The Power of Being Negative: Producing H_2 and Sequestered Carbon from Biomass and Waste Resources

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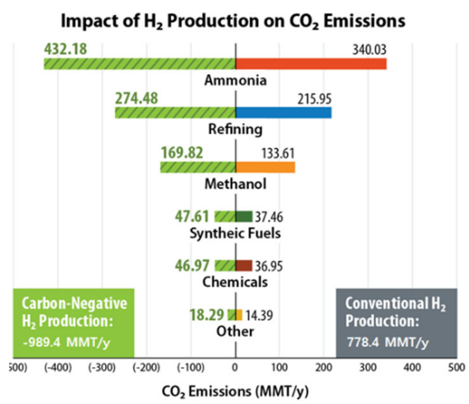
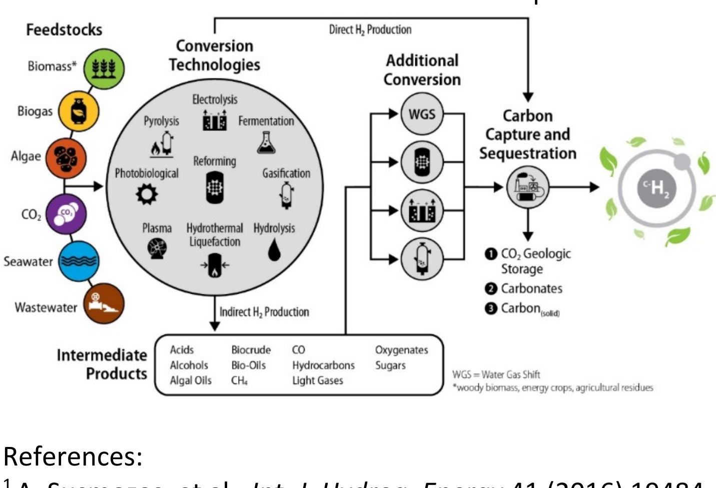
Hydrogen can serve as an enabler for decarbonizing our economy, especially for the transportation, manufacturing, and chemicals sectors. Low-carbon H_2 can be generated through a number of pathways, including (1) steam methane reforming coupled with carbon capture and sequestration, (2) water electrolysis utilizing renewable electricity, (3) methane pyrolysis, and (4) biomass and waste conversion. However, only the biomass and waste conversion pathway offers a route to *carbon-negative* H_2 when coupled with carbon capture and sequestration (CCS), thus providing both a service to our environment through carbon dioxide removal from the atmosphere and a valuable downstream product in H_2.

We define carbon-negative H_2 as H_2 produced with a life cycle carbon intensity below zero. For example, the carbon intensity of H_2 produced from biomass gasification with CCS has been reported to be -14kg CO_2-equivalent/kg of H_2.[1,2] If it were possible to meet global H_2 demand with carbon-negative H_2, we could avoid nearly 0.8 billion tons of CO_2 emissions per year *and* sequester another 1 billion tons of CO_2 per year (see figure to the right). For comparison, our global CO_2 emissions are greater than 35 billion tons per year. Thus, carbon-negative H_2 could enable us to transform our worst CO_2-emitting processes, such as ammonia synthesis, into carbon sinks – highlighting the power of being negative.



Potential biomass and waste feedstocks span terrestrial biomass (i.e., woody and herbaceous biomass, energy crops, agricultural and forest residues), biogas, algae, wastewater, waste plastics, and municipal solid waste, and a multitude of technologies from early-stage to commercial exist to convert these feedstocks into H_2 (see figure below). However, the availability, scale, handling challenges, and spatial distribution of these feedstocks and the competition for other uses (e.g., energy, biofuels, etc.) will play a key role in determining the extent of future H_2 production from these domestic resources. This presentation will discuss the value proposition of carbon-negative H_2 in the context of achieving a net-zero emissions economy, provide an overview of the existing technologies and costs of H_2 production, draw attention to key barriers limiting deployment, and ultimately propose one potential scalable platform for the future.



References:
[1] A. Susmozas, et al., *Int. J. Hydrog. Energy* 41 (2016) 19484 – 19491.
[2] A. Al-Qahtani, et al., *Appl. Energy* 281 (2021) 115958.