TOTAL

All about

Fuel Cell Electric Vehicle

In the face of climate issues and the evolution of technologies and uses, surface transports must also make the ecological and technological transition.
There is no one single energy that best meets each of our customers' needs but a mix of optimal solutions depending on their location and uses.

Hydrogen is one such alternative. Running cars and buses while only rejecting steam: nothing is impossible for the smallest atom, which is also the most abundant element in the universe.
Today, we see an increase in the control of its production and distribution and the first hydrogen service stations are being rolled out.

"While the number of Fuel Cell Electric Vehicle might still modest, we are innovating in pilot projects to prepare tomorrow's mobility. Fuel Cell Electric Vehicle has major advantages: it combines the advantages of electric vehicles in terms of emissions and those of internal combustion engine vehicles in terms of autonomy and recharge time."

This document should help you gain a better understanding of what is a **Fuel Cell Electric Vehicle** and what are the stakes and actions implemented by Total in this field.

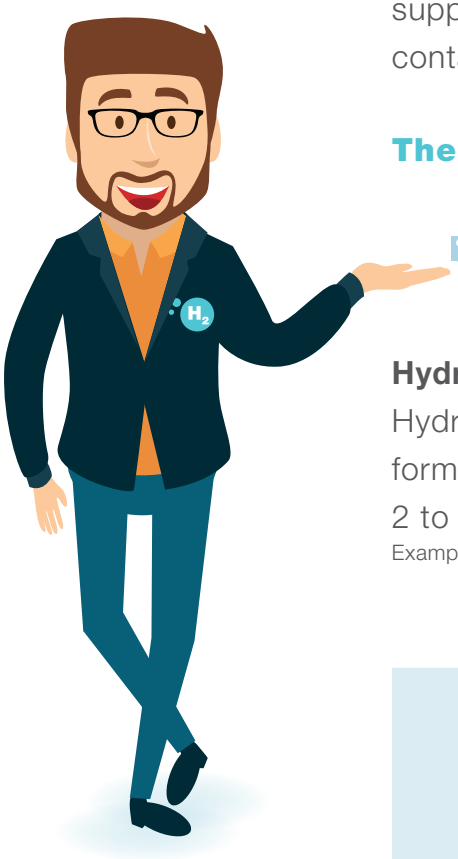
Happy reading!

Research Marketing Strategy
Product Marketing
TOTAL Marketing & Services

Contents

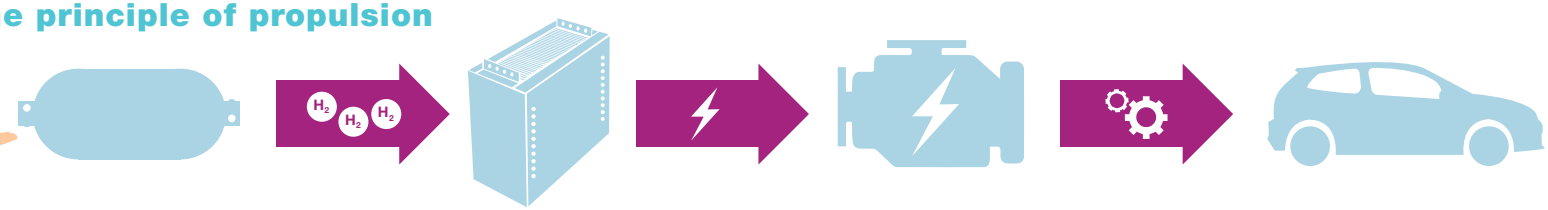
ESSENTIALS

How does a Fuel Cell Electric Vehicle work?



A Fuel Cell Electric Vehicle is primarily an electric vehicle. But the electricity powering the engine is not supplied via a battery like other electric vehicles. It is produced via a fuel cell, working with the hydrogen contained in the tank.

The principle of propulsion



Hydrogen tank under pressure
Hydrogen is stored in gaseous form in 1 or 2 tanks containing 2 to 3 kg of hydrogen each.
Examples: 350 bar (bus)
700 bar (light vehicle)

Fuel cell
As a vital part of the vehicle, the fuel cell uses hydrogen to produce electricity.

Electric engine
The electric motor converts electricity into mechanical energy to drive the vehicle.

The vehicle running
The vehicle runs without any exhaust… apart from steam!

Did you know?

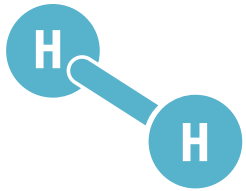
Unlike gasoline or diesel, hydrogen is not burned by a thermal engine. It is used to produce electricity through a fuel cell. This reaction is silent, which provides a superior noise comfort to an internal combustion engine vehicle.

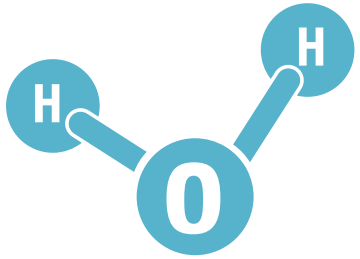
ESSENTIALS

What is hydrogen or H_2?

Hydrogen (or H_2 for dihydrogen) is **the most common element in the universe**.
Take water for example, it is found everywhere and contains two hydrogen atoms.

DIHYDROGEN MOLECULE
2 hydrogen atoms

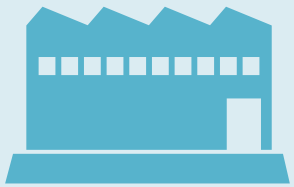




WATER MOLECULE
2 hydrogen atoms
and 1 oxygen atom

For which application?

Hydrogen in gaseous form is widely used in chemical and petroleum manufacturing processes.
On the other hand, its consumption dedicated to transport (the hydrogen is used to produce electricity via a fuel cell) is still unusual.



≈ 65%
CHEMICAL INDUSTRY

≈ 35%
REFINERY

< 1%
ENERGY

ESSENTIALS

How is hydrogen made?

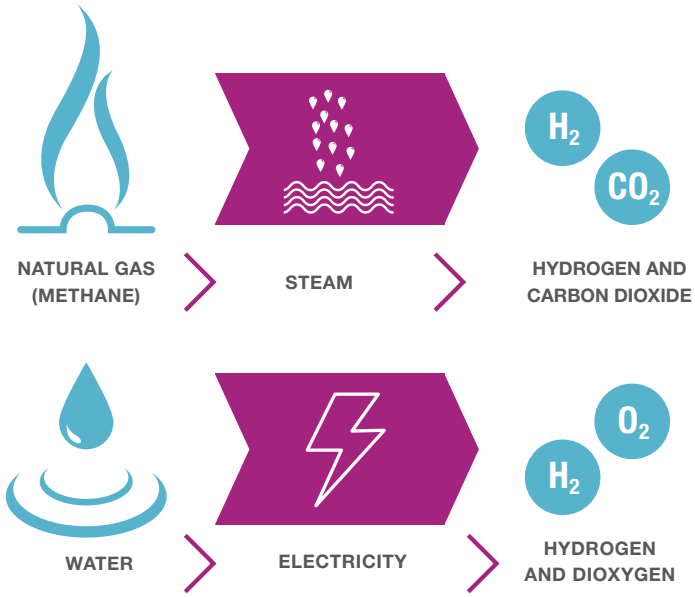
There are two industrial ways to produce pure hydrogen.

Most common process:
reforming from natural gas.

Natural gas (CH_4), composed of carbon atoms (C) and hydrogen atoms (H), is heated in the presence of steam. This chemical reaction produces dihydrogen (H_2) on one side and carbon dioxide (CO_2) on the other.

Secondary process:
electrolysis from water.

Water (H_2O), composed of oxygen atoms (O) and hydrogen atoms (H) is subjected to an electric current. This chemical reaction produces dioxygen (O_2) on one side and dihydrogen (H_2) on the other.



Did you know?

- It is possible to manufacture hydrogen from renewable sources! This requires that electricity or natural gas be of renewable origin. A real asset when the sector will develop.
- Total's R&D is working on green hydrogen generation projects (by electrolysis with renewable electricity) in refineries or near service stations.

ESSENTIALS

What are the advantages of a Fuel Cell Electric Vehicle?

A Fuel Cell Electric Vehicle is full of resources: **as an electric vehicle, Fuel Cell Electric Vehicle also deliver the rapid refueling and extended range usually associated with an internal combustion engine.**

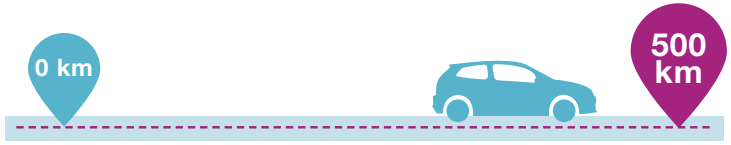
The advantages of the electric vehicle

A minimal local footprint:
zero emission of gaseous pollutants or CO_2 in the exhaust, making it an ideal vehicle for city traffic.

A unique comfort:
very quiet movements at low speed and dynamism especially during great acceleration.

The advantages of a thermal vehicle

Quick fill-up:
only takes 5 minutes!



A good autonomy:
500 km on average.

Hydrogen is a promising energy, but today, the high prices of the vehicles and service station infrastructures is a brake on its mass deployment.

ESSENTIALS

What vehicles and applications use hydrogen?

Some applications are experimenting with Fuel Cell Electric Vehicle.
In the future, it could be with us in our daily travels.

Cars: The Fuel Cell Electric car is still not very present. To address the general public, its price will have to gain competitiveness.

Buses: Several cities are already testing Fuel Cell Electric buses, helping to reduce local pollutant emissions and noise to improve the quality of life of their inhabitants.

Specific vehicles (mining, forklift trucks): Hydrogen is ideal for use in a confined atmosphere, as there is no discharge other than steam.

Underwater applications: Combined with a fuel cell, hydrogen allows for excellent discretion when traveling under the sea.

Aerospace: Hydrogen contains a large amount of energy. Burned, it is able to make a rocket take off!

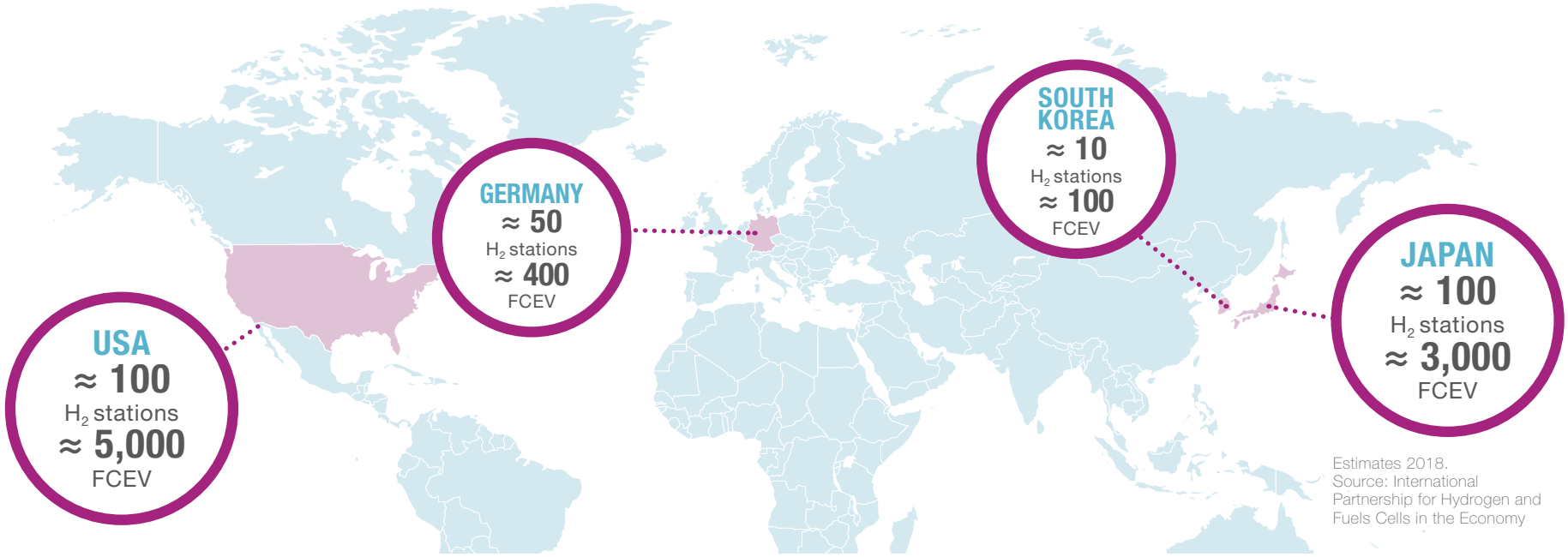
Did you know?

Fuel Cell Electric trucks are already in the prototype stage at the manufacturers.

ESSENTIALS

Fuel Cell Electric Vehicle across the world

Currently, only a few car manufacturers market Fuel Cell Electric Vehicle and the production and sale of Fuel Cell Electric Vehicle are still very seldom.



Estimates 2018.
Source: International Partnership for Hydrogen and Fuels Cells in the Economy

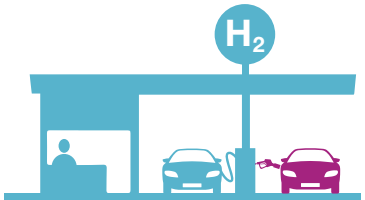
And tomorrow?

To become a part of our daily lives, the H_2 technology still has to present major savings and in particular to offer vehicles and clean energy (without CO_2 emissions) at more competitive prices.

IN PRACTICE

Filling up with hydrogen

To fill up with hydrogen is very simple: the operation is very similar to that performed with conventional fuels.



1st STEP

Go to a station
offering hydrogen
(self-service).

2nd STEP

Unhook the nozzle
and connect it to the vehicle socket.

Good to know: The connection between the vehicle and the station is tight: no evaporation or projection can occur. As long as the nozzle is not plugged properly, it is not possible to refuel.

3rd STEP

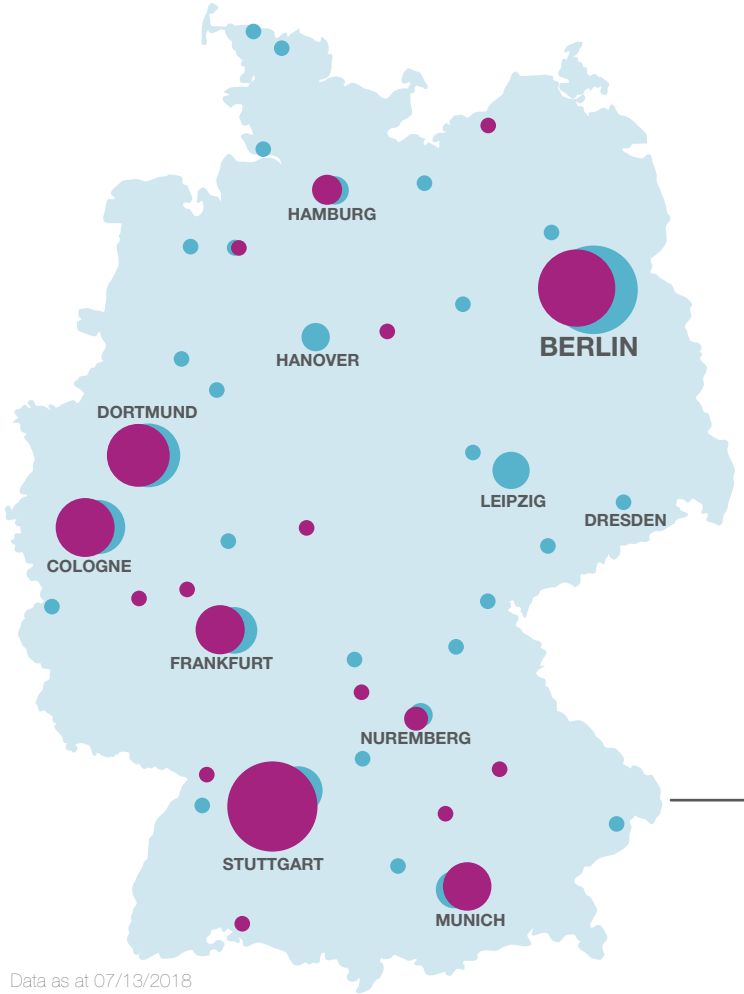
Help yourself!
Hydrogen is injected at very high pressure (700 bar) and at low temperature (-40°C) into the vehicle tank.
Result: it takes less than 5 minutes to fill up.

Did you know?

Filling up with hydrogen is measured in kg of hydrogen. In addition, the entire distribution meets specific European standards. For a light vehicle, 1 kg of hydrogen will give you about 100 km.

IN PRACTICE

Total and the service stations network of H_2 Mobility



Data as at 07/13/2018
Find out more: https://h2.live/

In Germany, Total has been a pioneer in hydrogen mobility since the early 2000s.

In 2015, together with 5 other partners, Total founded the H_2 Mobility Germany joint venture. Its goal? Develop the H_2 fuel sector throughout the country with nearly 100 H_2 stations planned for 2019 and 400 in the future.

The experience gained by Total in Germany will facilitate the potential of the industry in other countries.

- **ACTIVE STATIONS**
- **STATIONS UNDER PROJECT**

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Total is a major energy player committed to supplying affordable energy to a growing population, addressing climate change and meeting new customer expectations.

Those commitments guide what we do. With operations in more than 130 countries, we are a global integrated energy producer and provider, a leading international oil and gas company, and a major player in low-carbon energies. We explore for, produce, transform, market and distribute energy in a variety of forms, to serve the end customer.

Our 98,000 employees are committed to better energy that is safer, cleaner, more efficient, more innovative and accessible to as many people as possible. As a responsible corporate citizen, we focus on ensuring that our operations worldwide consistently deliver economic, social and environmental benefits.

Our ambition is to become the responsible energy major.

TOTAL MARKETING SERVICES
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Siège Social : 24, cours Michelet 92800 Puteaux - France

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