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SOCIAL REPORTERS #HybridRoadTrip

Toyota Motor Europe

TOYOTA SOCIAL REPORTERS #ToyotaIAA

#HybridRoadTrip

Agenda

1. Toyota in Europe
2. We are Hybrid
3. Mobility roadmap – EV / Hybrid / Fuel Cell
4. Hydrogen & Fuel Cell technology by Julien Roussel

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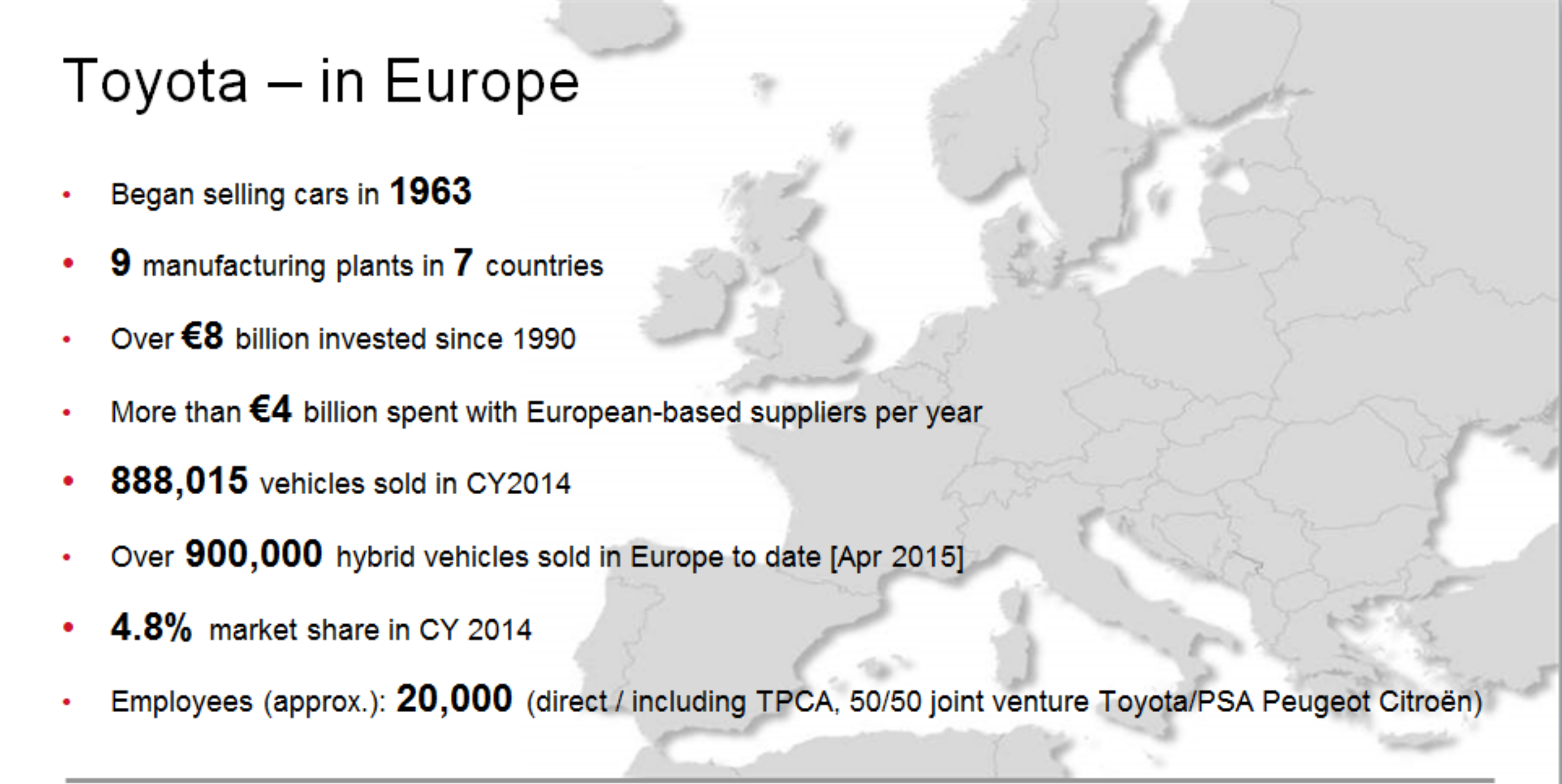
Toyota – in Europe



- Began selling cars in **1963**
- **9** manufacturing plants in **7** countries
- Over **€8** billion invested since 1990
- More than **€4** billion spent with European-based suppliers per year
- **888,015** vehicles sold in CY2014
- Over **900,000** hybrid vehicles sold in Europe to date [Apr 2015]
- **4.8%** market share in CY 2014
- Employees (approx.): **20,000** (direct / including TPCA, 50/50 joint venture Toyota/PSA Peugeot Citroën)

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HO & Supporting Facilities

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Manufactured Vehicles

2/3 of our vehicles sold in Europe are made in Europe:

- **Toyota AYGO**
- **Toyota Yaris**
- **Toyota Yaris Hybrid**
- **Toyota Auris**
- **Toyota Auris Hybrid**
- **Toyota Auris Touring Sports**
- **Toyota Auris Hybrid Touring Sports**
- **Toyota Verso**
- **Toyota Corolla**
- **Toyota Avensis**
- **Toyota Camry**
- **Toyota Dyna**









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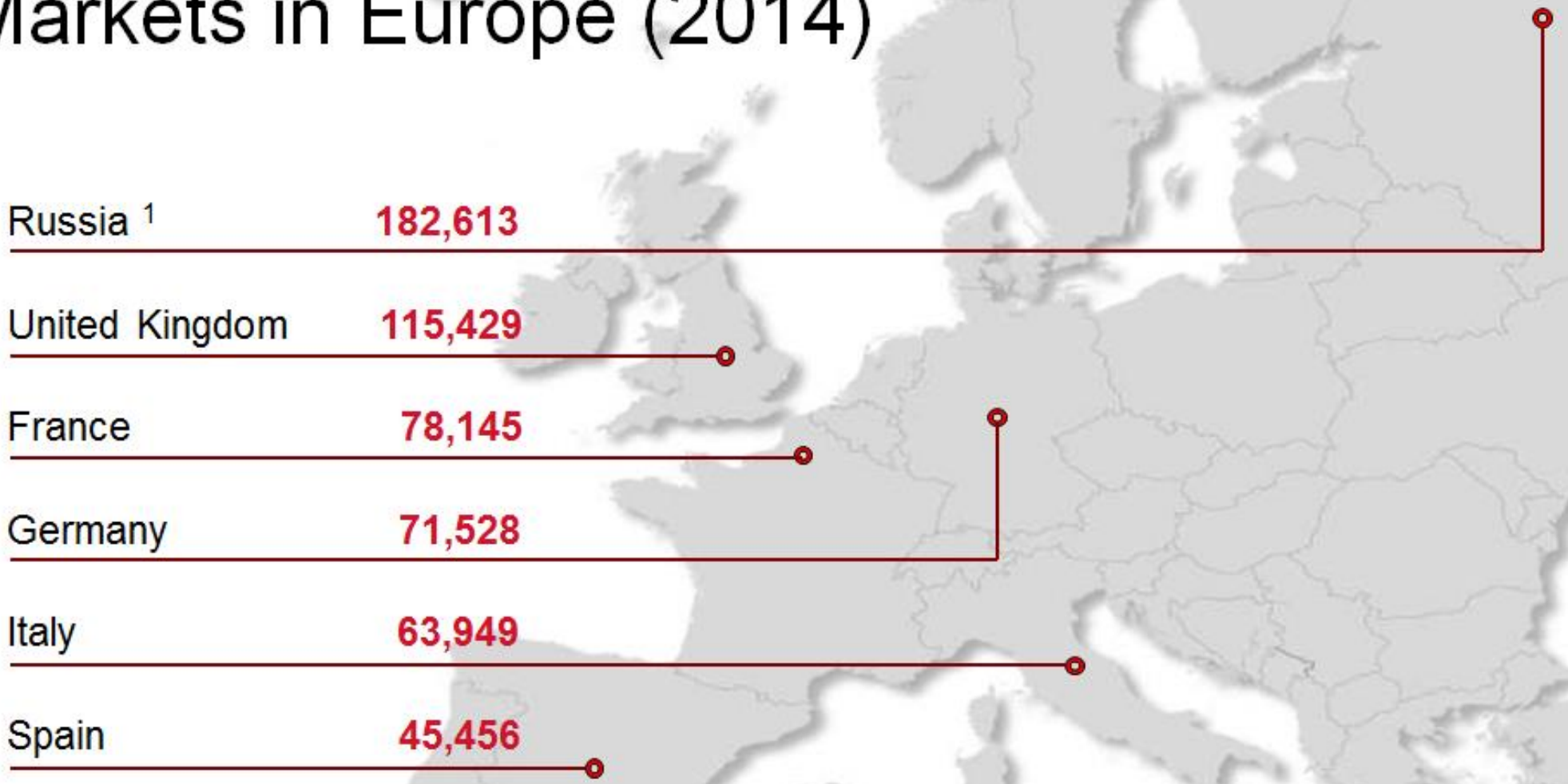
Major Markets in Europe (2014)



[1] includes sales in Russia and Belarus (both responsibility of Toyota Motor Russia (TMR)

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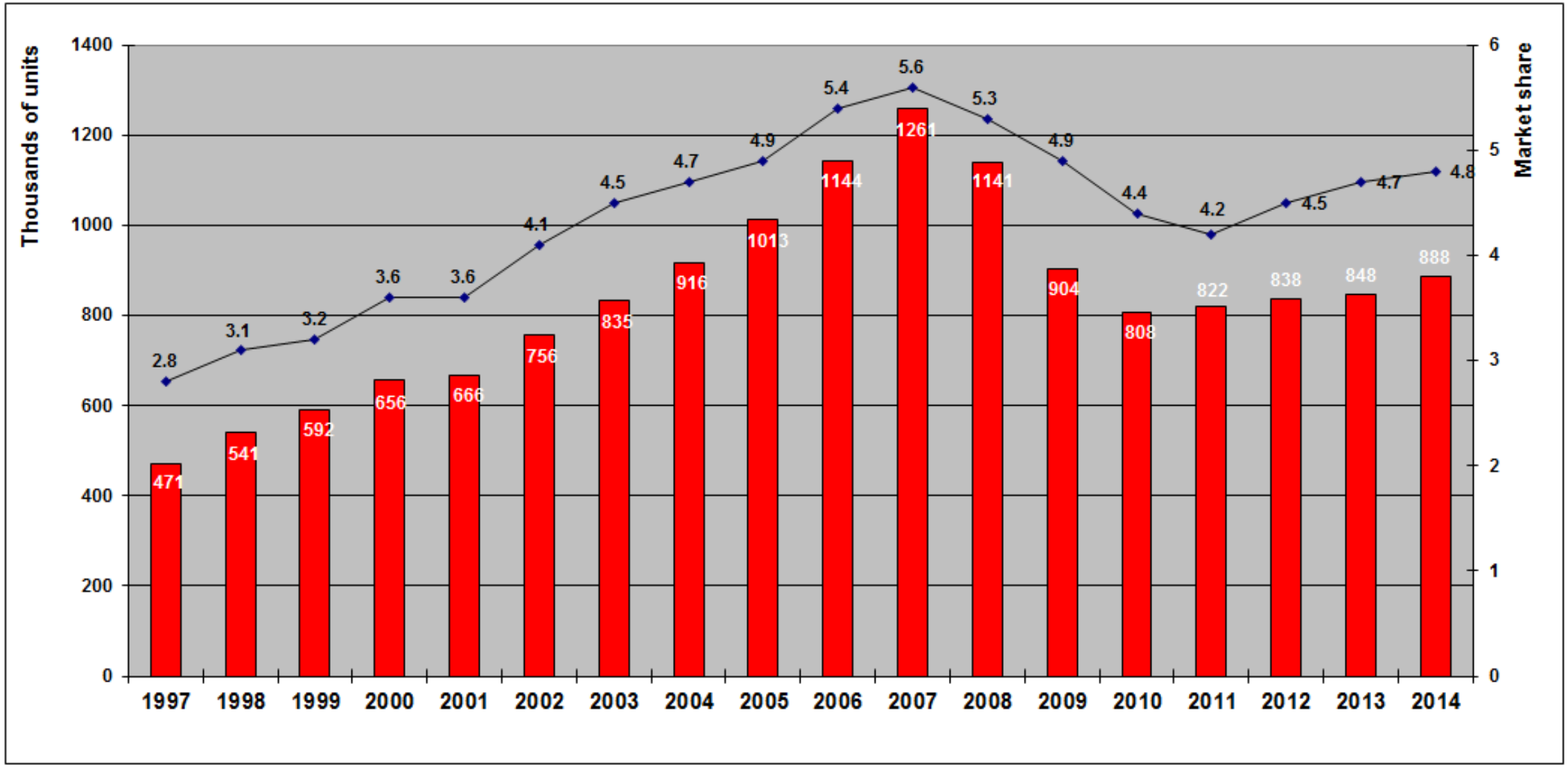
1997 – 2014: Sales Performance in Europe



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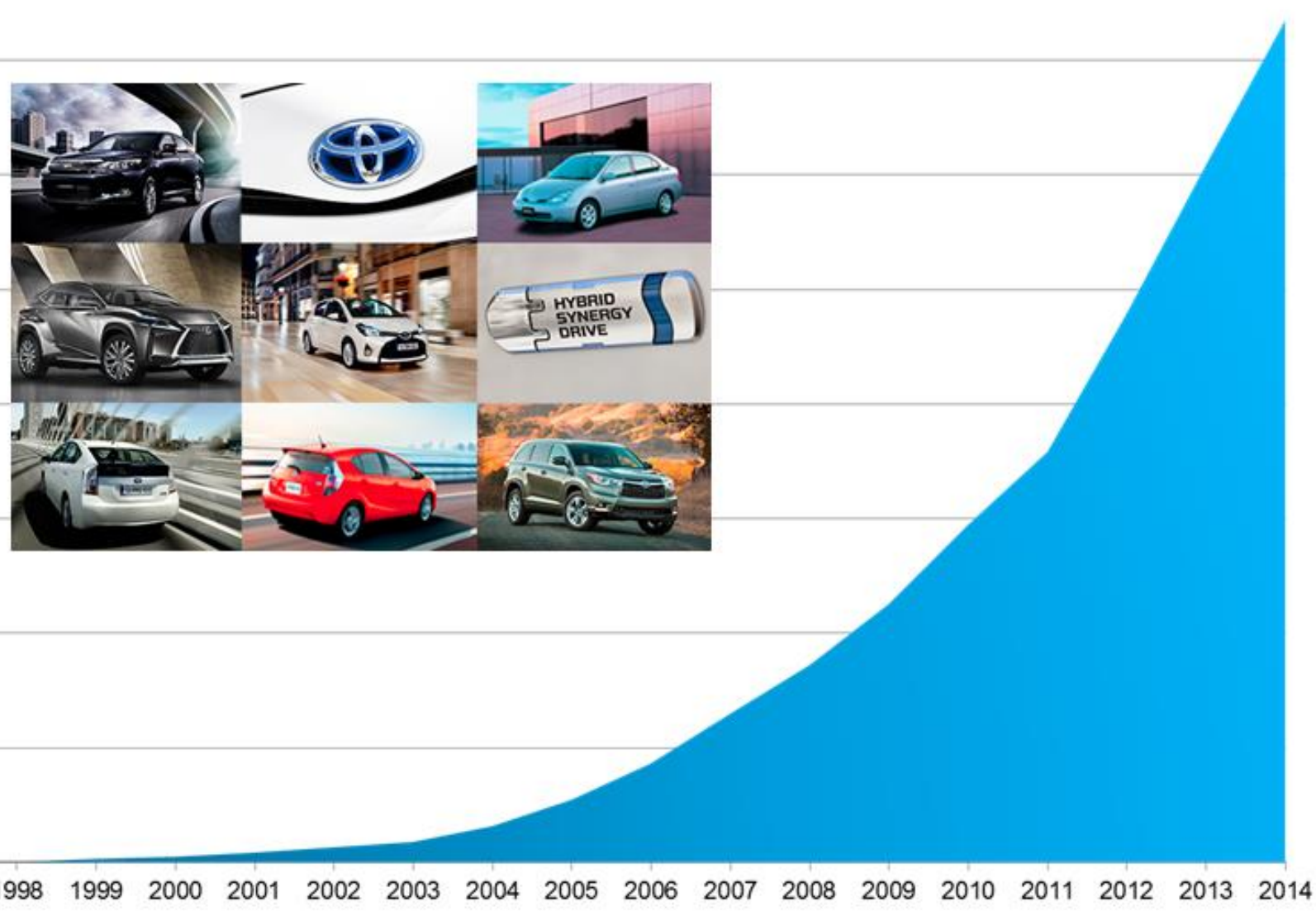
Global Sales of Hybrid Vehicles

More than **8** million hybrid vehicles sold worldwide, with Europe contributing more than 10% of this result.

- **31** hybrid models in more than 90 countries and regions
- This translates into global savings of approximately **58** million tonnes CO_2
- Hybrids also contribute to protecting air quality (extremely low emissions of NOx)



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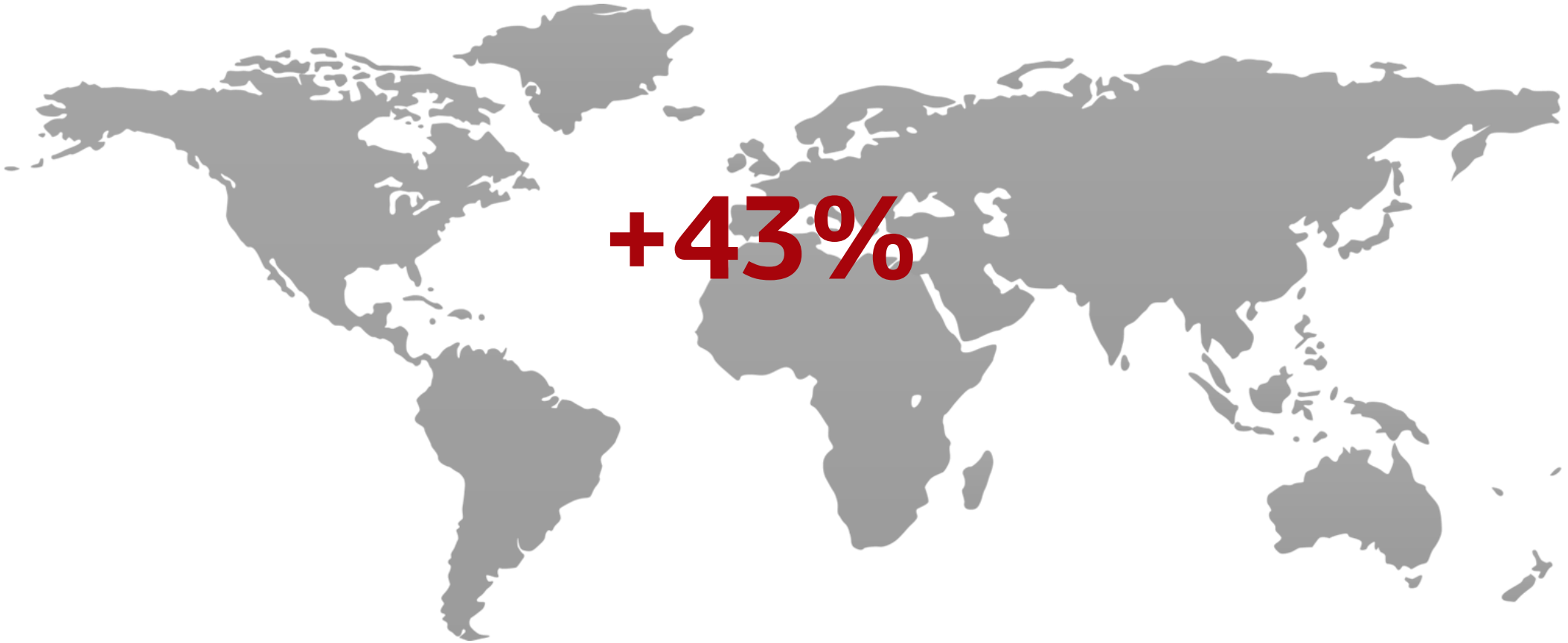
Fastest Hybrid sales growth region



8M Hybrid sales worldwide

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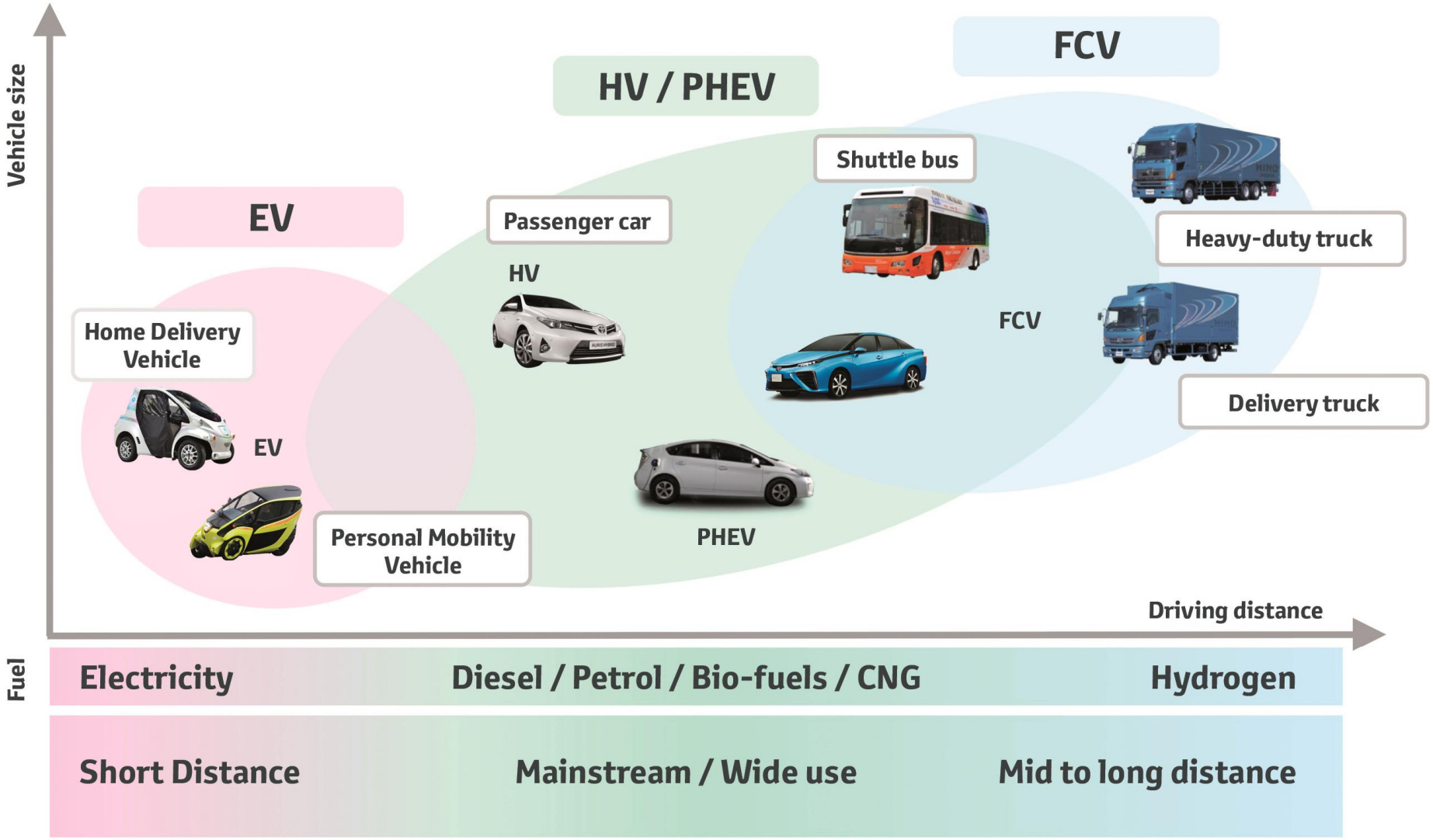
We Are Hybrid

Toyota powertrain roadmap



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Hydrogen and Fuel Cell Technology

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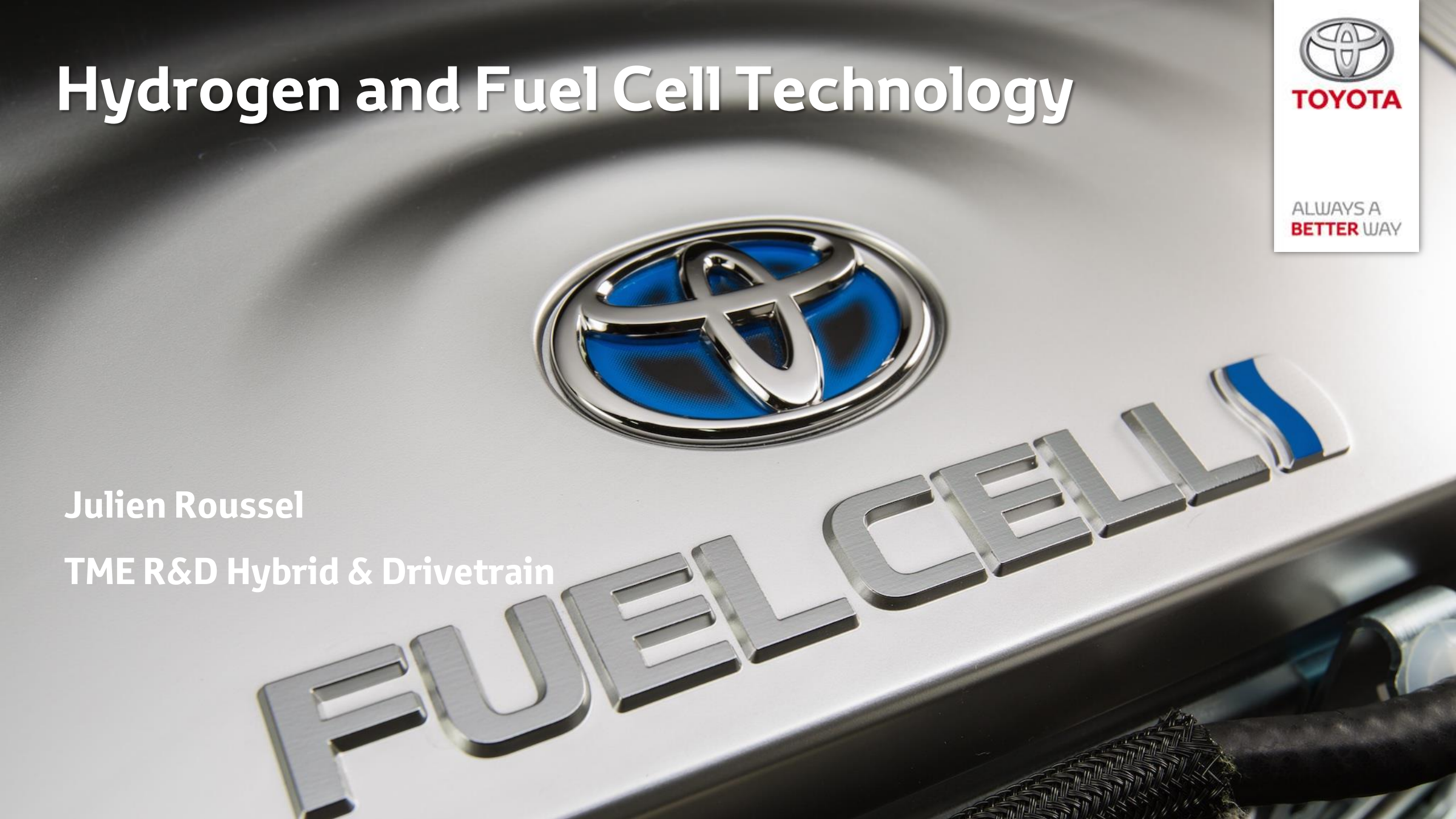

Julien Roussel

TME R&D Hybrid & Drivetrain

A Journey to sustainable mobility

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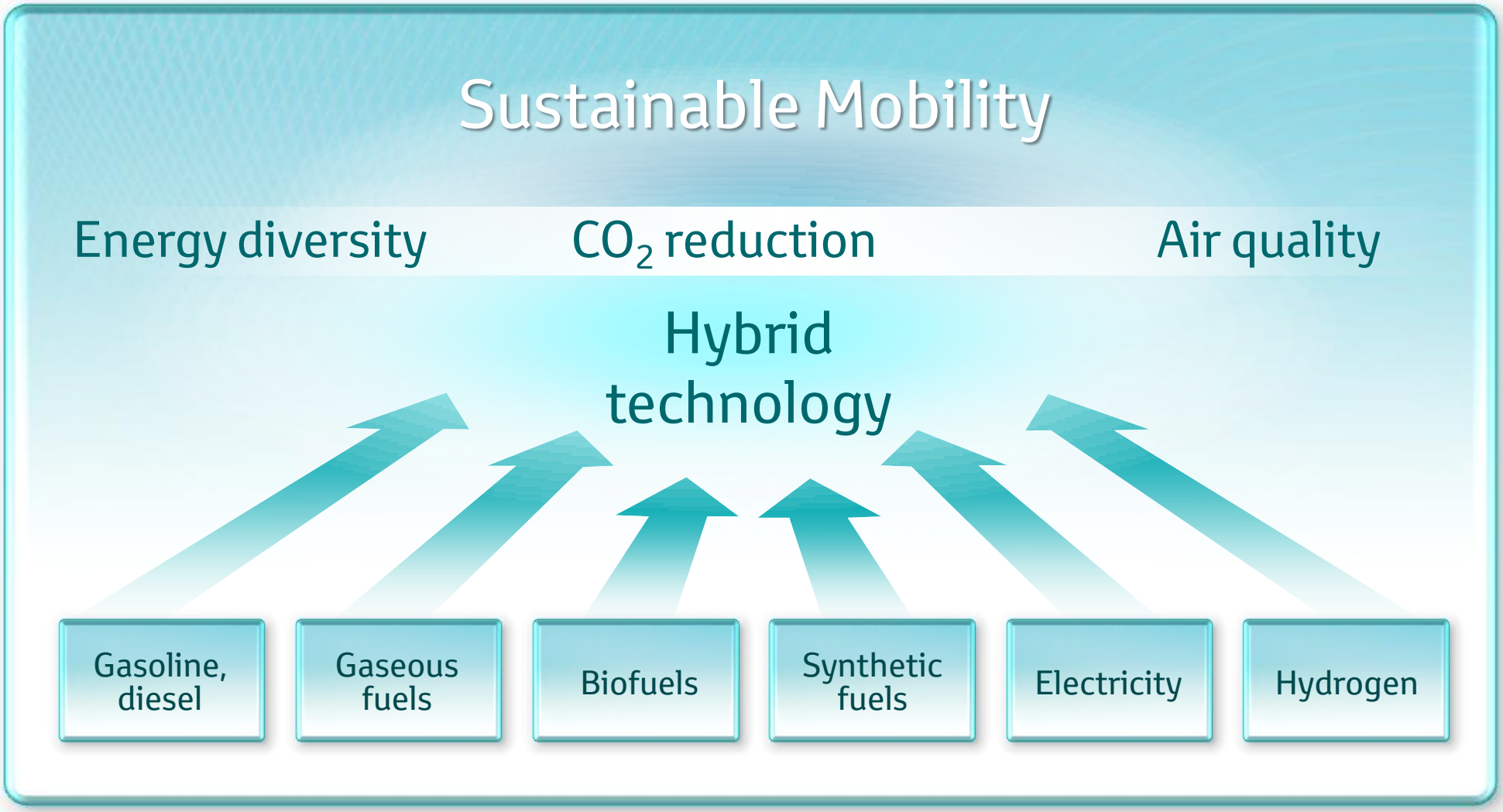

The right car, the right place, the right time

Content

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Facts & Figures about Hydrogen

Toyota's Hydrogen Fuel Cell Technology

Toyota's approach to uncompromised safety

Hydrogen: one name, different realities

Element vs Molecular Hydrogen?

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Hydrogen Element (H)

- Most abundant of the Universe
- Lightest element of the Universe
- Also called atomic Hydrogen

Molecular Hydrogen (H_2)

- Made of 2 Hydrogen atoms
- Real name di-hydrogen
- Not abundant on Earth

Hydrogen: one name, different realities

Gas vs liquid ⟨applicable to H_2 only⟩

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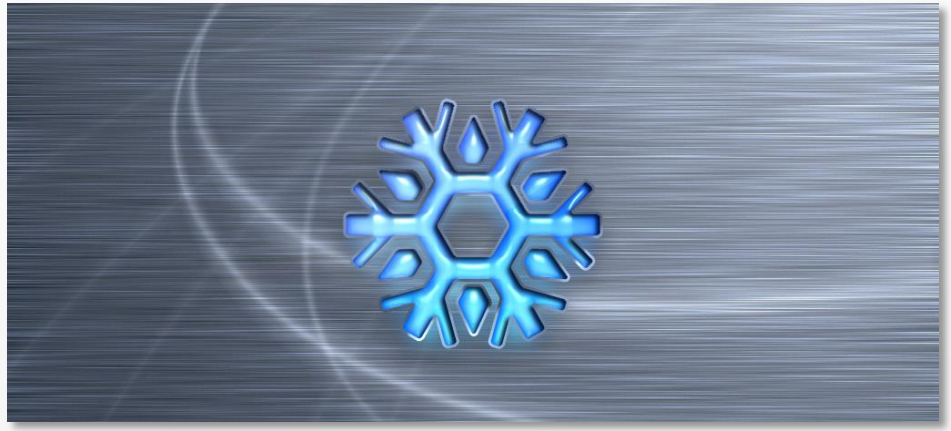
Gas-phase Molecular Hydrogen

- Natural state in most conditions
- Phase of storage in Mirai's tanks
- Usually pressurised for more density

Liquid-phase Molecular Hydrogen



- Requires cryogenic conditions (-250°)
- Past choice for BMW 7-series H_2
- Cryogenic does not mean liquid

Hydrogen: a broad range of sources

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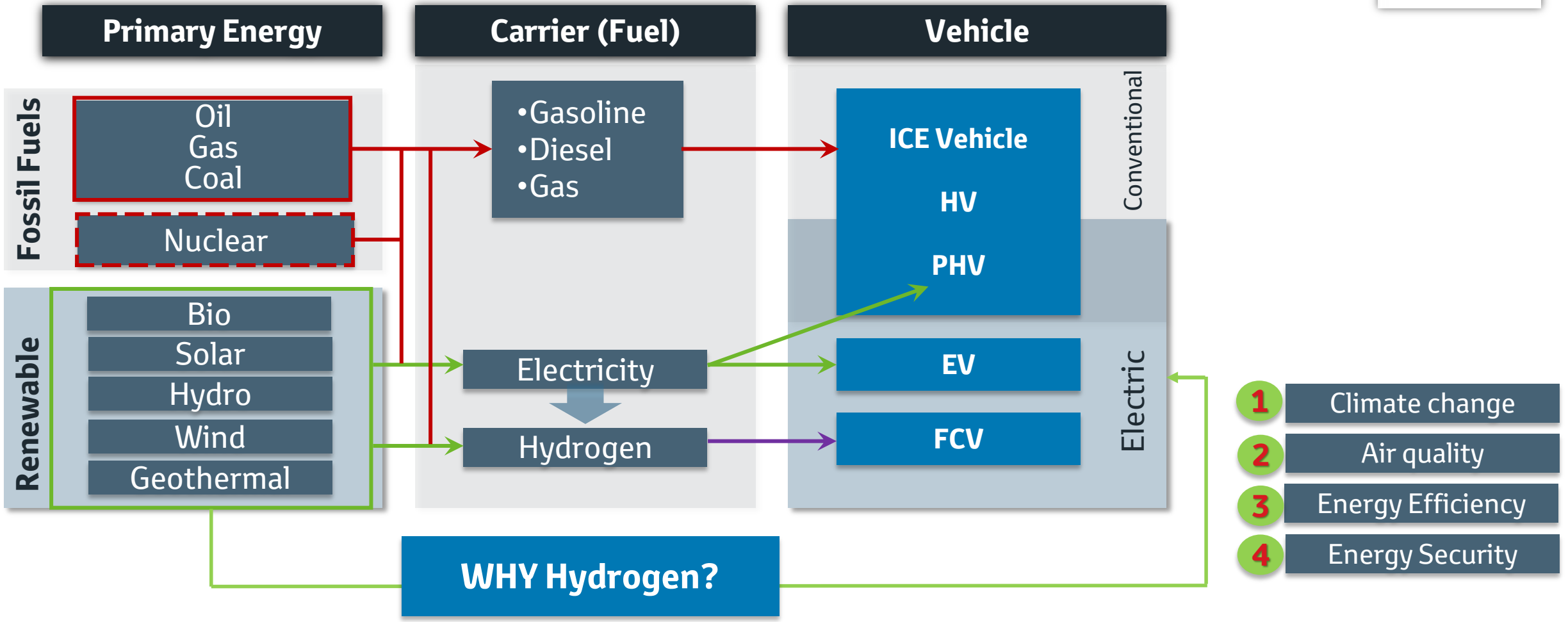

Hydrogen bridges clean energy to Mobility

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- Natural Gas
- Wind
- Solar
- Geo - Thermal
- Bio - Waste

Hydrogen: a long experience already

H_2 has been used for over a century…

Every year, millions of tons are generated, stored and transported safely

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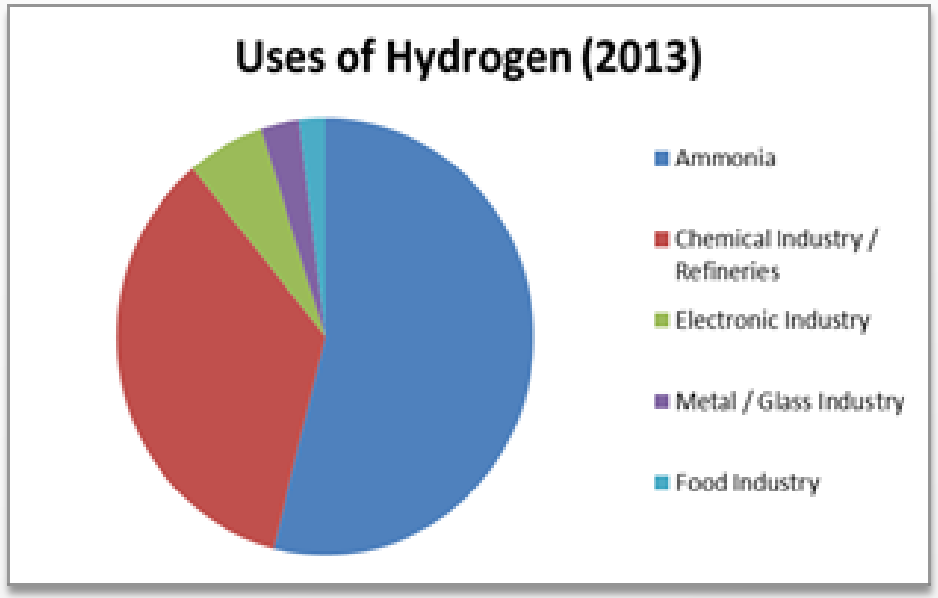
Hydrogen today

Main usages* are :

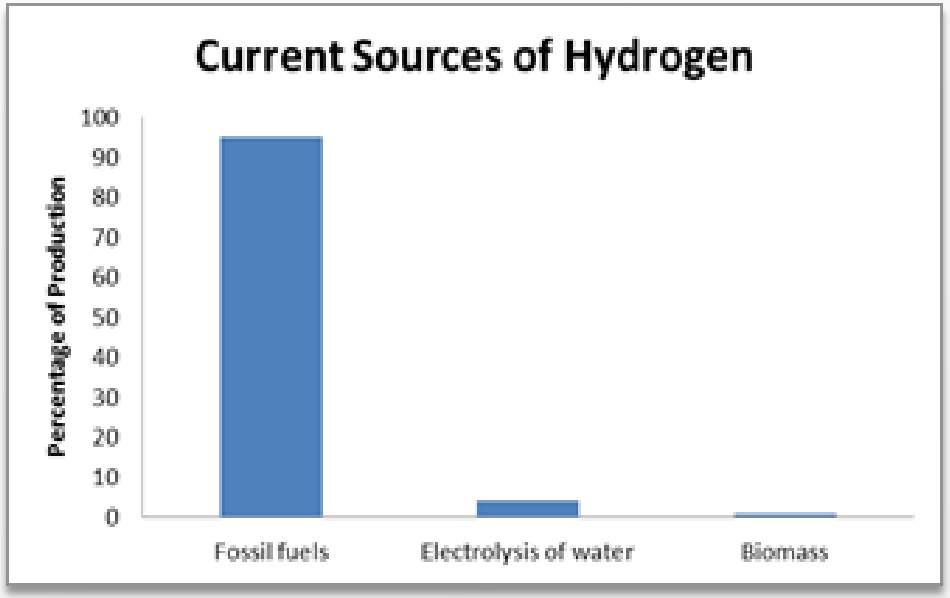
- Refineries to desulfurize fuels
- Ammonia Production

Type of Hydrogen*:

- Mainly from fossil origin
- Green hydrogen limited



Even 1 million Mirai represent very little in this pie-chart…



Green H_2 is rising as renewable energy ramps-up, but the road is long.

* Renewable and Sustainable Energy Reviews Volume 23, July 2013, Pages 443–462

Hydrogen: as clean as you make it

H_2 is a very interesting and special product:

- Non toxic
- Non-irritant
- Odourless
- Non-corrosive

Emissions:

- H_2 from renewable = Green or Blue H_2
  => Zero carbon, zero emission

- H_2 from fossil fuels= Brown or Grey H_2
  => Less carbon and CO2 than ICE

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Hydrogen's physical properties

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H_2 gas carries energy

=> As all fuels, H_2 should be handled carefully

- **H_2 is a stable molecule, it can burn but not explode by itself**
  Conditions for hydrogen fire:
  - oxygen (mixture between 4 & 74%)
  - ignition energy (very low threshold)

- **H_2 is the lightest & smallest molecule**
  High dispersion

=> A tank of pure hydrogen cannot explode (no oxygen)

=> In case of a leak, hydrogen disperses quickly in the air (venting is possible)

* Source: www.mathesongas.com/pdfs/products/Lower-(LEL)-&-Upper-(UEL)-Explosive-Limits-.pdf


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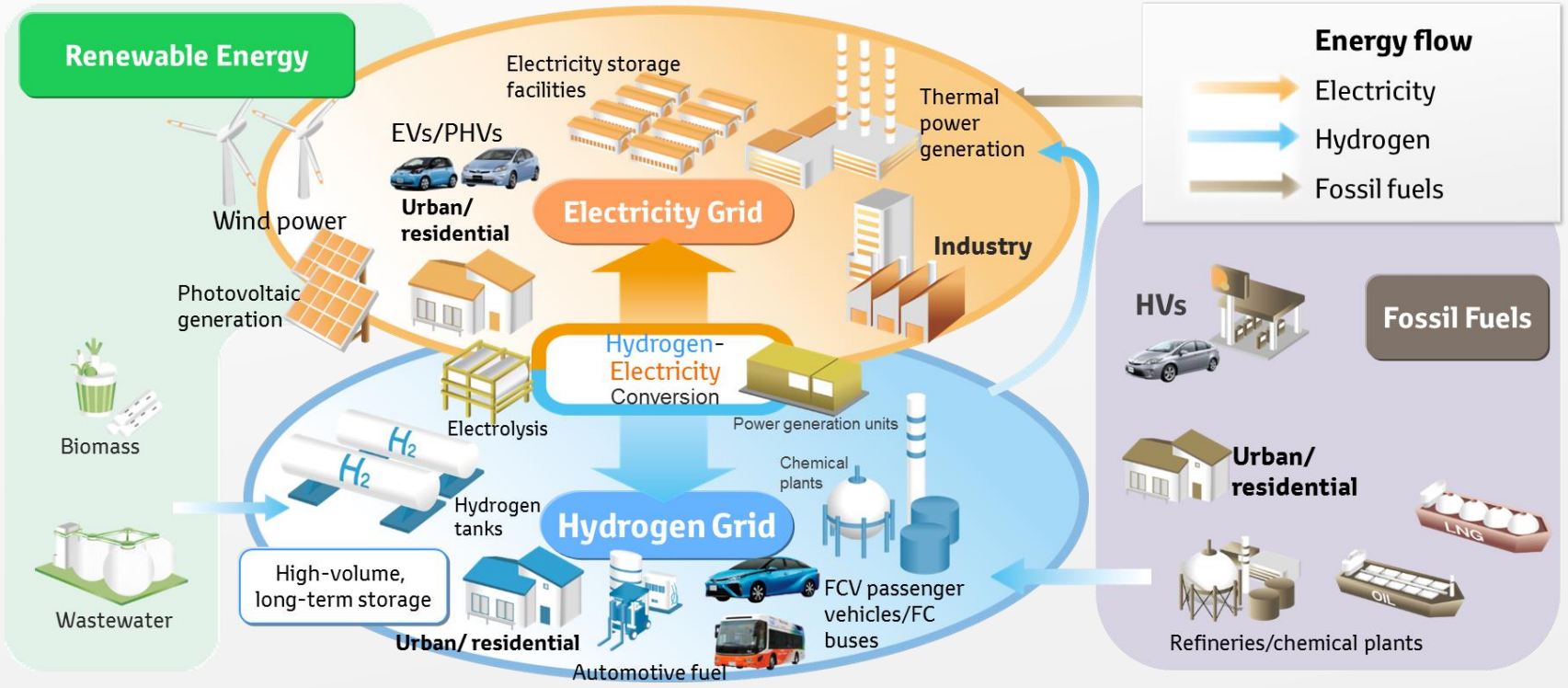
The Hydrogen Economy is Closer than you think

A Smart Energy Grid with H_2

Smart Grid concept extended to smart Energy grid (Power + HyGrid)

- Renewable power is highly intermittent (wind, solar…)
- H_2 is an effective storage means for renewable electricity

* Presented by Air Liquide, June 2011, Energy Storage solutions, FCV Europe



www.hygrid.jp/index_html 2012 HyGrid Study Group

Hydrogen fuelling stations: practicalities

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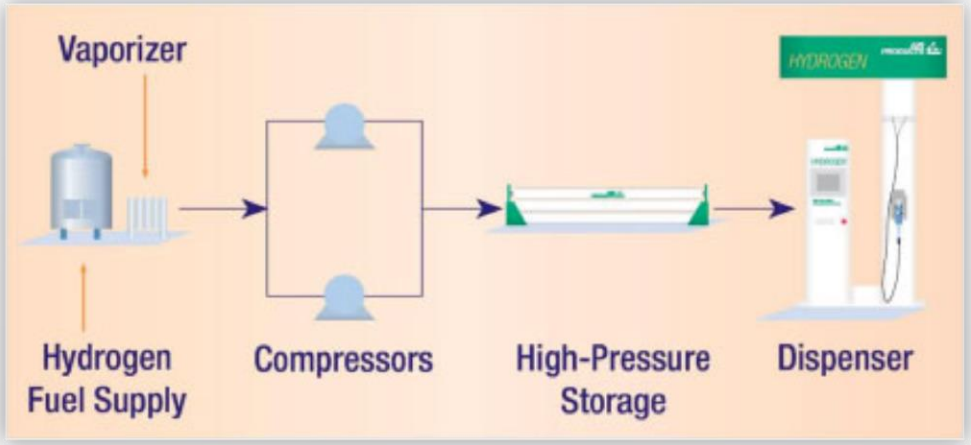
H_2 station elements

- Hydrogen supply
- Compressor
- High-pressure storage
- Dispenser



Fuelling

- Nozzle slightly different from gasoline
- Fuelling very similar to gasoline

=> 3-5 min (no hydrocarbon smell!)

Hydrogen fuelling stations: Safety first

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Excellent Safety Records

- Infra-red communication between station and car for safety
- Millions of km and thousands of refuelling already experienced

Where can I refuel in the EU?

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Suppliers/operators:

AIR LIQUIDE ADVANCED BUSINESS & TECHNOLOGIES

AIR PRODUCTS

H2 Logic

Linde

Countries & stations:

At least 80 stations secured in key countries by the end of 2015

Where can I refuel in the EU?

New stations compliant with all codes & standards have to be double-checked by TME R&D.

<u>Your collaboration is needed!</u>

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Facts & Figures about Hydrogen

Toyota's Hydrogen Fuel Cell Technology

Toyota's approach to uncompromising safety

Developing Hydrogen FCV for 20 years

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1996

FCEV Fuel:
hydrogen
(absorbing alloy)

1999

FCHV-3 Fuel:
hydrogen
(absorbing alloy)

2001

FCHV-4 Fuel:
hydrogen
(high pressure tank)

2002

FCHV-5 Fuel:
clean gasoline
(on-board

2005

FCHV:
1st FC vehicle
certification in Japan

2009

FCHV-adv Fuel:
hydrogen
(high pressure tank)

2011

FCV-R Fuel:
hydrogen
(high pressure tank)

1996 1999 2001 2002 2005 2009 2011 2013 2015

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Fuel Cell is our most advanced Hybrid solution

Built on Hybrid technology: sharing HV DNA

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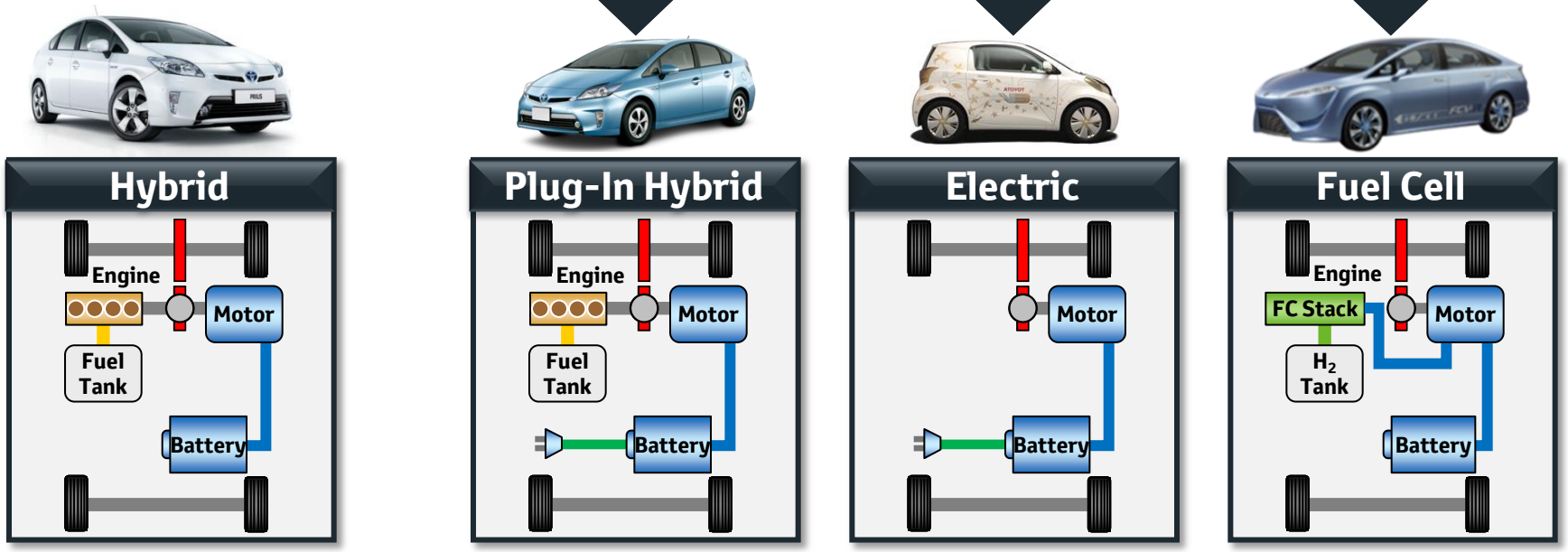
Using hybrid technology for Plug-In, EV and Fuel Cell



Usually Hybrid, and inherently electric: Hyundai's campaign

Hydrogen in the car… scientific definition

“A vehicle driven by an electric motor, powered by the electricity generated by the chemical reaction between onboard hydrogen and airborne oxygen.”

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MIRAI

Hydrogen in the car… simplified definition

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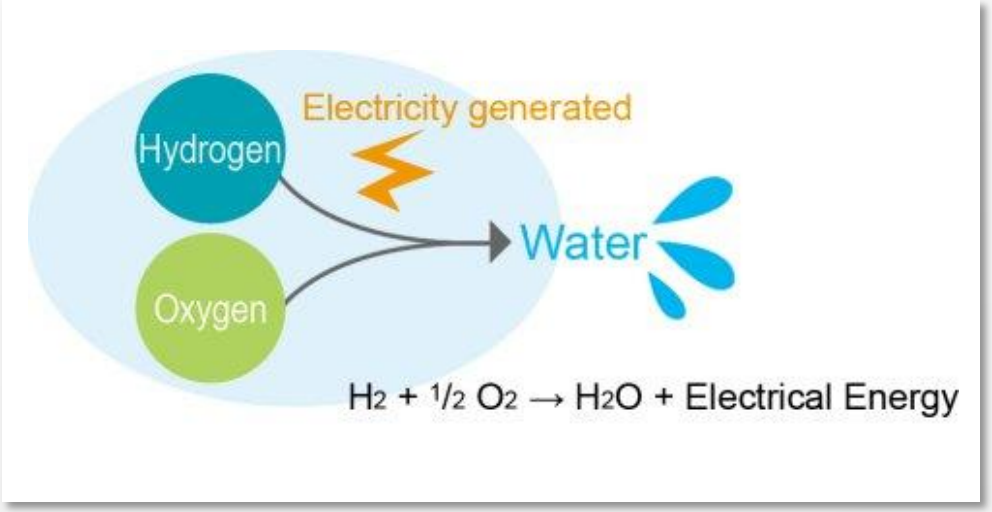
A Fuel Cell works like a battery… with on-board fuel (H_2)

Fuel Cells and Batteries are cousins

Fuel Cells generate water



Mirai's Fuel Cell Vehicle architecture

Built on the hybrid architecture, but replacing the combustion engine by a fuel cell stack, and the fuel tank by a hydrogen tank (Movie 1)

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Competition so far

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ix35 FUEL CELL

Fuel Cell
Output: 100 kW

Hydrogen tank
Storage method: 5.64 kg H_2
Filling pressure: 70MPa

Cruising range
Approx. 594 km

Filling time
3-4 minutes

Competition following Toyota's direction

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For many OEM, FCV are serious candidates, while for Toyota Mirai is now a Reality!

NOW

2016

2018

TOYOTA OPENED ACCESS TO 5,680 PATENTS

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Facts & Figures about Hydrogen

Toyota's Hydrogen Fuel Cell Technology

Toyota's approach to uncompromised Safety

Is Hydrogen safe? … Mythbusting

Misconceptions about Hydrogen make it perceived as dangerous

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Is Hydrogen safe? … Mythbusting

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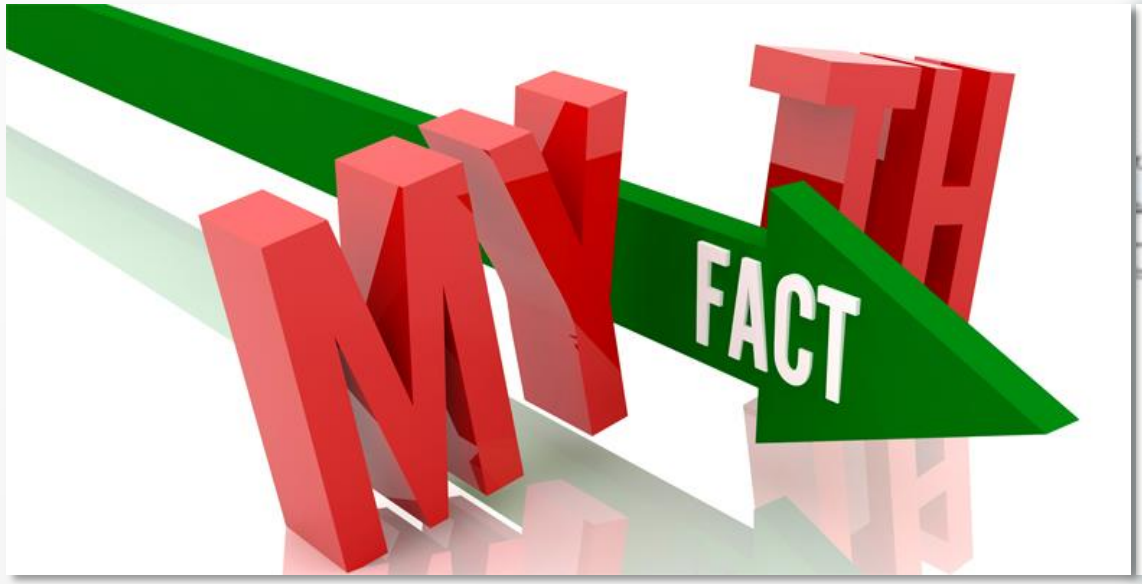
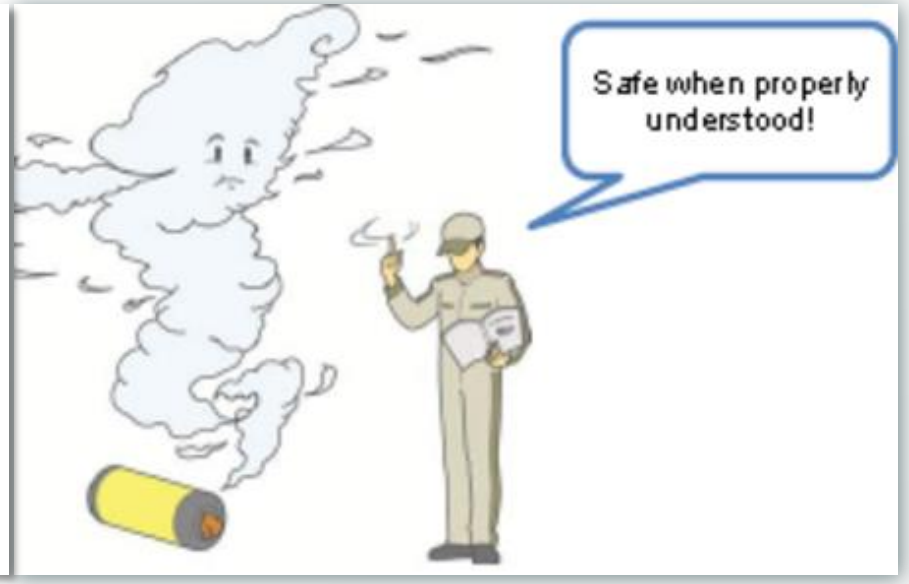
But H_2 is no ghost to be scared of!



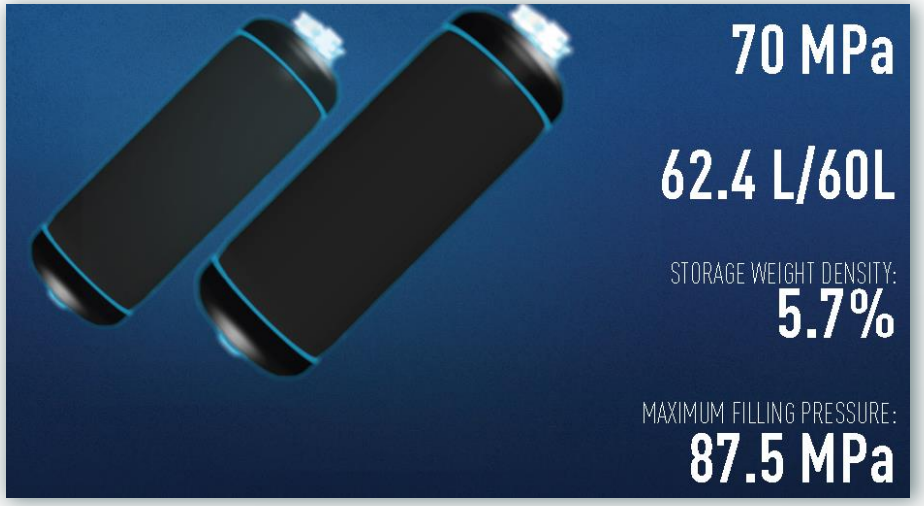


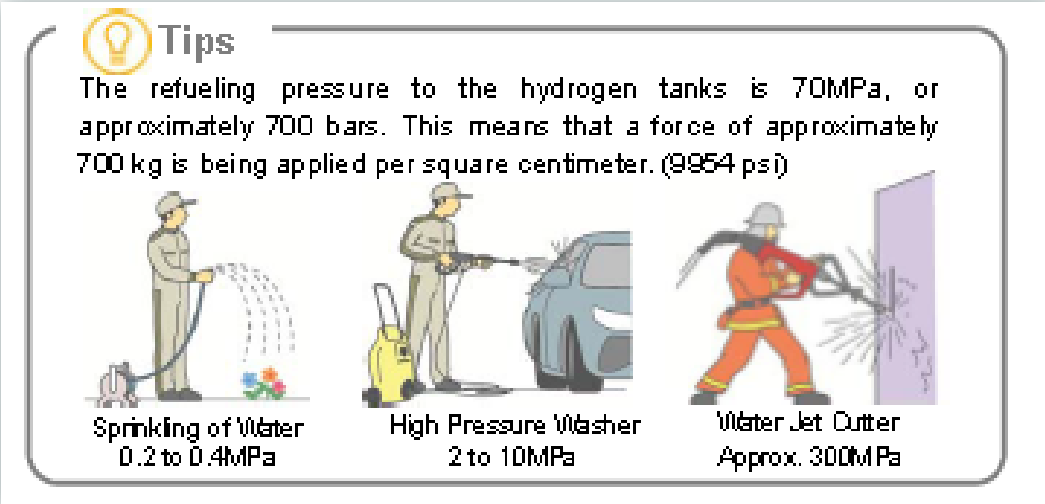
Toyota takes this very seriously

and Mirai is even safer than a gasoline car!

H_2 is safely stored in pressurised tanks

- Toyota makes high-pressure tanks with **unprecedented quality, safety and durability requirements**
- **Toyota authorised to self-inspect tank**

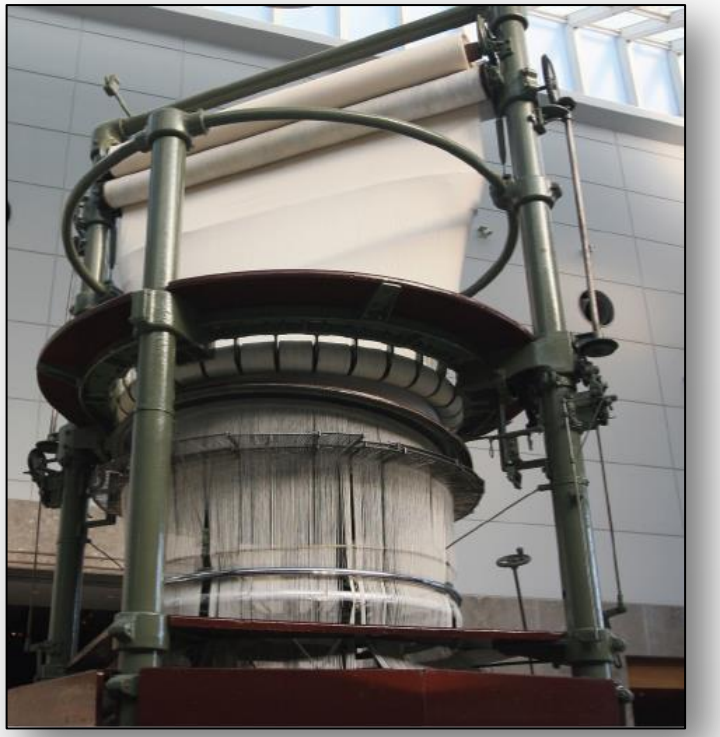




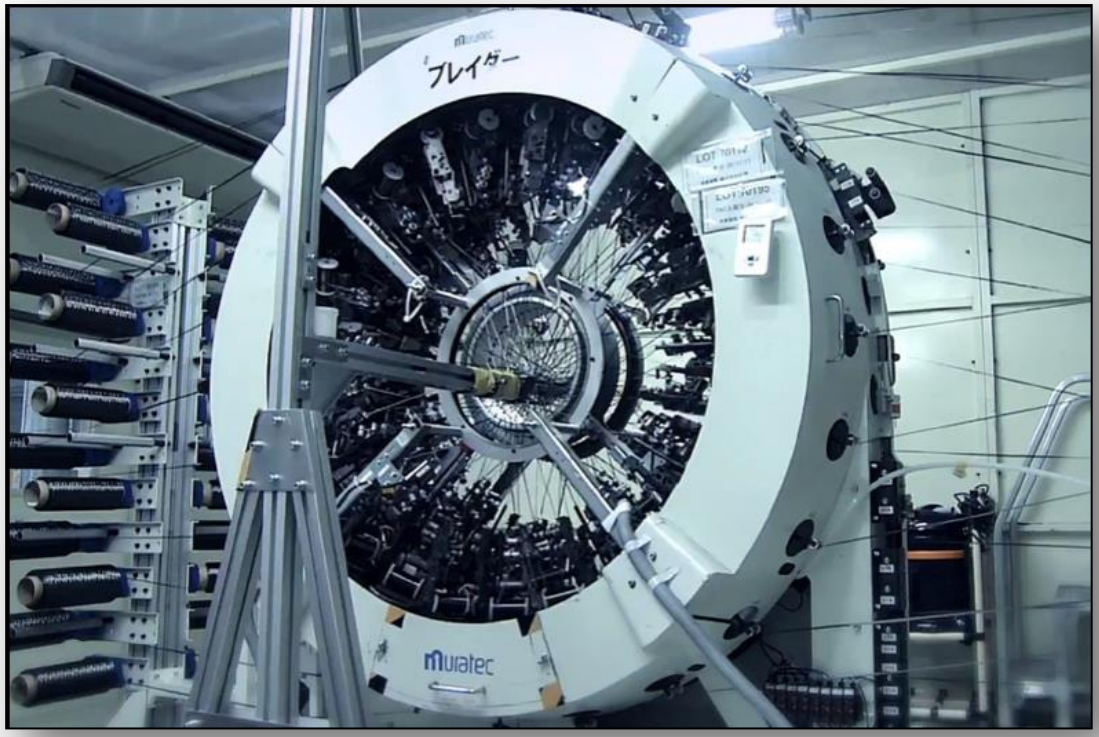
- **700 bars is the standard pressure**
- 700 kg/cm2 is huge, but **Toyota's carbon-fibre is designed to withstand 225% of this value**

- Source: Toyota's Safety Guidance manual 2015.
- 700 bars = 40 times what the stone bed of the Eiffel Tower withstands (18.7 kg/cm2)

Leveraging 90 years of know-how



TOYODA weaving machine 1926



TOYOTA H_2 tank weaving machine 2015

290 PATENTS!

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H_2 tank tests are extremely severe

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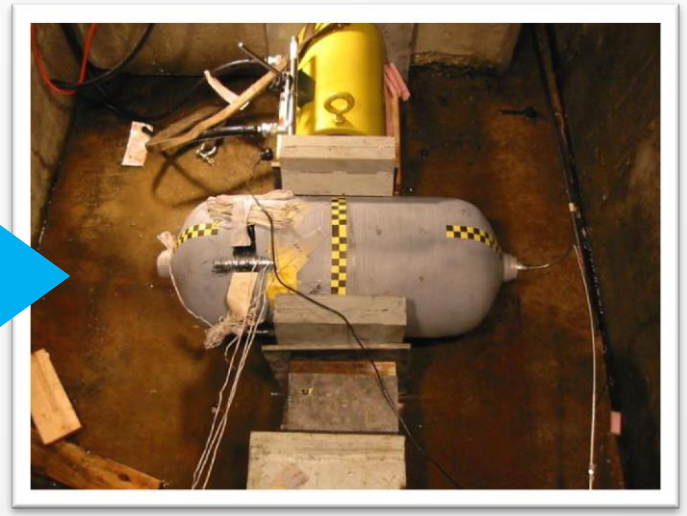
Tank designers and inspectors run a load of harsh tests in laboratories

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

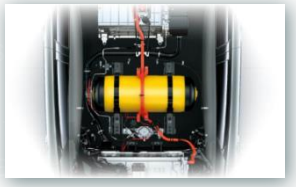


Armour-piercing 7mm test according to UN Technical Regulation

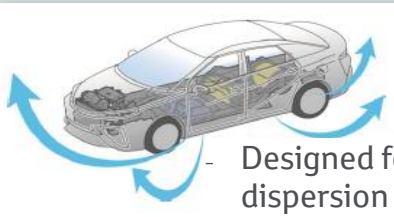
Mirai is designed for safest H_2 operation

A 4-fold comprehensive strategy to handle Hydrogen safely in any scenario

- No Hydrogen permeation
- Robust Carbon-fiber body
- Certification to stringent regulations
- Collision-safe body

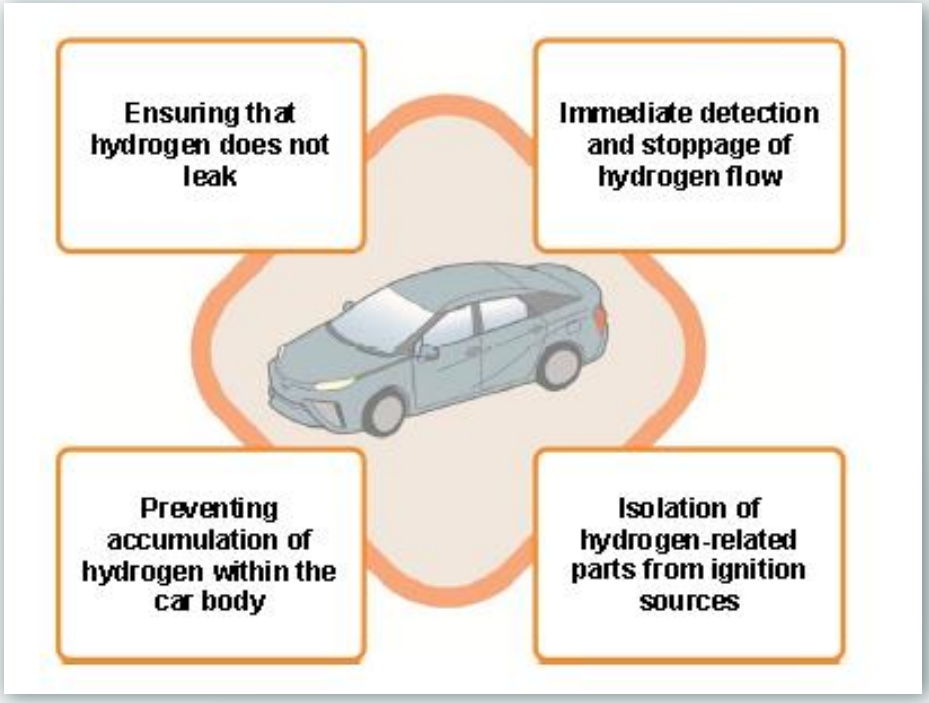


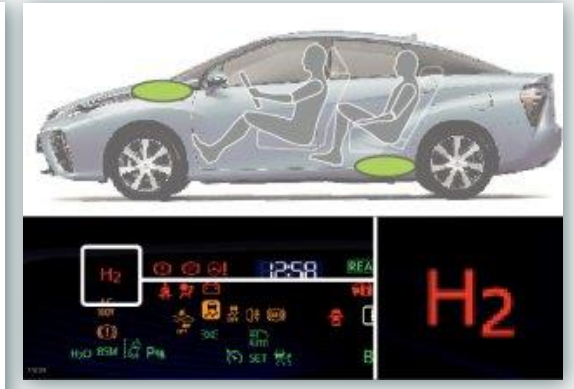
- Hydrogen detectors located in strategic spots
- If necessary, the valve on the tank is closed to automatically shut off the fuel line.

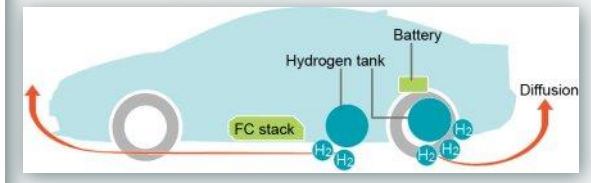


- Designed for easy dispersion of any H2

- All hydrogen-related parts (FC stack, hydrogen pipes, tanks located outside of the cabin.







- No ignition source installed in the vicinity of H2 components

Source: Toyota's Safety Guidance manual 2015.

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A Safe integration of TFCS*

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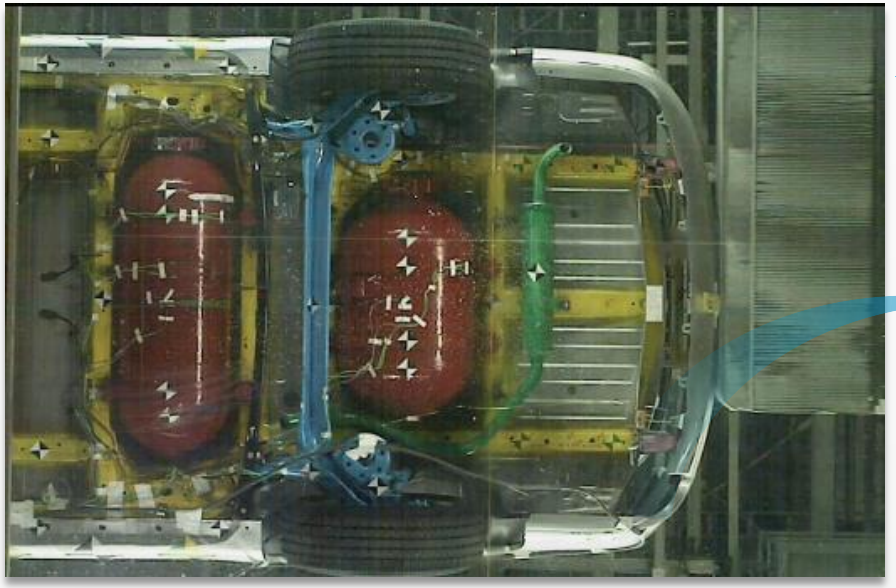
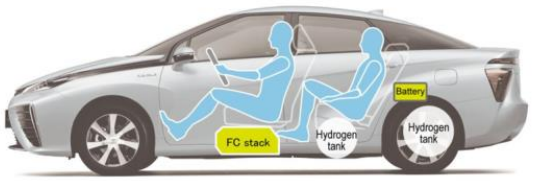
FCV or not, Toyota vehicles have to pass the same safety tests



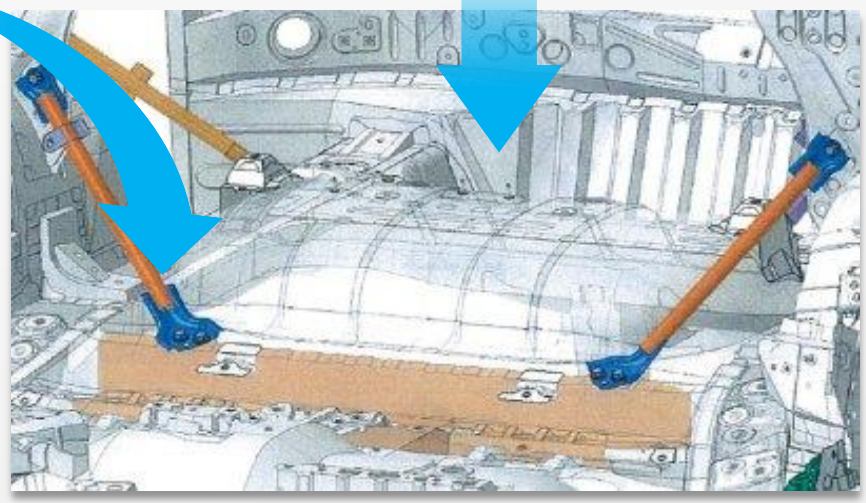
Torsional rigidity is enhanced by firmly connecting the underbody structure with the stack frame



Rear Crash Test on Mirai (Movie)

Ogiso Chief Engineer Briefing to Media, 17th Nov 2014, LA

Rigidity improved by using braces around the rear suspension



* Toyota Fuel Cell System...Cousin of Toyota HSD...

Conclusion

H_2 has a fantastic potential

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- Enables a higher mix of renewables
- Zero emissions
- Efficient transformation of energy
- Can be locally produced from various energy sources

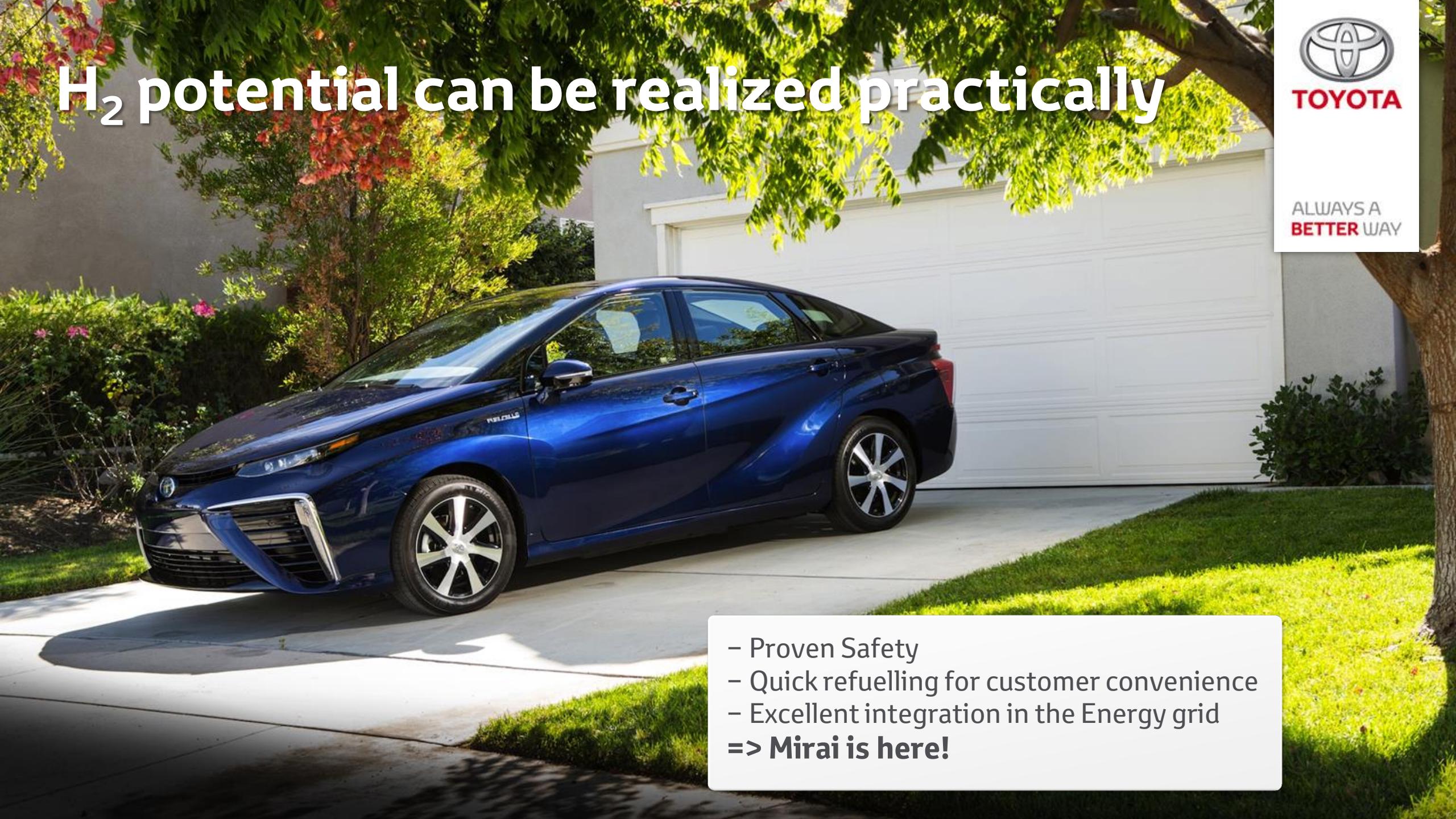
1 Climate change ✓

2 Air quality ✓

3 Energy Efficiency ✓

4 Energy Security ✓

H_2 potential can be realized practically



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- Proven Safety
- Quick refuelling for customer convenience
- Excellent integration in the Energy grid

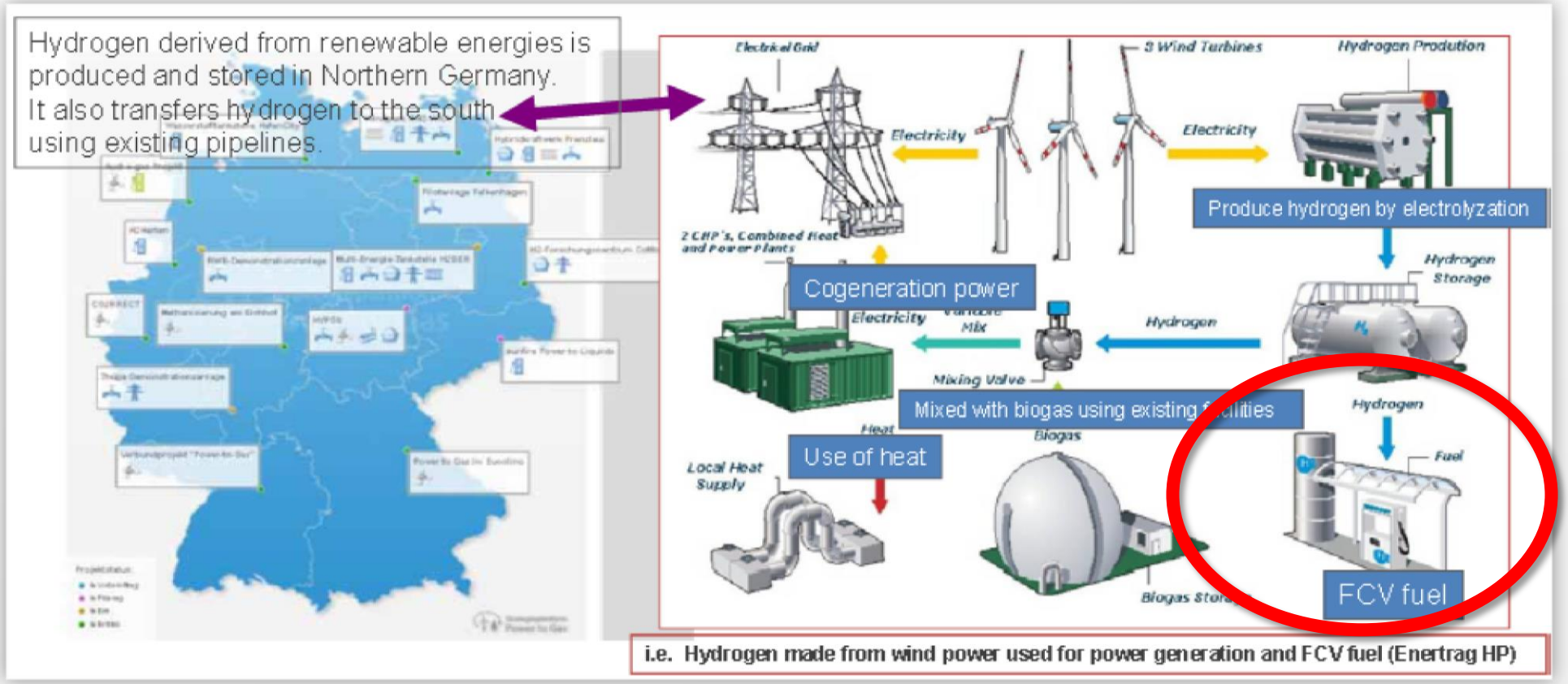
=> Mirai is here!

Thank you

Back up slides TBD

Example of smart H2 integration

- Smart H2 grid is already a reality in Germany (rising Wind Power)
- H2 is an effective storage means for renewable electricity



11 sites in operation, 2 under construction and 8 in planning phase

http://www.powertogas.info

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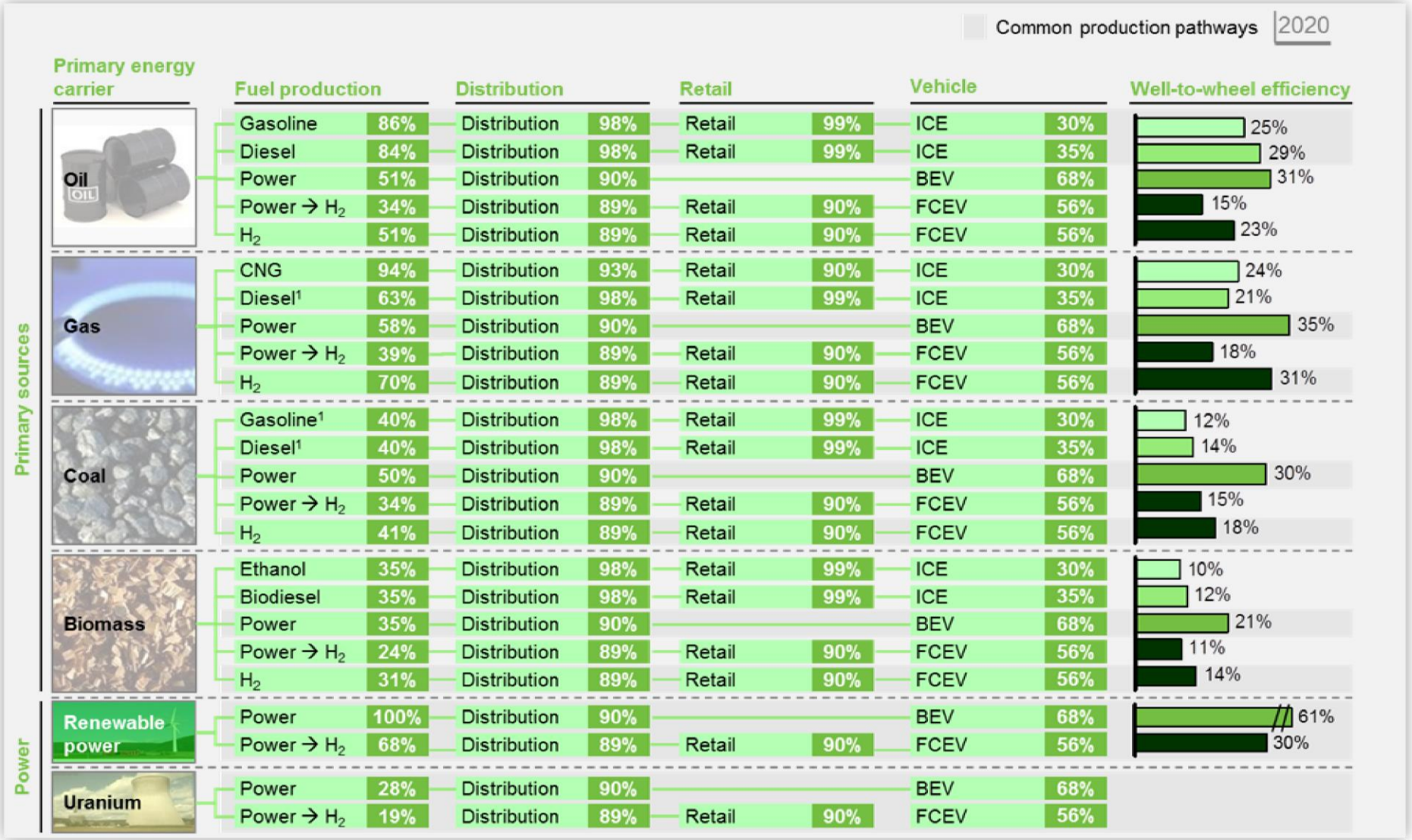
WtW efficiency FCV and EV well ahead

Source: 2010 study by McKinsey, Portfolio of Powertrains



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Our Hybrid heritage

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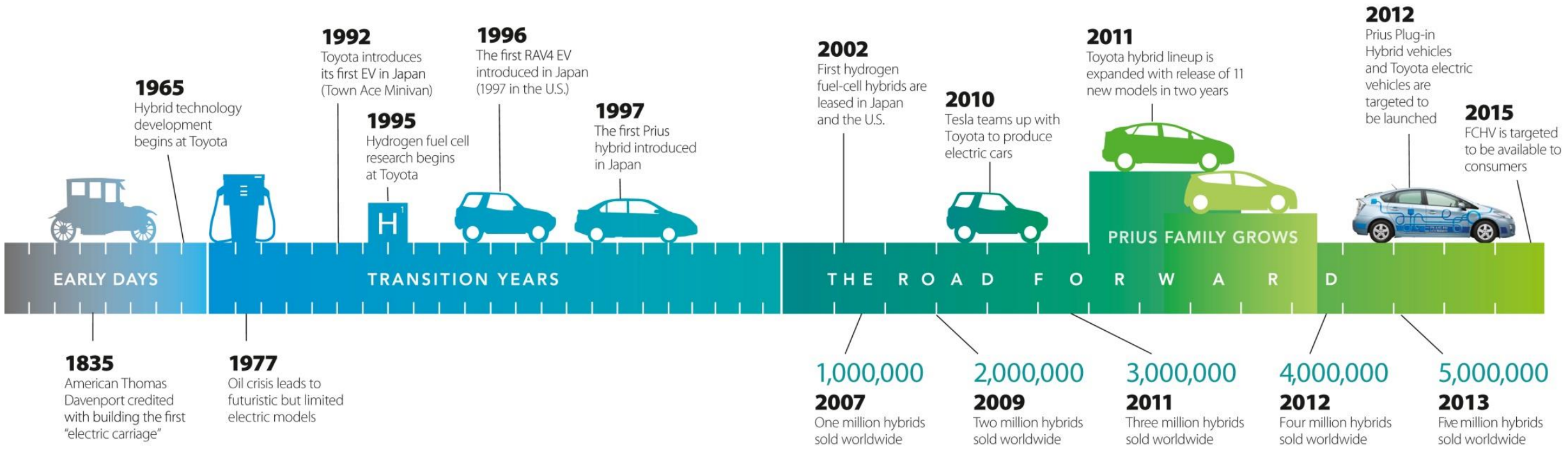

Great progress made

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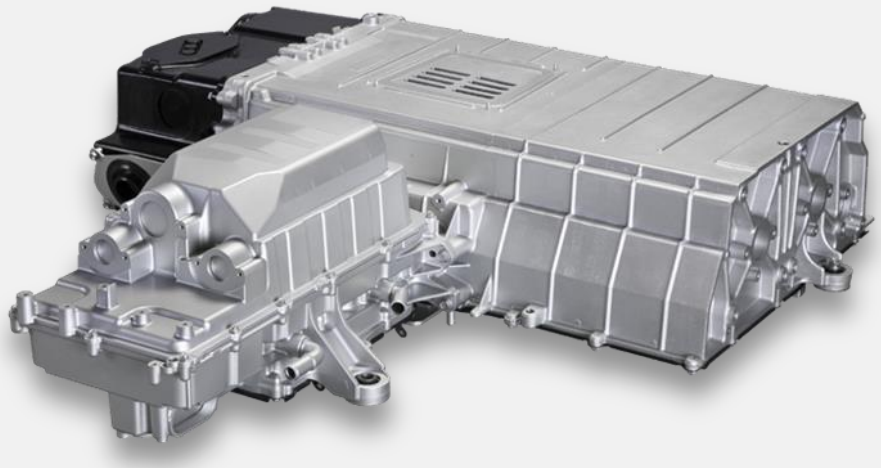
New Fuel Cell Stack



Compactness (Power density: 3kW/L)

From 4 to 2 hydrogen tanks

Lighter, more compact storage

Toyota FCV
Some Facts & Figures

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A Pioneering Powertrain

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Performant Fuel Cell Stack

Max Output 114kW / 155 DIN hp
Volume Power Density of 3.1 kW/L 🌍

Confident Performance

0-100 km/h in 9.6 sec
40-70 km/h in 3.0 sec
Top speed 178km/h

Silent and Smooth Electric Motor

Max Torque 335Nm

2 State-of-the-Art H2 Tanks

Storage Density of 5.7 wt%
Storage Mass of approx 5.0kg

🌍 **World top level, according to Nov '14 Toyota data**

Global Market introduction

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JAPAN Before April 2015

USA Summer 2015

US Special Ambitions

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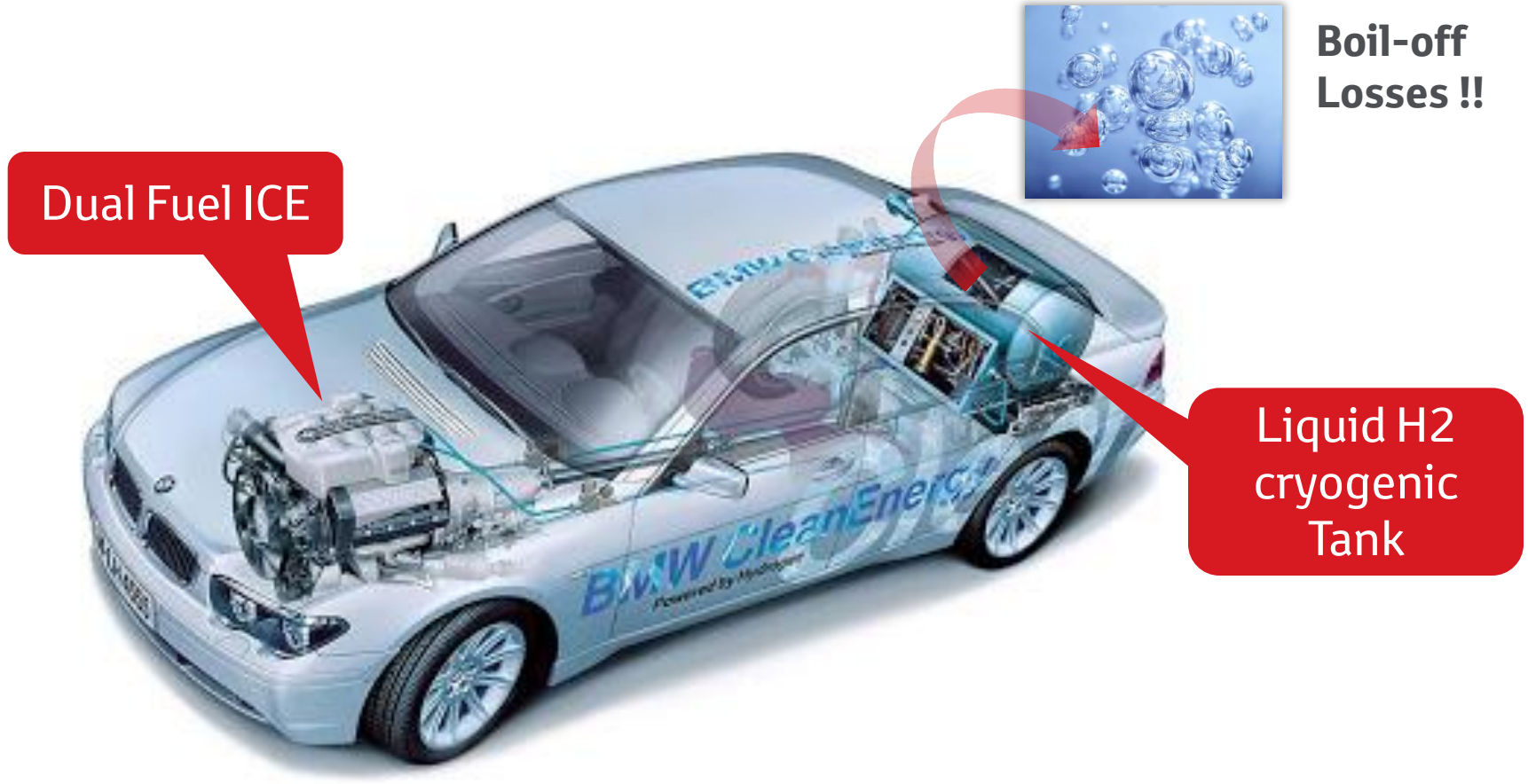
Frequent Confusion: ICE H2 vs FC

- Hydrogen can be burnt in an internal combustion engine (ICE)
- BMW built H2-ICE prototypes in the past using flagship 7 serie



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No unique solution, smart trade-offs

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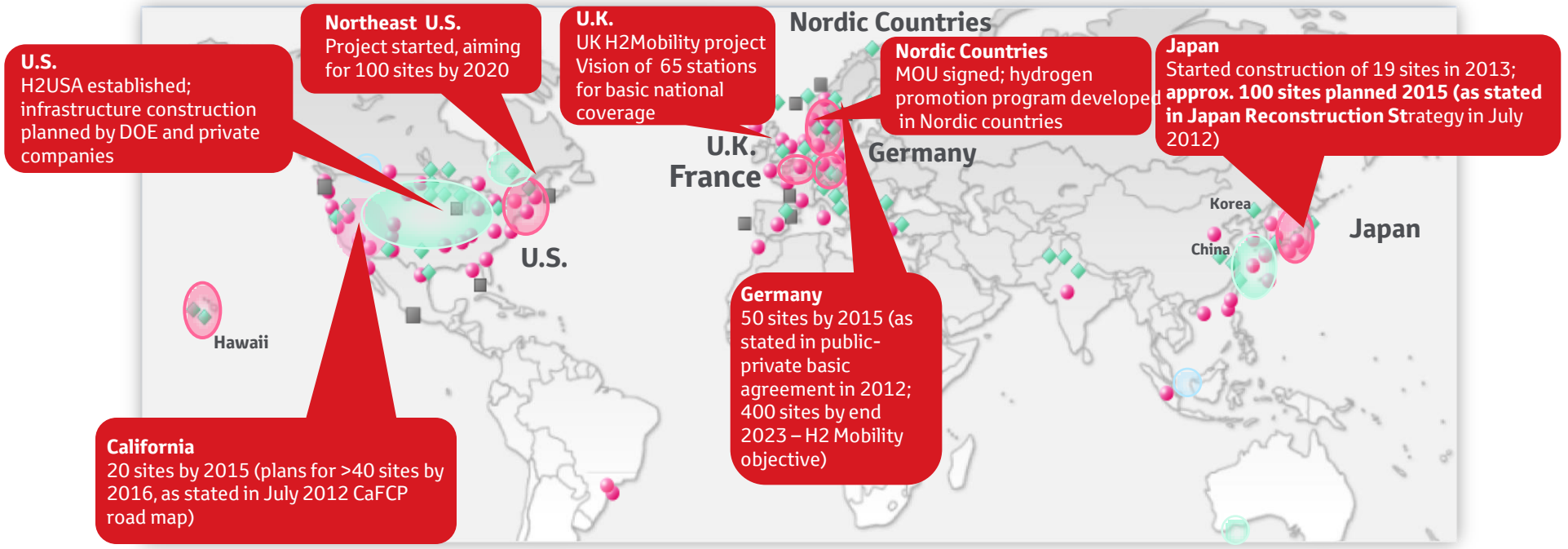
	Electricity **EV**	Hydrogen **FCV**	Biofuel **Internal combustion engines**	Natural gas **Internal combustion engines**
Well-to-wheel CO_2	Bad to Excellent	Bad to Excellent	Good to Excellent	Adequate
Supply volume	Excellent	Excellent	Bad	Excellent
Cruising range	Bad	Good	Excellent	Good
Dedicated infrastructure	Good	Bad	Excellent	Good

Where can I refuel in the world?



Several hundred hydrogen stations are planned by 2015 globally

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The Can Opener Wasn't Invented Until 48 Years After the Invention of the Can

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FCV and HRS will roll-out together