



EVS30 2017

The Future of Fuel Cell Vehicles (FCV)

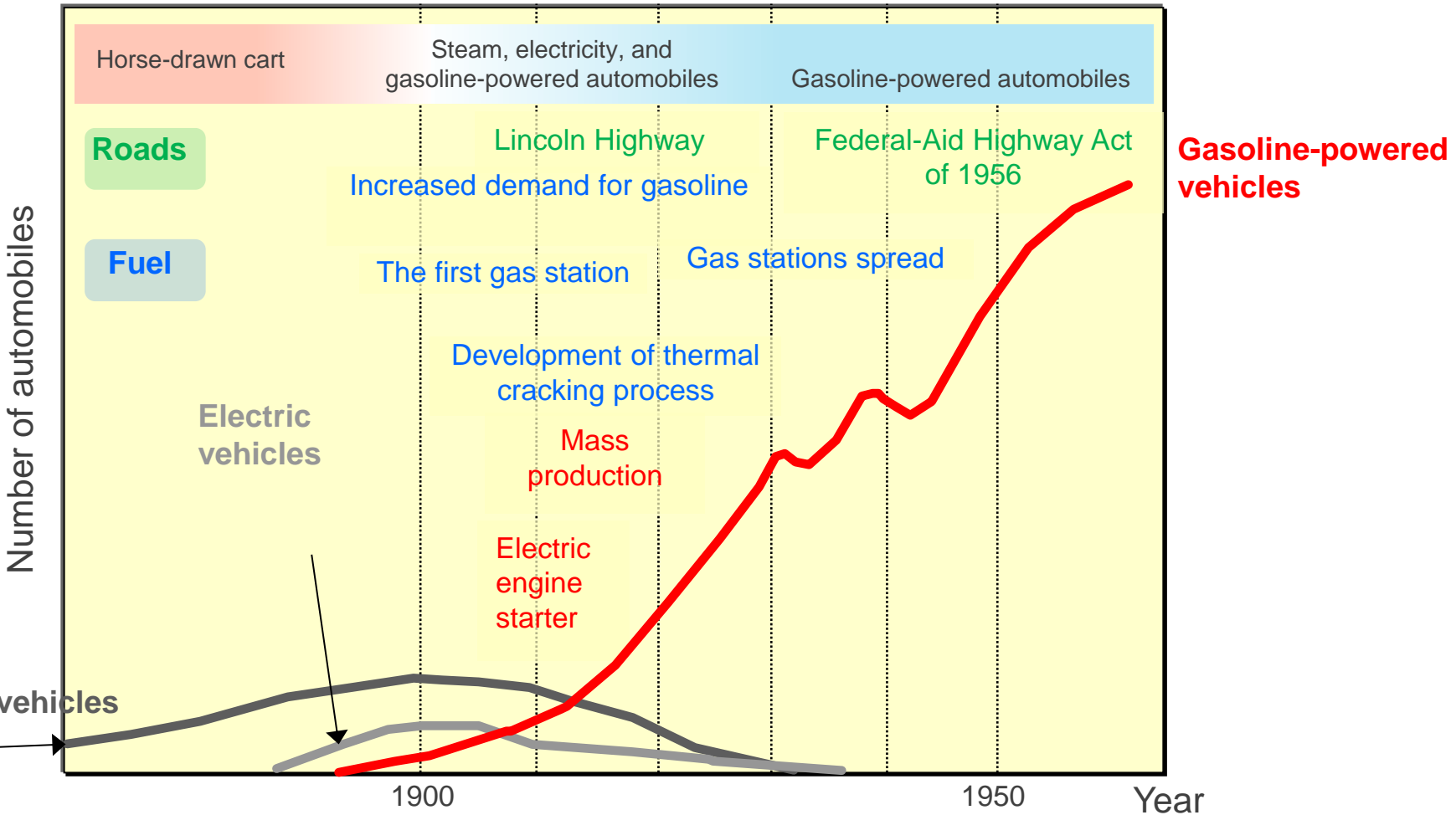
Oct. 9th , 2017

Yukihiro Sonoda

Toyota Motor Europe



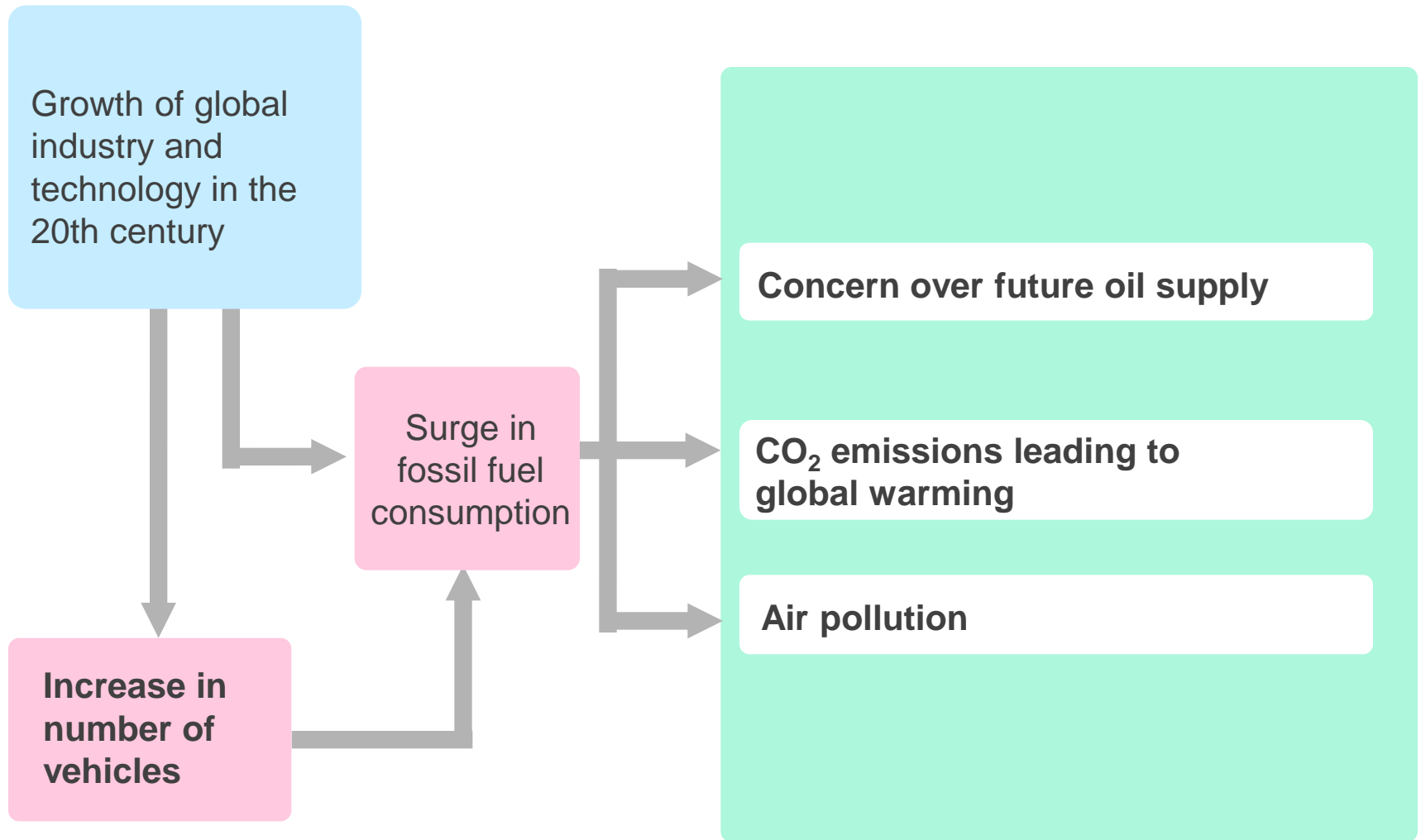
The age of gasoline-powered automobiles

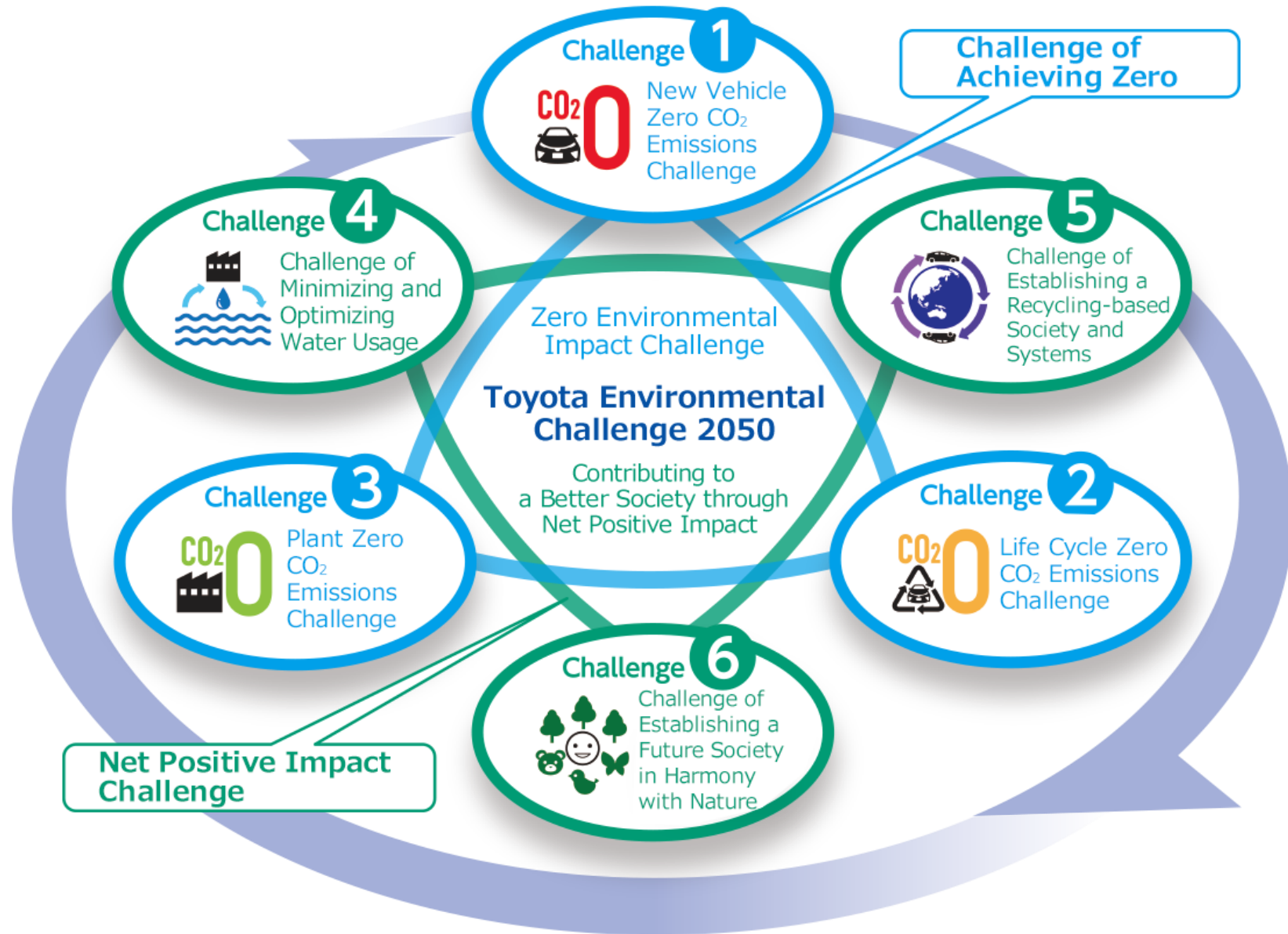


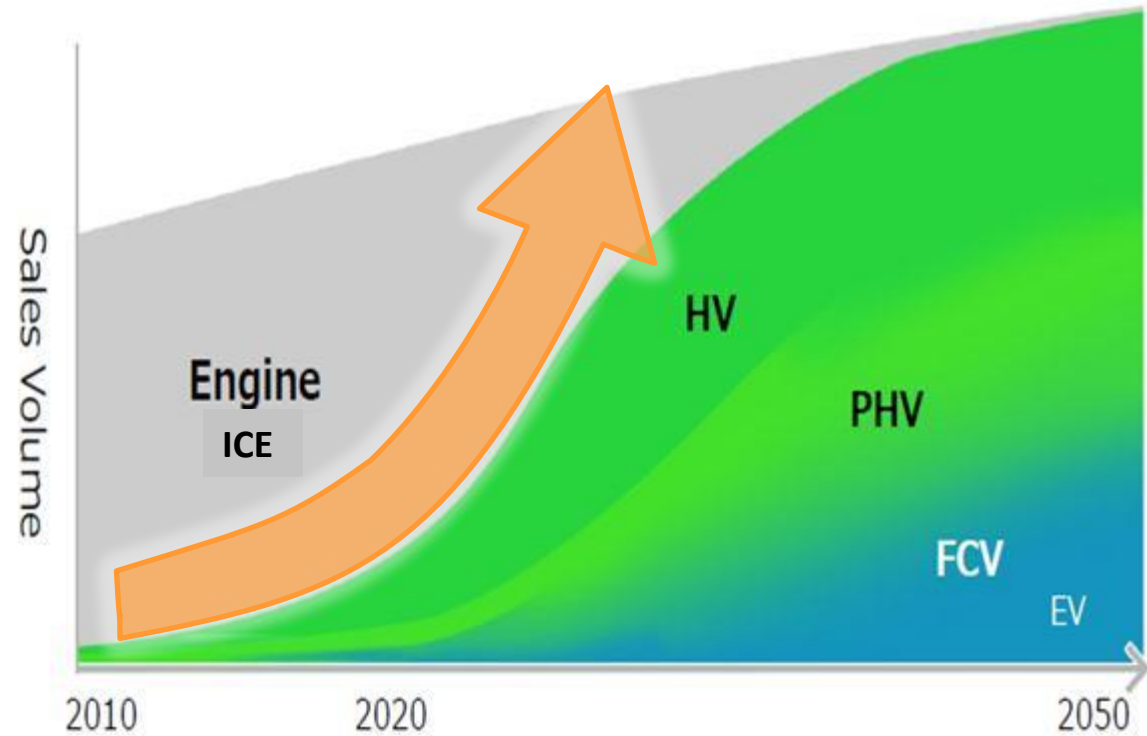
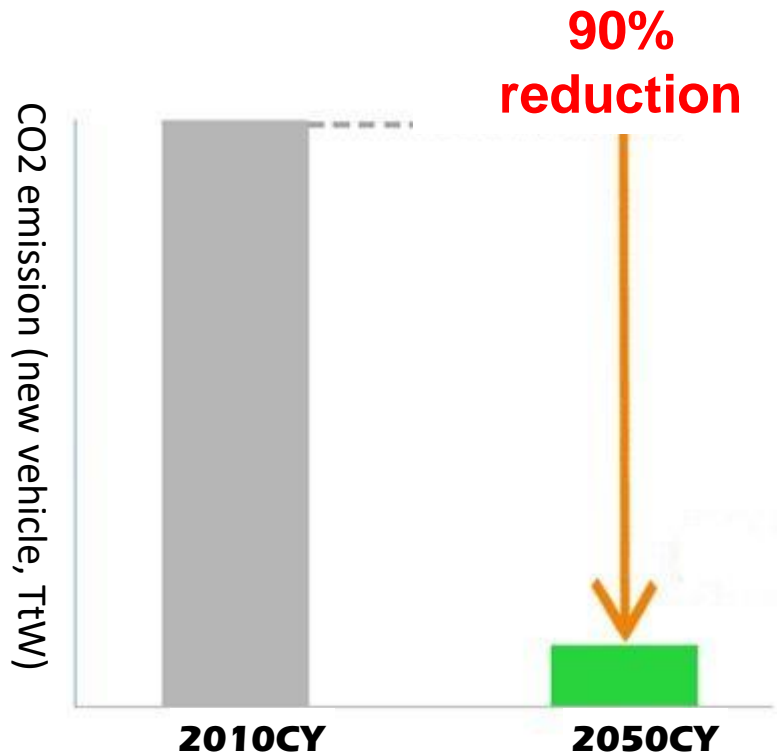
The simultaneous development of technologies, roads and fuel gave rise to the age of gasoline-powered automobiles



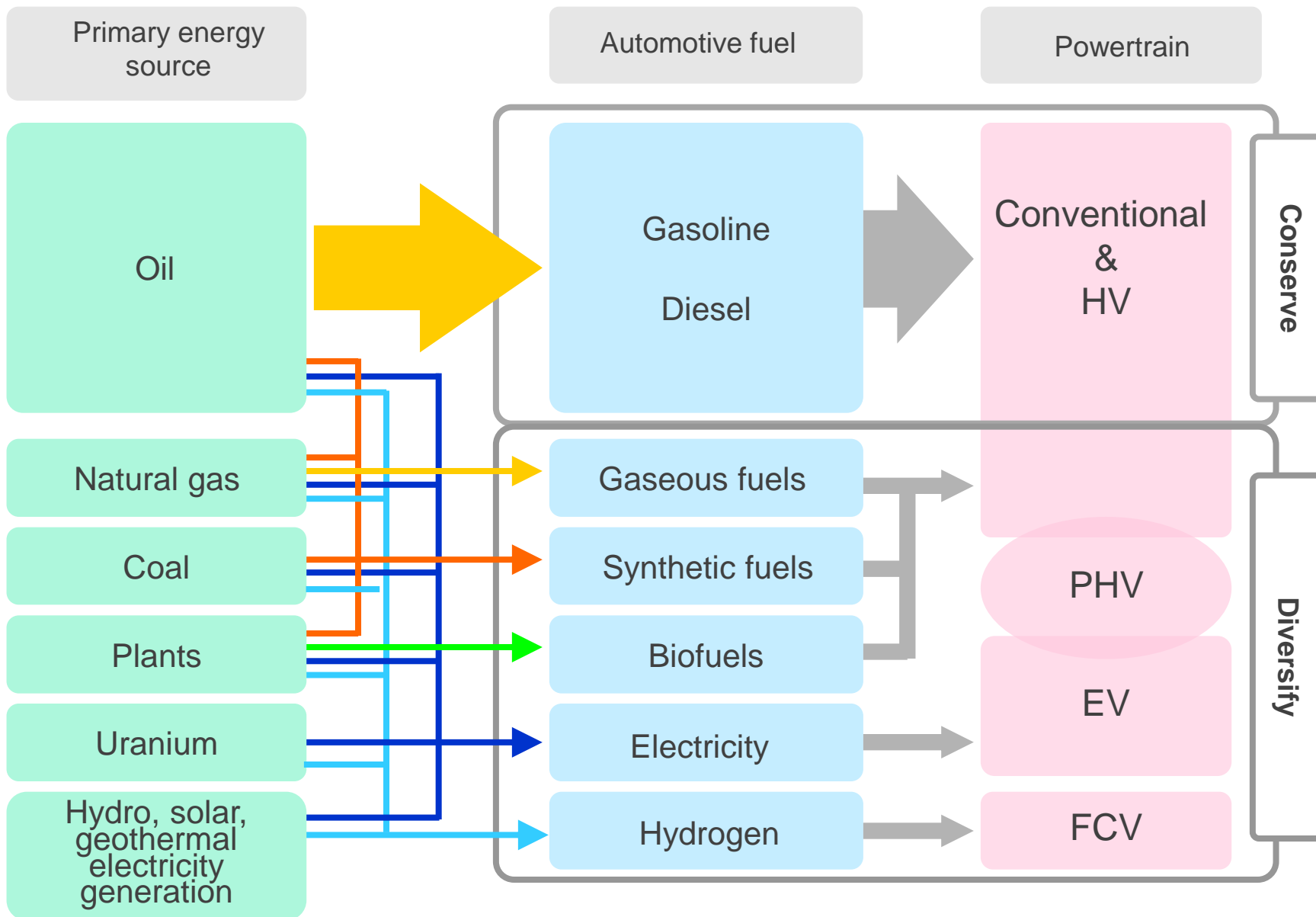
Challenges for automobiles during 21st century







- 90% CO2 reduction of new vehicles by 2050.
- Accelerate next generation vehicle development.

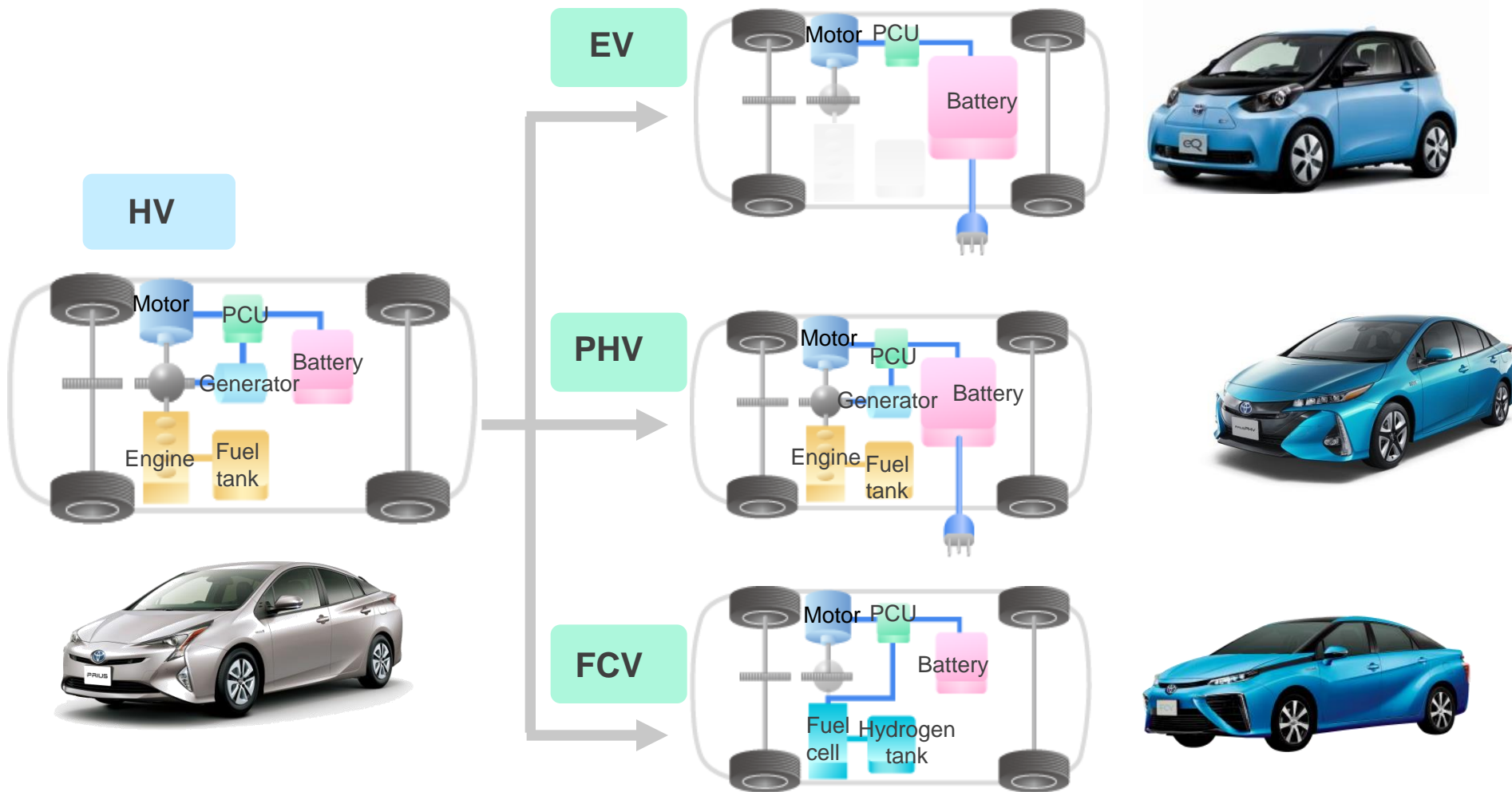




Corresponding to diverse energy sources

Developing efficient, low-emission vehicles

Push forward real and positive change by popularizing these vehicles



Hybrid technology underpins Toyota's PHV, EV and FCV



Energy diversification

- Hydrogen can be produced using a wide variety of primary energy sources

Zero emissions

- Zero CO₂ emissions during driving

Fun to drive

- Smooth and quiet operation
- Smooth start and good acceleration at low and medium speeds

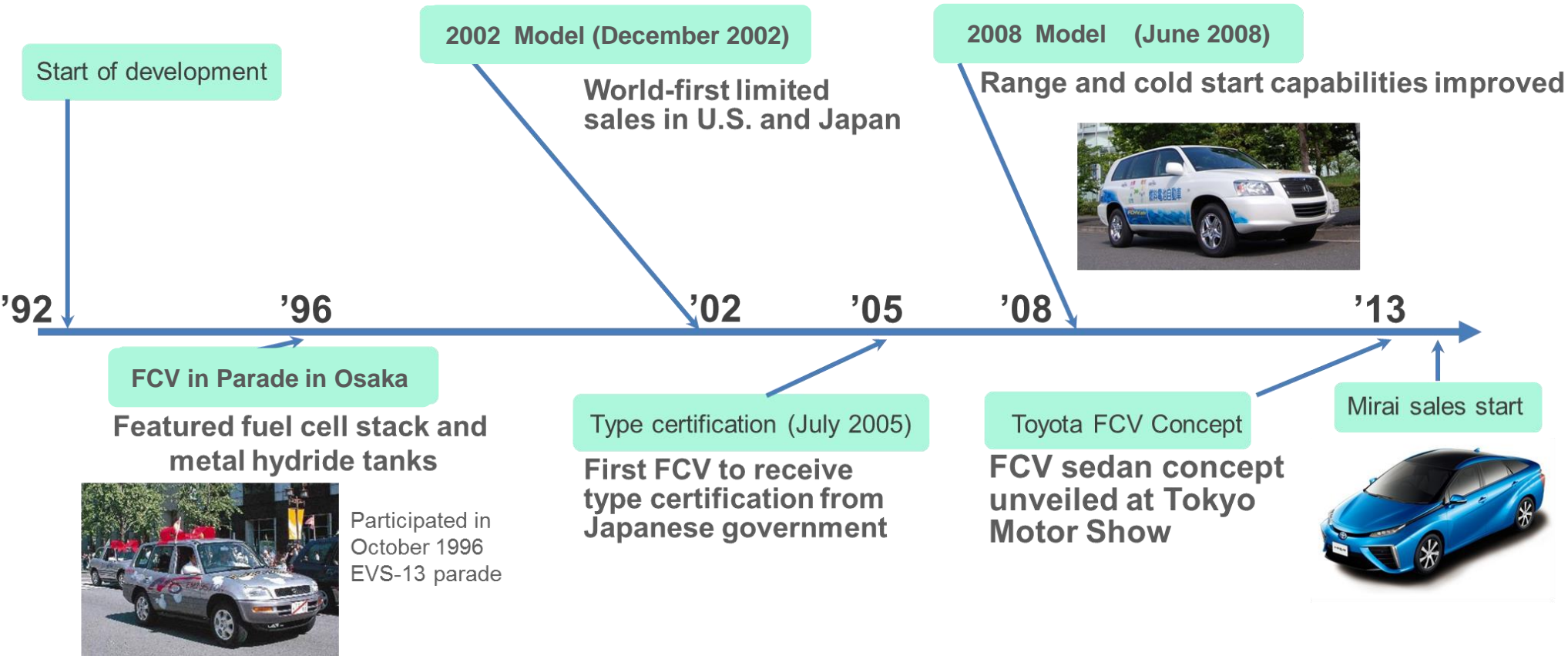


Performance

- Range similar to a gasoline vehicle
- Refuels in approx. 3 mins.

Large power supply capability for emergencies

- Can be used as a high-capacity power supply



Development began in 1992. Since then, over 100 FCVs have driven 2 million kilometers in Japan and North America

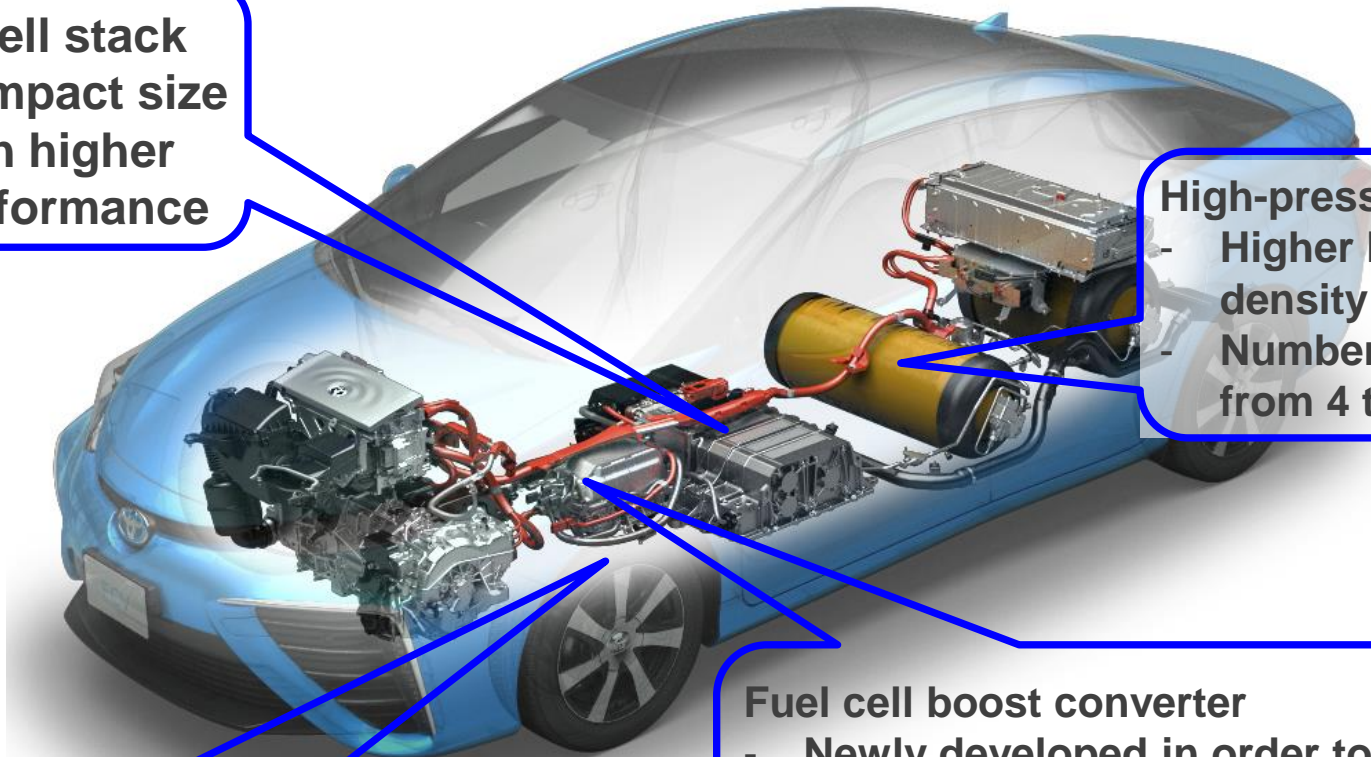


Launch of “MIRAI” Fuel Cell Sedan From December 15th, 2014 in Japan (from fall, 2015 in USA and Europe)

- Sales started from areas where hydrogen stations are in place and in surrounding areas.
e.g. 4 metropolitan areas in Japan
(Tokyo area, Chukyo, Kansai, Fukuoka)
- Vehicle price is 7.23 million yen (including tax)

The annual production increased to approx. 3,000 vehicles in 2017,
The MIRAI domestic registration number reached at approximately
1,400. (at end of December, 2016)





Fuel cell stack
- Compact size with higher performance

High-pressure hydrogen tank
- Higher hydrogen storage density
- Number of tanks reduced from 4 to 2

Elimination of humidifier
- Internal circulation system adopted

Fuel cell boost converter
- Newly developed in order to reduce the number of cells, for enabling the use of existing hybrid units.

The size and cost of the systems have been reduced, while the characteristic benefits of FCVs has been increased.



Toyota Motor Corporation
FCV

「MIRAI」



Hino Motors, Ltd.
FC bus



Toyota Industries Corporation
FC forklift



Pilot program period:
Dec. 2012-Mar. 2014

Location:
Kita Kyushu Plant, Toyoda Gosei

Aisin Seiki Co., Ltd.
Co-gen. SOFC system for household use




Generation efficiency:
46.5%
(world's highest level)

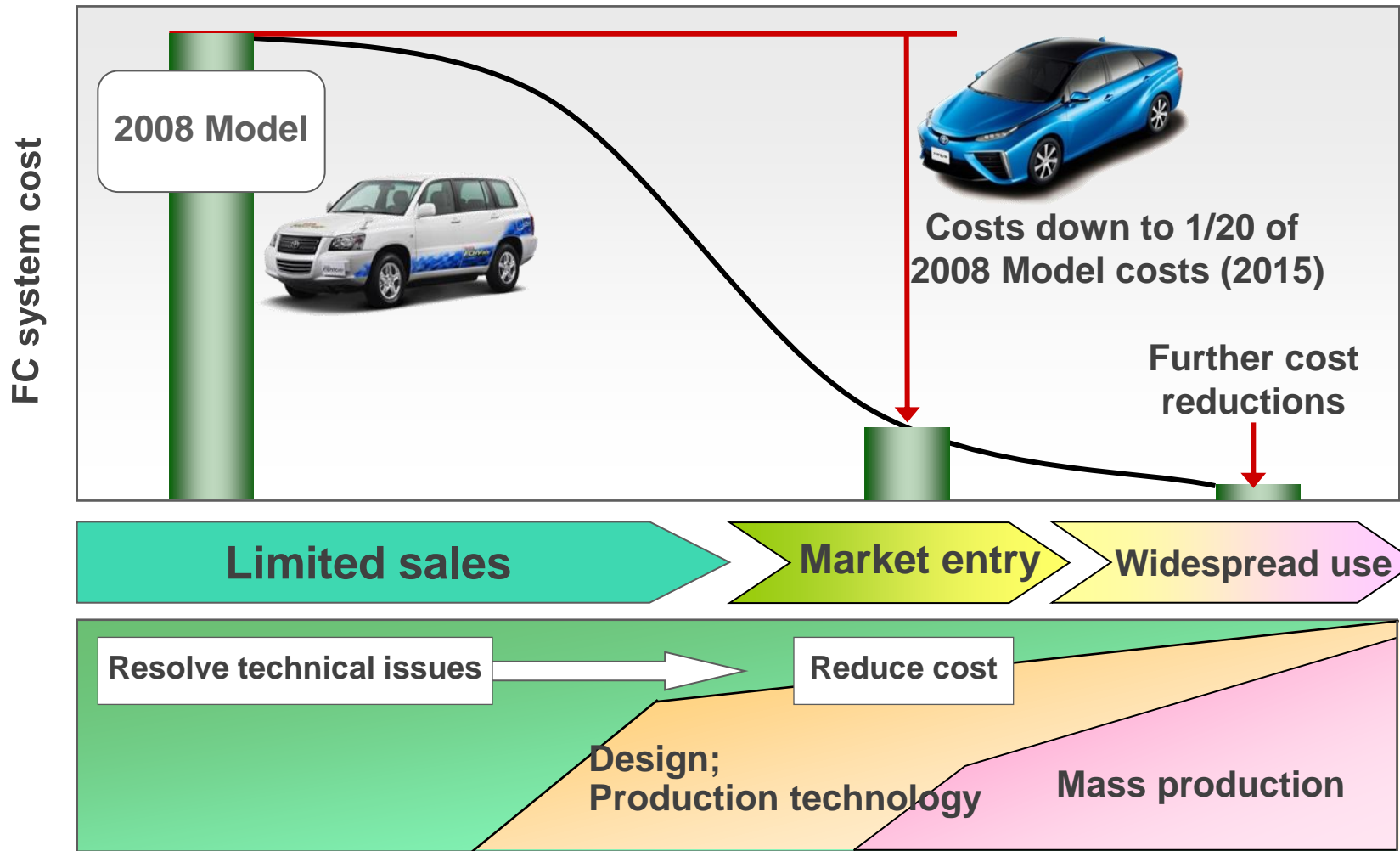
Launched April 2012

Osaka Gas, Kyocera,
and Chofu Seisakusho

Toyota Tsusho Corporation
Hydrogen filling station



Ecoful-town at Toyota city
(HySUT : Iwatani Corporation, TOHO GAS CO., LTD)



Fuel cell system costs have been reduced significantly. Effort of cost reductions will be continued



I. Elimination/Reduction of components

- **Elimination of humidification module**
- Reduction in the number of tanks

II. Use of mass-produced components

- Utilization of low price mass-produced components for hybrid vehicles, etc.



III. Simplification of component structure

- Review of structure of FC stack, high-pressure hydrogen tank, etc.

IV. Reduction of material cost

- **Increase in the FC Stack output density => Downsizing and enhancing performance**
- **Reduction in the Pt catalyst usage (FC Stack)**
- **Reduction in the carbon fiber usage for high-pressure tanks and its cost**

V. Improvement of production methods

- High speed electrolyte membrane handling (MEA)
- Automated cell stacking
- **High speed tank winding**

1/20 of FC system cost reduction



- FCV sales volume

Global : More than 30,000/year around 2020 and later

Japan : Approx. 1,000/month around 2020

1X,000/year @2020 and later

- FC bus introduction

to start from February 2017 for Tokyo

100 or more by 2020

for Tokyo Olympics/Paralympics



**Toyota to start sales of FC buses under the Toyota brand from early 2017
The Tokyo Metropolitan Government plans to utilize as fixed-route buses.**

- **Toyota aims to engage continuously in the diligent development targeted at the expansion of the introduction of the new FC buses from 2018**







*Existing component

Vehicle	Length/width/height	10,525/2,490/3,340 (mm)
	Capacity (seated+standing+driver)	77 (26+50+1)
FC stack* (Fuel Cell)	Name	Toyota FC stack
	Type	Solid polymer electrolyte
	Maximum output	114 kw x 2units
Motor*	Type	AC synchronous
	Maximum output	113kw x 2units
	Maximum torque	335N·m x 2units
High-pressure hydrogen tank*	Type	Compression hydrogen
	Nominal working pressure	70MPa
	Tank internal volume	600L
	Number of tanks	10
Drive battery*	Type	Nickel-metal hydride
V2H system	Maximum output/voltage	9kW/DC300V

**The FC bus was developed using a unit of MIRAI.
Cruising range is approximately 200km**



	scene	mileage (km/day)	Maximum speed (km/h)	Infra cooperation	Task	Introduction time
Large route bus 	The city and the suburban area	160	60	◎	Price Durability	FY 2016
Commuter bus 	Narrow road width, small route	100	60	◎	Market size	Undecided
Limousine 	City and airport interval	300	100	○	Power performance	Undecided
Large sightseeing bus 	From the city to the mountains Various areas	400~ 1000	100	△	Power Range	Undecided

◎ : Very Good ○ : Good △ : Fair



The spread from a route bus is the most suitable for hydrogen society realization



Fast-charge battery bus

Fuel cell bus

TRAM

	mileage	Route flexibility	Charge, Refueling	Service efficiency	Infra expense
Fast-charge battery bus	○	×	×	×	○
Night charge bus	×	○	×	×	○
TRAM	○	×	○	○	×
FC bus	○	○	○	○	○

○ : Good × : not suitable

Source : FCH 「Fuel Cell Electric Buses-Potential for Sustainable Public Transport in Europe」

At the point of view motorizing public transport, the fuel cell bus is more advantageous than charge battery bus and TRAM.



Tokyo metropolitan bus
Aug. '03-Dec. '04



Chita bus
Mar. '06-Dec. '09



Toyota city bus
Oct. '10- Mar. '13



Toyota city bus
(METI Prj: external power supply demonstration test)
Jan. '15-



Aichi Expo
Mar. '05- Sep. '05



Centrair Lamp bus
Mar. '06- Aug. '13
Kansai Airport Lamp bus
Nov. '12- Mar. '14



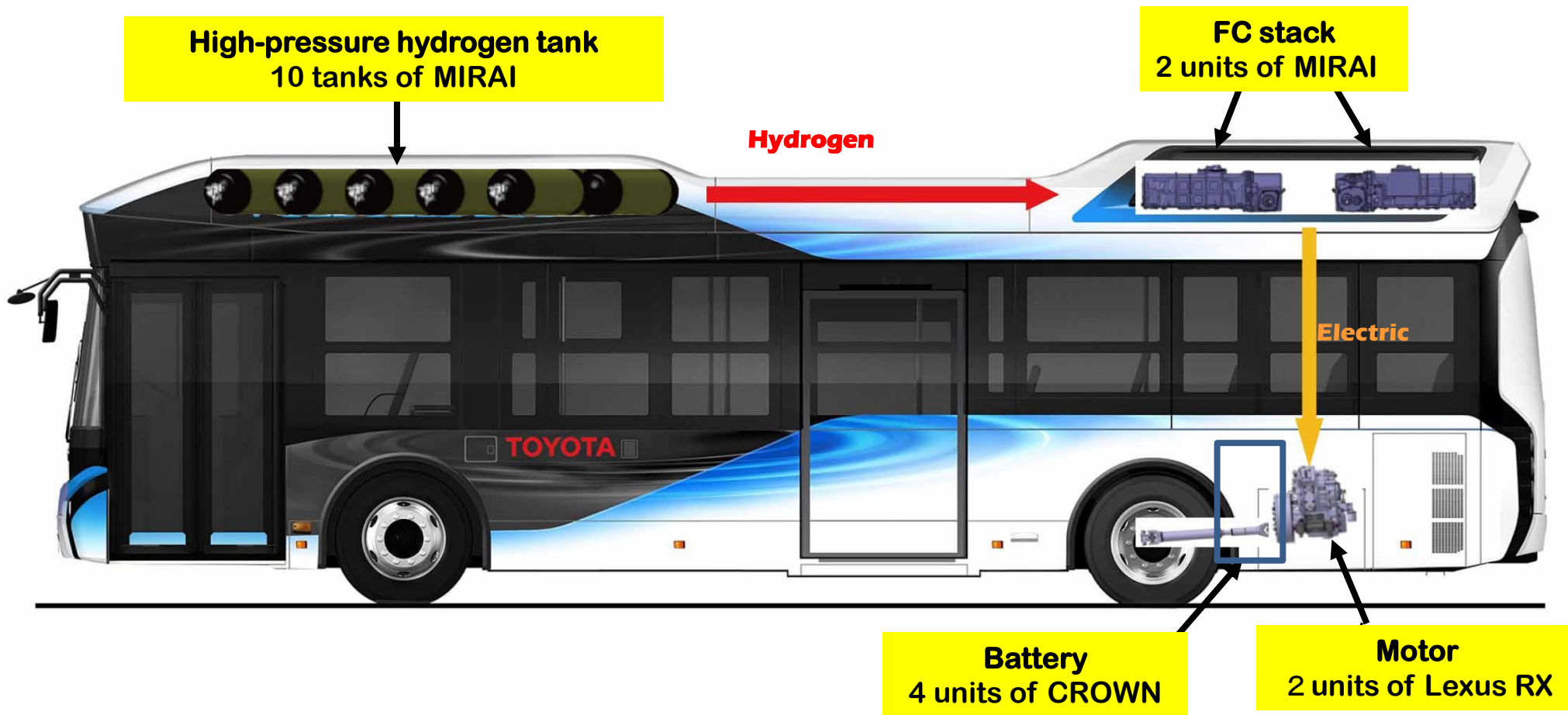
Shinjuku-Haneda Airport
Dec. '10- Sep. '13



Toyota city bus
(MOE Prj)
Apr. '13- Mar. '15



**We have continued a proof examination for fuel cell bus introduction.
Development is supported as a national project.**



Hydrogen is supplied from a high pressure hydrogen tank to FC stack. Electricity is produced by a chemical reaction of hydrogen and atmospheric oxygen.



Energy diversification

- Hydrogen can be produced using a wide variety of primary energy sources

Zero emissions

- Zero CO₂ emissions during driving

Comfort

- Smooth and quiet operation
- Smooth start and good acceleration at low and medium speeds



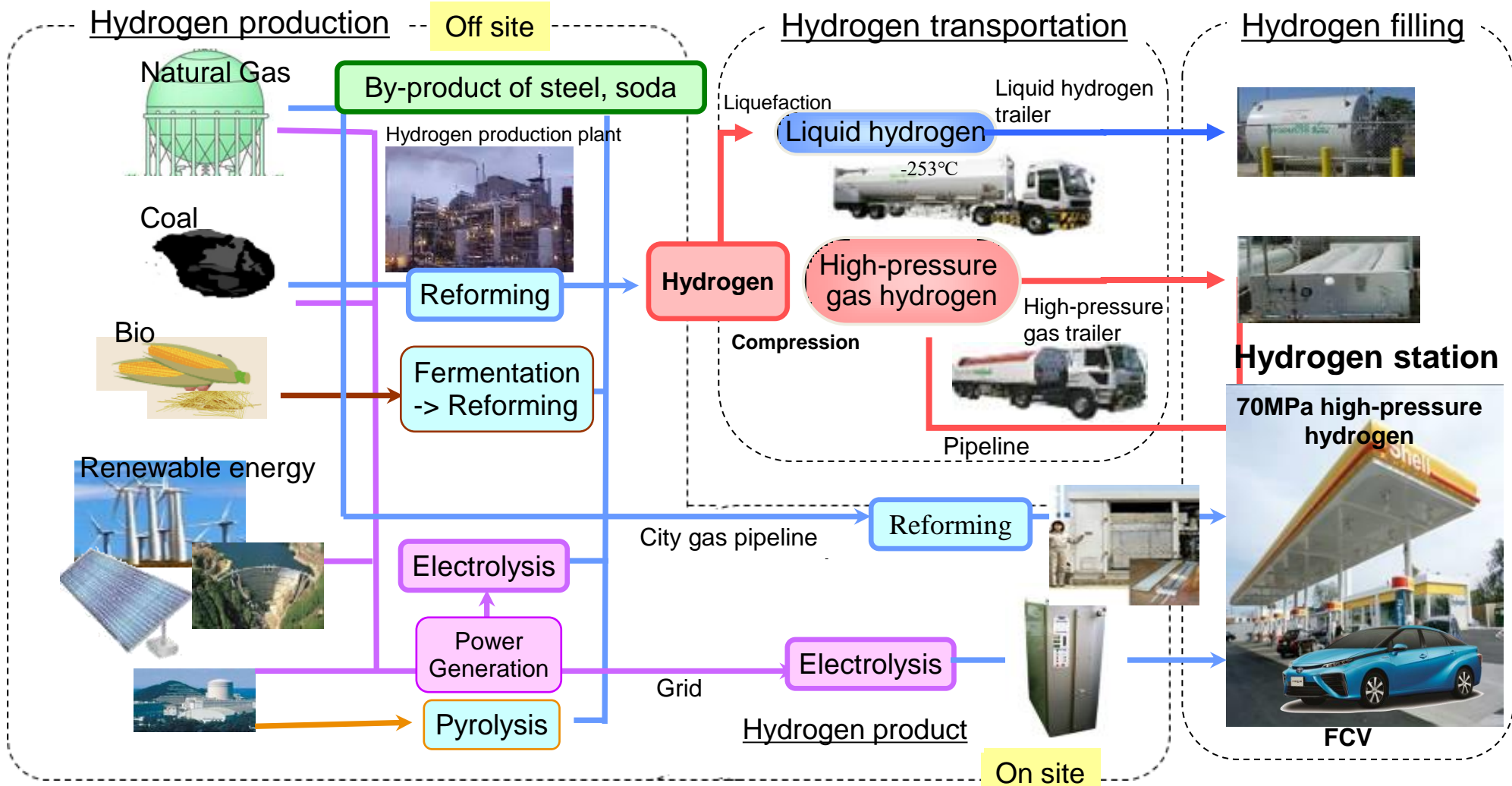
Performance

- Range approx. 200km*
- Refuels in approx. 10 mins.

* City area driving pattern
Toyota measurements

Large power supply capability for emergencies

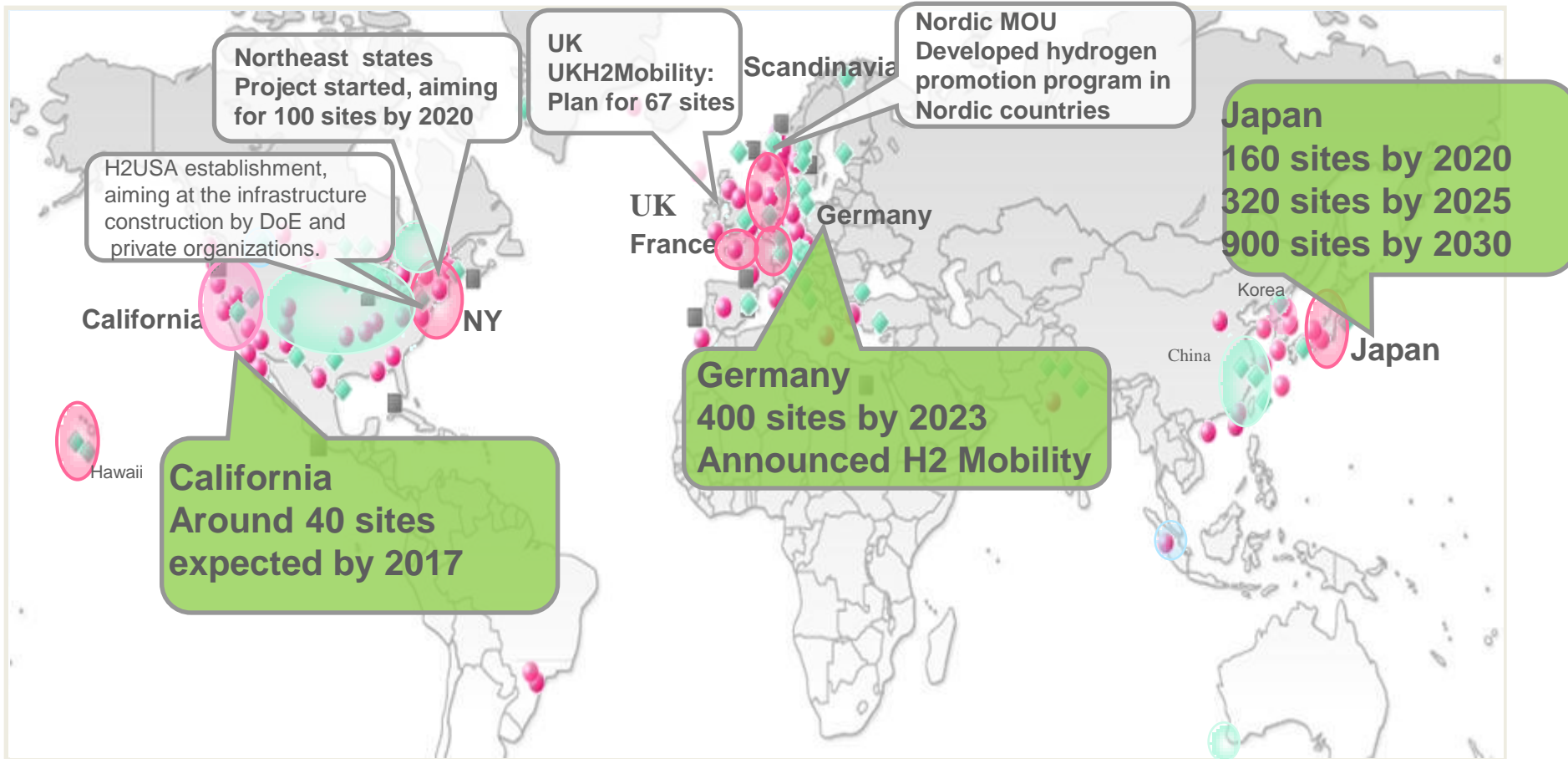
- approximately 4.5 days at evacuation center



Hydrogen has been already mass-produced for an industrial use. Hydrogen is able to produce from various primary energy sources.



Worldwide locations of hydrogen stations



- in operation
- ◆ planned
- Not in operation
- Areas where infrastructure development can be expected from early 2015
- Areas where infrastructure development can be expected after 2015

Several hundreds of hydrogen stations are expected by 2020



Joint Announcement in Jan. 2011

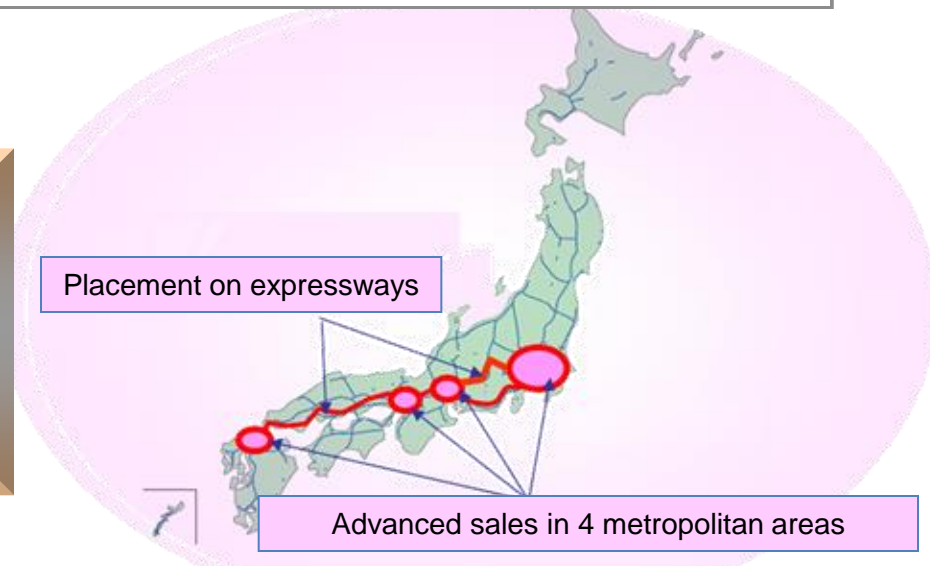
【Automakers】

- Plan to introduce mass-production FCVs in **4 major metropolitan areas** in **2015** for **sale to the general public**

【Hydrogen suppliers】

- Plan for advanced establishment of **supply infrastructure in approx. 100 locations**

**Now, 90 hydrogen STs are operated.
By March 2017, operation of 100 hydrogen
STs is expected.**



Work to introduce FCVs and hydrogen supply infrastructure nationwide



FCV + Hydrogen stations (Revised in March/2016)

Source : METI

Fuel Cell Vehicle(FCV)

◇Target

■40 thousands by 2020,200k by 2025,800k by 2030

◇Target Introduction of volume zone FCV into the market around 2025

Hydrogen Station

◇Clarify the construction target and sustainability establishment

■160 stations by 2020FY, 320 by 2025FY

※around 900 capacity stations necessary to fulfill 2030 vehicle target

■make stations economically sustainable before later half decade in 2020

here after station build accordingly vehicle growth

		2015	2020	2025	2030
ST	number	80	160	320	900
	cost	3.9M\$	2.3M\$	1.7M\$ (same as EU/US)	
	operation	0.47M\$	0.23M\$	0.15M\$ (same as EU/US)	
FCV(cumulative)		introduction	40,000	200,000	800,000



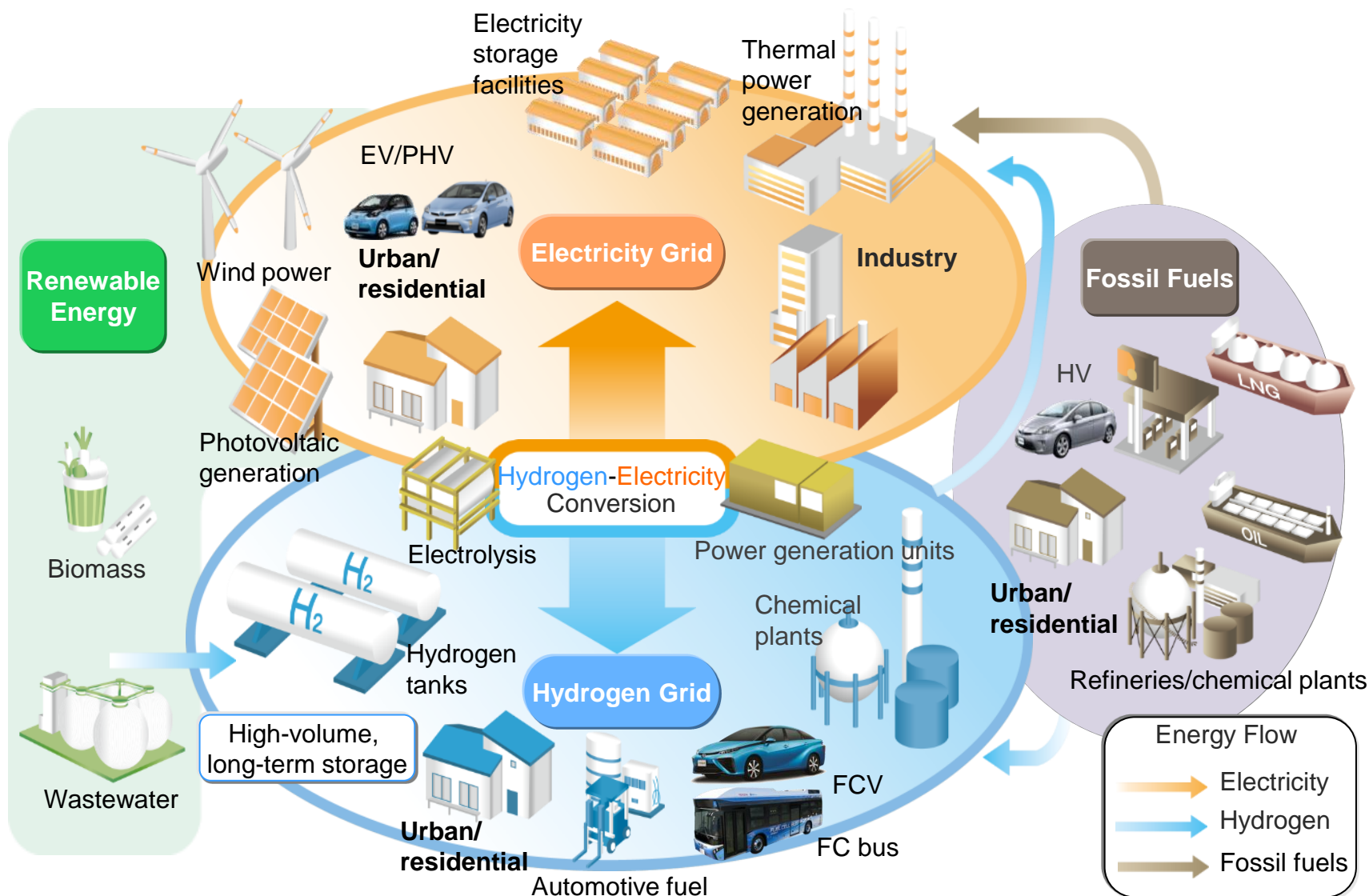
1. FCV products

**2. Operation of the hydrogen station
for the customers**

3. Hydrogen price



A society which uses diverse energy sources, with electricity and hydrogen infrastructures





1. The 21st century is the second coming of new powertrain diversification.
Toyota is developing a next-generation environmental vehicle as a core in a hybrid technology in all directions.
2. Toyota launched FCV MIRAI in December, 2014.
The MIRAI FC system would apply to Bus and Forklift.
FCV sales volume
Global: more than 30,000 unit/year around 2020 and later
Japan: approx. 1,000 unit/month around 2020
1X,000 unit/year @ 2020 and later
FC Bus introduction
to start from February 2017 for Tokyo.
100 unit or more by 2020 for Tokyo Olympics/Paralympics
3. We would like to contribute toward the realization of Hydrogen society
which a person lives together with a nature by renewable energy and CO2-free
hydrogen utilization.



The Hydrogen Society and Energy Sources of the Future

H₂HOPE





Thank you very much for your attention.