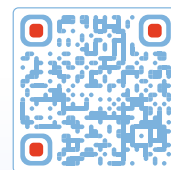
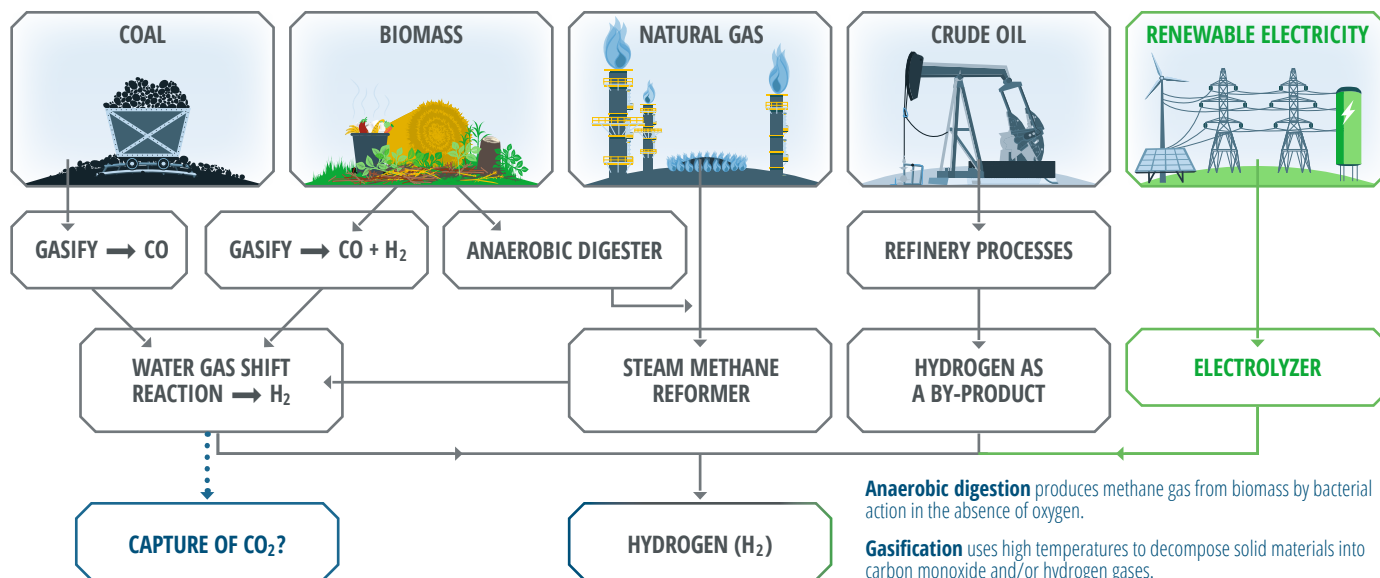


HYDROGEN

Follow the QR code for other factsheets, background information and references:



Hydrogen is a light and energy-dense gas with three times more energy per pound than gasoline. In the U.S., 95% of U.S. hydrogen is made from natural gas and 4% is from coal. Some experts see hydrogen as a major energy carrier in a low carbon economy.



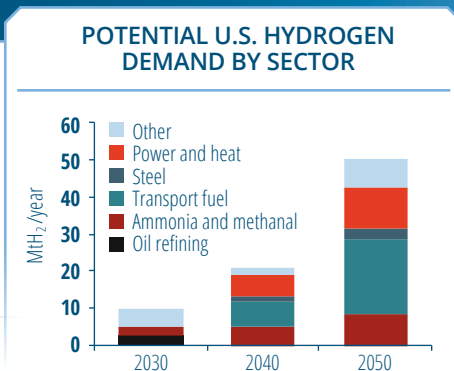
COLORS OF HYDROGEN

Colors are used as a shorthand for some hydrogen production processes, for example:

<p>GRAY HYDROGEN </p> <p>Gray hydrogen is made from fossil natural gas in a process called 'reforming' – most U.S. hydrogen is in this category.</p>	<p>BLUE HYDROGEN </p> <p>Blue hydrogen is simply gray hydrogen coupled with carbon capture and storage (CCS).</p>	<p>GREEN HYDROGEN </p> <p>Green hydrogen is made using renewable electricity to split water molecules into oxygen and hydrogen in a process called 'electrolysis'.</p>
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HYDROGEN DEMAND

- ◆ Hydrogen can be used as an energy carrier or a chemical reactant.
- ◆ Most announced low-carbon hydrogen production projects in the U.S. are for blue hydrogen.
- ◆ There is likely to be competition between sectors for access to supplies of low carbon hydrogen.



FUEL CELLS IN TRANSPORT

- ◆ Hydrogen-powered vehicles use fuel cells to drive an electric motor – this has an energy efficiency roughly double that of combustion engine vehicles.
 - ◇ Even gray hydrogen used in a fuel cell vehicle can reduce greenhouse gas emissions compared to a gasoline vehicle.
- ◆ Hydrogen fuel cell vehicles are classed as 'zero-emission vehicles' (ZEVs), as their only exhaust product is water vapor.
- ◆ Hydrogen fuel cell vehicles may be used in applications like long-distance trucking for which battery electric vehicles are less well suited.



TRANSPORT AND LEAKAGE

- ◆ Hydrogen gas occupies a lot of space; it is therefore made denser by compressing or liquefying it for storage, transport, and use.
- ◆ Hydrogen has a propensity to leak from pipelines and storage tanks, as it can corrode metals and its small molecular size makes it prone to escape through seals.
- ◆ This has climate implications: hydrogen has a climate warming effect about 37x stronger than carbon dioxide (over a 20-year interval), so leaks undermine the greenhouse gas benefits of using hydrogen.

IMPACTS...

...FROM GRAY HYDROGEN

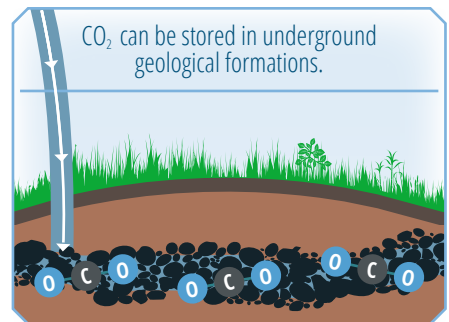
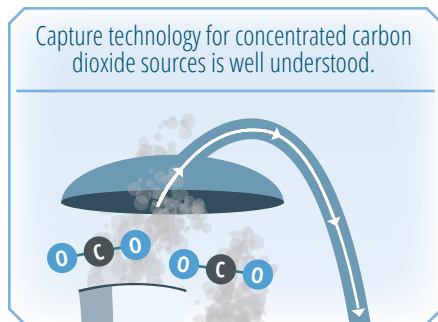
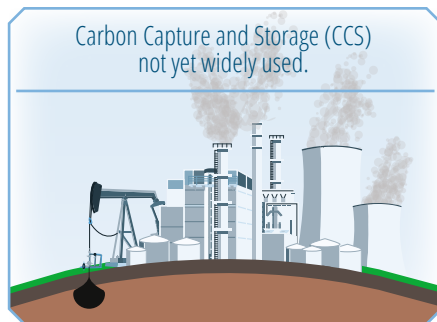
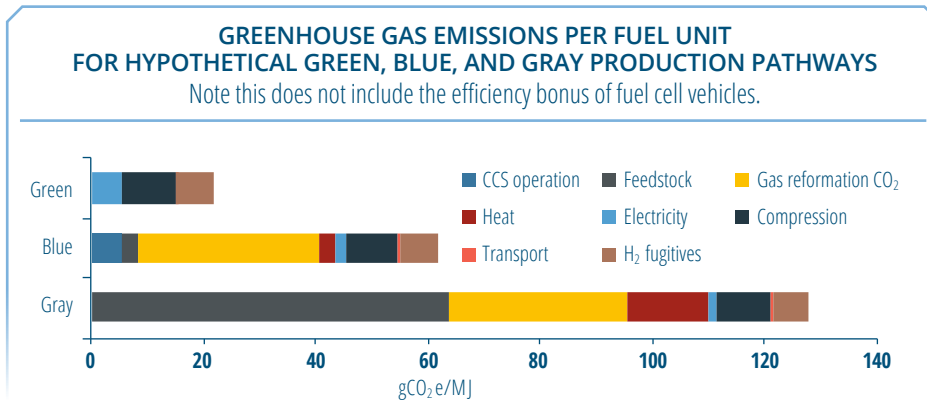
- ◆ Gray hydrogen is currently produced for oil refineries and for fertilizer and chemical production.
- ◆ In gray hydrogen production the carbon from the methane gas is released as CO₂.
- ◆ Methane is a powerful greenhouse gas, and (like hydrogen leaks) methane leaks along the supply chain can undermine climate performance.

...FROM BLUE HYDROGEN

- ◆ Blue hydrogen is the same as gray hydrogen except the CO₂ is captured.
- ◆ The process to capture and store CO₂ from blue hydrogen has been trialed but is not yet widely used.
- ◆ Concerns about CO₂ capture include leakage risk and the use of captured CO₂ to extract more crude oil from existing wells.

...FROM GREEN HYDROGEN

- ◆ To be truly low-carbon, electrolysers must consume renewable electricity to produce hydrogen.
- ◆ 4,000 metric tons of electrolytic hydrogen were produced in the U.S. in 2022... but mostly from grid electricity including fossil power.
- ◆ Producing ten million metric tons of green hydrogen in 2040 would require 50-60 gigawatt of dedicated non-stop renewable electricity supply.
- ◇ For comparison, 36 gigawatt of renewable capacity was added to the U.S. grid in 2023.
- ◆ Green hydrogen is not yet commercially viable without significant external support – in large part because of the cost of the electricity.



INDIRECT EFFECTS: ADDITIONALITY

Using renewable electricity for green hydrogen production offers no climate benefit if that renewable electricity is simply diverted from homes and other industries. To be truly low-carbon, green hydrogen production must be accompanied by the deployment of 'additional' renewables.