Hydrogen Opportunities for Texas

Texas Hydrogen Roundtable
The University of Texas at Austin
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Joseph B. Powell, PhD
retired Shell Chief Scientist - Chemical Engineering

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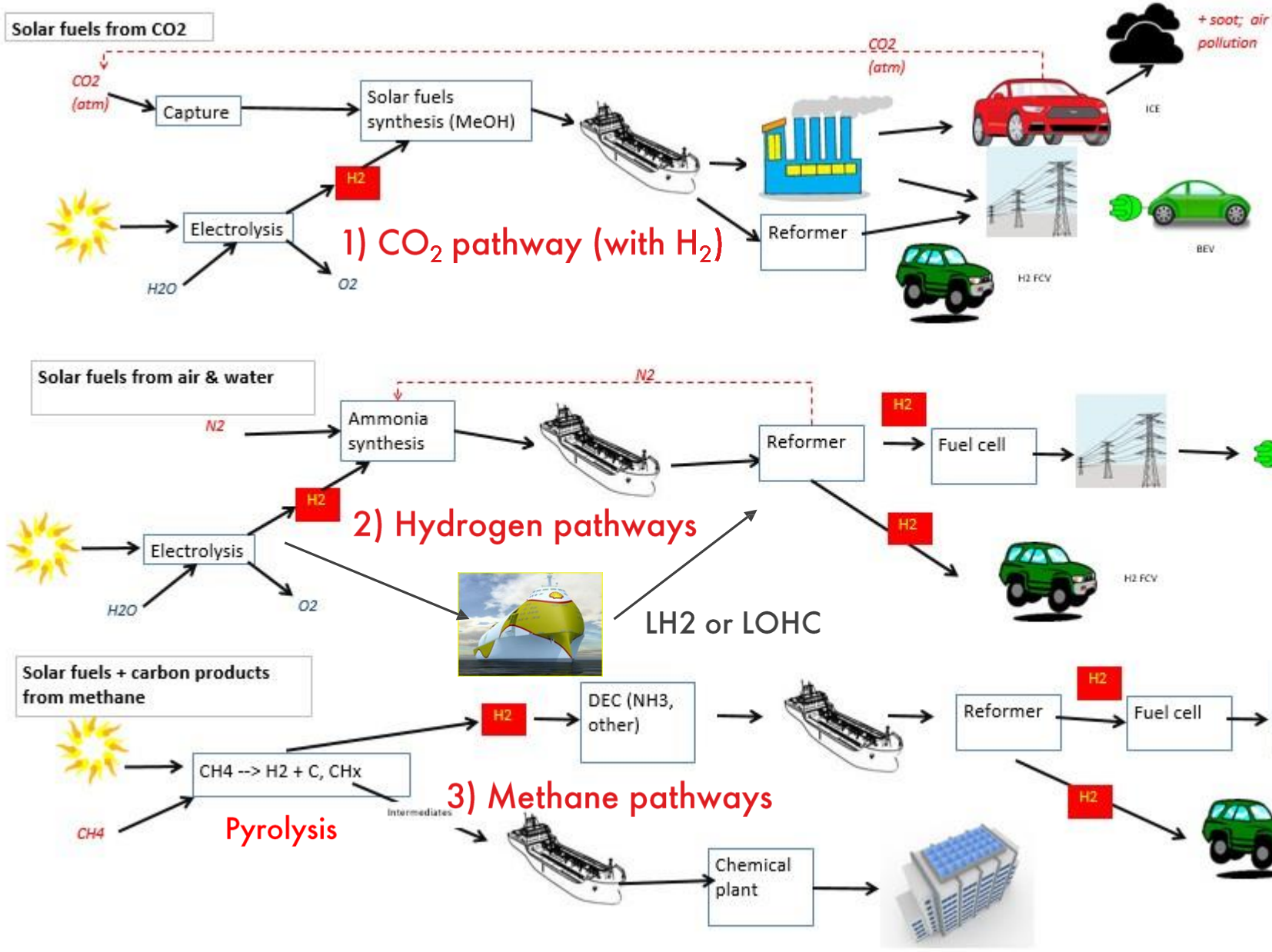
Definitions & cautionary note

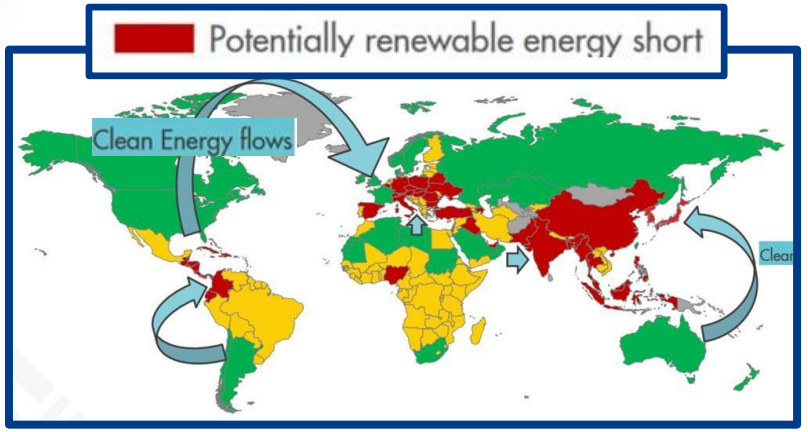
This [REPORT/BOOKLET/VIDEO/PRESENTATION, etc.] contains data and analysis from Shell's Sky scenario. Unlike Shell's previously published Mountains and Oceans exploratory scenarios, the Sky scenario is based on the assumption that society reaches the Paris Agreement's goal of holding the rise in global average temperatures this century to well below two degrees Celsius (2°C) above pre-industrial levels. Unlike Shell's Mountains and Oceans scenarios, which unfolded in an open-ended way based upon plausible assumptions and quantifications, the Sky scenario was specifically designed to reach the Paris Agreement's goal in a technically possible manner. These scenarios are a part of an ongoing process used in Shell for over 40 years to challenge executives' perspectives on the future business environment. They are designed to stretch management to consider even events that may only be remotely possible. Scenarios, therefore, are not intended to be predictions of likely future events or outcomes.

Additionally, it is important to note that as of August 2020, Shell's operating plans and budgets do not reflect Shell's Net-Zero Emissions ambition. Shell's aim is that, in the future, its operating plans and budgets will change to reflect this movement towards its new Net-Zero Emissions ambition. However, these plans and budgets need to be in step with the movement towards a Net-Zero Emissions economy within society and among Shell's customers.

Also, in this [REPORT/BOOKLET/VIDEO/PRESENTATION, etc.] we may refer to Shell's "Net Carbon Footprint", which includes Shell's carbon emissions from the production of our energy products, our suppliers' carbon emissions in supplying energy for that production and our customers' carbon emissions associated with their use of the energy products we sell. Shell only controls its own emissions. The use of the term Shell's "Net Carbon Footprint" is for convenience only and not intended to suggest these emissions are those of Shell or its subsidiaries.

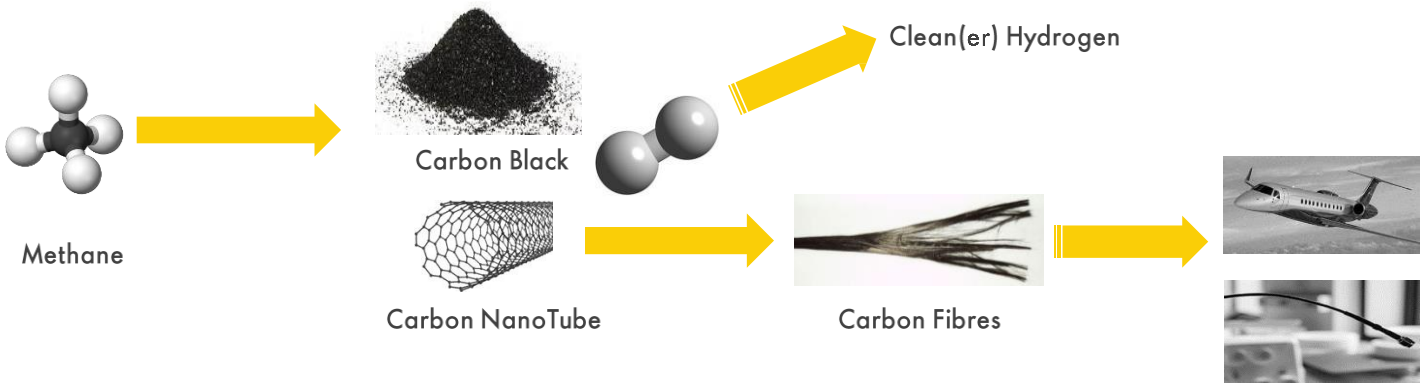
Systems Modeling: Renewable Energy Transport & Storage

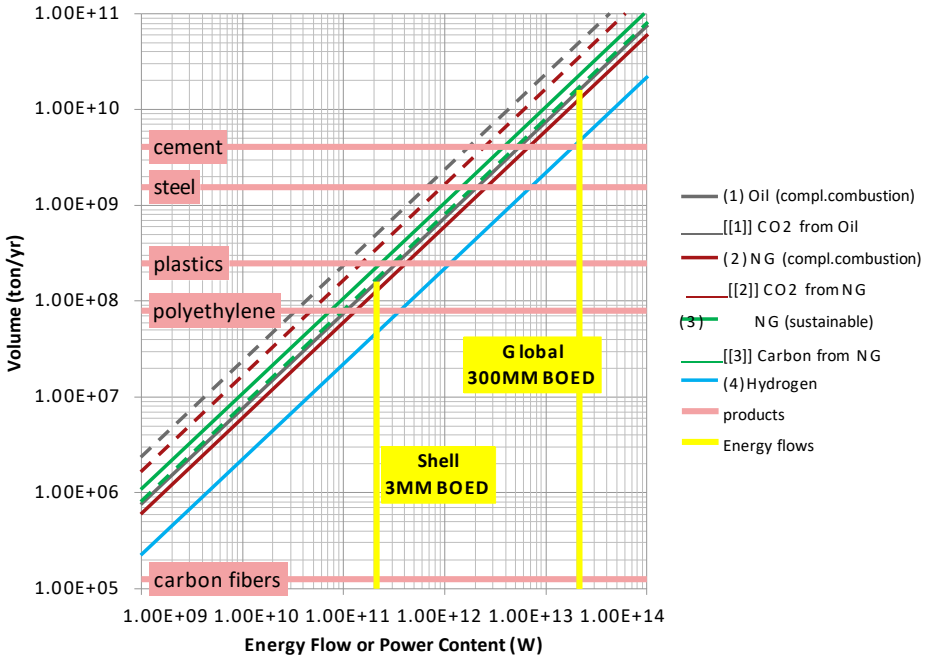




4) Alternative: local Solar & Wind with electrical energy or pumped hydro storage

Methane pyrolysis

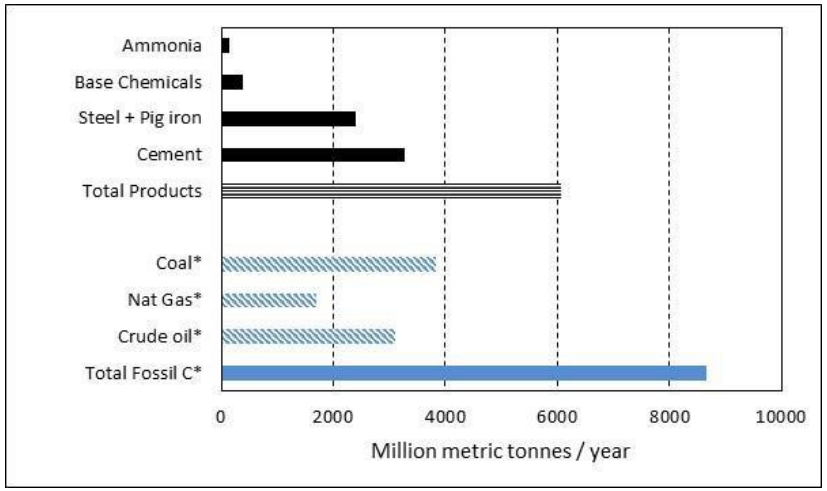




- **Impact:**
  - Large carbon sink via carbon utilization to build industry products.
  - H2 is freed for clean energy systems use (fuel cell)

3D printed advanced composite Shelby Cobra (ORNL)

Low cost advanced manufacturing composite building (Mark Goulthorpe MIT)



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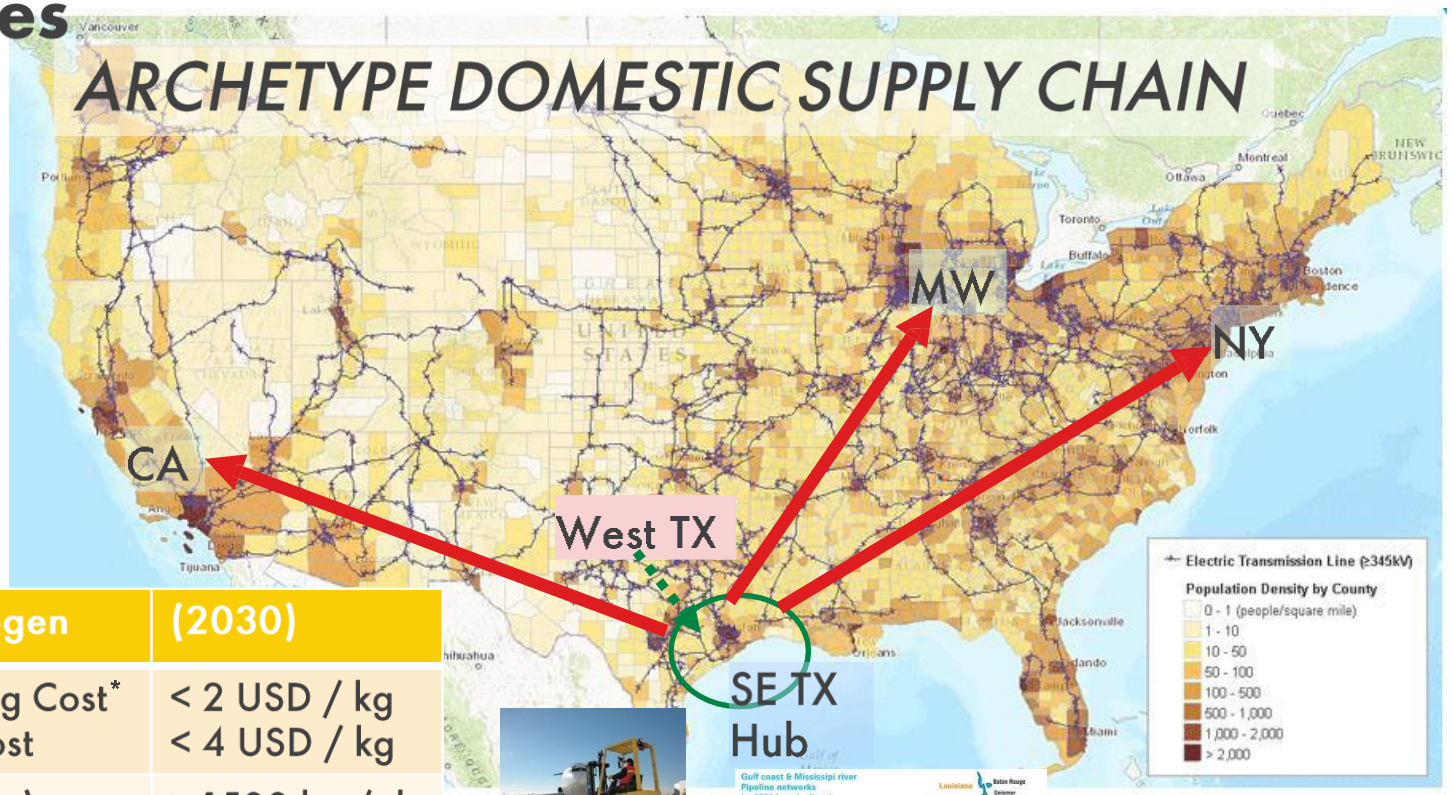
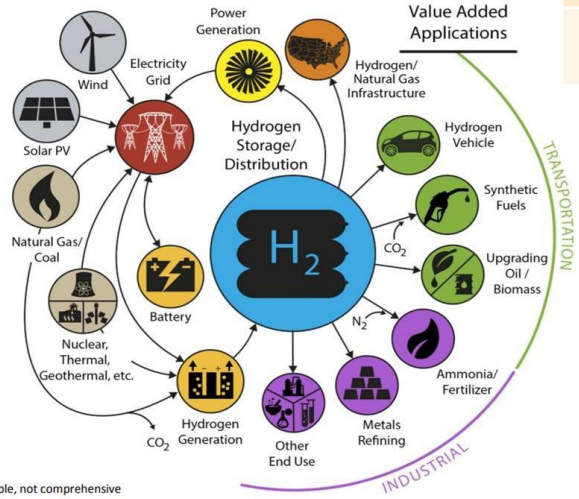
Hydrogen: US Opportunities

- ✓ Green / clean H_2 from West TX renewable + SE TX (Houston GC) waste heat
  - ✓ SMR/ Methane pyrolysis / water electrolysis
- ✓ H_2 heavy duty trucking, industry
- ✓ Commercial ride-share (Uber fleet)?
- ✓ City lift trucks / buses?
- ✓ H_2 Rail transit to US States with clean energy incentives; H_2 + NH_3 pipelines
  - ✓ LH_2 or NH_3
- ✓ Leveraged demo hub



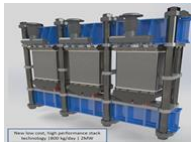
Clean Hydrogen	(2030)
Manufacturing Cost*	< 2 USD / kg
Dispensed Cost	< 4 USD / kg
Scale (per Site)	> 1500 kg / d

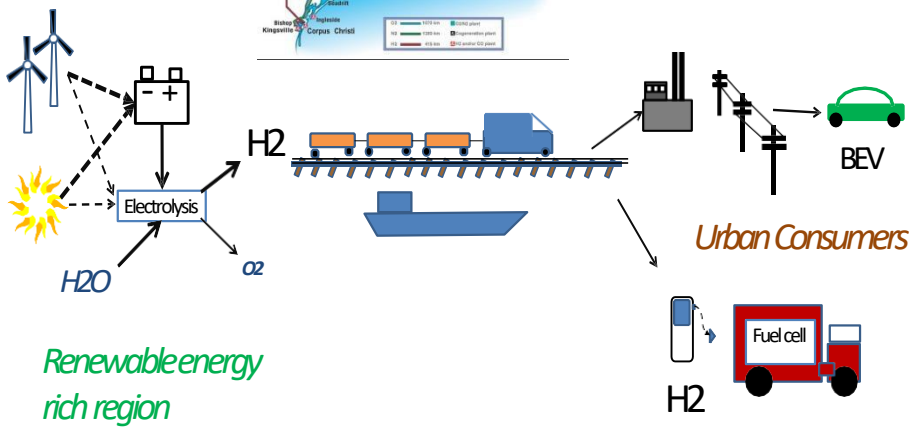
H_2 at Scale Energy System



*Illustrative example, not comprehensive
Source: NREL

Fuel Cell Electric Vehicle Prototype 2





* Distributed small/medium scale

Questions and Answers

JBP@ChemePD.com