

# Global Hydrogen Trends and Opportunities

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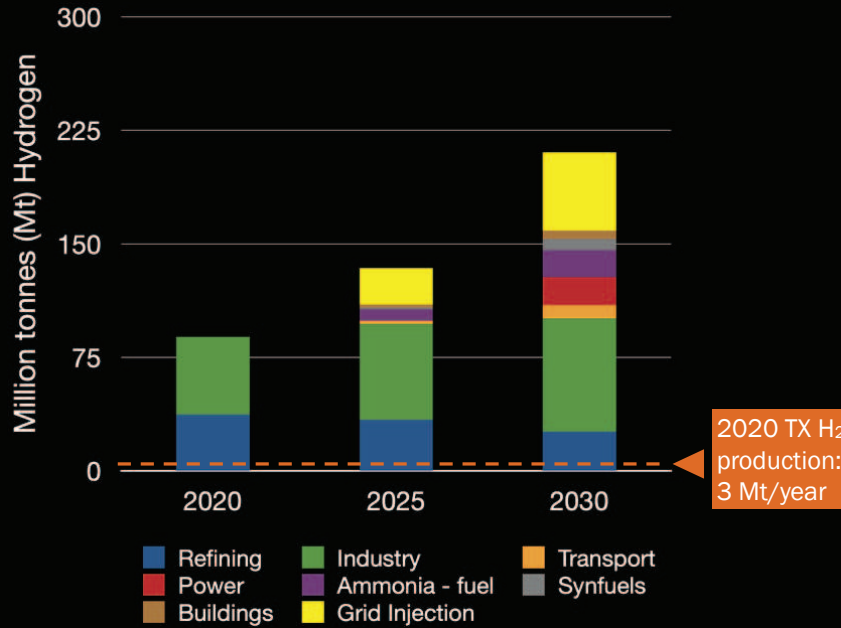
## Background

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# Hydrogen is increasingly being considered a key decarbonization tool

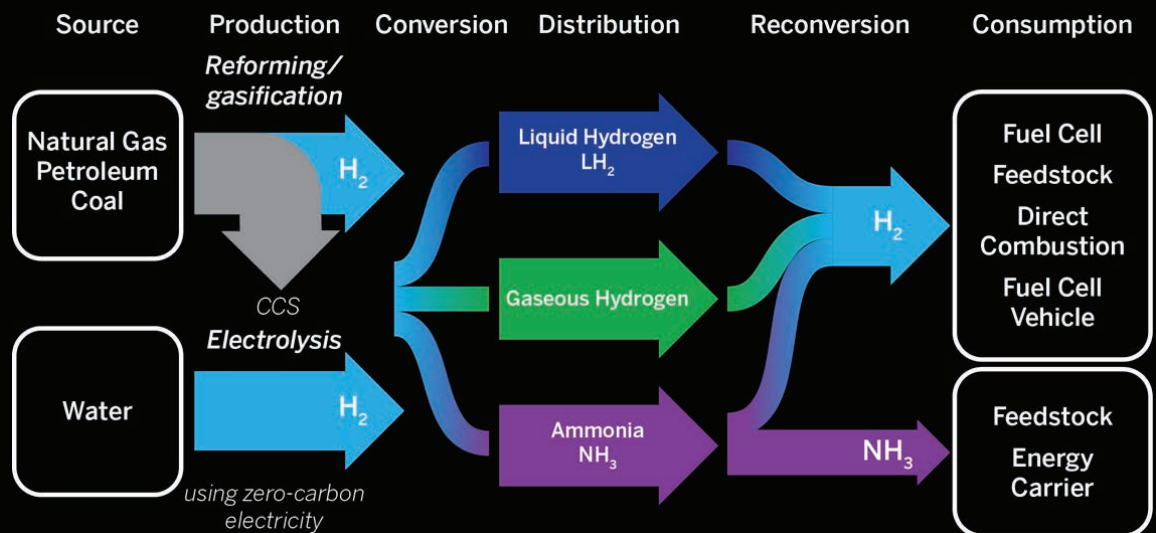
- Hydrogen (H<sub>2</sub>) releases no greenhouse gases when used
- Can serve as a fuel, feedstock, or energy carrier
- Potential emission reduction applications across many sectors (industrial, transportation, electricity)

Global hydrogen demand by sector in the IEA Net Zero Scenario



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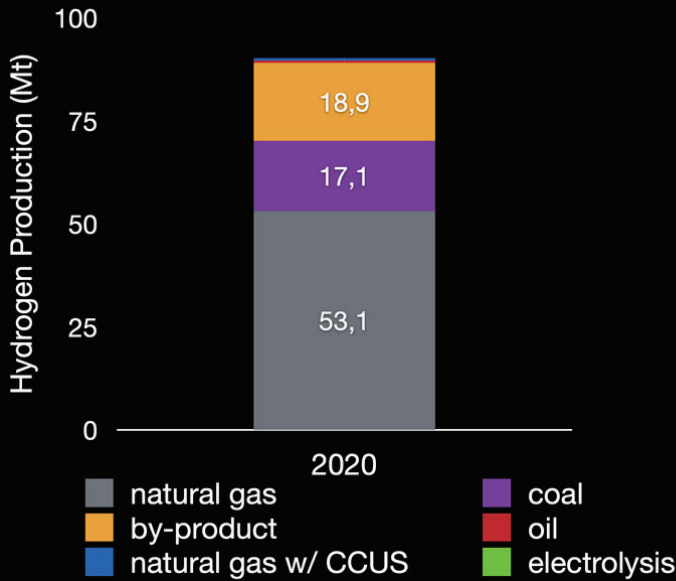
# Energy usage and emissions across the hydrogen supply chain are an important consideration for its use



Hydrogen supply chain may look like some version of this - illustrative of different supply chain components

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# Current hydrogen production methods emit greenhouse gases



- 59% of global hydrogen produced by steam methane reforming (SMR) of natural gas → ~9 kg CO<sub>2</sub>/kg H<sub>2</sub>
- 19% of global hydrogen produced from gasification of coal → ~19 kg CO<sub>2</sub>/kg H<sub>2</sub>
- Only 0.7% of global hydrogen production from steam methane reforming of natural gas with carbon capture and storage (CCUS) → ~0.9 - 3.6 kg CO<sub>2</sub>/kg H<sub>2</sub>
- Negligible production of hydrogen from electrolysis

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# Hydrogen production coded by 'color' misses some key considerations

## Steam Methane Reforming (SMR) of Natural Gas 'Grey Hydrogen'

- Splits methane (CH<sub>4</sub>) to produce H<sub>2</sub> with a by-product of CO<sub>2</sub>
- ~9 kg CO<sub>2</sub>/kg H<sub>2</sub> (at point of production)
- Must also consider upstream emissions
- Continued reliance on fossil fuel feedstocks
- ~95% of US hydrogen production

## Steam Methane Reforming (SMR) of Natural Gas with CCUS 'Blue Hydrogen'

- Adds carbon capture and storage (CCUS) to SMR
- ~0.9 - 3.6 kg CO<sub>2</sub>/kg H<sub>2</sub> (depending on capture rates)
- Must also consider upstream emissions
- Continued reliance on fossil fuel feedstocks

## Electrolysis with Renewable Electricity 'Green Hydrogen'

- Uses electricity to split water (H<sub>2</sub>O) into H<sub>2</sub> and O<sub>2</sub>
- Lifecycle emissions are dependent on electricity emissions
- Renewable electricity use yields zero-carbon hydrogen
- Negligible amount of global production currently

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First appeared as part of the conference materials for the  
18<sup>th</sup> Annual Renewable Energy Law Institute session  
"Trends and Recent Activity - Hydrogen Energy Projects"