Toyota’s Initiatives for Realizing Sustainable Mobility

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Toyota Motor Corporation
Executive Vice President

Masatami Takimoto
Recognizing Challenges

1. Reducing Oil Consumption and Promoting Wide Use of Alternative Energies

2. Reducing CO$_2$ (for preventing global warming)

3. Prevention of Air Pollution
Initiatives for Reducing Size and Weight of Vehicles

Size and weight reduction is crucial to energy conservation and lower CO₂ emissions.

Six methods by which world’s most compact vehicle was achieved:

<table>
<thead>
<tr>
<th>Method</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Differential gear reverse placement</td>
<td><img src="image" alt="Differential gear reverse placement" /></td>
</tr>
<tr>
<td>Center take-off gearbox</td>
<td><img src="image" alt="Center take-off gearbox" /></td>
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<tr>
<td>Placement of ultra-thin fuel tank under floor</td>
<td><img src="image" alt="Placement of ultra-thin fuel tank" /></td>
</tr>
<tr>
<td>Slimmed seat backs</td>
<td><img src="image" alt="Slimmed seat backs" /></td>
</tr>
<tr>
<td>Compact air conditioning unit</td>
<td><img src="image" alt="Compact air conditioning unit" /></td>
</tr>
<tr>
<td>Asymmetric installment panel</td>
<td><img src="image" alt="Asymmetric installment panel" /></td>
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</tbody>
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TOYOTA
Advanced Gasoline Engine Technology

Complete upgrading all of engine series from L3 1.0 _HP through V8

- Promote and expand valvematic system and new start & stop system
- Add variations of fuel-efficient engines
Advanced Gasoline Engine Technology

< Improvement of fuel efficiency >
Achieved improvement in fuel efficiency by introducing new engines

Fuel efficiency comparison (new-former)

< Weight reduction >
Reduced weight by using aluminum material, and modularized parts.

Engine weight comparison (new-former)

< Improvement of performance >
Performance improved by introducing D-4S, high compression ratio, and lowering friction.

Achieved improvement in fuel efficiency and in performance, and reducing weight at the same time

TOYOTA
Total number of production volume has reached 20 million

Wide variation lineup and production volume of Diesel Engines

TOYOTA
Encouraging “Eco Driving”

Eco Driving Indicator

- Instantaneous fuel consumption display
- Eco drive status indicator

Eco Driving Mode Switch

- Encouraging “eco driving” → reduced CO₂ emissions volume

Examples of Eco Driving

- Avoid sudden acceleration
- Set higher temperature in summer
- Set lower temperature in winter

New Eco Driving Support System

- Environmentally considerate driving
- Safe driving

- Environmental evaluation
- Safety evaluation
- Advice notification
- Point assignment

Advice
Environmenta

Environmental Superiority of Hybrid Vehicles (HV)

HVs contribute to reduced CO₂ emissions

TOYOTA
Expansion of HV Introduction

Accelerate introducing hybrid models to meet market demand
Evolution of Electric Motors for Hybrid Vehicles

Reducing size and weight by increasing output density

TOYOTA
Evolution of Inverter for Hybrid Vehicles

Reducing size and weight by increasing output density

Optimizing placement of parts
- Integrating the intelligent power module
- Improving cooling capability

Output density ratio

03 Prius  05 RX400h  06 GS450h

97 Prius  05 RX400h  06 GS450h

06 GS450h  07 LS600h
Evolution of Batteries for Hybrid Vehicles

Decreasing size and weight by increasing output density

TOYOTA
Evolution of Cost Reduction of Hybrid Vehicles

- Realized to cut HV system cost in half over the 1st Prius
- Continue to work for further reduction
Cumulative CO₂ emissions volume = No. vehicles sold × driving distance × fuel efficiency × CO₂ emissions factor

CO₂ emissions volume from conventional gasoline-powered vehicles of equivalent size and performance

CO₂ emissions volume from HVs

Cumulative HV sales

CO₂ emissions reduction of approximately 7.5 million tons

(toyota estimates)

Cumulative CO₂ emissions volume reduced by approximately 7.5 million tons due to sales of 1.6 million HVs

TOYOTA
- Toyota overcomes other car makers in HV sales
- Toyota HV superiors other makers’ HV in fuel efficiency
Plug-In Hybrid Vehicle

Recharging battery using an external power source
Short distance: EV, Long distance: HV

Household electricity

[Diagram showing a Plug-In Hybrid Vehicle with labels for Engine, Motor, Battery, Fuel Tank, and connections to a fuel pump and household electricity source.]
What is Plug-In Hybrid Vehicle?

- Short distance: EV
- Long distance: HV

Hybrid

Electricity
Results of Verification Testing for Plug-in Hybrid Vehicles

Verification testing is underway in Japan, Europe and the USA

Confirmation of improved fuel efficiency for plug-in hybrid vehicles

Data on driving in Japan
(13km EV driving distance)

< Fuel Efficiency Improvement >

Fuel efficiency (gasoline vehicle=1)
Level of gasoline vehicles
Driving distance after battery charged (km)

< Expected Values for EV Driving Distance >
(Result of the user questionnaires)

No Answer 19%
Other 22%
40km 20%
20km 30%
10km 7%

Partner: EDF
Partner: University of California Berkeley, Irvine
Biofuel compatible plug-in hybrid vehicle + Solar power generation system
→ Well to Wheel CO₂ emissions can be reduced to zero
Challenges for EV:
1) Cruising range, 2) cost, 3) charging time, 4) dedicated charging infrastructure

For the time being, a realistic option as compact commuter vehicles
Alternative Fuels Initiatives (Bio Fuels, Natural Gas, Hydrogen)

**Bio Fuels**
- Research for cellulose ethanol manufacture
- Completed all models to adopted to E10
- Development of vehicles like FFV or BDF-vehicles to satisfy regional demand

**Natural Gas**
- Introducing CNG vehicle

**Hydrogen**
- Steady advances in FC vehicle technology

Place HV and PHV as core technologies, Toyota develops and offers items based on the concept “right vehicle for the right place at the right time”
Scenarios for Response to Environment and Energy Issues

ICE Hybrid Vehicle

Hybrid technology

Electrical storage technology for EV and small EVs

Generator

Power split device

Motor

Battery

Engine

Fuel Tank

Bio-fuel, GTL/CTL/BTL, Gas, etc

Drilling and refining technology and cost

Gas storage technology

Build infrastructure

Gasification/synthetic technology

CO₂ reduction technology (during production of fuel)

Obtain desired properties, utilize cellulose

Stabilize supply

Electrical storage technology for PHVs and small EVs

Electrical storage technology for EV

CO₂ reduction technology (thermal power station)

Hydrogen storage technology

CO₂ reduction technology (during hydrogen production)

Hydrogen storage technology

Hydrogen production

Hydro, Solar, Geothermal energy

Biomass

Coal

Natural gas

Oil

Nuclear energy

Electricity generation

Oil

Gas Storage Technology

Build infrastructure

Gasification/Synthetic Technology

Obtain desired properties, utilize cellulose

Stabilize supply

Electrical Storage Technology for EV

Electrical Storage Technology for PHVs and small EVs

Electrical Storage Technology for Electric Cars

CO₂ Reduction Technology (Thermal Power Station)

Hydrogen Storage Technology

Hydrogen Production

Hydro, Solar, Geothermal Energy

Biomass

Coal

Natural Gas

Oil

Nuclear Energy

Electricity Generation

Ice Hybrid Vehicle

Hybrid Technology
Scenarios for Response to Environment and Energy Issues

Electric Vehicle

- Plug
- Motor
- Engine
- Fuel Tank
- Generator
- Power Split Device
- Motor
- Battery
- Plug

Hybrid technology

- Gas storage technology
- Build infrastructure
- Gasification/synthesis technology
- CO₂ reduction technology (during production of fuel)
- Obtain desired properties
- Technology utilizing cellulose
- Stabilize supply
- Electrical storage technology for PHVs and small EVs
- Infrastructure development
- CO₂ reduction technology (thermal power station)
- Hydrogen storage technology
- Electrical storage technology for EV
- CO₂ reduction technology during hydrogen production
- Infrastructure development
- Gasification/synthesis technology
- Build infrastructure
Scenarios for Response to Environment and Energy Issues

- **Oil**
- **Natural gas**
- ** Coal**
- **Biomass**
- **Nuclear energy**
- **Hydro, Solar, Geothermal energy**

**Hybrid technology**

**Fuel-Cell Hybrid Vehicle (FCHV)**

- **Hydrogen Tank**
- **FC Stack**
- **Generator**
- **Power Split Device**
- **Motor**
- **Battery**

- **Drilling and refining technology and cost**
- **Gas storage technology**
- **Build infrastructure**
- **Gasification/synthetic technology**
- **CO₂ reduction technology** (during production of fuel)
- **Obtain desired properties**
- **Technology utilizing cellulose**
- **Stabilizes supply**
- **Electrical storage technology** for PHVs and small EVs
- **Hydrogen storage technology**
- **CO₂ reduction technology** (thermal power station)
- **Electrical storage technology for EV**
- **Hydrogen production**

**Timeline**

- 2010
- 2030

**Technology**

- Electrical storage technology for PHVs
- Power control unit
- Infrastructure development
- CO₂ reduction technology during hydrogen production
- Gasification/synthetic technology
- Gas storage technology
- Build infrastructure

**Energy Sources**

- Hydro, Solar, Geothermal energy
- Nuclear energy
- Coal
- Natural gas
- Biomass
- Oil
New battery research department to be established as part of efforts to accelerate R&D for a next generation battery.

Research Organization for Next-generation Batteries

- Lithium-ion batteries
- Nickel-hydride batteries
- Traditional battery performance limit

Energy Density (W/l) (Cruising Distance)

Output Density (W/l)

Research bodies

Universities

Electrochemistry

Organic and inorganic chemistry

Physical chemistry

Solid-state physics

Chemical engineering

Analysis

Simulation

Recruitment and training of research personnel

Toyota battery research department (open laboratory)

Research Organization for Next-generation Batteries

Toyota

Sakichi Batteries
North America Research Center (TRI-NA) is newly-organized.
TODAY for TOMORROW