Towards Sustainability

The current status and future outlook of fuel cell vehicles in Toyota

WaterstofNet

18/02/2018

TOYOTA LEXUS

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World Leaders Agreement – COP21 Paris

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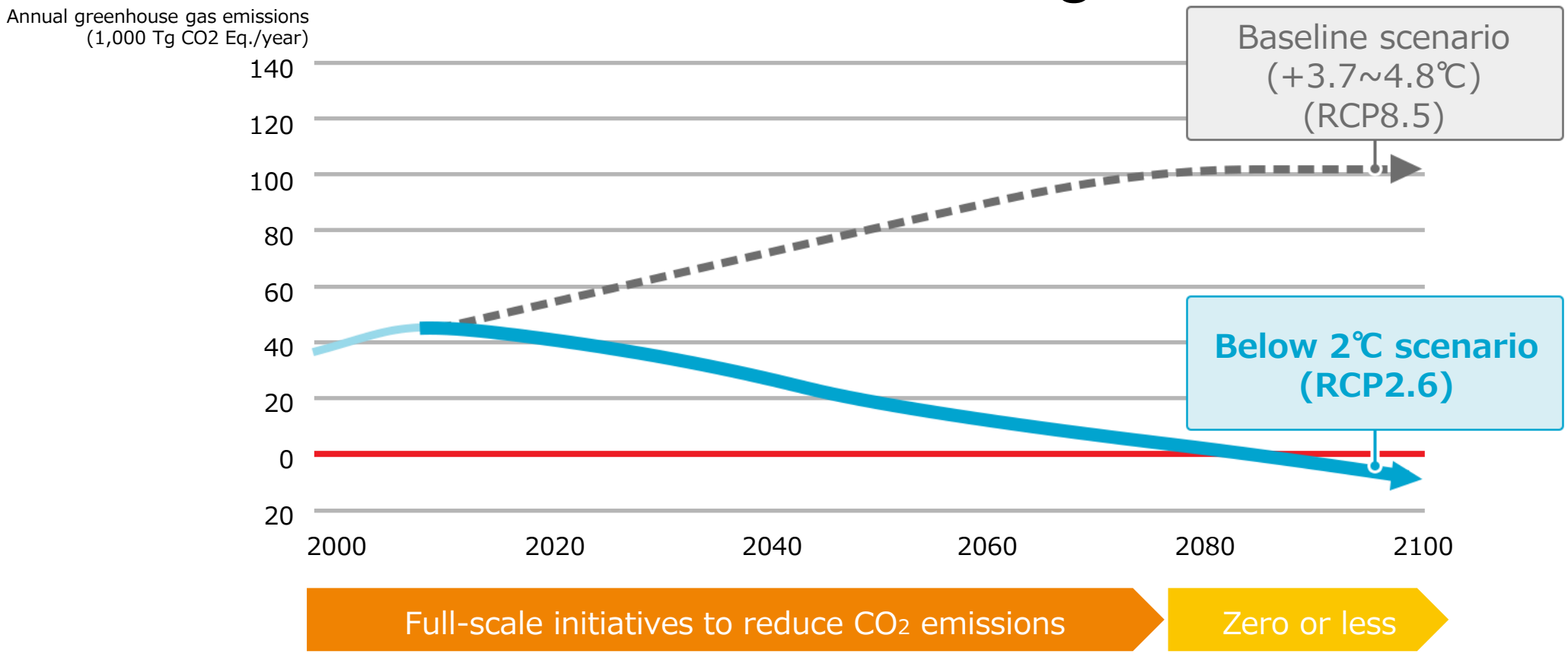
Forecast International Climate Change



Source: From the IPCC Working Group III 5th Assessment Report (2014)

Regarding GHG emissions, there is no time to lose

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European Challenge 2050

Cut Green House Gases emission to 80% compared to 1990 levels

2020 — 10% interconnection

- -20% Greenhouse Gas Emissions
- 20% Renewable Energy
- 20% Energy Efficiency

2030 — 15% interconnection

- -40% Greenhouse Gas Emissions
- >27%* Renewable Energy
- 27%* Energy Efficiency

* To be reviewed by 2020, having in mind an EU level of 30%

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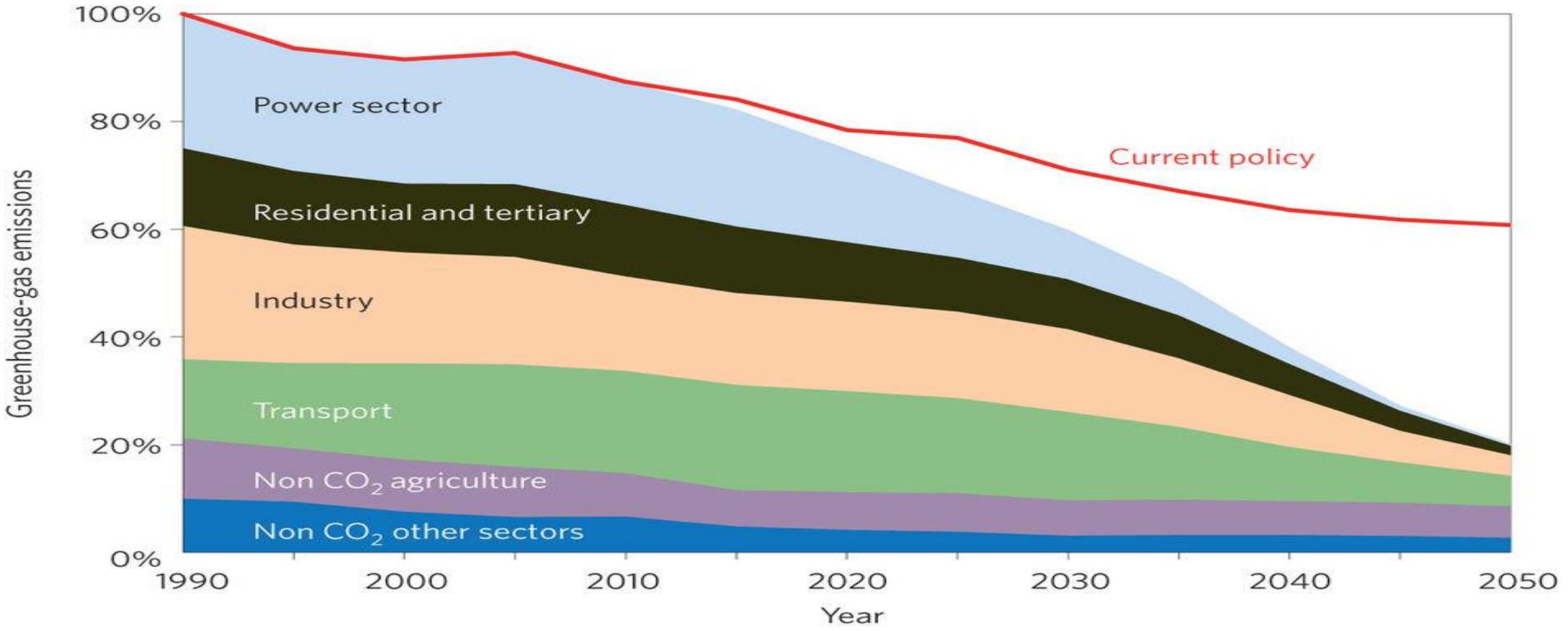
European Challenge 2050

Cut Green House Gases emission to 80% compared to 1990 levels



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Toyota 2050 Challenge

TOYOTA ENVIRONMENTAL CHALLENGE 2050

To go beyond zero environmental impact and achieve a net positive impact, Toyota has set itself six challenges. All these challenges, whether in climate change or resource and water recycling, are beset with difficulties, however we are committed to continuing toward the year 2050 with steady initiatives in order to realize sustainable development together with society.

Toyota 2050 Challenge

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Challenge 1: New Vehicle Zero CO_2 Emissions Challenge

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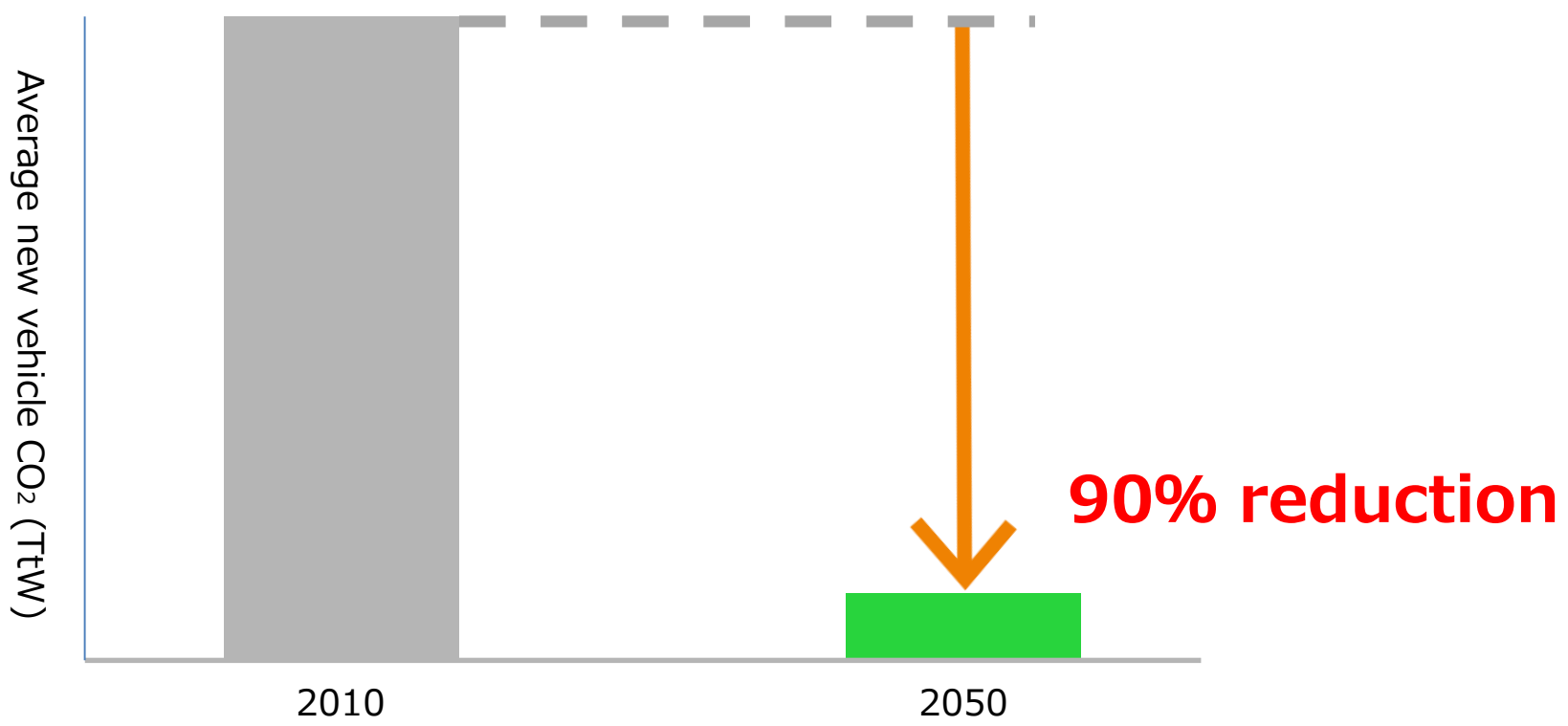
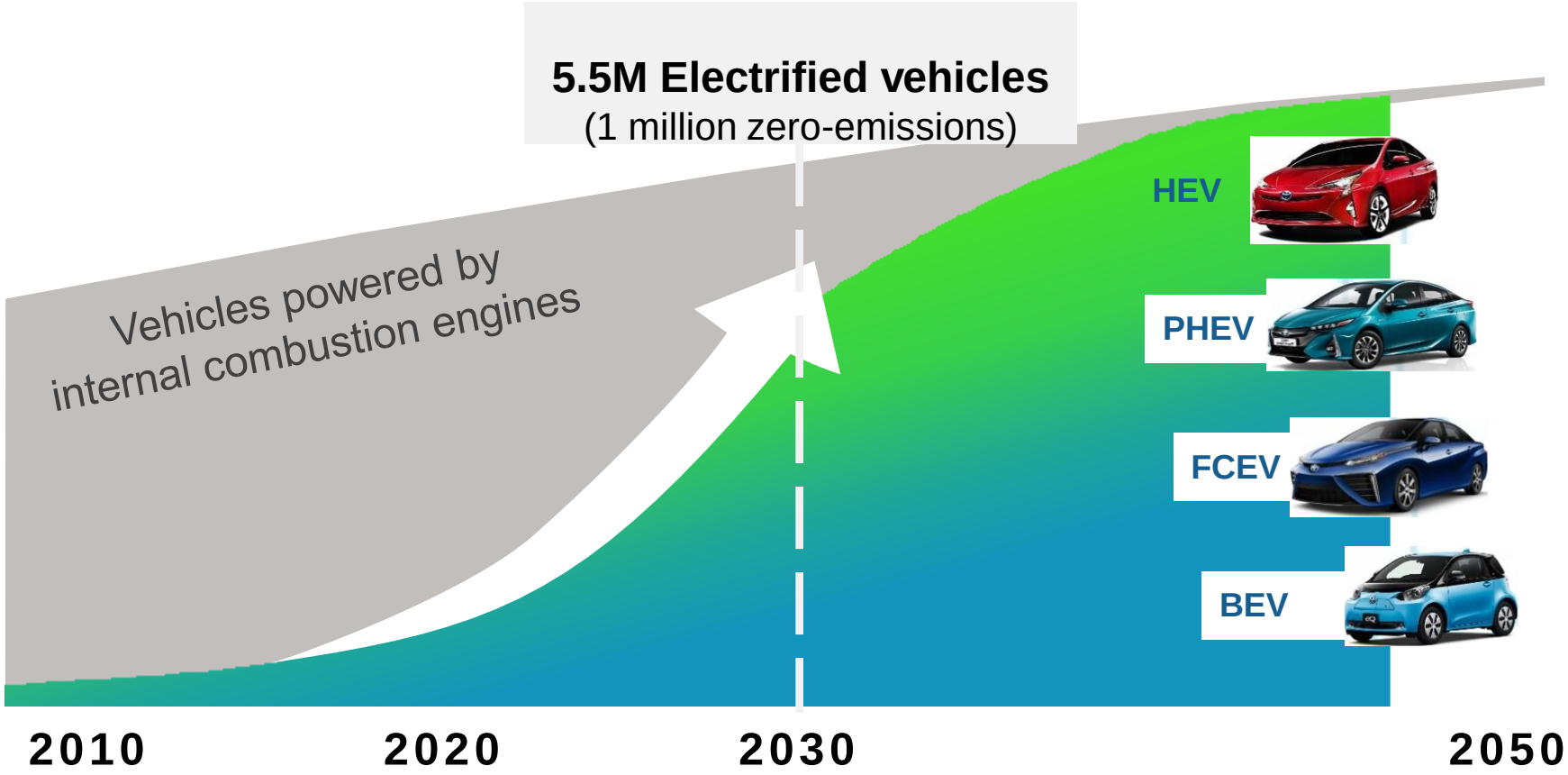


90% reduction of new vehicle CO_2 emissions by 2050 compared to 2010

Mix of powertrains required to achieve 90% CO2 reduction.



Electrification (including BEV and FCEV) will increase dramatically after 2020

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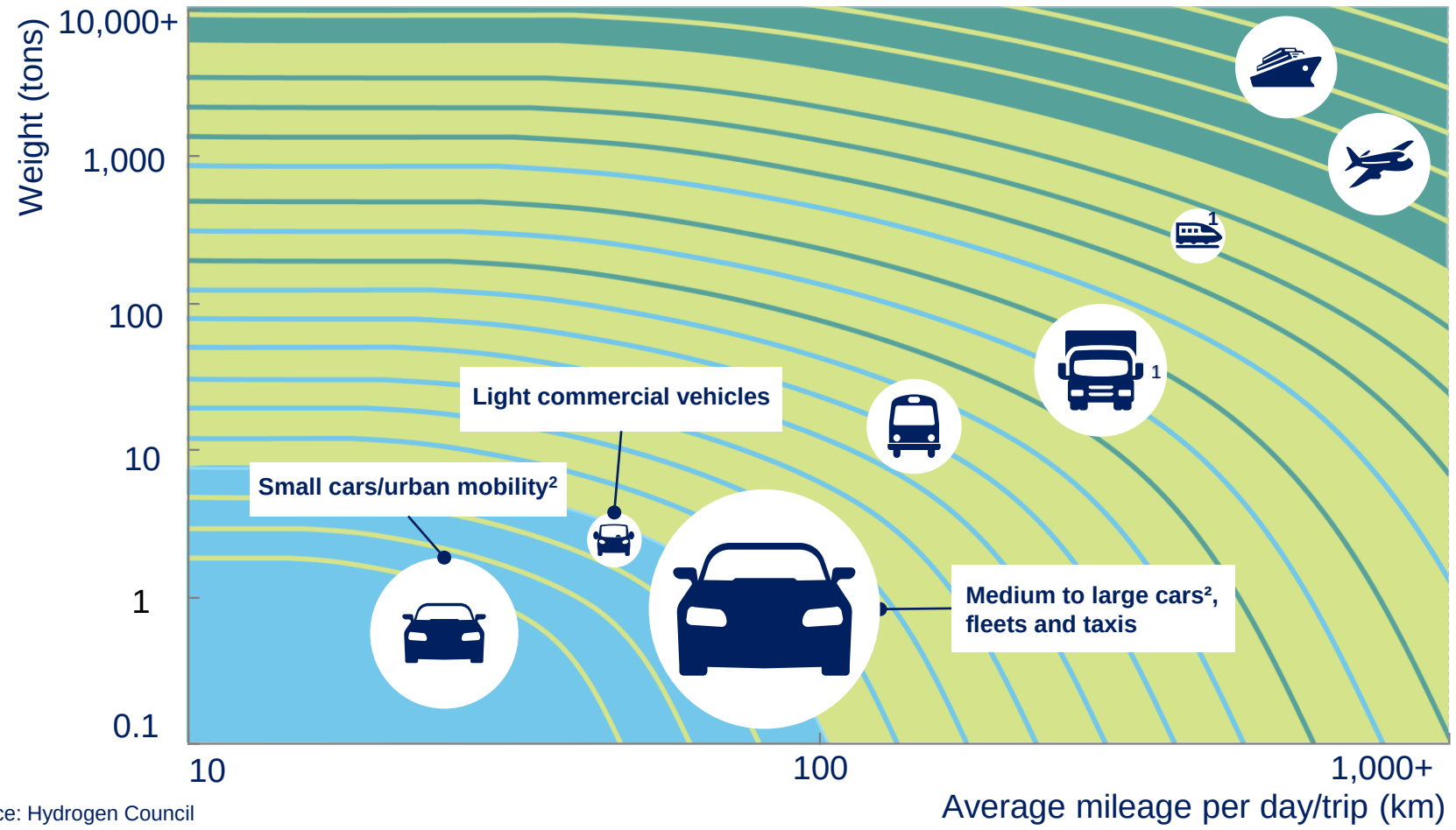
FCEVs are essential for decarbonising transport



BEV

FCEV

Bio- and (H_2-based) synthetic fuels

Bubble size represents relative annual energy consumption of this type in 2013

1 Battery-hydrogen hybrid to ensure sufficient power

2 Split in A- and B-segment LDVs (small cars) and C+-segment LDVs (medium to large cars) based on a 30% market share of A/B-segment cars and a 50% less energy demand

Source: Hydrogen Council

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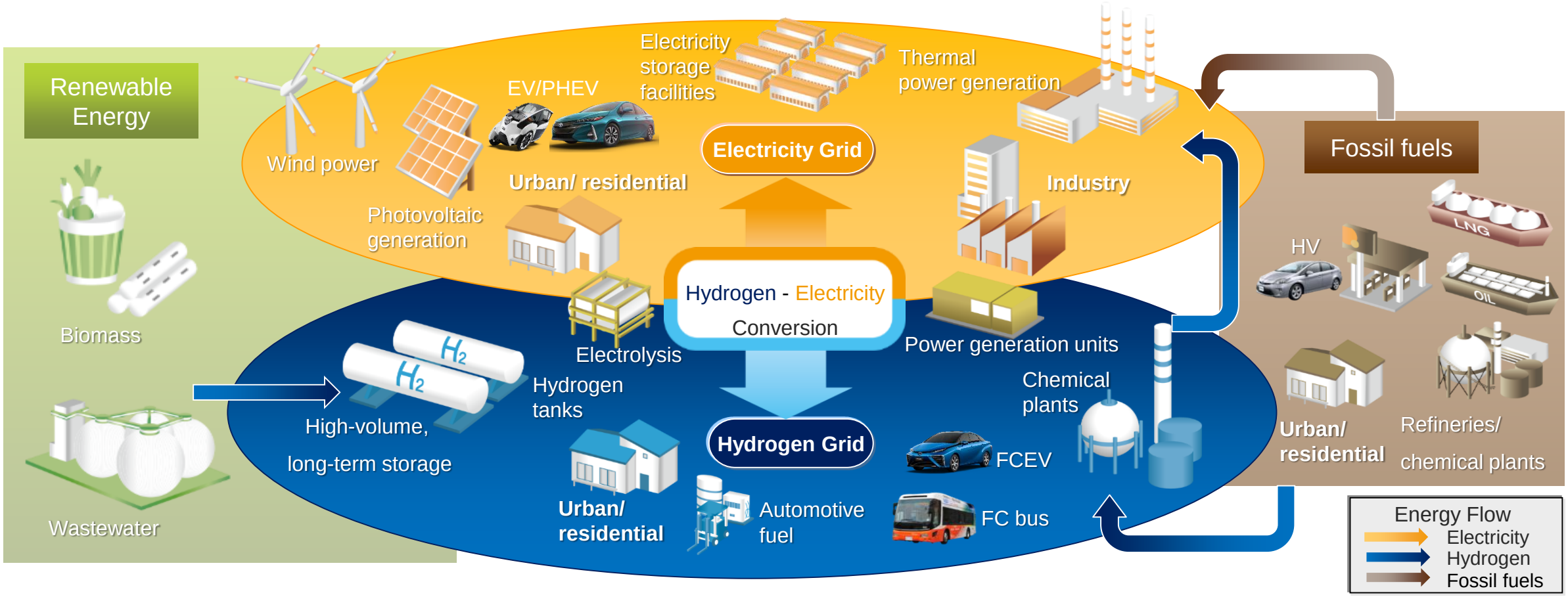
Future Vision: HyGrid (Hybrid Hydrogen – Electricity Grid)



Source: HyGrid Study Group HP

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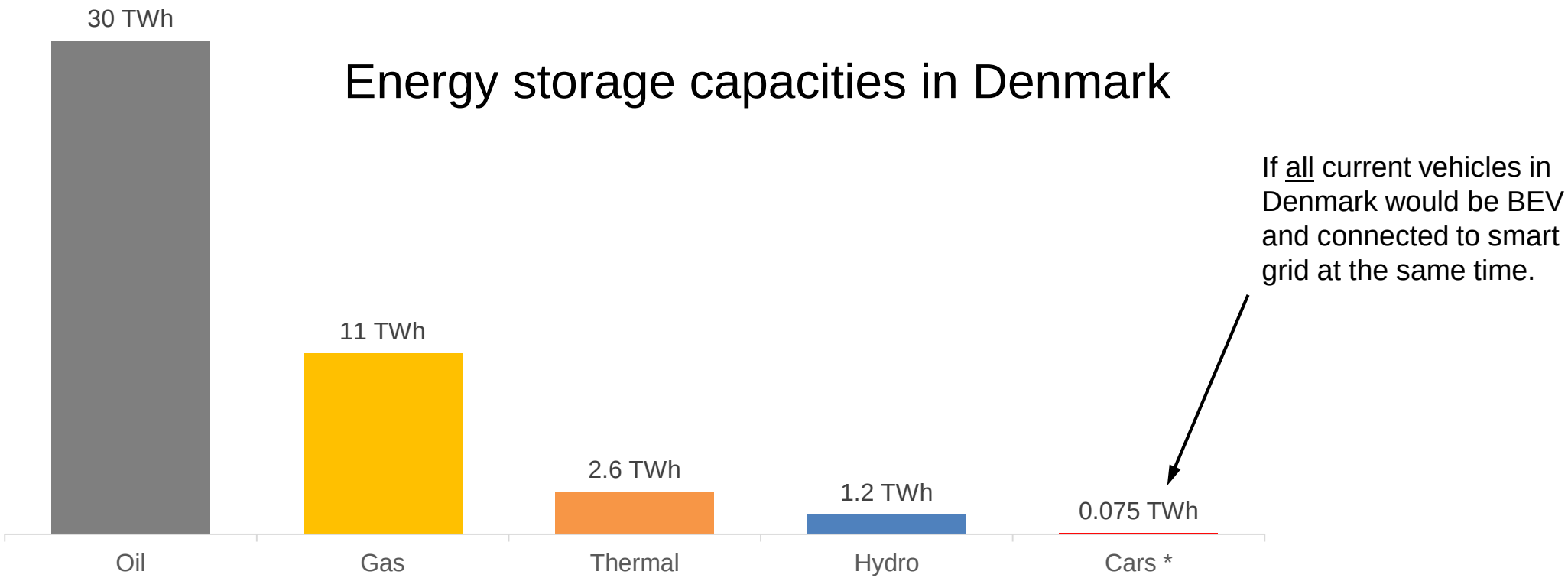
Using Hydrogen as a Storage for Renewables



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Using Hydrogen as a Storage for Renewables

Tesla Grid Storage Facility (Southern California)

Can store 80 MWh

Liquid hydrogen trailer:

3500 kg H_2 = 117 MWh

2,500 m³ of LH_2 = **5.9 GWh**

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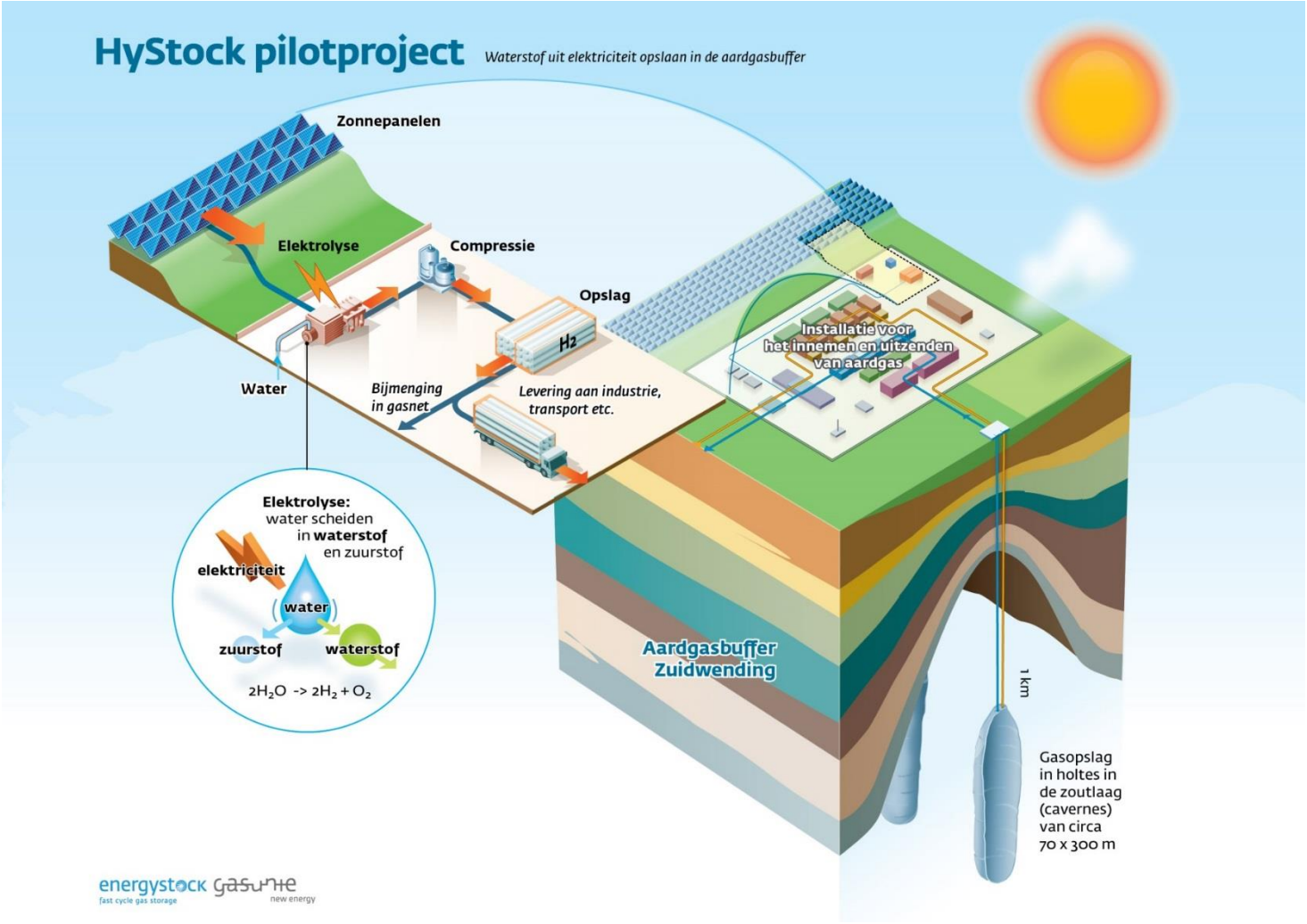
Using Hydrogen as a storage for renewables

and even further….

1MW Solar Power to Gas installation

Underground storage of up to 6100 tonnes of Hydrogen or **240 GWh**



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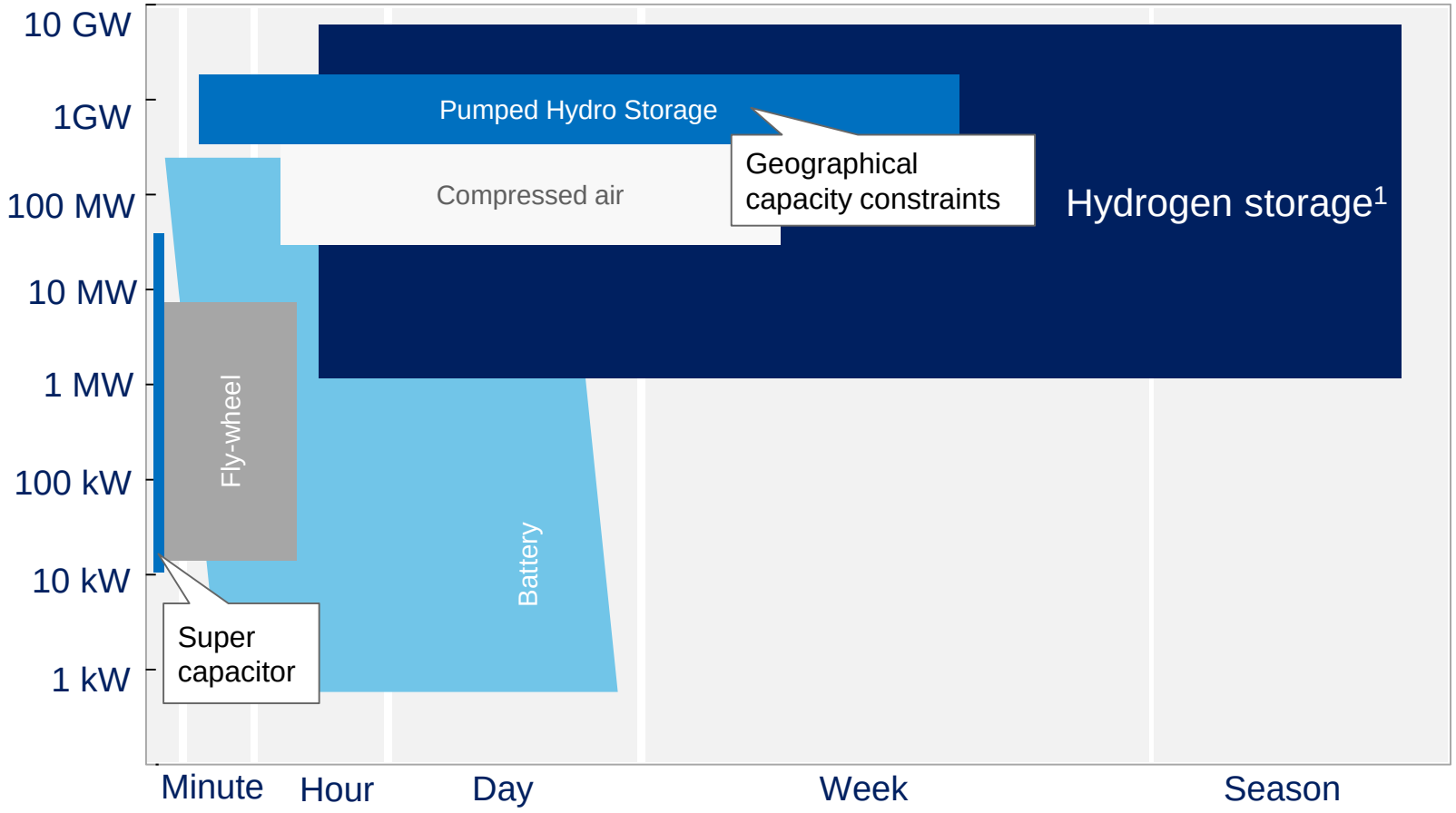
Using Hydrogen as a Storage for Renewables



Hydrogen is most promising for long-term and carbon-free seasonal storage

1 IEA data updated due to recent developments in building numerous 1MW hydrogen storage tanks

Source: IEA Energy Technology Roadmap Hydrogen and Fuel Cells, JRC Scientific and Policy report 2013

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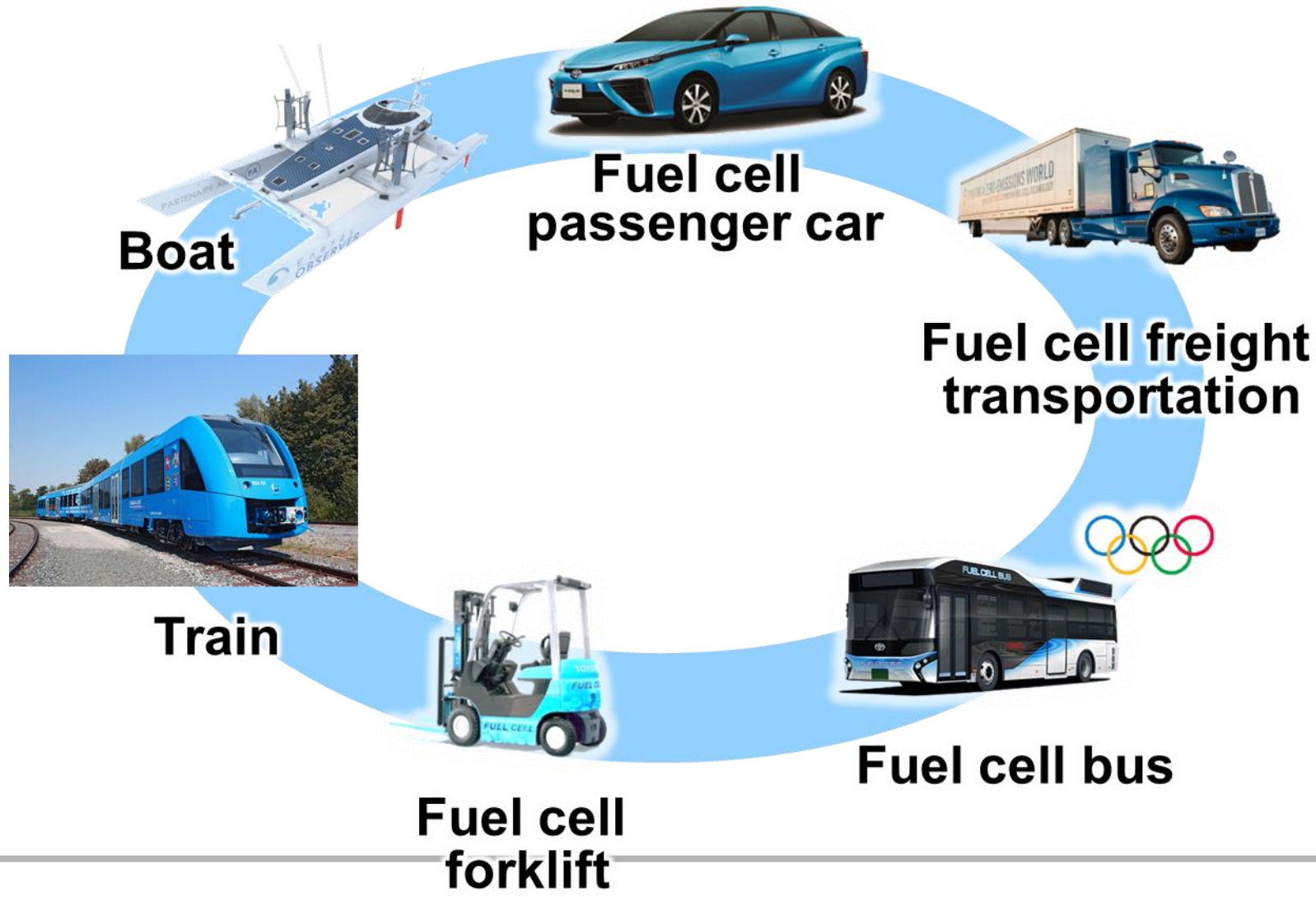
Using Hydrogen for Transportation



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Mirai is not a car, it’s a symbol

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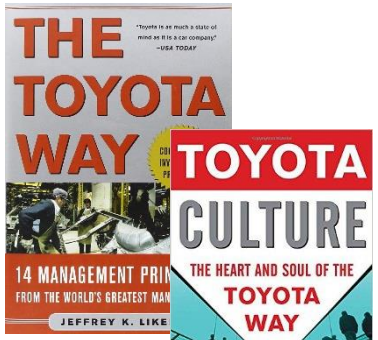
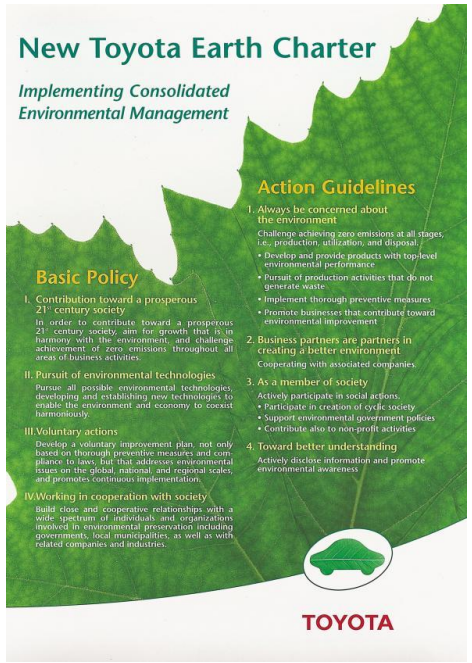
Mirai is not a car, it’s a symbol

The Toyota Way

“*Contribution to society through Monozokuri.*”





Toyota Earth Charter
(1992)

Prius at Tokyo Auto Show
(1995)

FCEV-1
(1996)

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Developing Hydrogen FCEV for 20 years

FCEV Fuel
H_2 Stored in adsorbing alloy

1992 — 1996

FCHV-4 Fuel
Hydrogen stored in high-pressure tanks

1999 — 2001

FCHV
Toyota-made tanks, 1st FCEV homologated

2002 — 2005

FCEV-R Fuel
Mirai precursor

2009 — 2011 — 2015

FCHV-3 Fuel
Hydrogen

(adsorbing alloy)

FCHV-5 Fuel
Hydrogen generated on-board by reforming on gasoline

FCHV-adv Fuel
New stack, stainless steel cells

Mirai
Revolutionary Titanium stack, 3.1 kW/L world record

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Mirai

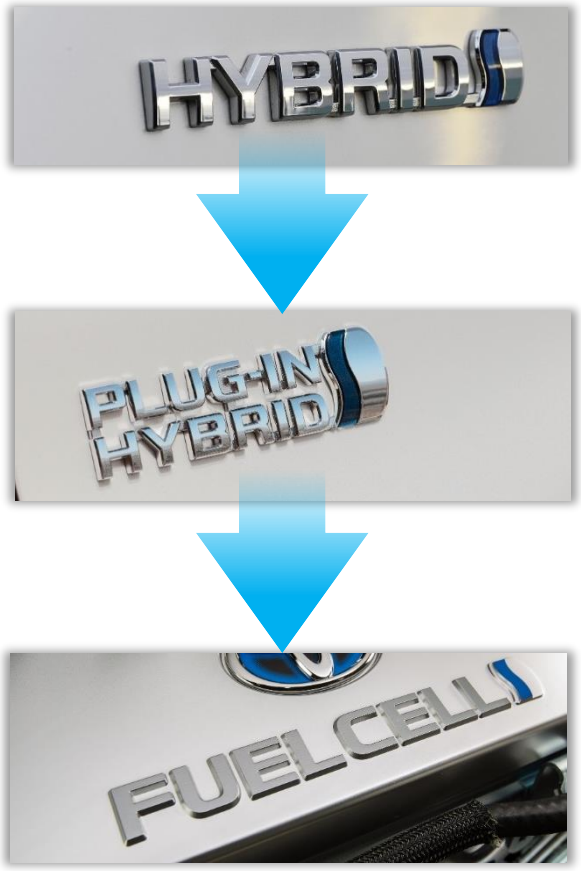
Mirai

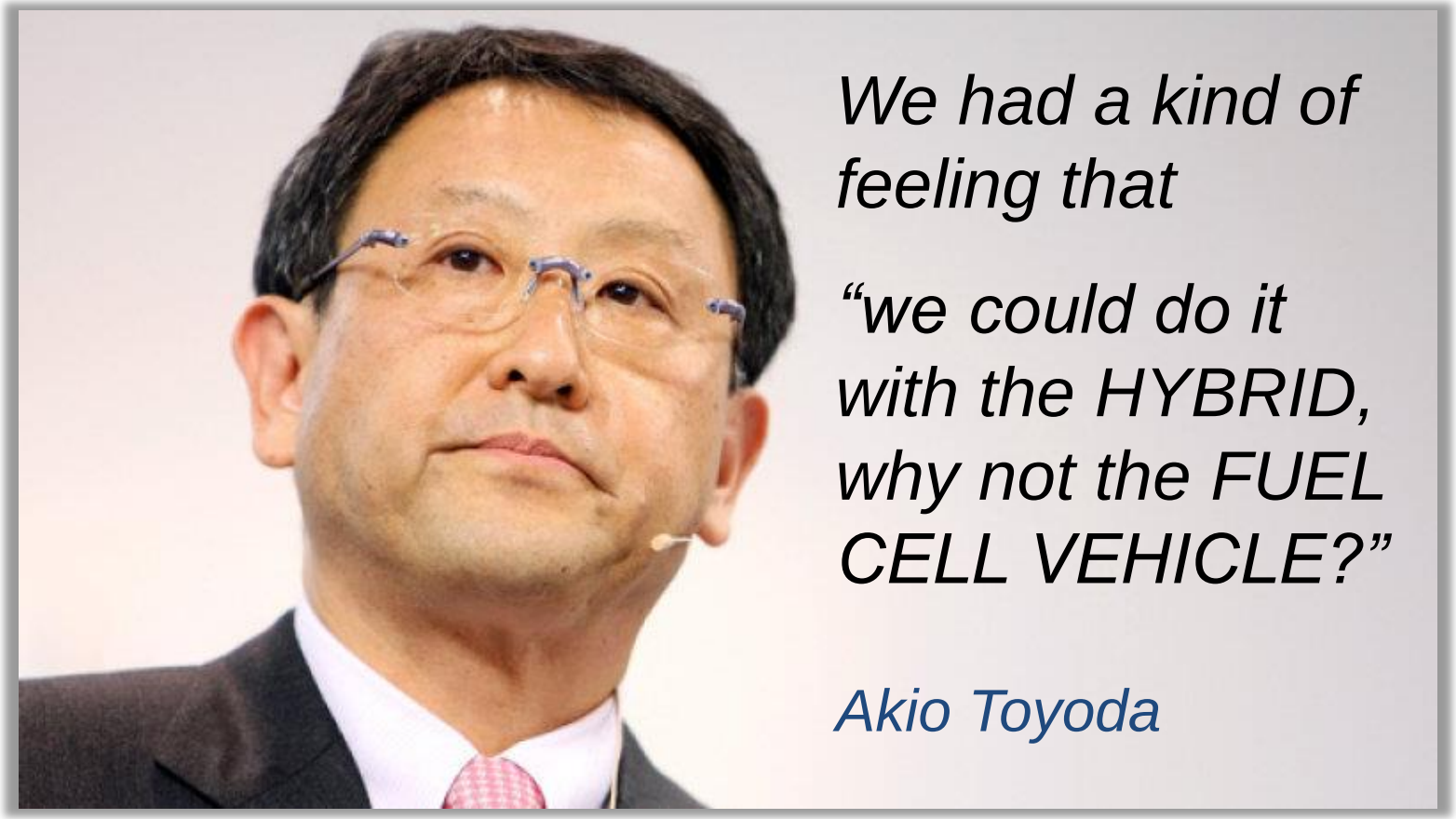
= “Future” in Japanese

未来

Toyota's Answer – Mirai, the obvious next step

未来





We had a kind of feeling that

"we could do it with the HYBRID, why not the FUEL CELL VEHICLE?"

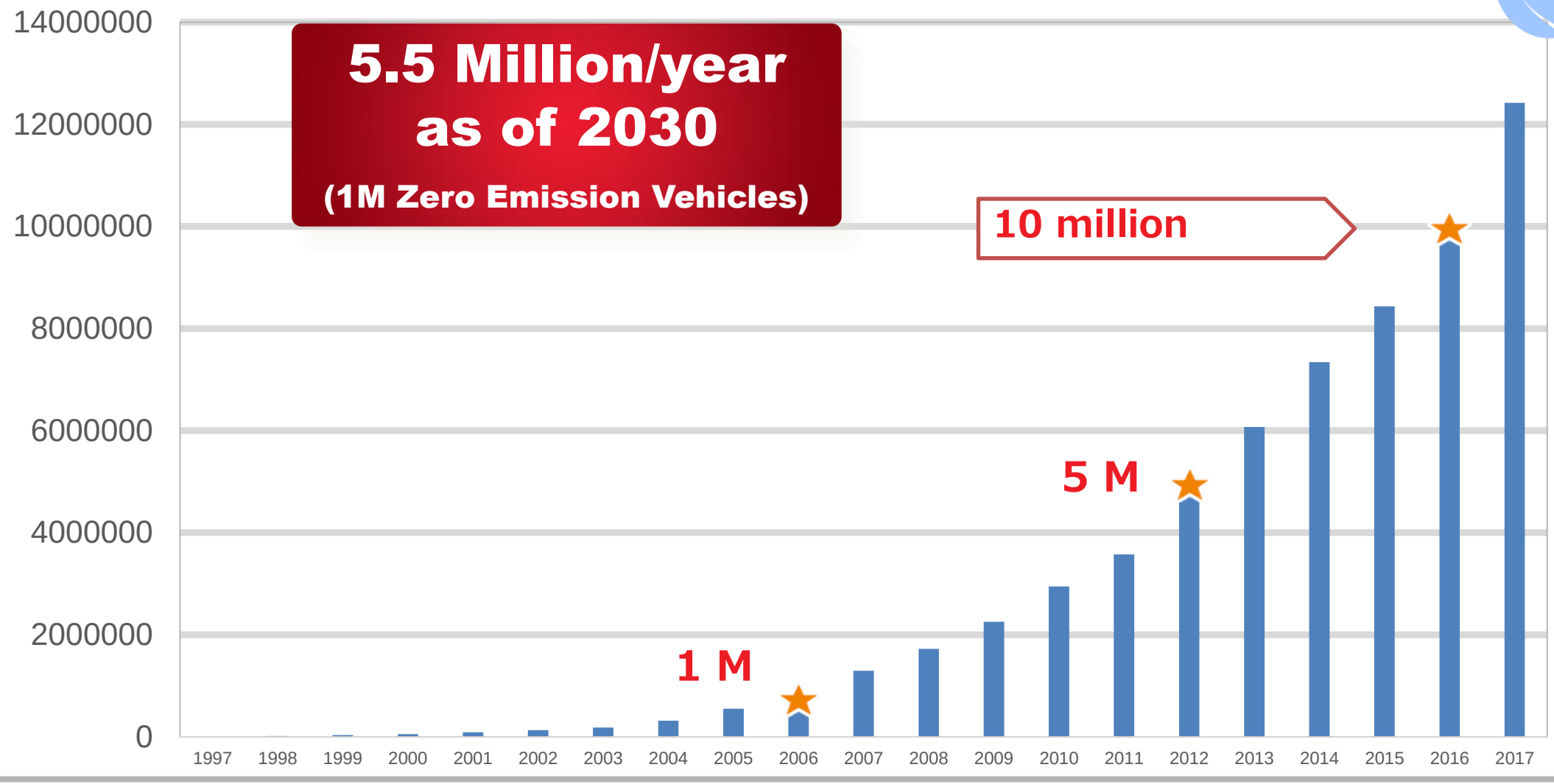
Akio Toyoda

Hybrid Global Sales

tons of CO_2 saved
vs comparable petrol engines

93M

MARCH 2018



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Toyota FCEV sales plan in 2020

GLOBALTARGET: More than 30,000 FC-stacks per year as of 2020

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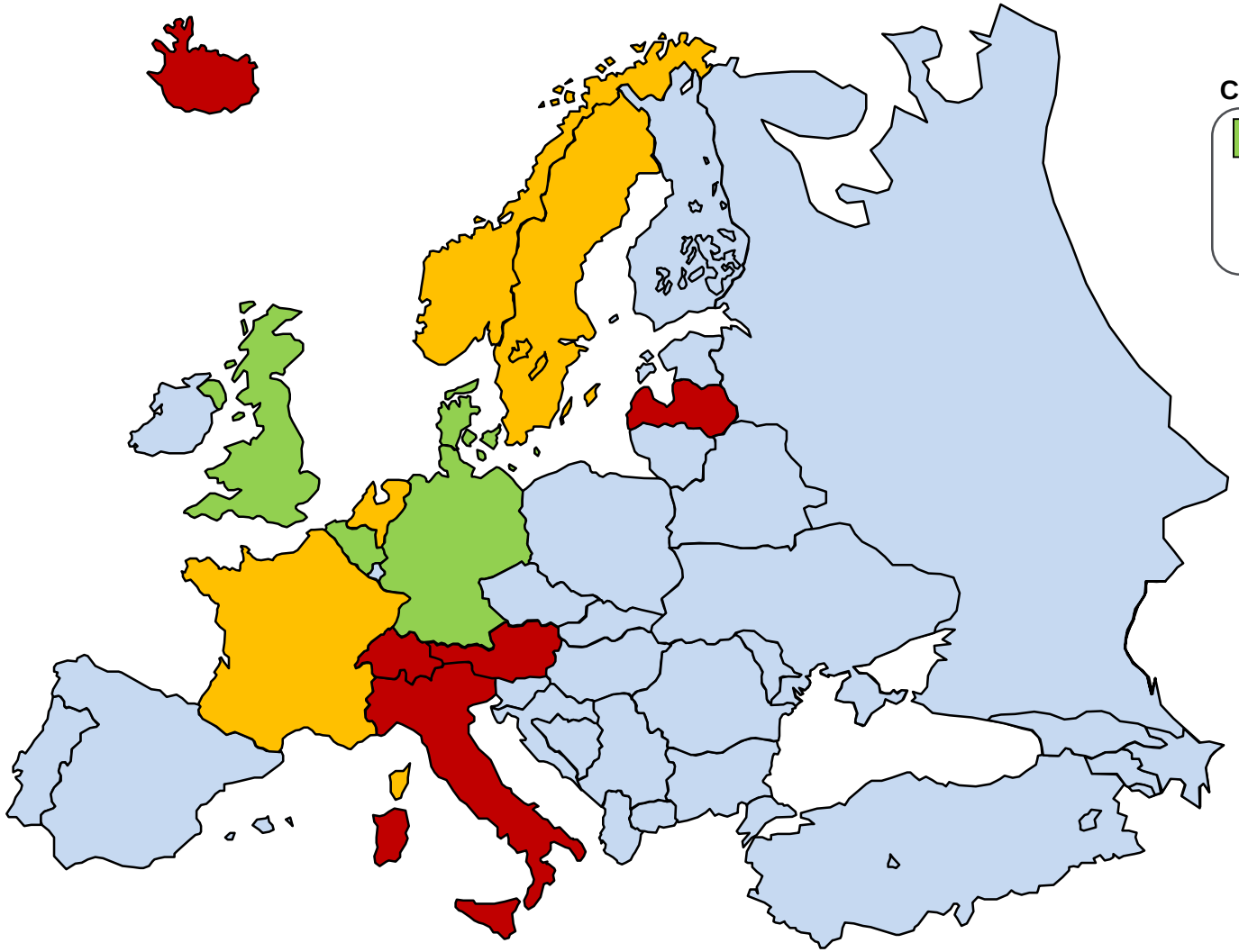
Mirai Sales Distribution in Europe



Countries introduction time

2015	2016	2017	2018
23	62	135	174

December 2018:

Japan:	2710
USA:	5038
EU:	345
TOTAL:	**7748**

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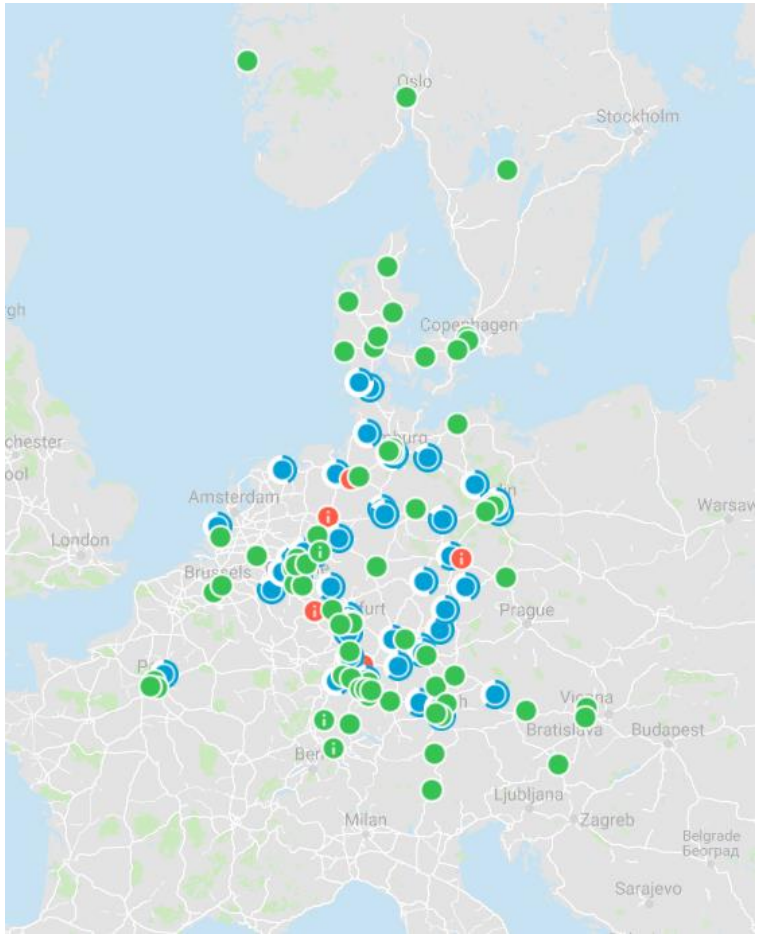
Hydrogen Refuelling Infrastructure



http://h2.live/en

700 bar station		2018 ACTUAL
Germany		60
UK		10
Denmark		10
Norway		4
Sweden		3
Netherlands		2
Belgium		2
France		4
Italy		1
Iceland		2
Austria		5
Switzerland		1
Latvia		1
TOTAL		**105**

END 2019

200 public 700 bar HRS

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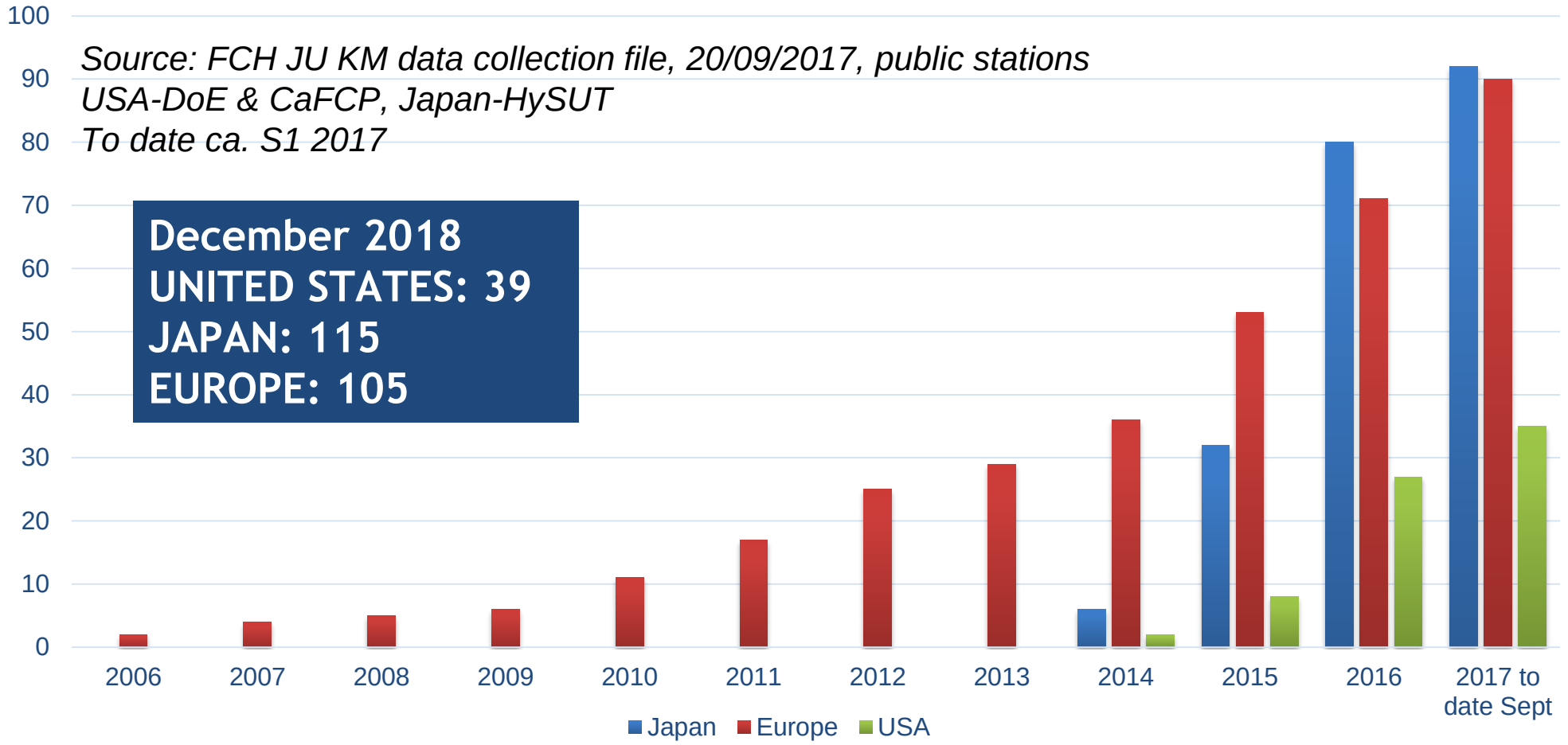
Public hydrogen refuelling stations (700 bar public)



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Toyota shares patents to accelerate the spread of FCEVs

ITEM	NUMBER OF PATENTS TO BE FREE	FREE USE PERIOD
FC stack	Approx. 1,970	Until the end of 2020
High-pressure hydrogen tanks	Approx. 290	
FC system control	Approx. 3,350	
Hydrogen station	Approx. 70	No expiration

Other developments

Caetano Fuel Cell Bus

Sora Fuel Cell Bus

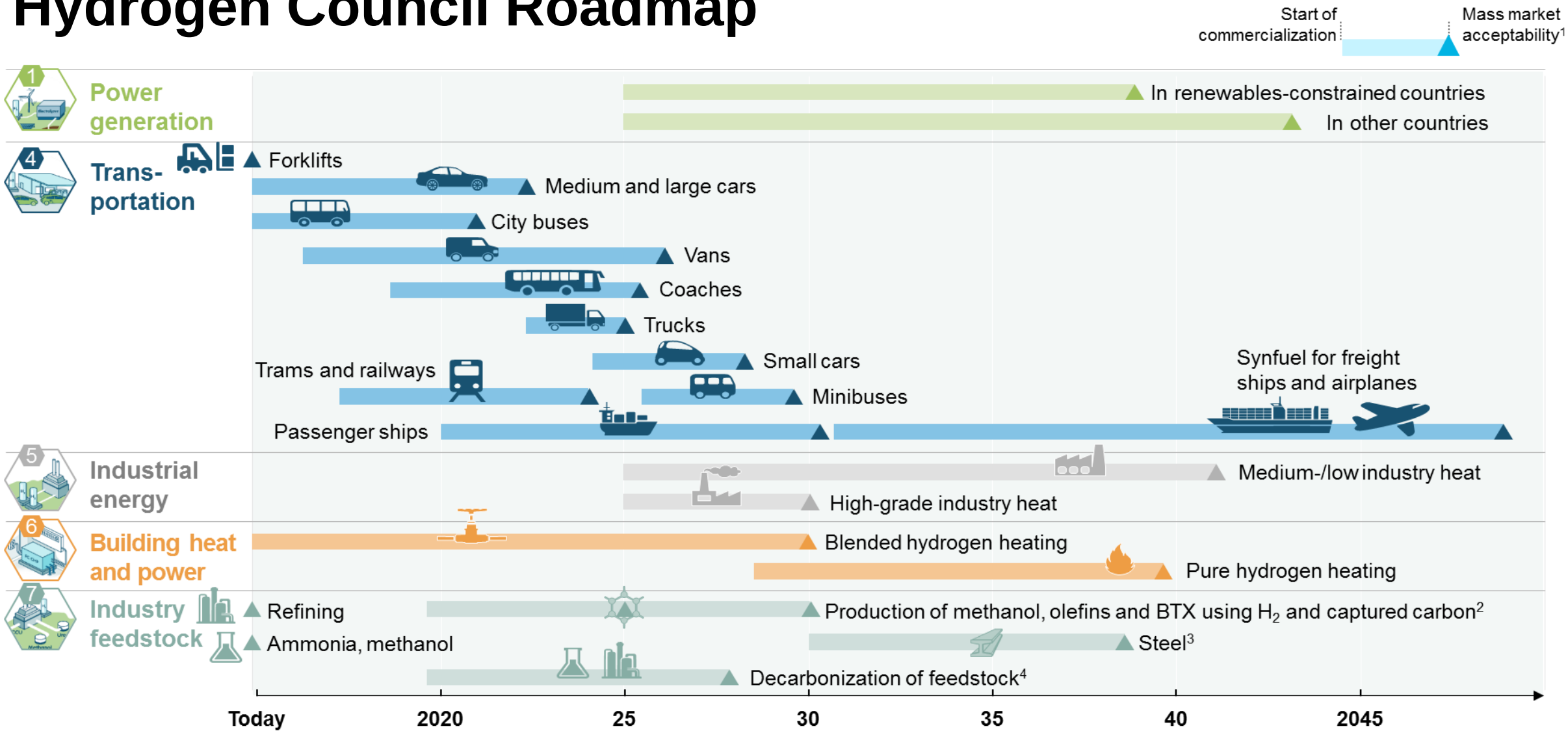
Tundra Fuel Cell Pizza delivery

Project Portal Fuel Cell Truck

Toyota Fuel Cell Truck

Toyota Fuel Cell Forklift

Hydrogen Council Roadmap



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Mirai Technology

FCEV Overview and Components

TOYOTA LEXUS

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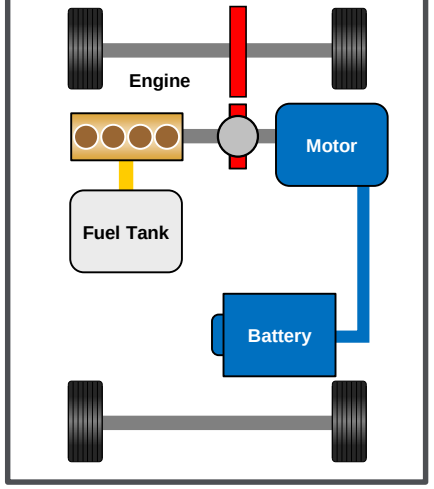
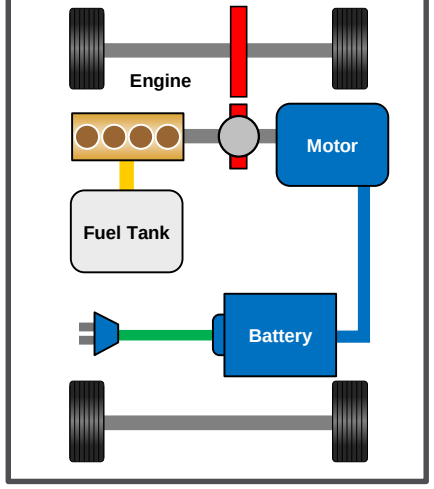
Pioneering Technology – Hybrid to Hydrogen < 20 year development

Using hybrid technology for Plug-In, EV and Fuel Cell

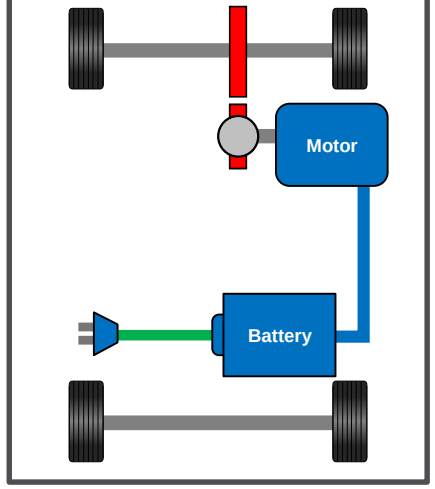
HYBRID



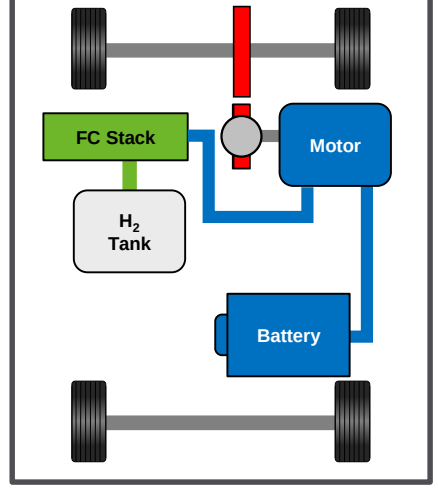
PLUG-IN HYBRID



ELECTRIC



FUEL CELL



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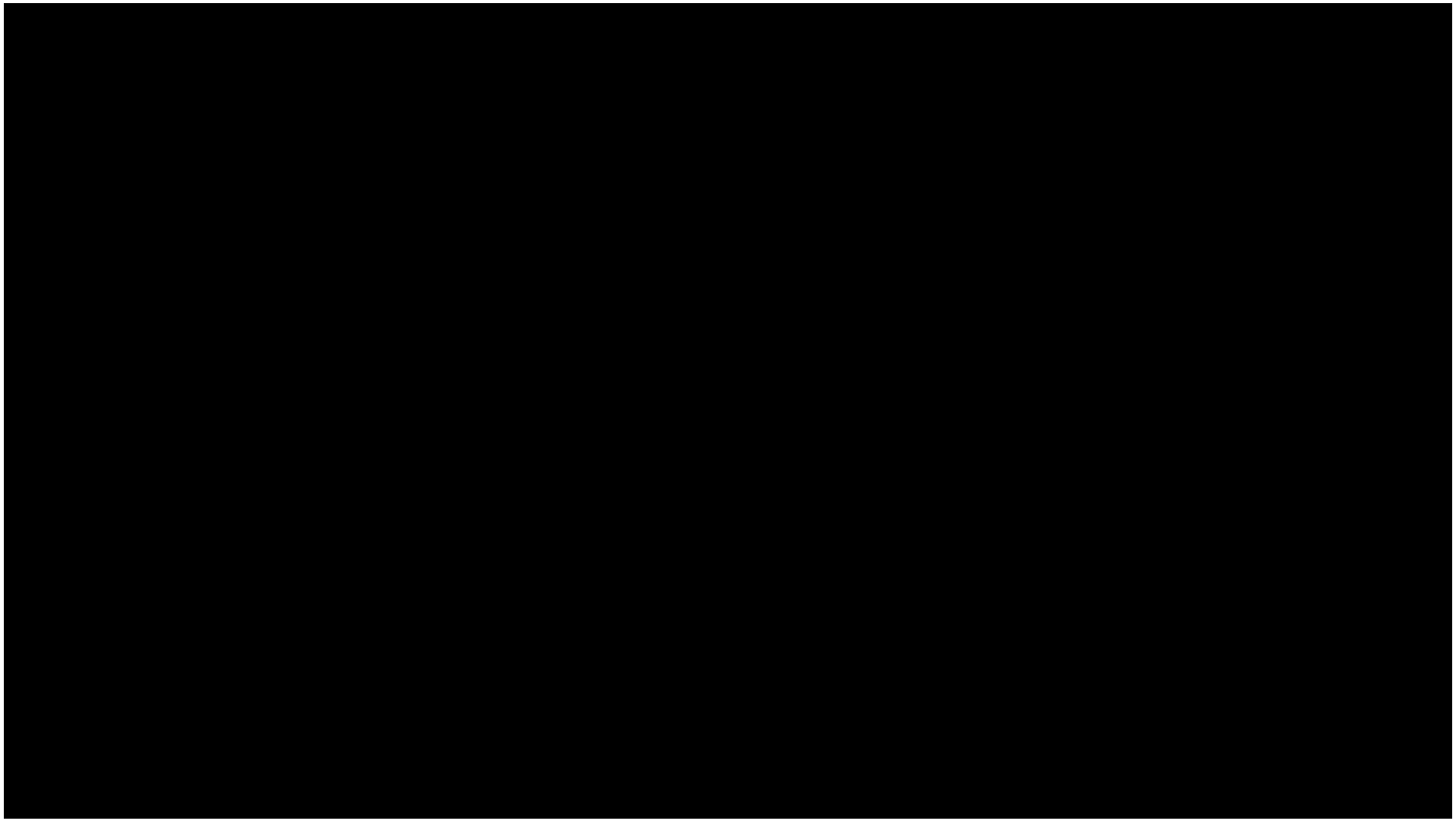
Mirai Hydrogen Working Principle



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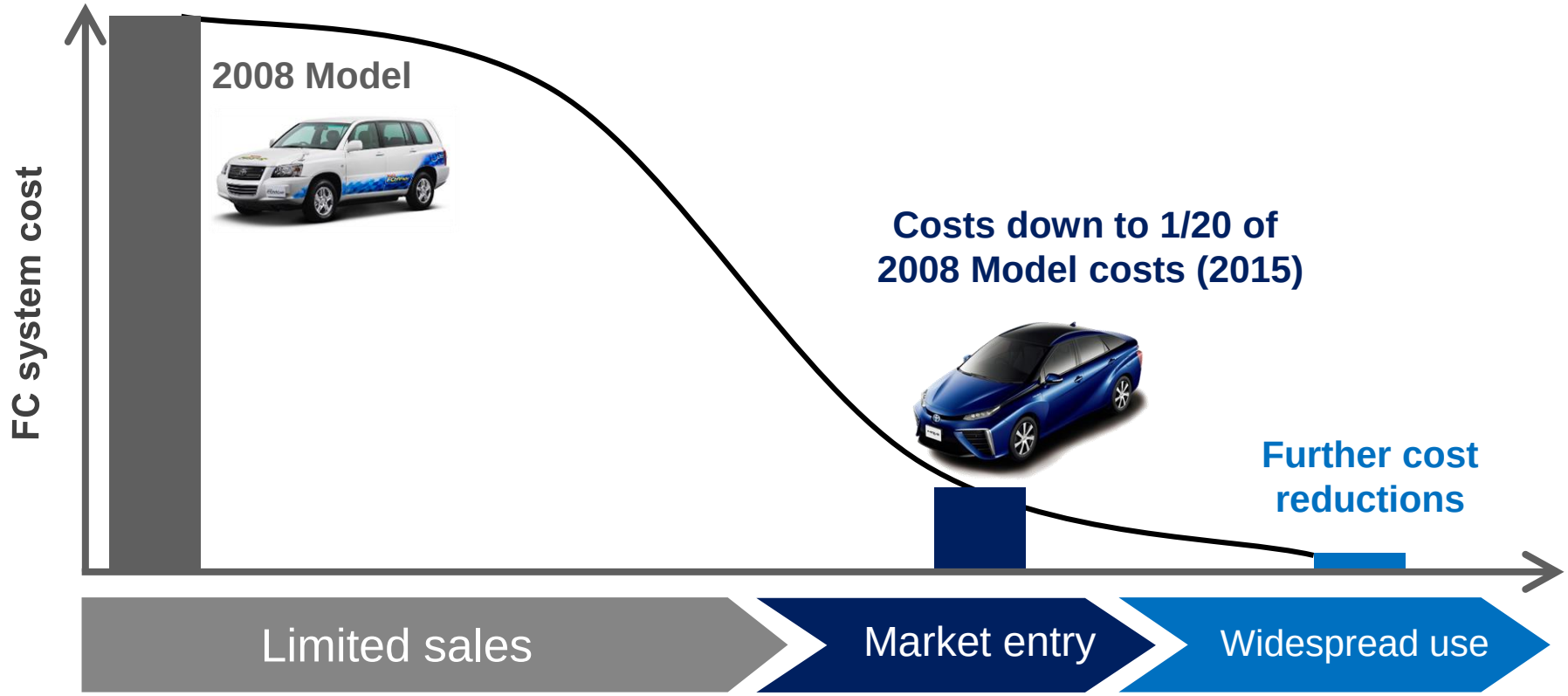
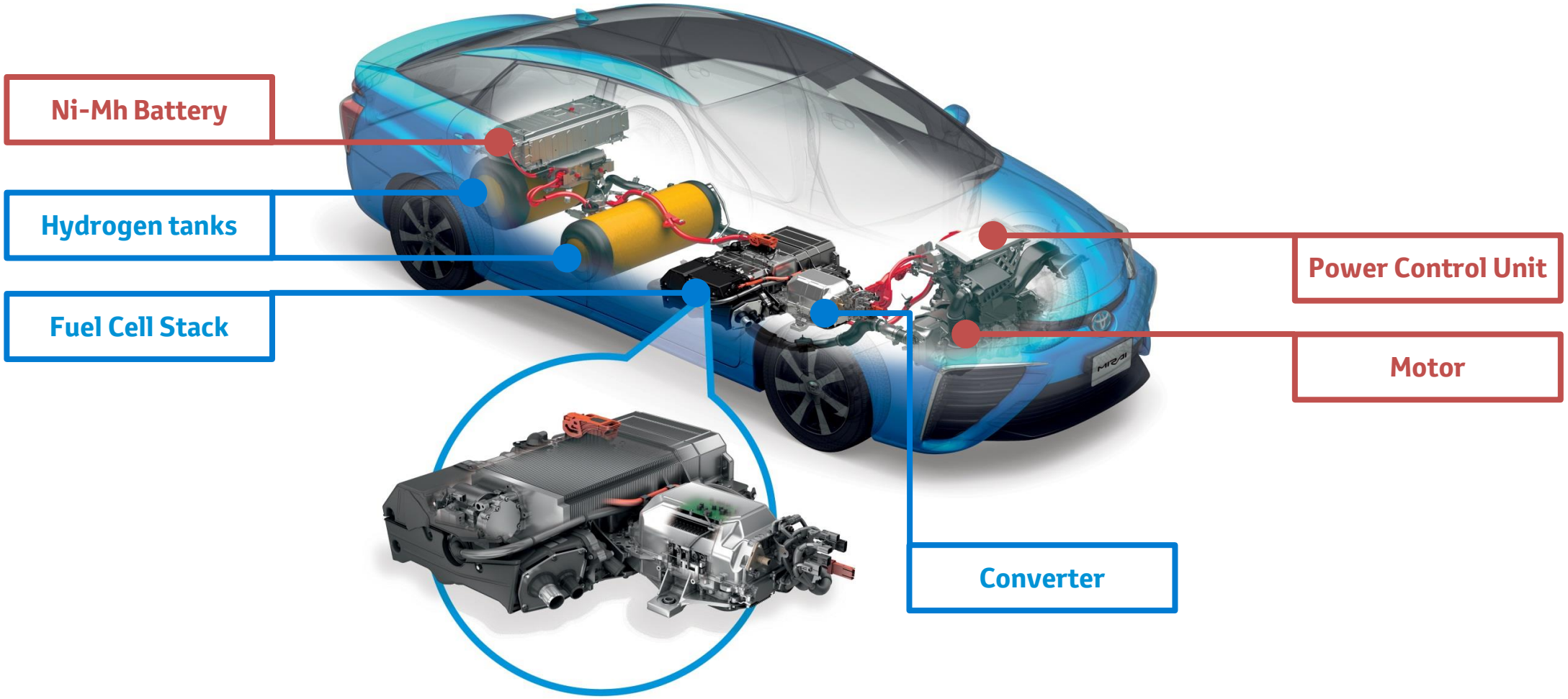
Huge potential for cost reduction



Fuel-cell components



Fuel Cell Components

★FC stack

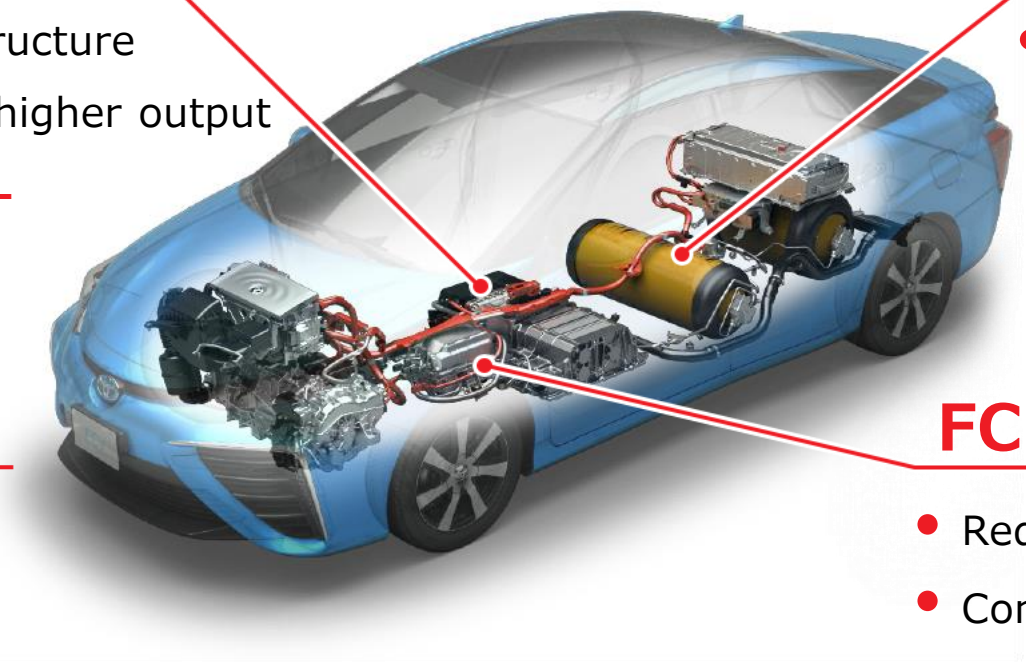
- Innovative flow channel structure and Electrodes of cells for higher output

Output/volume; 3.1kW/L

★High pressure hydrogen tank

- The light weight structure of carbon fiber reinforced plastic enabled

Storage; 5.7 wt%*



Humidifier less

- Internal circulation

FC boost converter

- Reduced number of cells in FC stack
- Common use of hybrid units

*Hydrogen mass/Tank mass

FC main components developed in-house to achieve world leading performance

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Warranty Period like any other Toyota hybrid

3 years / 100,000 km

Standard warranty for all general parts and components

5 years / 100,000 km

Extended warranty for all hydrogen and high voltage parts

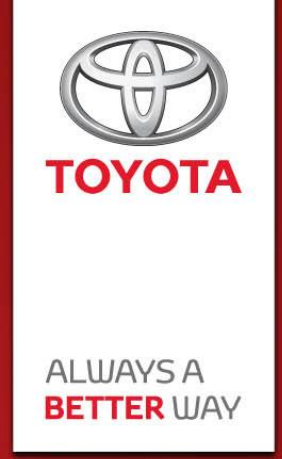
- Fuel tank
- FC stack
- HV battery
- Drive motor
- HV Inverter
- HV booster

TOYOTA

Thank you

Vincent.mattelaer@toyota-europe.com

Backup slides



Hydrogen Tanks

Tank designers and inspectors run a load of harsh tests in laboratories

- Burst test
- Cycling test
- Bonfire tests
- Crush test @150 tons force (Powertech)
- Cold weather tests
- Impact test (CEA/France hypactor.eu)
- Gunfire test (tested@Powertech)

7 mm Armour-Piercing bullet test

Durable under intense EU driving style

Challenge:
clocking up 200,000 kilometres in just over 250 days

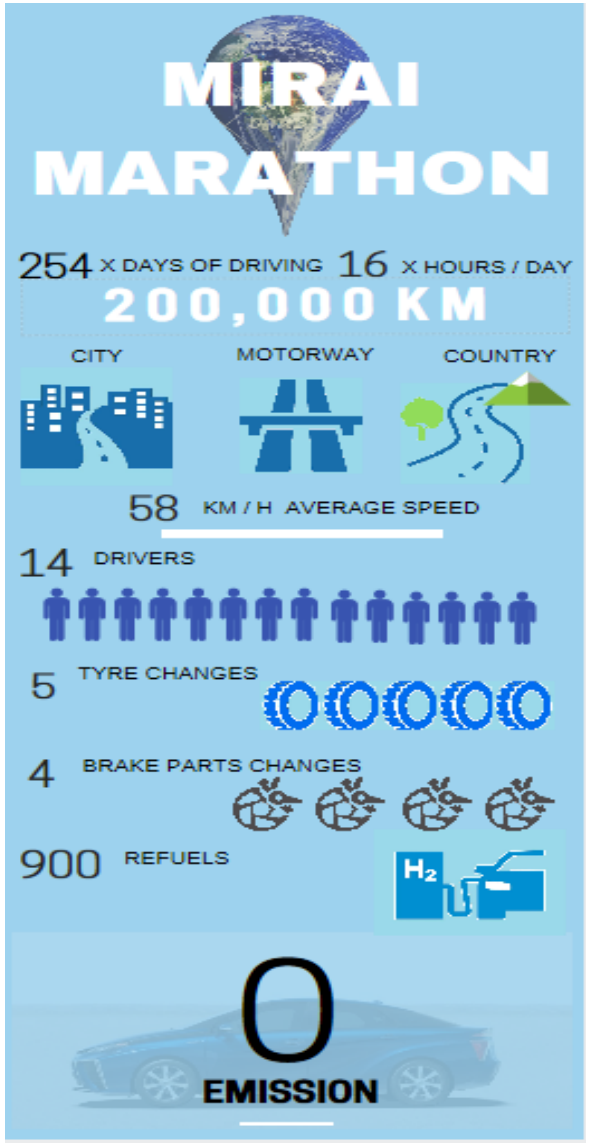
Driving style:
City traffic (Hamburg)
High speed driving (Germany)
Cold conditions down to -20°C (Norway)
Uphill-downhill in summer up to +37°C (Alps)

The Mirai operated with 100% reliability .

Condition

Excellent
H_2 Quality

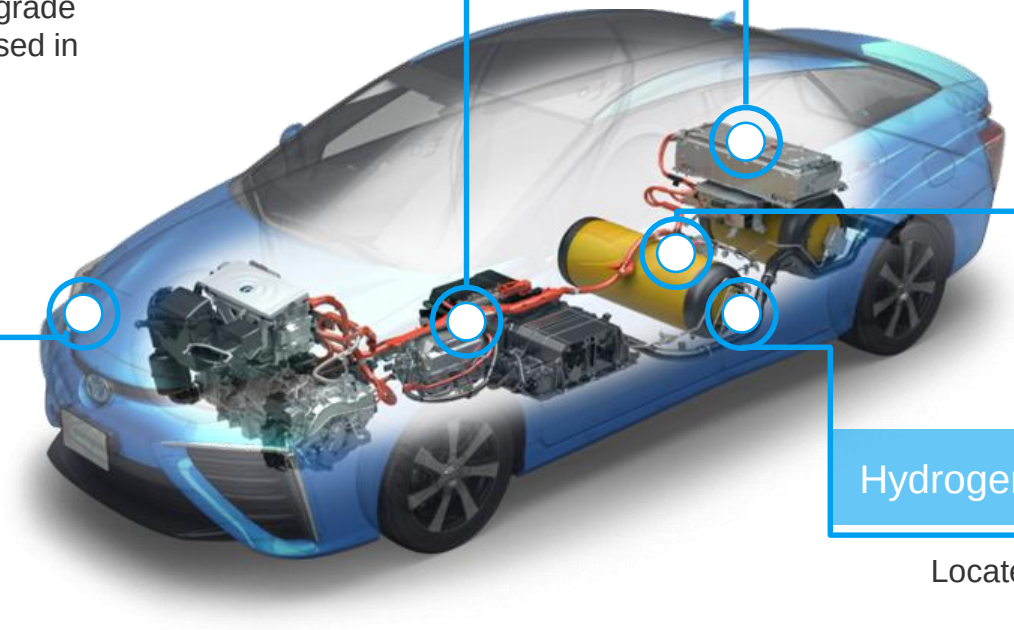
ISO 14687-2
EN 17124



Meaning for Europe:
Records like this brought by OEMs can build confidence and customer satisfaction.

TOYOTA

We ensure safety on board



Toyota FC stack

Steel frame and aircraft grade fibre-reinforced plastic used in protect the FC Stack

Hydrogen sensors

Provide warnings and can shut off tank main stop valves

Impact safety structure

Protects the FC Stack and Hydrogen tanks in the event of an accident

High pressure Hydrogen tank

Made from reinforced carbon of the highest quality

Hydrogen related parts

Located outside the cabin

FCEV Benefits for our Customers

*Depending on driving style