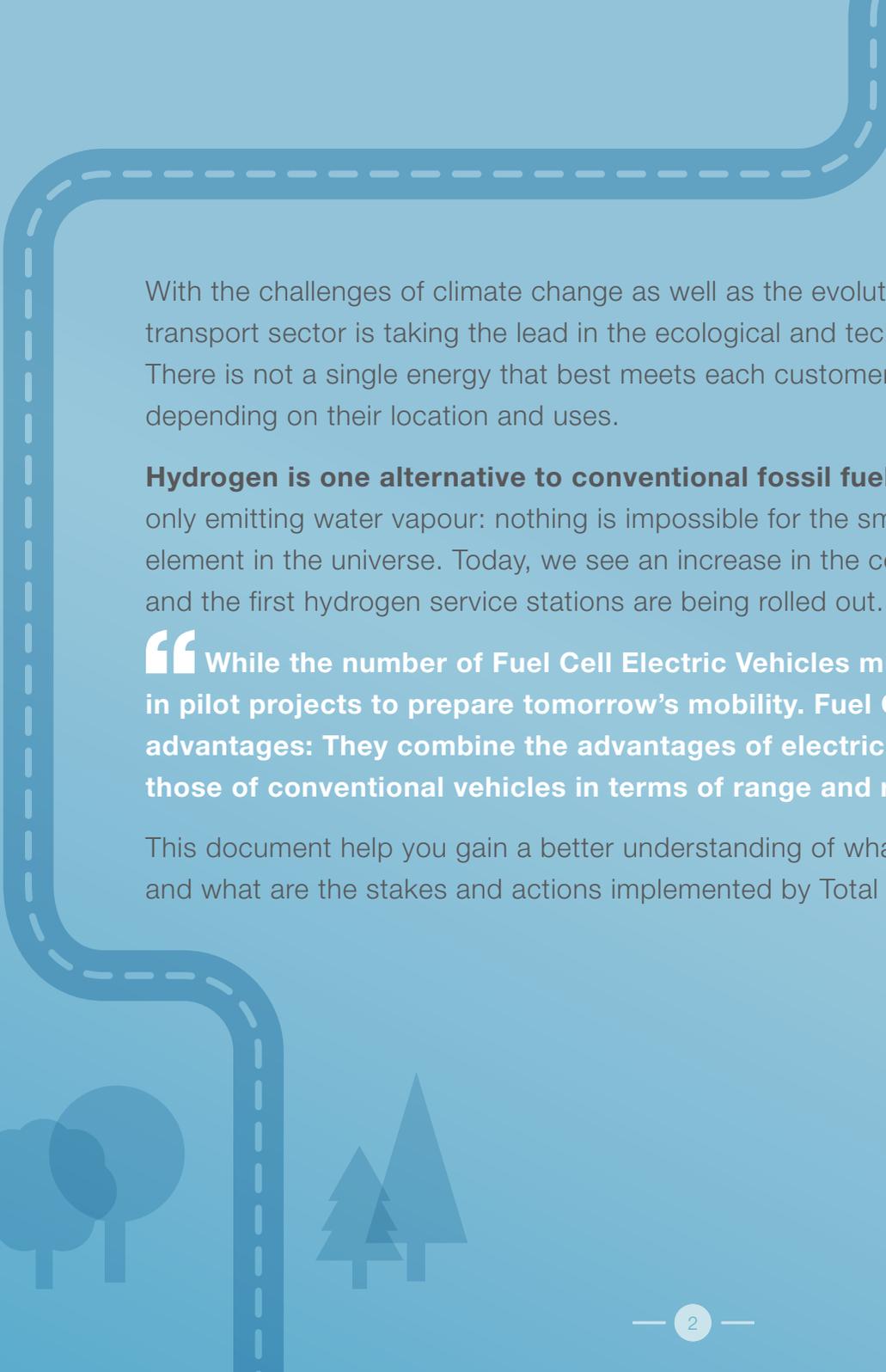




All about

# Fuel Cell Electric Vehicle





With the challenges of climate change as well as the evolution of technologies and applications, the road transport sector is taking the lead in the ecological and technological transition.

There is not a single energy that best meets each customer needs but a mix of optimal solutions depending on their location and uses.

**Hydrogen is one alternative to conventional fossil fuels.** Running car, buses, trucks and trains while only emitting water vapour: 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 Vehicles might still be modest, Total is innovating in pilot projects to prepare tomorrow’s mobility. Fuel Cell Electric Vehicles have major advantages: They combine the advantages of electric vehicles in terms of emissions and those of conventional vehicles in terms of range and refilling time. ”**

This document 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 Division**  
TOTAL Marketing & Services



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## ESSENTIALS

# How does a Fuel Cell Electric Vehicle work?

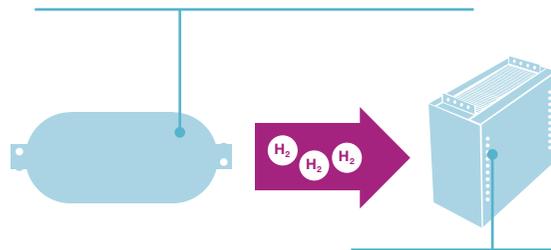
A Fuel Cell Electric Vehicle (FCEV\*) is primarily an electric vehicle. The way of supplying the electricity that powers the engine is different depending on whether the vehicle is electric or hydrogen powered. The electric vehicle uses a battery. The hydrogen vehicle has a fuel cell that runs on the hydrogen contained in the tank.



### The principle of propulsion

#### Hydrogen tank under pressure

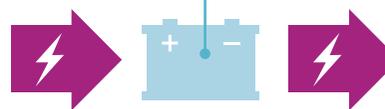
Hydrogen is stored in gaseous form in one or several tanks containing 2 to 8 kg of hydrogen each. 350 bar (bus, dumpster) ; 700 bar (light vehicle, heavy-duty vehicle in the future).



#### Fuel cell

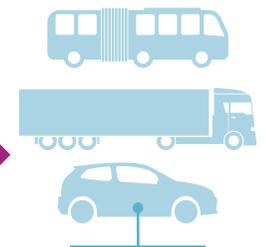
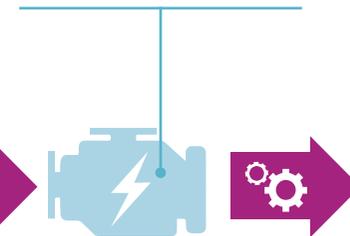
As a vital part of the vehicle, the fuel cell uses hydrogen to produce electricity.

#### Buffering battery



#### Electric engine

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



#### The vehicle

The vehicle runs without other exhaust... apart from water vapour!

### Did you know?

This reaction is done without noise, providing a superior driving experience compared to an ICE\*\*.

\*Fuel Cell Electric Vehicle

\*\*Internal Combustion Engine Vehicle



## ESSENTIALS

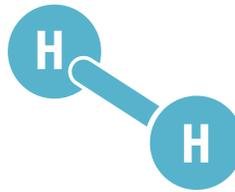
# What is hydrogen or H<sub>2</sub>?

Hydrogen is **the most common element in the universe.**

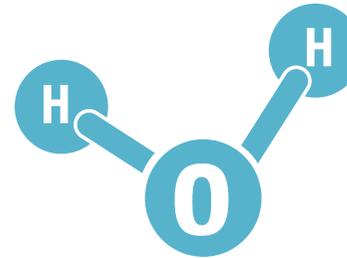
Take water for example, it is found everywhere and contains two hydrogen atoms.

Hydrogen as a gas (H<sub>2</sub>) is used in Fuel Cell Electric Vehicles.

**DIHYDROGEN MOLECULE**  
2 hydrogen atoms



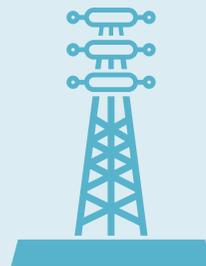
**WATER MOLECULE**  
2 hydrogen atoms  
and 1 oxygen atom



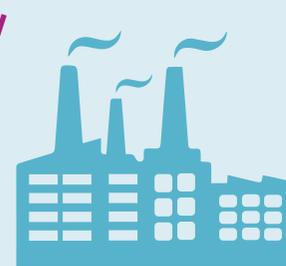
### For which application?

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 not very common yet.



< 1%\*  
ENERGY



≈ 40%\*  
REFINERY



≈ 60%\*  
CHEMICAL INDUSTRY

\*Data 2020



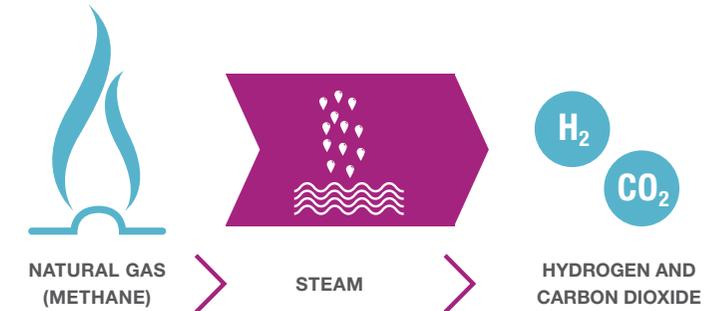
## ESSENTIALS

# How is hydrogen made?

There are two industrial ways to produce pure hydrogen.

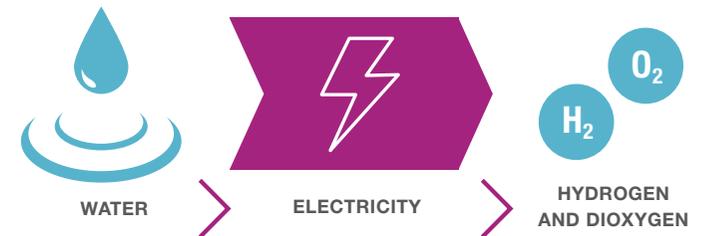
### Most common process: reforming from natural gas.

Natural gas ( $\text{CH}_4$ ), composed of carbon atoms (C) and hydrogen atoms (H), is heated in the presence of steam. This chemical reaction produces dihydrogen ( $\text{H}_2$ ) on one side and carbon dioxide ( $\text{CO}_2$ ) on the other.



### Alternative process: electrolysis from water.

Water ( $\text{H}_2\text{O}$ ), composed of oxygen atoms (O) and hydrogen atoms (H) is subjected to an electric current. This chemical reaction produces dioxygen ( $\text{O}_2$ ) on one side and dihydrogen ( $\text{H}_2$ ) on the other.



### Did you know?

- Producing hydrogen from renewable sources is possible thanks to electricity or natural gas, themselves from renewable origin. A real asset for the development of the sector!
- The Total Group is working on projects to generate renewable hydrogen (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 advantages: **as an electric vehicle, an FCEV also delivers a rapid refilling time and extended range usually associated with a conventional vehicle.**



### The advantages of the electric vehicle



#### A minimal local footprint:

with zero tailpipe emissions, hydrogen enables continuity of operations while benefiting from access to low-emission areas.



**Very quiet movements**  
at low speed.



**Dynamism**  
especially during great acceleration.

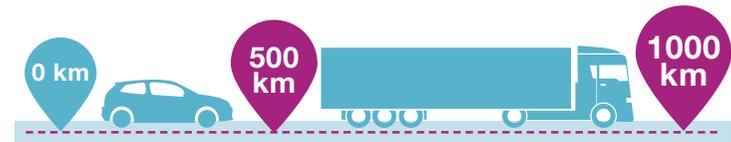


### The advantages of a thermal vehicle



#### Quick fill-up:

it only takes 10 to 20 minutes for trucks and buses and 5 minutes for cars.



#### A good autonomy:

500 km on average for cars and 1000 km for trucks.

Today, hydrogen is a promising energy. The high prices of the vehicles and service station infrastructures is a barrier to mass deployment.



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## ESSENTIALS

# The use of hydrogen in the mobility

Hydrogen is particularly suitable for segments with intensive use and high energy consumption:



**Heavy-duty** long-distance transport (44 tons tractor),



**Rail transport** as it is an excellent alternative to the electrification of lines,



**Articulated buses** 18 meters, or bus lines with high energy consumption (long or hilly lines).

Other applications are also possible such as for:



**Cars:** the Fuel Cell Electric car is still not very present. To address the mass market, its price will have to gain competitiveness.



**Total invests in the H24 Mission Program.**



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



**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!

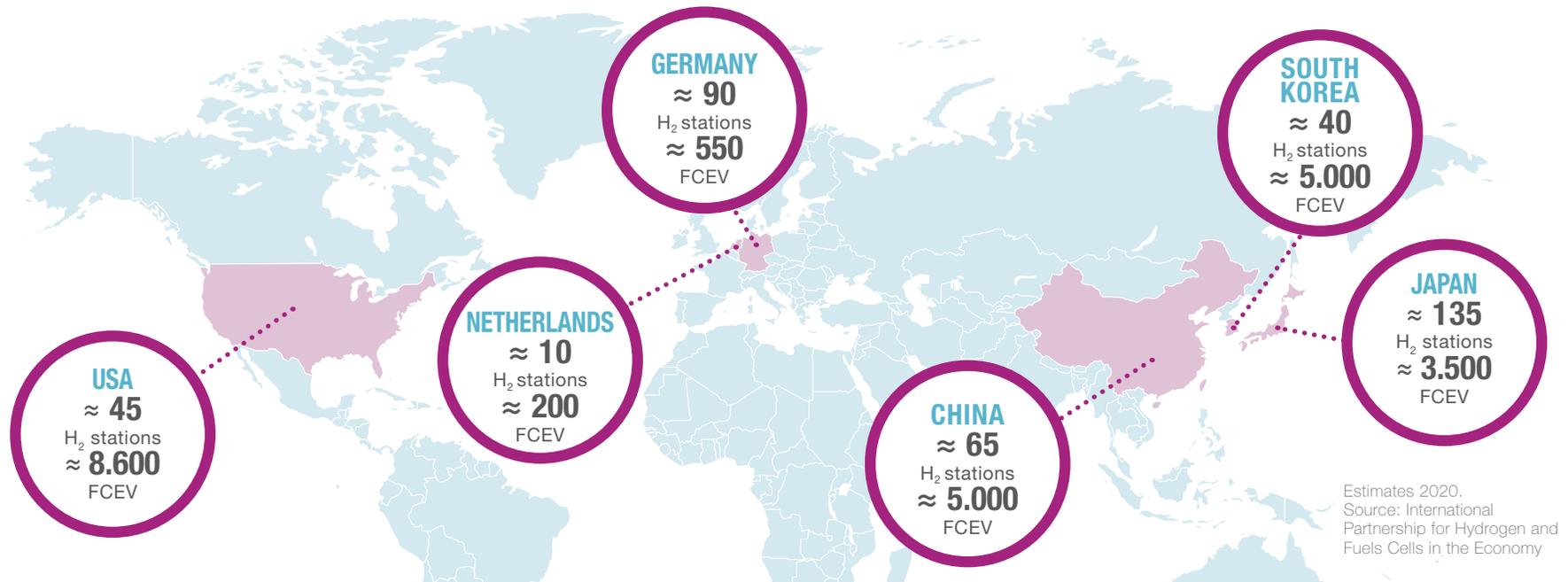


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## ESSENTIALS

# Fuel Cell Electric Vehicles across the world

Currently, only a few car manufacturers market Fuel Cell Electric Vehicles and production and sales of FCEVs is at an early stage.



### And tomorrow?

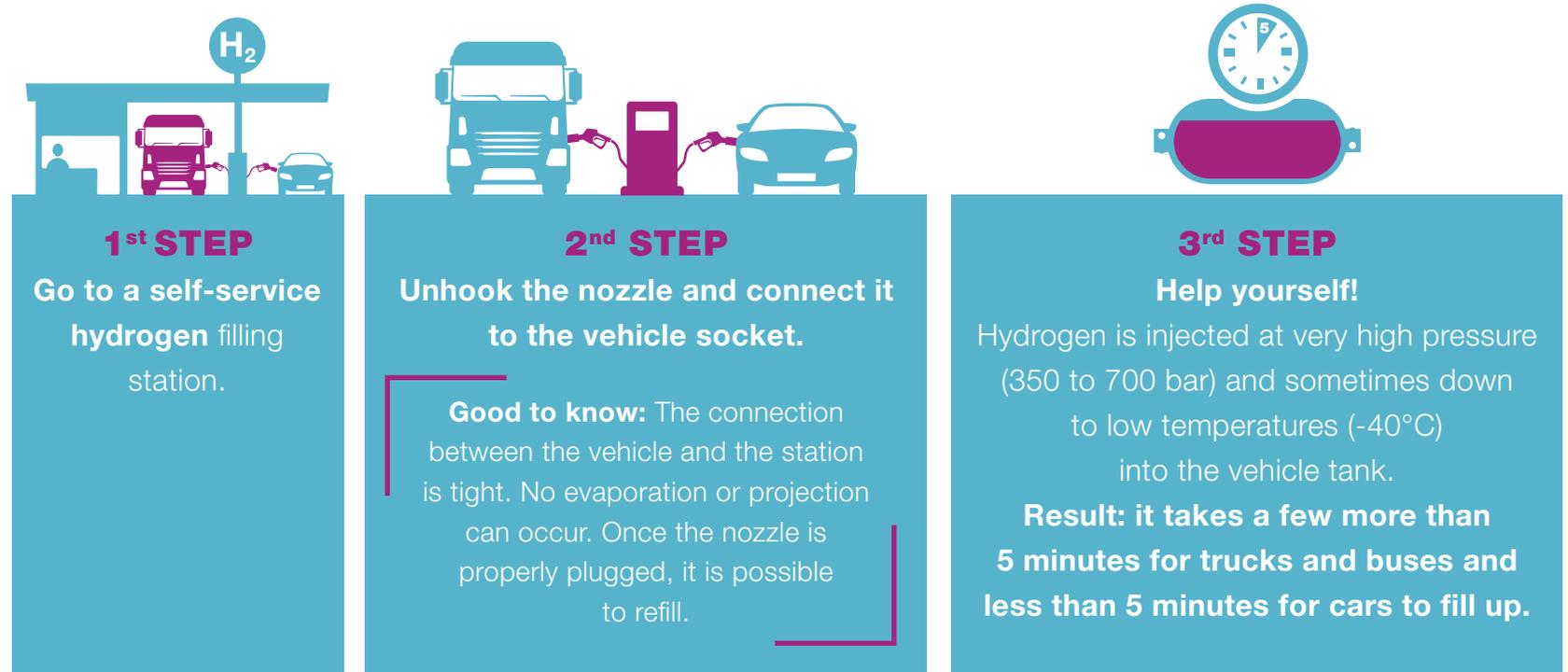
To become a part of our daily lives, the H<sub>2</sub> market still has to present major savings, in particular to offer vehicles and clean energy with low CO<sub>2</sub> emissions at more competitive prices.



## IN PRACTICE

# Filling up with hydrogen

Refilling is very simple: the operation is very similar to the one performed with conventional fuels.



### Did you know?

The entire distribution meets specific European standards. Filling up with hydrogen is measured in kg of hydrogen. For a light vehicle, 1 kg of hydrogen will give you about 100 km. For a truck or a bus (12 meters), depending on the use, the consumption could reach 8 to 10 kg of hydrogen per 100 km.



## IN PRACTICE

# Total and the Fuel Cell Electric Vehicle

While the number of Fuel Cell Electric Vehicles is still modest today, Total is developing numerous hydrogen projects to prepare the market for wider H<sub>2</sub> mobility adoption.

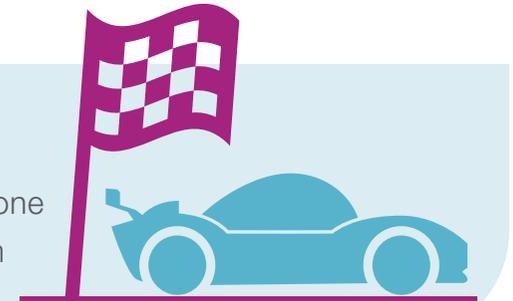
**Committed to H<sub>2</sub> for mobility since the early 2000s**, Total has a practical experience and know-how of hydrogen refilling infrastructure. **With approximately 30 Total H<sub>2</sub> stations** in Germany, Belgium, the Netherlands, Luxemburg, and France\*.



**Total provides a complete offer**, from design to installation, operation and maintenance, for public and private (dedicated to a particular context) refilling infrastructure.

### Did you know?

As its contribution to the Mission H24 project, Total developed a mobile hydrogen station. This is a world first! The station is currently moved from one European racetrack to another to supply hydrogen to the H24 Racing team during the prestigious Michelin Le Mans Cup.



\*Data July 2020

[total.com](https://www.total.com)



Total is a broad energy company that produces and markets fuels, natural gas and electricity. Our 100,000 employees are committed to better energy that is more affordable, more reliable, cleaner and accessible to as many people as possible. Active in more than 130 countries, our ambition is to become the responsible energy major.

Total's Marketing & Services business segment offers its professional and private customers a wide range of broad energy products and services—petroleum products, biofuels, charging and related services for electric vehicles, gas for road and maritime transportation—to support them in their mobility and help them reduce their carbon footprint. Every day, over 8 million customers visit our 16,000 service-stations all over the world.

As the world's number four in lubricants, we design and sell high-performance products for the automotive, industrial and maritime sectors. And to provide the best response to the needs of our B2B customers, we deploy our sales forces, our international logistics network and our diverse offering. We operate in 107 countries, where our 31,000 employees stand close to all of our customers.



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