

IPHE Forum
2/November/2016
@Gwangju,Korea

Honda Fuel Cell Vehicle Development and Toward the Hydrogen Society

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Honda R&D Co., Ltd.

■ Environment and Energy Issue

- Recognition of Issue
- Toward Next Generation technology
(Concept of sustainable society)

■ Fuel Cell Electric Vehicles as a Viable Alternative

- Honda Development Status
- Honda New FCV Concept
- Recent Trends toward Introduction

■ Summary

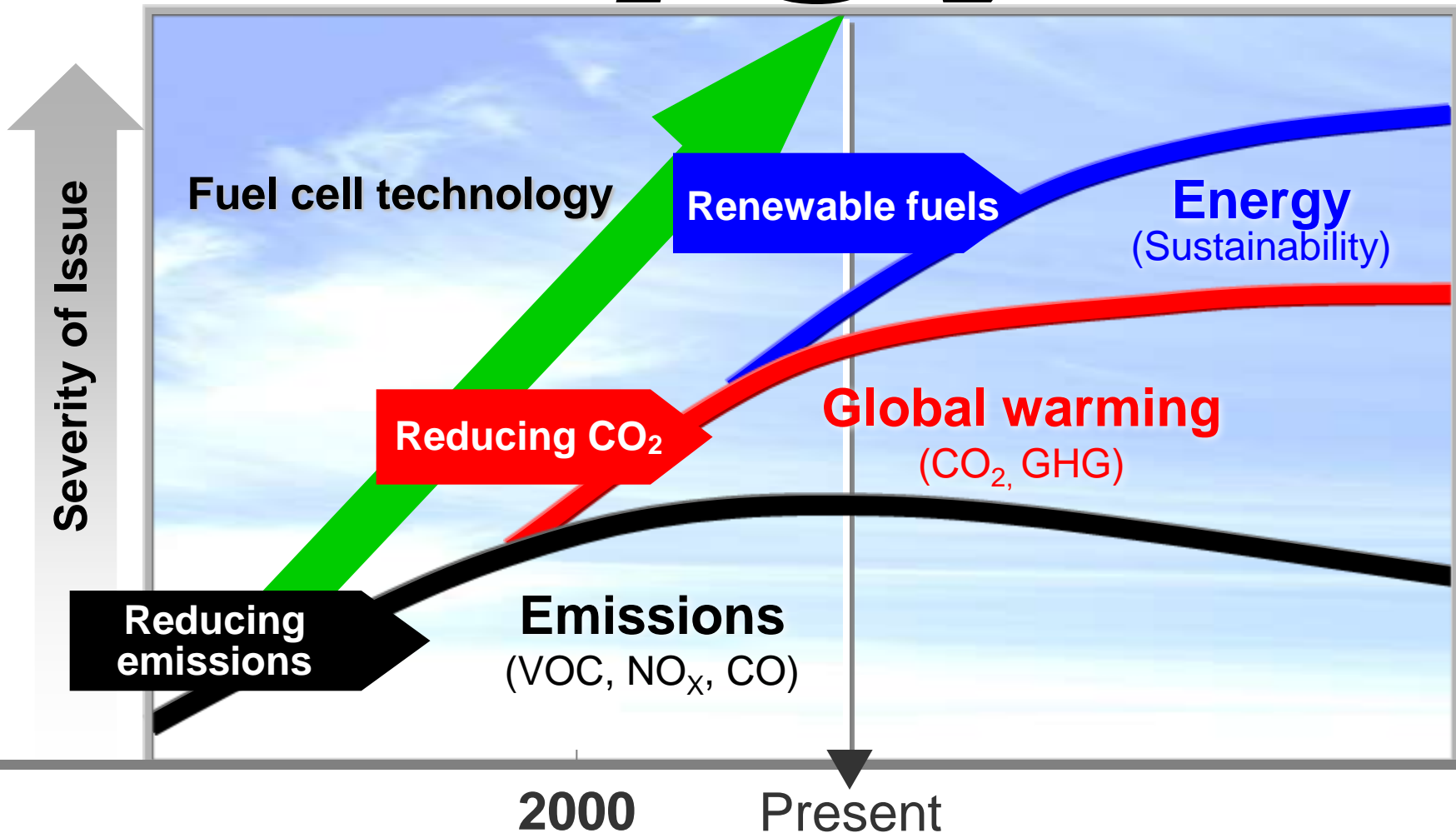
Energy and Environmental Issues

HONDA
The Power of Dreams

Running on naturally generated hydrogen

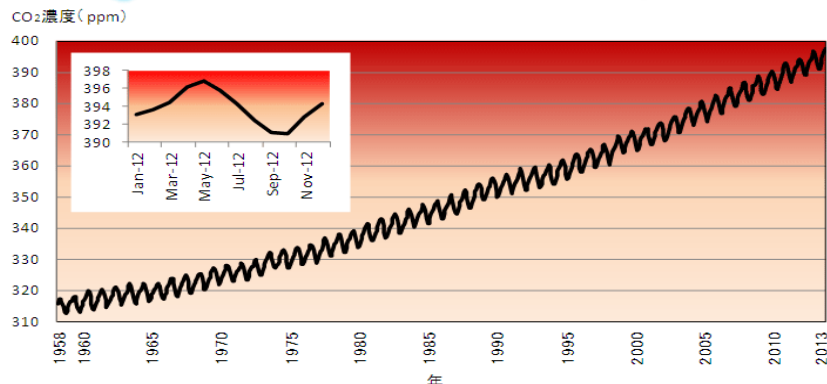
FCV

(Zero CO₂ emissions)



Global Warming

Keeling Curve Measured at Mauna Loa, Hawaii



Global Environmental Issue

Nations Unies

Conférence sur les Changements Climatiques 2015

COP21/CMP11

Paris, France



To reduce the exhaust GHG in the upper level in the range from 40% to 70% compare to 2010 GHG until 2050. 出展 : <http://www.huffingtonpost.jp>

Energy Issue

- Unstable Oil price related on OPEC
- Increasing demand based on increasing World population

Source : Honda estimation based on IMF etc



COP21
Paris
December 2015

COP21 Paris Agreement

- TARGET : less than 2°C
- Long term Targets
- Re-examination every 5 years
- Resetting higher targets
- Budget support system
- Bailout for loss and damage
- Validation system

Unstable Energy Supply

Variety of the Hydrogen Production

Primary Energy

OIL

(Oil Sand,
Oil shale)

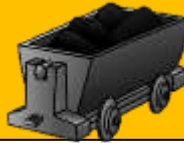


Natural Gas

(Shale gas,
Hydrate)



Coal



Biomass



Waste



Solar, Hydro
Wind
Geothermal



Nuclear



2nd Energy (Fuel, Carrier)

Gasoline

Diesel

CNG, LNG

DME

Methanol

Hydrogen

Electricity

Bio Ethanol

Bio Diesel

Vehicle

SI Engine
(Include HEV)



CI Engine
(Include HEV)



FCV



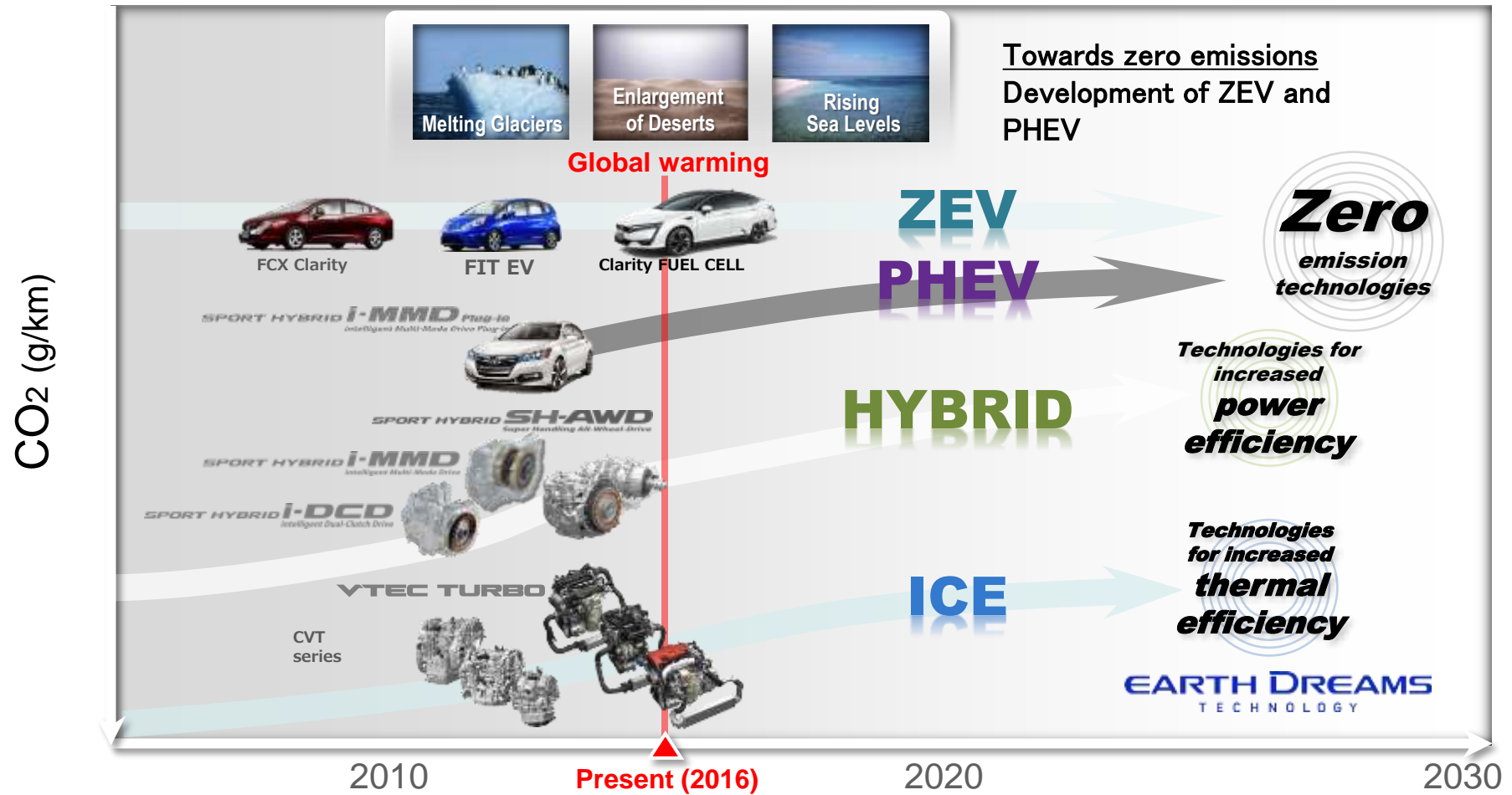
BEV
(Include PHEV)



Fossil Energy

Renewable Energy

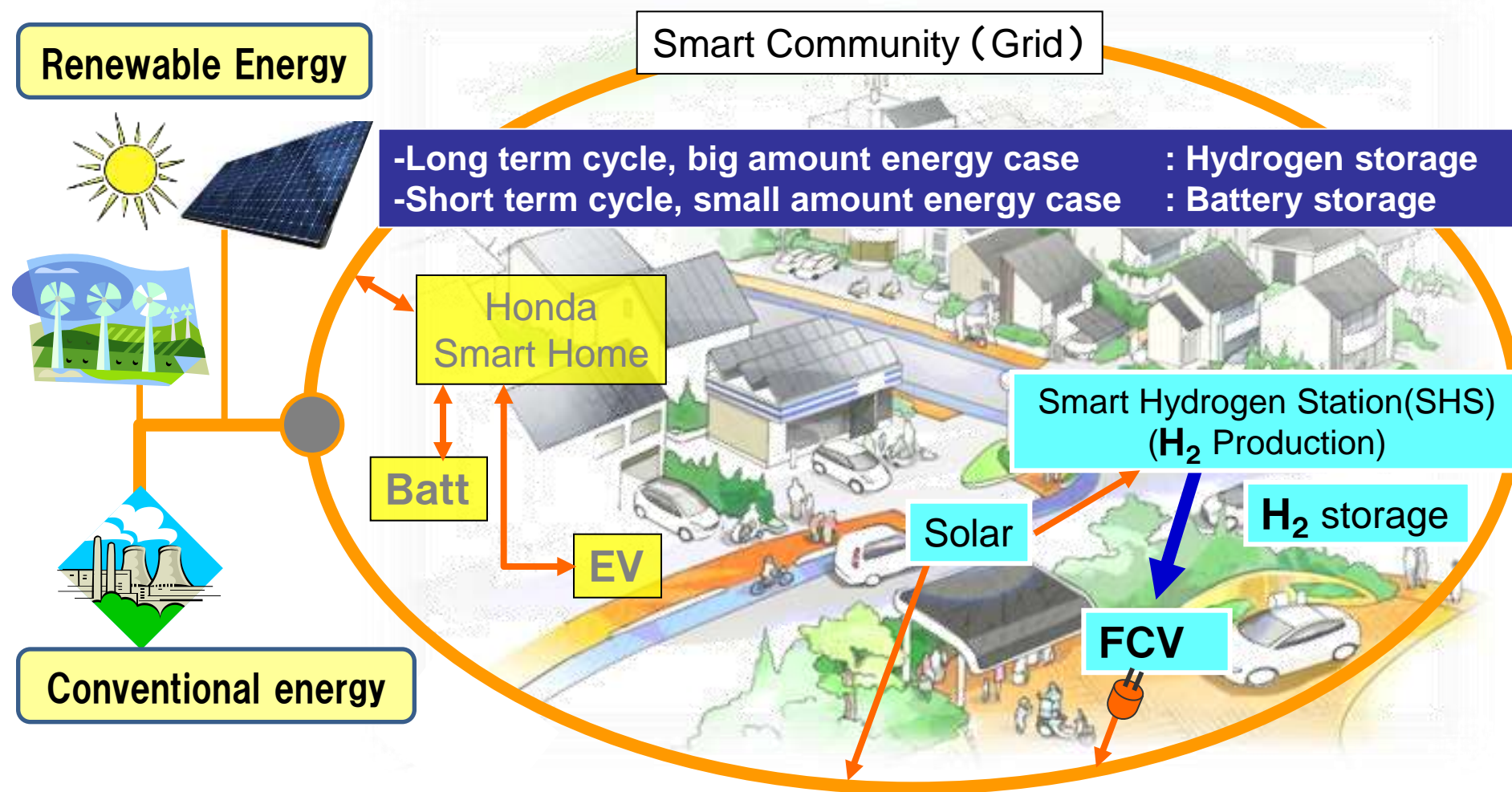
Honda's Initiatives to realize Environmentally Friendly Vehicles **HONDA** The Power of Dreams



Honda will strive to make two-thirds of our overall unit sales from plug-in hybrid/hybrid vehicles and zero-emissions vehicles such as, FCVs and battery EVs by around 2030.

Smart Community using Hydrogen (Image)

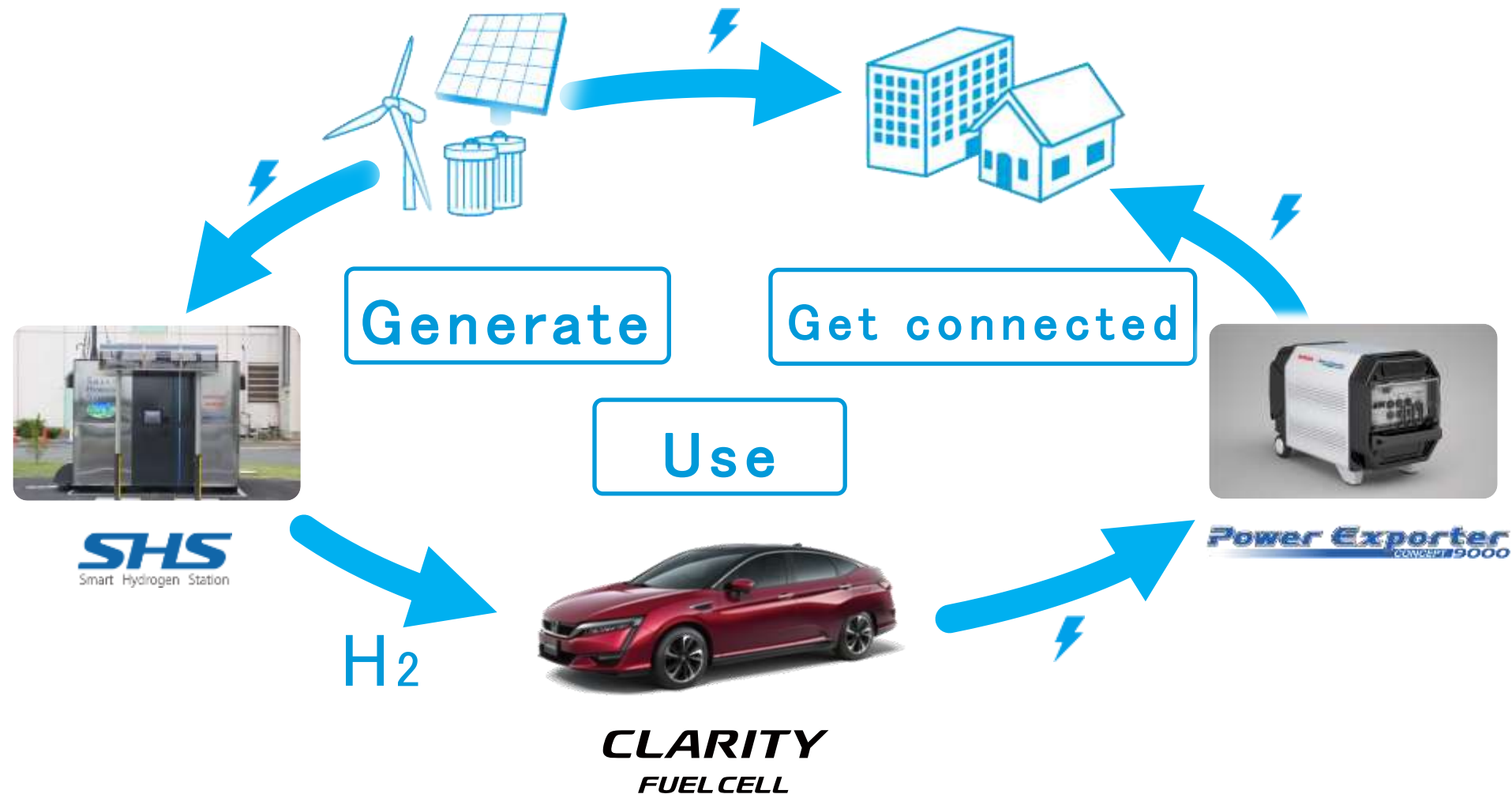
HONDA
The Power of Dreams



Renewable energy is usual not stable. Peak power storage is very useful for Levelization of energy management in community. Hydrogen production, storage, transportation and usage are very important to achieve future smart community.

Development Concept toward the Hydrogen Society

HONDA
The Power of Dreams



Development History of Honda

HONDA
The Power of Dreams

1996 2000 2002 2004 2008 2010 2012 2013 2016

Prototype

FCX

**FCX
CLARITY**

**CLARITY
FUEL CELL**



Use



SHS0

SHS1

SHS2

SHS
Smart Hydrogen Station

Fundamental Research

Generate



SHS0 (2002~2003) **SHS1** (2003~2009)

SHS2 (2010~) @LA (2012~) @JPN

EX500 Inverter

Mobile Inverter

Power Exporter
EVT-19000



Get connected

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Get connected

Electrolysis Hydrogen Station **HONDA**

The Power of Dreams

SHS
Smart Hydrogen Station

Renewable Energy : Low carbon footprint Hydrogen

Distributed Station : Possible to supply hydrogen everywhere connected existing water and electricity

Waste Generation



local production for
local consumption

Energy



**Renewable
energy**



**Honda Wako
Head Office**

**Operation start
From December
2015**



**Honda Aoyama
Head Office**

**Operation start
From April
2016**



Improvement of Electrolysis Hydrogen Station

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High Pressure
Electrolysis

Power
unit

Power
unit

35MPa Hydrogen

Hydrogen
Refueling
Nozzle

Integrated

Electrolysis

Compressor

Energy flow

100%

54%

Electrolysis

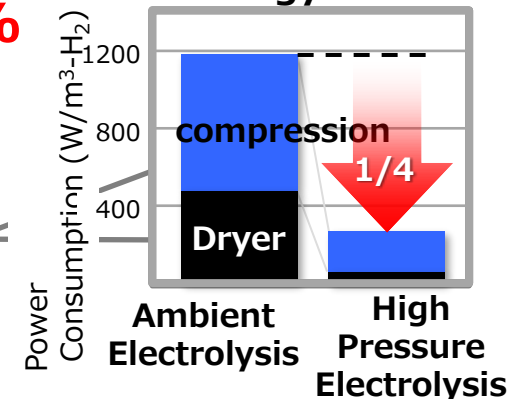
約20%

Compression

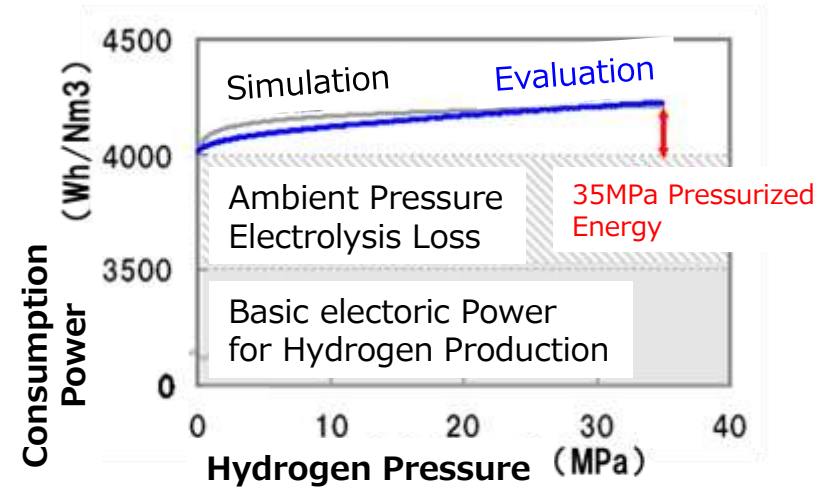
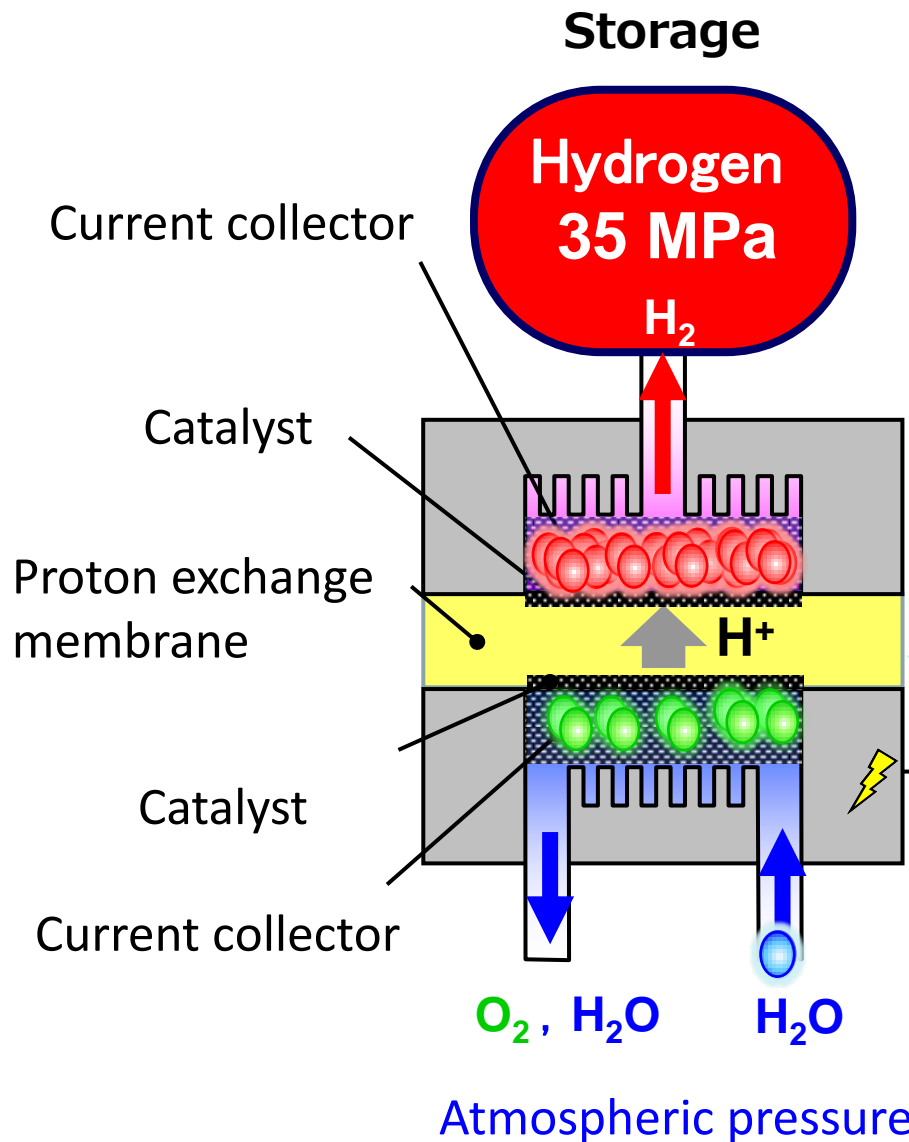
Power unit

•Auxiliary devices

Energy Loss

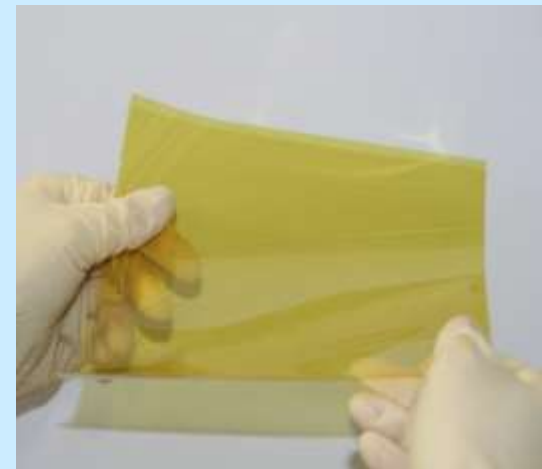


Scheme of High Differential Pressure Water Electrolysis for SHS



- Technical Barrier
- High Differential Pressure Electrolysis
 - Stack Structure etc

Proton exchange membrane



Smart Hydrogen Station (SHS)

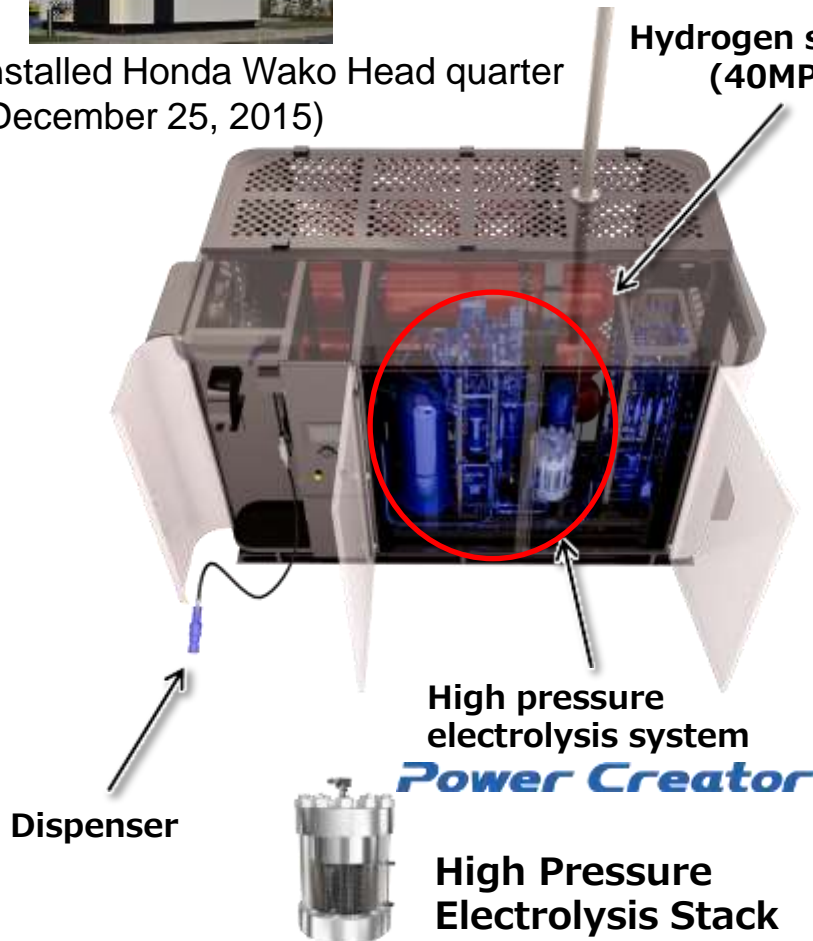
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The Power of Dreams

- **Simple**
- **Small**
- **Sustainable**

- 1 day installation connected water and electricity (without groundwork)
- Small package type (10ft Container 3m×2.5m)
- Hydrogen production from Renewable energy and the other low carbon power generation to realize the local energy production for local consumption according to characteristics of region



Installed Honda Wako Head quarter
(December 25, 2015)



Items	Specification
Max. Flow rate	1.5 kg/Day (0.7Nm ³ /h)
Pressure	35 MPa
Storage	19 kg @15°C (92L x8)
Purity	>99.99%
System Size	W3200 X D2438 X H2438 Foot-print app. 7.8 m ² 10ft Container size
Electrolysis Unit	High differential pressure electrolyzer
Refueling	Rapid refueling (3Banks·Cathcade)
Utility	200VAC/Tap Water

FCX Clarity with external power supply systems

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The Power of Dreams

100V Mobile Inverter Box(V2L)

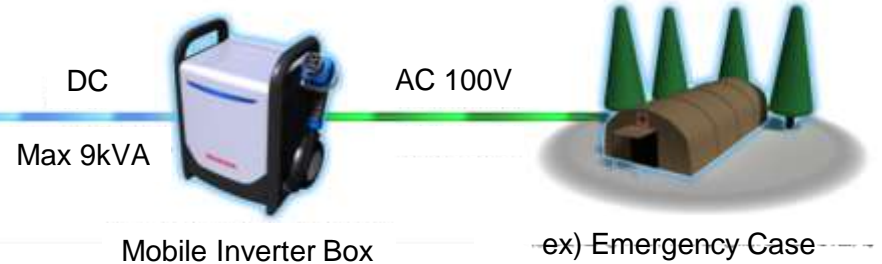


FCX Clarity with external power supply system

200V Mobile Inverter Box(V2H/V2L)

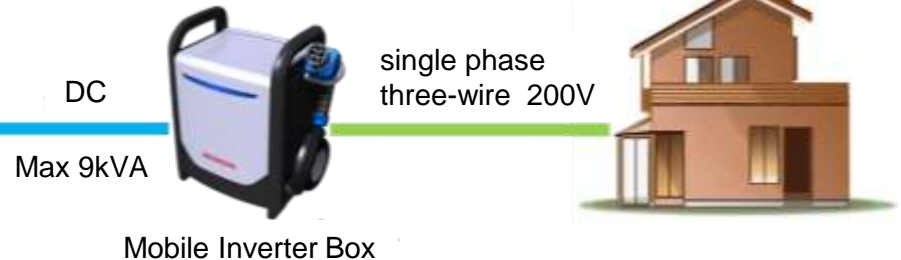


100V Mobile Inverter Box (V2L)

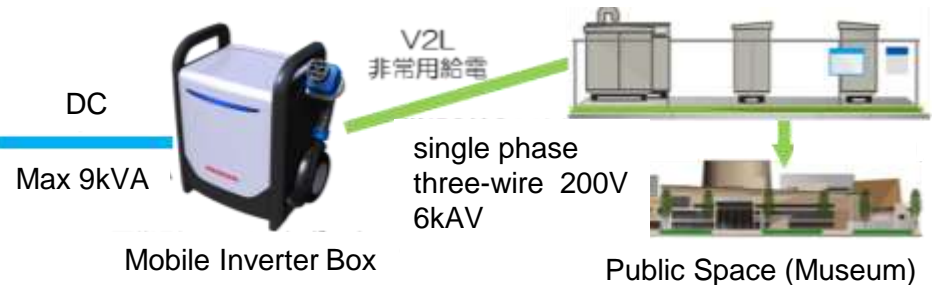


Saitama Prefecture Project

200V Mobile Inverter Box (V2H)



200V Mobile Inverter Box (V2L Emergency Case)



Kita-Kyushu Smart Community Project

“Connecting to Vehicle, Expanding to Livelihood”

- Maximum power supply 9kW connecting to FCV
- High reliability accumulated Honda inverter business
- High quality AC power output
- High general-purpose properties based on V2L guideline
- Usable in outdoor and emergency



AC100V 3kVA

Power supply to standard home

Single phase 3 lines
100/200V 6kVA

Large capacity heater,
Air conditioner
Electromagnetic cooker

* V2L guideline : 「The charge-discharge system guideline for Electric vehicle」 This standard defined the electric safety made by power supply system council for electric vehicle and compatibility between vehicle and connector.



Received the US Media Panel Innovation Award
In CEATEC (Combined exhibition of Advanced Technology) 2015

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HONDA
The Power of Dreams

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Prototype

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**FCX
CLARITY**

**CLARITY
FUEL CELL**



Use



SHS0

SHS1

SHS2

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Smart Hydrogen Station

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SHS0 (2002~2003) **SHS1** (2003~2009)

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EX500 Inverter

Mobile Inverter





Power Exporter
EVS1000



Get connected

Improvement of Honda FCV Development

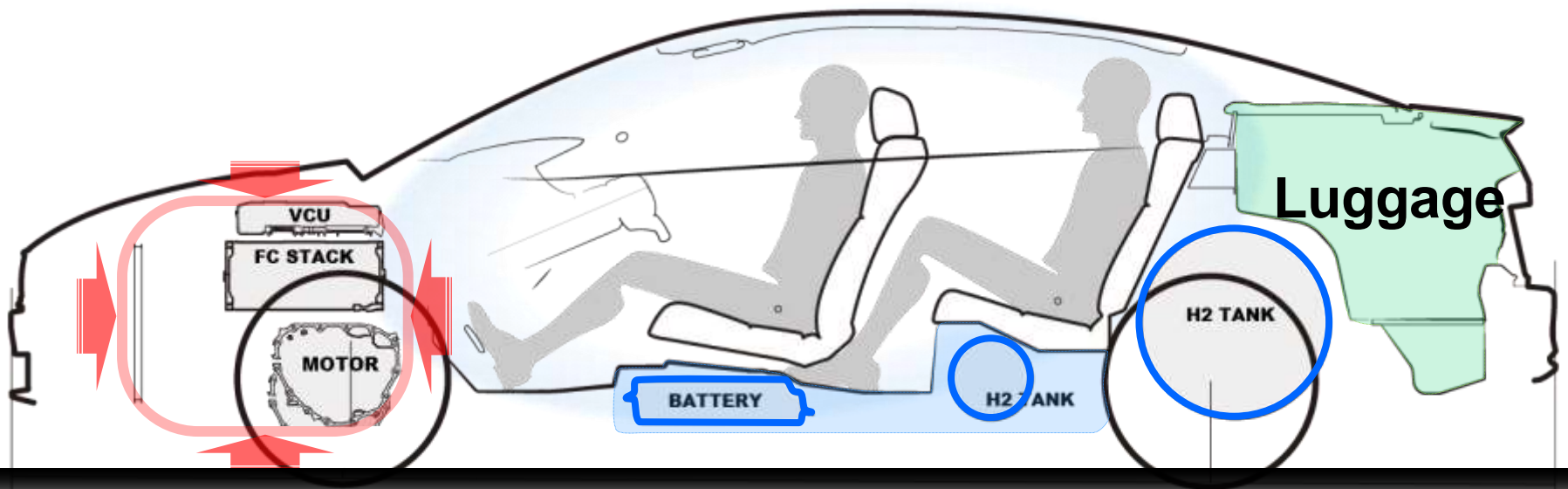
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The Power of Dreams

	2002 FCX 	2005 FCX 	2008 FCX Clarity 	2016 CLARITY FUEL CELL 
Door	2	←	4	←
Passenger	4	←	←	5
Cold Temp. Performance	>0	-20℃	-30℃	—
FC L/O	Under floor	←	Center tunnel	Under hood
Stack	Carbon	Stamped Metal	←	←
Base Body	EV Plus	←	New Body	←
Body Type	Small 2Box	←	Sedan	←
Range	360km	470km	620km	Apr. 750km*

* Japanese JC08 mode

MM Concept: Fuel Cell Sedan Package

Man maximum Machine minimum



High-efficiency package with fuel cell powertrain fitted under hood

Optimal positioning of battery and hydrogen tank realizes comfortable sedan passenger space

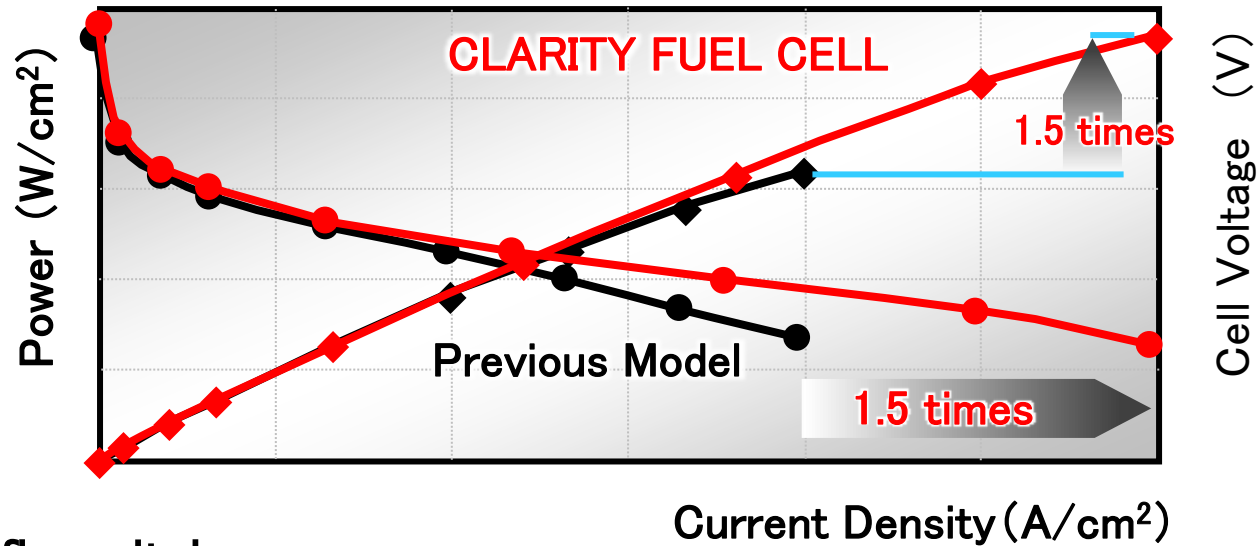
Luggage space large enough for 3 golf bags

Improvement of generating performance

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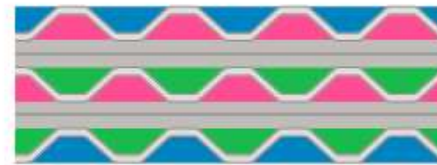
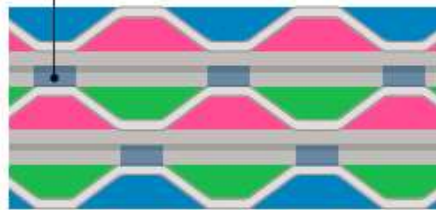
● Comparison of IV characteristics



● Narrow gas flow pitch

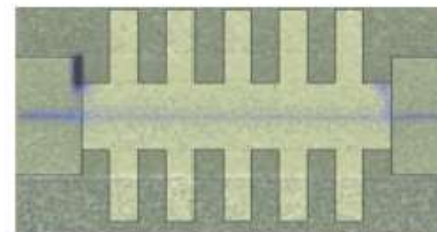
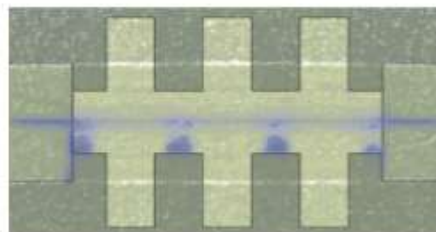
Gas diffusion is blocked by condense water.

Previous Model



**CLARITY
FUEL CELL**

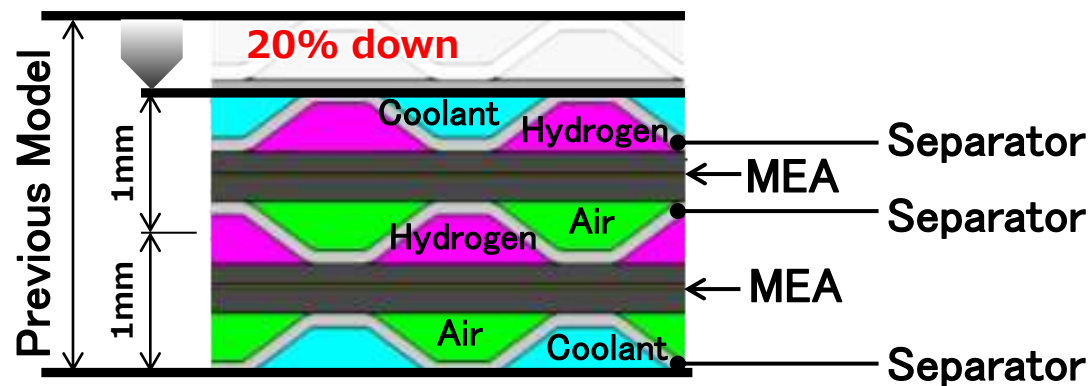
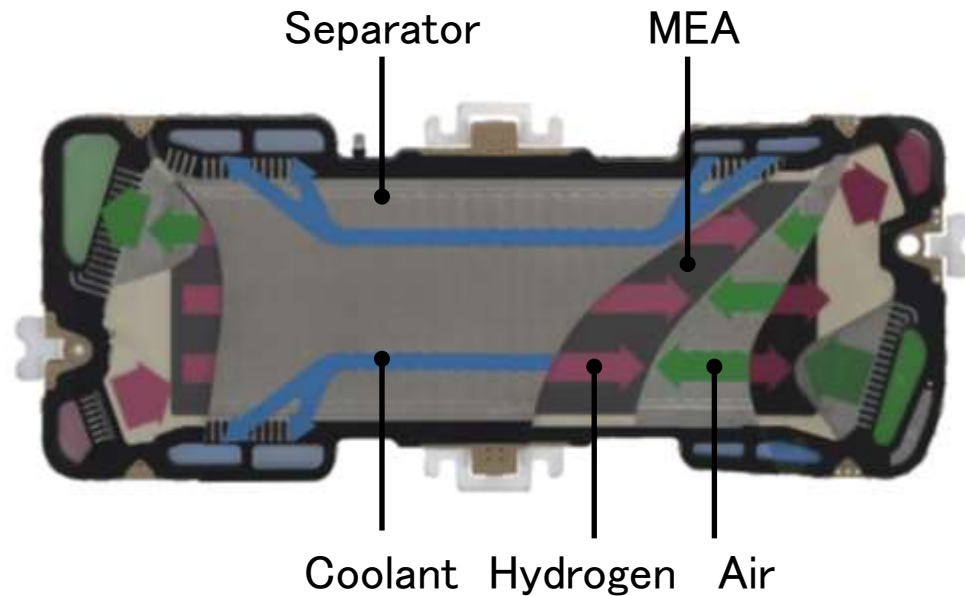
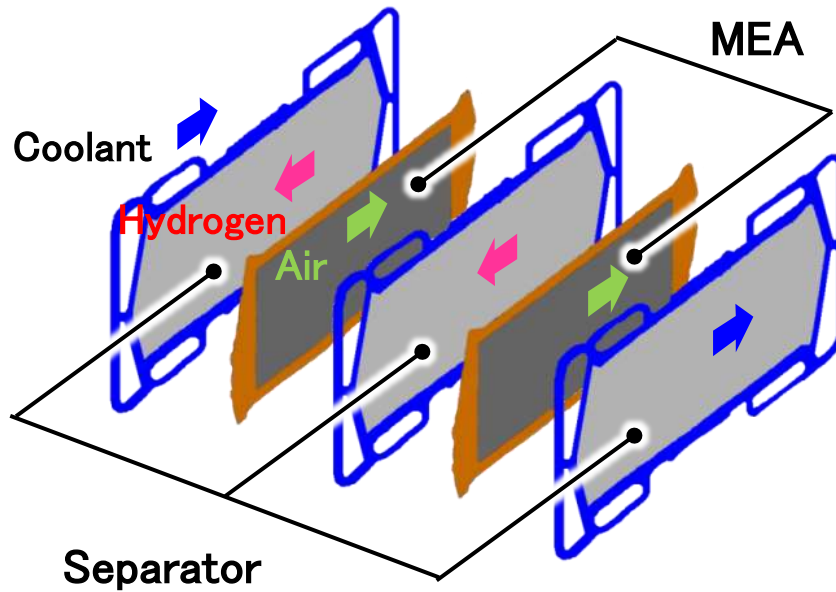
Narrow gas flow pitch



Condense water
exhaust performance
was improved
by narrow pitch.

Cell Structure

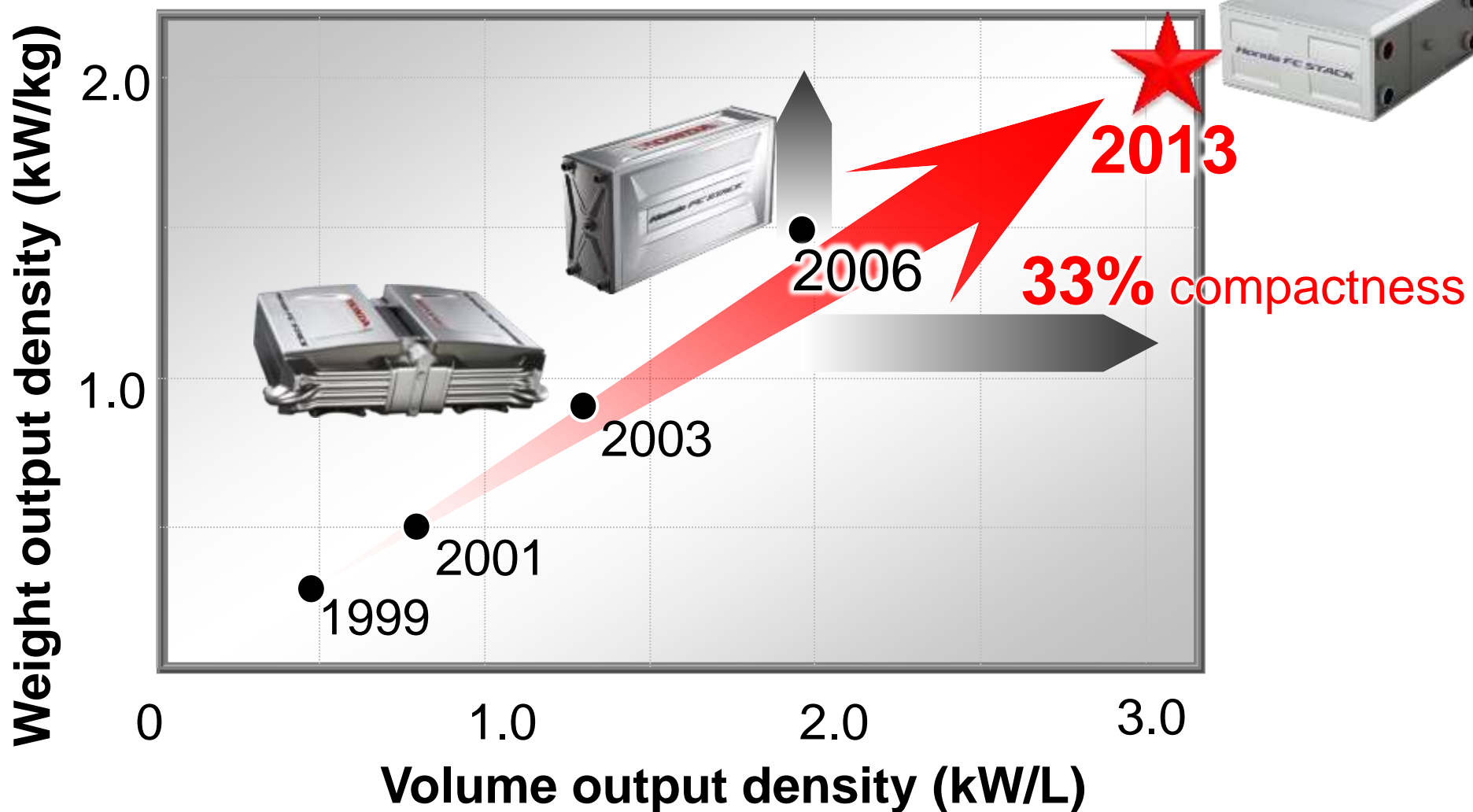
● 2 Cells cooling Structure



1 Unit (2 cells) is constructed by 2 MEAs and 3 separators.
1mm cell thickness is achieved by reduction of condense water.

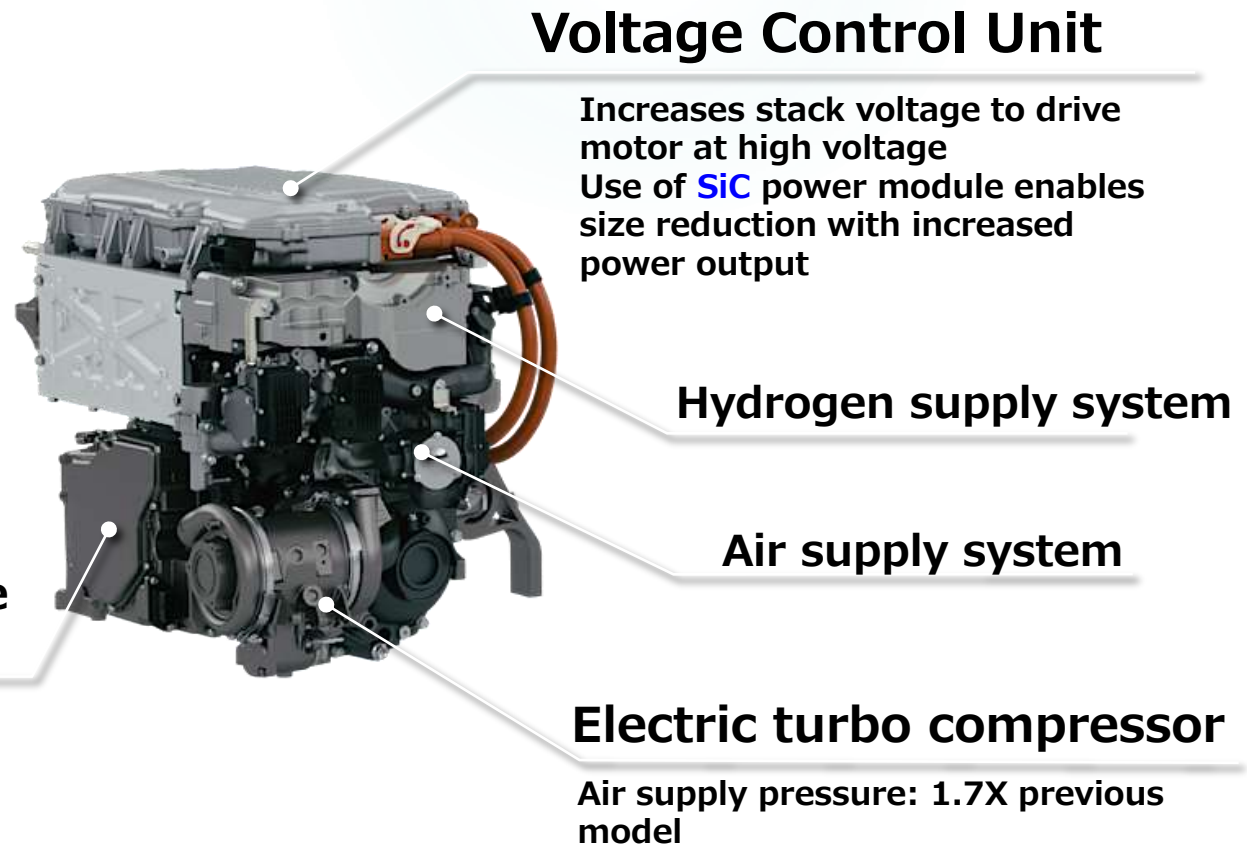
New Honda FC Stack

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The Power of Dreams



New Honda FC Stack achieved 33% compactness compared to previous model. Volume power density achieved over 3.1kW/L.

Compact fuel cell system and drive unit



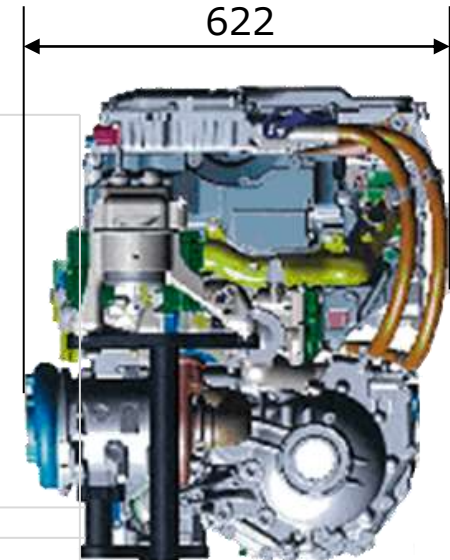
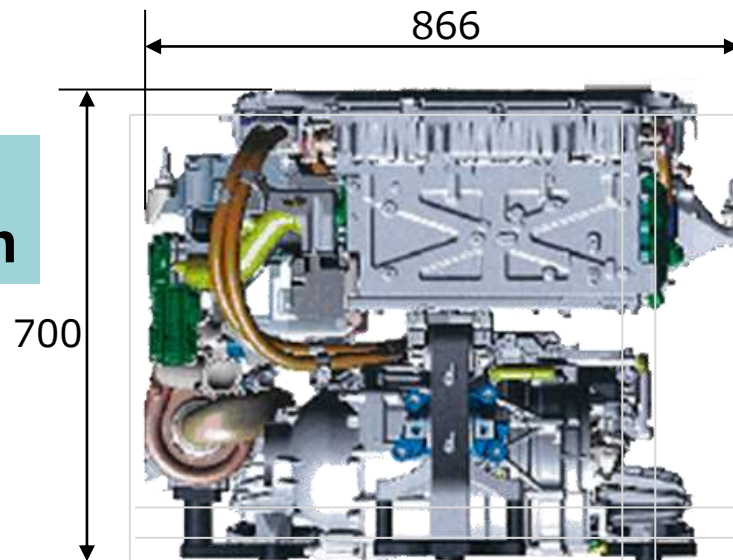
Fuel Cell Power Train is integrated compact fuel cell system and low height traction motor redesigned in order to install under engine hood.

Powertrain Size

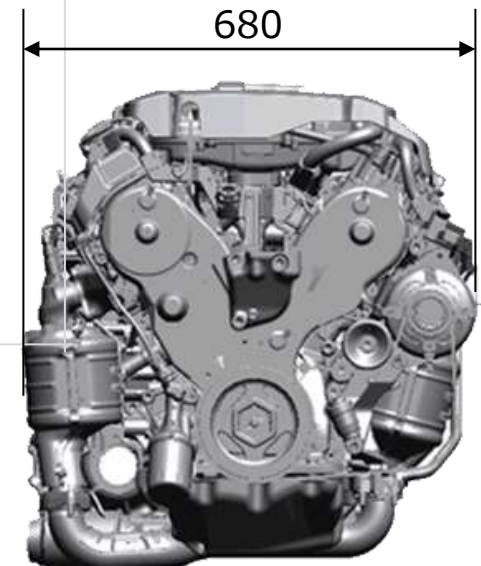
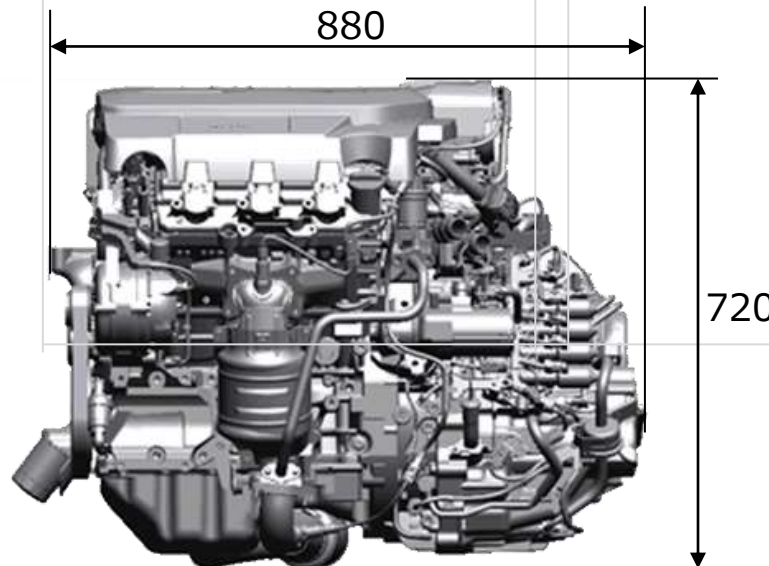
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**Fuel Cell
Powertrain**



**V6 3.5L
Engine**



Fuel Cell Powertrain size achieved almost same size of V6 engine.

Honda CLARITY FUEL CELL

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Vehicle dimensions	4,915 x 1,875 x 1,480 mm	
Number of passengers:	5	
Driving range (Reference figure)	App. 750km (Driving in JC08 mode; figure measured by Honda)	*1
Fuel cell power	More than 100kW	
Fuel cell stack power density	3.1kW/L (Figure measured by Honda)	
Hydrogen filling time	Around 3 minutes	*2
Hydrogen tank filling pressure	70MPa (700 atmospheres)	

*1 Figure measured by Honda after filling at a 70MPa hydrogen station employing standard conditions as specified by SAE standards (J2601). Because the volume of hydrogen in the tank may differ when filling at hydrogen stations with differing specifications, driving distance may also differ. Driving distance also varies significantly as a result of the use environment (temperature, traffic congestion, etc.) and the mode of use (sudden takeoffs, air conditioner use, etc.).

*2 Differences in filling pressure and external air temperature may result in differences in filling time

Fuel Cell electric Vehicle: Issues Lying Ahead

HONDA

The Power of Dreams

Performance
Size/weight reduction

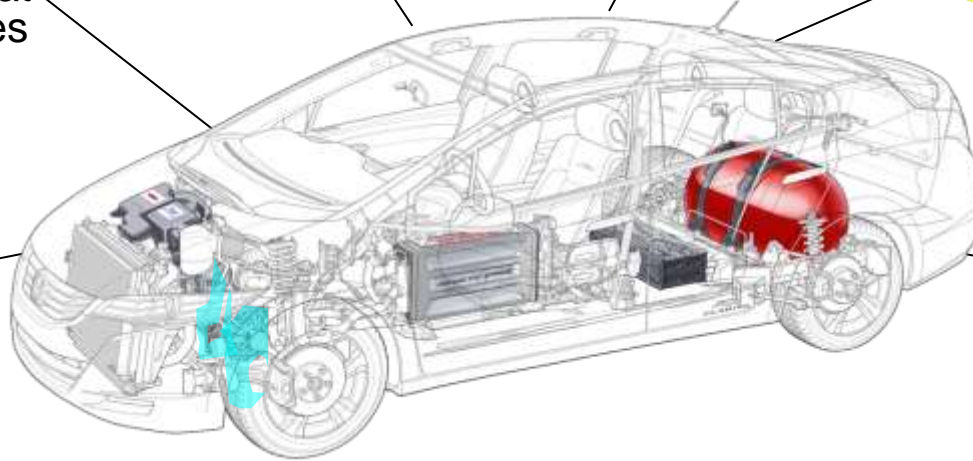
**Durability
Reliability**
Thousands of hours

Quality control
Cell uniformity

Cost
Reduce platinum use
Mass production
technology

Driving Range
Hydrogen storage

**Environment
adaptability**
Sub-zero startup
Heat dissipation at
high temperatures



- Hydrogen infrastructure
- Fuel cost

- Related regulations still in preparation
- Need for common international standard

Range, Environment adaptability and Performance are received vision from past developments. Durability, Reliability, Quality control and Cost reduction have a characteristics affected one other.

Summary of FCV development issues

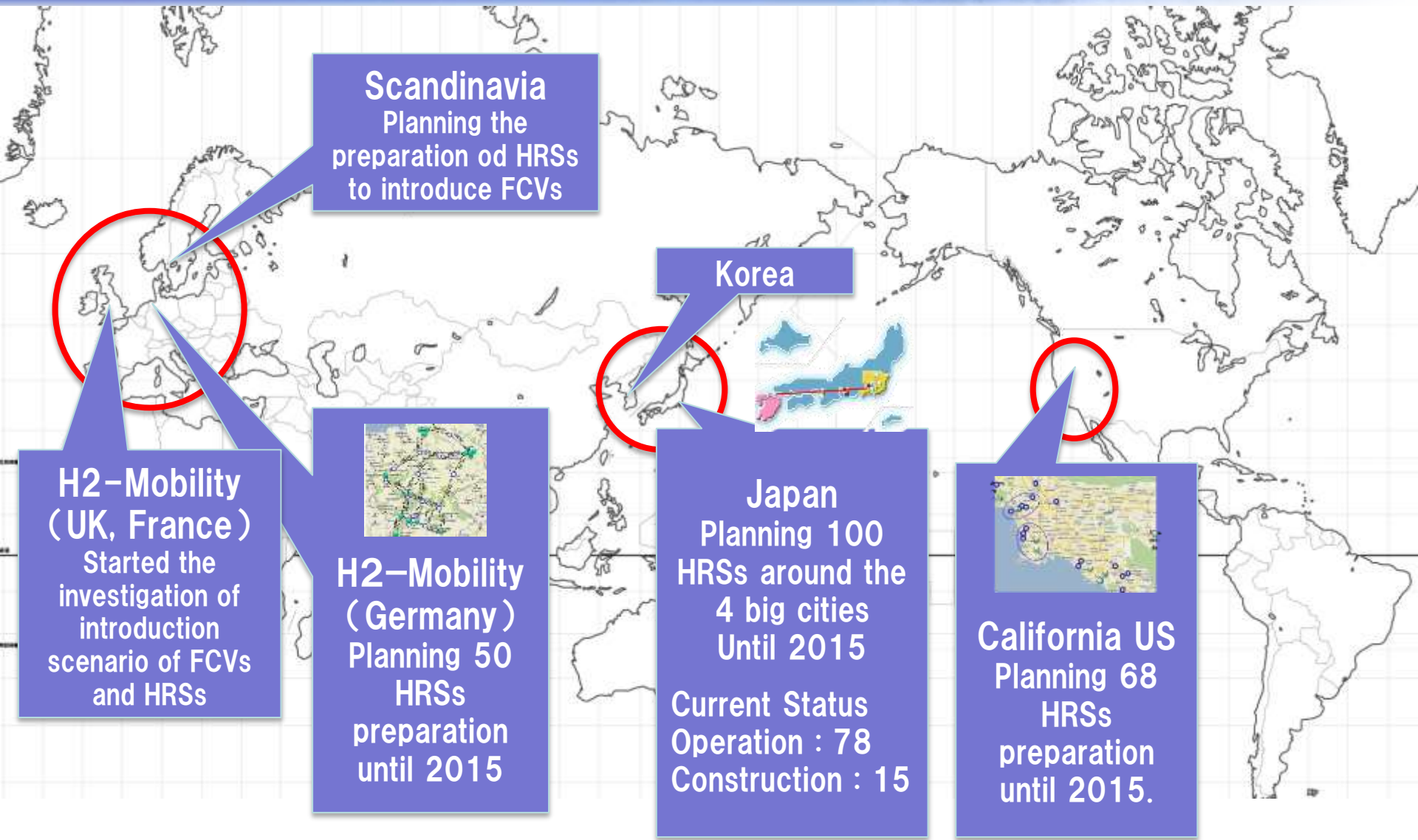
Items	Technology Development Status and Barriers
Durability Reliability	<ul style="list-style-type: none"> • Understood and fixed the degradation factors • Main degradation operation : Start/Stop (Parking) ⇒ It's important to keep constant circumstance in both Anode and Cathode electrode. (Control) ⇒ Prospected the durability performance
Quality Management	<ul style="list-style-type: none"> • FC Stack is very special mechanical structure (several hundreds functional cell series stacking) ⇒ Big damage by a failure of 1 cell (Power down, Hydrogen safety, High voltage safety) ⇒ More severe quality control (⇔ Cost Reduction)
Cost Reduction	<ul style="list-style-type: none"> • Material cost reduction using multipurpose material • Production cost reduction by short tact time (⇔ Quality management) • Reduction of precious metal (Low loading Pt electrode ⇔ Durability) ⇒ Key Points are Cost reduction technology establishment and production volume

Influence each other

For certain circumstances, technology is set and can be foreseen, however, for wide dissemination, there needs to be technology developed further to meet more severe circumstances. Therefore, continuous development to optimize the balance of above items.

Hydrogen Refueling Station (HRS) preparation **HONDA**

The Power of Dreams



Several countries start to prepare the HRSs for introduction of FCVs. Japan is most aggressive activities co-operating between government and industry.

Hydrogen / Fuel Cell Road map

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Value for Hydrogen Society

Energy Saving

Energy Security

Environmental Load-reducing

Industrial Promotion
Regional Activation

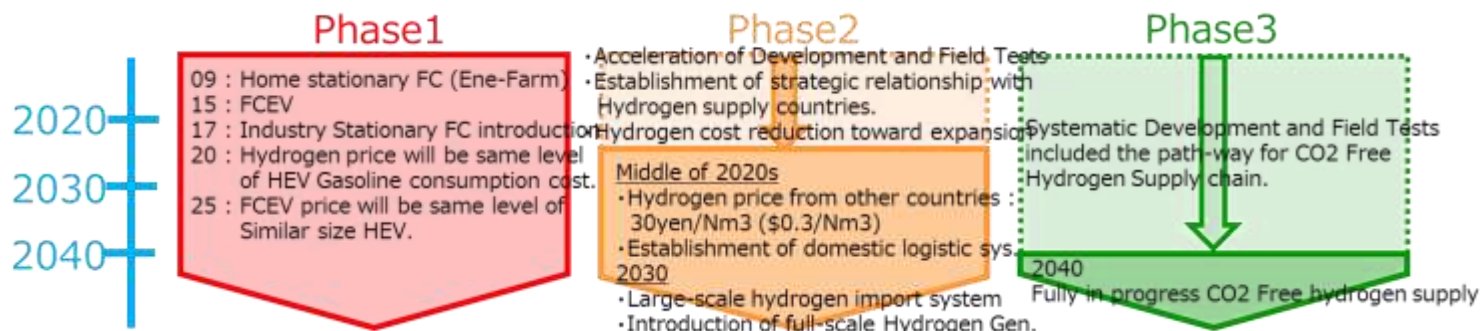
出典: <http://www.meti.go.jp/press/2014/06/20140624004/20140624004.html>

Direction toward the Hydrogen Society

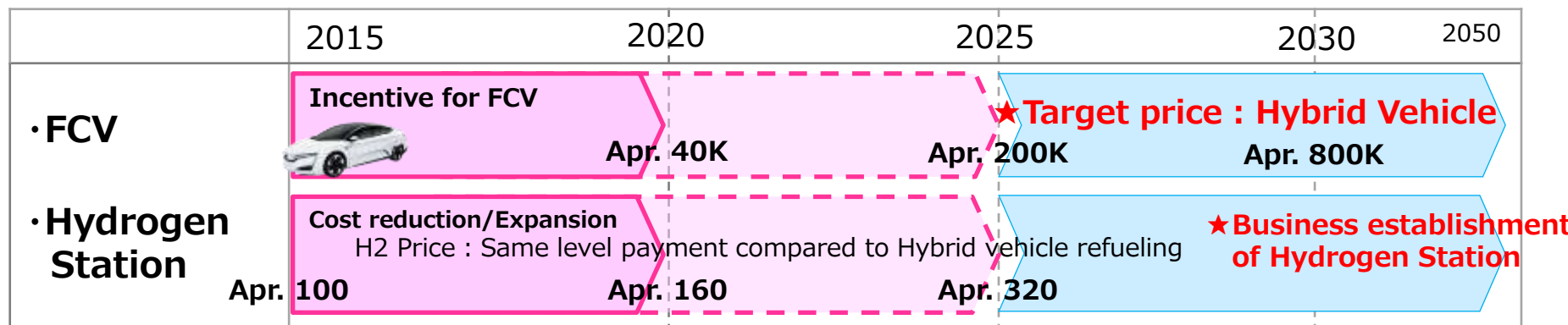
Phase1 : Significant expansion of Hydrogen usage
(Full-scale introduction of Fuel Cell Systems in Society)

Phase2 : Introduction of full-scale hydrogen generation system
Establishment of large-sized hydrogen supply system

Phase3 : Establishment of total CO2 free hydrogen supply system

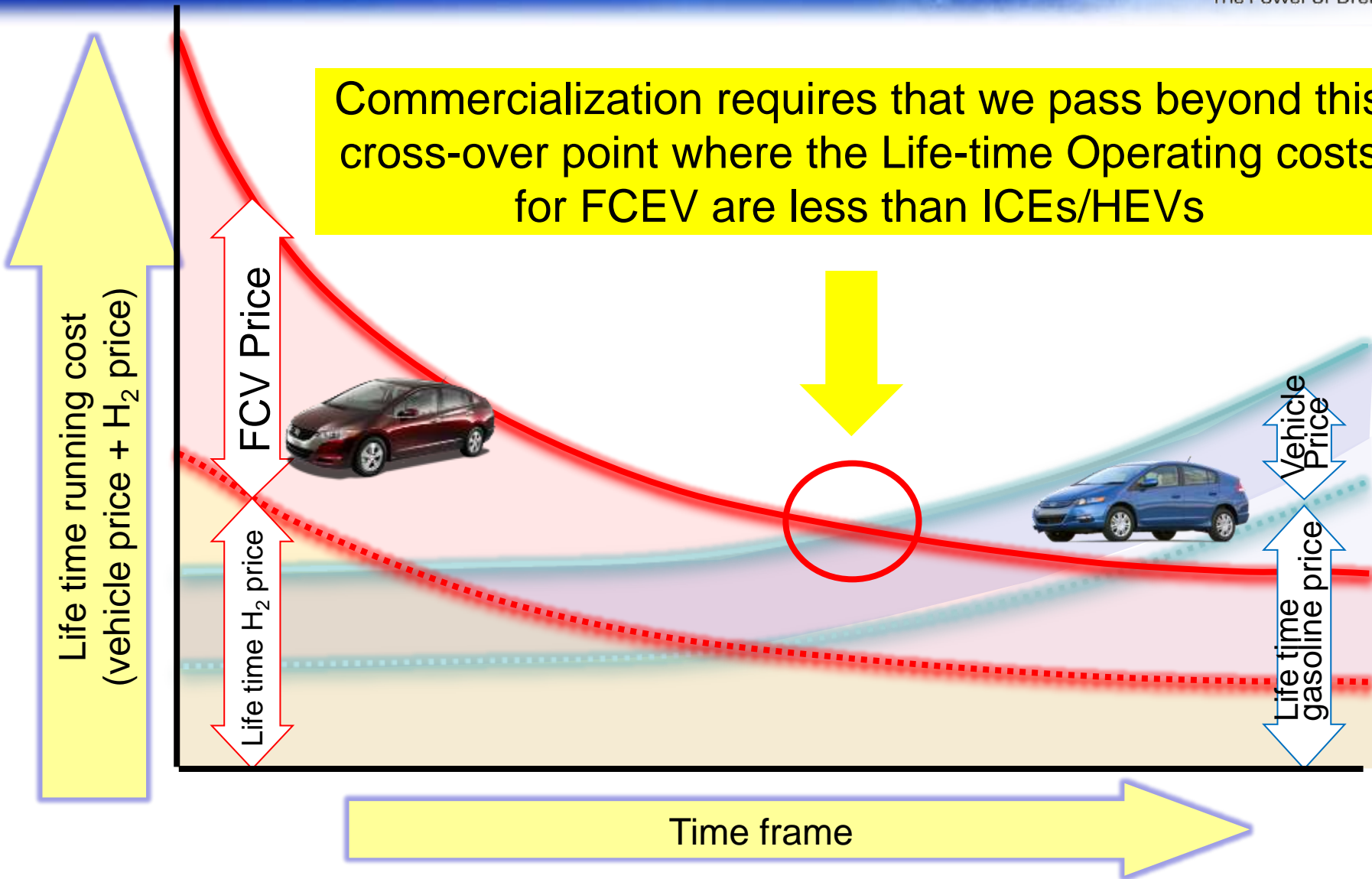


Hydrogen / Fuel Cell Road map was revised in March 22, 2016



Finding Customers' Merit (Image)

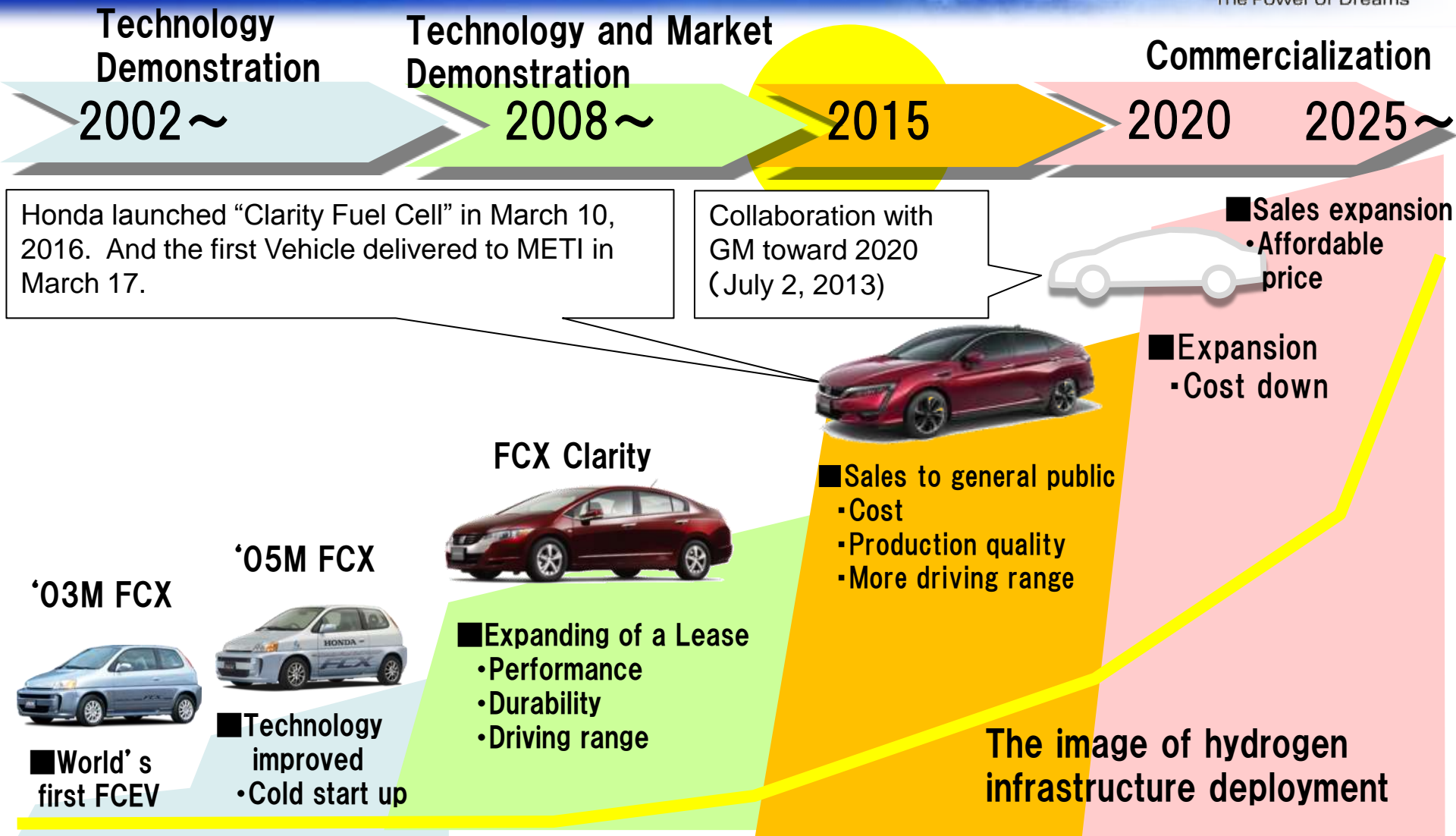
Commercialization requires that we pass beyond this cross-over point where the Life-time Operating costs for FCEV are less than ICEs/HEVs



Our target is to accelerate this cross-over point.

Roadmap to FCV Commercialization

HONDA
The Power of Dreams



Launch the CLARITY FUEL CELL in March 10, 2016.
Expansion the FCV collaborated with GM (technology and scale merit) in 2020
Necessary for cooperation of Hydrogen Refueling Station toward the FCV expansion

Summary

- For low CO₂ emission community, Hydrogen is very promising energy buffer of easily converting to electricity.
- Vehicle electrification is the main pathway toward reduced greenhouse gases and a shift to alternative, renewable sources of energy.
- Honda work positively to develop the various technologies to realize the future hydrogen society, based on concept of “Generate”, “Use” and “Get Connected”.
- Honda delivered New Fuel Cell Vehicle named “CLARITY FUEL CELL” from the March of 2016 and must continuously tackle to reduce cost and to establish quality control toward the future commercialization.
- A concerted effort among related industries/companies, the establishment of global standards and the creation of a hydrogen refueling infrastructure are also required if FCVs are to be marketed as scheduled starting.



BLUE SKIES FOR
OUR CHILDREN

HONDA

The Power of Dreams