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# **Innovation in Electric Vehicle Technology and Application for Public Transport**

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# **Innovation in Electric Vehicle Technology and Application for Public Transport**

## **1. Innovation in EV technology**

- Acceleration performance**
- Easy to drive**
- Quiet and comfortable drive**

## **2. Development of Electric bus for public transport**

- Specifications**
- Low CO2 emission of Electric bus**
- People prefer Electric bus with comfortable ride**

## **3. E-mobility for public transport**

- “Future City Initiative” in Japan**
- Electric bus**
- One-way ultra-compact EV**

# 1. Innovation in EV technology

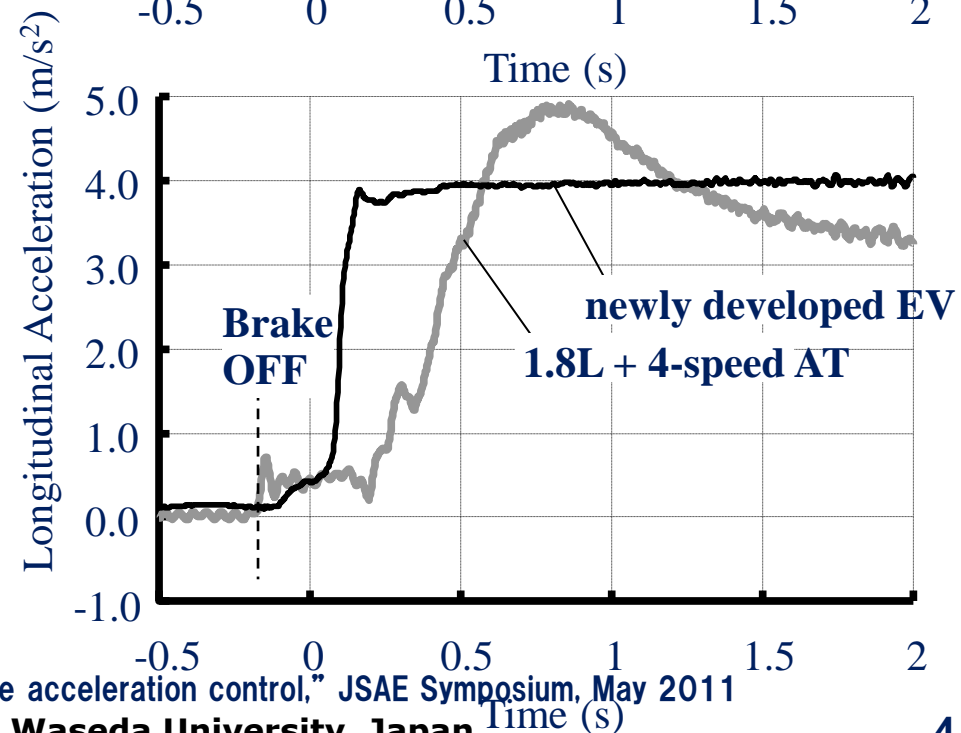
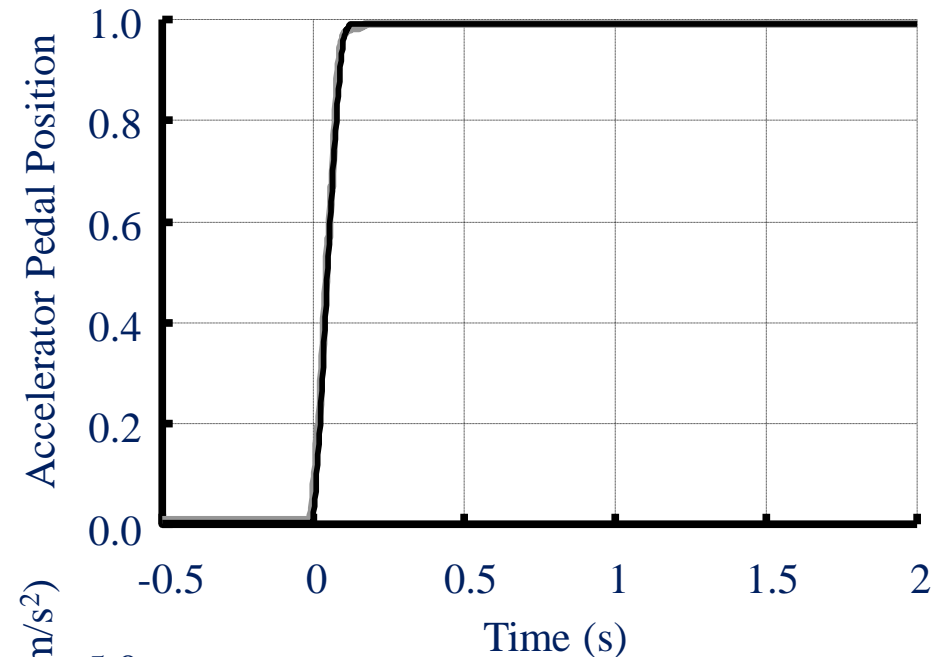
**Mass-production EV, LEAF introduced to the market in 2010**  
**80kW Motor, 30kWh Li-ion battery (2015 model)**  
**280km driving range (JC08 driving mode)**  
**Bestselling EV model: over 230,000 units (Sep. 2016)**

- **Excellent acceleration performance**
- **Easy to drive**
- **Quiet and comfortable drive**



# Acceleration performance

- Acceleration performance of an EV is much better than a gasoline vehicle.
- Response time of an EV is less than 0.1 sec. compared to 0.5 sec. of a base gasoline vehicle under various acceleration conditions.
- Reasons for the excellent acceleration are small inertia of motor rotor, large torque at low speed condition, no transmission, and advanced control strategy.

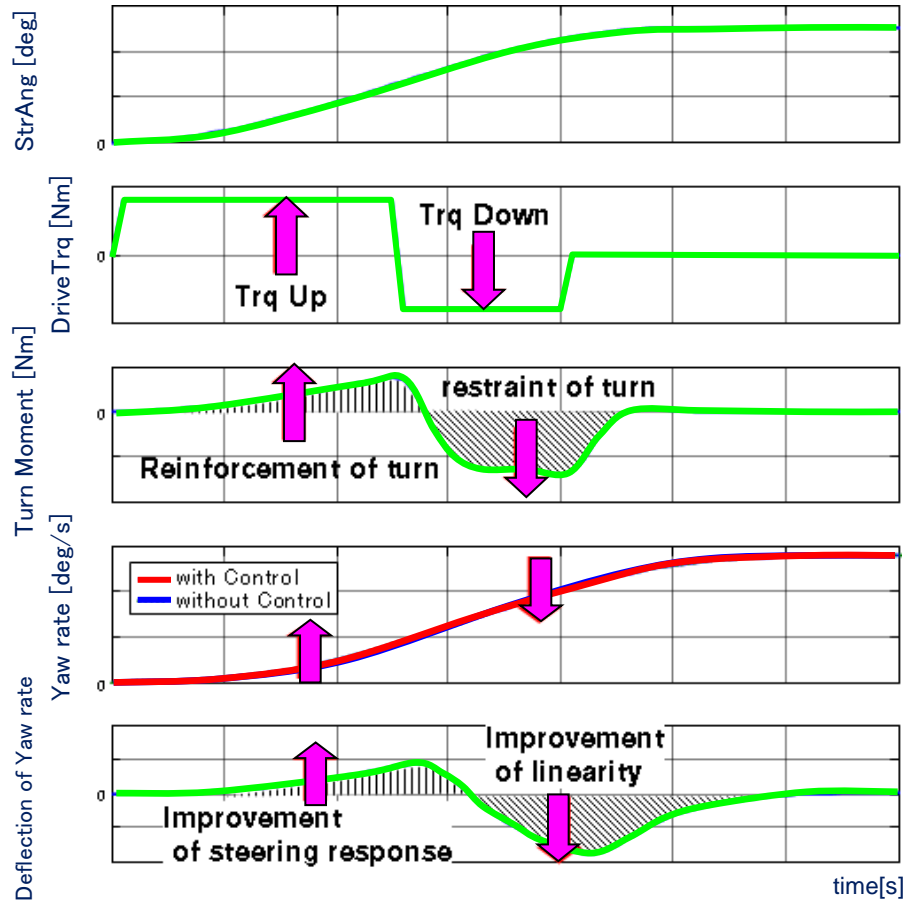
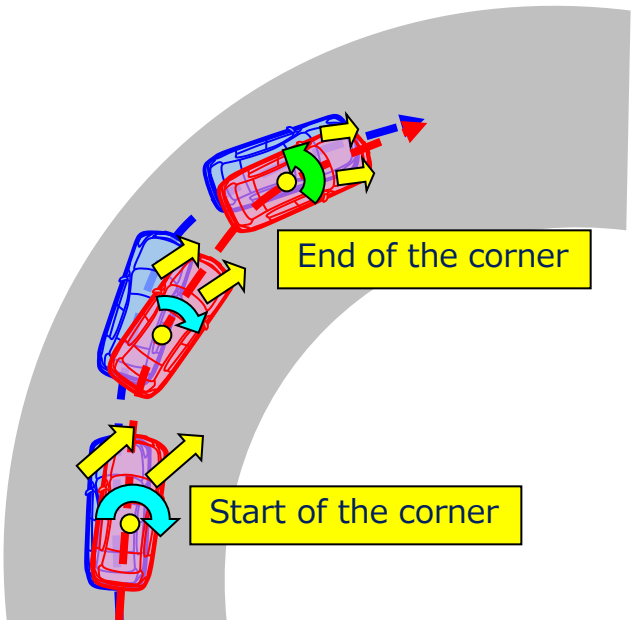


Source: Takaaki Karikomi, "Development of a highly-responsive acceleration control," JSAE Symposium, May 2011

Toshio Hirota, Environmental Research Institute, Waseda University, Japan

# Easy to drive: Handling performance

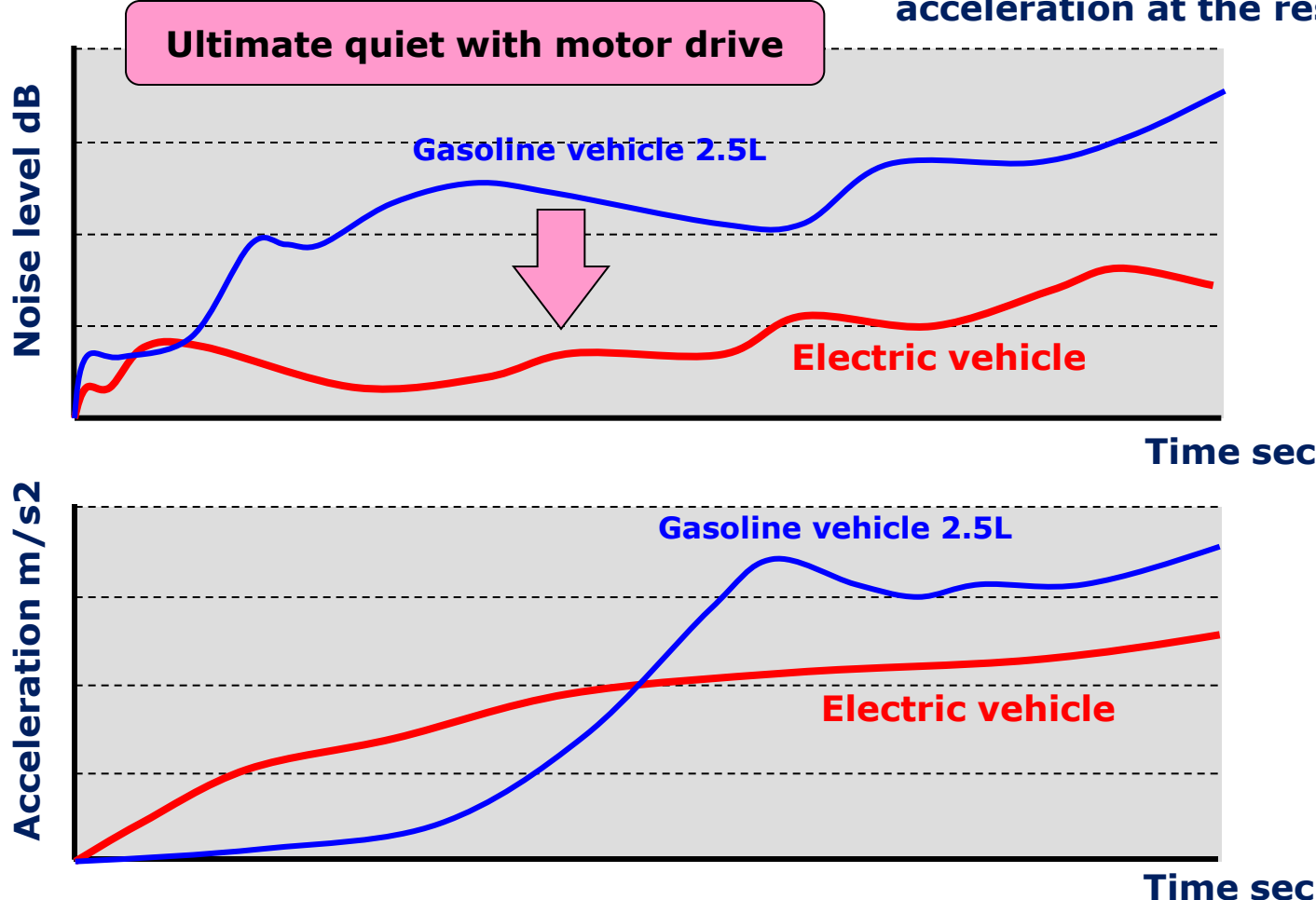
- Traction torque control with steering angle
- To increase the traction torque at the initial of the corner and to decrease the torque at the end of the steering
- It can be operated in line with the driver's intention.



# Quiet and comfortable driving

## ■ Low noise and low vibration under the start up to high speed driving

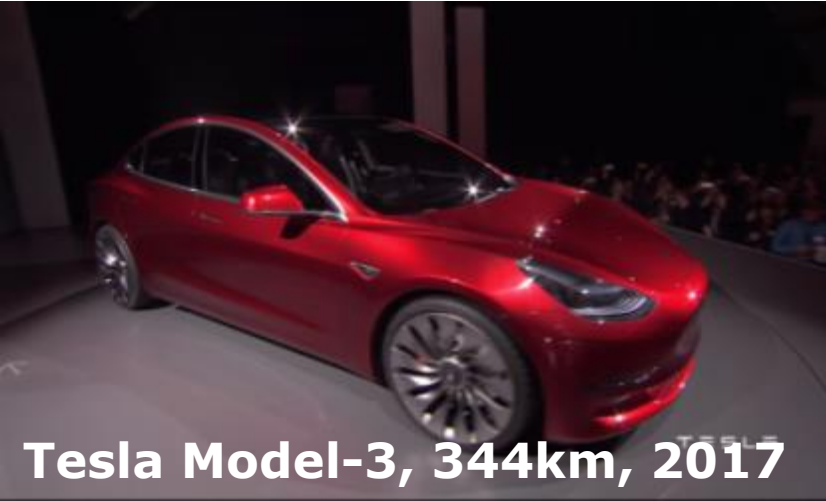
[Driving condition]  
Start up at the parking lot through acceleration at the residence area



Source: Tsuyoshi Kanuma, "Noise and vibration performance of the Nissan LEAF," Nissan technical review, No.69,70, 2012-1  
Toshio Hirota, Environmental Research Institute, Waseda University, Japan

# Advanced EVs will be introduced soon

- Technologies of Lithium-ion battery and electric power-train are improving very rapidly.
- Advanced EVs with longer driving range will be introduced to the market in the near future.



## 2. Development of Electric buses

- E-bus development at Waseda University since 2002
- Concept: Short driving range and frequent charging
- Demonstration field tests with local government since 2005
- Nagano city field test with 2 E-buses (2011 - 2013)

### WEB3:Waseda advanced Electric micro Bus(2010)

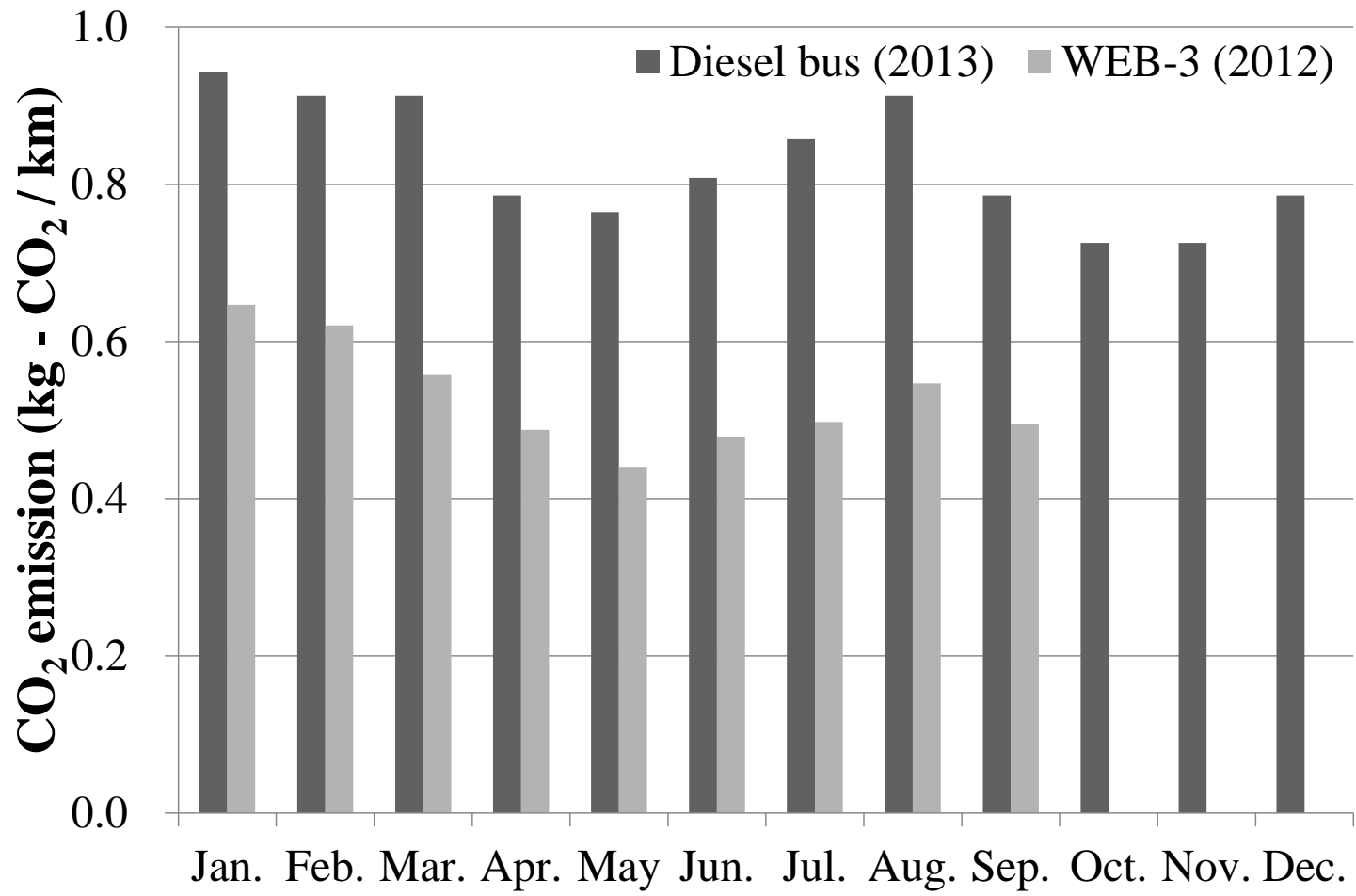
- Capacity 25 persons, Vehicle weight 6,430 kg
- Motor PMSM 145 kW/400Nm, Battery Mn Li-ion 44kWh





# CO2 emission of E-bus compared to Diesel bus

■ CO2 emission (WTW\*) of an E-bus is 40% lower than that of a diesel bus.



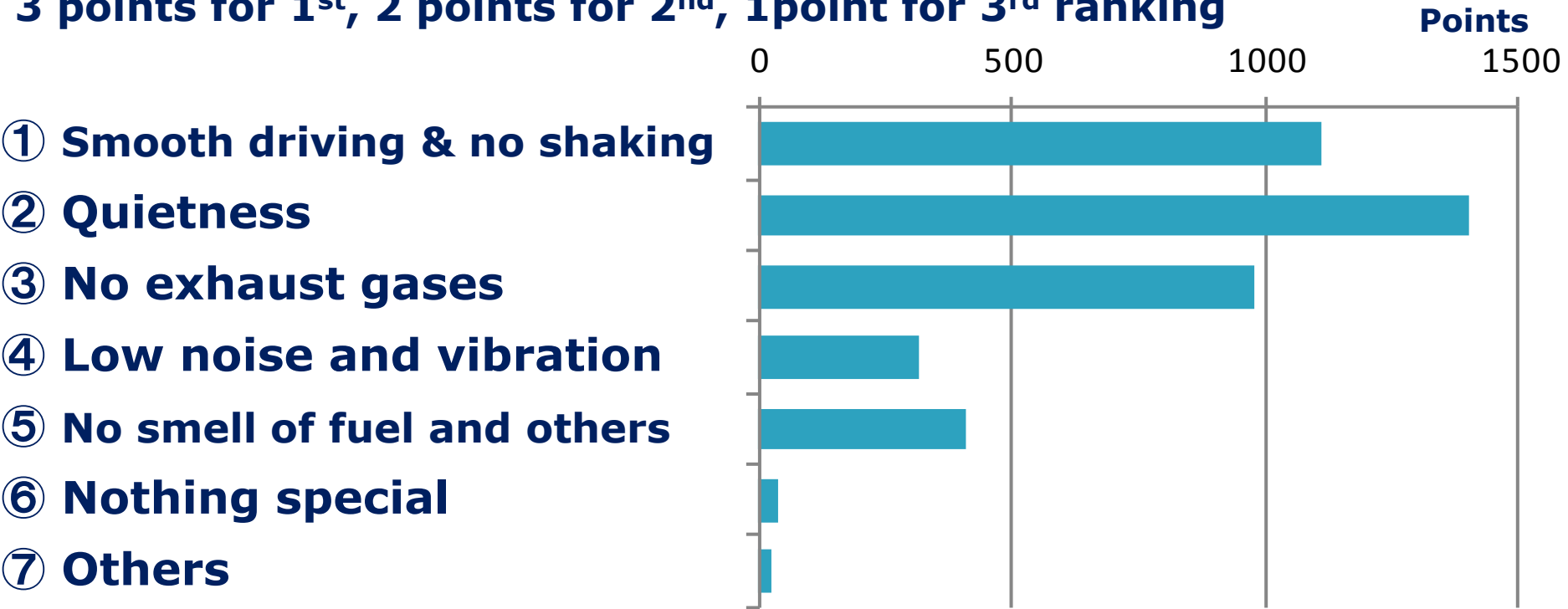
\*CO2 emission coefficient-WTW(Well to Wheel)  
Diesel fuel: 2.83 kg-CO2/L, Electricity: 0.473 kg-CO2/kWh (2010)

# Customer Survey: Attractiveness

## Good points of E-bus vis-à-vis diesel bus?

\*727 persons answered

3 points for 1<sup>st</sup>, 2 points for 2<sup>nd</sup>, 1 point for 3<sup>rd</sup> ranking



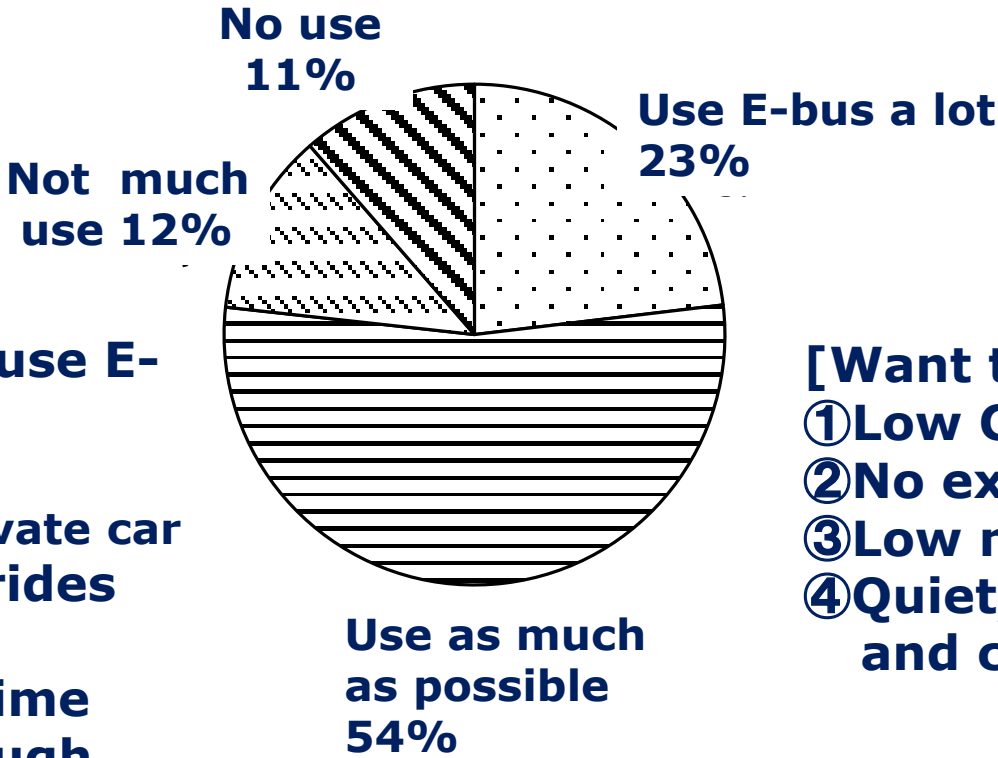
**Merit of E-bus:**

- ① Safety with smooth and no shaking
- ② Calm life on board with quietness
- ③ No smell of exhaust gases and diesel fuel

# Customer Survey: Shift to E-bus from private cars

## If the bus is changed to E-bus, will you try to use the E-bus instead of your private car?

\*701 persons answered



- [Do not want to use E-bus]**
- ① Inconvenience compared to private car
  - ② Less frequent rides
  - ③ High fare
  - ④ Not arrive on time
  - ⑤ Diesel bus enough

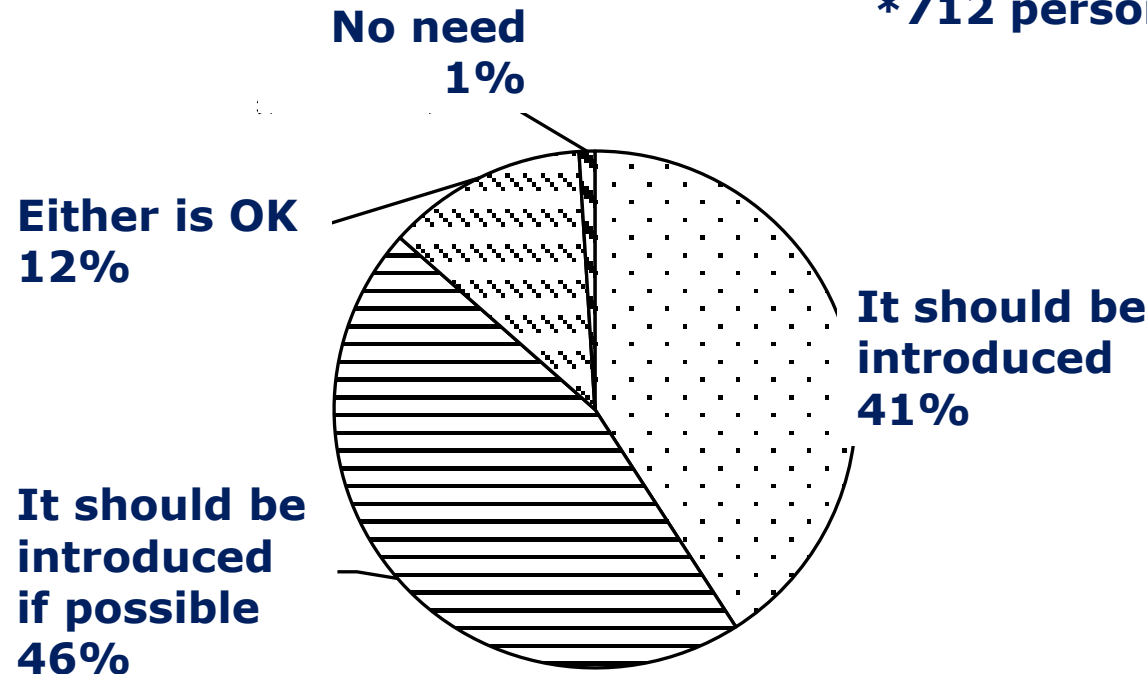
- [Want to use E-bus]**
- ① Low CO2 emission
  - ② No exhaust gases
  - ③ Low noise
  - ④ Quiet, no shaking and comfortable ride

- 77% of people want to use an E-bus.
- A lot of people would like to stop use a private car, and use an E-bus.

# Customer Survey: Introduction of E-bus

## Do you think E-bus should be introduced for public transport?

\*712 persons answered



- 87% of people want E-bus to be introduced for public transport.
- Regarding costs of E-bus purchases and charging equipment,
  - ① Government or municipality supports some of the cost.
  - ② Bus fares will be raised.
  - ③ Commercial facilities support some or all of the cost.

# 3. E-mobility for public transport

## “Future City Initiative”

2 issues that Japan will be the first to face,

- Declining and aging population
- Environmental and energy constraints

The 21st Century is the age of the city

By 2050, 70% of people will live in cities



Creating sustainable cities is an issue that all of mankind faces together

### Issues that Japan will be the first to face

- ✓ **Declining and aging population**  
Declining population: 130 million people (2004) → 95 million people (2050)  
Percentage of elderly: 23% (2009) → 40% (2050)
- ✓ **Environmental and energy constraints**  
Severe energy supply constraints due to nuclear power plant accident  
Global warming measures

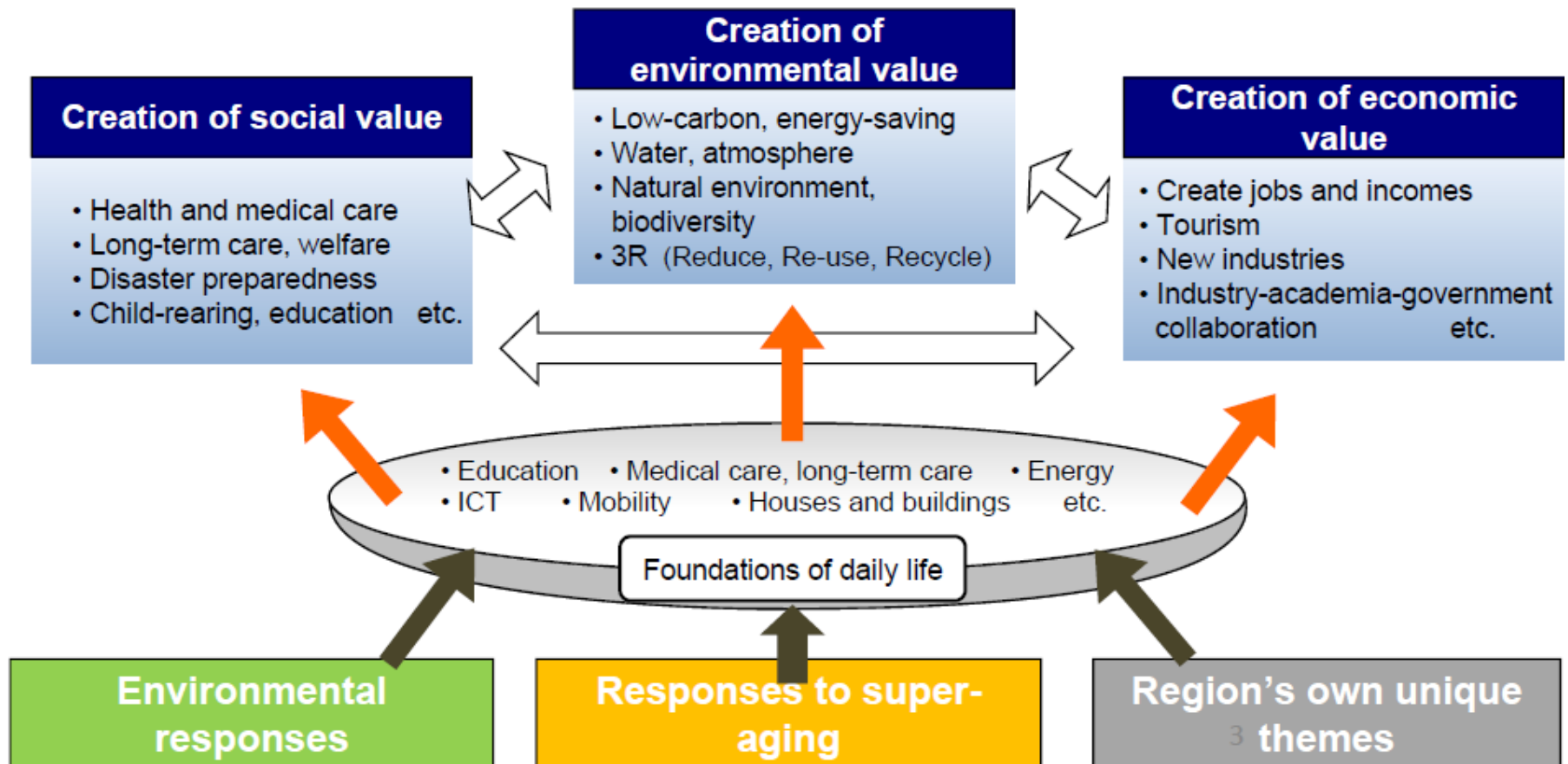
- Creation of new social and economic systems focused on cities
- Addressing challenges shared by the entire mankind before the rest of the world

Source: Japan government: Future City Initiative

Toshio Hirota, Environmental Research Institute, Waseda University, Japan

# “Future City Initiative”

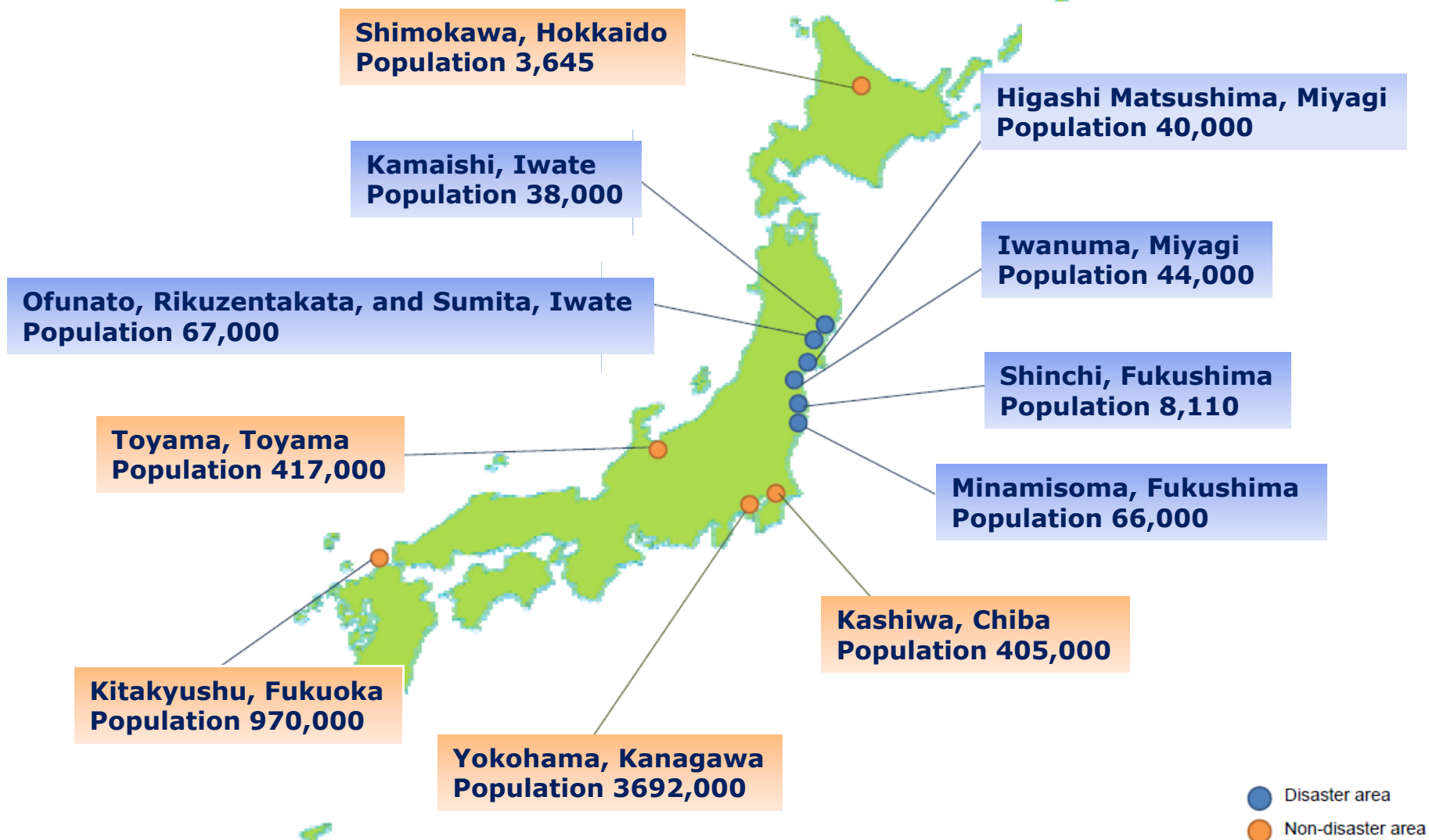
- Through the creation of environmental value, social value, and economic value, create **universally appealing communities and universally vibrant communities**
- Restore a sense of social connectedness Improve the quality of people’s lives
- Action on environment and super-aging is essential Add other themes as appropriate given individual city’s and region’s circumstances
- Build a model for sustainable value creation that can be deployed autonomously



Source: Japan government: Future City Initiative

Toshio Hirota, Environmental Research Institute, Waseda University, Japan

# “Future City Initiative”

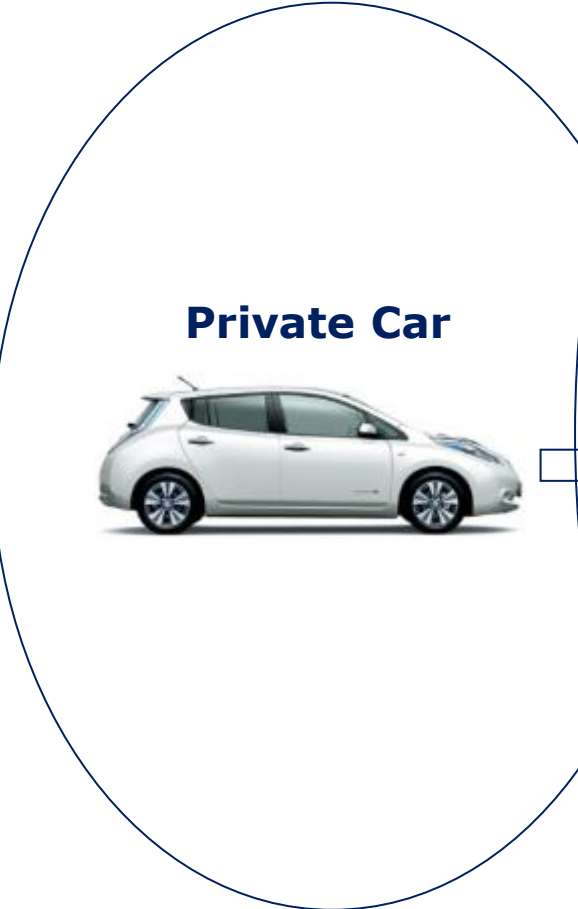


Source: Japan government: Future City Initiative

Toshio Hirota, Environmental Research Institute, Waseda University, Japan

# Shift from Private car to Public transport

Wide Variety of Mobility for City in the Future



Private Car



## New Mobility



Community Bus



Car Sharing



Ultra-small Car Sharing



Ride Sharing

## Public Transport



City Bus



Car Rental



taxi



# CO2 reduction by shift to public transport

## ■ CO2 emission (Japan, 2005)

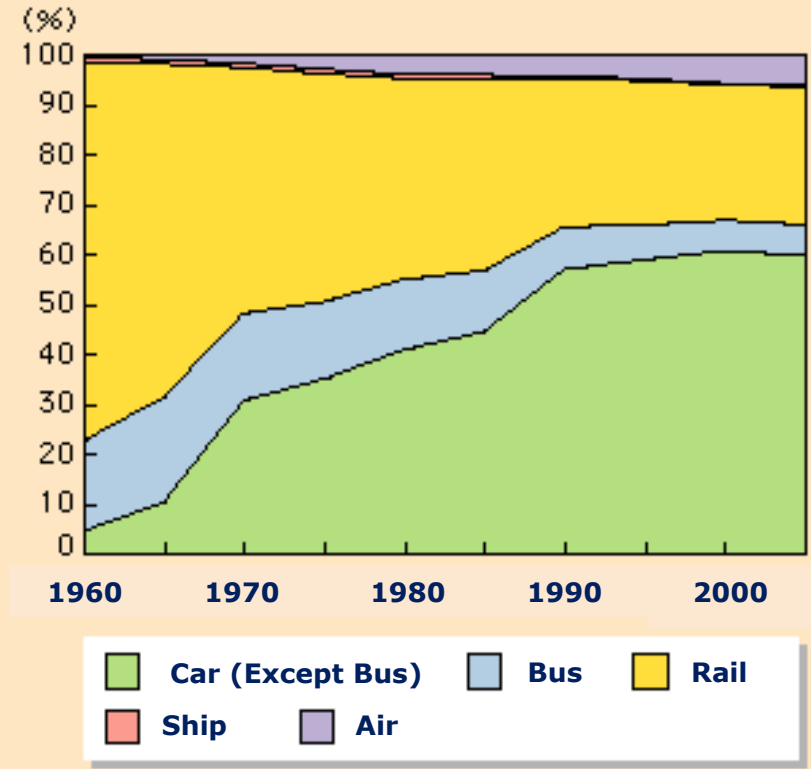
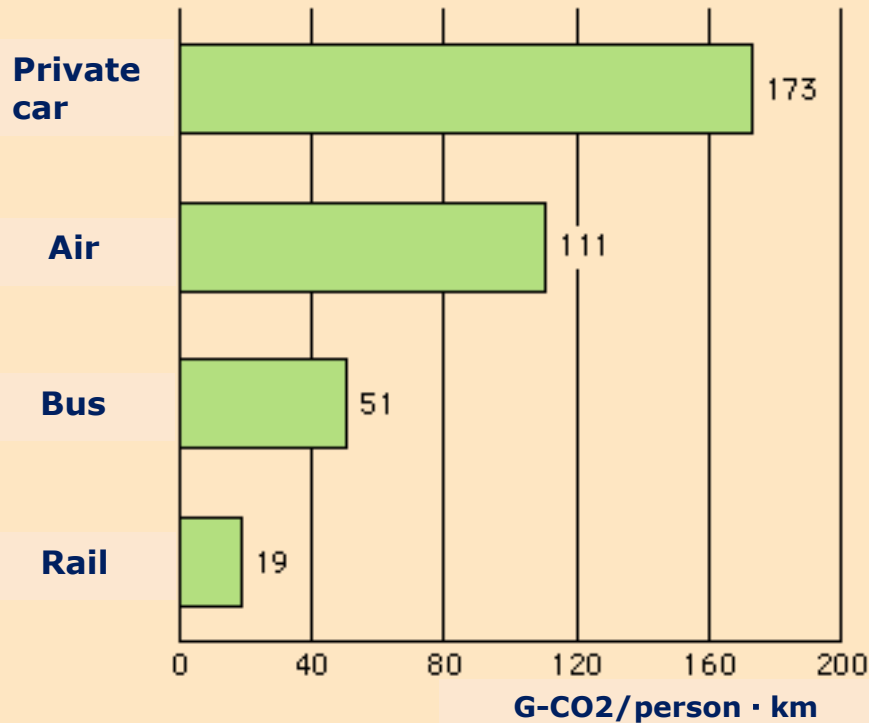
Private car: 173 g-CO<sub>2</sub>/person·km, City bus: 51 g-CO<sub>2</sub>/person·km

## ■ CO2 emission of Bus: 70% lower than private car

## ■ Share of transport:

Passenger car 60%, Bus 6.2%, Rail 28%, Air 5.9%

## ■ Share of public transport esp. local area has reduced: below 20%



Source: MLIT Ministry of Land, Infrastructure, Transport and Tourism

Toshio Hirota, Environmental Research Institute, Waseda University, Japan

# Nagano city started E-bus operation in 2014

- Start of E-bus operation at the central area in Nagano city  
Round trip from the station through Zenkoji, 7.5km 45 min.
- Since Oct. 2014 through Oct. 2016,  
42,000 km, 3.8k round trips, and 67k passengers estimated
- Including demonstration service since 2011,  
WEB-4, Waseda Electric Bus-4: Over 81,000 km, 120k passengers
- E-Bus has been evaluated as a clean and comfortable transport.



Nagano E-bus "Gururin-go"	
Operation	Oct. 2014 -
Route	Nagano st. – Zenkoji 7.5km, 45minutes
Trips	5 trips per day
Fare	Adult 150 yen Child 80 yen
<b>Total (2011 -2016, Estimated)</b>	
Mileage	81,000km
Trips	8,200 trips
Passengers	123,000 persons
E-consump.	0.85-0.91kWh-AC/km

# Advantages of E-bus compared to Diesel bus

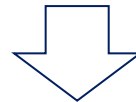
	<b>Diesel bus</b>	<b>E-bus</b>
<b>Safety</b>	<ul style="list-style-type: none"> <li>• Fear of falling accident</li> <li>• Vehicle shaking at start and stop conditions</li> <li>• Especially for elderly persons</li> </ul>	<ul style="list-style-type: none"> <li>• Feel safe even when standing</li> <li>• Smooth acceleration and no shock of gear change</li> </ul>
<b>Comfort</b>	<ul style="list-style-type: none"> <li>• Noise and vibration</li> <li>• hard to communicate</li> <li>• Smell of exhaust gas and fuel</li> <li>• Car sickness</li> </ul>	<ul style="list-style-type: none"> <li>• Quiet and easy to talk</li> <li>• Easy to hear announcements</li> <li>• No smell of exhaust gas and fuel</li> <li>• No car sickness</li> </ul>
<b>Convenience</b>	<ul style="list-style-type: none"> <li>• Does not arrive on time</li> <li>• No information where bus is</li> <li>• Insufficient service number</li> <li>• No service in the early morning and late-night</li> </ul>	<ul style="list-style-type: none"> <li>• Introducing information and on-demand bus system with ICT</li> <li>• Good compatibility with E-bus and ICT technology</li> </ul>



# MLIT caution: Safety when riding on the bus

\*MLIT: Ministry of Land, Infrastructure, Transport and Tourism

- Remain seated until bus stopped.
- When standing or walking toward exit for getting off the bus, grasp a handrail firmly.
- There are many falling accidents in the bus in Japan
- Elderly may break the bones and become bedridden.



**E-bus: Passengers feel safe even if they are standing with smooth acceleration and no shock of gear change.**

# Passenger's comments: Comfort

**Mrs. K**

**When I ride a diesel bus, I sometimes get motion sickness.**

**I prefer to ride an electric bus because of no smell of exhaust gas and diesel fuel.**

**Mr. T**

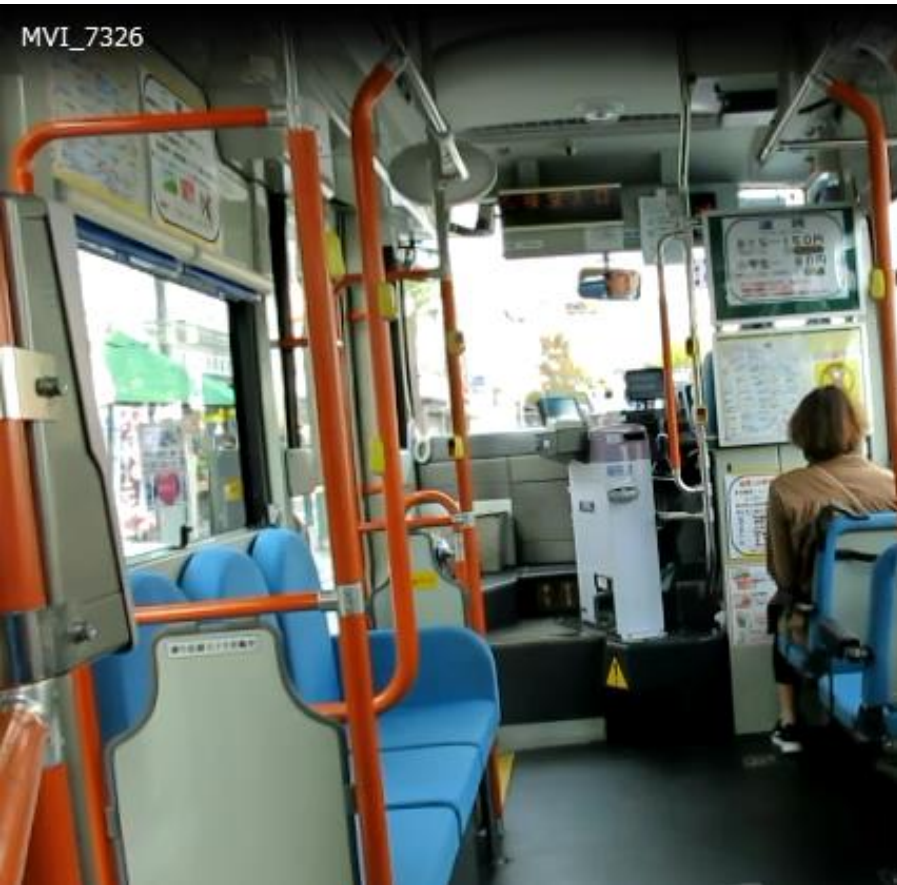
**I am a fan of the electric bus. It is very comfortable with quietness and low vibration. When I came to Nagano, I usually decline to ride on the diesel bus and wait for the electric bus and ride it.**



# Movie: Diesel bus vs. E-bus in Nagano

- Noise and vibration
- Hard to communicate
- Smell of exhaust gas and fuel

- Quiet and less vibration
- Easy to hear announcements
- No smell of exhaust gas and fuel



<https://www.youtube.com/watch?v=V53TqcDIPfM>

Toshio Hirota, Environmental Research Institute, Waseda University, Japan

# One-Way EV Car Sharing “Choi-Mobi Yokohama”

Demonstration field test of ultra-compact mobility vehicles, which are much smaller than regular vehicles and contribute to energy conservation and carbon emission reductions, to popularize them as a new mode of local transport

- 2 passenger ultra-compact lithium-ion battery EV
- Trial period: Oct 2013 – Sept 2015 (2 years)
- 70 vehicles, 110 parking spaces
- Operators: Nissan Motors, City of Yokohama



Sightseeing spot  
Minato-mirai

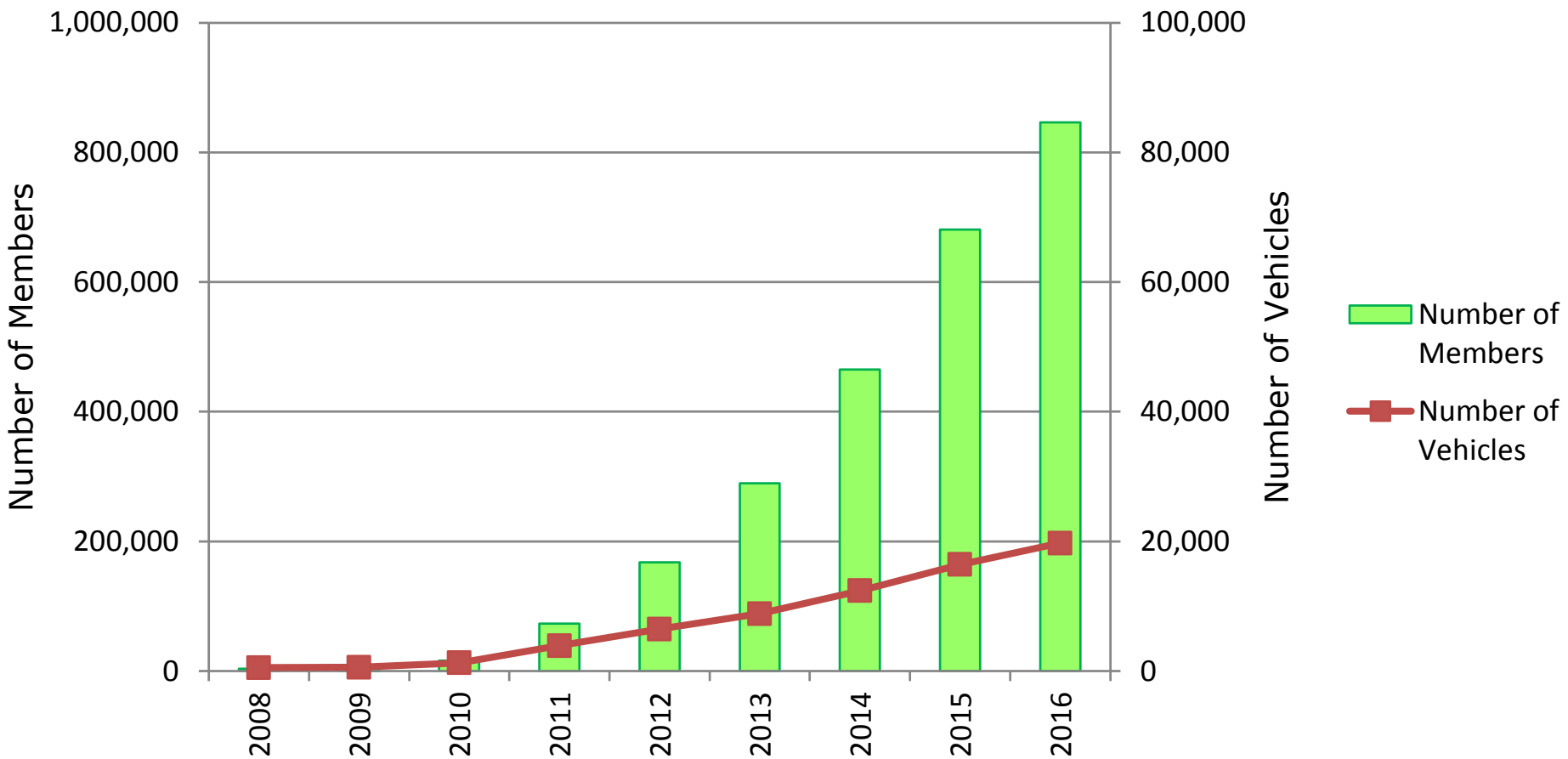


Ultra-compact EV

Source: Yokohama-shi, “For Mobility Required to Meet the Diverse Needs of the City,” Aug. 2016  
Toshio Hirota, Environmental Research Institute, Waseda University, Japan

# Spread of Car Sharing in Japan

- Number of members is increasing in Japan.
- 800,000 members in 2016 (0.6% of the population)
- 20,000 vehicles (40 members per vehicle)



Source: Foundation for Promoting Personal Mobility and Ecological Transportation  
Toshio Hirota, Environmental Research Institute, Waseda University, Japan



# Autonomous Car

- Autonomous drive technology and information communication technology are key technologies for E-mobility.
- These technologies makes E-mobility to be more convenient.
- Part of the technologies were already introduced to the market.

- Adaptive Cruise Control
- Lane Keep Assist
- Pre-Collision Braking
- Pre-Collision Throttle Management

- Adaptive Cruise Control
- Lane Keep Assist
- Emergency Braking
- Parking Assist
- Smart Room Mirror



Subaru "EyeSight ver.3" 2014

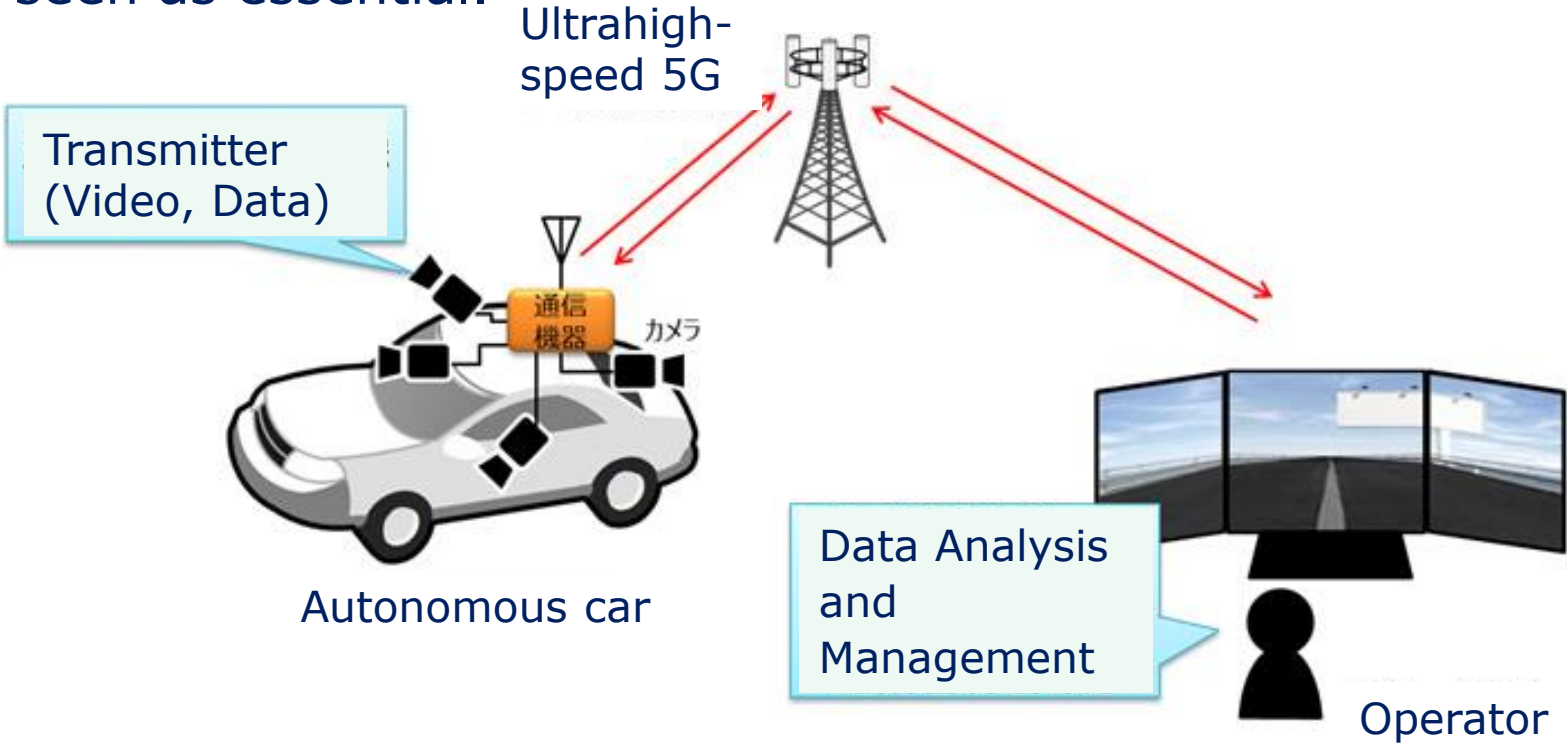


Nissan "ProPILOT" 2016

# DoCoMo, DeNA developing Ultrahigh-speed 5G

## Communication Tech for self-driving car Nov. 10, 2016

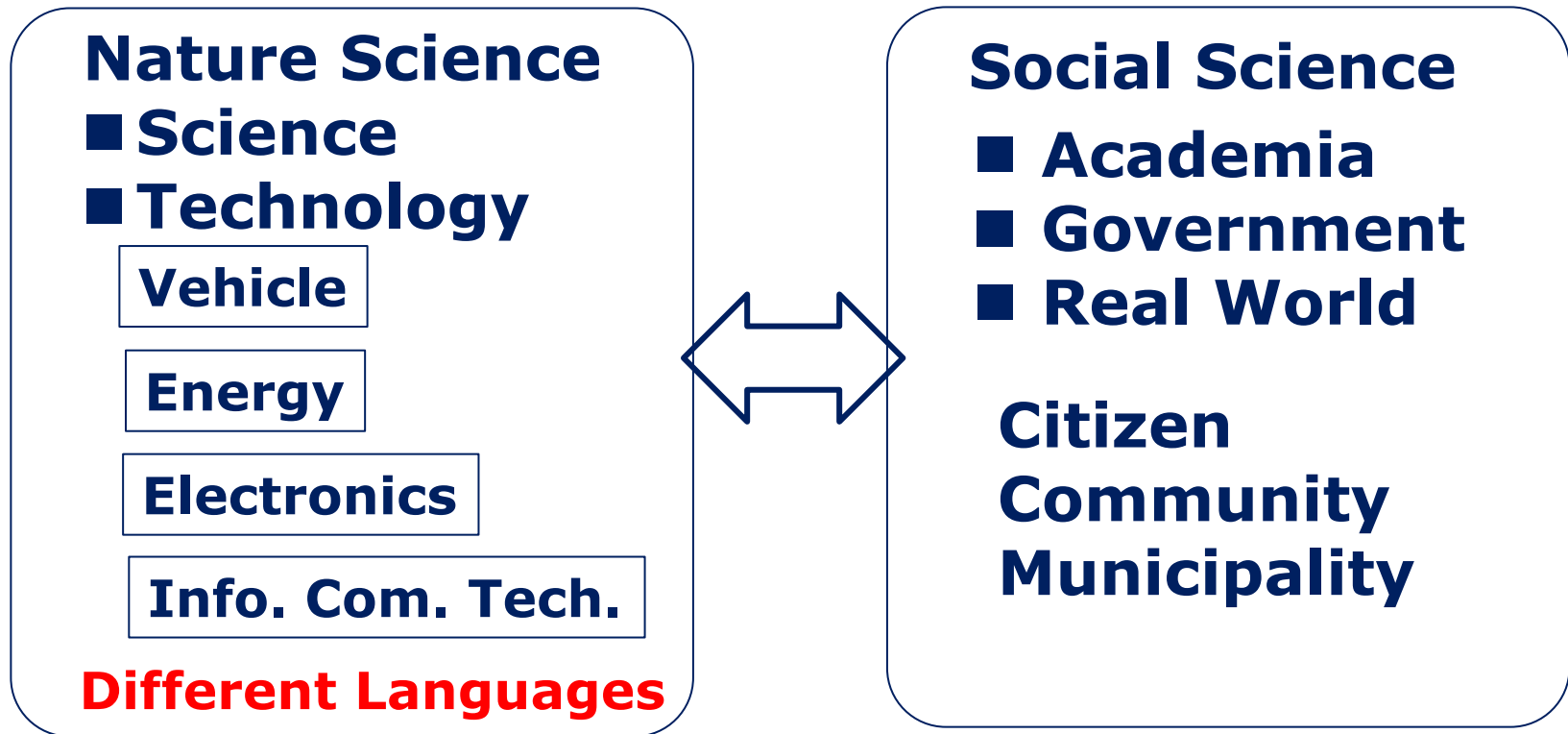
- Japanese mobile phone service provider NTT DoCoMo and internet service company DeNA are developing high-speed communication system for autonomous car.
- In self-driving, even a small data transmission lag could lead to an accident. So the ultrahigh-speed 5G communication technology -- which is said to be 100 times faster than existing LTE technology - - is seen as essential.



# Summary

## Create Sustainable Mobility

- E-mobility technology will be getting ready.
- How the tech. will be applied for community?
- Key: Communication with different fields



- Communicate to create sustainable mobility

**Thank you for your attention**

