



Mateusz Figaszewski

Vienna, 18/11/2021

**Hydrogen as a fuel
for zero emission
mobility of the
future**



THERE ARE NOW
7.7 BILLION PEOPLE
IN THE WORLD

BY 2050
OVER **60% OF THE POPULATION**
WILL LIVE IN URBAN AREAS

An aerial photograph of a dense city skyline, likely New York City, with numerous skyscrapers. A thick layer of white smoke or steam is rising from the buildings, partially obscuring the sky. The overall tone is dark and somber, emphasizing the environmental impact of urban development.

CITIES ARE RESPONSIBLE FOR
70% OF CO₂ EMISSIONS



25% CO₂ EMISSIONS
IN EUROPE
COME FROM TRANSPORT

A Solaris bus is shown in profile, parked on a city street. The bus is white with a brown stripe and has the number '1508' on its side. A charging station is attached to the side of the bus. In the background, there are multi-story buildings with ornate facades and large trees with green leaves. The text 'IT IS PUBLIC TRANSPORT THAT MAY PLAY AN IMPORTANT ROLE IN MAKING THE CITIES MORE SUSTAINABLE' is overlaid on the image in white and green capital letters.

IT IS **PUBLIC TRANSPORT** THAT
MAY PLAY AN IMPORTANT ROLE IN MAKING
THE **CITIES MORE SUSTAINABLE**



AND REDUCE **CITY TRAFFIC**
SIGNIFICANTLY

A blue and white Solaris bus is parked on a city street. In the foreground, a cyclist is riding past the bus. The background shows modern buildings and trees. The text "THE TECHNOLOGY IN PUBLIC TRANSPORT HAS BEEN DEVELOPING AND GOING GREEN" is overlaid on the image.

THE **TECHNOLOGY** IN PUBLIC
TRANSPORT HAS BEEN DEVELOPING
AND **GOING GREEN**

ENVIRONMENTAL REQUIREMENTS ARE BECOMING MORE AND MORE DEMANDING

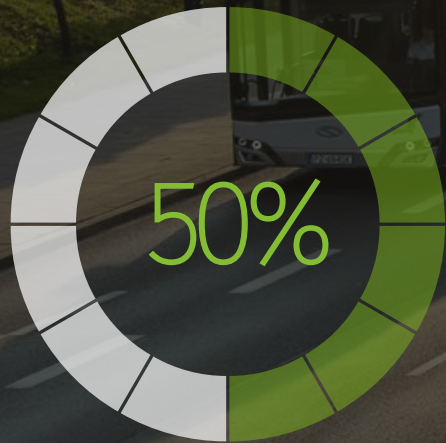


A wide, multi-lane road with a bus and cars, overlaid with text. The road is paved and has a central median. A bus is driving on the left side of the road, and several cars are driving on the right side. The background shows a modern building and some trees.

AT THE END OF 2018,
THE EUROPEAN PARLIAMENT SET ITSELF
THE GOAL TO BE PURSUED

Share of electric buses
in new registrations

2025



2030

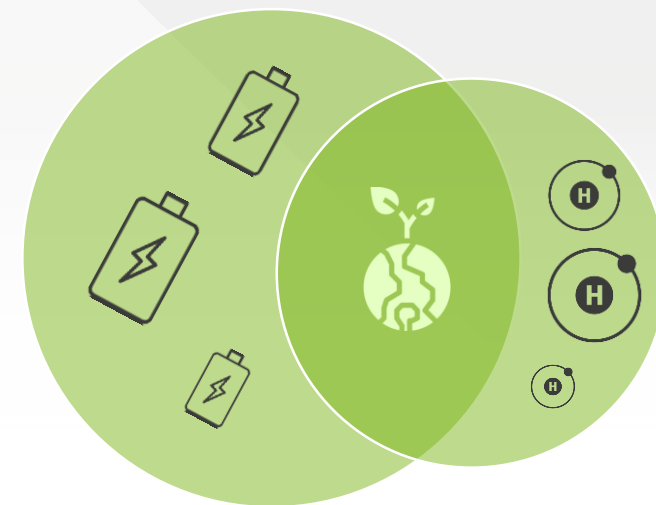




E-mobility is the future

The synergy of the development of all electro-mobility branches is indispensable to ensure **efficient decarbonisation of transport.**

Hydrogen technology **complements** battery drives, the two are not competitive.



When to use **hydrogen?**

Hydrogen-powered vehicles are best suited for the **following applications and requirements:**



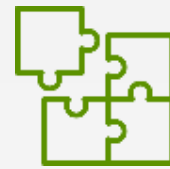
Long-range
requirement



Heavier loads



Routes requiring
fast refueling



A great need for
flexibility



Why to use hydrogen?

- All the advantages of an electric drive
 - completely **emission-free** driving
 - extremely **quiet**
 - **it does not generate vibrations**
- **Wide range**
 - 350 km on routes with different conditions
- **Fast fueling**
 - about 10 minutes
- Hydrogen fuel cell guarantees **reduction of carbon emissions**, the only by-product of the chemical reaction taking place in the hydrogen cell is **water**



All the **advantages of electric drive** with increased range and fast refuelling.



Deployment barriers

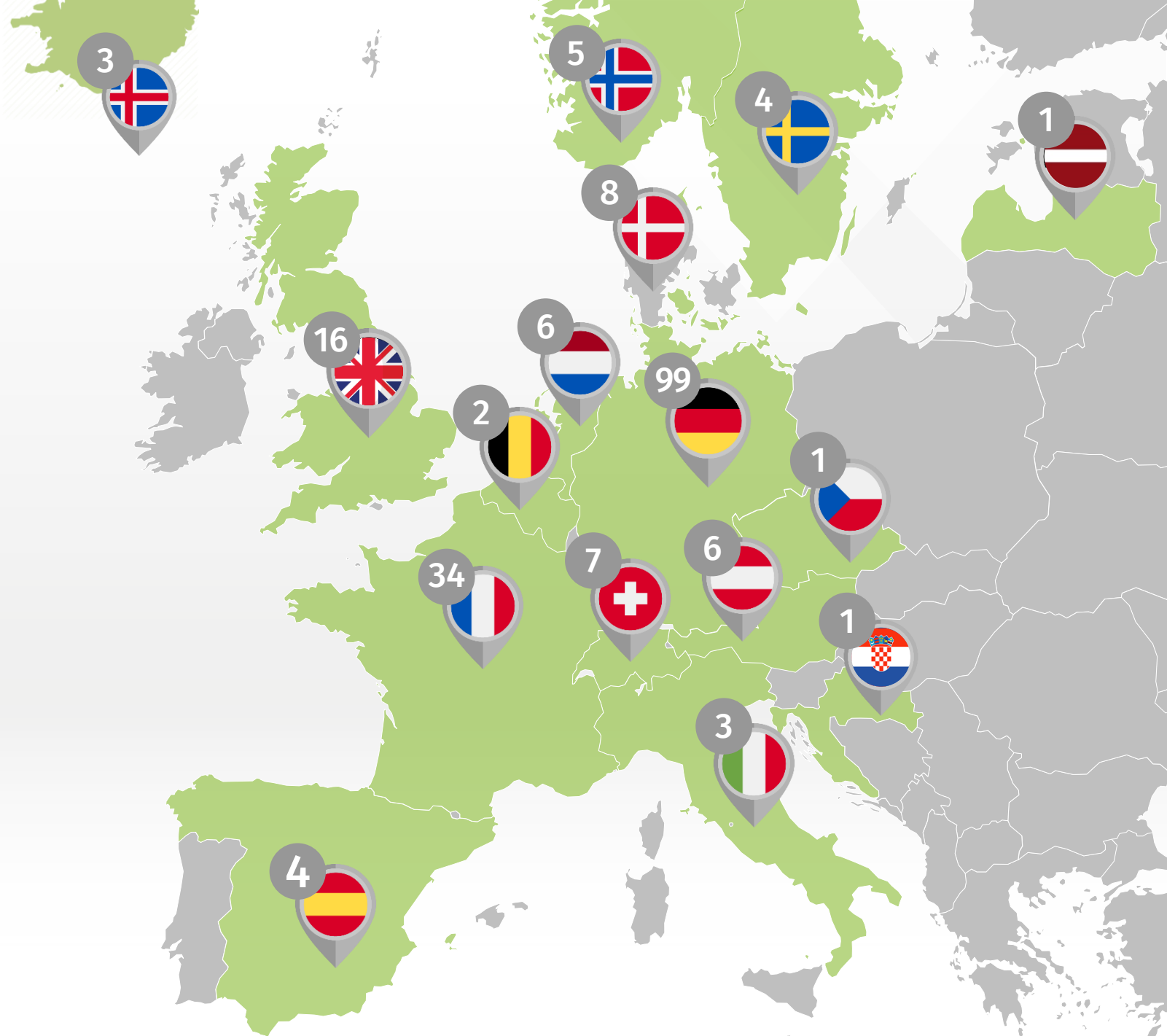


- High upfront costs
(comparing to ICEV and BEV)
- Limited hydrogen resources
- Technological barriers

Hydrogen filling stations in Europe

200 working stations
(marked on the map)

107 stations in progress

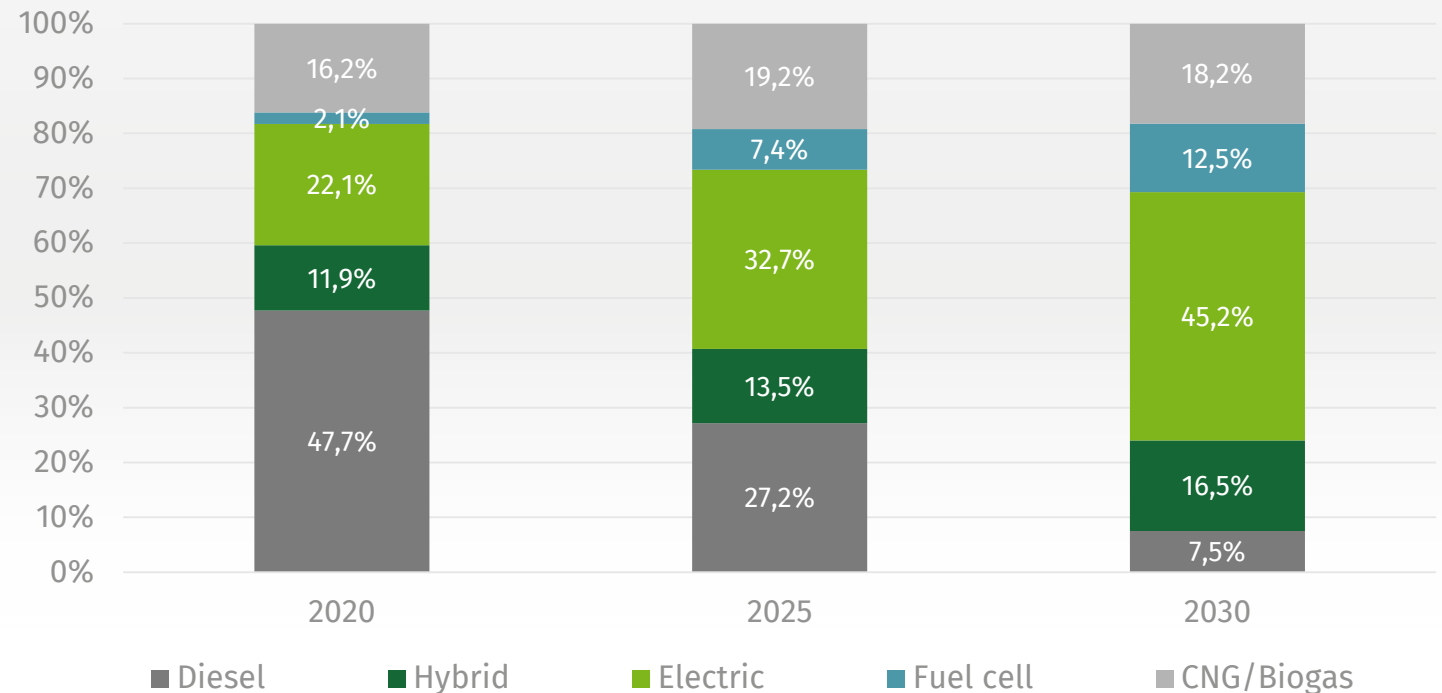




Electric drives

– dynamically growing trend

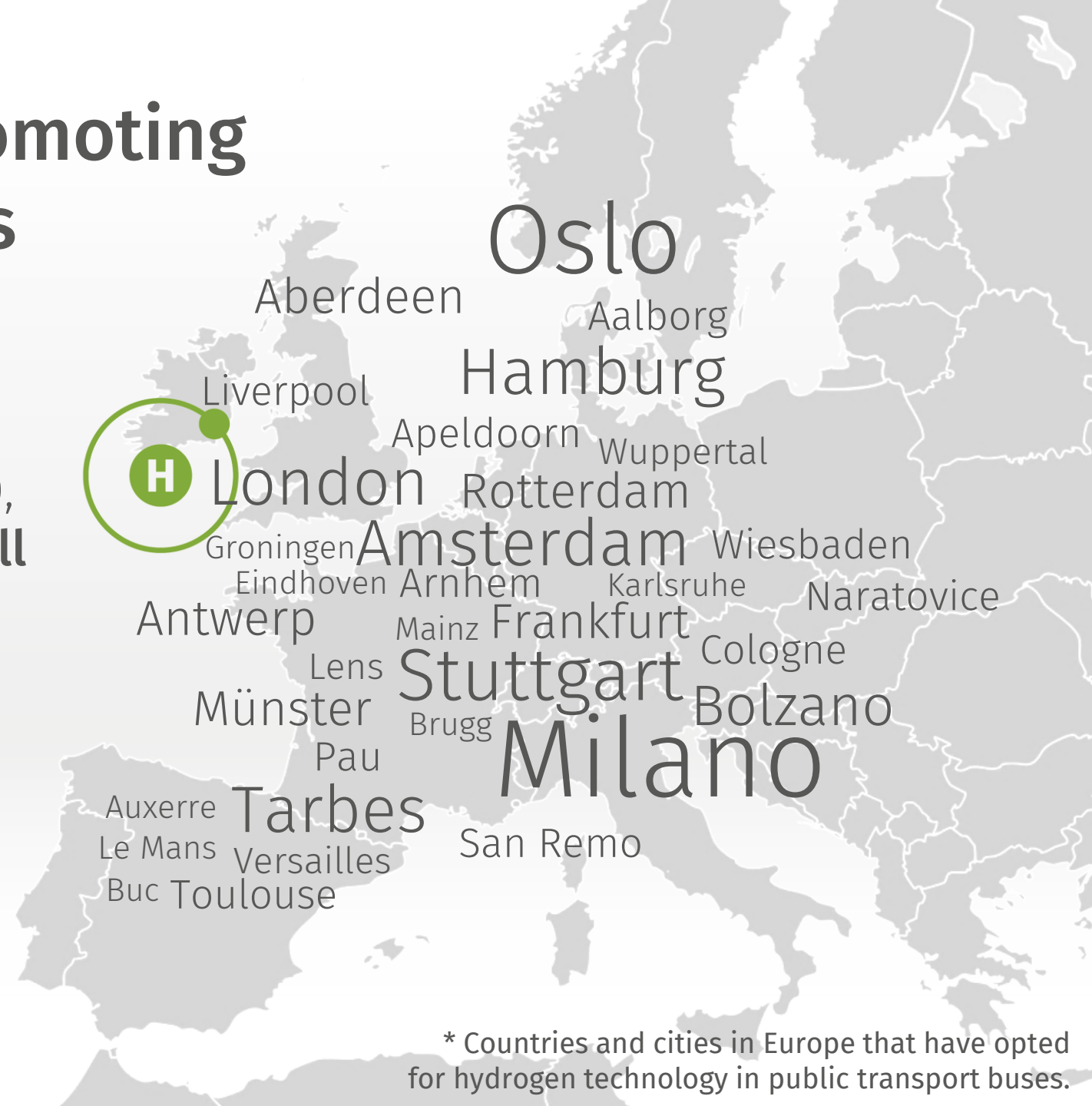
Newly registered buses with an alternative drive in Europe in 2020-2030



European activities **promoting hydrogen technologies**

- In the period between 2010-2020, **more than 300 hydrogen fuel cell buses** in total were contracted to 32 cities in Europe

- **71** of them are **Solaris buses**



* Countries and cities in Europe that have opted for hydrogen technology in public transport buses.

European activities promoting hydrogen technologies



* Solaris has been a member of the Association since 2016

Thanks to the EU subsidies it is possible to **deploy a significant number of vehicles in a short time**



FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

* Partner



JIVE



ZERO EMISSION

* Project for buses



MEHRLIN



ZERO EMISSION

* Project for infrastructure

Solaris activities

as part of the JIVE project

- **RIGA** (Rīgas satiksme)

Contract for **10 trolleybuses** with hydrogen range extenders + **10 hydrogen buses** as an option (JIVE)

- **BOLZANO** (SASA Bolzano)

Contract for **12 hydrogen buses**

- **COLOGNE/WUPPERTAL** (Verkehrsverbund Rhein-Ruhr)

Contract for **25 hydrogen buses**

- **SOUTH HOLLAND** (Connexxion)

Contract for **20 hydrogen buses**

- **GELDERLAND** (Arriva Netherlands)

Contract for **10 hydrogen buses**

- **SANDVIKEN** (Transdev Sverige)

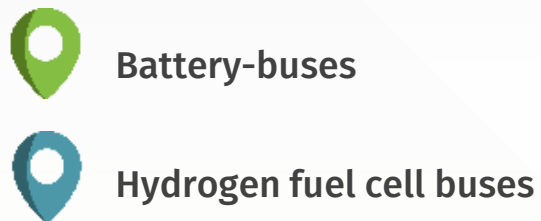
Contract for **2 hydrogen buses**



Solaris electric buses

on the roads of European cities

- Over **1000 e-buses**
– contracted and delivered
- Customers in **82 cities**
in 18 countries



Our hydrogen experience



HAMBURG

- 2 x Solaris Urbino electric 18.75 with a **hydrogen range extender**

- Hochbahn Hamburg **Innovation Line 109**

- The bus performs up to **300 km a day**



Fuel cell range extender
Ballard 85 kW

120 kWh batteries
Solaris High Energy

Plug-in depot charger
(20 kW)

TSA Central motor

Vossloh Kiepe drive



Our hydrogen experience



RIGA

- **10 x Trollino 18.75** with a hydrogen range extender for Riga
- Trolleybuses operate without traction for **up to 100 km**
- **Unique solution** at European level



Fuel cell
Ballard 85 kW

1 x Solaris High Power

Medcom traction motor

Hydrogen tanks (~20 kg)

Air-conditioning



Solaris Urbino

12 hydrogen

Urbino 12 hydrogen

- **Battery**

- 1 x Solaris High Power

- **Hydrogen fuel cell**

- Ballard 70 kW

- **Hydrogen tanks**

- Type 4, 37,5 kg

- **Electric axle**

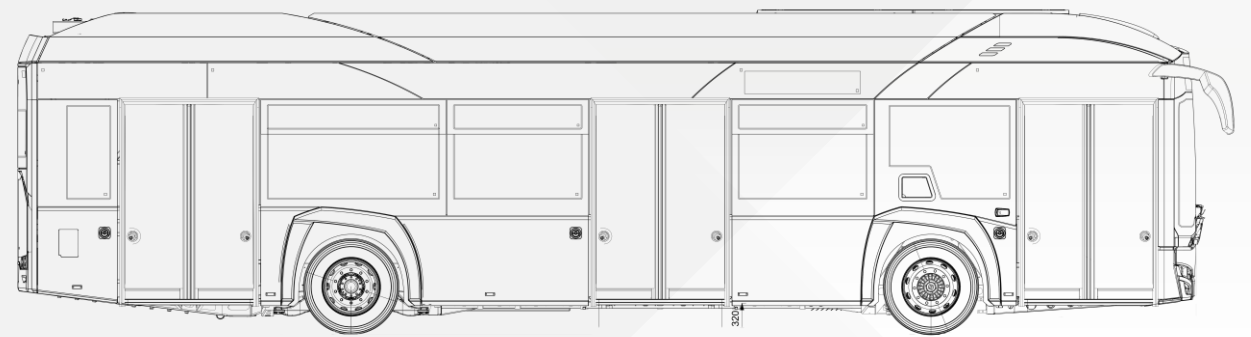
- ZF AxTrax (2 x 125 kW)

- **CO₂ air-conditioning**

- with pump heating function

 **GVW**
19.2 tonnes

3,300 mm
height



12,000 mm low floor

Solaris Urbino

12 hydrogen



33 seats
for the 3-door version

37 seats
for the 2-door version



89 passengers



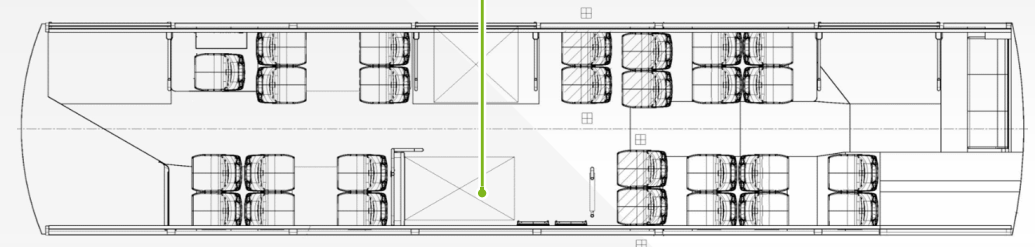
~10 passengers more
+10-15%

electric buses with a range of
~200 km available on the market

Solaris Urbino 12 hydrogen
with 19,2 t VGW

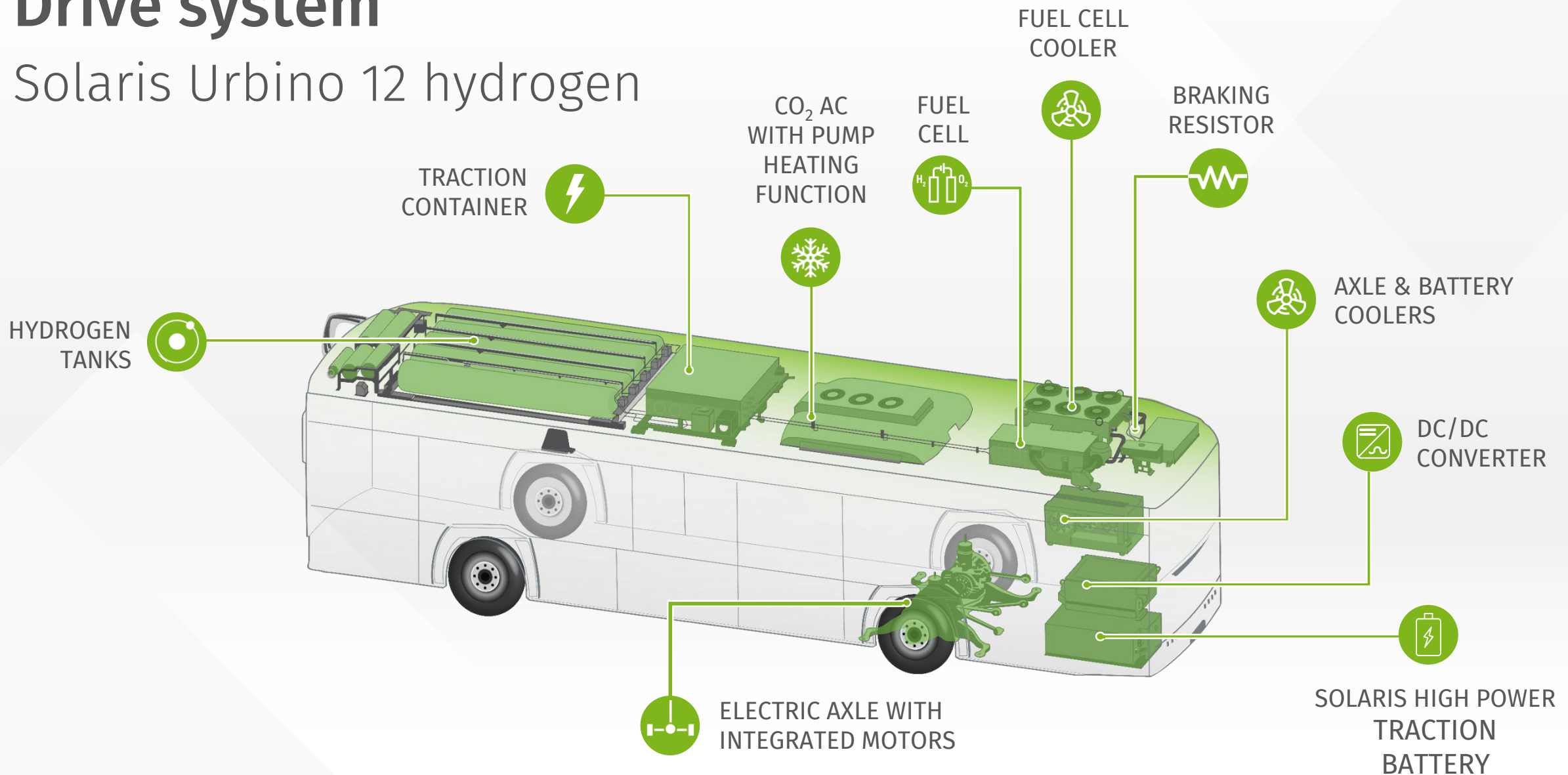


2,000 mm space
for a wheelchair



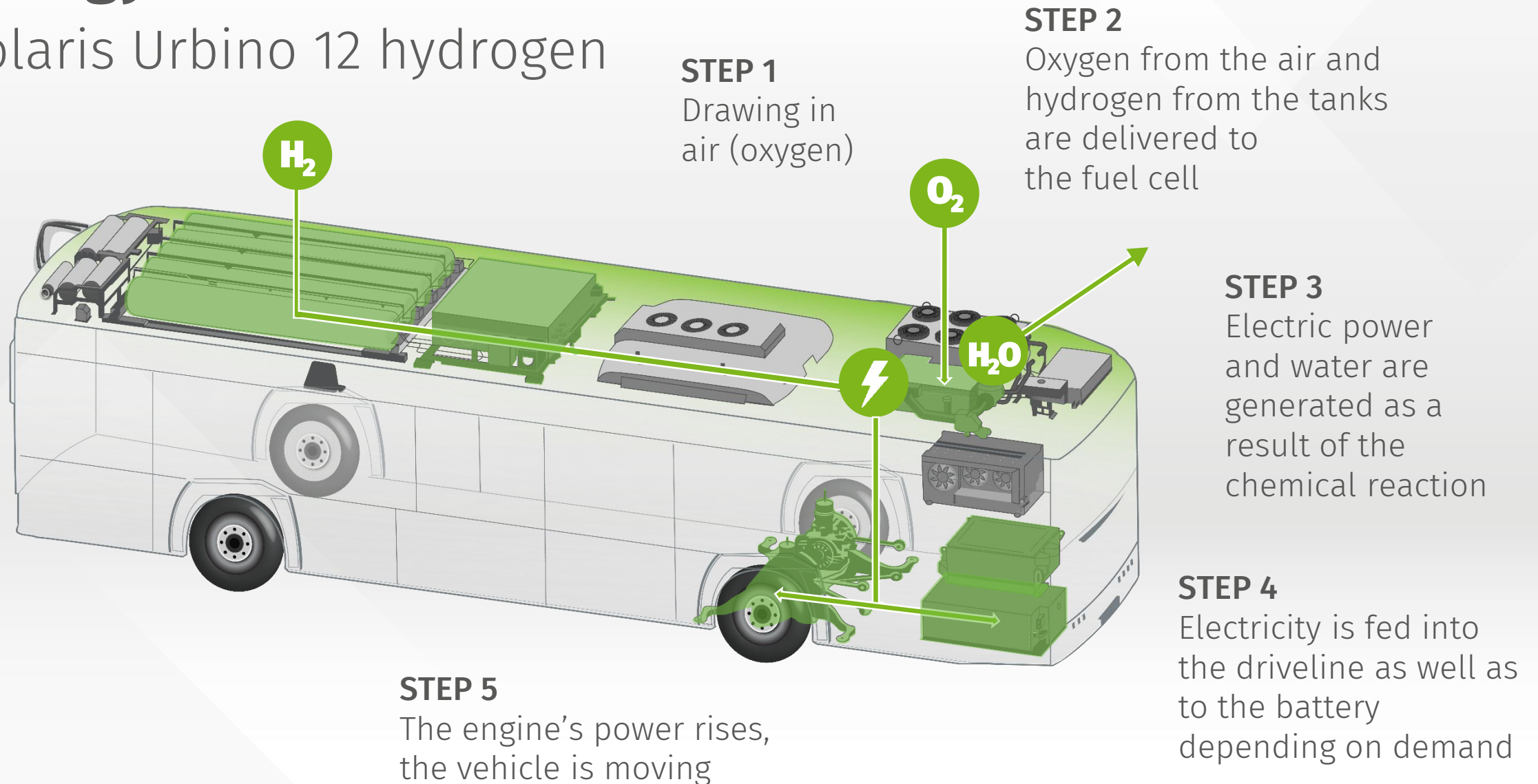
Drive system

Solaris Urbino 12 hydrogen



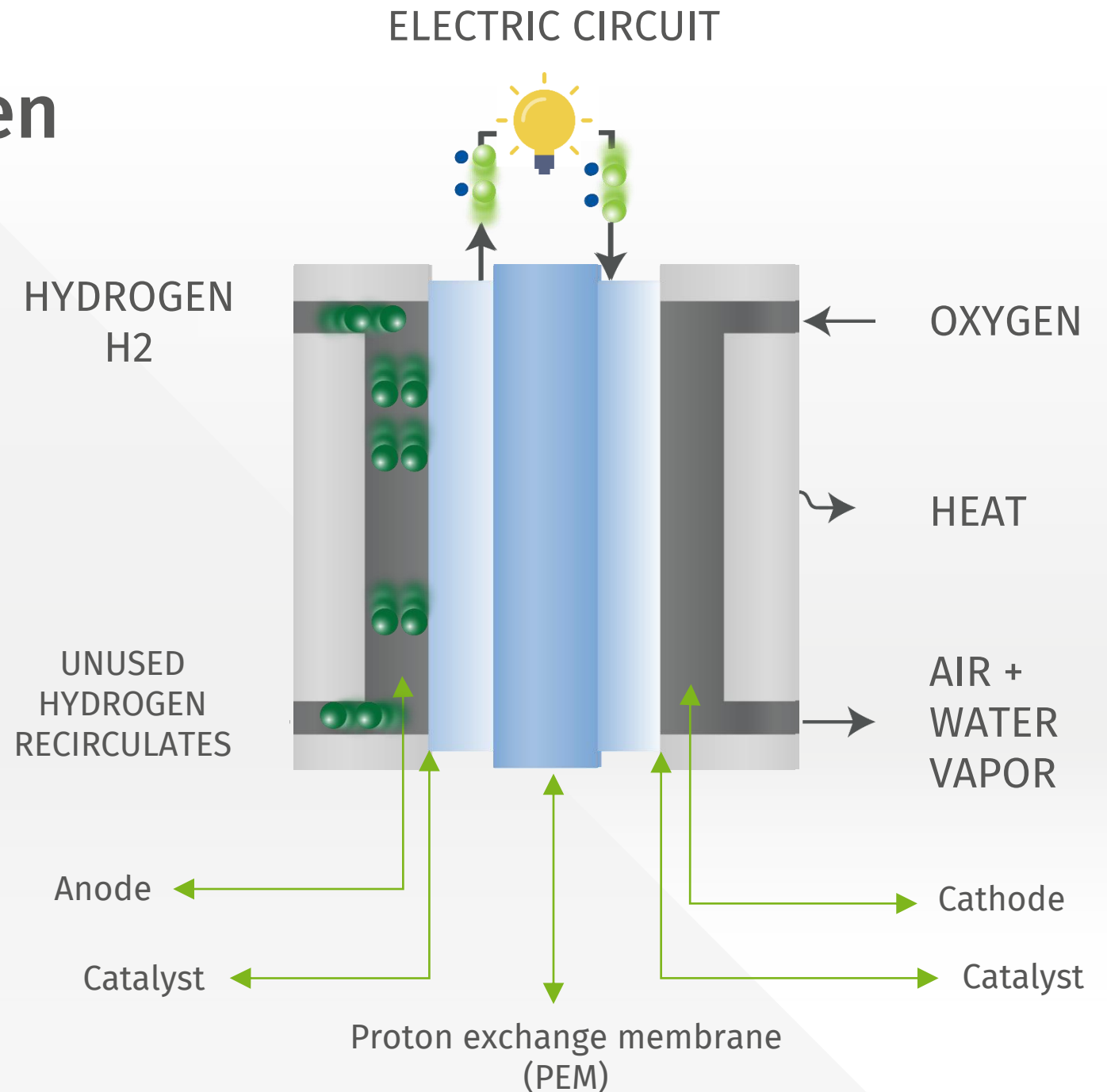
Energy flow

Solaris Urbino 12 hydrogen



How does the **hydrogen fuel cell** work?

1. The hydrogen reaches the catalyst
2. **The hydrogen splits** into protons and electrons
3. Only **protons permeate the PEM membrane**, crossing over to the cathode
4. Electrons go to an external electric circuit. **The resulting electricity is used by the drive system**
5. The protons, returning electrons, and the oxygen, create **water and heat**



New generation FCmove-HD fuel cell

- Rated power

70 kW

- Maximum efficiency

57%

- Estimated life time of
>30 000 working hours

- Stored in temperatures
as low as **-40°C**

- Freeze start

from -25°C (no pre-conditioning or external power required over night)

- Works in the temperatures
ranging from 60 to 80°C

- No need for external power supply



70 kW



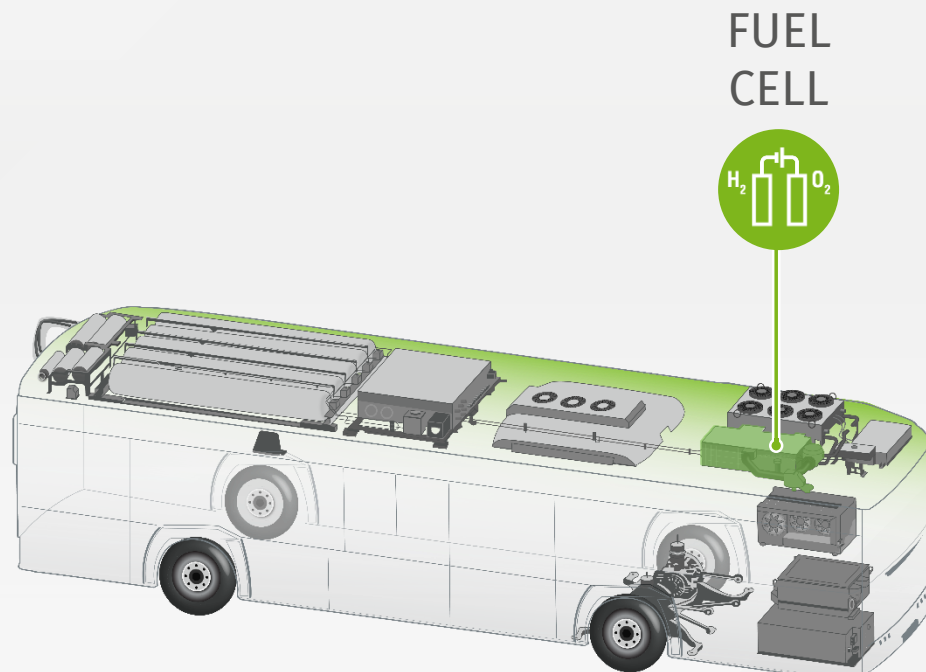
57%



60-80°C



New generation FCmove-HD fuel cell



1. Fuel cells grouped into stacks



2. Hydrogen system



3. Air preparation system



4. Part of a cooling system

Hydrogen tanks

Type 4

- 5 cylinders of **Type 4**
- Water capacity: **1,560 l (5 * 312)**
- Total amount of stored hydrogen: **37.5 kg**
- Useful amount of hydrogen: **34.2 kg**
- Working pressure (at 15oC): **350 Bar**



HYDROGEN
TANKS



Hydrogen tanks

Type 4

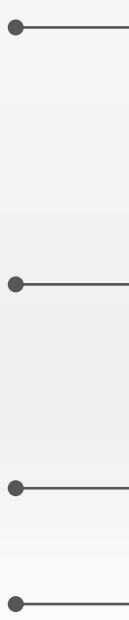


20% lower weight
when compared to the
previous generation of tanks

Tanks made entirely
of **composite materials**

Impregnated with epoxy resin

Tanks made of a continuous fiber
with a **non-metallic inner coating**



HYDROGEN TANKS
Type 4



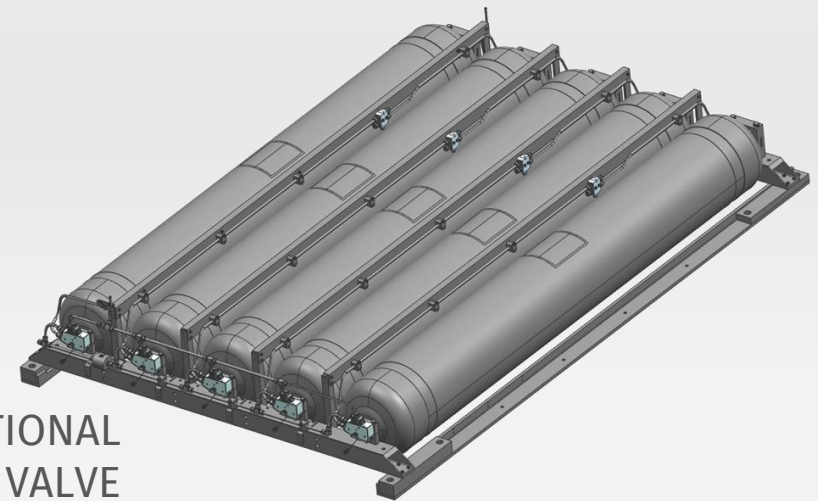
NON-METALLIC
INNER COATING

Safety

- **Excess flow valve**
 - cutting off the gas flow in case of a leak from the system
- **4 hydrogen detecting sensors**
 - monitor leak tightness
 - located near the main hydrogen system components as well as in the passenger compartment
- Each hydrogen tank consists of **multifunctional valve**
 1. **Electromagnetic** valve
 2. **Temperature** sensor
 3. **3 x TPRD valves on each tank**
 - safe removal of hydrogen from the installation in case of high temperature to protect against dangerous pressure increase.
- **Refuelling connector** features additional safety precautions



MULTIFUNCTIONAL
VALVE



Our hydrogen experience



COLOGNE

15 x Urbino 12 hydrogen

The vehicles will be delivered to the customer by the end of 2021

Rheinisch-Bergisches Kreis: 5 units

Rhein-Sieg district: 5 units

Hürth: 5 units



Fuel cell
Ballard 70 kW

Solaris High Power
battery

350 km range
on a single refill

Hydrogen tanks (37 kg)

Air-conditioning



Our hydrogen experience



BOLZANO

- **12 x Urbino 12 hydrogen**

- The vehicles will be delivered to the customer by the end of June 2021



Fuel cell
Ballard 70 kW

Solaris High Power
battery

350 km range
on a single refill

Hydrogen tanks

Air-conditioning



Safe public transport also during a pandemic



ANTI-VIRUS SOLUTION PACKAGE

to increase the safety of bus passengers and drivers
ready to be used in both **new and already delivered vehicles**

Touch free door opening
and closing
by passengers



Disinfectants



Intercom
– contactless
driver-passenger
communication system



Passenger counting
systems



Closed
driver's cabin





SOLARIS

A CAF GROUP COMPANY



Any
questions?

Hydrogen as a fuel for zero
emission mobility of the
future