AUTOMOTIVE SUMMIT 2015

ASEAN...the emerging Automotive Hub of the World

24th - 25th June 2015

Bitec Bangna, Bangkok

<Thailand Automotive Summit 2015>

Toyota's Development of Environmental Technologies for Sustainable Mobility

24 June. 2015

Yasuki Nakagawa

Toyota Motor Asia Pacific
Engineering & Manufacturing Co., LTD.
(TMAP-EM)

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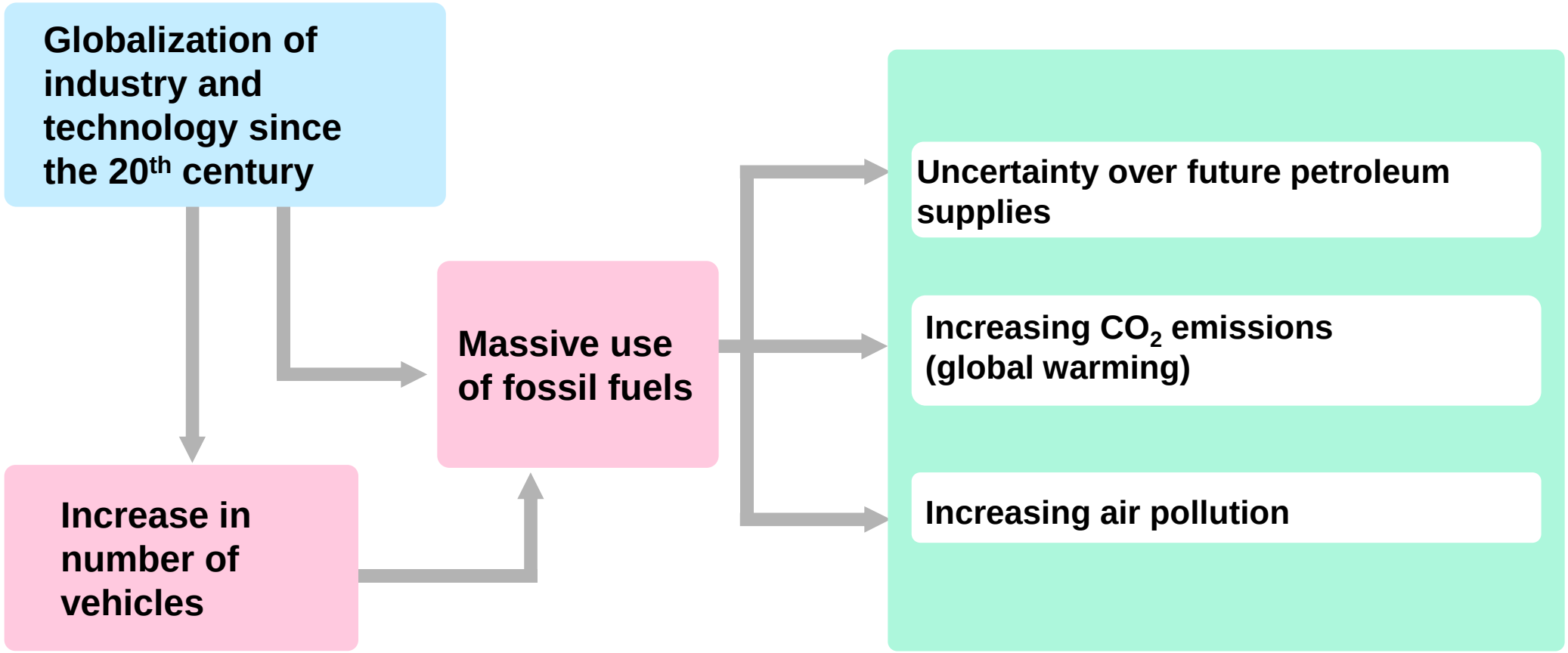
Current challenges facing the automotive industry



Toyota's fundamental approach

Energy conservation

Fuel diversification

Green vehicles can only contribute significantly to the environmental issues when they are widely used.

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To improve fuel efficiency

What is the most efficient way to turn each drop of fuel into energy and move the vehicle with that energy?

Improving powertrain efficiency

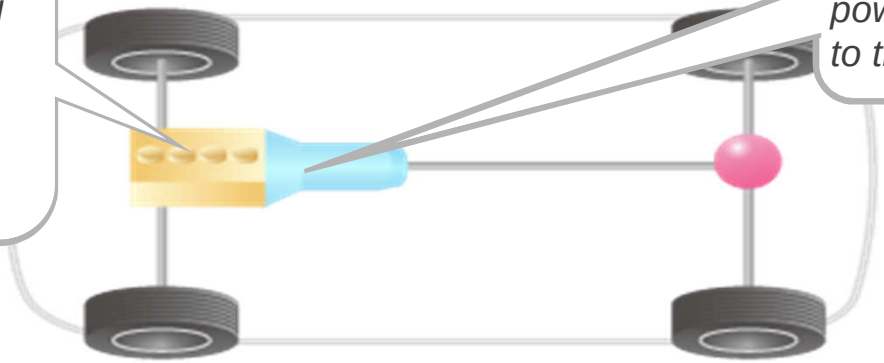
Reducing running resistance

Improving engine thermal efficiency

Improving drivetrain efficiency

How do we change each drop of fuel into engine revolutions with the highest efficiency?

How do we deliver energy, the source of power, most efficiently to the wheels?

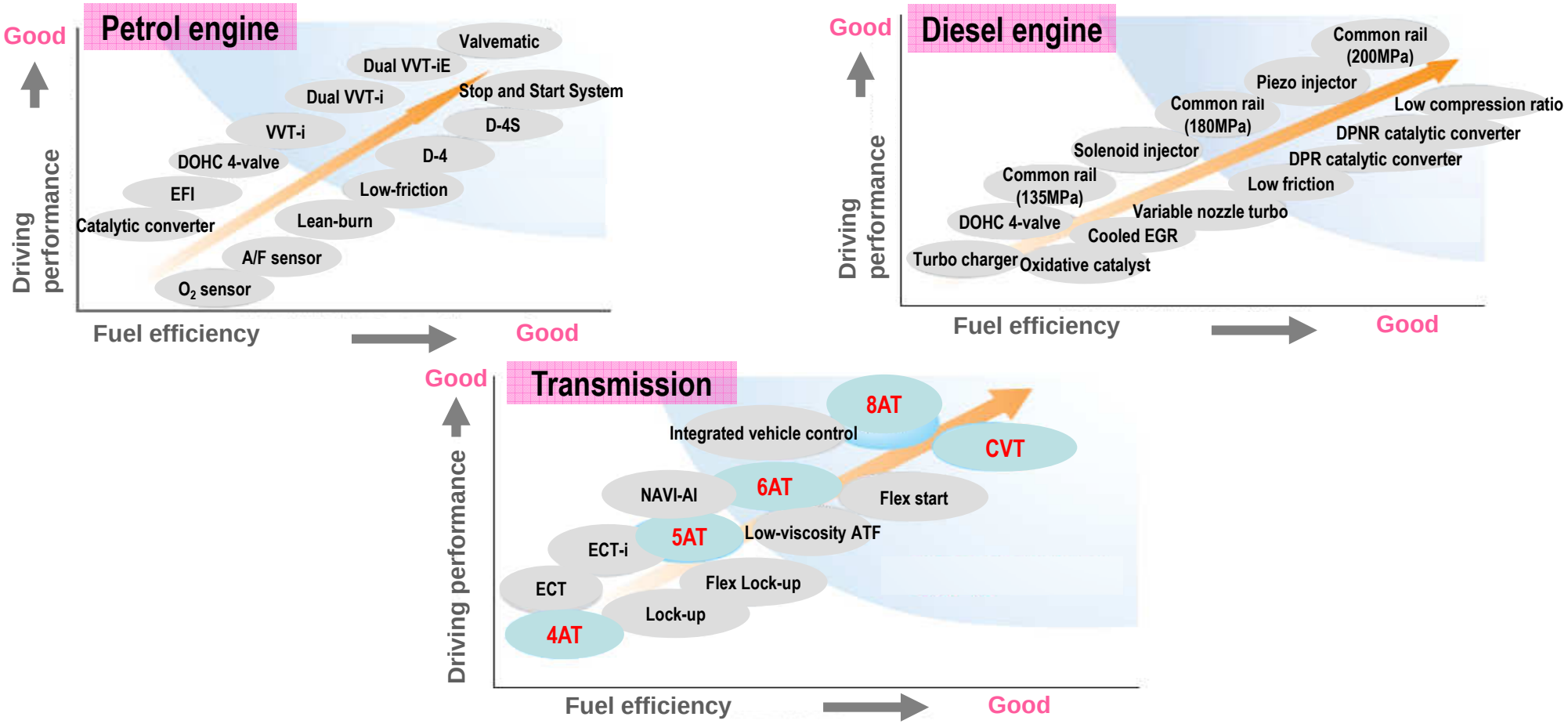


Reducing air resistance

Reducing weight

Effective ways to increase fuel efficiency: Improving engine thermal efficiency & Enhancing drivetrain power transfer efficiency

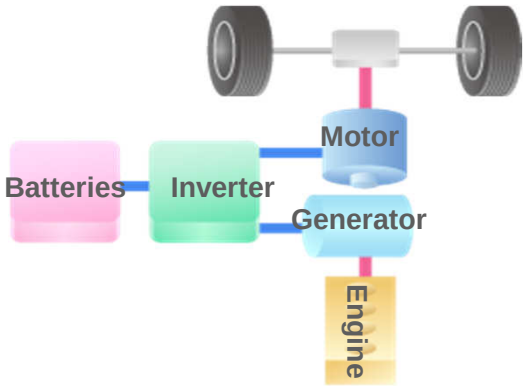
Powertrain Development concept



Engines and transmissions are revamped through ongoing incorporation of new technologies.

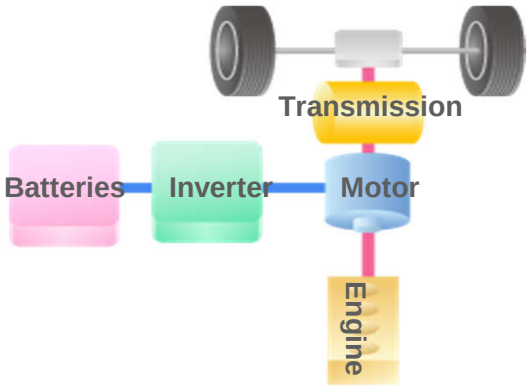
Types of hybrid systems

Series hybrid



The engine operates the generator, and electric motor drives the wheels with the generated power

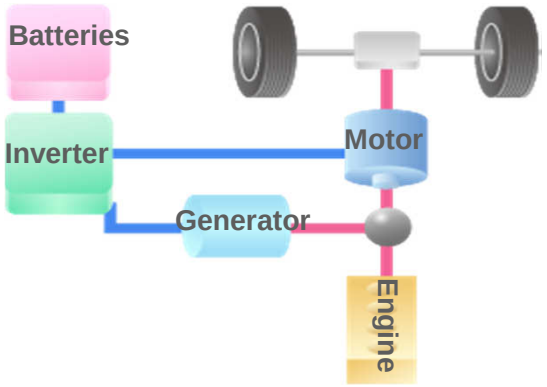
Parallel hybrid



The engine and electric motor drive the wheels. When the electric motor is generating power, it can't be used for driving the wheels

Series parallel hybrid

Toyota Hybrid System



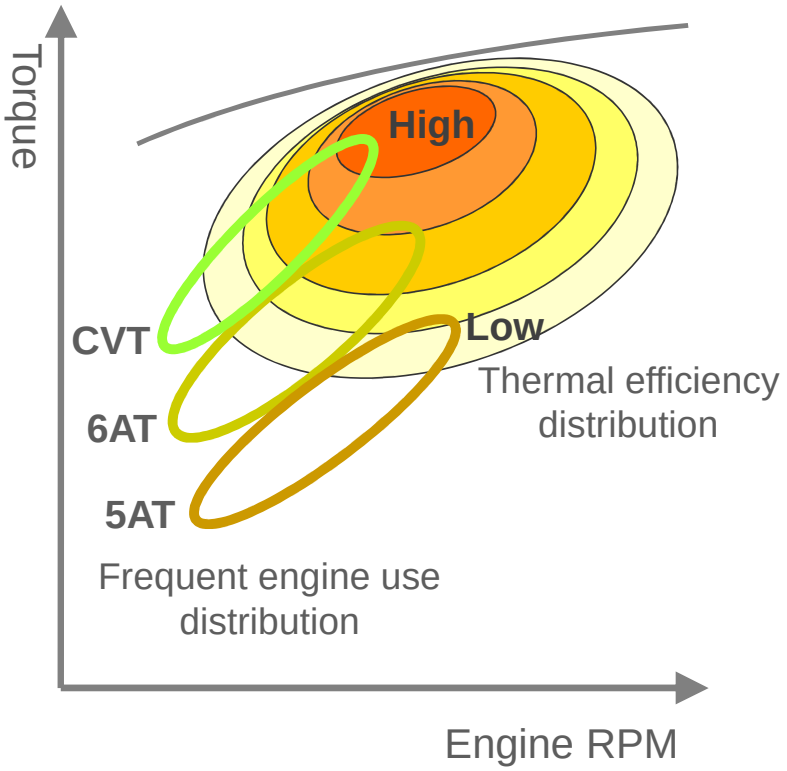
Depending on driving conditions, the engine and the electric motor can work together, or the motor alone can propel the vehicle

Mechanical power route Electrical power route

Toyota's hybrids: series parallel hybrids

Toyota Hybrid System: Reasons for higher fuel efficiency

Conventional engine

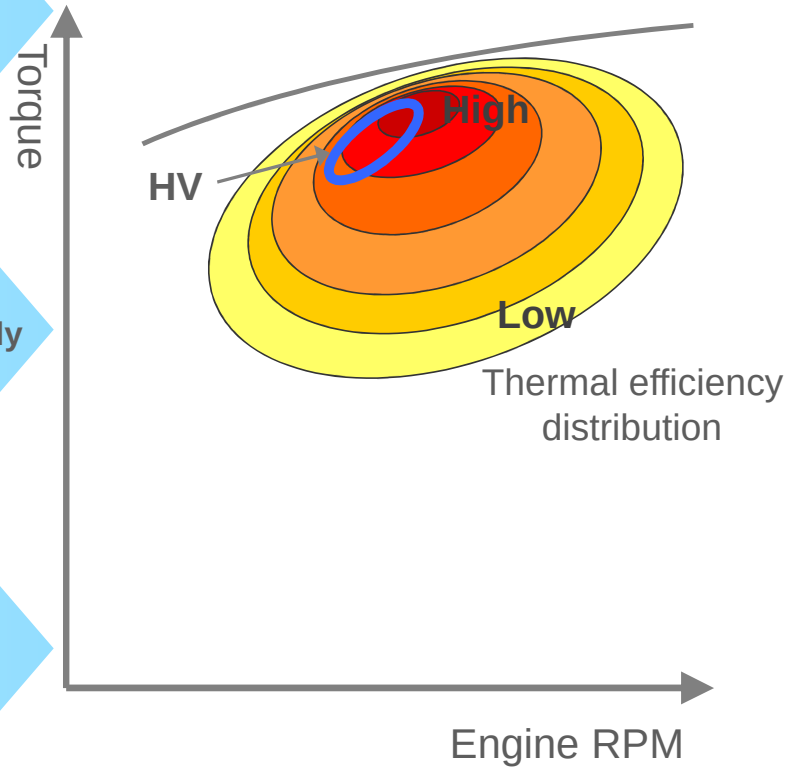


Improved thermal efficiency by Atkinson cycle

Engine stops where thermal efficiency is low. Vehicle is only propelled by electric motor

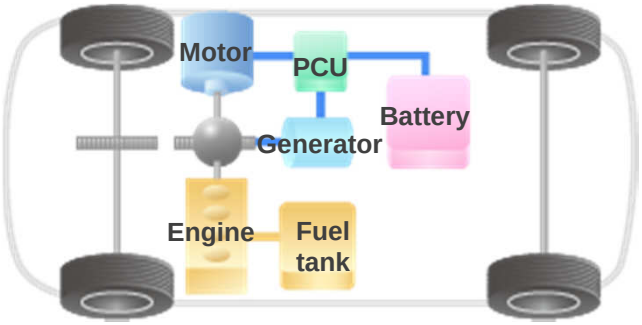
Engine operates in higher thermally efficient area

Toyota hybrid system

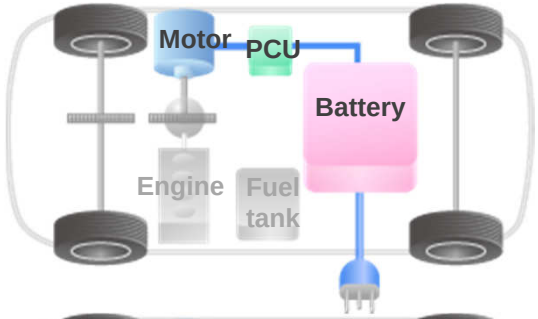


Development of hybrid technology

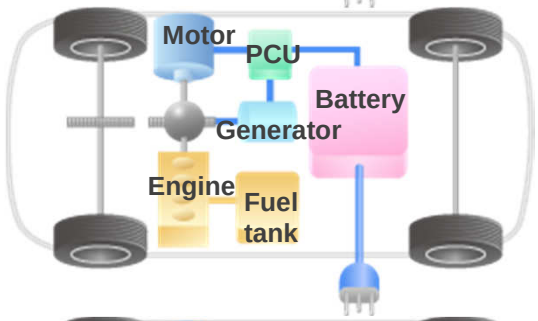
HV



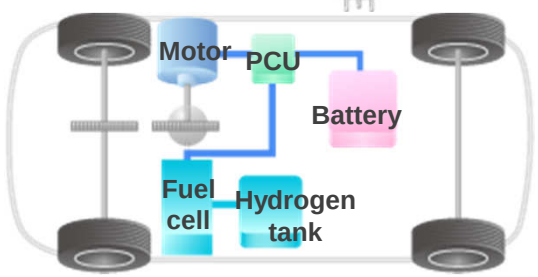
EV



PHV



FCV



Hybrid technology underpins Toyota's PHVs, EVs, and FCVs.

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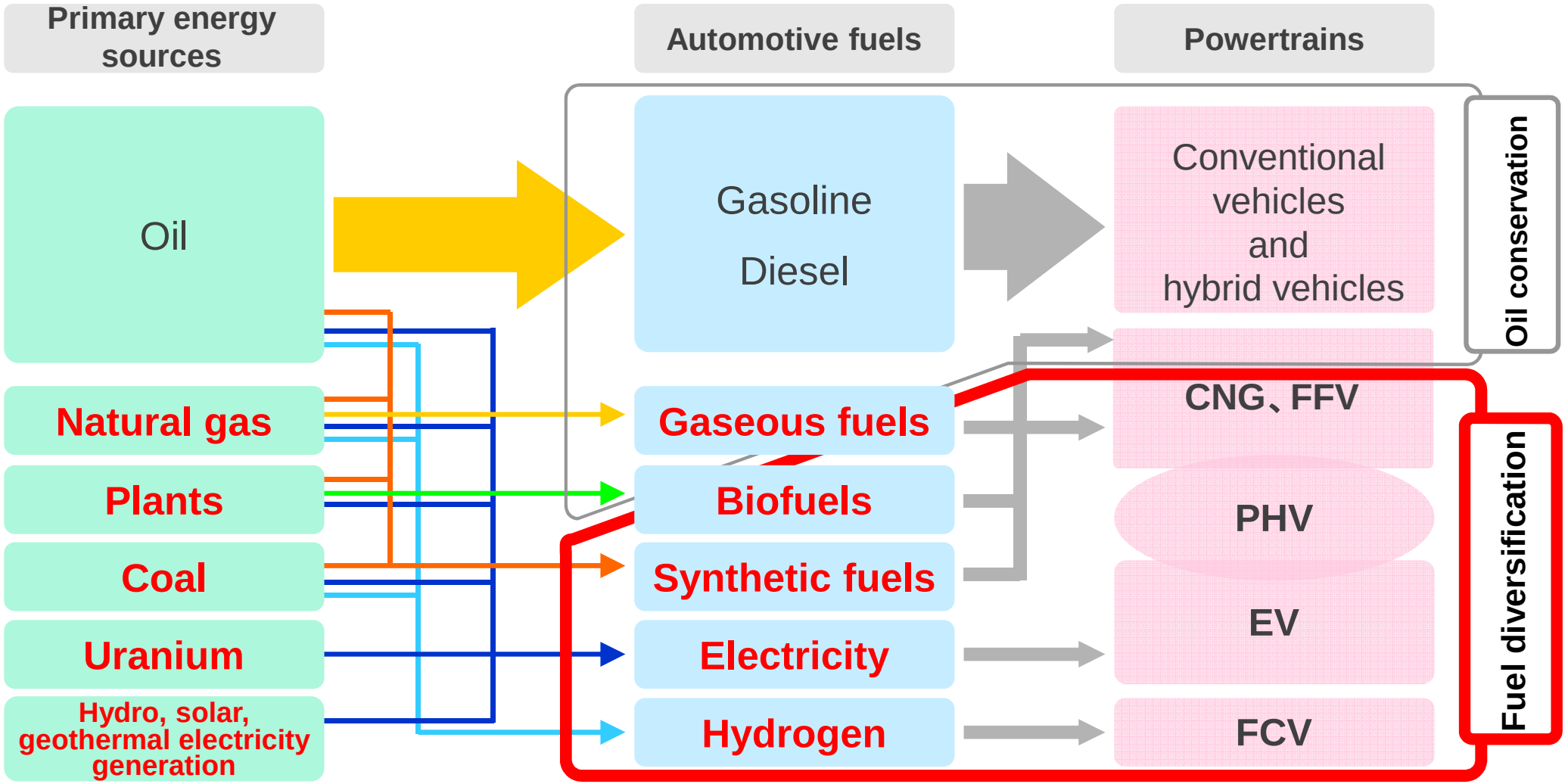
Diversification of automotive fuels and powertrains

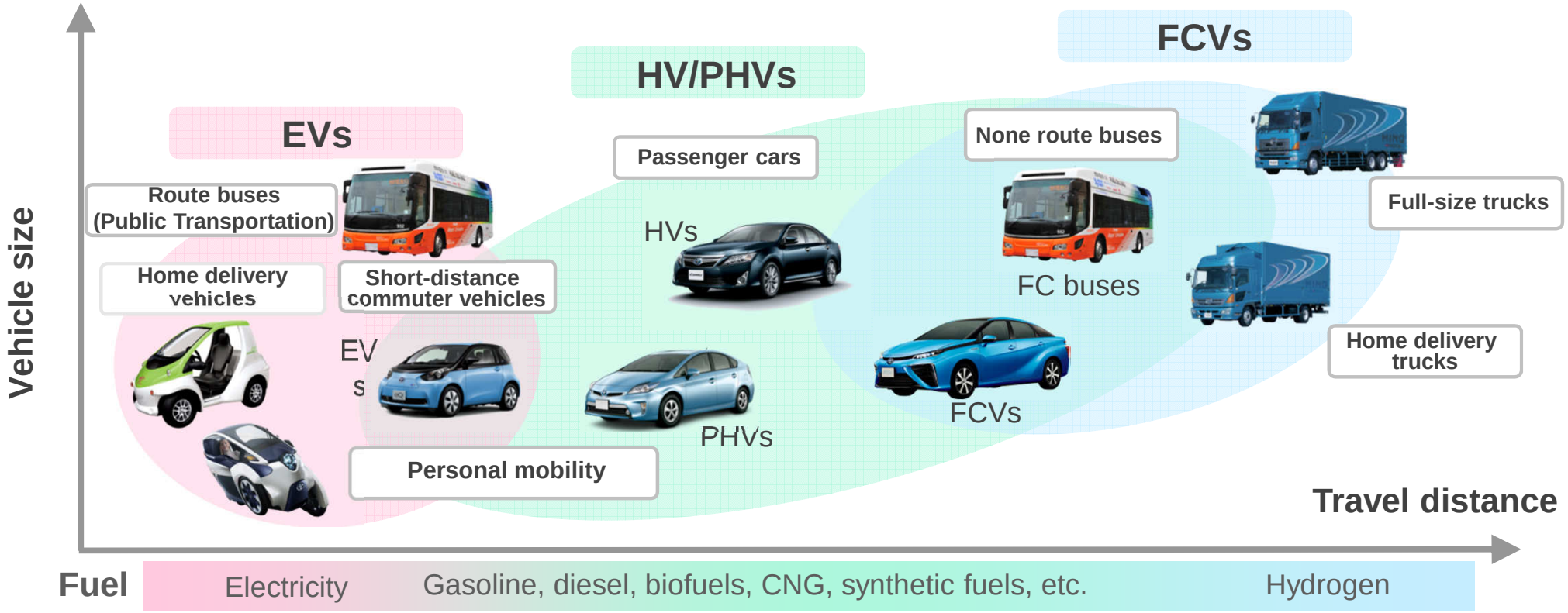


Characteristics of alternative fuels

	Electricity **EV**	Hydrogen **FCV**	Biofuels **Internal combustion engines**	Natural gas **Internal combustion engines**
Well-to-wheel CO_2	Poor to excellent	Poor to excellent	Poor to excellent	Good
Supply volume	Excellent	Excellent	Poor	Good
Cruising range	Poor	Excellent	Excellent	Good
Fueling/charging time	Poor	Excellent	Excellent	Excellent
Dedicated infrastructure	Good	Poor	Excellent	Good

Strengths of individual alternative fuels

Fuel diversity and uses



EVs: Short-distance, HVs & PHVs: Wide-use, FCVs: Medium-to-long distance

CNG, Bio fuel (E85/FFV)

For Thailand

2008 2012

Bio Fuel

E20 GASOHOL


Camry


Corolla


Camry 2012


Yaris


Vios


Avanza

E85-FFV

Corolla FFV

Bio Diesel

Vigo


Hlace

Fortuner

Natural Gas

CNG

Corolla CNG

Vigo CNG

Pros and cons of EVs

Advantages

- Zero emissions when driven
- Quiet
- Rechargeable from household outlet

Disadvantages

- Shorter range
- High battery costs
- Long charging time
- Need for rapid charger infrastructure

EVs are appropriate for short-distance commuting and fleet use.

Innovative car sharing system by Evs (Ha:mo project)

Drive little when you want to: ”Ha:mo RIDE”

Ha:mo RIDE

Easy to transfer from/to other public transportation

Ultra-compact EV enables easy drive through narrow streets in more ecology way

Can drop-off nearby the goal

Home

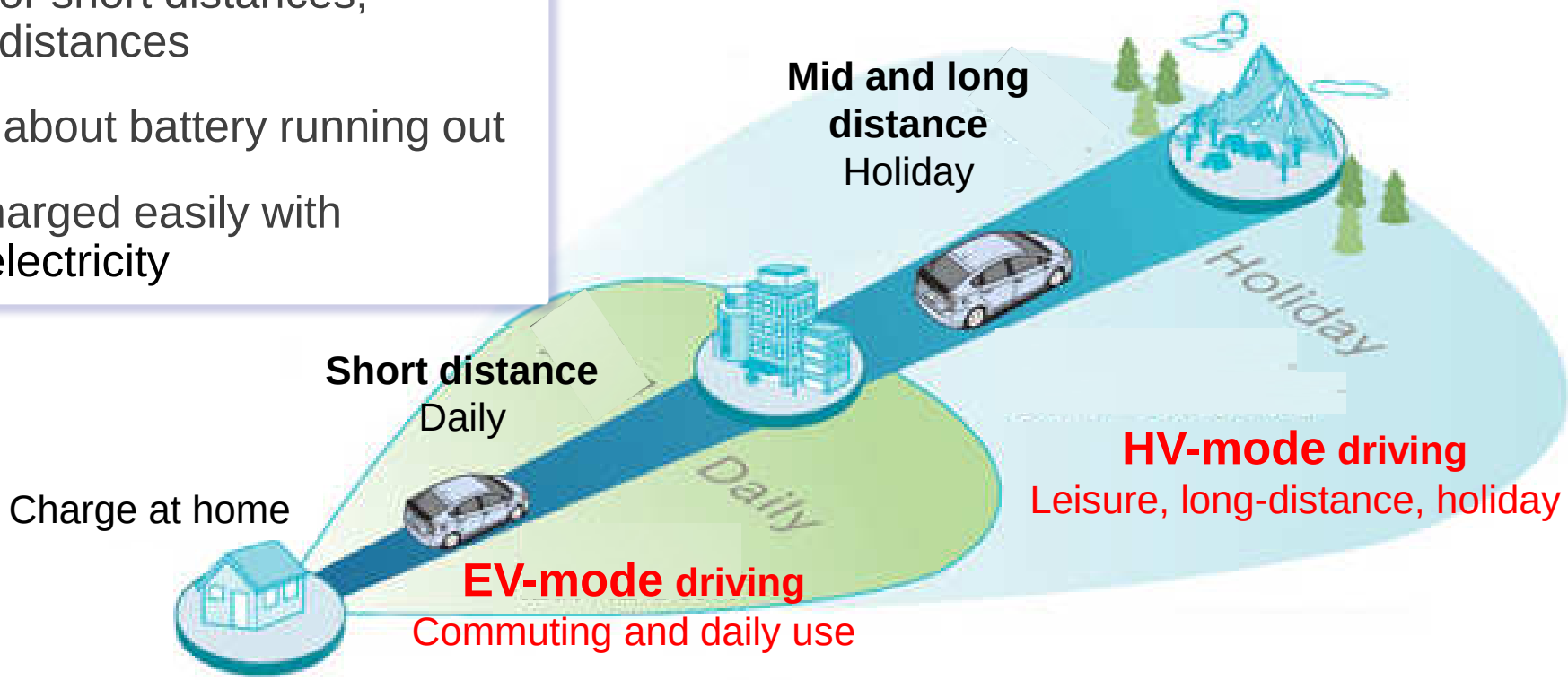
Goal

Length : 2.4m Width : 1.1m Occupants : 1 person Recharging time : 6hrs Cruising range : 50km Maximum speed : 60km/h

Next-generation urban transport system which combines ultra-compact electric vehicle with public transportation

PHV characteristics

- Use as EV for short distances, HV for long distances
- No concern about battery running out
- Can be recharged easily with household electricity



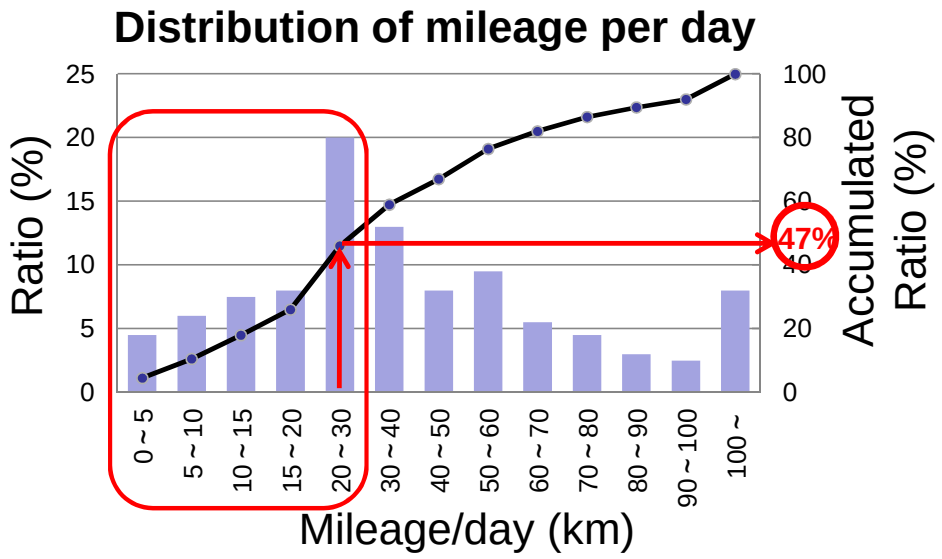
PHVs are the result of the integration and innovation of HV and EV technologies.

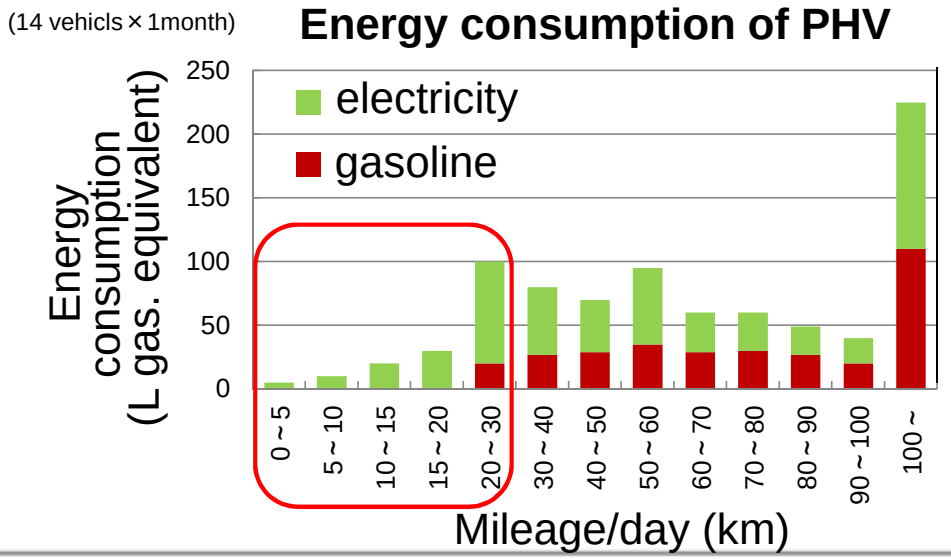
Prius PHV: User driving results

<Results of verified demonstration program for Prius PHV on the road in Tianjin, China>

Test Terms : Apr 2011～Jan. 2012 (10 months)
Test car : Prius PHV (14 vehicles)
Prius HV (1 vehicle)
Corolla (1 vehicle)
Driver : Volunteers (27 people)

Total fuel consumption
Prius PHV : 3.41L/100km (average)
Prius HV : 5.72L/100km
Corolla : 9.38L/100km
▲64% reduction



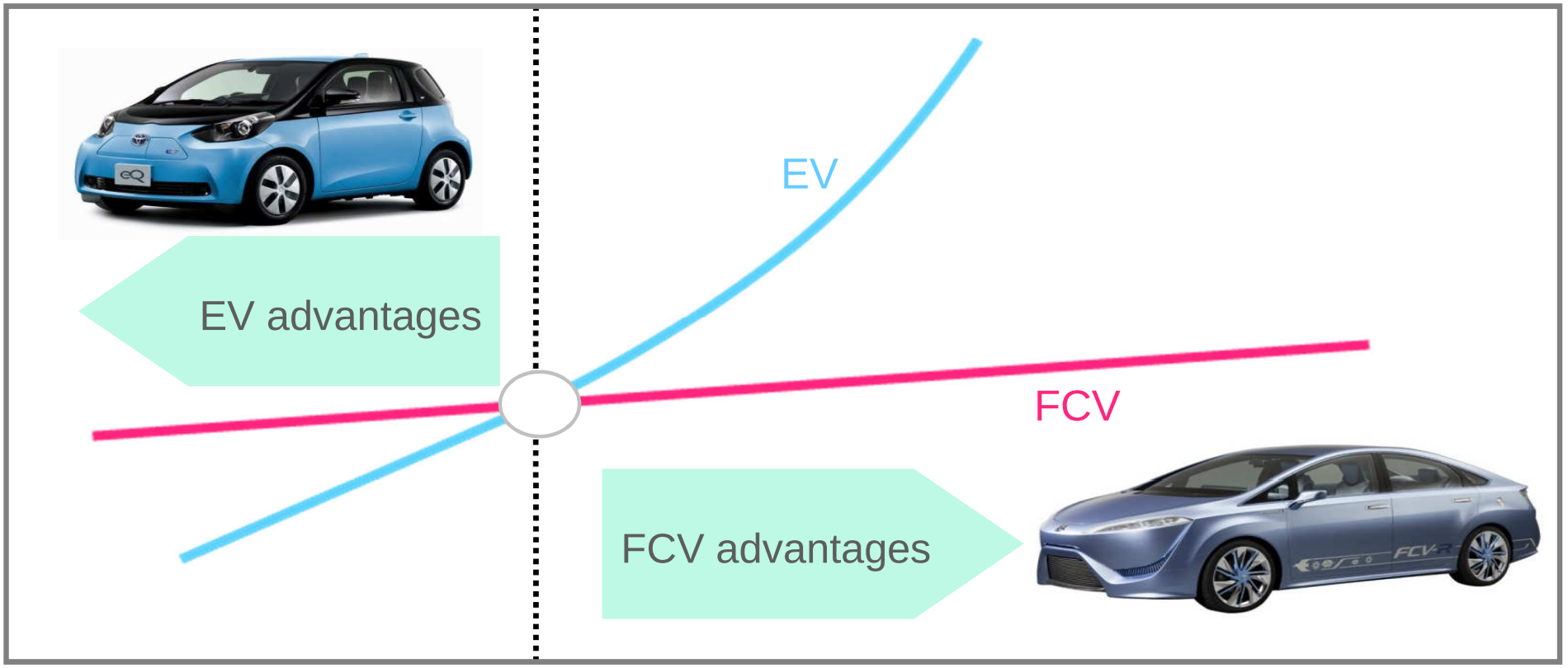


The importance of PHVs

PHVs can be used safely and without limitations, at all times

Next-generation electric vehicles for widespread use

EV-FCV comparison



FCV system's cost increase over long cruising ranges is rather small.
➡ Has advantages in mid-to-long ranges

Advantages of FCVs

Energy diversification

- Hydrogen can be produced using a variety of energy sources

Zero emissions

- Zero CO_2 emissions during driving

Driving pleasure

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

Performance

- High cruising range
- Low refueling time

Large power supply capability for emergencies

- Power supply capabilities

Mirai FCV

Toyota's fuel cell sedan, the Mirai, was launched in Japan in 2014.

U.S.: in autumn 2015
Europe: in September 2015

The Mirai fuel cell vehicle runs on electricity generated by a chemical reaction between hydrogen and oxygen.

- More energy efficient than internal combustion engines
- No CO_2 emissions when driving
- Cruising range of 650 km (JC08 test cycle)
- Hydrogen refueling time of about 3 min.

Summary

- **Next-generation eco-friendly cars should be used depending on its powertrain and fuel characteristics**

- **Hybrid technology as core technology to correspond energy saving and fuel diversification**

- **Electricity utilization in transportation :**
  - **PHV is the most realistic solution to utilize electricity for normal private passenger car**
  - **B-EV is more suitable for specific uses such as short distance commuting and use in commercial fleets (e.g. Bus)**

Toward Sustainable Mobility Society

TOYOTA

THANK YOU