Advanced Propulsion Technology Strategy

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Global Powertrain and Global Quality

The Challenge

- Global energy demand exceeds our current glide path for supply.
  There are several risks that can disrupt the existing supply:
  - Insufficient refinery capacity
  - Geopolitical issues
  - Natural disasters, wars and hostile regimes that take a significant amount of capacity offline
- Growing concern about Global Warming due to CO2
- Potential for regulations that exceed both technical capability and business feasibility

Source: DOE Energy Information Agency
MBDOE: Millions of barrels per day oil equivalent
Energy Diversity – Blending Strategy

**Liquid Fuels/Electricity/Hydrogen** as the In Vehicle Energy Carriers

**Energy Resource**  
**Conversion**  
**Energy Carrier**  
**Propulsion System**

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**Advanced Propulsion Technology Strategy**

- Displace Petroleum
- Improved Vehicle Fuel Economy & Emissions
- **Hydrogen Fuel Cell**
- **Battery Electric Vehicles (E-Flex)**
- **Hybrid Electric Vehicles (including Plug-In HEV)**
- **IC Engine and Transmission Improvements**

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Energy Diversity:

- **Petroleum** (Conventional & Alternative Sources)
- **Bio Fuels** (Ethanol E85, Bio-diesel)
- **Electricity** (Conventional & Alternative Sources)
- **Hydrogen**

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Global Advanced Propulsion Technology Roll-Out

IC Engine and Transmission Improvements

<table>
<thead>
<tr>
<th>Active Fuel Management</th>
<th>9 engine variants in 15 models, &gt;1.0 million annually</th>
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<tbody>
<tr>
<td>Variable Valve Timing</td>
<td>26 engine variants in 66 models, &gt;2.0 million annually</td>
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<tr>
<td>Spark Ignition Direct Injection</td>
<td>2 engine variants in 9 models, &gt;0.9 million annually by 2010 MY</td>
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<tr>
<td>Port Deactivation</td>
<td>6 engine variants in 16 models, &gt;0.5 million annually</td>
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<tr>
<td>Turbocharged Gas Engines</td>
<td>14 engine variants in 18 models</td>
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<tr>
<td>Diesel Engines</td>
<td>17 engine variants in 45 vehicle lines, &gt;1 million annually</td>
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<tr>
<td>Six-speed Transmissions</td>
<td>10 FWD, RWD and AWD variants, &gt;3 million annually by 2010</td>
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Continuing to Deliver...

**MY 2008**

14 New Engines and Transmissions

- 6.2L V-8
- Vortec 5.3L V-8
- Vortec 6.0L V-8 Hybrid
- 3.9L V-6 VVT with AFM
- 3.9L V-6 VVT with E85
- 1.2L
- 1.9L
- 1.4L
- 2.0L with E85
- 6T40 FWD
- 6T45 FWD
- 2-Mode RWD Hybrid
Why E85?

- Domestic renewable fuel
- Reduces greenhouse gas emissions
- Enables maximum ethanol usage

E85 Can Significantly Reduce GHG Emissions
Reduction in Greenhouse Gases Per Mile Traveled Using E85 vs. Gasoline

<table>
<thead>
<tr>
<th>Reduction in Greenhouse Gases</th>
<th>E85 Flex Fuel</th>
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<tbody>
<tr>
<td>Corn</td>
<td>21 to 29%</td>
<td>86%</td>
</tr>
<tr>
<td>Cellulose</td>
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Source: Argonne National Laboratory, Wang
E85 Ethanol Has the Greatest Potential to Reduce Oil Consumption

Assumptions: All OEMs produce 90% FFV by 2020 and all vehicles used the maximum amount of ethanol.

Ethanol potential assumes all OEM FFV production of 50% in 2012, 75% in 2015, and 90% in 2020, and the FFV parc uses E85. Adjusted for energy equivalency with gasoline.

Oil information source: EIA – 2007 Annual Energy Outlook Table 11

GM 2007 Ethanol Vehicles

14 FlexFuel models in U.S. & Canada

In LAAM, 95% of product portfolio is currently Flexpower

BioPower in Europe
GM Driving Industry Standard Technology/Performance Defining Industry Future Direction

• More than 50% of US vehicle volume will be FlexFuel by 2012 MY
• 16 new hybrids in the next 4 Years…or 1 every 3 months for the next 4 years!
  ⇒ Cost effective hybrid in cars and small SUVs
  ⇒ Fuel economy leadership in 2 Mode Hybrid applications
  ⇒ Plug in 2 Mode Hybrid in medium crossover utility segment
• New applications of clean passenger car and light duty truck diesels in North America
• E Flex/Chevrolet Volt/Equinox Fuel Cell vehicles strengthen technology leadership

Summary

• GM’s Advanced Propulsion Technology Strategy will…
  ⇒ Be sustainable through energy diversity
  ⇒ Displace petroleum
    - Alleviate the issue of demand outgrowing limited supply
    - Reduce our dependence on a supply subject to uncontrollable risks
  ⇒ Reduce GHG emissions
• By Incorporating…
  ⇒ Continued improvement of conventional powertrains
  - Gas engines, diesel engines, and transmissions will be the principle propulsion systems for the foreseeable future
  ⇒ Alternative fuels
    - Biofuels such as E85 ethanol and Biodiesel (i.e. B20)
    - Synthetic fuels derived from coal, natural gas, or biomass
  ⇒ Increased electrification of the automobile
    - Rapid expansion of our hybrid portfolio, including plug ins
    - EV range extenders
    - Ultimately, hydrogen fuel cells