EnerWaste

The Importance of MSW in the Hydrogen Economy

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EnerWaste Asia Pacific Ltd.

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Outline

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- Introduction - EnerWaste Asian Pacific Limited
- Pathways to Clean Hydrogen
- Current Status & Obstacles
- U.S. Approaches to Clean Hydrogen Production
- Wastes to Hydrogen
- Potential Impacts

EnerWaste is part of the Urban Gateway Family

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Urban Gateway is a private equity group that leverages *de-risked* and *disruptive* urbantech from global SMEs and *commercializes* them through *four climate-action driven* companies

Energy Intensity Reduction
focus on commercial and industrial cooling sector

EnerCool
Asia Pacific Limited

Electric Market Reform
focus on virtual power, highest disruptive potential

EnerCloud
Asia Pacific Limited

Alternative Energy
focus on transforming waste to highest value-added sustainable products — hydrogen & biofuels

EnerWaste
Asia Pacific Limited

Low Carbon Development
focus on technologies that enable cost effective low carbon real estate development

EnerProp
Asia Pacific Limited

EnerWaste Asia Pacific Limited

EnerWaste

reimagining waste for climate impact

- focus on ***low carbon*** technologies
- converting waste to ***fuels, energy and materials***
- enabling ***zero waste*** urban center development

First partnership with ***Omni*** Conversion Technologies Inc.

ZERO emissions, carbon ***NEGATIVE***, cost ***COMPETITIVE*** and ***PATENTED*** technology

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Pathways to Clean Hydrogen

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- Hydrogen is a dynamic fuel
- Electrolysis (water)
- Thermal conversion (fossil & biomass) with CCUS
- Wastes coupled with biomass

Comparison of Commercial, State-of-the-Art, Fossil-Based Hydrogen Production Technologies (Pending Peer Review)

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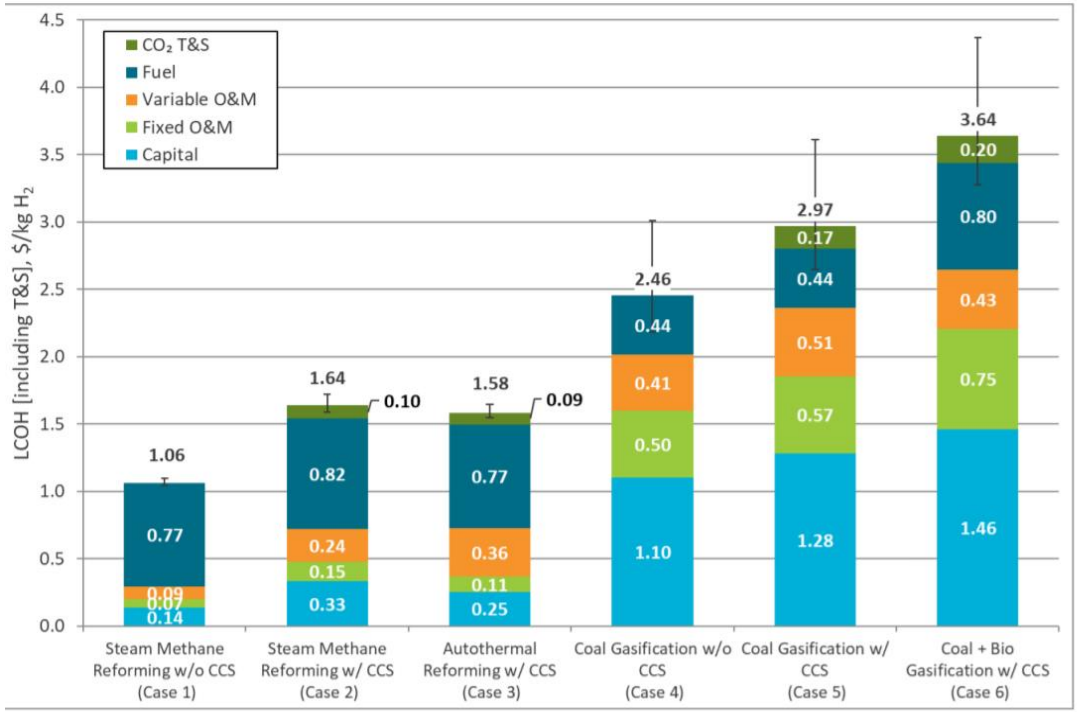
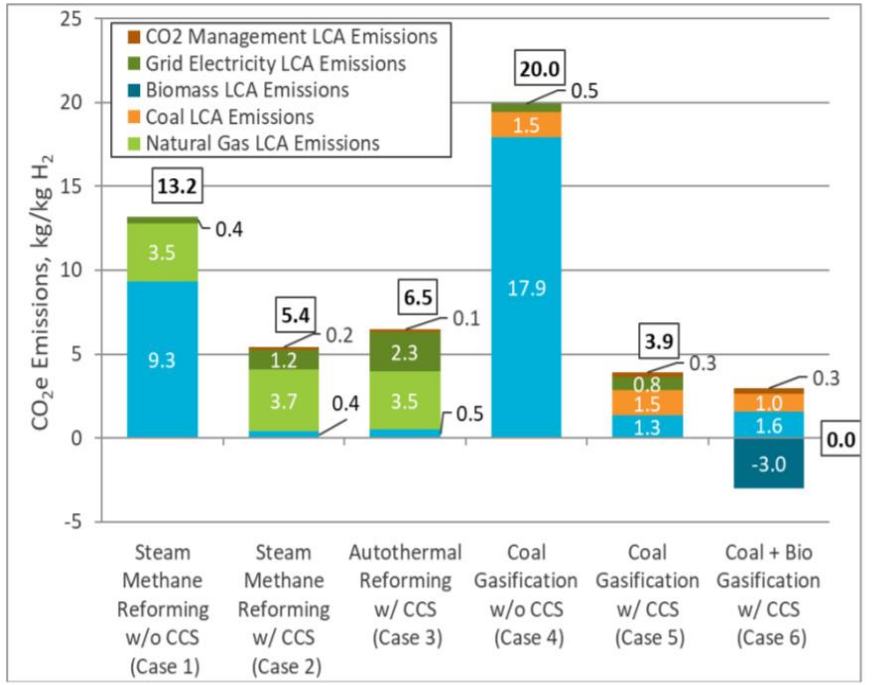


- Lowest reforming cases – SMR w/o CCS ($1.06/kg H_2)
- Highest reforming case – SMR w/ CCS ($1.64/kg H_2)
- Lowest gasification case – coal w/o CCS ($2.46/kg H_2)
- Highest gasification case – "net-zero" coal/biomass ($3.64/kg H_2)

Global Warming Impact Factors (100-yr, with climate feedback)

- U.S. Electricity, 2016 National Average Profile[1]: 590 kg CO_2e/MWh
- Production and Delivery, Cradle-to-city gate[2]: 0.99 kg CO_2e/kg NG
- Bituminous, Transport Distance (MRO Average)[3]: 0.19 kg CO_2e/kg of coal
- Torrefied, non-pelletized SRWC[4]: -0.72 kg CO_2e/kg AR biomass
- CO_2 Management, saline aquifer[5]: 0.02 kg CO_2e/kg CO_2 sequestered



Eric Lewis, NETL Presentation at Hydrogen Shot Summit, August 31, 2021

US DOE Hydrogen Program Goal

Sunita Satyapal, US DOE Hydrogen Shot Summit, August 31, 2021

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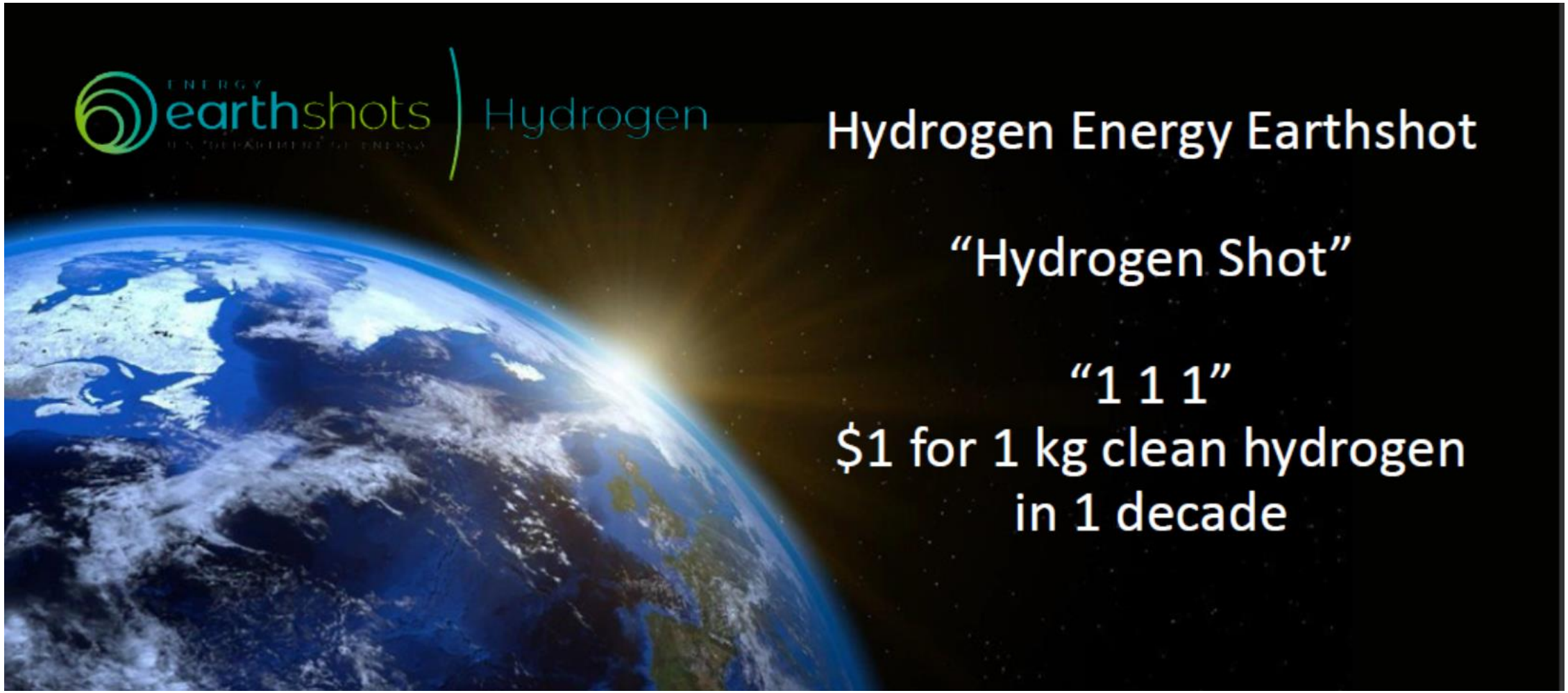

SunShot Program Lesson Learnt

Arun Majumdar, Stanford University, US DOE Hydrogen Shot Summit, August 31, 2021

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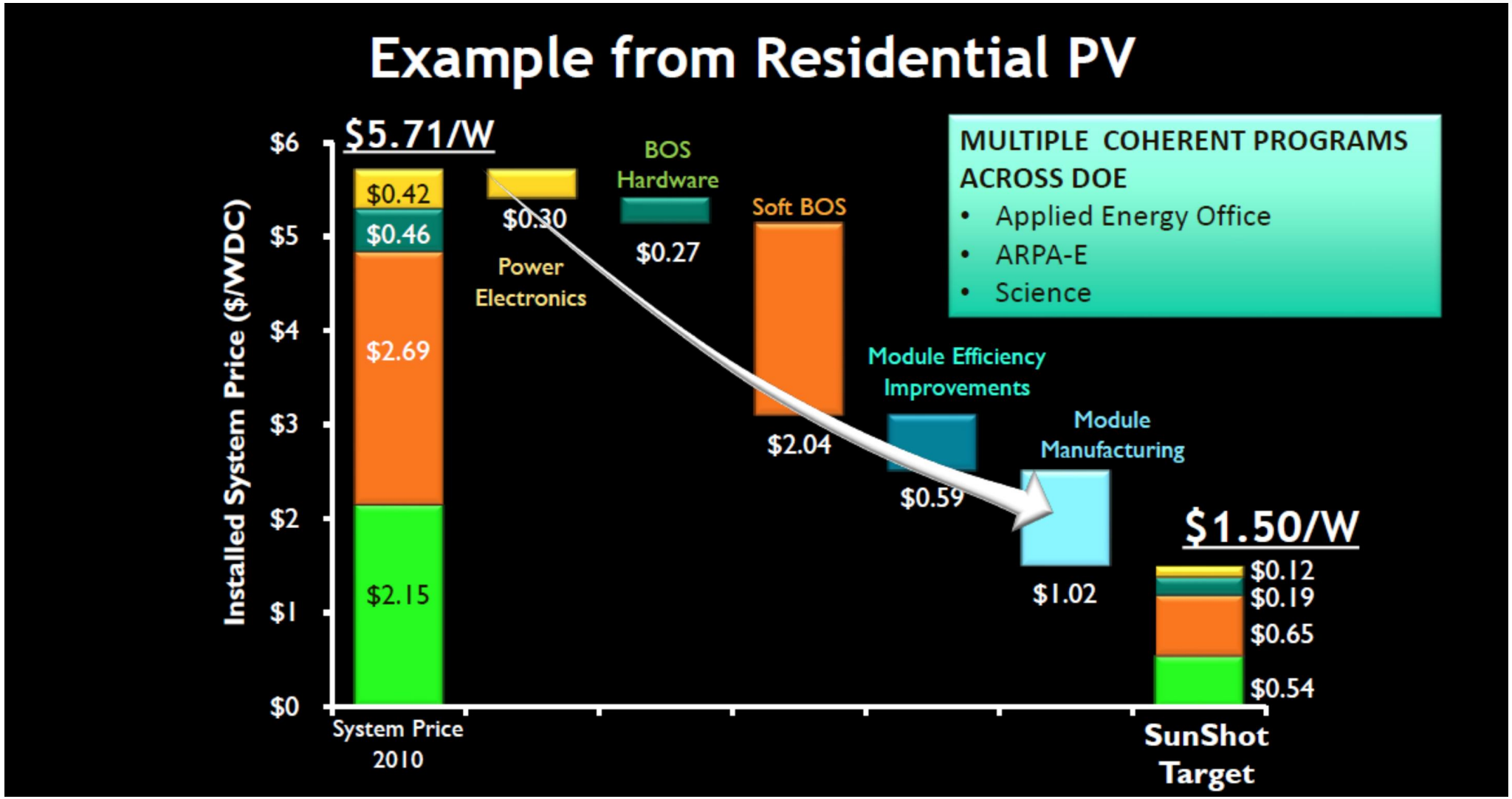

Electrolysis Pathway

Sunita Satyapal, US DOE Hydrogen Shot Summit, August 31, 2021

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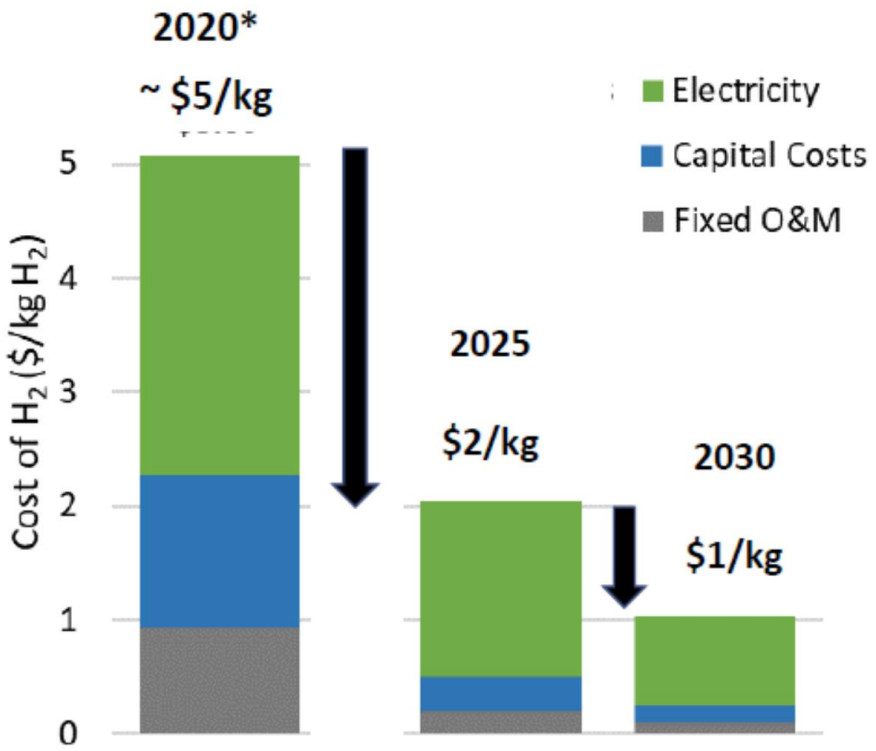
Example: H_2 Cost from PEM Electrolysis



Pathways to meet Goal

- Reduce electricity cost and improve efficiency and utilization
- Reduce capital cost >80%
- Reduce operating & maintenance cost >90%

*2020 Baseline: PEM (Polymer Electrolyte Membrane) low volume capital cost ~$1,500/kW, electricity at $50/MWh. Pathways to targets include capital cost < $300/kW by 2025, < $150/kW by 2030 (at scale). Assumes $50/MWh in 2020, $30/MWh in 2025, $20/MWh in 2030

Thermal Conversion of Waste Pathway

Sunita Satyapal, US DOE Hydrogen Shot Summit, August 31, 2021

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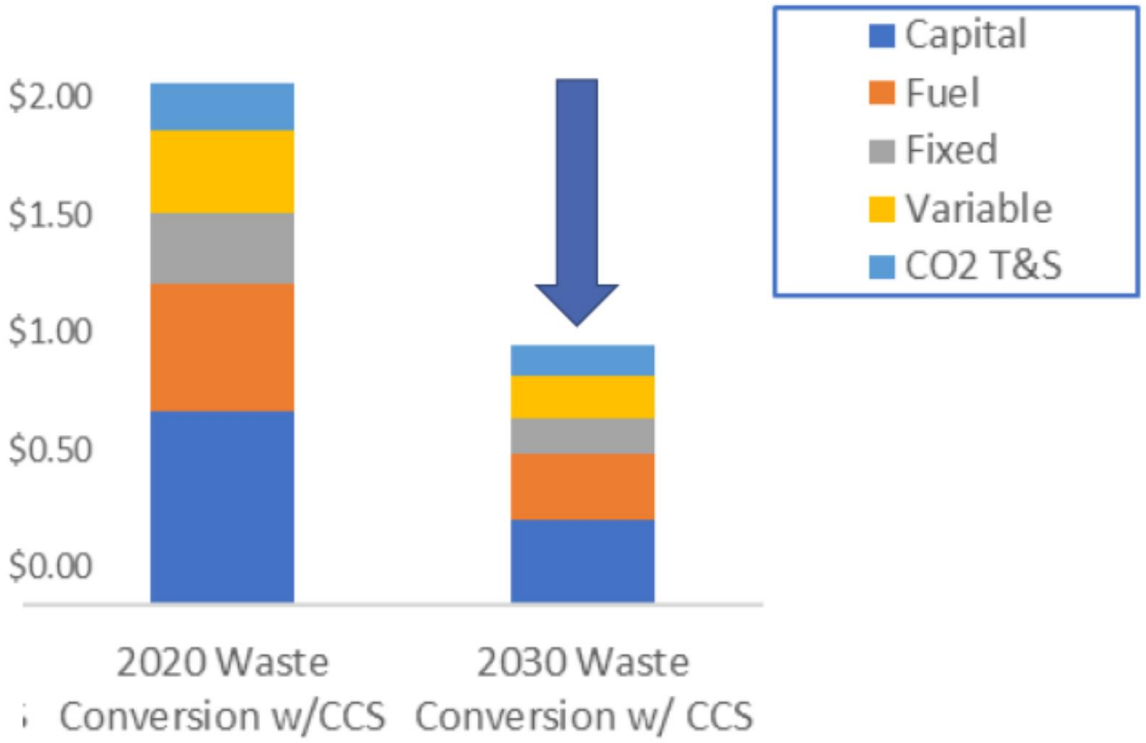
Example: H_2 Cost from Waste Conversion + CCS



* Waste coal, plastics, biomass residuals, municipal solid waste (MSW), and biogas

Examples of RD&D

- Includes reforming, pyrolysis, and other pathways with focus on low life cycle emissions
- Process intensification and optimization
- Improvements in air separation, catalysts, carbon capture, and upstream emissions

OMNI CT Gasification & Plasma Refining System (GPRS™)

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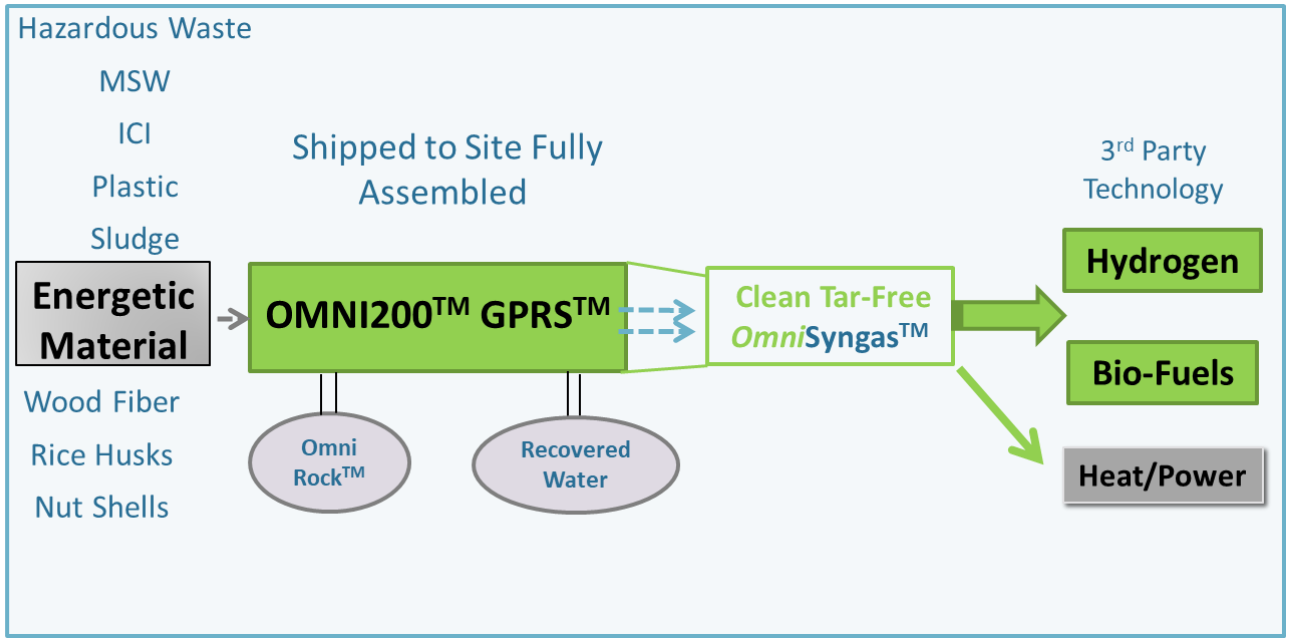
- Any combination of materials
- Recyclable glass, metal and large inert objects removed
- Shredded to 10cm



Complete Conversion of Waste to Value

MSW to Hydrogen Production & CO_2 Capture

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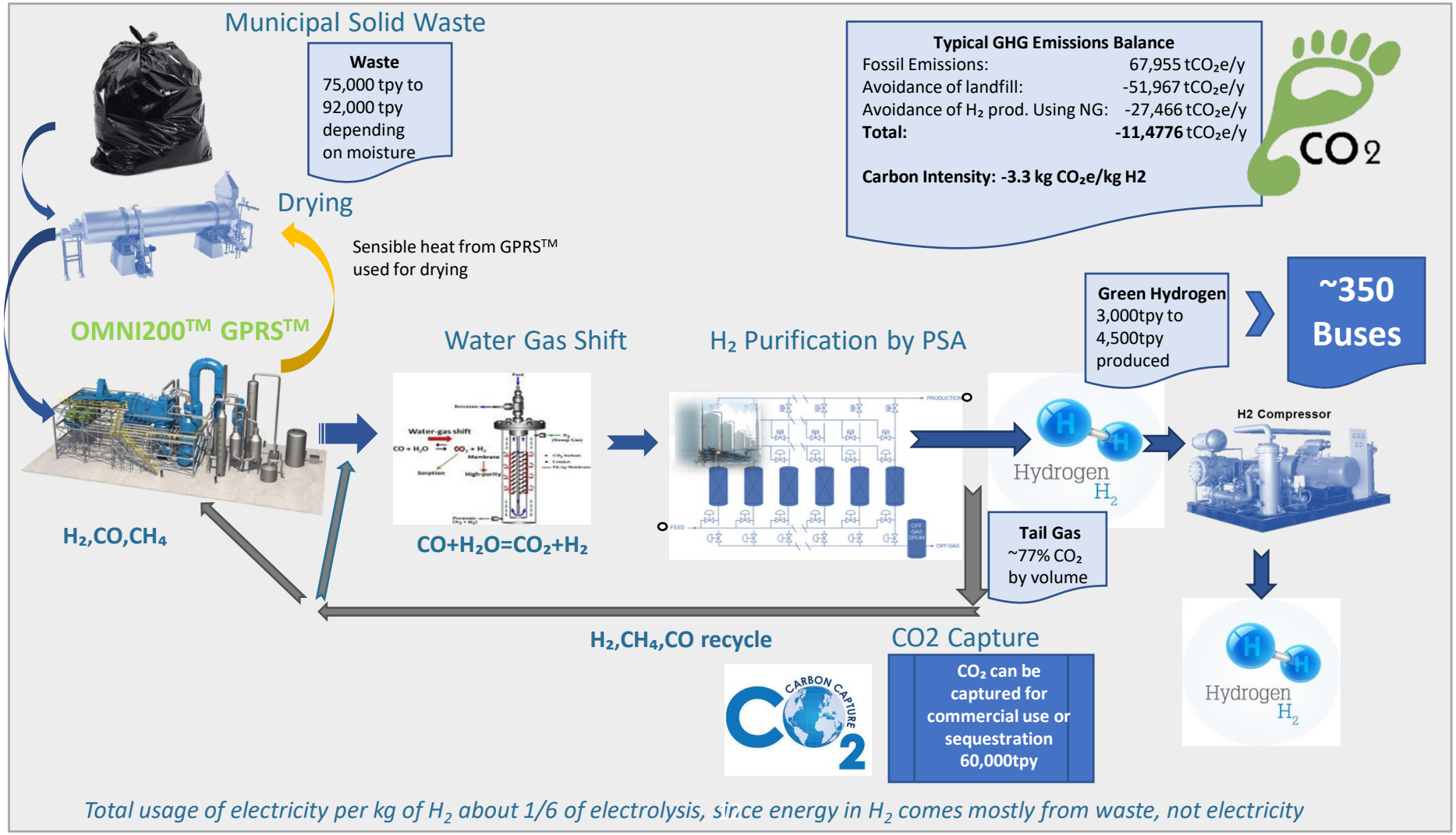

Total usage of electricity per kg of H_2 about 1/6 of electrolysis, since energy in H_2 comes mostly from waste, not electricity

Minimal Waste Preparation, High Fuel Flexibility

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OMNI200™ GPRS™

Minimally prepared “black bag” waste on GPRS™ input conveyor in Ottawa

No sorting, one stage of shredding to 100mm-, one magnet, no rejects

Fluidized Bed Gasifier

Waste Preparation for typical Fluidized Bed Gasifier

Sorting, shredding, removal of all metals and hard particles, drying, sizing

OMNI200™ GPRS™ Unlike Other Gasifiers

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- Type of energetic Feedstock does not matter – Omnivorous
- No Ash requiring disposal – all particulate is vitrified into ***Omni*Rock™**
- No Dioxin and Furan formation – no need to remove difficult wastes with high plastics and other sources of halogens
- Gasification of Feedstock done by excess heat:
    - Plasma only used to refine Syngas
    - Reduced electrical demand
- Plasma not used directly on waste – Plasma used to crack tars in raw Syngas
- Moving grate gasifier + Updraft gasifier – Vs. Others' Fluidized bed gasifier
- Only Gasification process designed to create valuable Syngas for Biofuels:
    - Syngas cleaned & conditioned in OMNI CT gas cleaning system to create ***Omni*Syngas™**
    - No emissions to atmosphere in waste conversion to ***Omni*Syngas™**
- ***Omni*Syngas™** can be tailored for downstream conversion into Biofuel, Hydrogen, aviation fuel

Thermal Conversion Products from Waste-Derived Syngas

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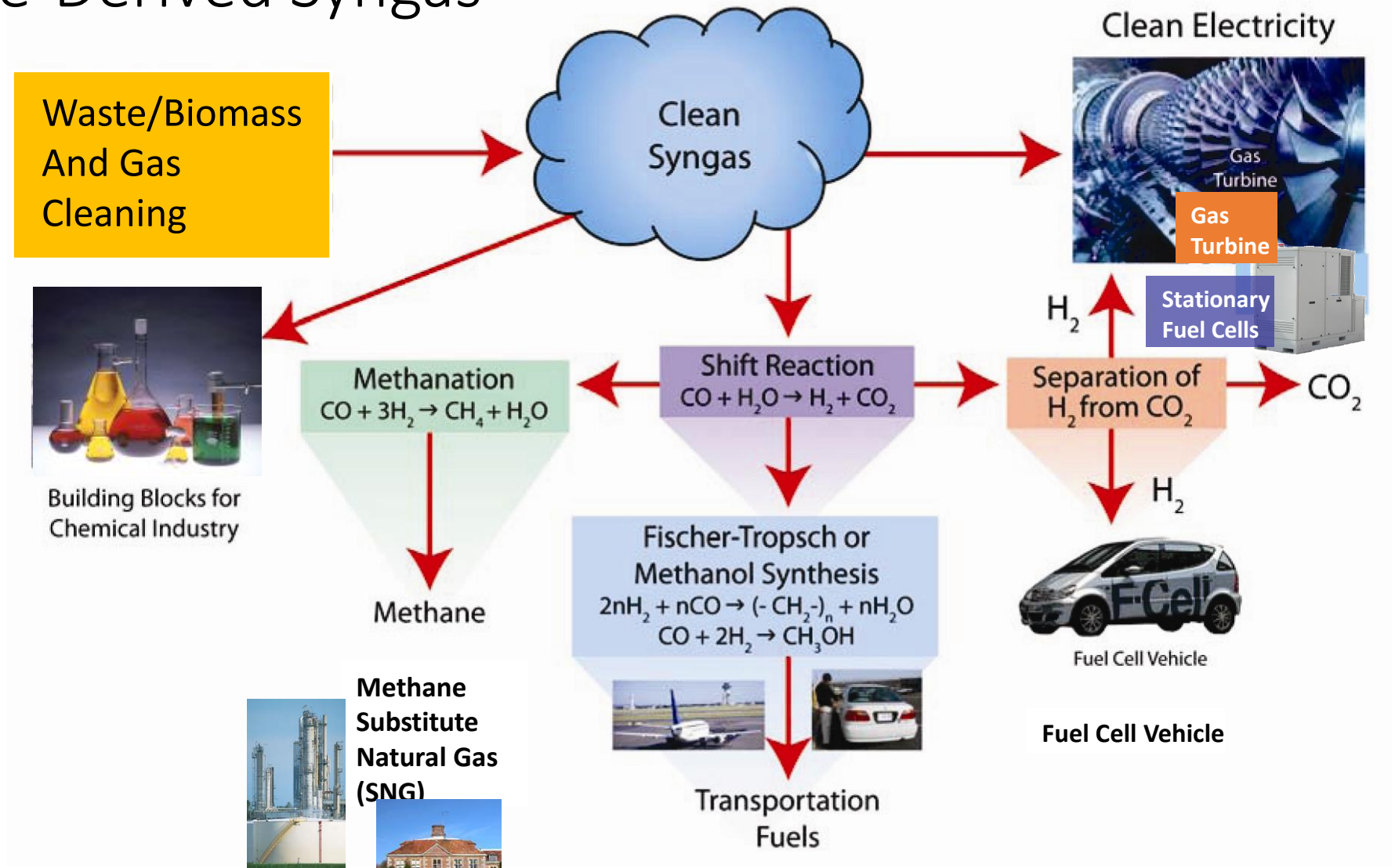

Generalized Syngas Reaction Scheme

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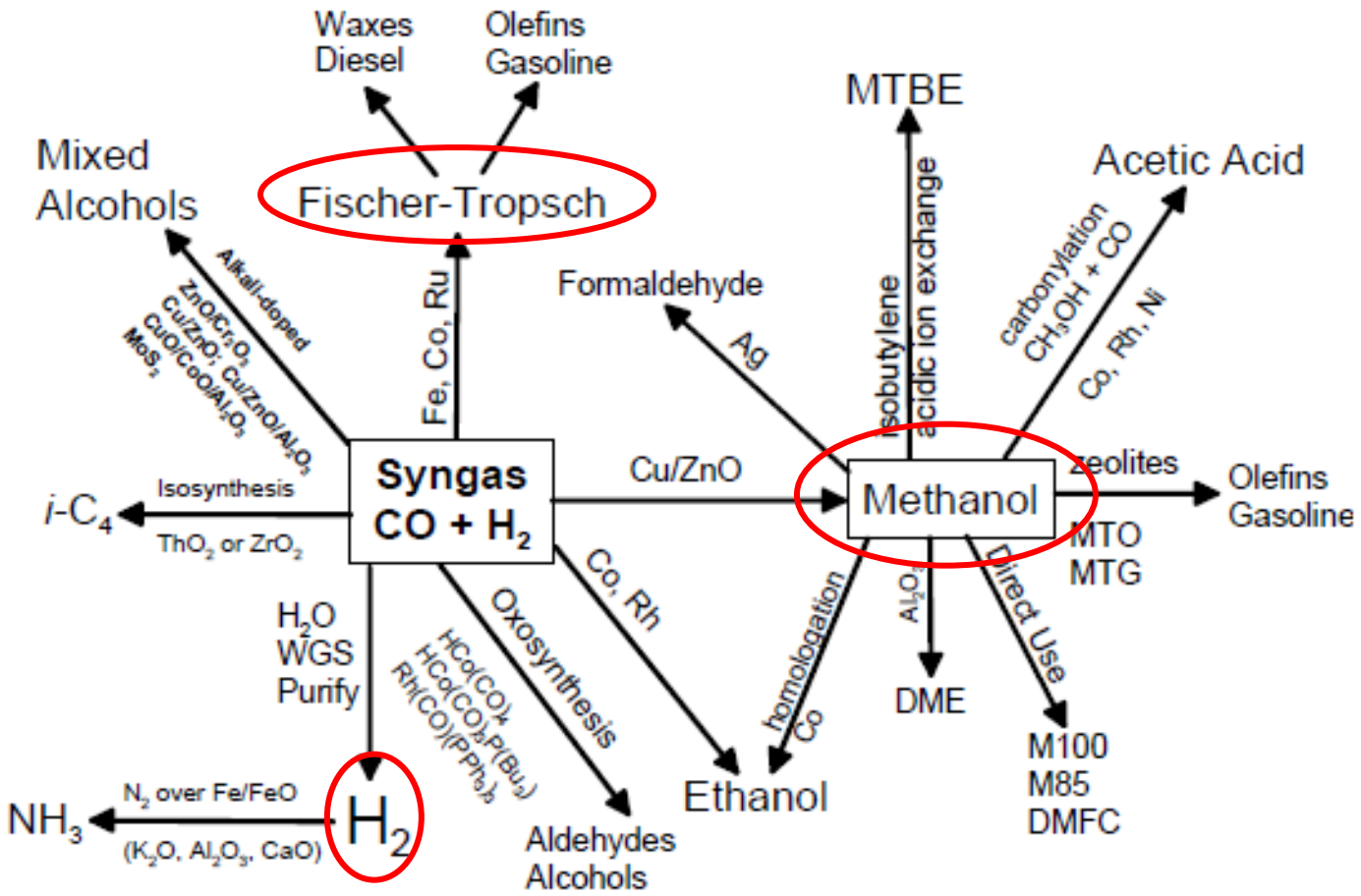

Potential Impacts

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From Hydrogen Council Roadmap Study: By 2050

- $2.5 trillion in global revenues
- 30 million jobs
- 400 million cars, 15-20 million trucks
- 18% of total global energy demand

The hydrogen ecosystems will appear around clusters of large-scale users, such as sea-ports, refineries, fertilizers, steel, and power

https://hydrogencouncil.com/en/

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Thank You!

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