

# Making Hydrogen

FEBRUARY 2023

Hydrogen (H<sub>2</sub>) is an important energy carrier for net-zero carbon economy; its emission profile and cost depends on the production method.

Equivalent emission in kilogram of CO<sub>2</sub> for every kilogram of H<sub>2</sub> produced:



## From **Water**

Water (H<sub>2</sub>O) can be split into H<sub>2</sub> and O<sub>2</sub> using electricity, heat, or sunlight.



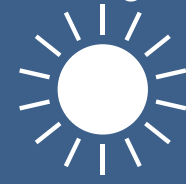
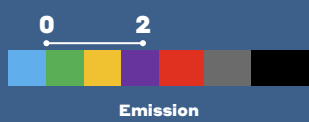
### Electrolysis

Uses electricity to split water.



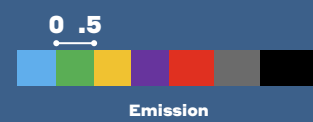
### Thermolysis

Uses heat to split water.



### Photolysis

Uses visible light energy to split water.



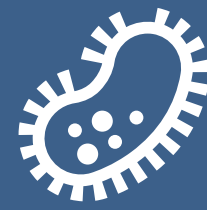
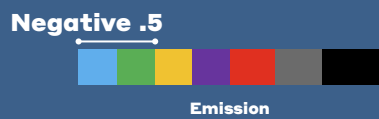
## From **Biomass**

Organic materials can produce H<sub>2</sub> using chemical and biological processes.



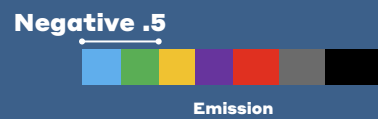
### Thermo-chemical Process

Biomass can be broken down into H<sub>2</sub> and a mixture of gases (synthetic gas or syngas) using oxygen and steam.



### Biological Process

Some algae and bacteria can produce H<sub>2</sub> from glucose or water.



## From **Fossil Fuels**

Fossil fuels can be broken down into H<sub>2</sub> and other co-products. Carbon dioxide (CO<sub>2</sub>) produced from these processes can be captured, compressed, and stored in geologic formations underground; a process referred to as carbon capture and storage.



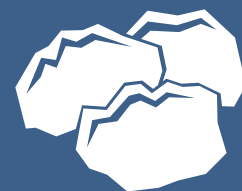
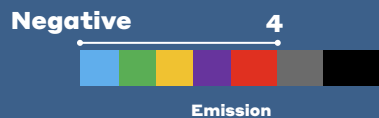
### Methane Reforming

Using O<sub>2</sub> and/or steam, methane (CH<sub>4</sub>) can be split into H<sub>2</sub> and CO<sub>2</sub>.



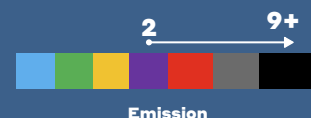
### Methane Pyrolysis

Using a catalyst, low-carbon CH<sub>4</sub> can be split into H<sub>2</sub> and solid carbon.



### Coal Gasification

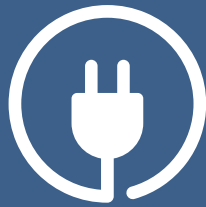
Using steam, coal can be broken down into a mixture of gases including H<sub>2</sub>.



# Using Hydrogen

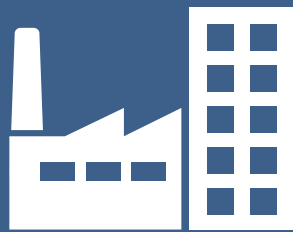
Hydrogen can serve as a low- or zero-carbon fuel in various end uses, enabling decarbonization across multiple sectors. Scalability and market maturity differs by application.

## Electricity



Pure and blended hydrogen can be used in gas turbines to produce electric power. Energy conversion devices like stationary fuel cells can produce backup heat and power.

## Industrial Heat



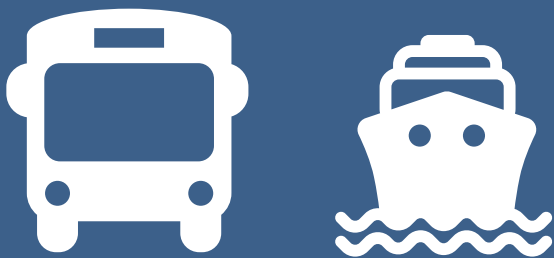
High-heat industrial processes make up the majority of industrial emissions. Hydrogen can provide high-density industrial heat without producing carbon emissions.

## Raw Material



Hydrogen can be used as feedstock in various chemicals and products such as ammonia and synthetic fuel production. Hydrogen can also be used as a chemical agent to facilitate the production of steel.

## Transportation



Light-duty and heavy-duty vehicles, rail, aviation, and marine vessels can be powered by hydrogen. Hydrogen is a light gas with high energy density, enabling fast refueling and long ranges.

## Building Heat



Hydrogen can be blended with natural gas or substitute natural gas to decarbonize building spaces and water heating.

### References

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