Working together for a low-carbon economy

Session 3: Sectorial Perspectives

Making Energy Efficiency work in Transport

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Environmental Affairs Group
Toyota Motor Europe

Three Major Issues towards Zero Emissions

1. Energy
2. CO₂ (global warming measures)
3. Air quality

Global development of industry & technology in the 21st century

Accelerated consumption of fossil fuels

Population growth (in USA, Asia, etc.)
Growing number of motor vehicles
Global increase in vehicles

1.2 billion by 2020!

Source: Handbook of automotive industry 1999
CO₂ emissions increase

Reducing CO₂ is essential for our sustainable growth

Source: IPCC report 2007
CO₂ emissions by sector
Breakdown of worldwide CO₂ emissions sources

Transport accounts for 23% of all man made CO₂ emissions. Comprehensive CO₂ constraints are needed in each sector.

Source: IEA
# Environmental initiatives must be underpinned by regulatory compliance

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>More to come:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emissions</strong></td>
<td>Euro 5</td>
<td></td>
<td></td>
<td>Euro 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(2014)</td>
</tr>
<tr>
<td><strong>CO₂</strong></td>
<td></td>
<td></td>
<td></td>
<td>130g/120g</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(2012)</td>
</tr>
<tr>
<td><strong>CO₂ car taxation guideline</strong></td>
<td>Voluntary Agreement</td>
<td>140g</td>
<td>ACEA</td>
<td>JAMA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(2015)</td>
</tr>
<tr>
<td><strong>EU biofuels target</strong></td>
<td>25% CO₂ based</td>
<td>50% CO₂ based</td>
<td></td>
<td>7% (2015)</td>
</tr>
</tbody>
</table>

Environmental initiatives must be underpinned by regulatory compliance.
## CO₂ – from voluntary commitment to legislation

<table>
<thead>
<tr>
<th>Year</th>
<th>Target</th>
<th>Form</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>'07</td>
<td>140g/km</td>
<td>Voluntary Commitment</td>
<td>EU15</td>
</tr>
</tbody>
</table>
| '08  | 140g/km| Voluntary Commitment | • EU27  
   • 140 → 130 by vehicle motor technology  
   • 130 → 120 by 6 complementary measures |
| '09  | 120g/km| Legislation | |
| '12  | 120g/km| Legislation | |
| '20  | 95g/km | Target for research project | |

**Calculation methodology not clear**
CO₂ reduction part of national legislation

Example: CO₂ taxation

- CO₂ tax introduced already
- CO₂ tax in discussion
- / tax incentives
- No CO₂ tax discussion

Example: CO₂ labelling

<table>
<thead>
<tr>
<th>Belgium</th>
<th>Brandstofverbruik en CO₂-uitstoot personenauto's</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Brandstofverbruik gemiddeld per km (liter/100km)</td>
</tr>
<tr>
<td></td>
<td>6,2</td>
</tr>
<tr>
<td></td>
<td>CO₂-uitstoot gemiddeld per km (g/km)</td>
</tr>
<tr>
<td></td>
<td>148</td>
</tr>
</tbody>
</table>

Number of Countries

Belgium
Consumer expectations changing

‘More than two-thirds of consumers globally believe that “not harming the environment” is the number one responsibility of big corporations’

Source: Corporate Social Responsibility Monitor 2007
Our stance on Climate Change

• We accept man made global warming
• We recognize importance of target-setting
• We agree actions are needed to address environmental concerns without depleting resources for future generations

Today for Tomorrow
aim: zero emissions
Our Energy / CO₂ Prioritization Strategy

- Eliminate
- Reduce Use at Source
- Efficient Conversion
- Renewable Energy
  - Onsite Generation
  - Offsite Generation
  - Purchase
- Cap&Trade / Offsetting
- CCS

Same thinking: EU Waste hierarchy
Towards the ultimate ‘eco-car’ with hybrid as the platform

Source: Toyota Motor Europe - Sustainability Report 2007, p. 28
Progress towards low Exhaust Emissions

Development of Emission Standards in Europe, Japan and the USA

- Toyota D-CAT
- US Tier-2 Bin5 (2007): 0.03 / 0.006
- US Tier-2 Bin8 (2007): 0.0875 / 0.0125
- Japan (2000): 0.28 / 0.052
- Japan (2005): 0.14 / 0.013
- Euro 4 Diesel (2005): 0.25 / 0.025
- Euro 6 Diesel (2014): 0.08 / 0.005
- Euro 5 Diesel (2009): 0.15 / 0.013
- Euro 3 Diesel (2000): 0.50 / 0.050

* No regulation on PM
** under discussion

Evolution of Hybrid Units

Continuous improvements (KAIZEN) and the challenge to achieve higher performance with smaller and lighter units in other words, improved output density, is a key objective for hybrid development.
Motor

Unit for FWD vehicle
- RX400h
- Camry HV
- Estima HV

Graph showing motor torque with and without a motor speed reduction device.

Output increase to 250%, same size

Parameters:
- PRIUS: 50kW, 400Nm, 6000rpm
- RX400h: 123kW, 333Nm, 12400rpm
## Inverter / Power Control Unit

<table>
<thead>
<tr>
<th></th>
<th>'97 Prius</th>
<th>'03 Prius</th>
<th>'05 RX400h</th>
<th>'06 GS450h</th>
<th>'07 LS600h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><img src="image1" alt="Car Image" /></td>
<td><img src="image2" alt="Car Image" /></td>
<td><img src="image3" alt="Car Image" /></td>
<td><img src="image4" alt="Car Image" /></td>
<td><img src="image5" alt="Car Image" /></td>
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</table>

<table>
<thead>
<tr>
<th>Output density ratio *</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
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<tbody>
<tr>
<td>'97 Prius</td>
<td><img src="image6" alt="Component Image" /></td>
<td><img src="image7" alt="Component Image" /></td>
<td><img src="image8" alt="Component Image" /></td>
<td><img src="image9" alt="Component Image" /></td>
<td><img src="image10" alt="Component Image" /></td>
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<tr>
<td>'03 Prius</td>
<td><img src="image11" alt="Component Image" /></td>
<td><img src="image12" alt="Component Image" /></td>
<td><img src="image13" alt="Component Image" /></td>
<td><img src="image14" alt="Component Image" /></td>
<td><img src="image15" alt="Component Image" /></td>
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<tr>
<td>'05 RX400h</td>
<td><img src="image16" alt="Component Image" /></td>
<td><img src="image17" alt="Component Image" /></td>
<td><img src="image18" alt="Component Image" /></td>
<td><img src="image19" alt="Component Image" /></td>
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<tr>
<td>'06 GS450h</td>
<td><img src="image21" alt="Component Image" /></td>
<td><img src="image22" alt="Component Image" /></td>
<td><img src="image23" alt="Component Image" /></td>
<td><img src="image24" alt="Component Image" /></td>
<td><img src="image25" alt="Component Image" /></td>
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<tr>
<td>'07 LS600h</td>
<td><img src="image26" alt="Component Image" /></td>
<td><img src="image27" alt="Component Image" /></td>
<td><img src="image28" alt="Component Image" /></td>
<td><img src="image29" alt="Component Image" /></td>
<td><img src="image30" alt="Component Image" /></td>
</tr>
</tbody>
</table>

* Volumetric base


TOYOTA
Inverter / Power Control Unit

GS450h vs RX400h:
- Weight reduction -43%
- Volume reduction -63%
## Battery

<table>
<thead>
<tr>
<th>Year</th>
<th>'97</th>
<th>'98</th>
<th>'99</th>
<th>'00</th>
<th>'01</th>
<th>'02</th>
<th>'03</th>
<th>'04</th>
<th>'05</th>
<th>'06</th>
<th>'07</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV</td>
<td>'97 Prius</td>
<td>'00 Prius</td>
<td>'03 Prius</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Battery module</td>
<td>Cylindrical</td>
<td>Prismatic</td>
<td>New prismatic resin case</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>New prismatic metal case</td>
<td>'05 RX400h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Battery pack</td>
<td>New</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Battery

<table>
<thead>
<tr>
<th>Lighter</th>
<th>‘03 Prius</th>
<th>RX400h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Prismatic resin case)</td>
<td>(Prismatic metal case)</td>
</tr>
<tr>
<td>35% up</td>
<td></td>
<td>30% up</td>
</tr>
<tr>
<td>‘00 Prius</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Prismatic resin case)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘97 Prius</td>
<td>(Cylindrical)</td>
<td></td>
</tr>
</tbody>
</table>

Output density (W/kg)
Plug-in Hybrid: Issues

- Twice the battery capacity of current Prius
- 13km electric drive range in Japanese 10-15 mode
- Necessary electric range to be determined

Battery innovation = Key for plug-in hybrid concept
Plug-in Hybrid Vehicle (PHV)

- Road testing in Europe since September 2007 in partnership with EDF
- Lithium-ion PHVs in Europe by 2010
Toyota D-CAT
Toyota’s Fuel Cell Technology

Prius

Engine

Secondary battery

Power control unit

Motor

FINE-X

Fuel Cell

Secondary battery

Power control unit

Motor
Challenges for fuel cell vehicles

Performance in very cold conditions

- Achieve starting & driving under –30°C
- Range now proven at 560km on one tank
Personal Mobility
for a New Traffic Environment: i-REAL
Biofuels – Toyota’s stance

- Allow for 10% ethanol and 5% bio-diesel blending
- Need for clear consumer information and awareness to avoid confusion at the pump & possible problems
- Need for fuel quality standards on alternative fuels
- Flex Fuel Vehicles in certain markets (Brasil, USA)
- Preference is 2nd Generation: better overall CO₂ reduction
Biofuels development

Standard Fuel
(Petrol, Diesel)

Niche Fuel
B100
E85

- Improve existing technologies
- R&D on 2nd Generation

Deployment of 2nd Generation

Large-scale production of 2nd Generation

EU targets
2010
2020
5.75%
10%
Towards the Ultimate ‘Eco-Company’ with EMS as the platform

Integrated Environmental Management System - EMS (ISO 14001)

- Global Warming
- Air Quality
- Energy

- Green Month Campaign
- Procedures
- ARERAP
- ELV
- KPIs

- Environmental Training
- Green Purchasing Guidelines
- Legal Compliance
- Performance

- Awareness
- Risk Management

Sustainable plants: benchmark performance

Using natural resources whilst existing in harmony with natural surroundings

1. Renewable Energy
2. Plantation on & around Sites
3. Environmental Performance
Energy use per vehicle produced has been reduced by 44% since 2001

We are currently at 1,332 kWh/car

Consolidated Data

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Plants Included</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Data (kWh/unit)</td>
<td>2,424</td>
<td>1,949</td>
<td>1,697</td>
<td>1,560</td>
<td>1,536</td>
<td>1,332</td>
</tr>
</tbody>
</table>
‘Greening’ our network of European retailers

Our retailer vision in France
Support for EcoDriving

Gear Shift Indicator (manual transmission)
- Indicates gear shift point for good fuel economy drive

Eco Drive Indicator (Automatic transmission, CVT)
- ECO: Indicates good fuel economy condition
- Momentary FE 11.4km/L: Indicates momentary fuel economy value

Driver education program
Summary

- More than 1 million Toyota and Lexus hybrid vehicles were sold during the last 10 years, mainly in the US, Japan and Europe.

- Toyota will continue and expand the development of hybrid vehicles and technology because hybrid is one of the important solutions for environmental and energy issues.

- With plug-in HV technology Toyota develops today promising technology for the future, however innovative battery technology is required.
Thank you for your kind attention!