Advanced Technologies at Toyota

Mobile Sources Technical Review Subcommittee

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The “Big 4” Issues Driving Change in Business

1. Energy & Fuel Diversification
2. CO₂ Reduction
3. Air Quality
4. Urban Congestion

All affect Auto Industry

Global development of industry and technology in the 21st century
Accelerated consumption of fossil fuels
Population growth
Growing number of motor vehicles
Continued growth in liquid fuels is not sustainable. Diversification will be necessary.
Sources of CO₂ Emissions

- Power Generation: 39.9%
- Transportation: 20.8% (Automotives: 17.5%)
- Industry: 17.3%
- Residential: 13.8%
- Others: 8.2%

World CO₂ emissions arising from fuel combustion by sector
**excludes animal husbandry**

Total CO₂ Emissions: 23.6 billion tons

Growth in Vehicle Ownership Resulting in Pollution & Congestion

Source: Sustainable Mobility Project calculations.
The Automobile Challenge

1. Balance reduction of environmental impact with meeting consumer wants
   - *It doesn’t matter how “green” a product is if no one will buy it*

2. Mass market appeal
   - *Must sell millions to make real impact*

3. Life Cycle Assessment
   - *Must look beyond “tailpipe” for true environmental impact*
Regulations Complicate Vehicle Development

CAFÉ
Safety Standards
Carbon Legislation
Fuel Mandates

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AB 1493
AB 32
ZEV

Differing timeframes, measurement techniques and legislative uncertainties greatly increase compliance costs and may conflict with market demand.
Toyota’s Multi-Path Approach

**Issues**

- CO₂ Reduction
- Energy Diversification
- Reduced Emissions
- Urban Congestion

**Sustainable Products**

- Alternative fuel HV
- Diesel HV
- Plug-in HV
- FCHV
- HSD
- D-4
- Lean burn
- VVT-i
- EV
- CNG
- Synthetic fuels
- Common rail DI
- Biofuels
- DPNR

**Hybrid Technology**

- Electrical energy
- Gasoline engines
- Diesel engines
- Alternative fuel engines
Toyota’s First Hybrid

1967 S800 Gasoline Turbine Hybrid

- Gas Turbine
- Battery
- Transmission
- Motor
- Starter
- Generator
- Electricity Control Unit (Chopper)
Toyota’s Line of Hybrids in America

**TOYOTA MODELS**

- **Prius**
  Midsize 5 Door

- **Camry Hybrid**
  Midsize 5 Door

- **Highlander Hybrid**
  Midsize SUV

**LEXUS MODELS**

- **RX400h**
  Luxury SUV

- **GS450h**
  Premium Sport Sedan

- **LS600h**
  Flagship

Combined US sales averaging over 23,000 / month in 2008
A Million & Half Hybrids Sold & Growing

Cumulative Hybrid Sales thru July 2008

Energy Benefits to Date*

• 660 Million gallons of gasoline saved
• 13.1 Billion lbs of CO₂ emissions avoided

Global Sales
1,500,000

US Sales
900,000


*Toyota Estimate
Hybrid as a Foundation

- Toyota’s Hybrid Synergy Drive is the powertrain foundation for next generation technologies
  - Flexibility
  - Reduced development time & cost
  - Lower cost higher volume potential
Toyota’s Current PHV Prototype

**Vehicle Benefits**
- Fuel diversification (energy security)
- Potential greenhouse gas reduction
- Reduced fuel cost

**Prototype Objectives**
- Study consumer behavior (US)
- Study public charging (Europe)
- Demonstrate system, not battery capability

**Challenges**
- Battery cost & life – key for commercial introduction
- Packaging
- Need for cleaner electricity

The Toyota Current PHV Prototype uses a household electricity source to charge its Nickel metal hydride battery and a second nickel metal hydride battery on board.
Toyota PHEV Performance Specifications

- **EV Performance (Charge-depleting)**
  - Top speed in EV mode – 62 mph
  - Max EV power ~ 40 kW
  - EV range ~ 7 miles

- **Battery (2 x NiMH)**
  - 2 x 6.5 Ah (13Ah / 2.6kW-hr)
  - 202 V

- **Charging Time**
  - 1-1.5 hr on 220V
  - 3-4 hr on 120V

- **Max system power 100kW (20kw more than Prius)**
2010 – The Next Step

• Toyota has announced our next generation PHEV:
  – Significant numbers beginning in 2010 model year
  – Global program
  – Commercial fleets
  – Li-Ion batteries
    • Manufactured by Panasonic EV (Joint venture with Toyota)
    – Results to help determine suitability for consumer market
• Re-evaluate suitability of battery electric vehicles for consumer market
**Toyota’s Current Fuel Cell Prototype**

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<th>PROTOTYPE OBJECTIVES</th>
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<td>Zero tailpipe emissions</td>
<td>Public education on hydrogen</td>
<td>Fuel cell system cost</td>
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<td>Potential non-petroleum, diversified fuel sources</td>
<td>Demonstrate technology</td>
<td>Fuel cell stack life</td>
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<tr>
<td>Low / zero carbon fuel</td>
<td>Identify infrastructure issues</td>
<td>Lack of infrastructure</td>
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Key System Components

**Power control unit (PCU)**
Controls precisely the distribution of electric power of the fuel cell and secondary battery.

**Secondary battery**
Stores the regenerative electric power and assists output of the fuel cell at acceleration.

**Toyota FC Stack**
Unit (fuel cell) that generates electric power from the hydrogen and oxygen in the air.

**High-pressure hydrogen tank**
Stores the hydrogen supplied to the Toyota FC Stack.

**Motor**
Generates the driving force of the vehicle.
Steady Improvement

Compactness / Compactness / High Power Density

Stack Durability

High & Low Temperature

Challenges Remain

Next targets

Cost

1/10 by design / materials × 1/10 by mass production

High & Low Temperature

Driving Range

Over 500 miles demonstrated
Conclusions

• The auto industry must adapt to multiple energy and environmental issues and regulations

• Hybrid is the foundation for future vehicle technologies at Toyota – Fuel Cell & PHEV are evolutions

• Fuel Cells & PHEVs show environmental & energy security promise, but only if produced in large volumes

• Durability, cost and infrastructure are challenges for Fuel Cells & PHEVs.

• Without “green” fuels, the environmental benefit (GHG reduction) of these technologies will be modest at best
Thank You!

Questions?