

S Y Z Y G Y
P L A S M O N I C S

ENERGY. TECHNOLOGY. SUSTAINABILITY.

Reframing Challenges as Opportunities: Sustainability, Hydrogen and the Houston Innovation Ecosystem

Dr. Lynn Frostman – VP Engineering

AADE Fluids Management Group
New Perspectives on Fluids and the Environment
September 23, 2021

Mindset

- ❑ Retain faith that you will prevail AND confront the brutal realities

- Jim Collins, *Good to Great*

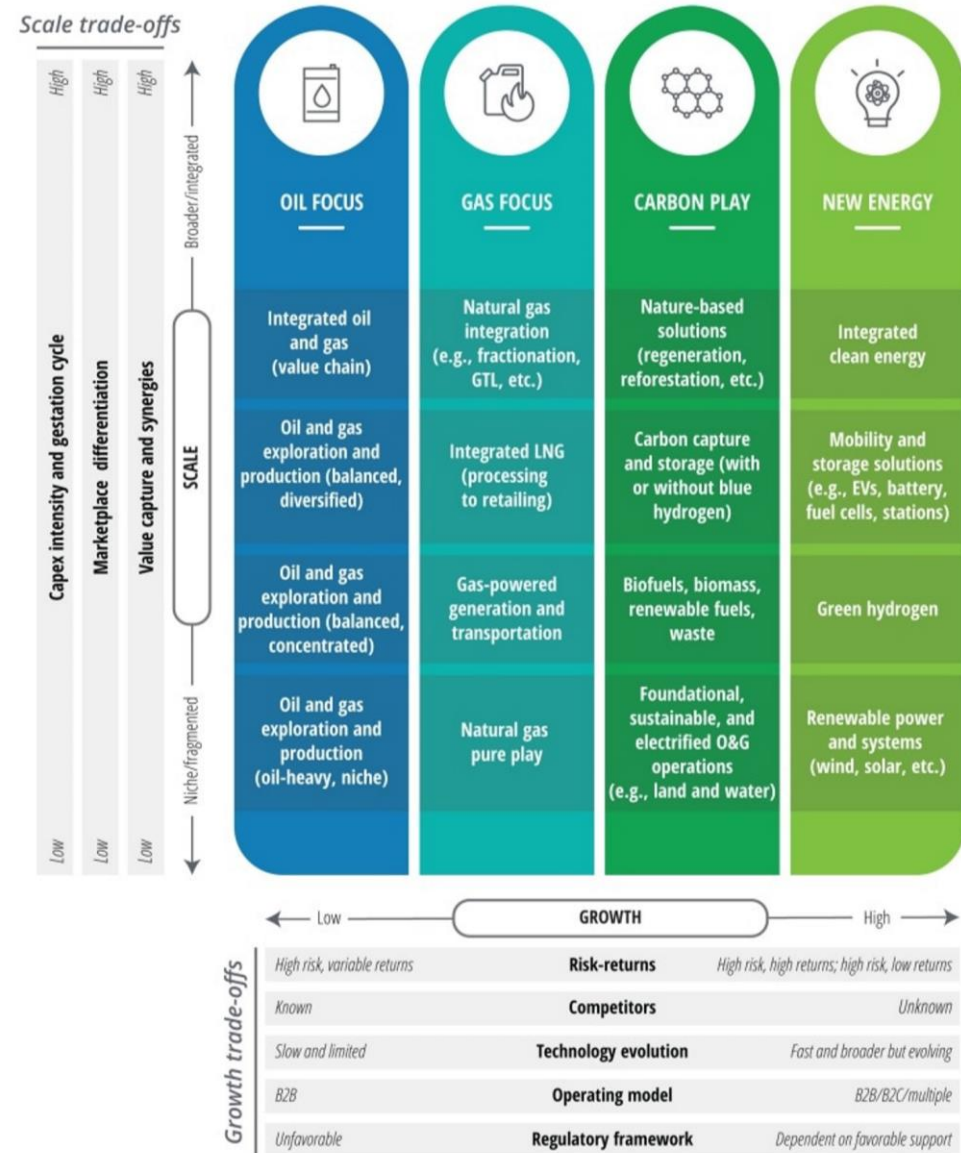
-
- ❑ Change is inevitable, but growth is optional

- Arin Reeves, *The Next IQ*



Dilemma or Opportunity?

The portfolio frontier grid of choices and trade-offs for oil and gas companies



Source: Deloitte analysis.

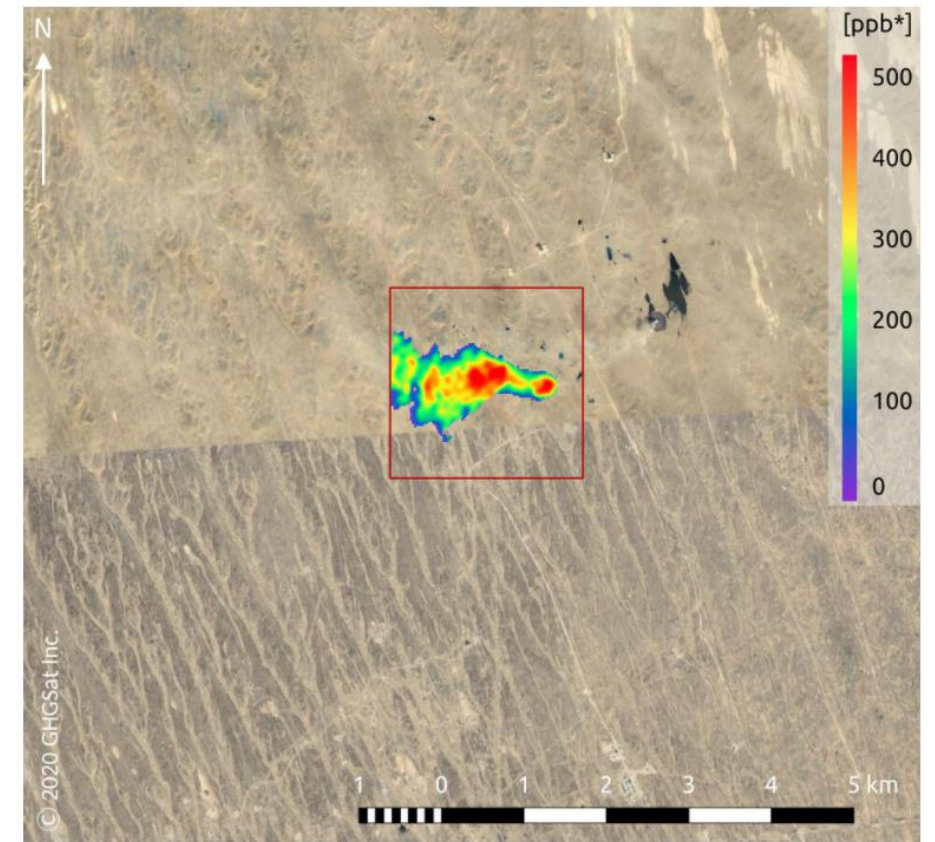
Further Opportunities

A few technologies that need our skill set:

- Geothermal
- Methane monitoring
- CCUS
- Hydrogen

A few resources to learn more:

- [TexasGeo.org/About](https://www.texasgeo.org/About) – link to PIVOT 2021 videos
- [SPE.org/en/GAIA/](https://www.spe.org/en/GAIA/)
- The technological and economic prospects for CO2 utilization and removal. *Nature* **575**, 87–97 (2019). <https://doi.org/10.1038/s41586-019-1681-6>
- [iogp.org/transitioning-world/](https://www.iogp.org/transitioning-world/)



— Methane plume from oil & gas infrastructure in the Caspian Sea region

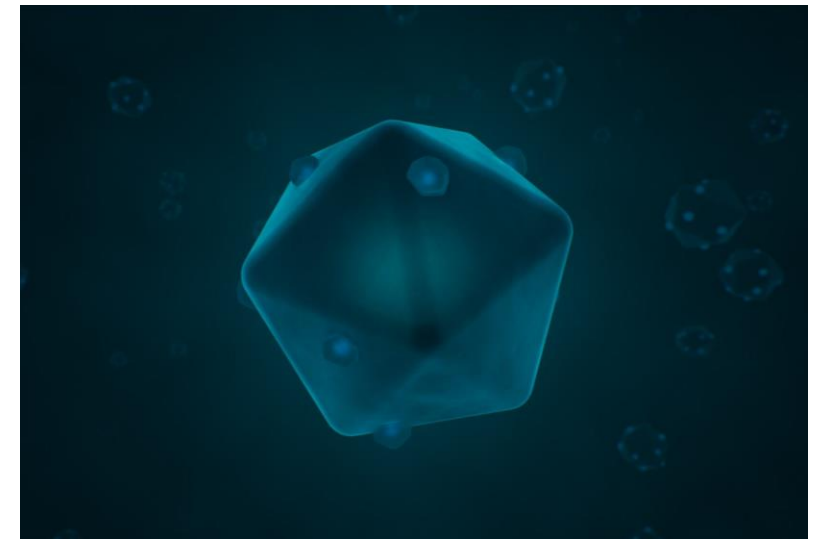
Hydrogen 101

Hydrogen offers the benefit of zero emissions at point of use & is particularly attractive to decarbonize the hard to abate sectors.



Technologies to Make H₂

- Steam Methane Reforming (SMR) – with or without CCUS
- Electrolysis (multiple technologies)
- Gasification (coal or biomass) – with CCUS
- Pyrolysis (multiple technologies)
- Plasmonic photocatalysis (double reforming, ammonia splitting)



Hydrogen: The Opportunity Is Real, But the Devil's in the Details

1. Significant effort is needed to meet clean (net zero carbon) hydrogen targets.



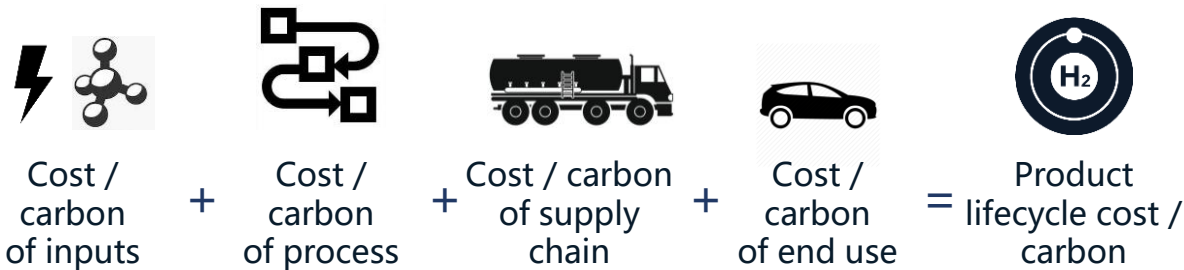
1 Dollar



1 Kilogram

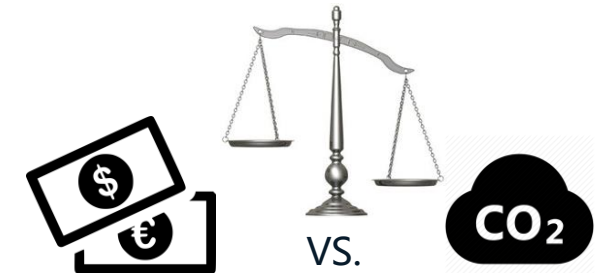


1 Decade

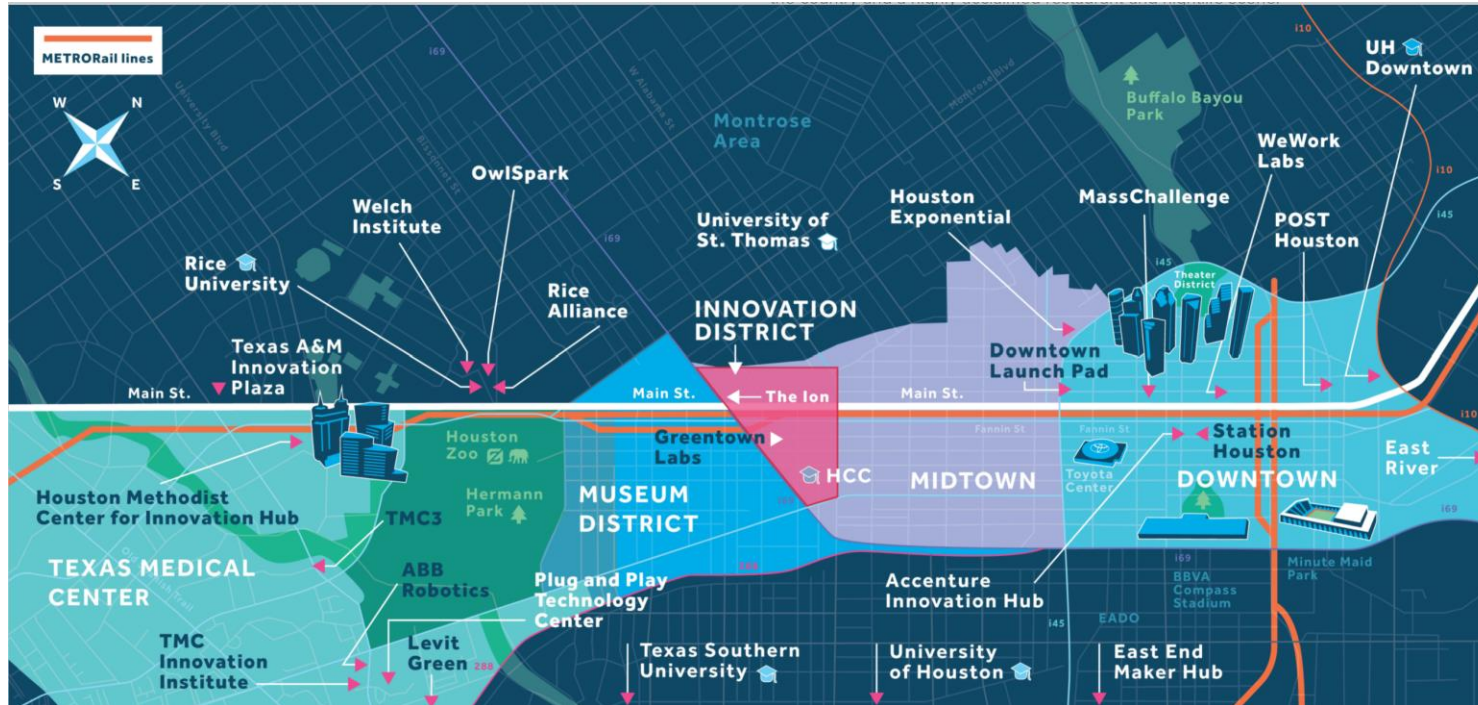


2. It is necessary to do a value chain / lifecycle assessment of cost & carbon intensity for each project.

3. Key factors affecting the H₂ lifecycle equation are cost & source of inputs, proximity to end user, and regulation.



Houston Innovation Ecosystem



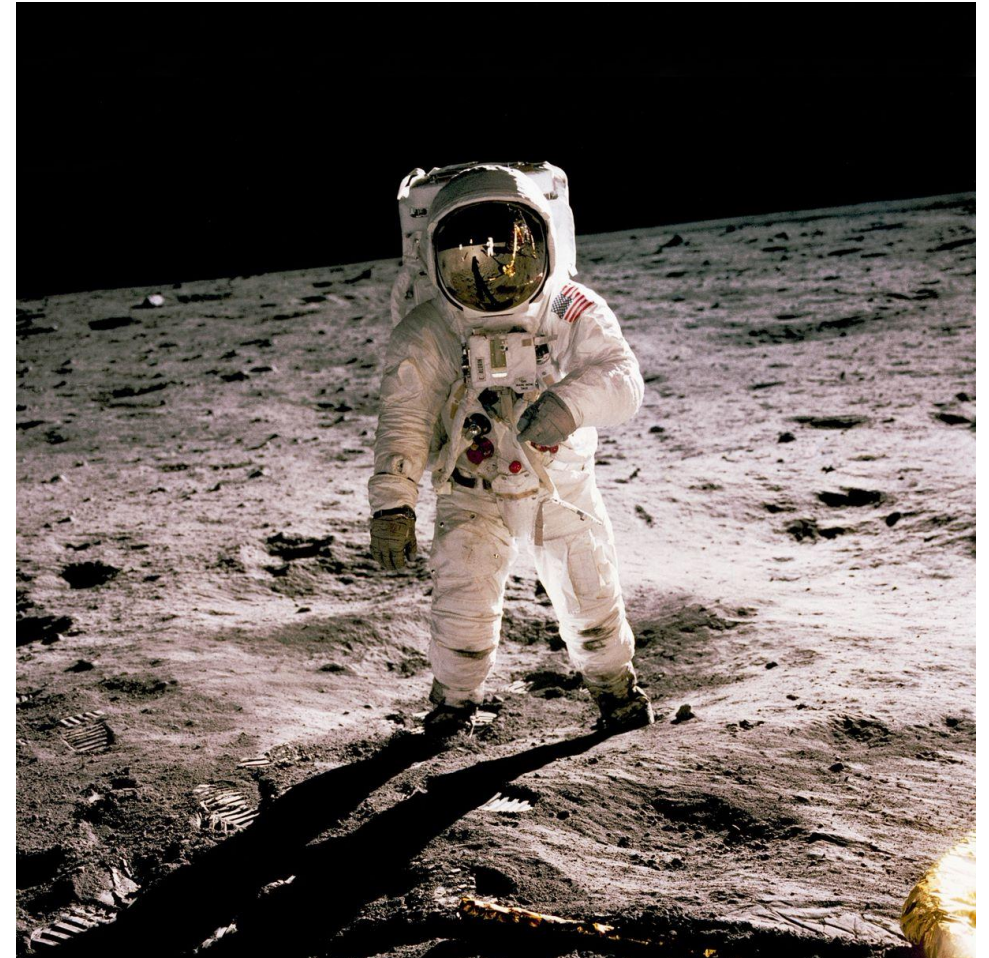
A few resources to learn more:

- ❑ [Houston Innovators Podcast](#)
- ❑ [HoustonInnovationMap.com](#)
- ❑ [Houston.org/Innovation-Corridor](#)
- ❑ [HoustonExponential.org](#)
- ❑ [CenterforHoustonFuture.org](#)
- ❑ [GreentownLabs.com/Houston/](#)
- ❑ [Alliance.Rice.org](#)
- ❑ [UH.edu/UH-Energy/](#)

- ❑ > 800 Start-ups
- ❑ >38 Accelerators, incubators, & other start-up support orgs
- ❑ >\$1B in venture capital investments YTD

Houston, we have an opportunity!

- ❑ What skills & mindset are you bringing to the table?
- ❑ How are you engaging ...
 - ... with your company?
 - ... with your stakeholders?
 - ... with the Houston ecosystem?



Questions?

Contact Information:
Dr. Lynn Frostman
VP Engineering
Syzygy Plasmonics

Email: Lynn@plasmonics.tech
URL: www.Plasmonics.tech