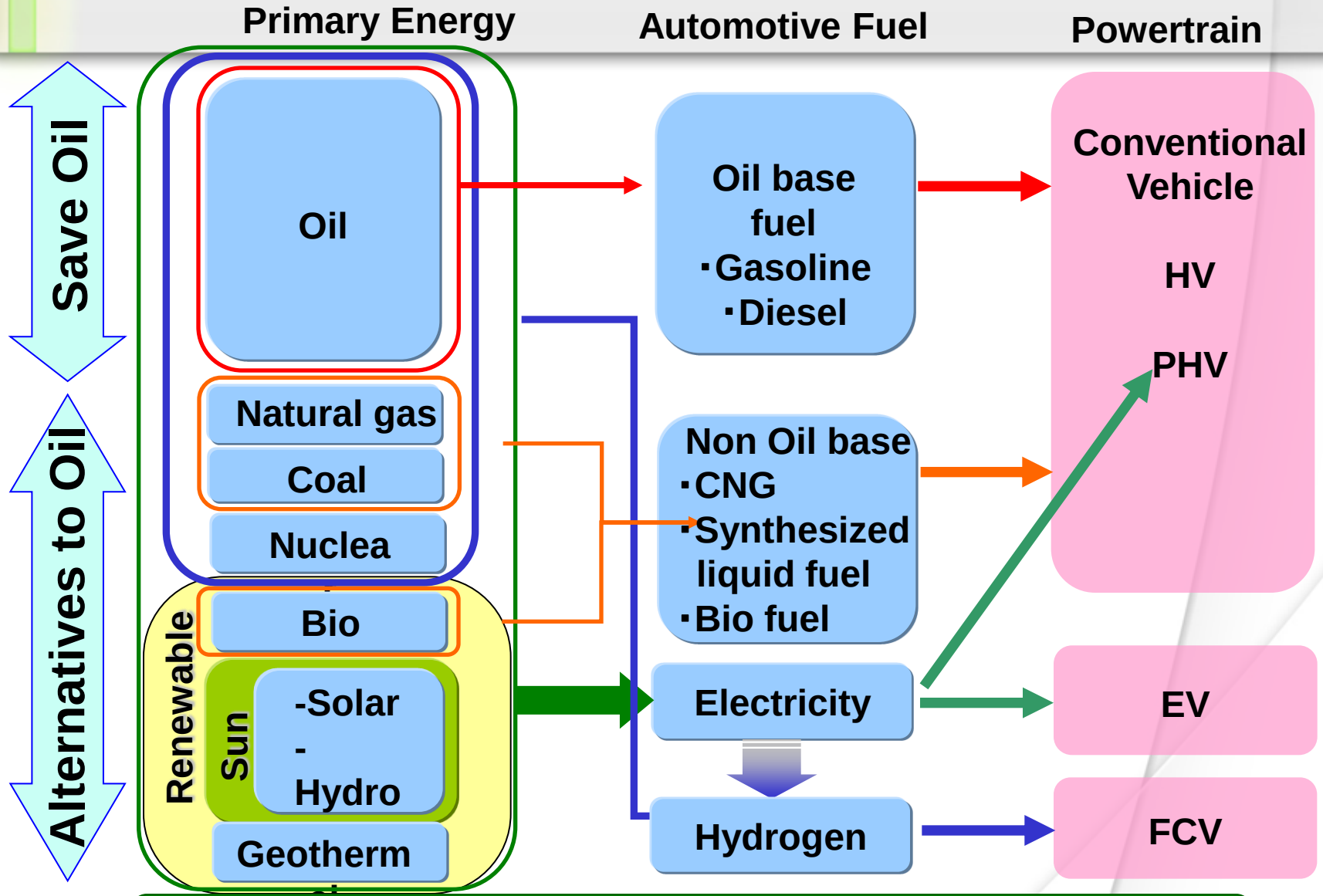
Toyota's Approach to Sustainable Mobility And Fuel Cell Vehicle Development

Katsuhiko HIROSE

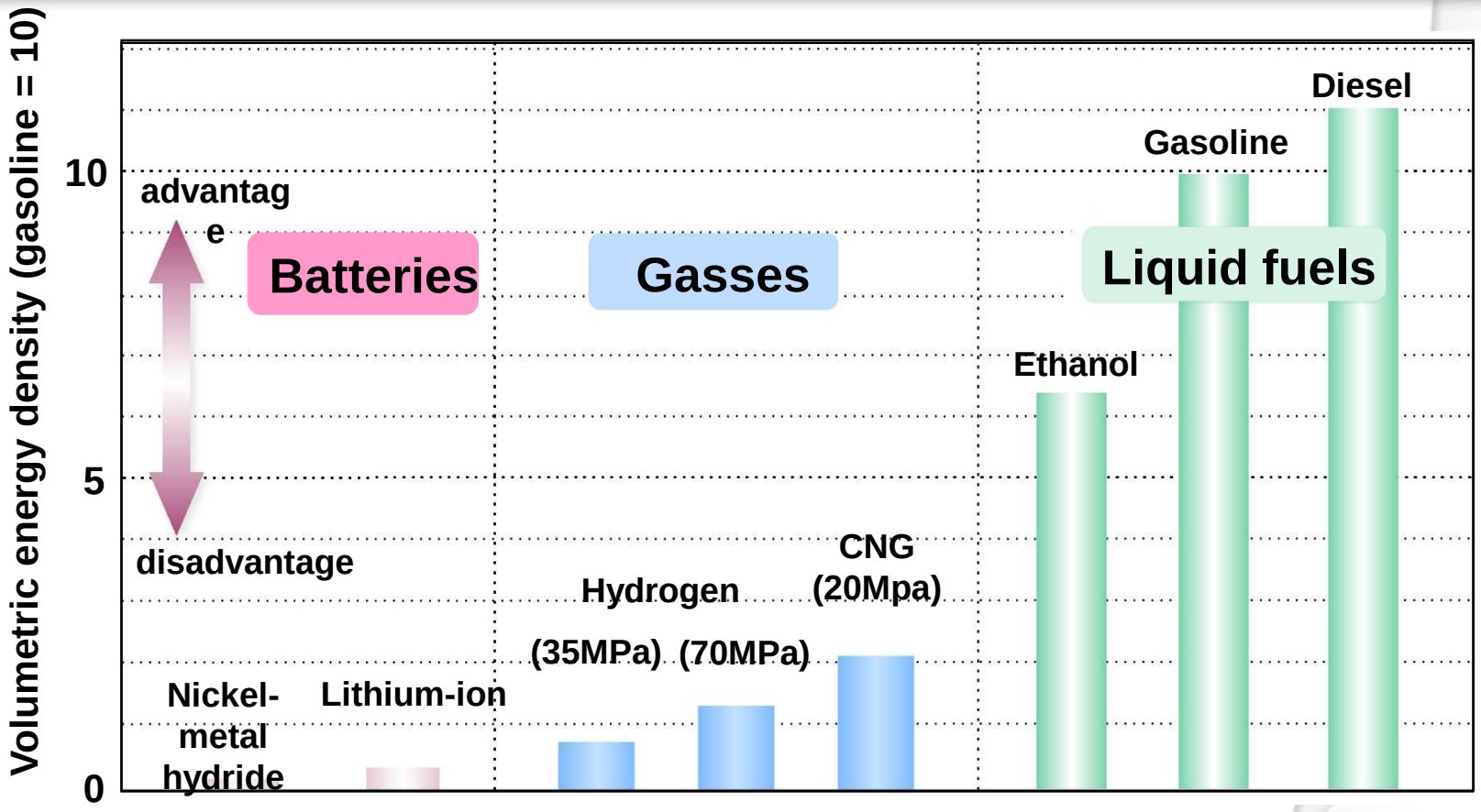
Toyota Motor Corporation

Diversification of Automotive Fuels and Power Trains



As fuel diversifies, vehicle powertrains diversify.

Comparison of Energy Density



(Calculated by Toyota)

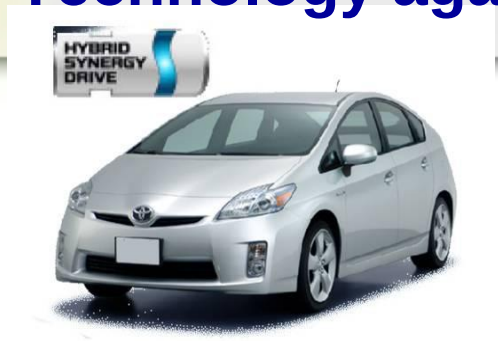
Energy density of electricity is approx. 1/50 of gasoline.

Characteristics of Alternative Fuels

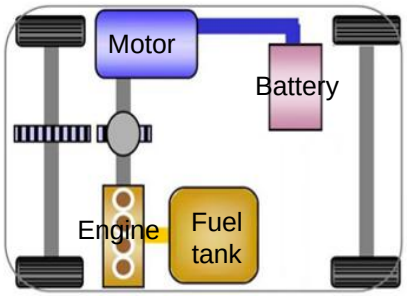
	Electricity EV	Hydrogen FCV	Bio fuels ICE	Natural gas ICE
Well to Wheel CO_2	Poor to Very good	Poor to Very good	Good to Very good	Fair
Supply availability	Very good	Very good	Poor	Very good
Cruising range	Poor	Good	Very good	Good
Dedicated infrastructure	Good	Poor	Very good	Good

- Each alternative fuel has advantages and disadvantages
- Energy policy depends on the country or region
Difficult to decide main energy source for automobiles.

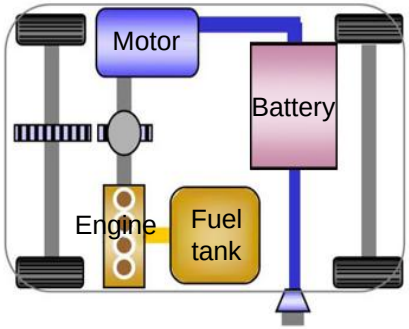
Technology against Energy / Environmental Issue



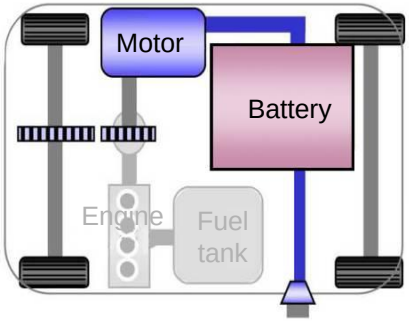
HV



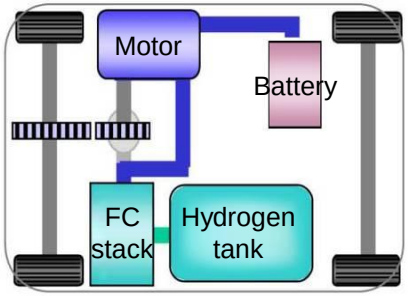
PHV



EV

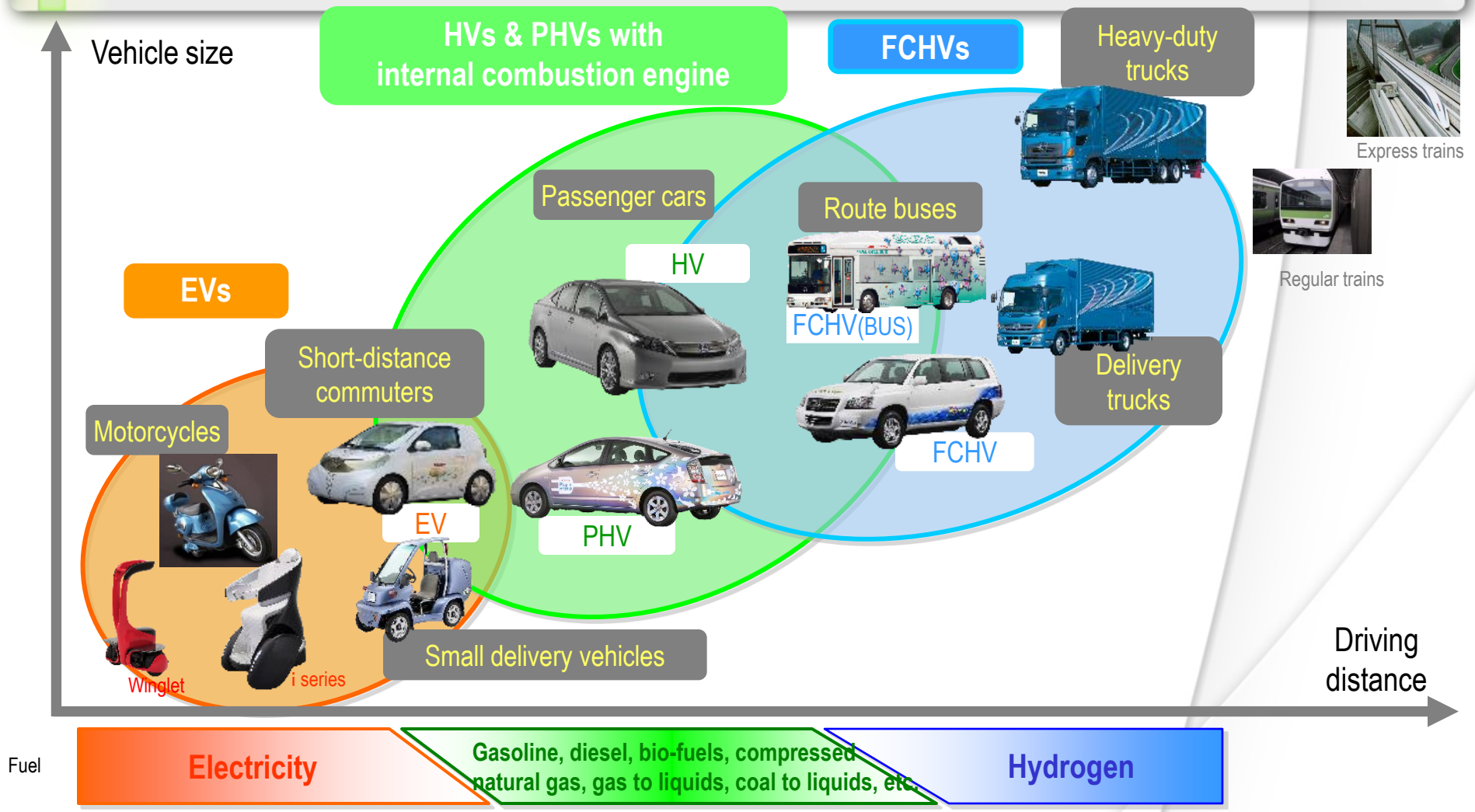


FCV



Hybrid technology is core technology applicable to all alternative powertrains.

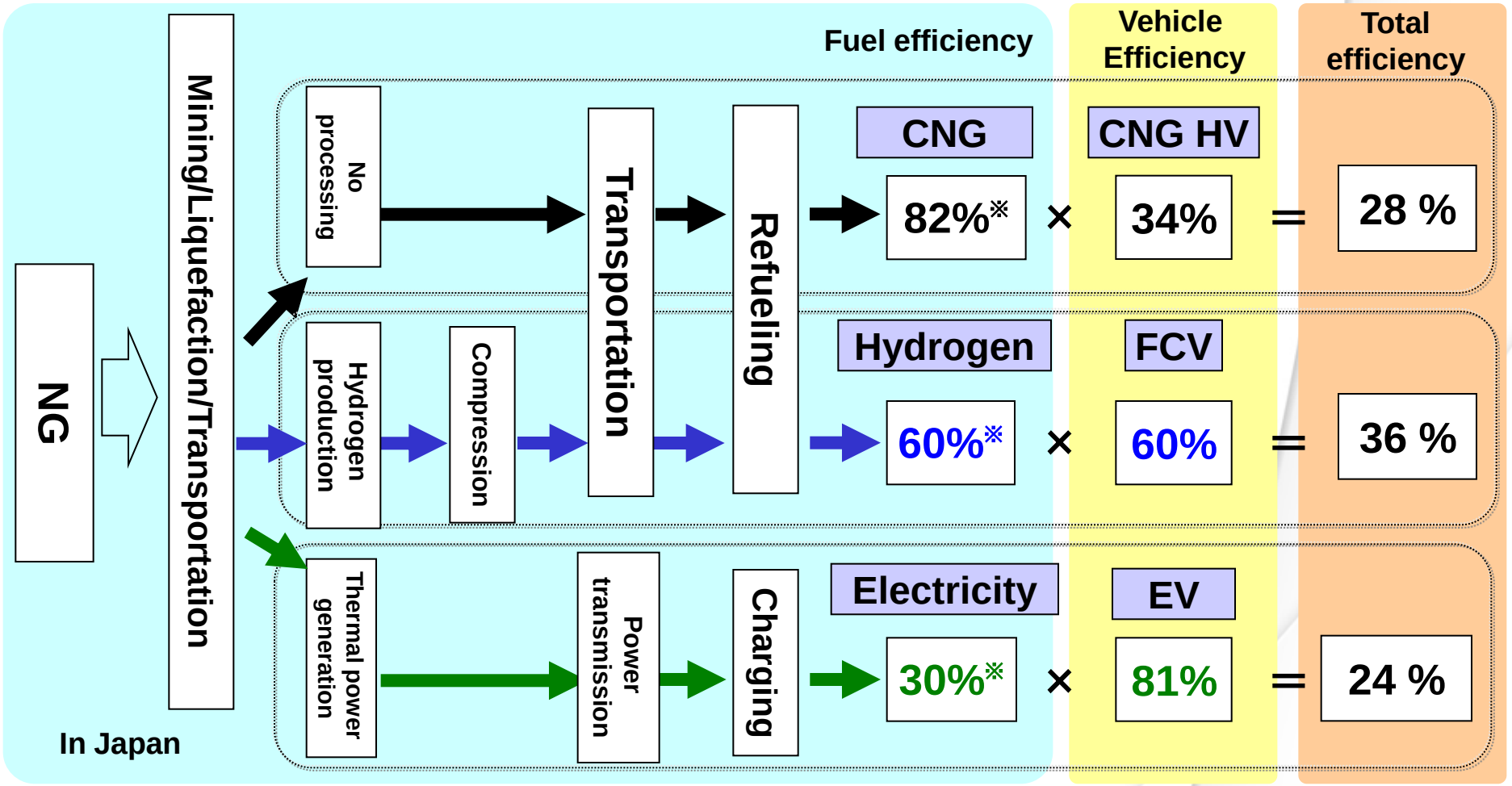
Vision of Low-Carbon Transport



HVs or PHVs with internal combustion engines: wide use;
EVs: short-distance compact commuters; FCHVs: medium-to-large vehicles and buses.

Comparison of total efficiency primary from NG

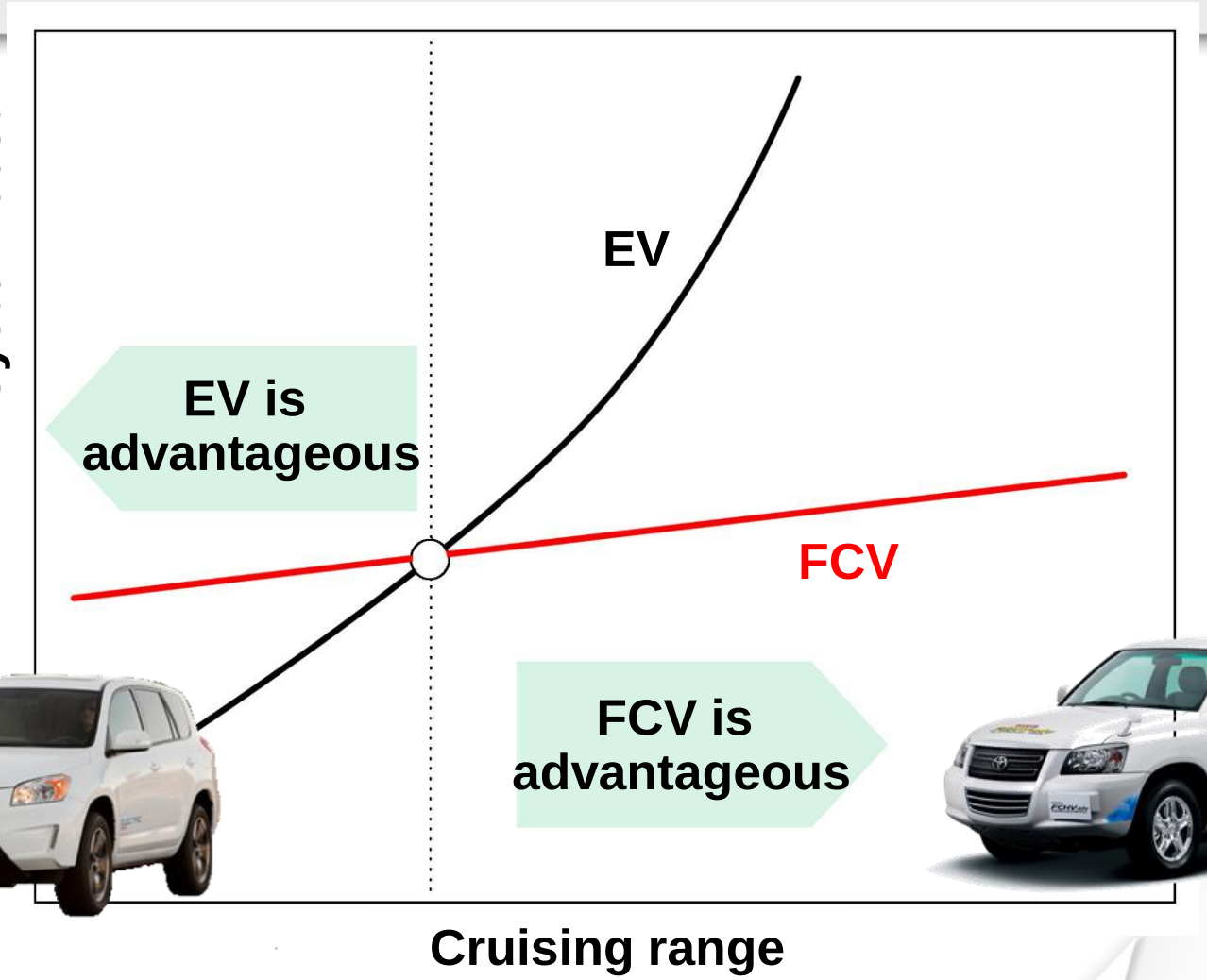
Toyota estimation



※ JHFC Report

Total efficiency of Hydrogen – FCV is the highest and about 1.5 times that of Electricity – EV.

System Cost Comparison Between EV and FCV



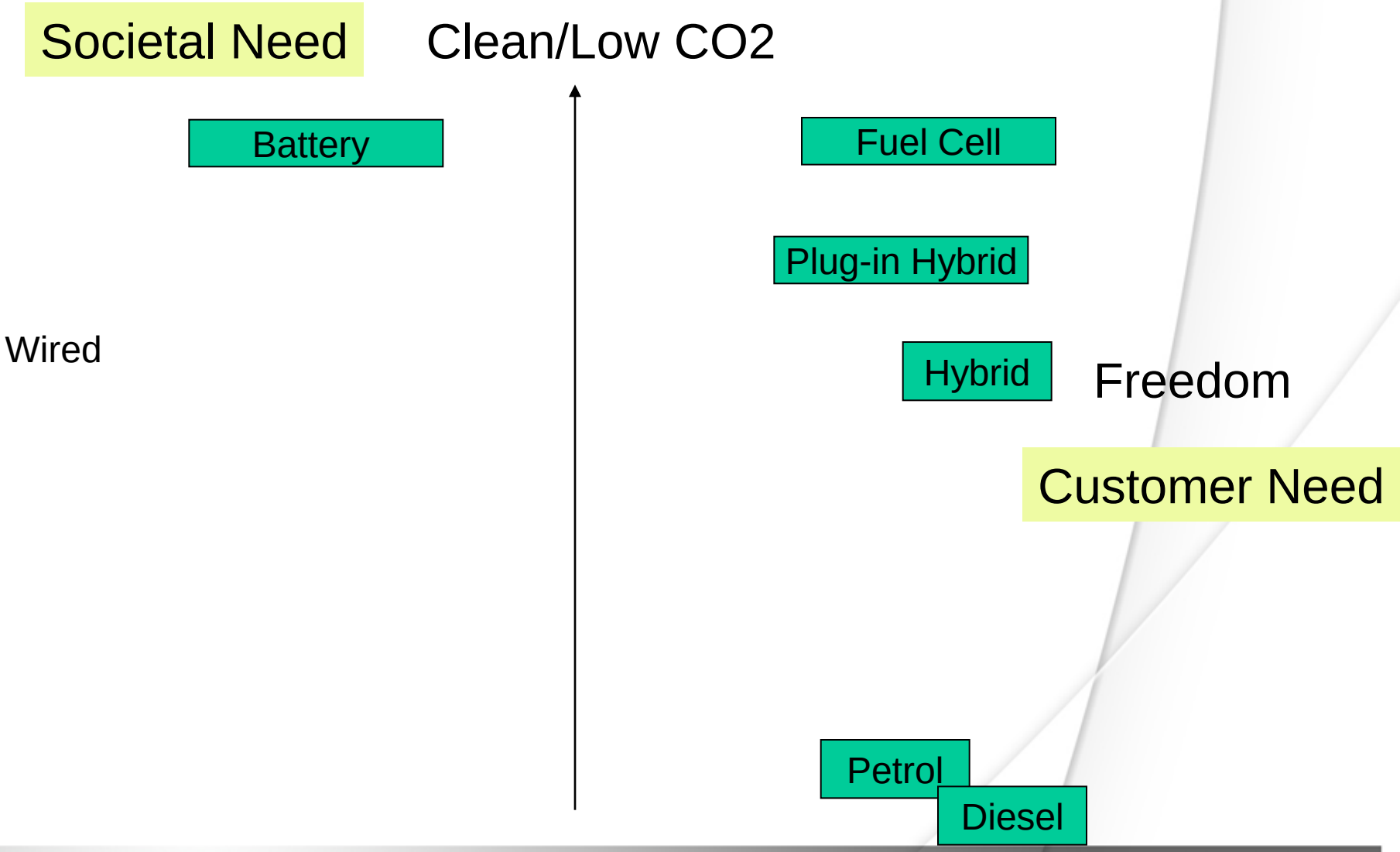
FCV: System cost increase for longer cruising distance is relatively sma

- It is advantageous in mid-to-long-drive-range applications.

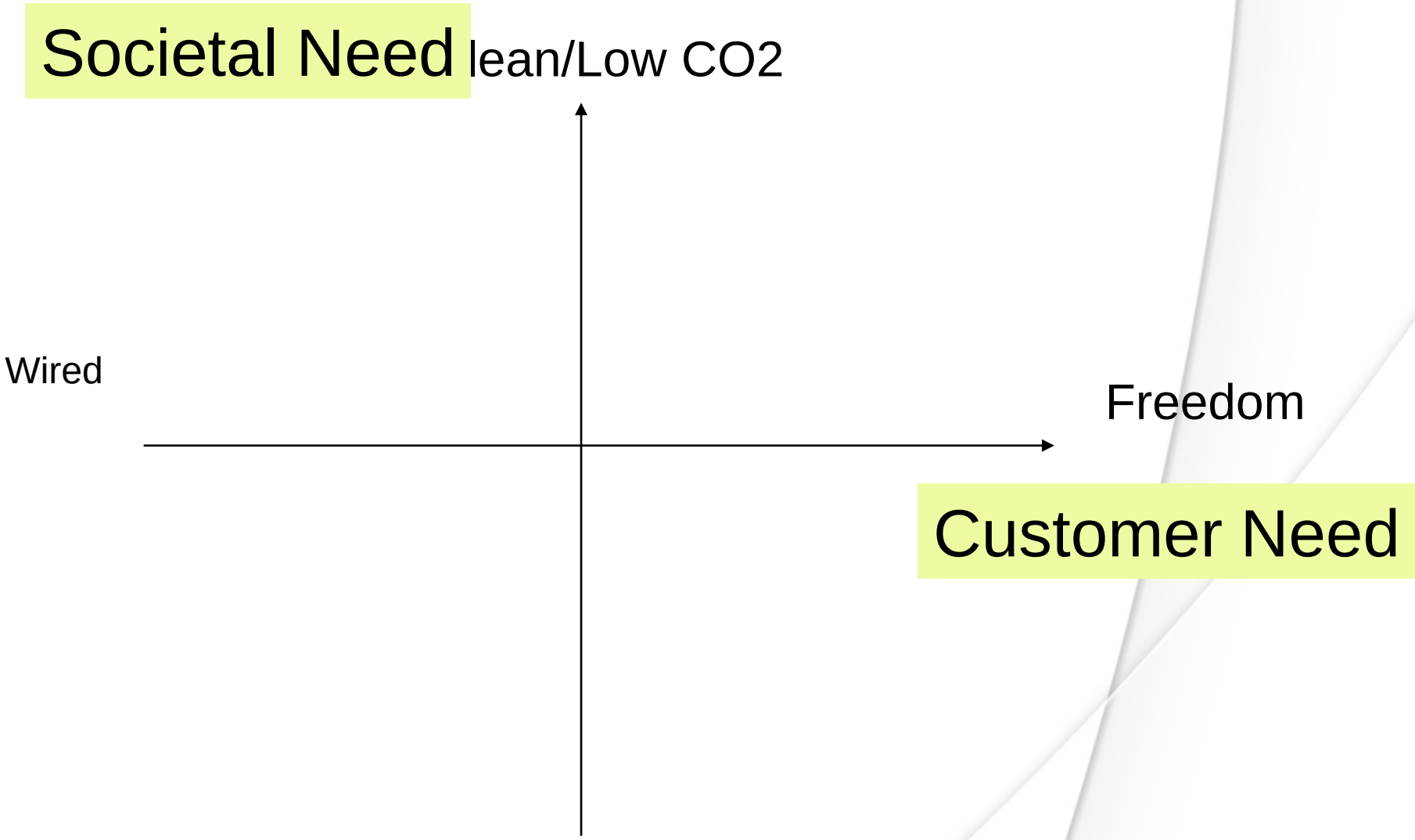
Product to be implemented

Societal Need

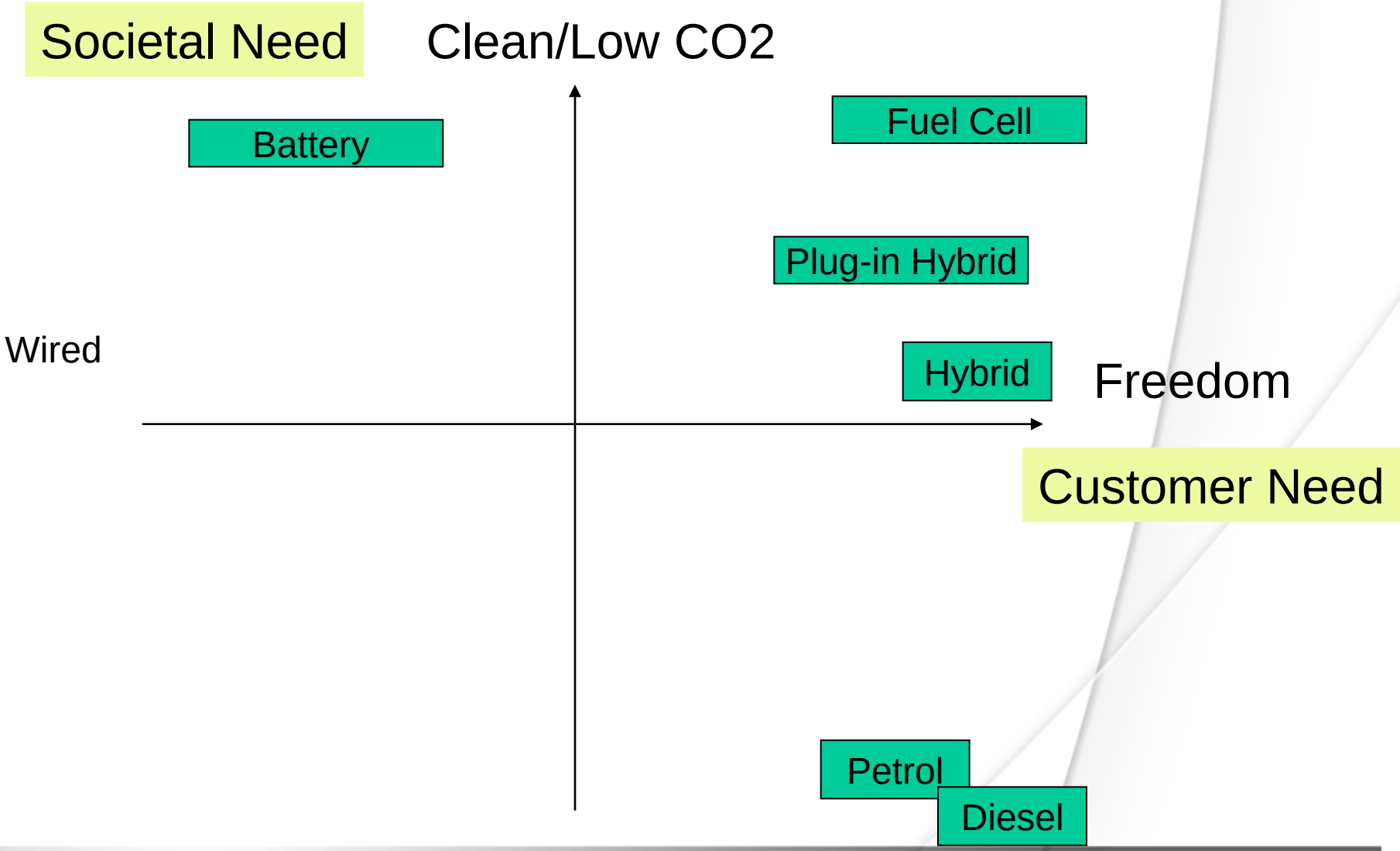
User points VS Societal requirement



Product to be implemented



User points VS Societal requirement



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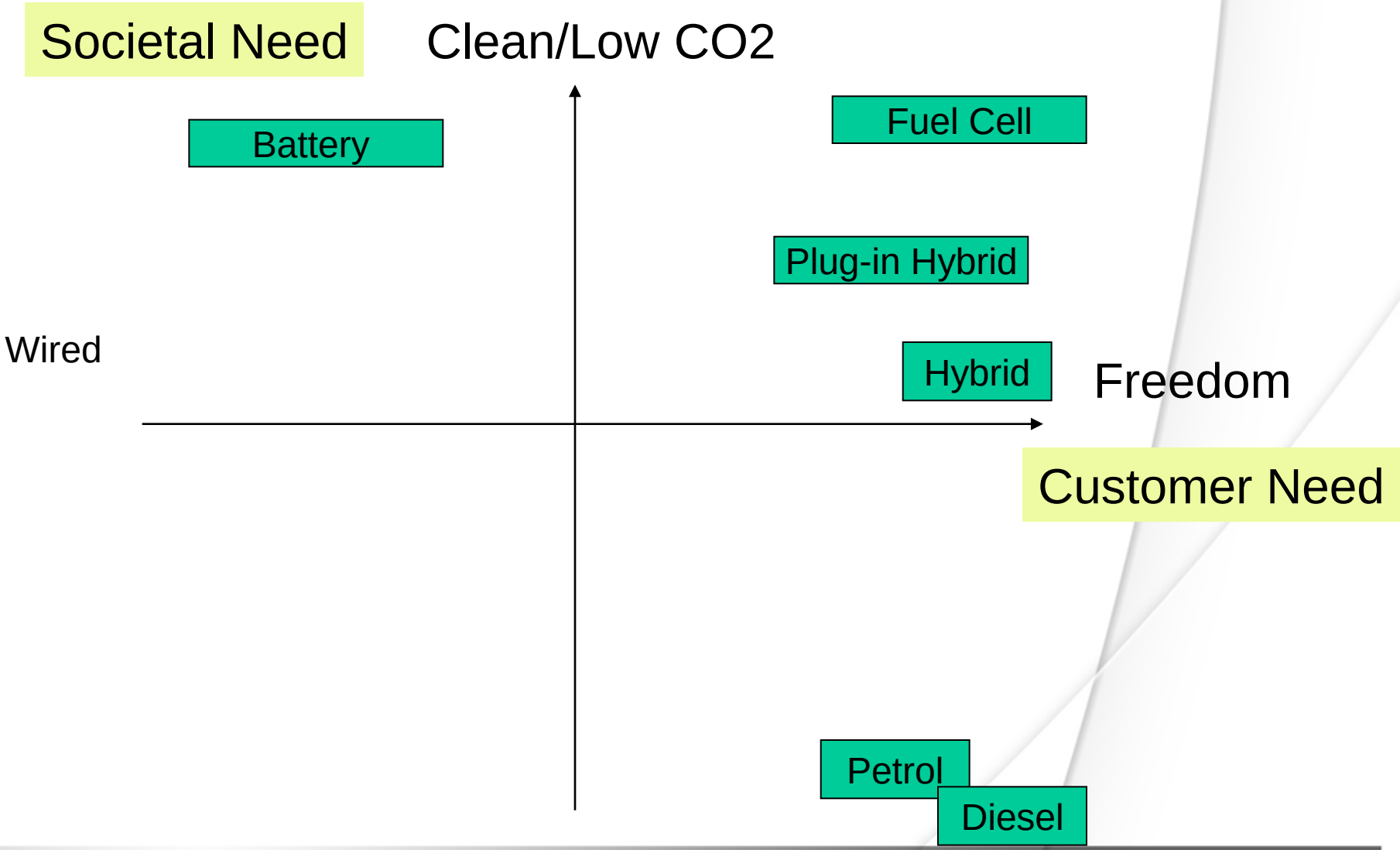

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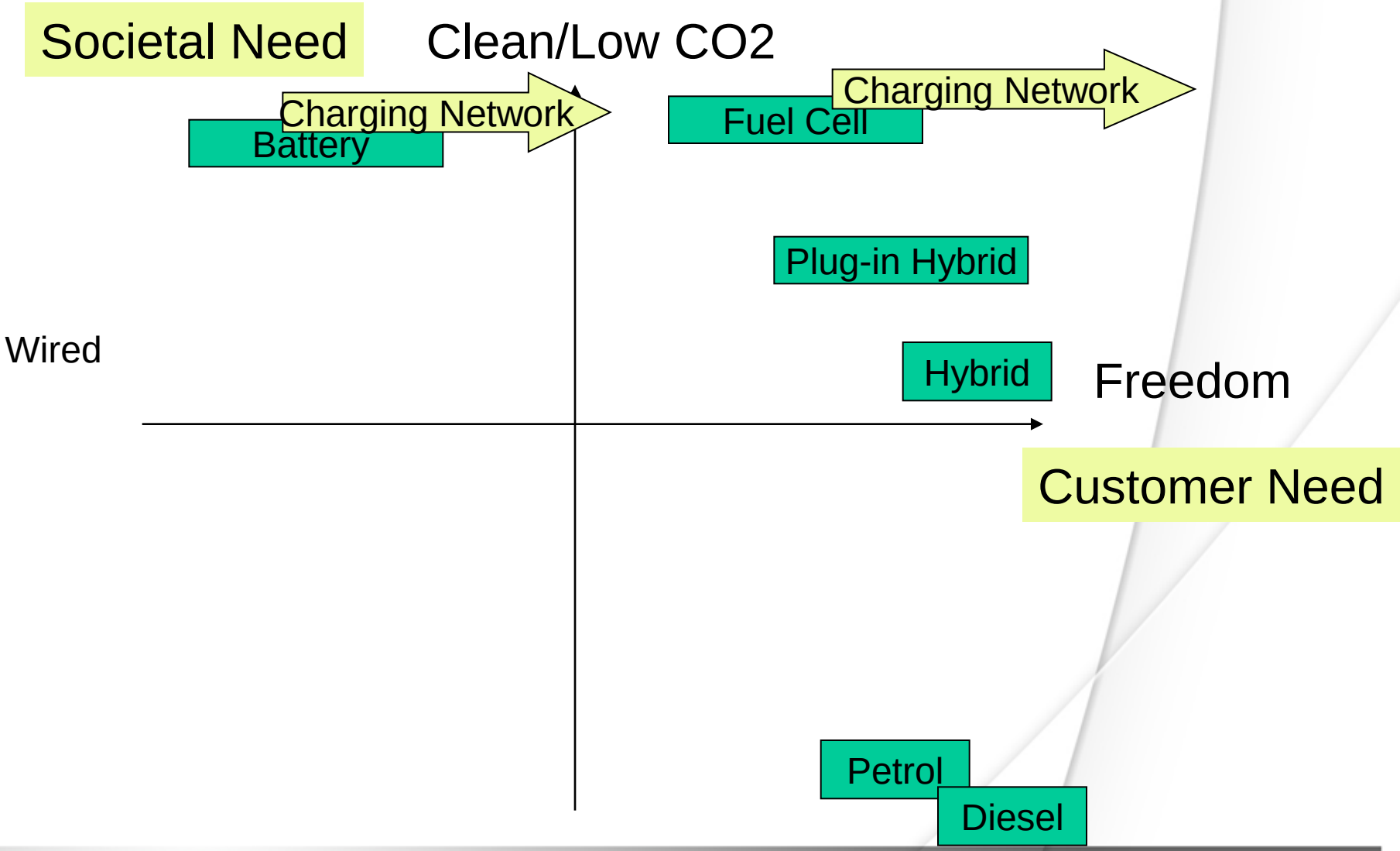


Where are we Now?

Strategies for Cost Reduction

1. Elimination/Reduction of components

- Elimination of humidifier
- Reduction in the number of tanks

3. Simplification of component structure

- Modification of FC stack structur
  high-pressure hydrogen tank, etc

2. Use of mass-produced components

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

4. Reduction of material cost

- Reduction in the amount of Pt catalys
- Development of high-strength low-co
  carbon fiber for tanks

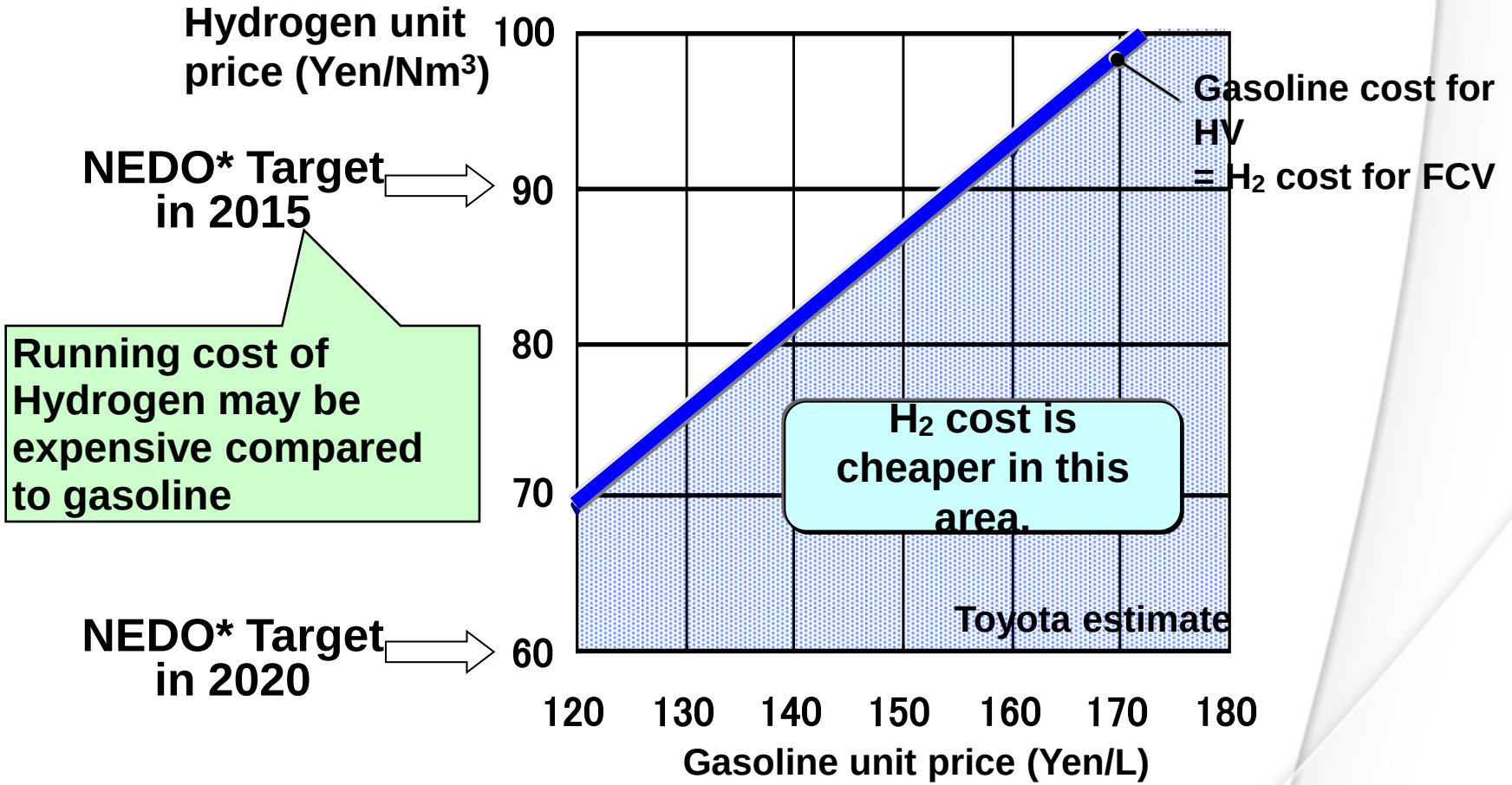
5. Improvement of production methods

- Automated cell assembly
- High speed tank winding

FC system cost reduction to 1/20

Economy(2): Running Cost of Fuel

Fuel cost difference between FCV and HV considering fuel economy difference (in J

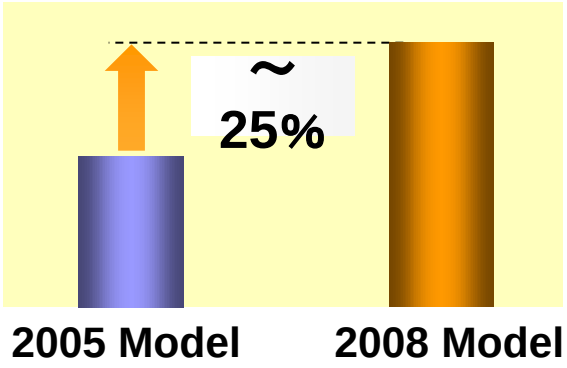


＊：New Energy and Industrial Technology Development Organization

Advantages for customers with further improvement of fuel economy and reduced of H_2 price are expected.

Customers' Convenience(1): Range

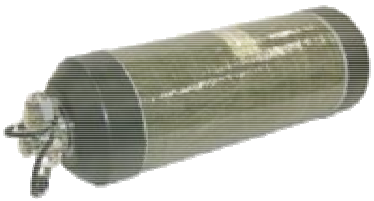
1. Fuel Economy：Improvement by 25%



- Improvement in FC efficiency
- Reduction in auxiliary loss
- Increase in regenerative energ

2. Hydrogen storage capacity: Doubled

- Hydrogen pressure：35MPa → 70MPa
- Increase in tank volume

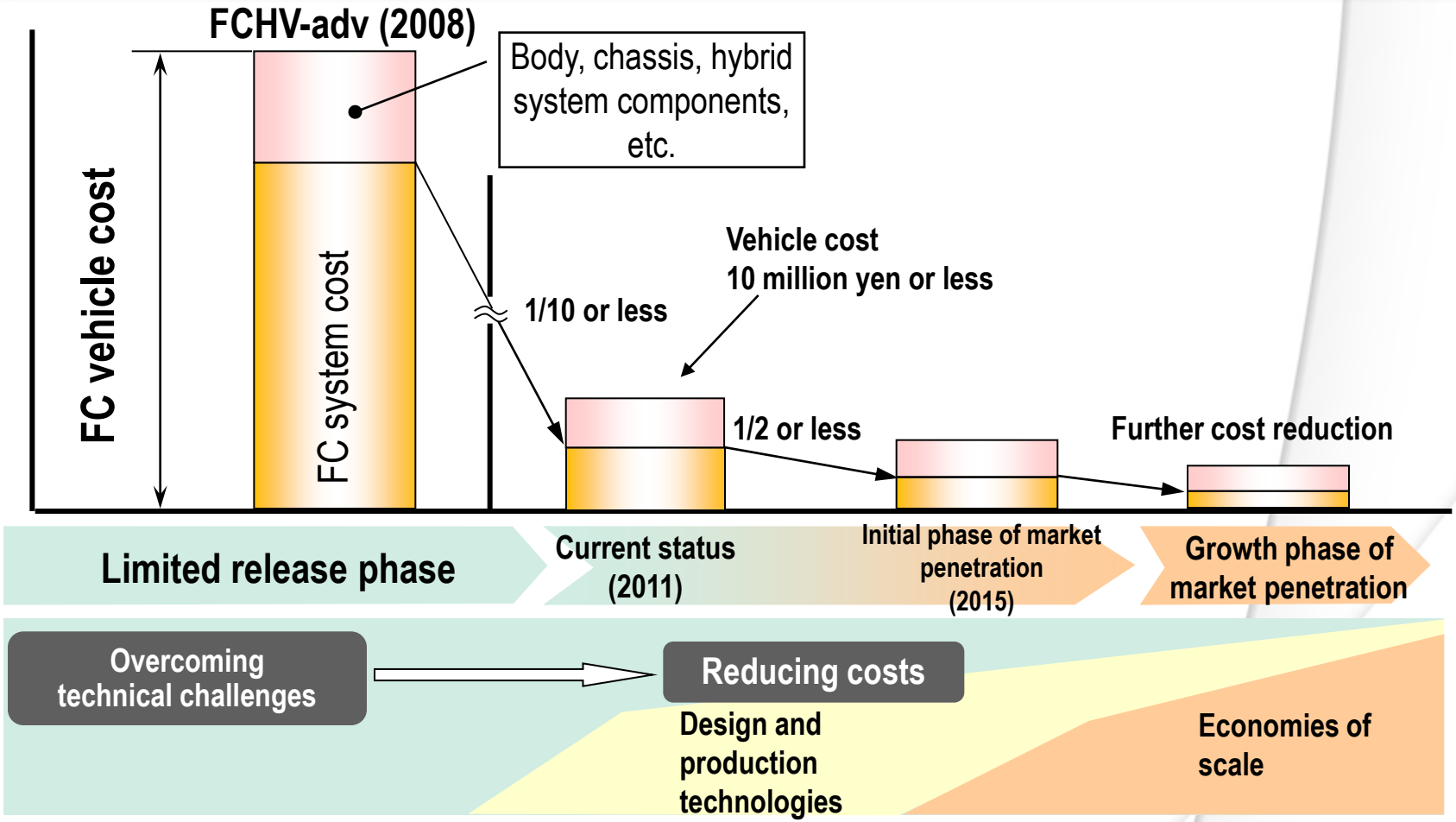


2005 Model

2008 Model

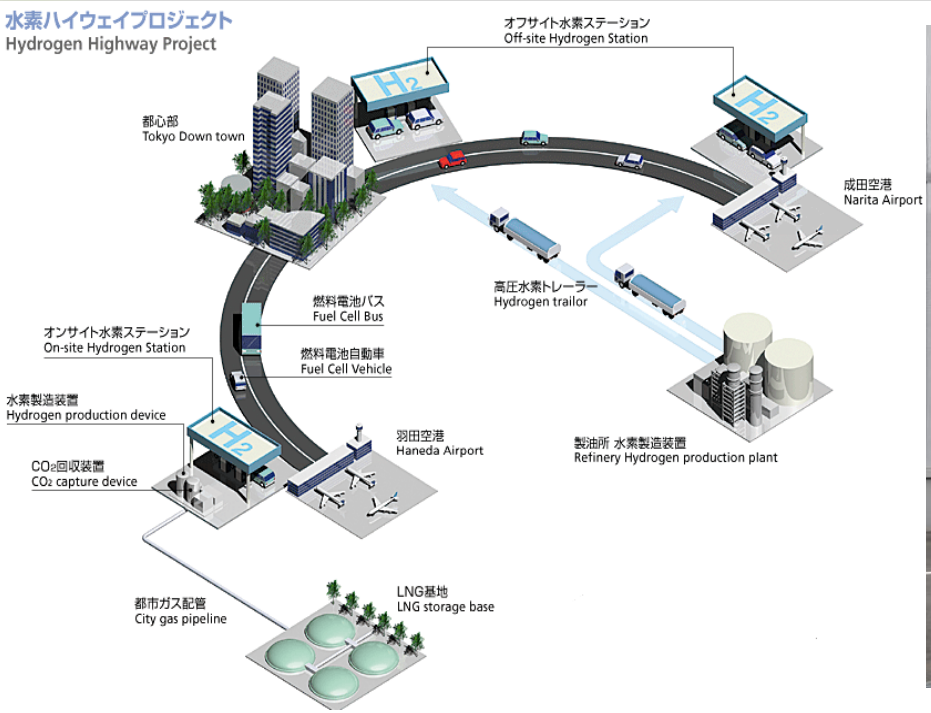
Improved Fuel Economy & Increased Hydrogen Storage Capa contributed to extended range of FCV.

FC Vehicle Cost Reduction



Current status: FC system cost reduction of 1/10 has been achieved and the vehicle cost is 10 million yen or less.
In 2015: Aiming at another 1/2 FC system cost reduction

Hydrogen Highway Project and FCHV-BUS



Demonstration Program for Establishing a Hydrogen-Based Social System

Haneda-Shinjuku Bus in operation since Dec 15, 2010

1. Haneda Airport <=> Shinjuku area, Limousine bus
2. Narita Airport <=> Passenger's home, Limousine taxi (FCHV-adv)

Source: The Research Association of Hydrogen Supply/Utilization Technology (HySUT)

Future Plan for FCVs

- Hydrogen FCV is promising as a future alternative vehicle.
- The TOYOTA group focus on developing the technology and commercial products for passenger vehicles and buses.

TOYOTA will start selling sedan type FCVs around 2015:

In Japan

-initially in four major metropolitan areas in Japan where Hydrogen infrastructure deployment is expected.

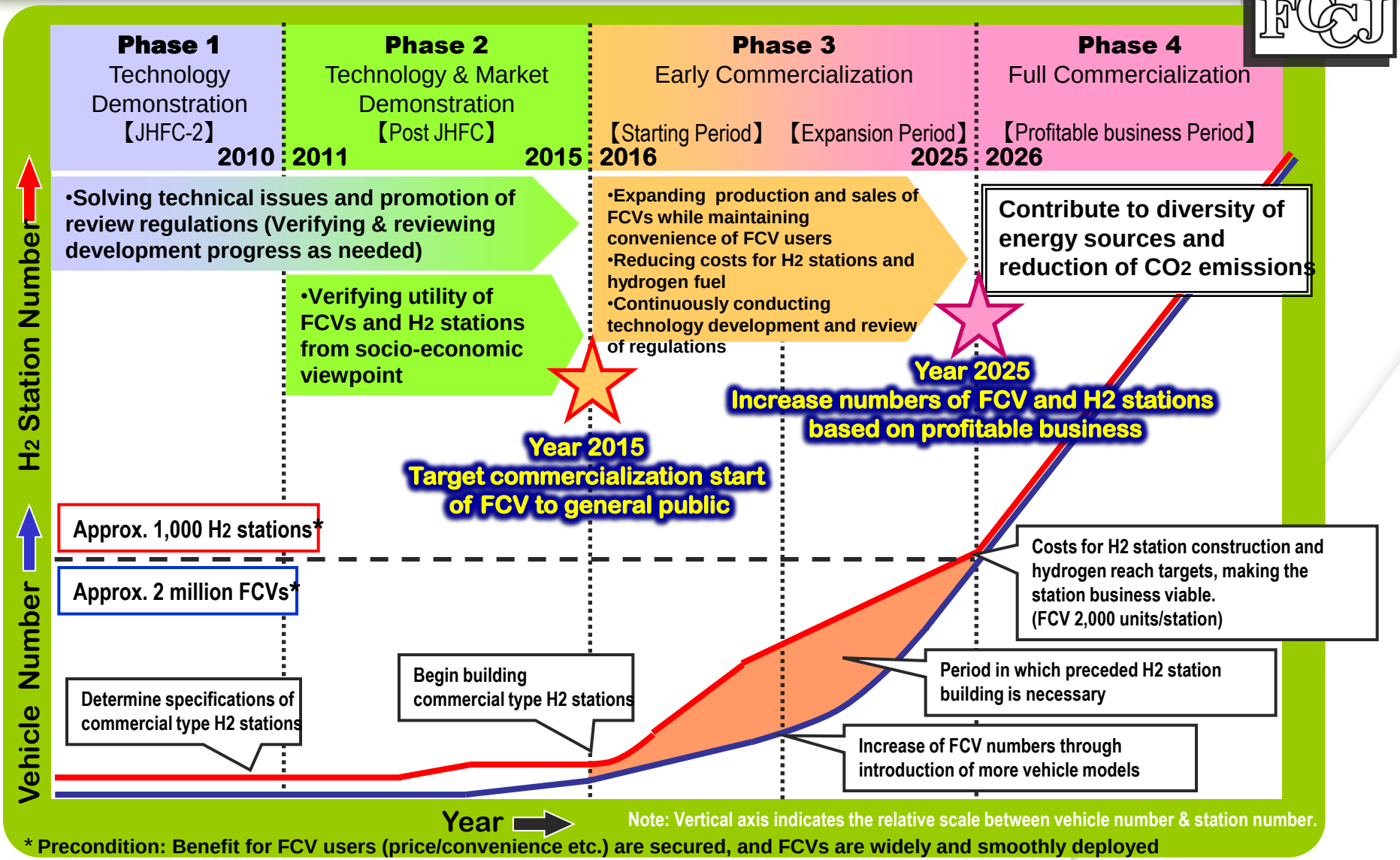
- In the world

-Place where customers and hydrogen are

- at a reasonable and affordable price for customers.

Infrastructure development in Japan

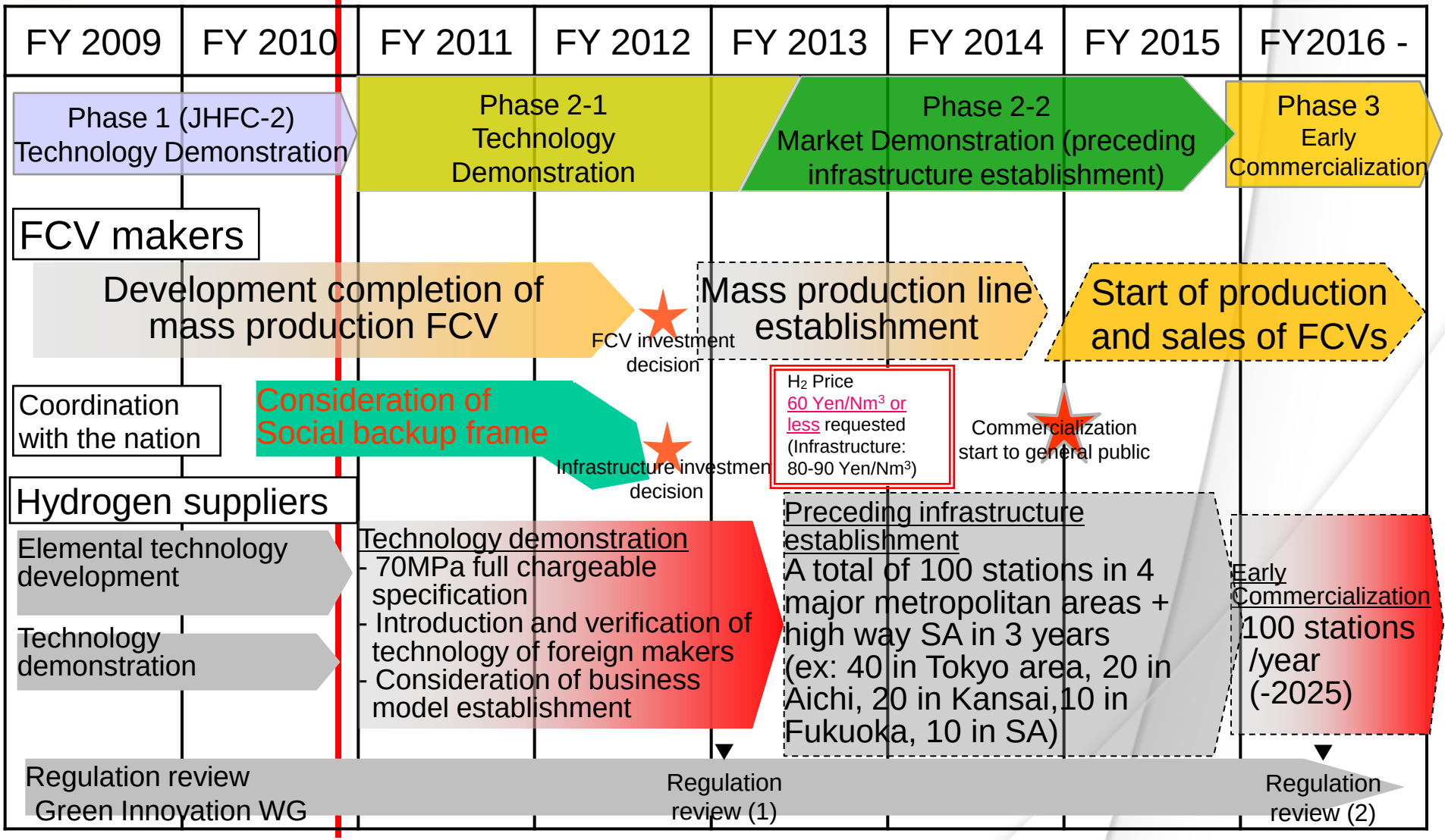
FCCJ Commercialization Scenario



* Precondition: Benefit for FCV users (price/convenience etc.) are secured, and FCVs are widely and smoothly deployed

Source: Fuel Cell Commercialization of Japan (**FCCJ**), TOYOTA added some comment

Infrastructure Development Scenario



13 Japanese Companies Eye Smooth Domestic Launch of FCVs

–Development of Hydrogen Supply Infrastructure Key–

2011,Jan. 13 Tokyo

- As development of fuel-cell systems progresses, Japanese automakers are continuing to drastically reduce the cost of manufacturing such systems and are aiming to launch FCVs in the Japanese market—mainly in the country's four largest cities—in 2015. The automobile industry hopes to popularize the use of FCVs after their initial introduction as a way of tackling energy and environmental issues.
- Hydrogen fuel suppliers are aiming to construct approximately 100 hydrogen fueling stations by 2015, based on the number of FCVs expected to initially enter the market, to ensure a smooth launch and to create initial market.
- With an aim to significantly reduce the amount of CO2 emitted by the transportation sector, automakers and hydrogen fuel suppliers will work together to expand the introduction of FCVs and develop the hydrogen supply network throughout Japan. The two groups are looking to the government to join them in forming various strategies* to support their joint efforts and to gain greater public acceptance of the technology.

Toyota Motor Corporation
Nissan Motor Company, Ltd.
Honda Motor Company, Ltd.
JX Nippon Oil & Energy Corporation
Idemitsu Kosan Company, Ltd.
Iwatani Corporation
Osaka Gas Company, Ltd.
Cosmo Oil Company, Ltd.
Saibu Gas Company, Ltd.
Showa Shell Sekiyu K.K.
Taiyo Nippon Sanso Corporation
Tokyo Gas Company, Ltd.
Toho Gas Company, Ltd.

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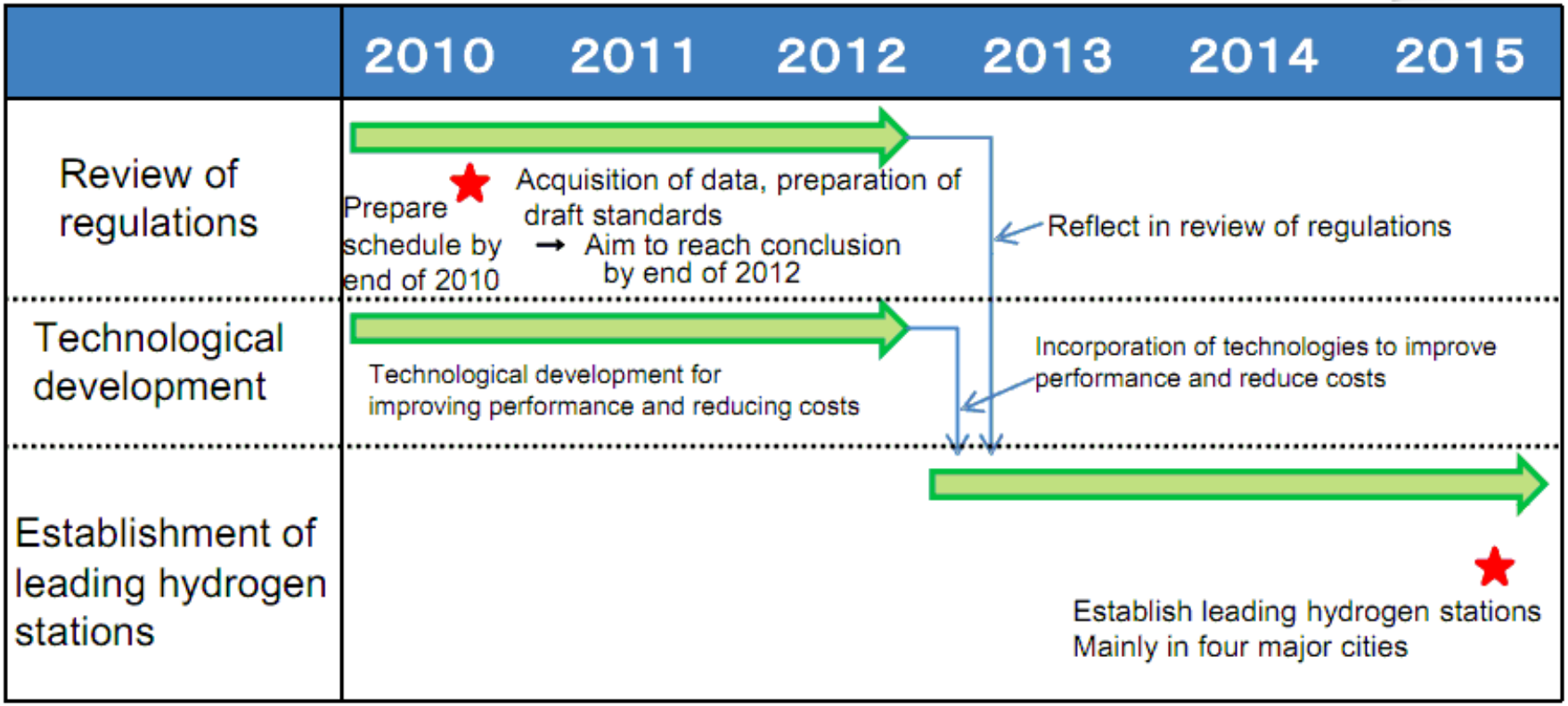
Schedule for Starting Introduction of FCVs in 2015

Towards starting introduction in 2015

By 2012, reach a conclusion on the reexamination of principal regulations, and implement technical development to enhance performance of dispensers and accumulators, and reduce costs.

From 2013, start building leading hydrogen stations reflecting the above results.



16 Priority Issues For Policy Reforms

1	Maintain Technical Basis and Exemplified Basis compliant to 70MPa hydrogen stand	High Pressure Gas Safe
2	Alleviate the distance regulation that facilitate of building CNG stands	High Pressure Gas Safe
3	Formulate Safety Inspection Regulation to simplify process of safety inspection and assign at the Safety Inspection Announcement	High Pressure Gas Safe
4	Increase of hydrogen holdings in the urban area	Building Standard Law
5	Simplify the application of Technical Standards Adaptation for specific facilities and pluming of low design coefficient	High Pressure Gas Safe
6	Enhance of usable steal stock mentioned in Exemplified Bas	High Pressure Gas Safe
7	Revise the Exemplified Basis in order to raise the maximum refueling pressure (35MPa to 45MPa) of the compound vessels for compressed hydrogen vehicles	High Pressure Gas Safe
8	Revise the Exemplified Basis of accessories to add thermal actuation safety valve (glass bulb) to the compound vessels for compressed hydrogen vehicles	High Pressure Gas Safe
9	Establish exception for stamping compound vessels and accessories for compressed hydrogen vehicles	High Pressure Gas Safe
10	Simplify the application of Technical Standards Adaptation of compound vessel usage for hydrogen stand accumulator	High Pressure Gas Safe
11	Rationalize regulations of fueling stations related to the setting of the hydrogen stations	Fire Service Law
12	Establish alternative measures for barriers related to the distance between public roads and dispensers	High Pressure Gas Safe
13	Allow hydrogen refueling to those who are not permitted of high pressure gas manufacturing, set forth to realizing self-refueling hydrogen stands	High Pressure Gas Safe
14	Clearly articulate the explosion protection zone basis related to hydrogen dispensers	High Pressure Gas Safe
15	Ensure refueling stands to accommodate out of gas vehicles on public roads	High Pressure Gas Safe
16	Change maximum refueling pressure for Full-refueling and revise Exemplified Basis (container related) Change maximum refueling pressure for Full-refueling and revise Exemplified Basis (general related)	High Pressure Gas Safe

Hydrogen Station Implementation

1. Hydrogen station deployment

2015

"Early commercialization"

In 4 major metropolitan areas

100 stations

2025

"Commercialization expanding"

47 prefectural capitals covered

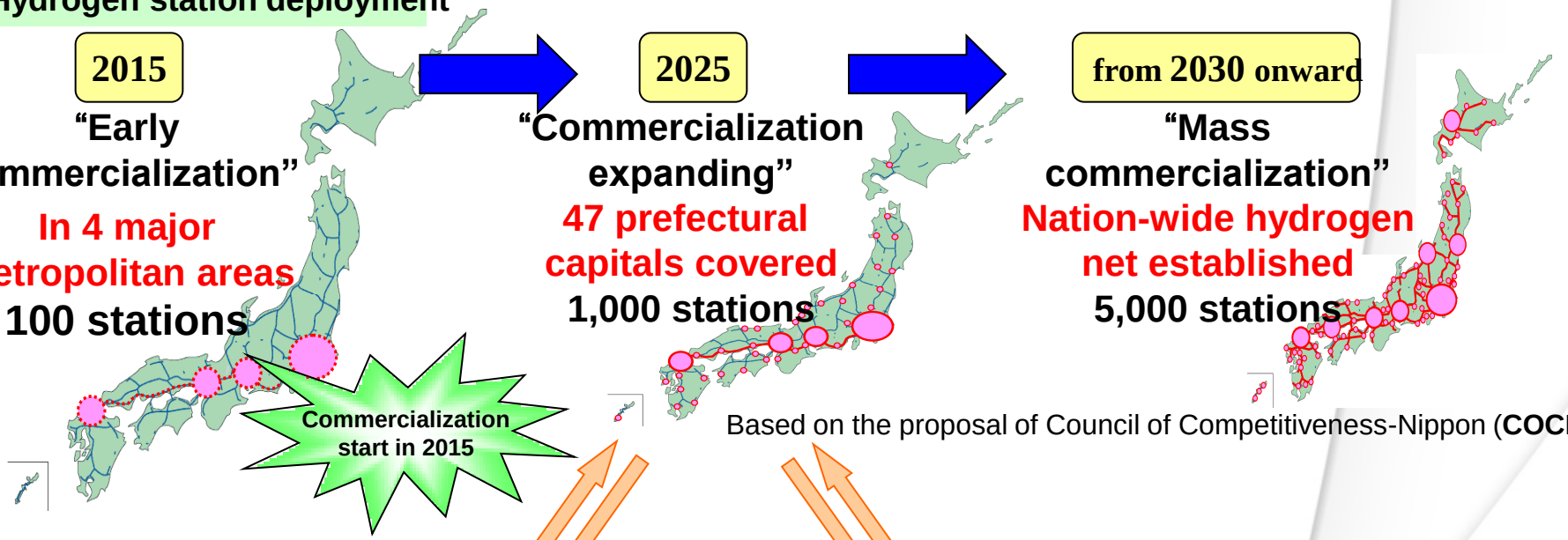
1,000 stations

from 2030 onward

"Mass commercialization"

Nation-wide hydrogen net established

5,000 stations



Based on the proposal of Council of Competitiveness-Nippon (**COCN**)

2. Station technology development

Example of container-type low cost station (Linde, Germany)

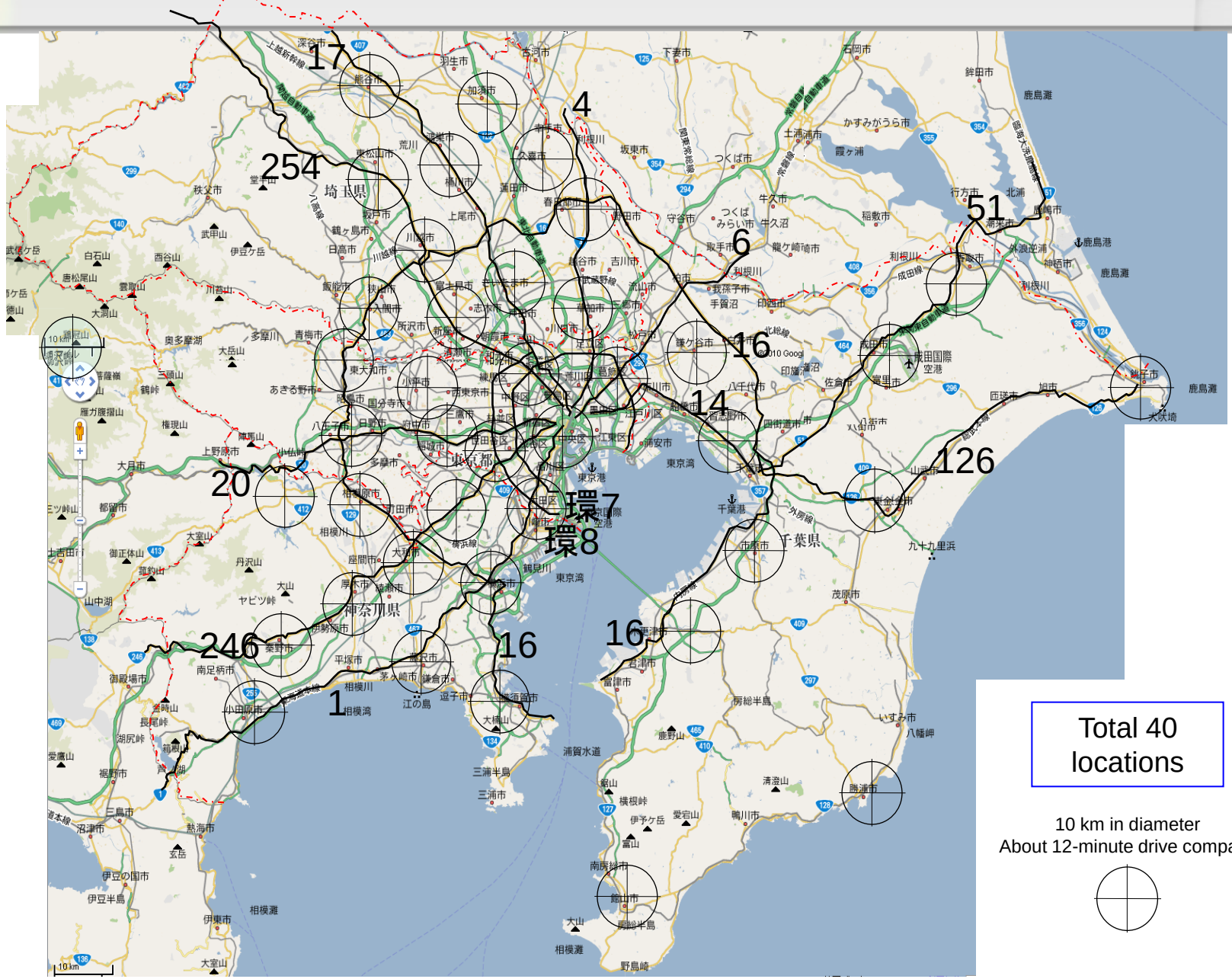
3. Regulation review

"Action plan for regulation review" was announced in Dec 2010.

- Material standards
- Pressure standards
- Accumulator structure
- Adjacent stations
- Periodic inspection method
- Self-service stations, etc.

It is necessary to solve these three issues for hydrogen station establishment.

Picture of H_2 Station Deployment in Kanto Area



“End of stone age was not due to the lack of stone”

The technological innovation and new idea change the society.

What we learned

- **Future is not predictable.**

- **We can prepare for Future.**

Today For Tomorrow

Thank you for your attention.