GTI ENERGY

solutions that transform

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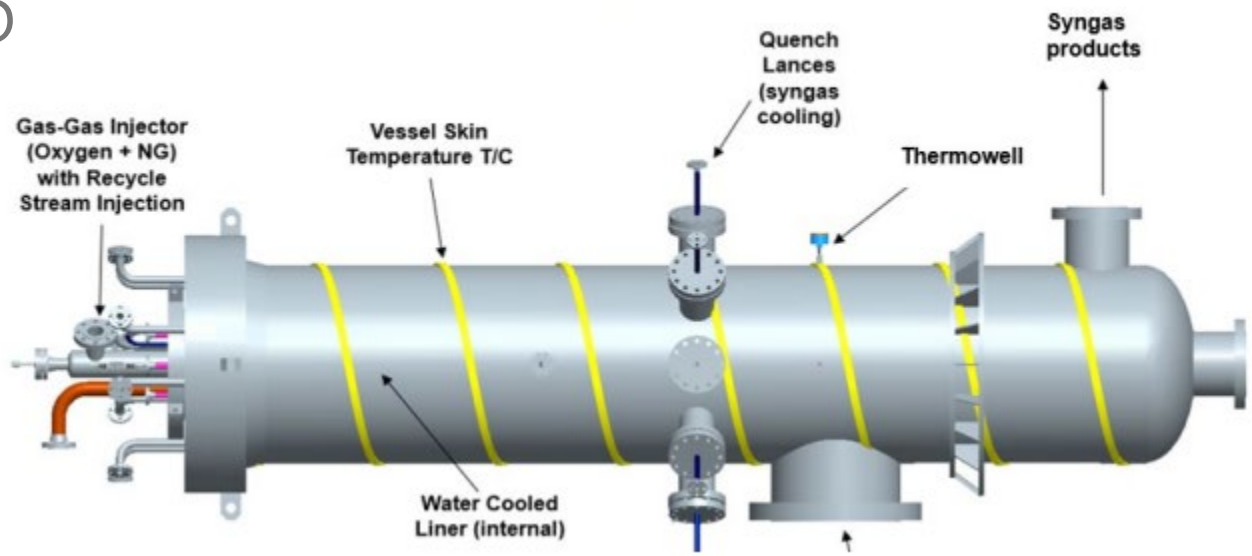
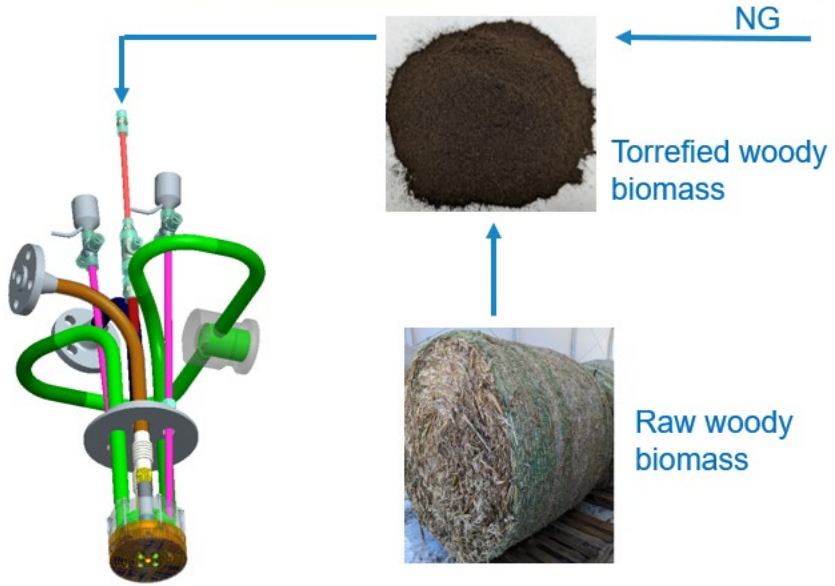
R-GAS POX

- Partial-Oxidation (POX) reactor thermo-chemically converts Natural Gas (NG) feedstocks to syngas
- Advanced oxy-fired burner design for NG: Rapid mix burner injectors for intense heat with robust water-cooling
- Compact plug-flow reactor: Reactive 1-D flow that maintains high-temperature reaction zone for maximal conversion.
- Actively Cooled Liner: eliminates refractory for transportability, minimal field installation, operational flexibility.
- Water Spray Direct Quench: Syngas cooling and H2 augmentation



R-GAS POX: Solution for Net-negative H2

- Current blue H2 production method that relies on NG as feedstocks cannot achieve net-negative H2 mainly because of upstream emissions.
- GTI Energy is looking to advance a technical approach where NG and biomass are co-injected in a POX reactor to ultimately achieve net-negative H2 production → **This approach not feasible with SMRs and ATRs.**
- GTI Energy maintains a unique talent for designing sophisticated rocket-engine-inspired injectors that can handle both solid and gaseous feedstocks.



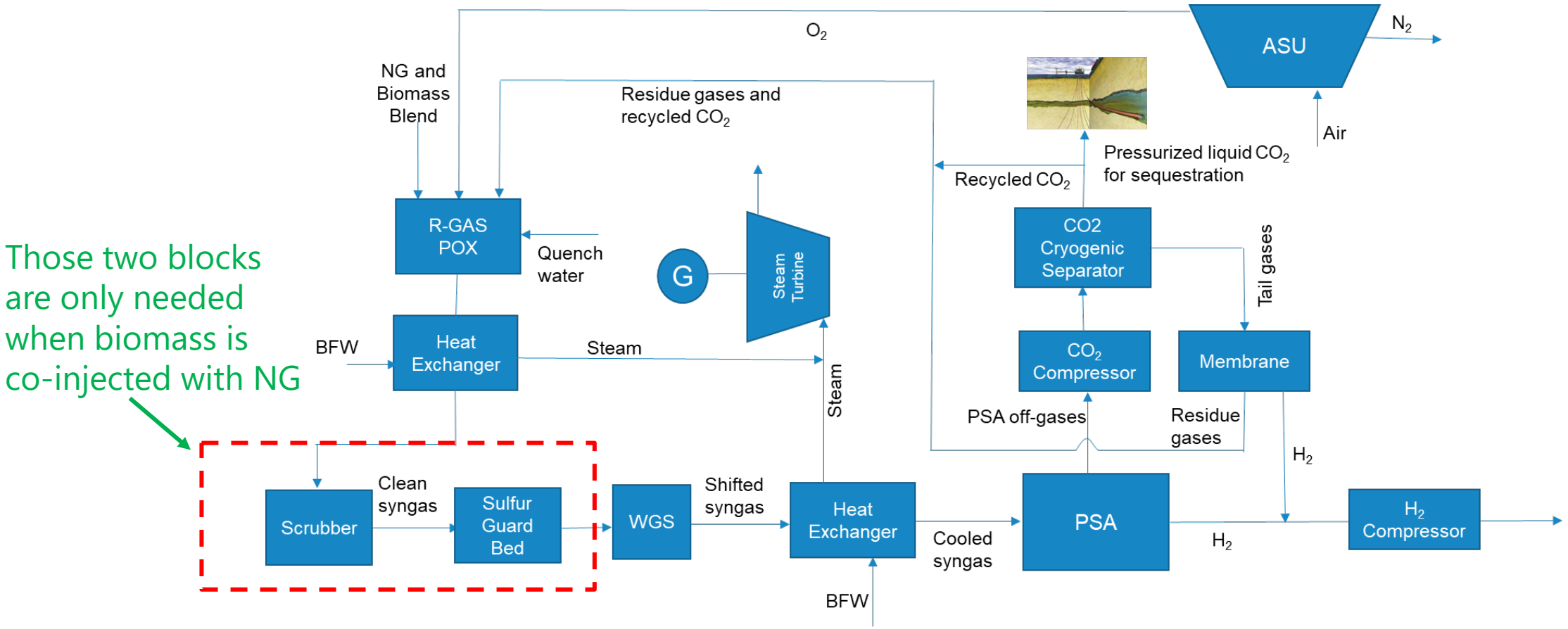
2.10 kg $CO_2e/kg\ H_2$

H_2 Carbon Intensity

<0 kg $CO_2e/kg\ H_2$

R-GAS POX for Net-negative H_2 - Flowsheet

- **98.5% CO_2 capture** and **>99% H_2 product purity**.
- Sulfur guard bed and scrubber are needed for the NG and biomass blends applications.



R-GAS POX for Net-negative H2 – TEA Comparisons

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- Except for the R-GAS POX island, the CAPEX and annual OPEX figures are derived from the **NETL-2022/3241 report released by the United States (U.S.) Department of Energy in April 2022**.

	R-GAS POX (100% NG) with CCS	R-GAS POX (70% NG& 30% Biomass) with CCS	R-GAS POX (60% NG& 40% Biomass) with CCS	SMR with CCS	ATR with CCS
Net Production of H2 (kg/hr)	27567.86	27567.86	27567.86	20167.73	27557.73
Fuel Cost	0.73	0.74	0.74	0.82	0.77
CO2 Transportation and Sequestration (T&S) Cost	0.07	0.07	0.07	0.10	0.09
Capital Cost	0.25	0.29	0.30	0.33	0.26
Fixed Cost	0.11	0.15	0.15	0.15	0.11
Variable Cost	0.23	0.36	0.37	0.24	0.36
Levelized Cost of Hydrogen ($/kg)	1.38	**1.62**	**1.64**	1.64	1.59

R-GAS POX for Net-negative H2 – LCA Comparisons

- This LCA assumes that clean power is being supplied to the hydrogen production plant and does not include downstream transportation.

	R-GAS POX (100% NG) with CCS	R-GAS POX (70% NG& 30% Biomass) with CCS	R-GAS POX (60% NG& 40% Biomass) with CCS	SMR with CCS	ATR with CCS
Upstream Emissions (kg CO2e / kg H2)	1.49	1.39	1.34	1.69	1.49
Facility (kg CO2e / kg H2)	0.61	-1.62	-2.73	0.53	0.65
Well-to-Gate Emissions (kg CO2e / kg H2)	2.10	-0.23	-1.40	2.22	2.14

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Open Hydrogen Initiative

Advancing Transparency and Credibility in Hydrogen Markets

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C2FC

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Queen Mary University of London

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

evergreen climate innovations

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Pillars of Success

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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**

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Solid Conversion Route

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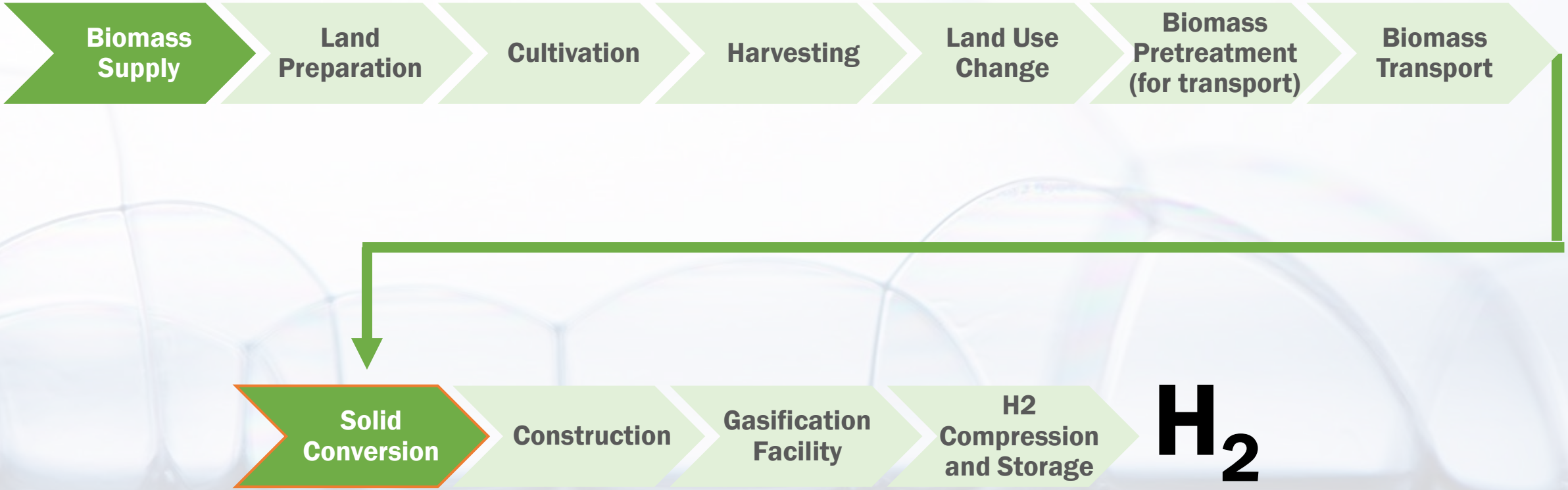

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Gas Conversion Route

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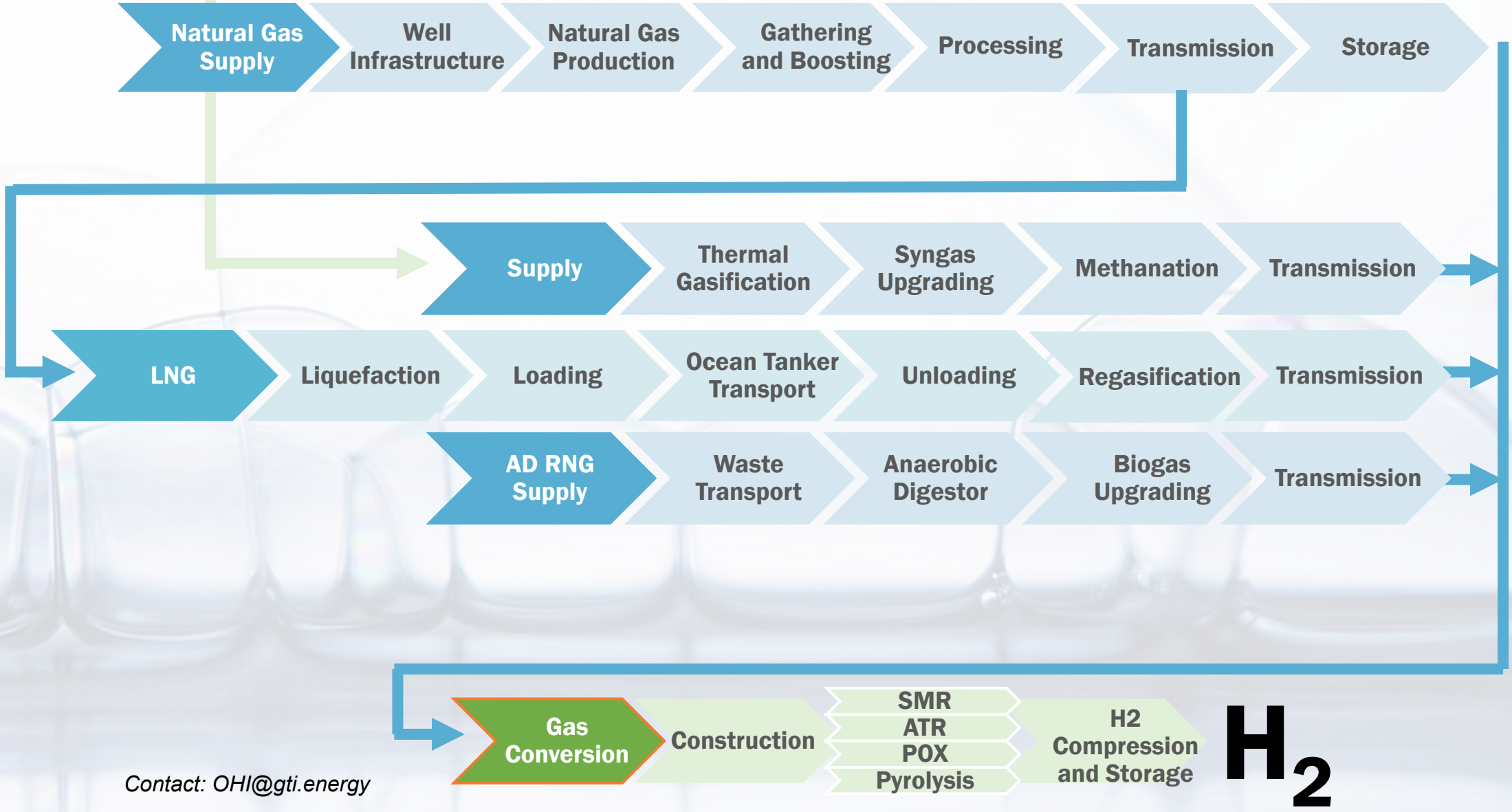

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Power Conversion Route

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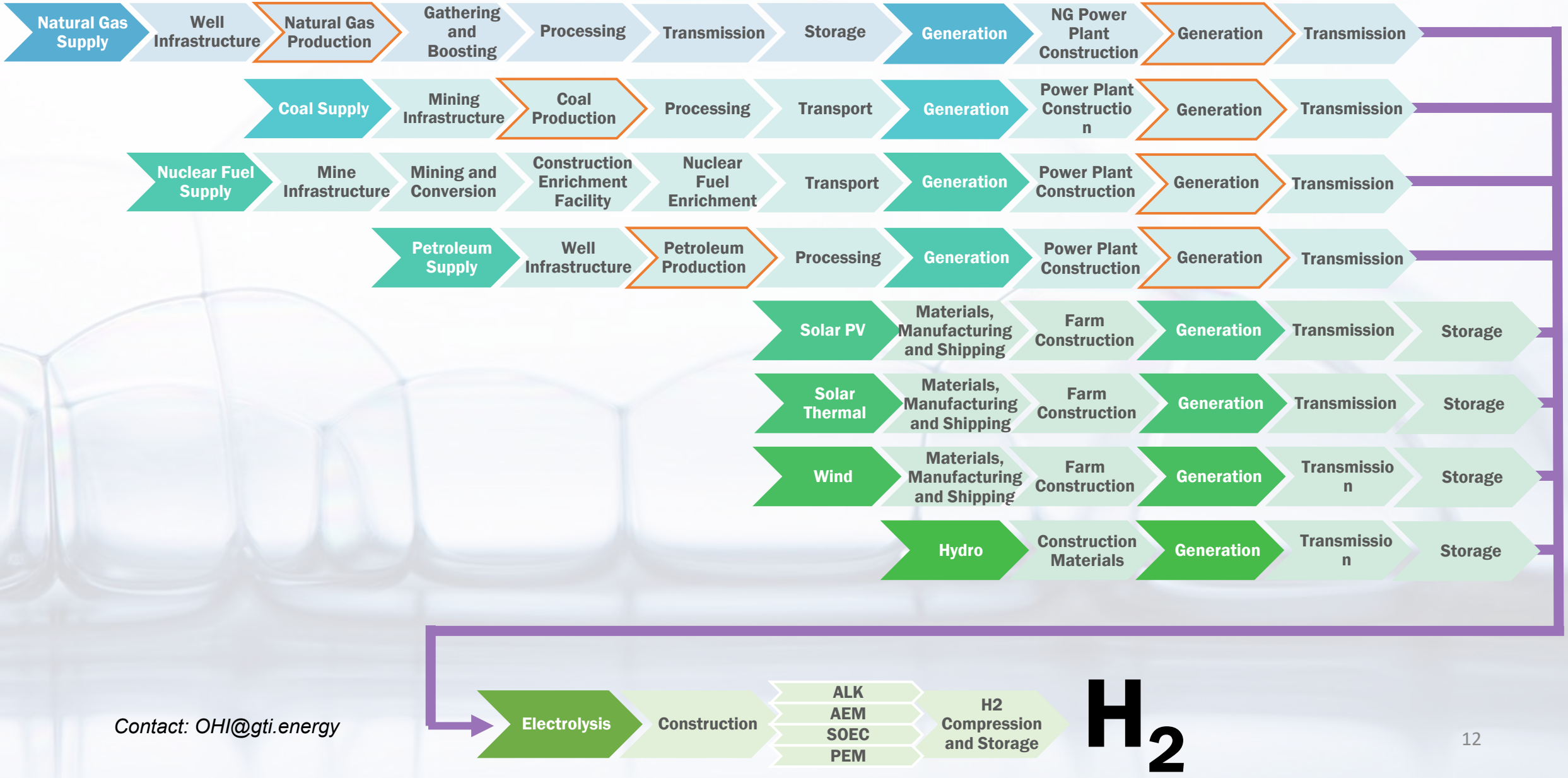

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Carbon Management

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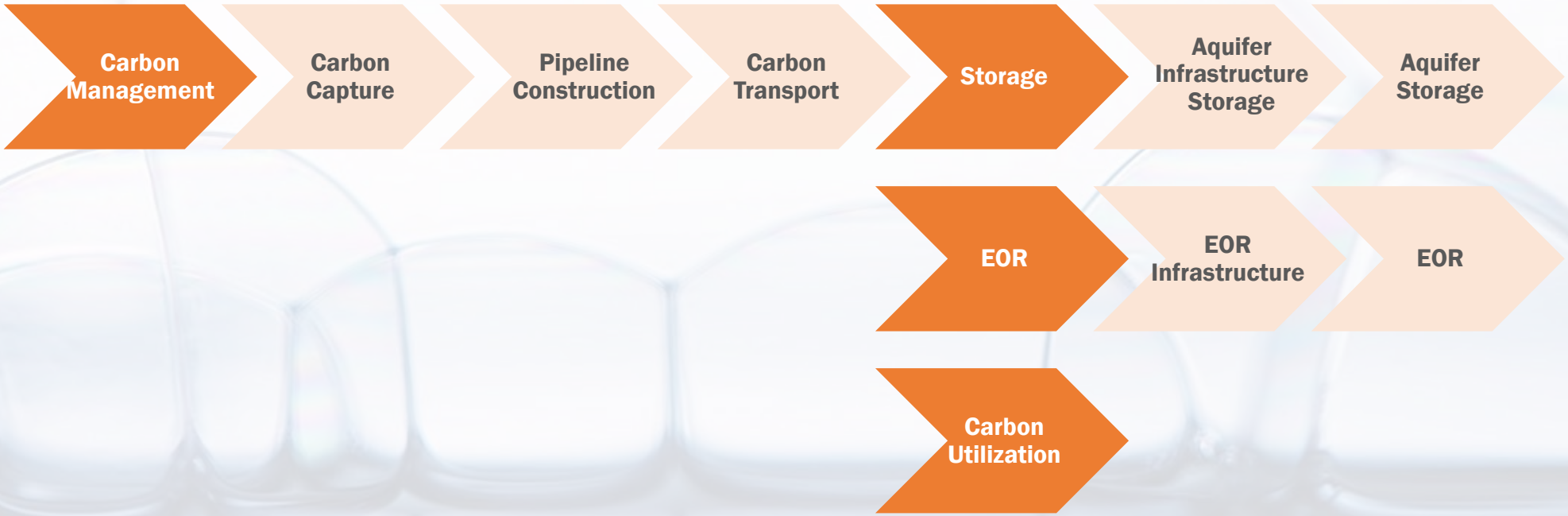

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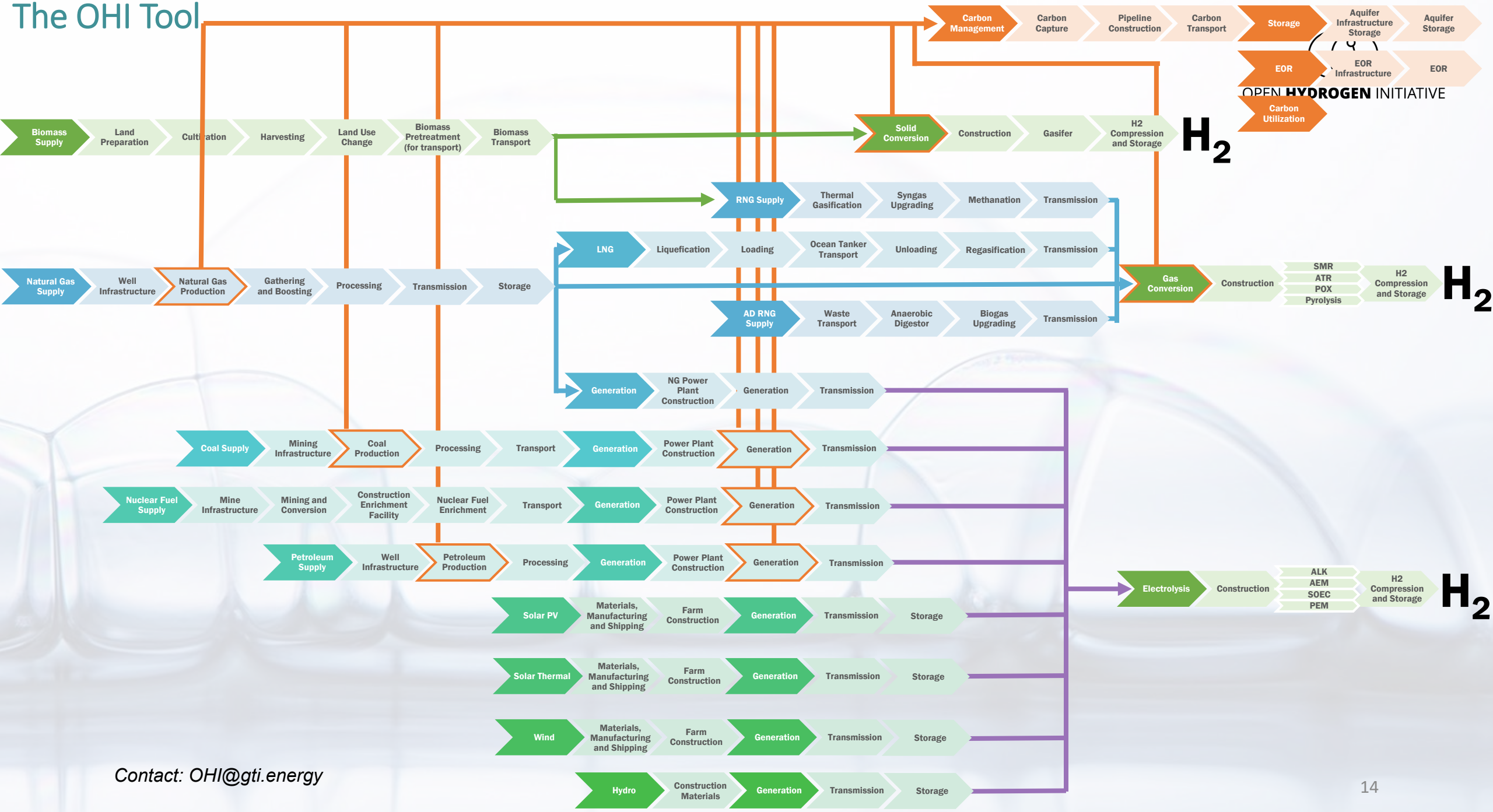
The OHI Tool



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How do we embrace complexity while still creating a practical tool?

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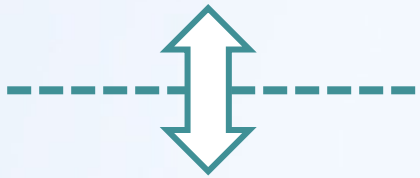
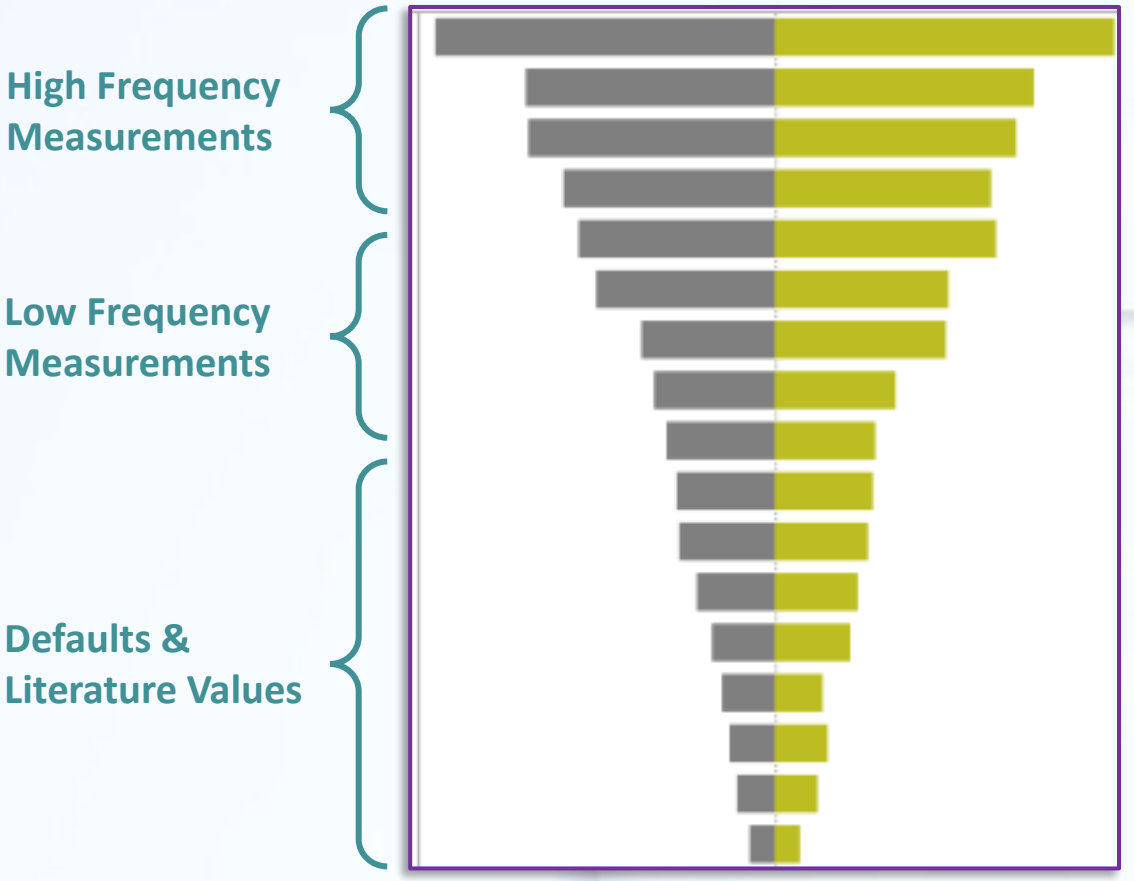
- **Contribution Analysis:** *a search for factors that contribute to an observed change*
- Identify highest impact parameters
- Focus measurement efforts on top contributors

PRACTICAL



RIGEROUS



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Data Quality Index: Dealing with Data Uncertainty

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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

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Project Schedule

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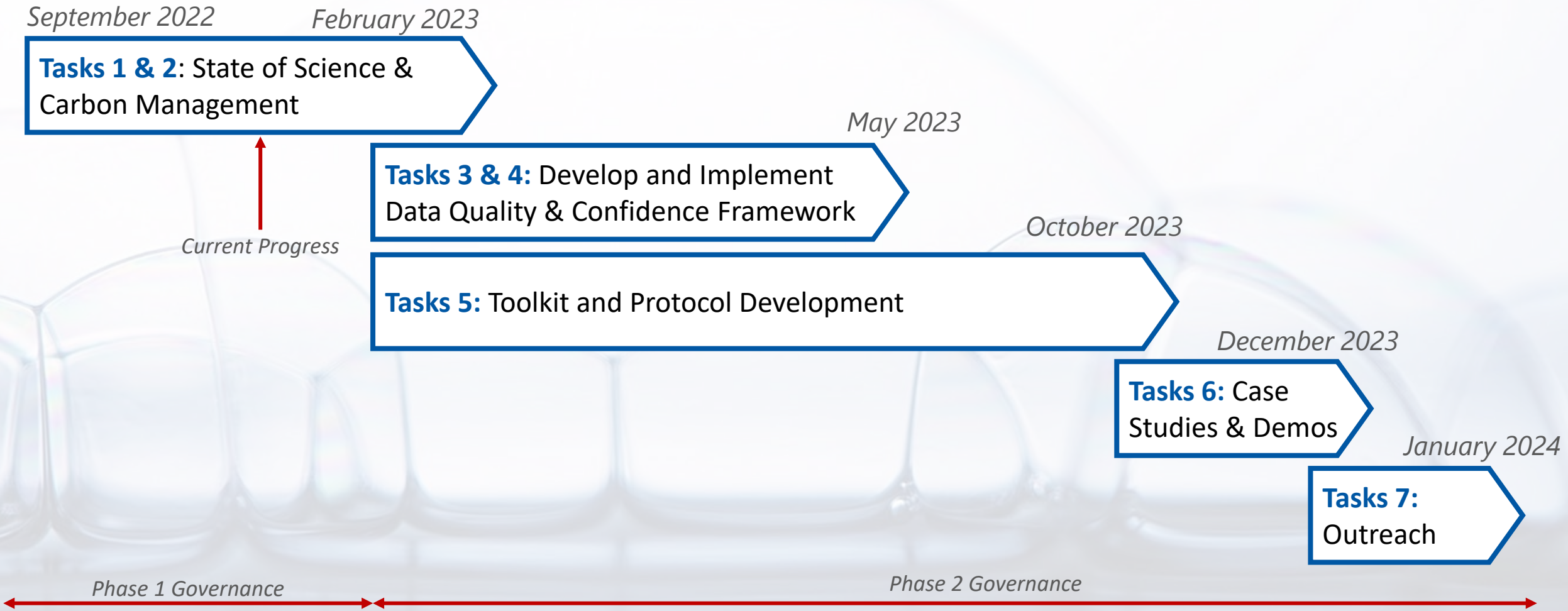

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Thank You

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Extra slides

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