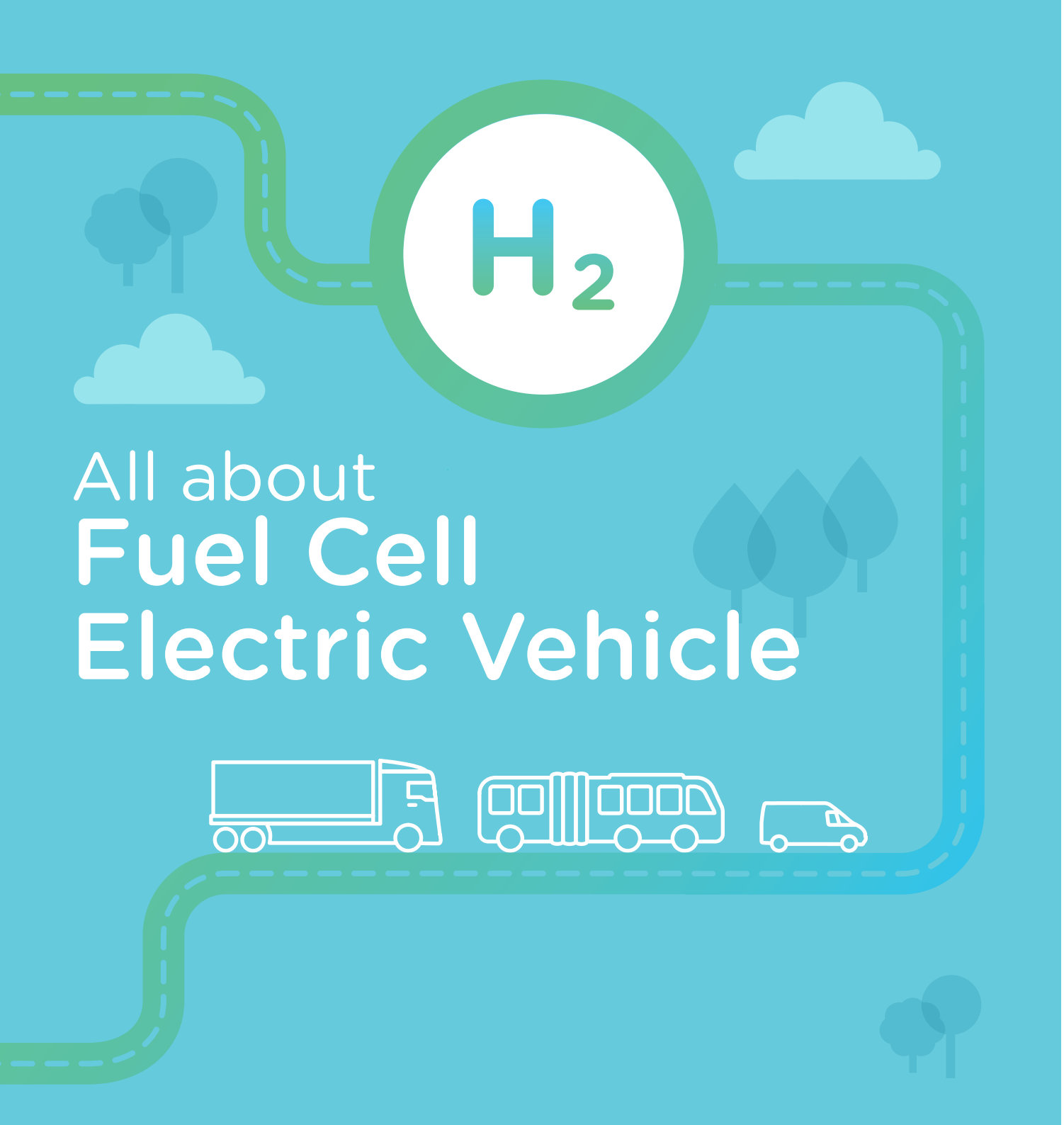

All about Fuel Cell Electric Vehicle

Hydrogen:
towards sustainable mobility

TotalEnergies

In the face of climate concerns changing practices and technology, the transportation sector has a major role to play in hastening the energy and environmental transition. The industry is developing a host of initiatives to provide its customers with efficient transportation alternatives.

Hydrogen is one such alternative to conventional fossil fuels. Running cars, buses, trucks and trains with only water vapor emissions? That goal is within reach thanks to hydrogen, the smallest atom and also the most abundant element in the universe. Today, the use of hydrogen for transportation is growing, and hydrogen service stations are making their first appearance.

> **“Although there’s still only a few Fuel Cell Electric Vehicles on the road, TotalEnergies is innovating with pilot projects to prepare for the mobility of the future. Fuel Cell Electric Vehicles offer major advantages: they combine the emissions benefits of electric vehicles with the driving range and quick refueling times of conventional internal combustion vehicles.”**

This booklet offers a brief introduction into how Fuel Cell Electric Vehicle works. You’ll also learn more about the challenges involved and what TotalEnergies is doing to make it happen.

We hope you enjoy your reading!

New Mobilities and Marketing Division
TotalEnergies Marketing Services

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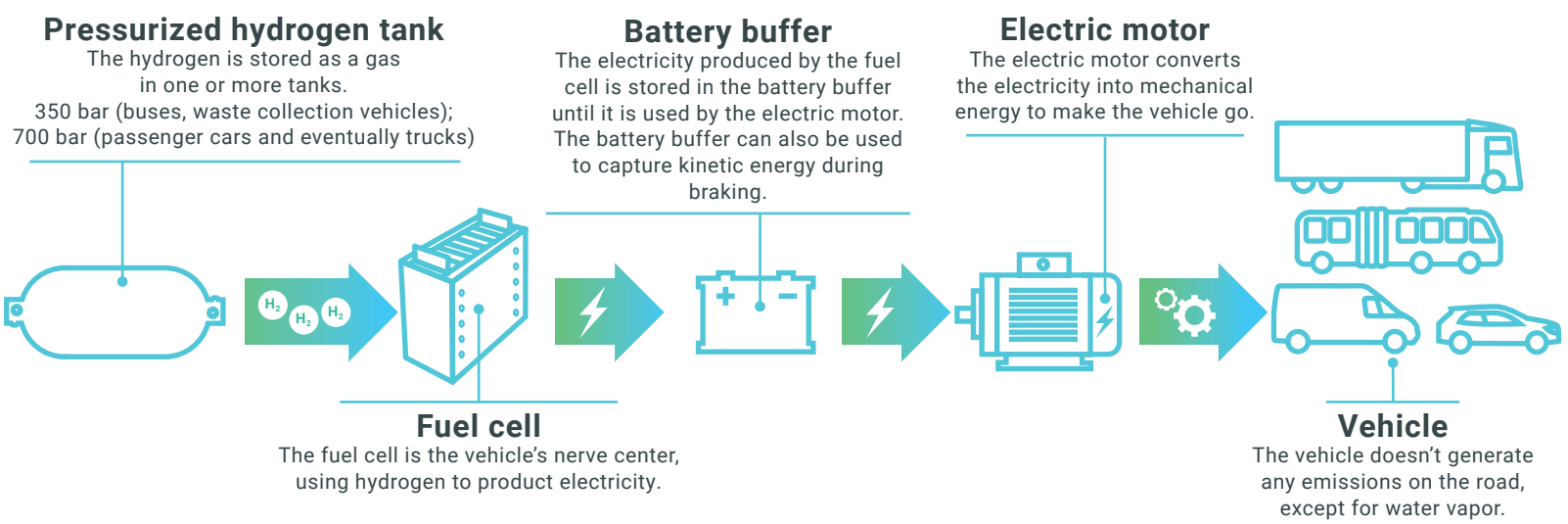
ESSENTIALS

How does a Fuel Cell Electric Vehicle work?

Fuel Cell Electric Vehicles (or FCEVs*) are members of the electric vehicle family. With an FCEV, the vehicle stores energy in its tank in the form of pressurized hydrogen. The fuel cell converts that hydrogen into electricity.

The propulsion system



Did You Know?

The fuel cell produces electricity without making any noise. So you enjoy a much quieter ride than with a conventional internal combustion vehicle.

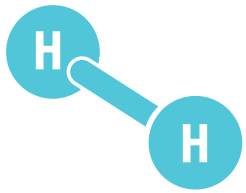
*FCEV: Fuel Cell Electric Vehicle

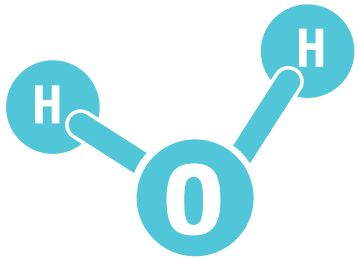
ESSENTIALS

What is hydrogen or H_2?

Hydrogen is **the most common element in the universe.**
Water, for example, can be found everywhere, and it contains two hydrogen atoms.
FCEVs use hydrogen in gas form (H_2).

HYDROGEN MOLECULE
2 hydrogen atoms





WATER MOLECULE
2 hydrogen atoms
and 1 oxygen atom

How is it used?

Hydrogen in gaseous form is widely used in processes for manufacturing chemicals and petroleum products. But hydrogen consumption in transportation (where hydrogen is used to produce electricity via a fuel cell) is still unusual.

≈ 60%*
CHEMICAL INDUSTRY

≈ 40%*
REFINING

< 1%*
ENERGY

*2020 figures

ESSENTIALS

How is hydrogen produced?

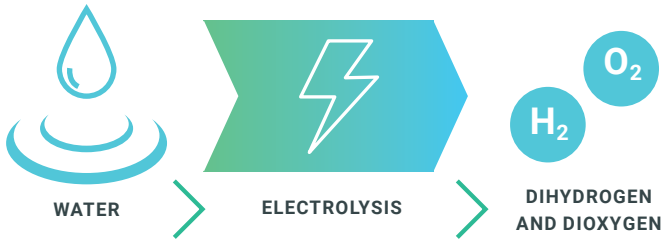
There are a variety of ways to produce hydrogen on an industrial scale.

The most common process: steam reforming from natural gas

Natural gas (CH_4), which comprises carbon (C) and hydrogen (H) atoms, is heated in the presence of steam. That chemical reaction produces both molecular hydrogen (H_2) and carbon dioxide (CO_2).

An alternative process: water electrolysis

Water (H_2O), which consists of both oxygen (O) and hydrogen (H) atoms, is subjected to an electric current. That chemical reaction produces both molecular dioxygen (O_2) and molecular dihydrogen (H_2).



Did You Know?

- It's now possible to produce renewable hydrogen, thanks to renewable electricity or natural gas. That's a real asset for boosting the industry.
- TotalEnergies is working on a number of renewable hydrogen generation projects, using electrolysis powered by electricity from solar panels at La Mède.

ESSENTIALS

What are the advantages of a Fuel Cell Electric Vehicle?

A Fuel Cell Electric Vehicle is highly versatile: **as an electric vehicle, it combines the advantages of an internal combustion vehicle with quick refueling and an extensive driving range.**

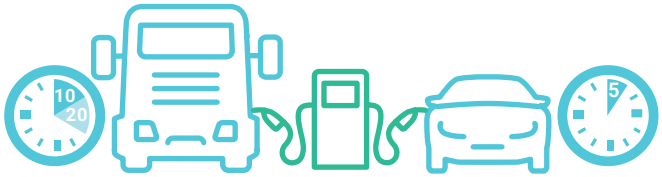
The advantages of electric vehicles

Minimal local impact:
since they generate no exhaust emissions, Fuel Cell Electric Vehicle can be used in low-emission zones.

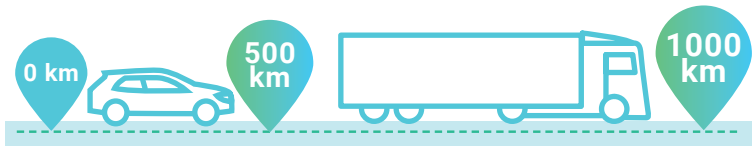
Exceptionally quiet operation
at low speeds.

Dynamism especially
during great acceleration.

The advantages of an internal combustion vehicle



Quick refueling: 10 to 20 minutes for trucks and buses and just five minutes for cars.



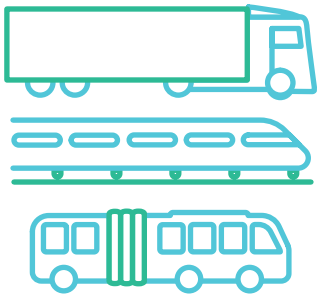
Excellent driving range:
an average of 500 kilometers for cars and up to 1,000 kilometers for trucks.

Hydrogen is a promising energy source. But for now, the high cost of Fuel Cell Electric Vehicles and service station infrastructure is hindering its growth.

ESSENTIALS

The use of hydrogen in the mobility

Hydrogen is especially suited for market segments where vehicles are used intensively and consume large amounts of energy:

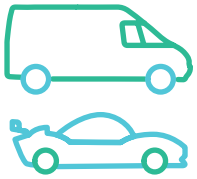


Heavy transport over long distances (44-ton trucks).

Rail, for which it offers an excellent alternative to electrified regional rail lines.

Articulated buses and other bus lines with high energy consumption (long routes or hilly terrain).

There are other potential applications as well:



Light commercial vehicles and cars that are used intensively in a way that makes battery electric vehicles unsuitable.

Auto racing with the H24 Racing team (see page 11 to learn more).

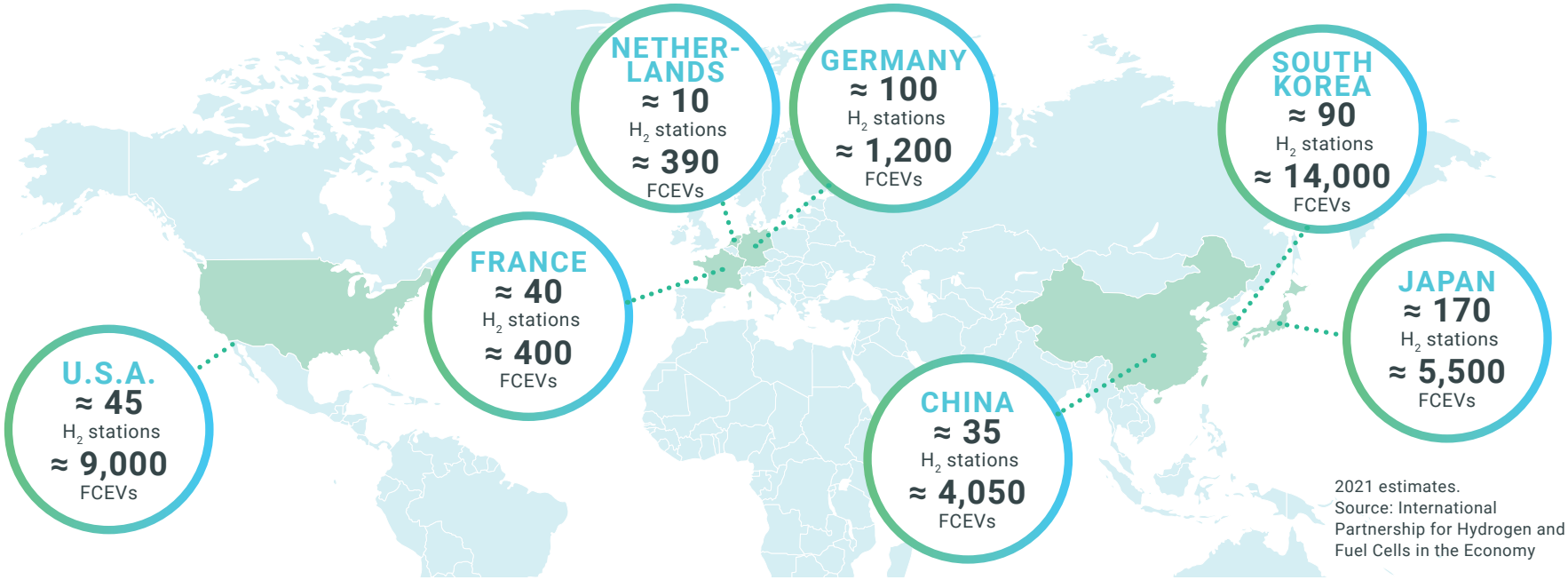
Did You Know?

Hydrogen offers additional applications for niche markets, including off-road vehicles, subsea vehicles, aerospace, aeronautics and navy vessels.

ESSENTIALS

Fuel Cell Electric Vehicles across the world

Zero-emission technology will be essential if we are to meet regulatory targets. And hydrogen mobility has a role to play. Today's truck manufacturers are focusing particular attention on Fuel Cell Electric Vehicle.



2021 estimates.
Source: International Partnership for Hydrogen and Fuel Cells in the Economy

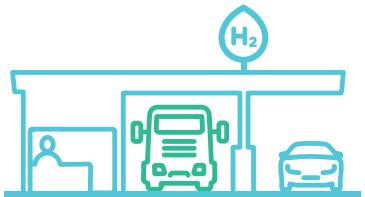
Looking Ahead

Before it can become part of our daily lives, the market for Fuel Cell Electric Vehicle still needs to achieve economies of scale, particularly in the number of cars available and the production of low-carbon energy at a more competitive price.

IN PRACTICE

Refueling with hydrogen

It's quite simple, and much like refueling with conventional fuels.



STEP 1

Visit a self-service station that sells hydrogen.

STEP 2

Take the hose from the pump and insert it in the vehicle nozzle.

Remember: The connection between the vehicle and the pump is sealtight. The hydrogen cannot evaporate or escape into the air. You can only begin fueling once the pump is properly inserted in the nozzle.

STEP 1

Fill up!

Hydrogen is injected into the vehicle tank at very high pressure (350–700 bar) and a very low temperature (-40°C).

Result: it takes 10 to 20 minutes to refuel buses and trucks and just five minutes for cars.

Did You Know?

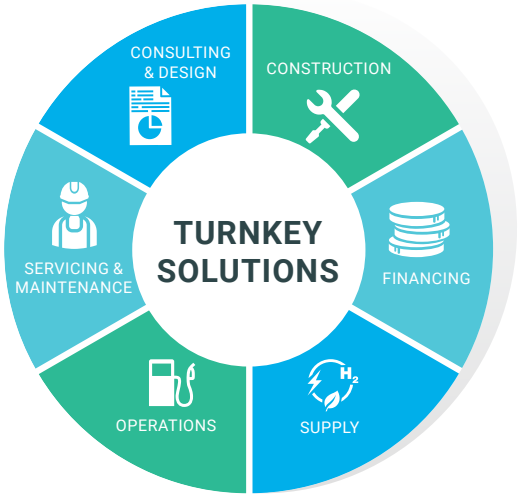
All hydrogen fueling meets specific European Union standards. A full tank is measured in kilograms of hydrogen. A passenger vehicle can travel about 100 kilometers on 1 kilogram of hydrogen. Depending on their use, trucks consume 8 to 10 kilograms of hydrogen per 100 kilometers.

IN PRACTICE

TotalEnergies and the Fuel Cell Electric Vehicle

Fuel Cell Electric Vehicle may still be few in number, but TotalEnergies has a host of hydrogen projects in the works to prepare the market for broader adoption of H_2 mobility.

Committed to H_2 mobility since the turn of the millennium, TotalEnergies boasts extensive experience and expertise in the hydrogen fueling infrastructure. Some thirty H_2 stations are open to customers in Germany, Belgium, Luxembourg, the Netherlands and France*.



TotalEnergies offers a full array of services, from design and installation to operation and maintenance, for both public and private fueling networks.

Did You Know?

For the Mission H24 hydrogen-powered race car project, TotalEnergies developed the world's first mobile hydrogen refueling station. The station traveled to racetracks across Europe supplying hydrogen to the H24 Racing team during the prestigious Michelin Le Mans Cup.

*2020 figures

TotalEnergies Marketing Services

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ALL ABOUT FUEL CELL ELECTRIC VEHICLE
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