Toyota’s Initiatives for Realizing Sustainable Mobility

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Toyota Motor Corporation
1. **Reduce Oil Consumption**
   and Promote Wider Use of Alternative Energies

2. **Reduce CO₂** (for prevention of global warming)

3. **Prevent Air Pollution**
Size and weight reduction is crucial to energy conservation and lower CO₂ emissions.

Initiatives for Reducing Size and Weight of Vehicles

- Reverse placement of differential gear
- Centered take-off gearbox
- Placement of ultra-thin fuel tank under floor
- Slimmed backs of car seats
- Compact air conditioning unit
- Asymmetric installment panel

Six methods by which the world’s most compact vehicle was achieved.
Advanced Gasoline Engine Technology

Complete upgrading of entire engine series from L3 (1.0 L) to V8

Add variations of fuel-efficient engines

TOYOTA
Advanced Gasoline Engine Technology

< Improvement of fuel efficiency >

Achieved improvement in fuel efficiency by introducing new engines

Fuel efficiency comparison (former-new)

- Lexus RX
- Lexus GS
- Lexus LS
- Avensis

CO₂ Declared Value (g/km)

< Weight reduction >

Engine weight comparison (former-new)

Reduced weight by using aluminum material and modularized parts.

- 1.0L class
- 2.0L class
- 3.0L class
- 4.0L class

< Improvement of performance >

Performance improved by introducing D-4S, high compression ratio and lowering friction.

Output comparison (kW/L)

Achieved improvements in weight reduction, fuel efficiency and performance at the same time

TOYOTA
Diesel Engine Line-up

- 1.4 liter
- 1.6 liter class
- 2.0-2.2 liter
- 2.5-3.0 liter
- V8 4.5 liter

Debut scheduled for 2012

Production Volume of Diesel Engines

Total cumulative production has reached 20 million

Expand line-up and increase production

TOYOTA
Environmental Superiority of Hybrid Vehicles (HV)

CO₂ Emission (g/km)
 Vehicle Weight (ton)

Large

Heavy

HV contribute to reduced CO₂ emissions

TOYOTA
Increase promotion of HV

Annual sales of Toyota HV (worldwide)

Accelerate promotion of hybrid models to satisfy market demand
# Evolution of Electric Motors for HV

<table>
<thead>
<tr>
<th>Year</th>
<th>Model</th>
<th>Output Density Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>'97</td>
<td>Prius</td>
<td>33 kW</td>
</tr>
<tr>
<td>'03</td>
<td>Prius</td>
<td>50 kW</td>
</tr>
<tr>
<td>'05</td>
<td>RX400h</td>
<td>123 kW</td>
</tr>
<tr>
<td>'06</td>
<td>GS450h</td>
<td>147 kW</td>
</tr>
<tr>
<td>'07</td>
<td>LS600h</td>
<td>165 kW</td>
</tr>
</tbody>
</table>

## Technology
- **Permanent Magnet Motor**
  - Increase in voltage
  - Increase in speed
  - Two-stage motor speed reduction gear

**Increase in output density and reduction in size and weight**
Evolution of Batteries for HV

Increase in output density and reduction in size and weight

TOYOTA
- Toyota far exceeds other car makers in HV sales
- Toyota HV are superior in fuel efficiency
Plug-in Hybrid Vehicle

Recharge battery using an external power source

Short distance: EV        Long distance: HV

Household electricity

TOYOTA
What is a 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 confirming improved fuel efficiency for plug-in hybrid vehicles.
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.

**EV Initiatives**

- Toyota RAV4 EV
- Toyota e-com

Accelerate R&D of new generation EV (in early 2010s)
New battery research department to be established as part of efforts to accelerate R&D for a next generation battery.
Alternative Fuels Initiatives (Bio Fuels, Natural Gas, Hydrogen)

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

**Natural Gas**
- Introduce CNG vehicles

**Hydrogen**
- Steady advances in FCV technology

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

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

**Electricity generation**
- Gasoline and diesel fuel (from conventional oil fields)
- Gasoline and diesel fuel (from deep-sea oil fields, oil shales, etc.)
- Gas storage technology
- Build infrastructure
- Gasification/synthetic technology
- CO₂ reduction technology (during production of fuel)
- Obtain desired properties
- Technology utilizing cellulose
- Stabilize supply
- Bio-ethanol / bio-diesel
- Electrical storage technology for PHVs and small EVs
- Electrical storage technology for EV
- Infrastructure development
- CO₂ reduction technology (thermal power station)
- Hydrogen storage technology
- CO₂ reduction technology (during hydrogen production)
- Infrastructure development

**Synthetic fuels (GTL/CTL/BTL)**
- Gas

**Electricity**
- Hydrogen
- Hydrogen storage technology

**Hydrogen**
- Gas storage technology
- Build infrastructure
- Gasification/synthetic technology
- STabilize supply
- Gas field

**ICE Hybrid Vehicle**
- Fuel Tank
  - Bio-fuel, GTL/CTL/BTL, Gas, etc
- Engine
- Power split device
- Generator
- Power Control Unit
- Motor
- Battery

TOYOTA
Scenarios for Response to Environmental and Energy Issues

- **Plug-in Hybrid Vehicle**

- **Hybrid technology**
  - **Fuel Tank**
    - Bio-fuel, GTL/CTL/BTL, Gas, etc.
  - **Engine**
  - **Generator**
  - **Power split device**
  - **Motor**
  - **Battery**
  - **Plug**

- **Gas**
  - **Gas storage technology**
  - **Build infrastructure**

- **Synthetic fuels (GTL/CTL/BTL)**
  - **Gasification/synthetic technology**
  - **CO₂ reduction technology during production of fuel**

- **Biomass**
  - **Obtain desired properties**
  - **Technology utilizing cellulose**

- **Electrical storage technology for PHVs and small EVs**

- **Electricity**
  - **Electrical storage technology** for PHVs and small EVs
  - **Hydrogen storage technology**
  - **CO₂ reduction technology during hydrogen production**

- **Coal**
  - **Drilling and refining technology and cost**

- **Natural gas**
  - **Gas storage technology**

- **Oil**
  - **Gas storage technology**
  - **Build infrastructure**

- **Nuclear energy**
  - **CO₂ reduction technology (during production of fuel)**

- **Hydro, Solar, Geothermal energy**
  - **Electrical storage technology**
  - **Hydrogen storage technology**

- **Greenhouse Gas (GHG) emissions**

- **2010-2030**

- **TOYOTA**
Scenarios for Response to Environmental and Energy Issues

Hybrid technology

Fuel-Cell Hybrid Vehicle (FCHV)

Battery

Motor

Power split device

Hydrogen Tank

FC Stack

Generator

Power Control Unit

Motor

Basis

Gasoline and diesel fuel (from conventional oil fields)

Gasoline and diesel fuel (from deep-sea oil fields, oil shales, etc.)

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TODAY for TOMORROW