ASEAN...the emerging Automotive Hub of the World
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Bitec Bangna, Bangkok
Toyota’s Development of Environmental Technologies for Sustainable Mobility

24 June. 2015
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Toyota Motor Asia Pacific Engineering & Manufacturing Co., LTD. (TMAP-EM)
1. Toyota’s environmental technology development concept

2. Energy-saving initiatives (conservation)
   Conventional vehicles (gasoline, diesel), hybrid vehicles

3. Fuel diversification initiatives
   Plug-in hybrid vehicles, electric vehicles, fuel cell vehicles
1. Toyota’s environmental technology development concept

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Current challenges facing the automotive industry

1. Globalization of industry and technology since the 20th century
   - Massive use of fossil fuels
     - Increase in number of vehicles
     - Increasing CO₂ emissions (global warming)
     - Uncertainty over future petroleum supplies
     - Increasing air pollution

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Toyota’s fundamental approach

- Energy conservation
- Fuel diversification

Green vehicles can only contribute significantly to the environmental issues when they are widely used.
1. Toyota’s environmental technology development concept

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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
- Improving engine thermal efficiency
- Improving drivetrain efficiency

Reducing running resistance
- Reducing air resistance
- Reducing weight

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

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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.

![Series hybrid diagram](image)

#### 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.

![Parallel hybrid diagram](image)

#### Series parallel hybrid

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

![Series parallel hybrid diagram](image)

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**Toyota’s hybrids: series parallel hybrids**

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Toyota Hybrid System: Reasons for higher fuel efficiency

Conventional engine:
- Improved thermal efficiency by Atkinson cycle
- Engine operates in higher thermally efficient area
- Engine stops where thermal efficiency is low. Vehicle is only propelled by electric motor
- Thermal efficiency distribution

Toyota hybrid system:
- Engine operates in higher thermally efficient area
- Engine stops where thermal efficiency is low. Vehicle is only propelled by electric motor
- Improved thermal efficiency by Atkinson cycle
- Thermal efficiency distribution
Hybrid technology underpins Toyota’s PHVs, EVs, and FCVs.
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Diversification of automotive fuels and powertrains

Primary energy sources:
- Oil
- Natural gas
- Plants
- Coal
- Uranium
- Hydro, solar, geothermal electricity generation

Automotive fuels:
- Gasoline
- Diesel
- Gaseous fuels
- Biofuels
- Synthetic fuels
- Electricity
- Hydrogen

Powertrains:
- Conventional vehicles and hybrid vehicles
- CNG, FFV
- PHV
- EV
- FCV

Oil conservation

Fuel diversification
### Characteristics of alternative fuels

<table>
<thead>
<tr>
<th></th>
<th>Electricity</th>
<th>Hydrogen</th>
<th>Biofuels</th>
<th>Natural gas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well-to-wheel CO₂</td>
<td>Poor to excellent</td>
<td>Poor to excellent</td>
<td>Poor to excellent</td>
<td>Good</td>
</tr>
<tr>
<td>Supply volume</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Cruising range</td>
<td>Poor</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good</td>
</tr>
<tr>
<td>Fueling/charging time</td>
<td>Poor</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Dedicated infrastructure</td>
<td>Good</td>
<td>Poor</td>
<td>Excellent</td>
<td>Good</td>
</tr>
</tbody>
</table>

**Strengths of individual alternative fuels**
Fuel diversity and uses

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

<table>
<thead>
<tr>
<th>Vehicle size</th>
<th>Travel distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVs</td>
<td></td>
</tr>
<tr>
<td>Home delivery</td>
<td>Route buses (Public Transportation)</td>
</tr>
<tr>
<td>Personal mobility</td>
<td></td>
</tr>
<tr>
<td>Vehicle size</td>
<td>Fuel</td>
</tr>
<tr>
<td>EVs</td>
<td>Electricity</td>
</tr>
<tr>
<td>Short-distance</td>
<td>Gasoline, diesel, biofuels, CNG,</td>
</tr>
<tr>
<td>HVs</td>
<td>synthetic fuels, etc.</td>
</tr>
<tr>
<td>PHVs</td>
<td>Hydrogen</td>
</tr>
<tr>
<td>FCVs</td>
<td></td>
</tr>
<tr>
<td>None route buses</td>
<td></td>
</tr>
<tr>
<td>Full-size trucks</td>
<td></td>
</tr>
<tr>
<td>Home delivery</td>
<td></td>
</tr>
<tr>
<td>trucks</td>
<td></td>
</tr>
</tbody>
</table>

**EVs: Short-distance, HVs & PHVs: Wide-use, FCVs: Medium-to-long distance**
CNG, Bio fuel (E85/FFV)

For Thailand

<table>
<thead>
<tr>
<th>Bio Fuel</th>
<th>2008</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>E85-FFV</td>
<td>Camry</td>
<td>Camry 2012</td>
</tr>
<tr>
<td></td>
<td>Yaris</td>
<td>Avanza</td>
</tr>
<tr>
<td>Bio Diesel</td>
<td>Vios</td>
<td>Corolla FFV</td>
</tr>
<tr>
<td></td>
<td>Vigo</td>
<td>Corolla CNG</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Fortuner</td>
<td>Vigo CNG</td>
</tr>
</tbody>
</table>

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TOYOTA
### Pros and cons of EVs

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero emissions when driven</td>
<td>Shorter range</td>
</tr>
<tr>
<td>Quiet</td>
<td>High battery costs</td>
</tr>
<tr>
<td>Rechargeable from household outlet</td>
<td>Long charging time</td>
</tr>
<tr>
<td></td>
<td>Need for rapid charger infrastructure</td>
</tr>
</tbody>
</table>

**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"

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

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

Home

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

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

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

**PHV characteristics**

- **Mid and long distance**
  - Holiday

- **Short distance**
  - Daily

**Charge at home**

**RV-mode driving**
- Leisure, long-distance, holiday

**EV-mode driving**
- Commuting and daily use

**PHVs are the result of the integration and innovation of HV and EV technologies.**
<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)
△ 64% reduction
Prius HV: 5.72L/100km
Corolla: 9.38L/100km

Distribution of mileage per day

Energy consumption of PHV
(14 vehicles × 1 month)

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The importance of PHVs

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

Next-generation electric vehicles for widespread use
FCV system’s cost increase over long cruising ranges is rather small. It 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
Toyota’s fuel cell sedan, the Mirai, was launched in Japan in 2014.

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 CO₂ emissions when driving
- Cruising range of 650 km (JC08 test cycle)
- Hydrogen refueling time of about 3 min.
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
THANK YOU