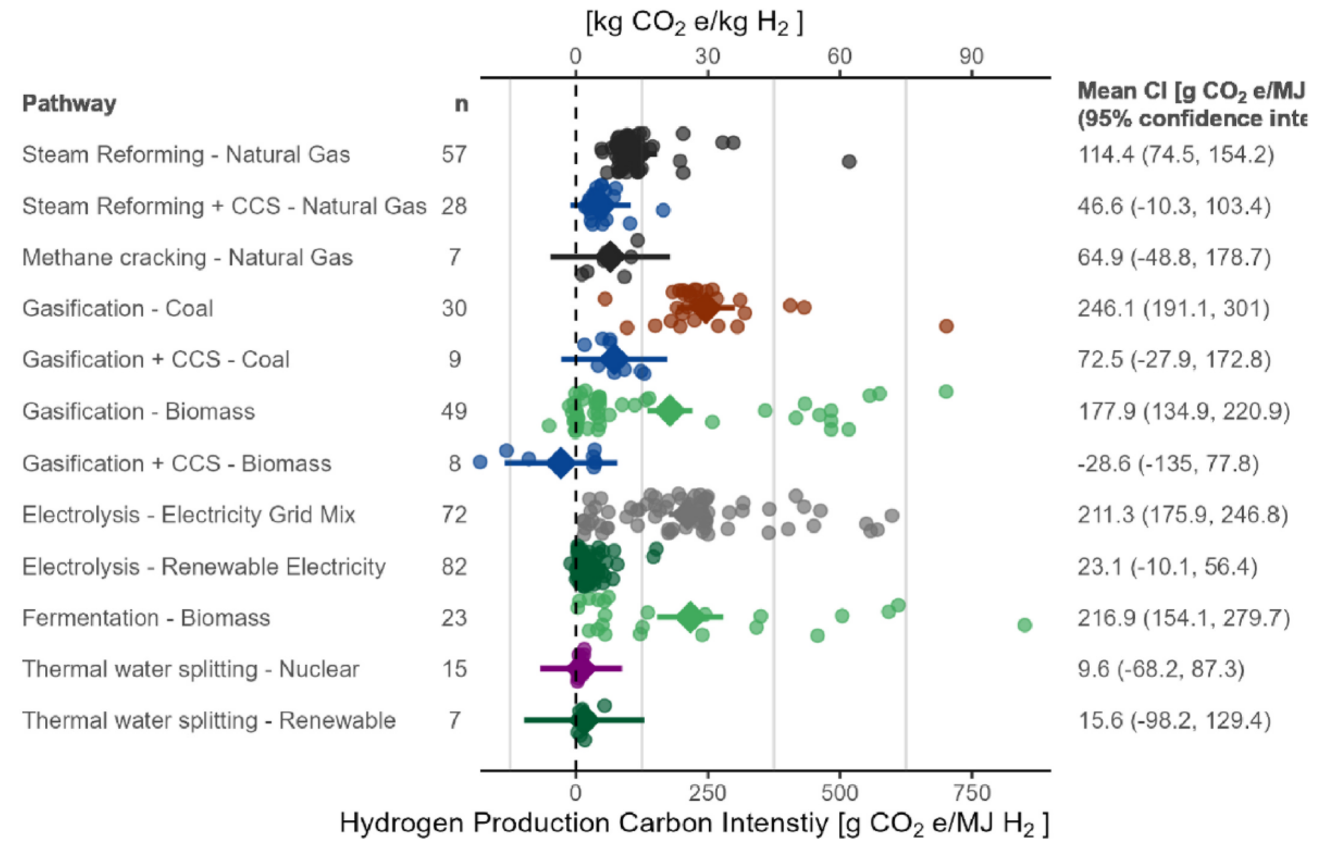


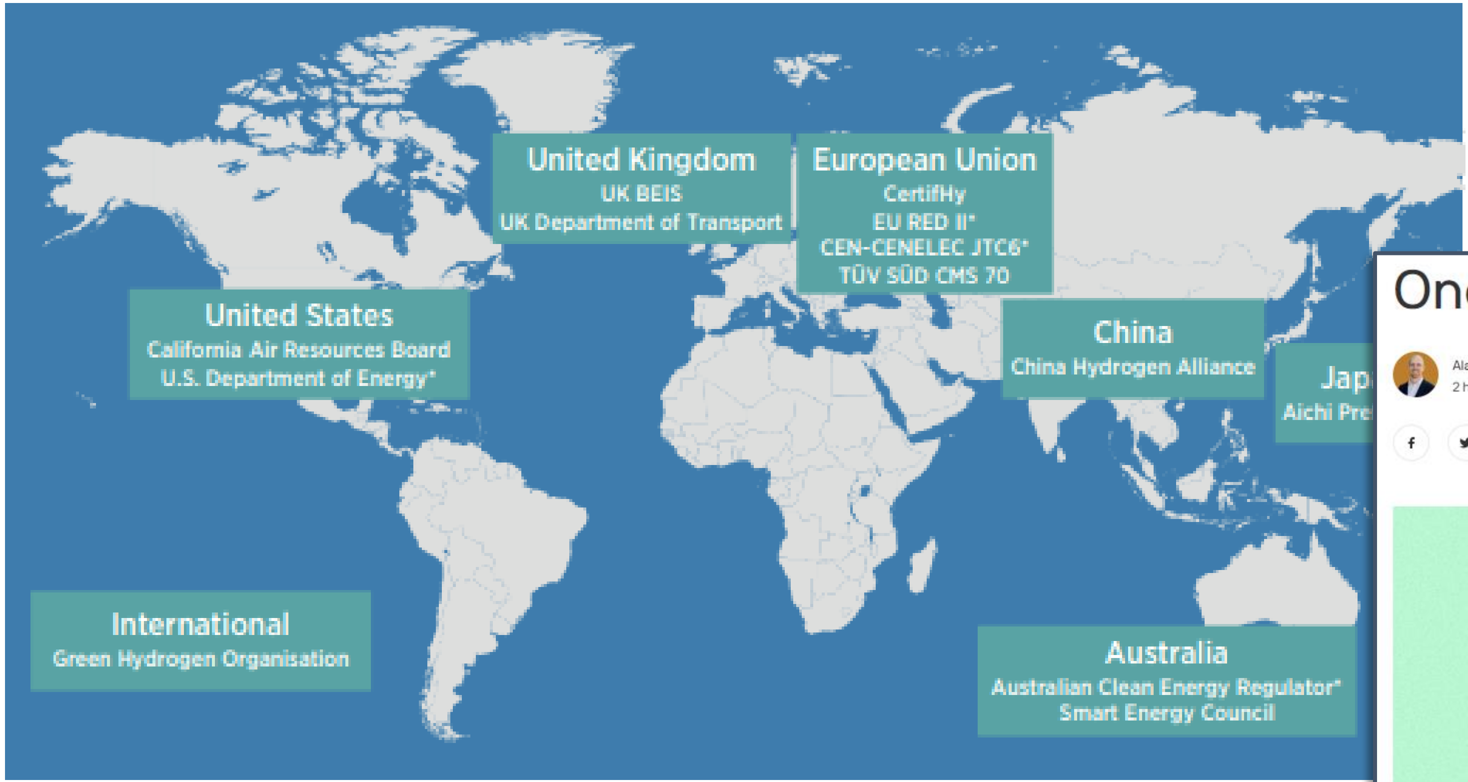
Fig. 2. Summary of the CI for the main Hydrogen production pathways. n = 387. The large diamond shows the average value with their respective 95% estimated confidence interval (for the mean) through a linear regression model using the hydrogen production pathways as categorical variables [121]. One CI for biomass gasification with a very high value of 1972 gCO_2e/MJ H_2 is omitted from the chart.

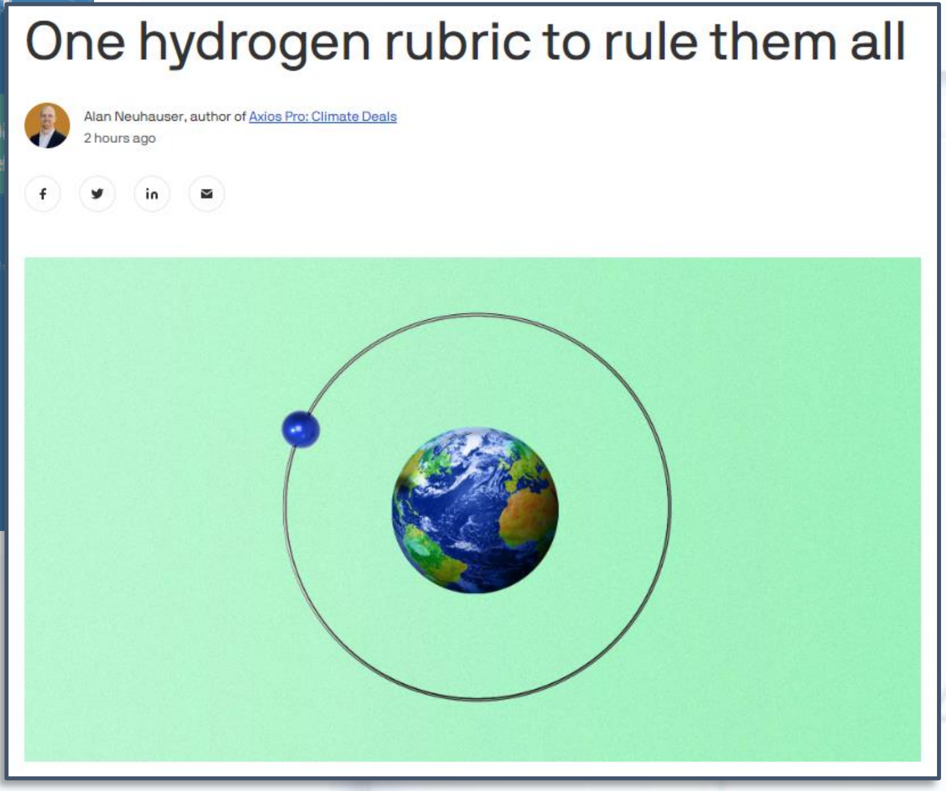
Source: Kendall et al. 2023

ONE TOOL TO HARMONIZE THE WAY WE CALCULATE THE CARBON INTENSITY OF H2

OPEN **HYDROGEN** INITIATIVE

Figure 5 Map of organisations working on hydrogen certification





One hydrogen rubric to rule them all

Alan Neuhauser, author of Axios Pro: Climate Deals
2 hours ago

A Fragmented System of Regional Standards

Contact: OHI@gti.energy

Sobre OHI

Contact: OHI@gti.energy

WHAT IS THE **OPEN HYDROGEN INITIATIVE?**

OPEN **HYDROGEN** INITIATIVE

The Mission

The **Open Hydrogen Initiative** is laying the foundation for low-carbon hydrogen marketplaces

The Objective

OHI will develop an analytical toolkit to assess the carbon intensity of hydrogen production

- **Versatile (customizable for Facility Level)**
- **Cradle-to-Gate (use agnostic)**
- **Compatible with International Norms & Best Practices**
- **Comprehensive Stakeholder Engagement**
- **Open Sourced**

STAKEHOLDERS & SPONSORS

OHI Leadership

- GTI ENERGY
- NATIONAL ENERGY TECHNOLOGY LABORATORY
- S&P Global Commodity Insights

Foundational Sponsors

- ExxonMobil
- nationalgrid
- Capgemini
- EQT
- EY
- Shell

Technical Sponsors

- أرامكو السعودية saudi aramco
- equinor
- Black Hills Energy Ready
- Dominion Energy Actions Speak Louder
- DTE
- ENBRIDGE
- AURORA HYDROGEN
- LanzaTech
- Nicor Gas
- NYSEG
- DUKE ENERGY
- Oklahoma Natural Gas. A Division of ONE Gas
- SOUTHWEST GAS
- National Fuel

NGOs, Academic Partners, and Observers

- Alberta
- British Columbia
- Breakthrough Energy
- CATF Clean Air Task Force
- Ammonia Energy Association
- RMI
- RHA Renewable Hydrogen Alliance
- Bipartisan Policy Center
- Center for Houston's Future
- Hydrogen Forward
- CH2FC
- OTD Operations Technology Development
- evergreen climate innovations
- Stanford Energy Hydrogen Initiative
- UC Davis University of California
- Rice
- Queen Mary University of London
- The University of Newcastle Australia
- CICE B.C. Centre for Innovation & Clean Energy

OHI PILLARS OF SUCCESS

OPEN **HYDROGEN** INITIATIVE

CREDIBLE | COMPATIBLE | TRANSPARENT | OPEN SOURCE | PRAGMATIC

Benefits and Motivation

- **Regionally sensitive** technology deployment
- A **consolidated** hydrogen marketplace
- Greater incentive to **innovate** and **invest**
- Less barriers to **financing** new projects
- **Faster** and **cheaper** hydrogen adoption
- **Technology-agnostic** policy and regulation

Technical Solution

- **State of the Science**
- **Cradle-to-Gate** Life Cycle Analysis
- **Data Quality Confidence Metric**
- Best practices for **data collection**, **tracking**, **traceability**, and **reporting**
- Full suite of **industry demonstrations**

Contact: OHI@gti.energy

Como creamos OHI?

Contact: OHI@gti.energy

TECHNICAL TEAM

Key Leadership & Research Teams

Saad Siddique
Gas Conversion

Bob Stevens
Solid Conversion

Zane McDonald
Executive Director

Tim Skone
NETL LCA **Lead**

Michael Bradford
Sold Conversion
Lead

Ansh Nasta
Power Conversion

Travis Warner
CO_2 Management

Rosa Dominguez-Faus
Technical Director

Alan Hayse
S&P Global Market **Lead**

Asmara Soomro
Solid Conversion

Wade Mao
Power Conversion

Shirley Sam
Power Supply

Ally Reilly
Ext. Relations Manager

Jorge Izar-Tenorio
Biomass & RNG

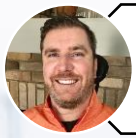
Matt Davidson
Solid Conversion

Greg Hackett
Power Conversion

Victoria Toetz
Power Supply

Dr. Paula Gant
Exec. Advisor & CEO GTI Energy

Matt Jamieson
Lead



David V. Wagener
Gas Conversion
Lead

Michelle Krynock
CO_2 Management
Lead

Scott Matthews
NG Supply **Lead**

Kristine Wiley
Exec. Advisor & SVP H2 Tech Center

Megan Henrikson
NETL **Coordinator**

Patrick Littlewood
Solid Conversion

Bob Wallace
Biomass & RNG Lead

John White
Power Supply

Shannon Katcher
Exec. Advisor & VP Data & Digitalization

John Brewer
Power Supply

Hari Mantripragada
CO_2 Management

Joseph Chou
Power Supply

Mike Blackhurst
NG Supply

Derek Wissmiller
Exec. Advisor & Dir. Energy Systems

Ron Stanis
Power Conversion Lead

Sheik Afzal
Gas Conversion

Srijana Rai
Biomass & RNG

Eric Lewis
Gas Conversion

Selection of Hydrogen Production Technologies

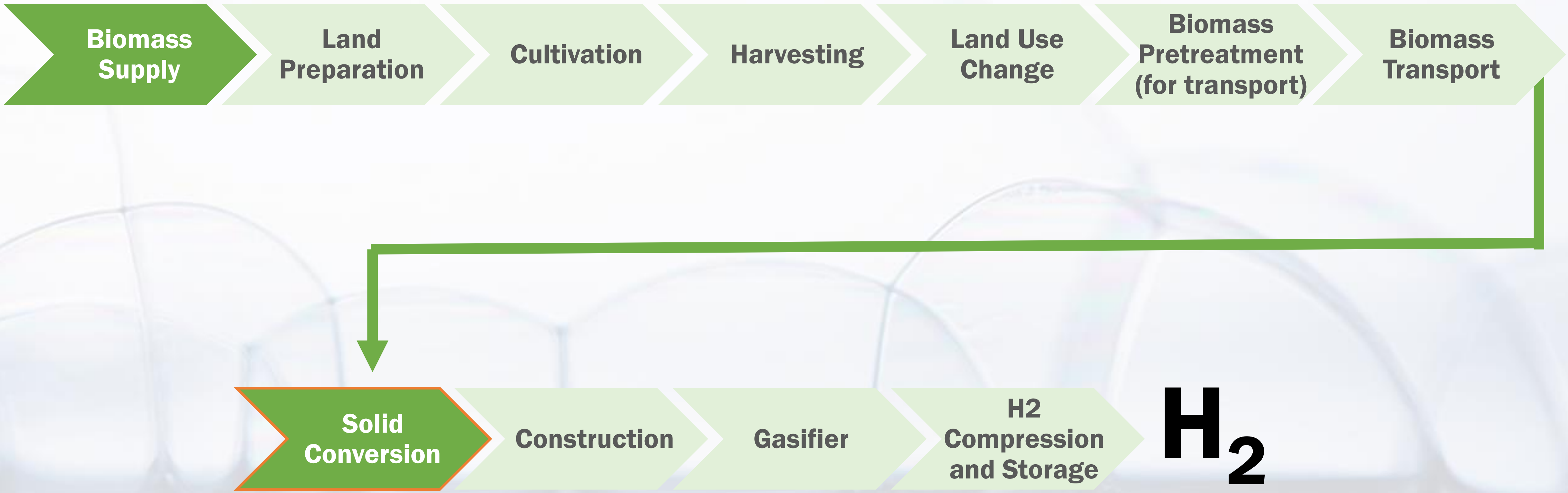
OPEN **HYDROGEN** INITIATIVE

- **Hydrogen Production Technologies**
  - **Solid Conversion** – biomass pretreatment (sizing, treatment specific to the plant), ASU, Hydrocarbon gasification, pressure swing absorption, sulfur recovery, particulate controls, NOx controls, CO_2 separation, cooling systems
  - **Gas Conversion** – SMR, ATR, POX, Pyrolysis, water gas shift, PSA off-gas treatment, pre-reforming treatment
  - **Power Conversion** – PEM, ALK, SOEC, AEM
- **Feedstock Supply:**
  - **Biomass & RNG** – biomass supply (various sources considered), collection, dehydration, pelletizing, digestion, sulfide removal, biogas upgrading, transportation & compression, gas refining, solid biomass processing
  - **Feedstock Supply: Natural Gas** – well exploration and development, oil and gas separation, NGL separation, gas processing plant, non-hydrocarbon gas removal, venting/flaring, storage, compression, transmission, distribution,
  - **Feedstock Supply: Power Generation** – Infrastructure manufacturing (solar & wind), primary energy supply, prime mover, step-up transformer, transmission, distribution
- **CO2 Management** –-carbon separation, electric and thermal carbon capture, purification, compression, subsurface site development, transmission, storage, leakage

Contact: OHI@gti.energy

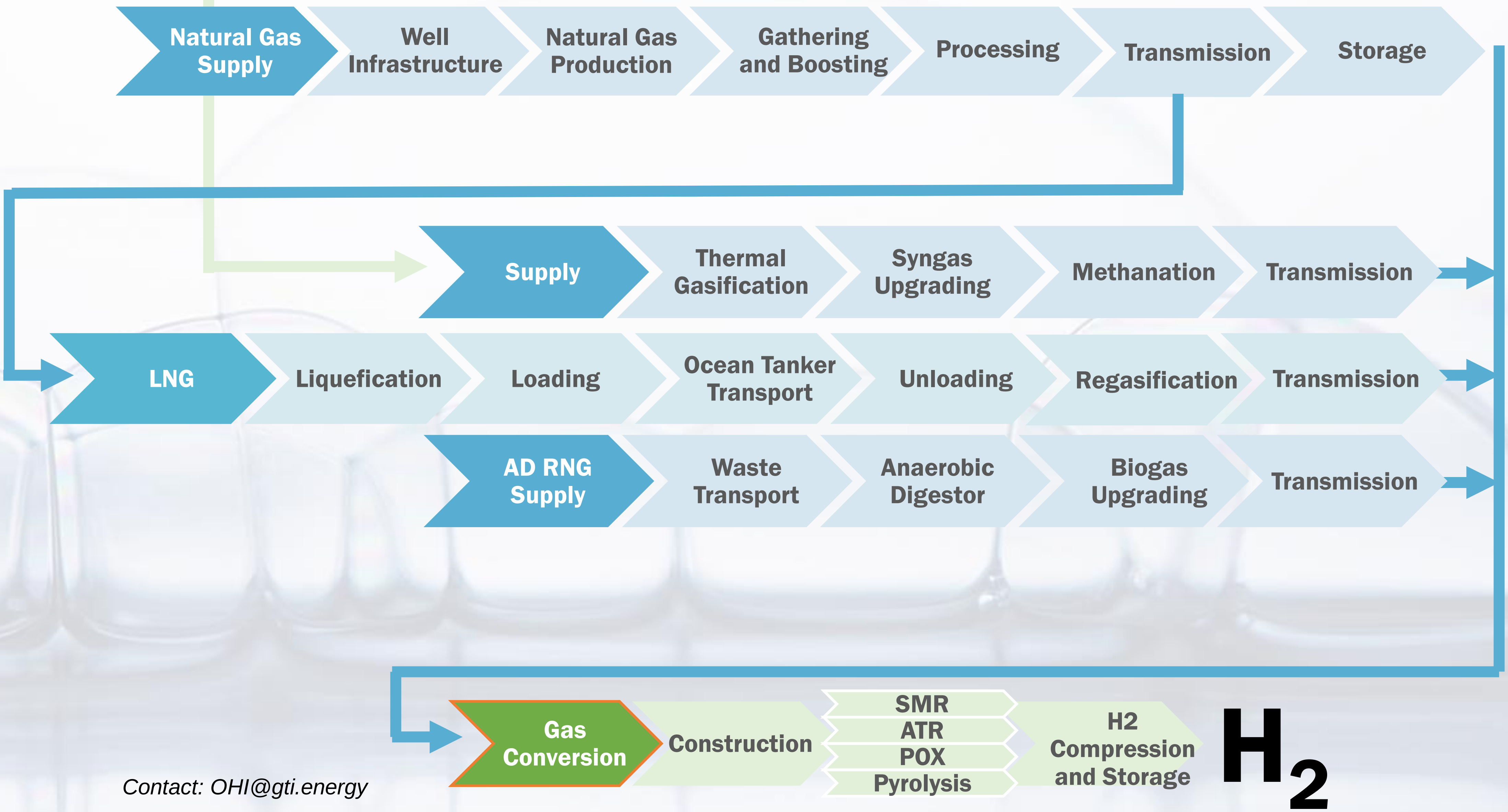
Solid Conversion Route

OPEN **HYDROGEN** INITIATIVE



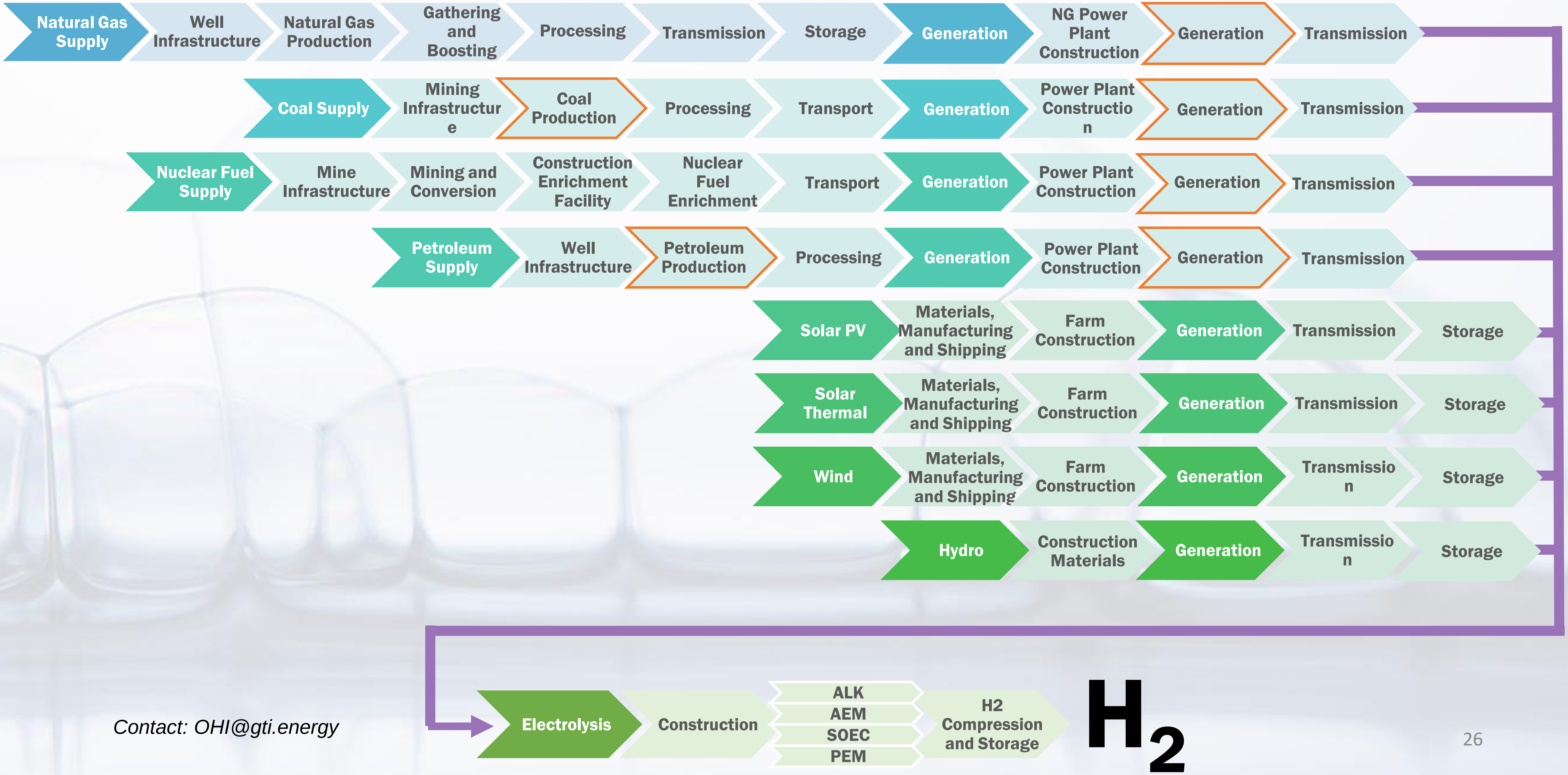
Contact: OHI@gti.energy

Gas Conversion Route



Contact: OHI@gti.energy

Power Conversion Route

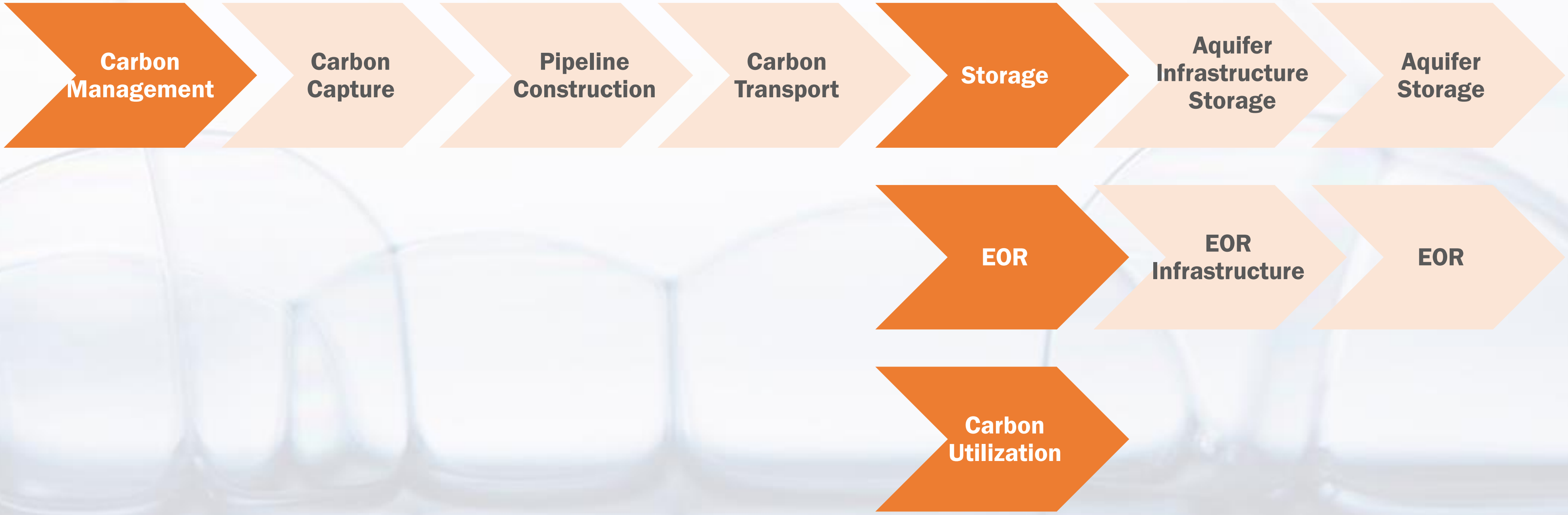


OPEN **HYDROGEN** INITIATIVE

Contact: OHI@gti.energy

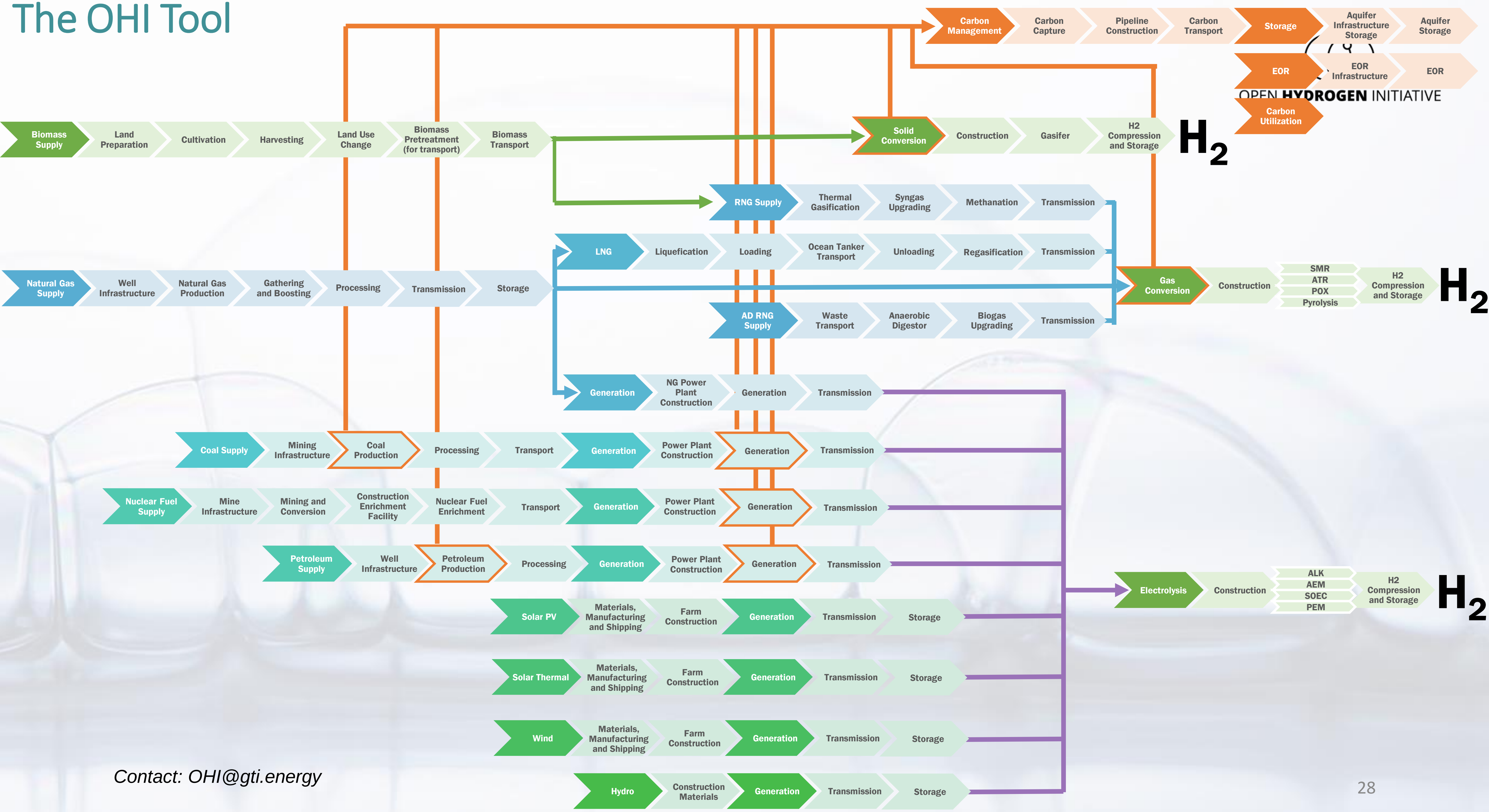
Carbon Management

OPEN **HYDROGEN** INITIATIVE



Contact: OHI@gti.energy

The OHI Tool



Contact: OHI@gti.energy

Unit Process **Library**

- Lists **materials and heat flows, parameter scenarios, references, calculations and assumptions**, and initial data quality assessment
- Thorough **documentation**

Contact: OHI@gti.energy

Unit Process Example

OPEN **HYDROGEN** INITIATIVE

Geographical Coverage:	United States
Region	N/A
Year Data Best Represents:	2018
Process Type:	Basic Process (BP)
Process Scope:	Gate-to-Gate Process (GG)
Allocation Applied:	No
Completeness:	Individual Relevant Flows Captured
Flows Aggregated in Data Set:	☑ Process ☑ Energy Use ☐ Energy P&D ☐ Material P&D

Goal and Scope:
Reference Flow: 1 kg of Hydrogen, 100 vol-%, 290 psia (1.99 MPa)

This unit process provides a summary of relevant input and output flows a
hydrogen. This process occurs in a series of SOECs fueled by electricity
Hydrogen (H2), 100 vol-%, 290 psia.

Note: All inputs and outputs are normalized per the reference flow (e.g., p

SECTION II: PARAMET

This section includes adjustable parameters, calculations needed to support adjustable parameters, and flow calculations based upon adjustable parameters.Hover over "Mean

	Parameter Name	Formula	Value	Uncertainty	Mean or Min	Std Dev or Max	Flow Type	Unit	Refere
6	h2_out		1.00E+00				Technosphere	kg/kg	1.
17	process_withdrawn		1.20E+01				Technosphere	kg/kg	1.
17	cooling_withdrawn		1.28E+02				Elementary	kg/kg	1
6	o2_out		7.94E+00				Elementary	kg/kg	1
15	electricity_net		3.98E+01				Technosphere	kWh/kg	2
14	natural_gas_in		4.32E-01				Technosphere	kg/kg	2
14	h2o_discharged		1.25E+02				Elementary	kg/kg	1
	End of List	<select this entire row, then insert new row>							

SECTION III: INPUT FL

This section includes all input flows considered for this unit process. Hover over "Tracked" for descrip

Parameter	Flow Name	Value	Units	Parameter	Unit	Total	Units per RF	Trac
process_withdrawn	Technosphere Flows/Water, purified	1	kg	1.20E+01	kg/kg	11.99	kg	X
cooling_withdrawn	Elementary Flows/resource/water/Water, fresh	1	kg	1.28E+02	kg/kg	127.50	kg	
electricity_net	Technosphere Flows/Electricity, AC, 120 V	1	kWh	3.98E+01	kWh/kg	39.76	kWh	X
natural_gas_in	Technosphere Flows/Natural gas, combusted	1	kg	4.32E-01	kg/kg	0.43	kg	X
End of List	<select this entire row, then insert new row>	Factor				Amount		

This section includes all output flows considered for this unit process. Hove

Parameter	Flow Name	Value	Units	Parameter	Unit	Total
h2_out	Hydrogen, 100 vol-%, 290 psia (1.99 MPa)	1	kg	1.00E+00	kg/kg	1.0
o2_out	Elementary Flows/emission/air/Oxygen	1	kg	7.94E+00	kg/kg	7.9
h2o_discharged	Elementary Flows/emission/water/Water, fresh	1	kg	1.25E+02	kg/kg	125.0
End of List	<select this entire row, then insert new row>	Factor				

Note: Inventory items not included are assumed to be zero based on best engineering judgment or assumed to be zero because no data was available to categ

Calculations

Calculations [Yellow-highlight cells are carried to data summary]

Subheader as Needed

Flow	Value Poplar	Value Corn Stover	Value Loblolly Pine	Units	Notes	Assumptions	References
Biomass,	20.9	28.8	18.6	kg biomass / kg H2			5
Air Demand, kg O2 / kg H2	95.7	127.6	88.4	kg air / kg H2			5
Natural gas demand, kg CH4 / kg H2	0.542	0.747	0.482	kg CH4 / kg	For biomass drying		5
Pure CO2 produced, kg CO2 / kg H2	29.8	38.1	28.8	kg CO2 / kg H2			5
Sulphur acid gas produced, kg / kg H2	0.0027	0.0036	0.000119901	kg / kg H2			5
Ash produced, kg Ash / kg H2	0.54	2.12	0.34	kg Ash / kg H2			5
Electricity requirement, H2 compression	2.34	2.34	2.34	MJ / kg H2	Quadratic approximation, accurate +/-5% between 300 and 1500 psi		5
Electricity generation, Tail Gas Utilization	7.10	8.70	7.70	MJ / kg H2			
Net electricity import, MJ / kg H2	30.24	37.10	26.56	MJ / kg H2	Net requirement, (total, minus steam turbine, plus H2 compression)		5
CO2 flue produced from biomass drying	1.49	2.06	1.32	kg CO2 / kg	Fossil CO2 flue from natural gas burning to dry feed		
CO2 flue from tail gas utilization (biogeni	5.27	6.50	5.26	kg CO2 / kg	Biogenic CO2 flue from tail gas utilization from PSA		
CO2 flue gas (total), kg CO2 / kg H2	6.76	8.56	6.58	kg CO2 / kg H2			5
Ammonia produced, kg NH3 / kg H2	0.0099	0.00739	0.0077	kg NH3 / kg H2			5
VOC emissions from drying, kg/kg H2	0.0167	0.023	0.0149	kg VOCs / kg H2			5
PM solids handling, kg / kg H2	1.476E-05	2.128E-05	1.304E-05	kg PM / kg H2 (<30 microns)		Estimated based on ash and solid feed, 5 m/s a	5,6
Hydrogen purity factor	1.09	1.09	1.09	N/A	Factor accounting for additional feed, power etc. required for higher purity H2		
Hydrogen purity factor toggle	1.00	1.00	1.00	N/A	Toggle for hydrogen purity factor (toggled on Data Summary tab)		
Fugitive emissions:						Assumes all gas leaks are syngas	
# of valves in plant	160	160	160				
# of flanges in plant	1200	1200	1200				
# of compressors in plant	8	8	8				
Syngas CO content	34%	34%	34%				
Syngas H2 content	33%	33%	33%				
Syngas CO2 content	33%	33%	33%				
Fugitive emissions, kg/hr	1.258445645	1.258445645	1.258445645	kg/hr	lb/hr converted to kg / hr		7

Data Quality Index

Data quality is determined using the EPA pedigree matrices for process-level and flow-level scores.

Process-Level DQI Determination

	Process Review	Process Completeness
Biomass gasification	4	2

Indicator	1	2	3	4	5 (default)
Process review	Documented reviews by a minimum of two types[1] of third party reviewers	Documented reviews by a minimum of two types of reviewers, with one being a third party	Documented review by a third party reviewer	Documented review by an internal reviewer	No documented review
Process completeness	>80% of determined flows have been evaluated and given a value	60-79% of determined flows have been evaluated and given a value	40-59% of determined flows have been evaluated and given a value	<40% of determined flows have been evaluated and given a value	Process completeness not scored

Reviewer documentation checklist

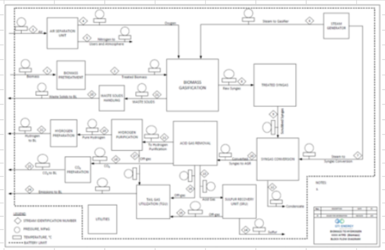
Type of review	Internal or external
Elements of review	Goal and scope definition
	Raw data
	Unit process, single operation (unit process inventory)
	Aggregated process inventory
	LCI results or partly terminated system
	LCIA methods that are applicable
	Dataset documentation
	Check of the data quality indicators (DQIs)

Flow Type	Point Value	Flows Expected	Flows Evaluated	% Complete	Calculated Score	Notes	Definition
Reference product	6.8	1	1	100%	6.8		Primary functional process output to which all values are scaled
Co-products	13.5	1	1	100%	13.5	Captured CO2	Secondary functional process outputs
Intermediate inputs	27.0	4	3	75%	20.3	Construction is not included in this process	All purchased inputs, including non-durables, durables, and infrastructures
Land occupied/ transformed	0.0	0	0	100%	0.0		Land occupied or converted
Raw material/energy inputs							
Raw material inputs	5.4	1	1	100%	5.4	Air	Includes fossil resources, minerals and metals, biomass, and carbon dioxide sequestered
Raw energy inputs	0.0	0	0	100%	0.0		Energy from wind, sunlight, geothermal, waves, etc. captured in unit process
Water inputs	6.8	1	0	0%	0.0	Process water (e.g. cooling, cooling tower loss) not accounted for	Treated or untreated water input
Waste to treatment							
Solid and hazardous waste	6.8	3	2	67%	4.5	Ash, captured VOCs; not accounted for VOC capture bed material	Solid and hazardous waste sent to a treatment facility or reclaimed/recycled
Liquid waste	6.8	1	1	100%	6.8	Ammonia in wastewater	Wastewater
Emissions to air							
GHGs	6.8	1	1	100%	6.8	CO2 in flue	e.g. CO2, CH4, N2O, SF6

Assumptions

Assumption #	Description	References
1	Biomass gasification follows a generic process as described by the block flow diagram to the right.	5
2	The plant production capacity is 50,000 kg H2/day	1,2,3,4
3	Ammonia, sulphur, ash, VOC byproducts are removed for further treatment/disposal (technosphere)	
4	Natural gas is used to dry the incoming biomass	5
5	Syngas conversion is done by sour shift, acid gas treatment by a Selexol-type process	5
6	H2 purification is done by PSA, tail gas is burned to make steam	5
7	Excess steam is used to make electricity in a turbine	5
8	The CO2 product leaves the battery limit but is not emitted; CO2 emitted in flue is accounted for separately	

Assumption #1. Generic block flow diagram.



OPEN HYDROGEN INITIATIVE

Unit Process Library

OPEN **HYDROGEN** INITIATIVE

RNG & Biomass Supply	Power Generation	Natural Gas Supply
Anaerobic Digestion of Animal Manure	Battery Storage	LNG Liquifaction
Anaerobic Digestion of MSW	Coal Power Gen	LNG Loading
Anaerobic Digestion of Wastewater	Hydro Power Gen	LNG Ocean Transportation
Biogas Upgrading via Water Scrubbing	Natural Gas Power Gen	LNG Unloading
Biogas Upgrading via MDEA Scrubbing	Nuclear Power Gen	LNG Regasification
Biogas Upgrading via MEA Scrubbing	Oil Power Gen	Natural Gas Compression
Biogas Pretreatment	Solar PV	Gathering & Boosting
Methanation for Thermal Gasification	Solar Thermal	Pipeline Transportation
Biomass Cultivation	Uranium Mining	Natural Gas Processing
Biomass Harvesting	Wind	Natural Gas Production
Land Preparation	Transmission & Distribution	Natural Gas Storage
Land Use Change		Transmission Station
Syngas Cleanup for Thermal Gasification	**Power Conversion**	
Thermal Gasification	AEM Electrolysis	**Carbon Management**
	Alkaline Electrolysis	CO2 Utilization
Gas Conversion	Solid Oxide Electrolysis	CO2 Capture
Autothermal Reforming	PEM Electrolysis	CO2 EOR
Methane Pyrolysis		CO2 Saline Aquifer Storage
POX	**Solid Conversion**	CO2 Transport
Steam Methane Reforming	Thermal Gasification	CO2 Utilization

OPEN **HYDROGEN** INITIATIVE

Important LCA questions:

- What is the Functional Unit?
  - H2 purity
  - H2 compression level
- What is the appropriate scale of the facilities?
- LCA Scope: Well-to-gate (not including transport)
  - Should we CAPEX emissions? (materiality principle)
  - Should we include LUC and iLUC?
  - Include H2 fugitive emissions?
- What kind of feedstocks are appropriate?
- How do we treat biogenic products?
- How to treat process waste in the LCA?
- What CCU types are we including?
- Market mechanism: RECS, PPA
- Policy mechanism: Avoidance credit
- Materiality according to ISO
- Allocation methods
- How do we deal with regionality and globality?
- Block flow diagrams
  - Flows to be included/excluded
  - Wastes and byproducts
- CAPEX emissions
- H2 fugitive emissions

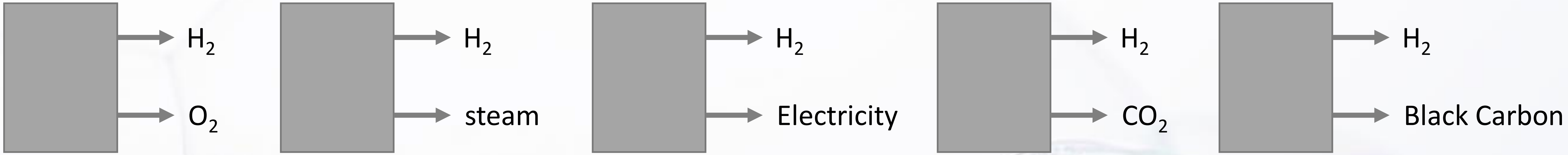
Contact: OHI@gti.energy

"In any pathway,
the **emission burden**
must be **apportioned**
to the different **coproducts**"

Contact: OHI@gti.energy

What kind of by-products in each route?

OPEN HYDROGEN INITIATIVE



Allocation methods:

- Partition
- System expansion with displacement or substitution
- Energy
- Mass
- Molar
- Enthalpy
- Market

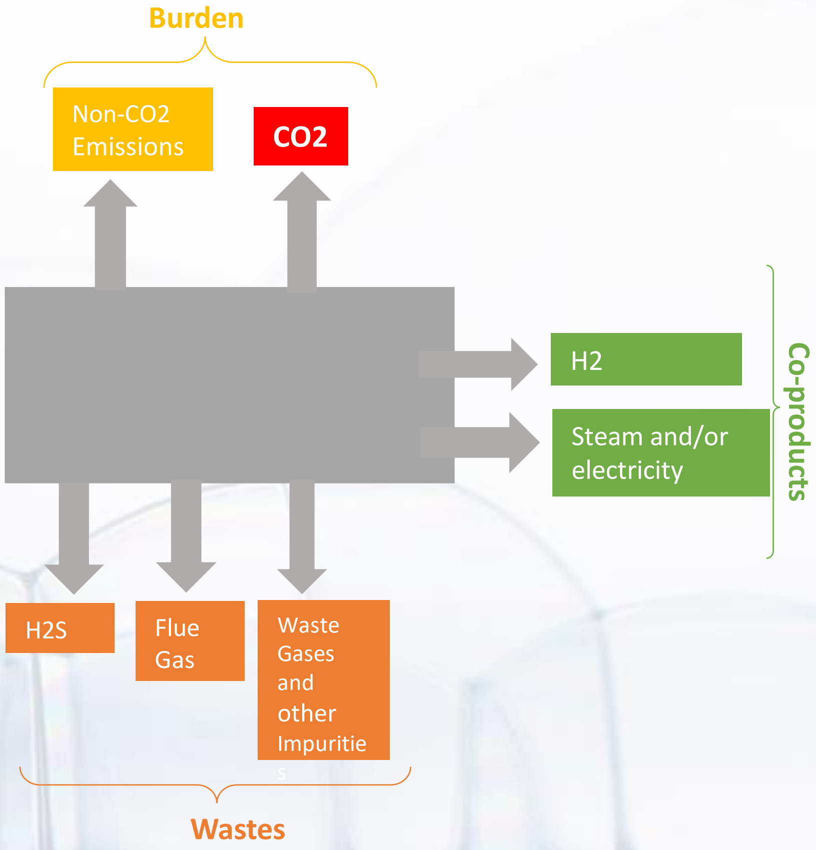
Hierarchy of Allocation methods:

- Physical
- Displacement
- Market

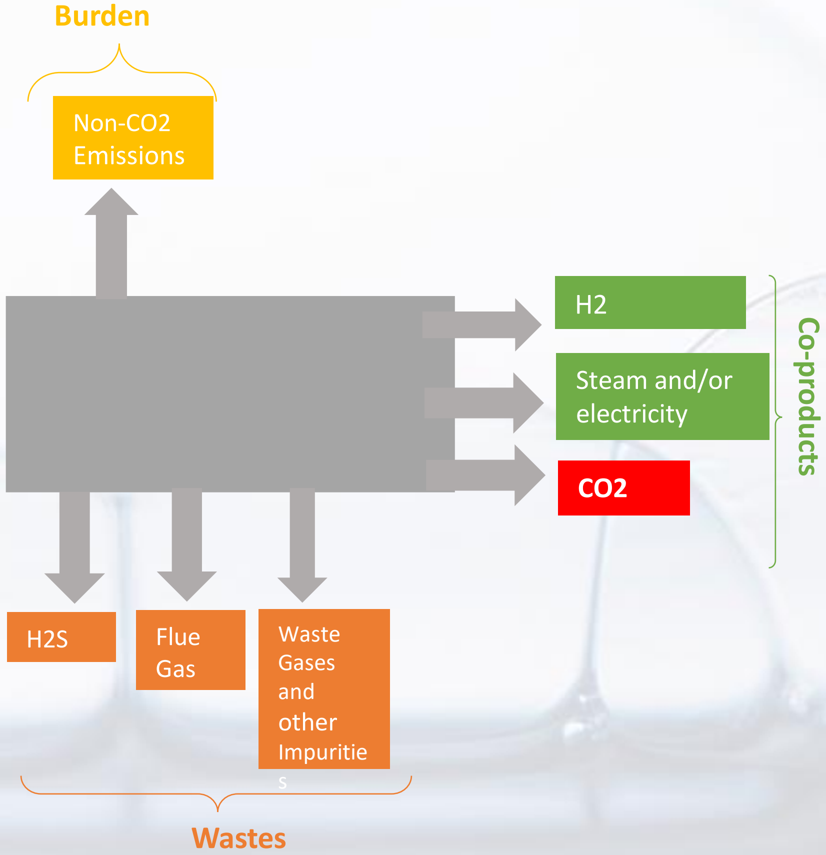
Contact: OHI@gti.energy

OPEN HYDROGEN INITIATIVE

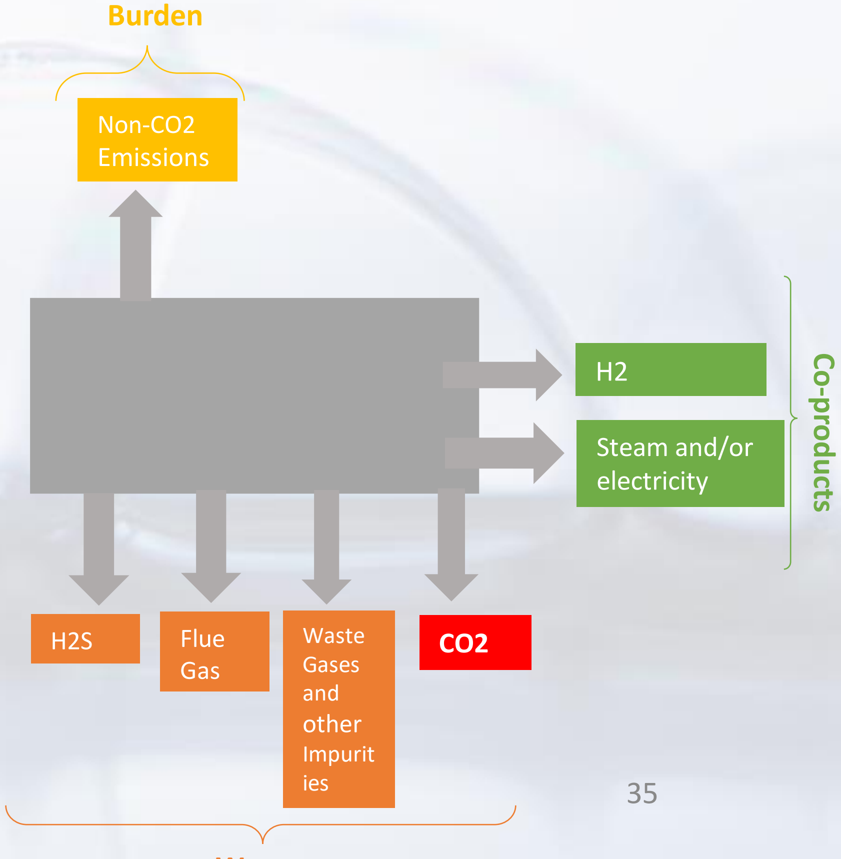
CO2 is an emission



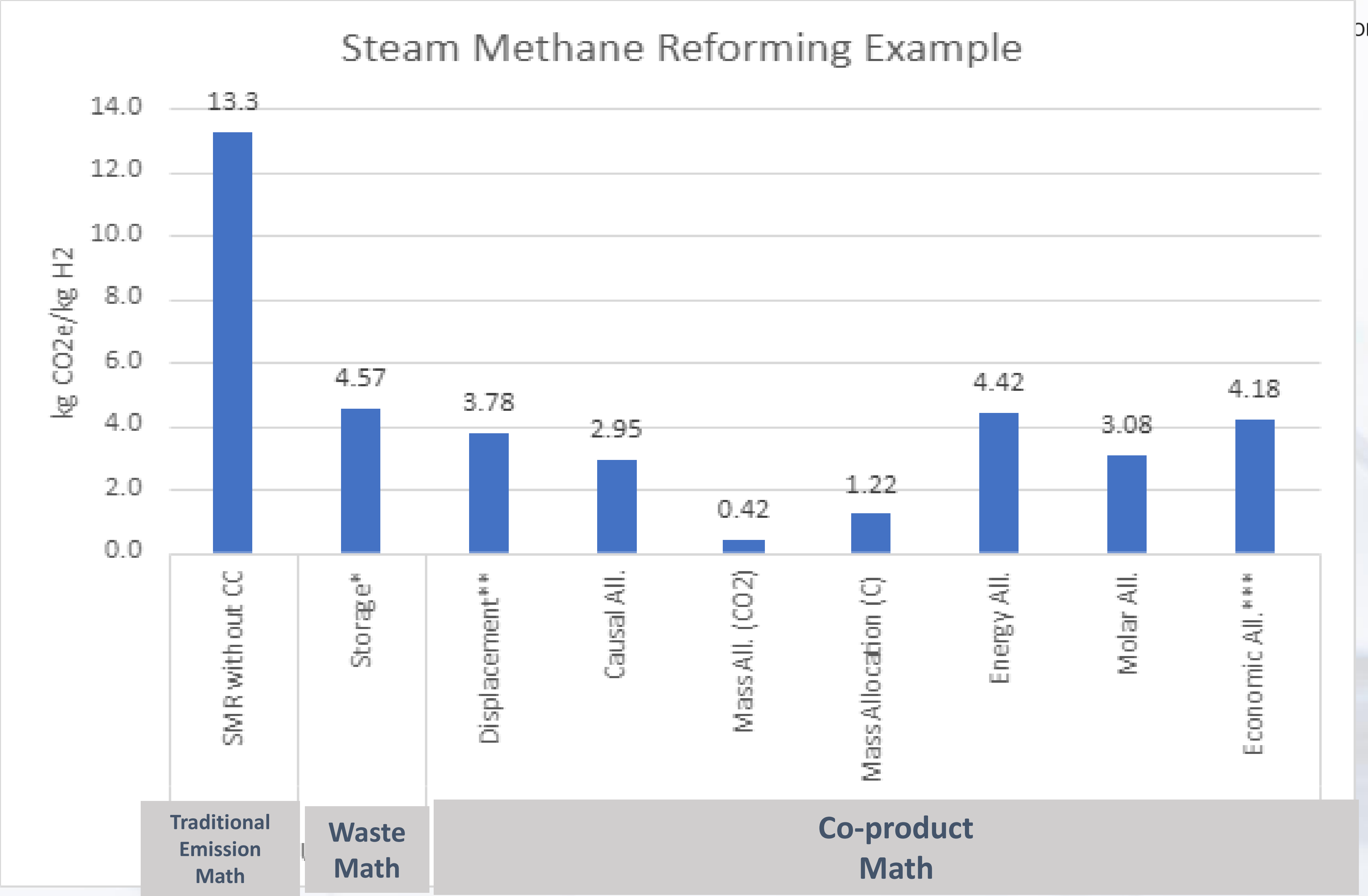
CO2 is a co-product



CO2 is a waste

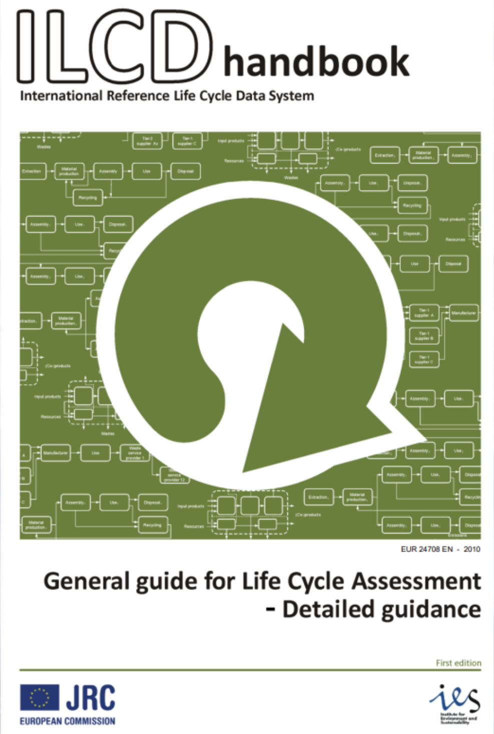


Contact: OHI@gti.energy

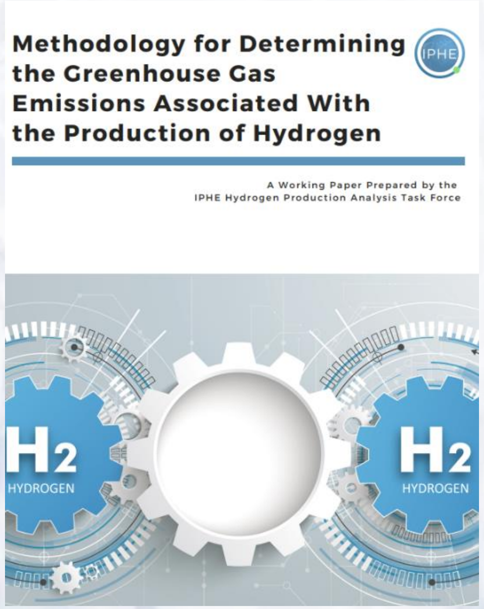

Steam Methane Reforming Example
kg CO2e/kg H2
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
13.3
4.57
3.78
2.95
0.42
1.22
4.42
3.08
4.18
SMR with out CC
Storage*
Displacement**
Causal All.
Mass All. (CO2)
Mass Allocation (C)
Energy All.
Molar All.
Economic All.***
Traditional Emission Math
Waste Math
Co-product Math

OPEN **HYDROGEN** INITIATIVE

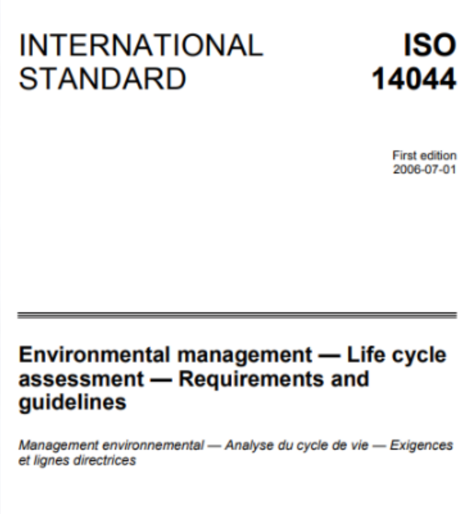
Adopting **best practices**



ILCD handbook
International Reference Life Cycle Data System
EUR 24708 EN - 2010
General guide for Life Cycle Assessment - Detailed guidance
First edition
JRC EUROPEAN COMMISSION

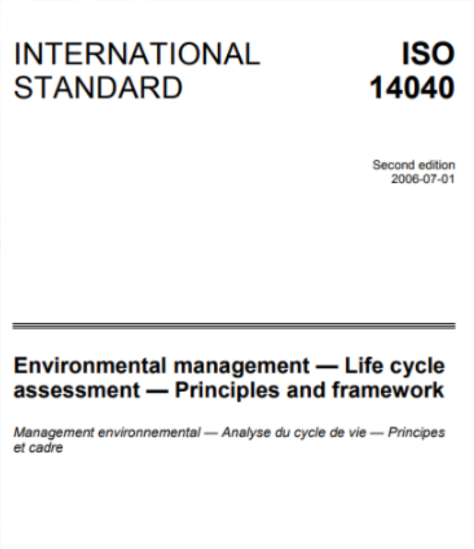


Methodology for Determining the Greenhouse Gas Emissions Associated With the Production of Hydrogen
IPHE
A Working Paper Prepared by the IPHE Hydrogen Production Analysis Task Force



INTERNATIONAL STANDARD
ISO 14044
First edition 2006-07-01
Environmental management — Life cycle assessment — Requirements and guidelines
Management environnemental — Analyse du cycle de vie — Exigences et lignes directrices

INTERNATIONAL STANDARD
ISO 14067
First edition 2018-08
Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification
Gaz à effet de serre — Empreinte carbone des produits — Exigences et lignes directrices pour la quantification



INTERNATIONAL STANDARD
ISO 14040
Second edition 2006-07-01
Environmental management — Life cycle assessment — Principles and framework
Management environnemental — Analyse du cycle de vie — Principes et cadre

OPEN HYDROGEN INITIATIVE

Panel de Expertos Independientes

OPEN **HYDROGEN** INITIATIVE

Dr. Naomi Boness, Stanford University

Dr. Anne-Sophie Corbeau, Columbia University

Janet Anderson, Van Ness Feldman

Dr. Alissa Kendall, University of California, Davis

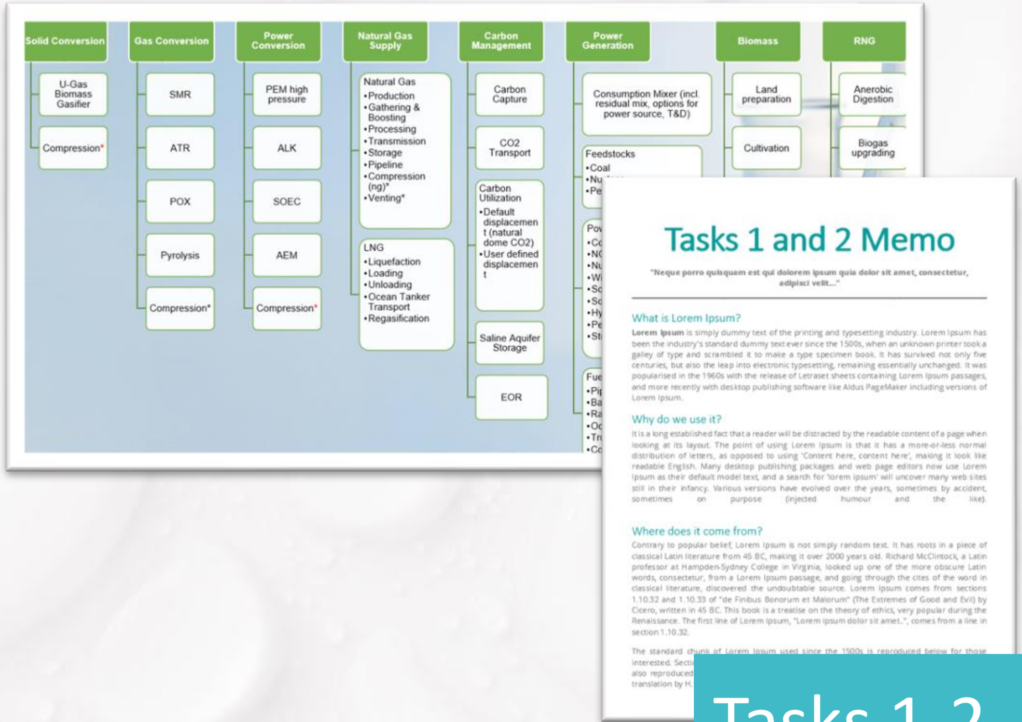
Dr. Dianne Wiley, University of Newcastle, Australia

Dr. Rachel Meidl, Rice University

Dr. Paul Balcombe, Queen Mary University of London

Dr. Michael Webber, University of Texas, Austin

Unit Process Files + Memo

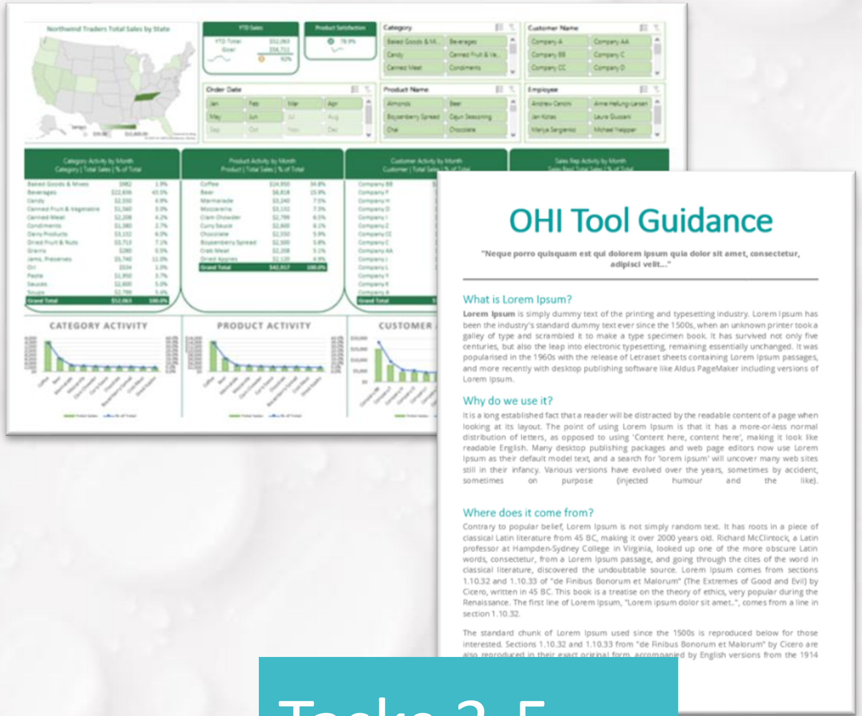


Tasks 1-2

7 working groups:
Different subject matter expertise

LCA Tool + Protocols

OPEN HYDROGEN INITIATIVE



Tasks 3-5

1 working group:
LCA expertise

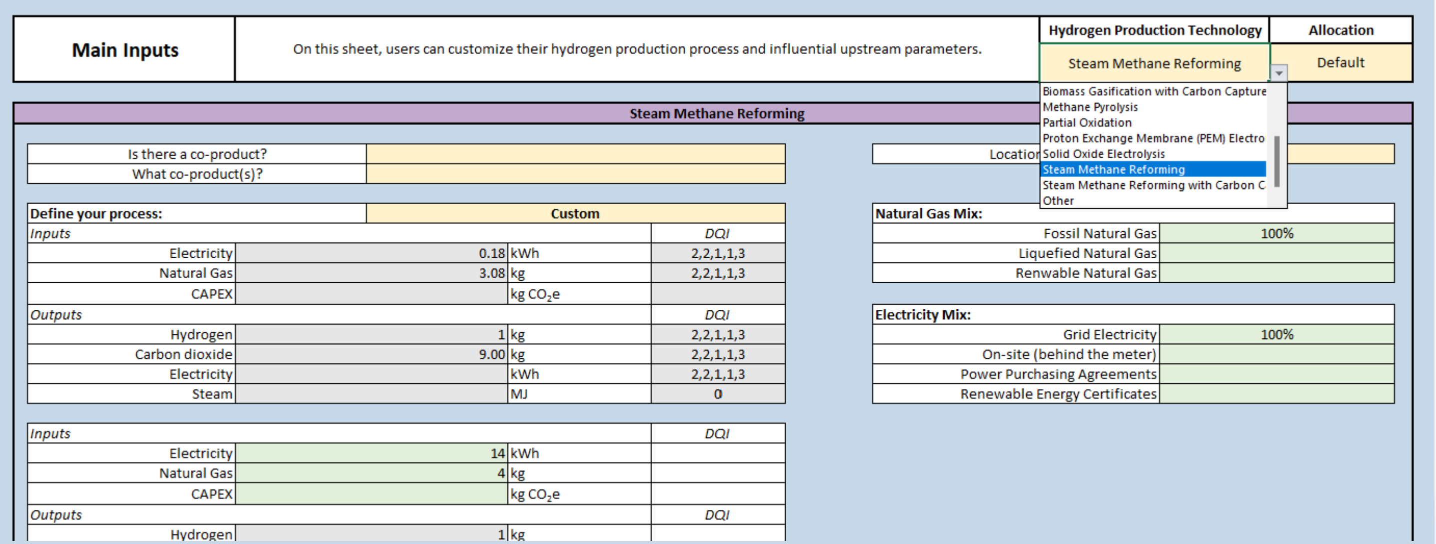
Contact: *OHI@gti.energy*

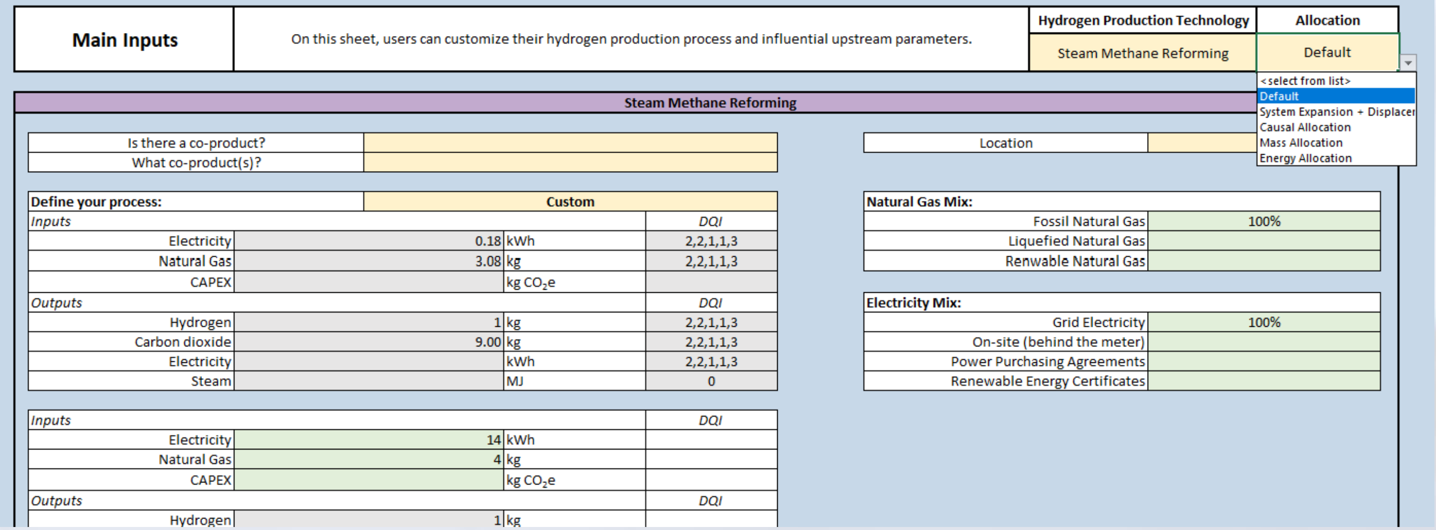
Extremely versatile

OPEN HYDROGEN INITIATIVE

- Unit process data serving as defaults, but users can **customize** their process.

- Most influential parameters will be visible on this sheet for user adjustment.





Contact: OHI@gti.energy

Main Inputs Interface

Example: Data Selection

OPEN **HYDROGEN** INITIATIVE

Location:	United States of America (the)
Balancing Authority:	USA-PJM Interconnection, LLC

Define your process:		Default
Biomass	0.6%	
Coal	16.9%	
Geothermal	0.0%	
Hydroelectric	1.3%	
Natural Gas	41.1%	
Nuclear	35.8%	
Oil	0.1%	
Solar Photovoltaic	0.8%	
Solar Thermal	0.0%	
Storage		
Wind	3.4%	
Other	0.0%	

<select from list>
- Default
- Custom Mix
- User Override

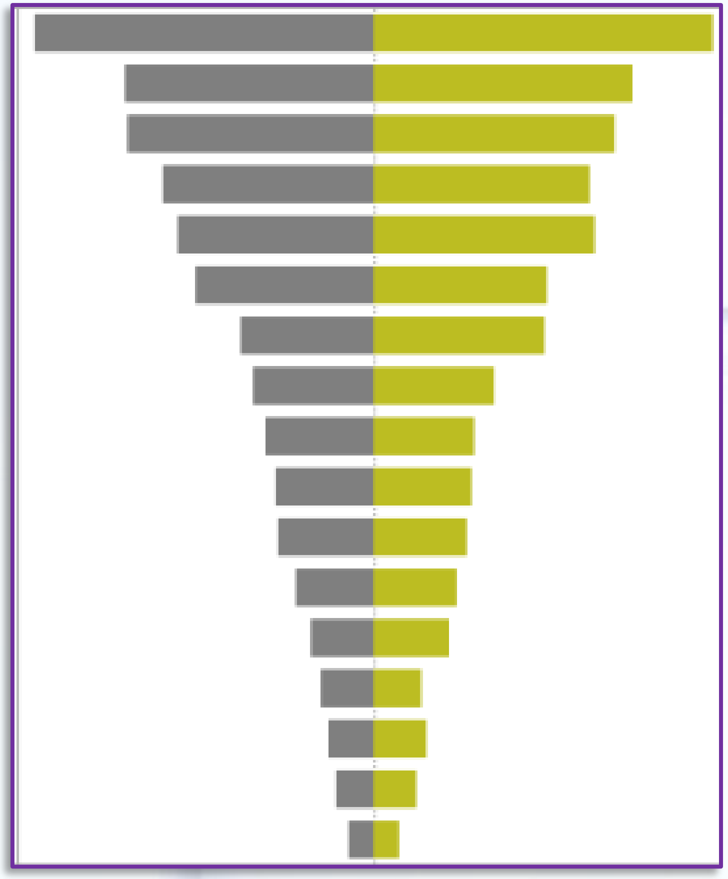
Contact: OHI@gti.energy

OPEN HYDROGEN INITIATIVE

How do we embrace complexity while still creating an operable tool?

OPEN **HYDROGEN** INITIATIVE

- Contribution Analysis
- Systematic procedures for estimating the effects of the choices made regarding methods and data on the outcome of a CFP study
- Identify top parameters that contribute to the majority of the LCA number
- Focus on getting the most accuracy for those



Contact: OHI@gti.energy

Data Quality Index: Dealing with Data Uncertainty

Percentage	Letter grade	Description
90 – 100	A +	Exceptional
80 – 89	A	Excellent
70 – 79	B	Good
60 – 69	C	Satisfactory
50 – 59	D	Barely acceptable
0 – 49	F	Unacceptable

Contact: OHI@gti.energy

OPEN HYDROGEN INITIATIVE

Project Schedule

OPEN **HYDROGEN** INITIATIVE

September 2022 – *February 2023*

Tasks 1 & 2: State of Science & Carbon Management

May 2023

Tasks 3 & 4: Data Quality Index

October 2023

Tasks 5: Toolkit and Protocol Development

Jan 2024

Tasks 6a: Case Studies

1Q2024

Tasks 6b: Demonstrations

Phase 1 Governance

Phase 2 Governance

Contact: OHI@gti.energy

CASE STUDIES

OPEN **HYDROGEN** INITIATIVE

- Case studies
  - Biomass gasification with CCS in Australia,
    - Which biomass?
    - From Australia?
  - ATR w/CC in UK with LNG imports from US
  - PEM electrolysis in Argentina with solar

- Demos
  - Shell, Enbridge, National Grid, Aurora, ExxonMobil

OPEN HYDROGEN INITIATIVE

OHI Toolkit Demonstrations

OPEN **HYDROGEN** INITIATIVE

- Tool MVP (3Q2023)
- Case Studies (4Q2023)
- Industry Demonstrations (1Q2024)
- Public Launch (2Q2024)

FOR DEMONSTRATIONS:

- **Mid-summer**: Demonstration Charter and request for volunteers
- **October 2023**: Final deadline for volunteering
- **Nov & Dec 2023**: Stage-setting, coordination, information sharing
- **January 2024**: Demonstrations begin
- **March 2024**: Demonstrations conclude
- **April 2024**: Public Launch

Contact: OHI@gti.energy

Open Hydrogen Initiative

Contact: ohi@gti.energy

OPEN **HYDROGEN** INITIATIVE

OHI is end-use agnostic. We focus on crade-to-gate but will define system boundaries transparently and with flexibility

Contact: OHI@gti.energy

OPEN **HYDROGEN** INITIATIVE

OHI will create transparent documentation on sources of data and methods.

Contact: OHI@gti.energy

OPEN **HYDROGEN** INITIATIVE

OHI is end-use agnostic. We focus on crade-to-gate but will define system boundaries transparently and with flexibility

Contact: OHI@gti.energy

OHI will create transparent documentation on sources of data and methods.

Contact: OHI@gti.energy

OPEN **HYDROGEN** INITIATIVE

OHI will develop Protocols

A single static value will always be incorrect when assessing the carbon intensity of individual hydrogen production at the facility level.

Instead of attempting to identify a standard value, governments and market participants should be collaborating to develop agreed-upon structures and methodologies for identification of high-fidelity measured values representative of real-time operation and supply-chain characteristics.

In doing so, carbon intensity calculations become reflective of the **real-world operations of a single facility at a single point in time.**

This approach not only increases accuracy, but also creates a structure that incentivizes the rapidly growing industry to implement incremental, facility-level decarbonization solutions that would otherwise not be captured in a less granular approach.

Contact: OHI@gti.energy