A View From the Bridge

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Overview

PART 1: New GM

PART 2: Collaborative Model for Powertrain Development

PART 3: Integrated Systems Approach
  • Energy & Transportation
July 10, 2009... just 40 days after filing

A New GM Launches

with a focus on Customers, Cars and Culture

more...
New GM

- **Stronger Brands and Dealers**
  - 4 Core Brands; 34 US nameplates
  - ~3,600 dealers down from ~6,000

- **Stronger Balance Sheet**
  - US debt of ~11 billion (reduced from more than $40 billion)
  - 34 US Assembly, Powertrain and Stamping plants (down from 47)
  - GM expects to increase capacity utilization from less than 45% in 2009 to nearly 100% in 2011
  - US Employment reduction from ~91k at the end of 2008 to ~64k at the end of 2009
“...Will continue and increase its investment and leadership in fuel economy and advanced propulsion technologies and is committed to meeting or exceeding new federal fuel economy and emissions regulations while contributing to the development of advanced engineering and manufacturing capabilities in the United States...”
“...GM will launch the **Chevrolet Volt** extended range electric vehicle in 2010, expects to have **14 hybrid models** in production by 2012 and will have **65 percent of vehicles** alternative-fuel capable by 2014.”
Advanced Propulsion Technology Strategy

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

Energy Diversity

Petroleum (Conventional and Alternative Sources)

Alternative Fuels (Ethanol, Biodiesel, CNG, LPG)

Electricity (Conv. & Alternative Sources)

Hydrogen
Collaborative Model for Powertrain Development

Robust Supply Base

Partnership Between Automakers & Energy Providers

Collaboration Between Automakers, Academia & Governments

Engaging the Customer
Great demand for technical work force with expertise in new regimes

- GM has initiated research and education programs at universities around world (Shanghai Jiao Tong University in China, University of Wisconsin, University of Michigan, Politecnico di Torino, Technical University of Vienna)

- GM has a number of key industrial partnerships with other OEM’s – Ford, Chrysler, Daimler, BMW, SAIC, Suzuki

- GM has collaboration activities with all DOE labs, NIST, ARDEC, TARDEC, NREL, Ames Lab, Pacific Northwest National Lab, and EPA

“…..Need to run the business with more collaboration and shared structures.”
**Collaboration with DOE**

- **Collaboration with multiple labs**
  - Oak Ridge National Lab, Sandia National Lab, Argonne, Brookhaven, NREL, Los Alamos National Lab, and Lawrence Livermore Lab

- **Examples of successful collaboration**
  - Development of Molybdenum free casting process at Oak Ridge National Lab for cost reduction
  - Research at Sandia Combustion Laboratory providing key insights into HCCI and Diesel technology
  - Plug-and-Play Model Architecture and Development Environment with Argonne Lab providing a key tool to model vehicle systems for system performance and optimization
  - Energy System Modeling at Sandia Laboratory to study well-to-wheel impact of ethanol usage
Strategic Alliances

- GM is committed to the rapid commercialization of “The Next Generation of Ethanol”
- GM has strategic alliances with two leading cellulosic ethanol start-ups, Coskata and Mascoma
- The processes used by these companies will make ethanol from non-food, renewable resources
- Fuel production cost goal: $1.00-1.35/gallon
Collaboration with Oil Industry

Reduction in Emissions

Vehicle Manufacturers

- 3 way Catalytic Converter >2L
- Lambda Sensor
- Electronic fuel injection
- 3-way Catalytic Converter generalization
- IDI
- Mechanical pump with elec. control
- MPI
- EGR on/off
- Oxidation catalyst
- Cold start tuning strategy
- OBD
- DI
- Turbo
- Common Rail
- Cooled electr. EGR
- Common Rail with Piezo inject.
- Opti. Combustion chamber
- In some cases,
- DPF or NOx trap
- Engine out emissions
- After treatment Improvement
- 1800-2000 bar
- NOx Trap
- Downsizing

Tier I
EURO I
1990
EURO II
1996
EURO III
2000

Tier I+NLEV
EURO IV
2005

Tier II
EURO V
2010/11

Tier III

Vehicle

Manufacturers

Oil Industry

Unleaded Gasoline

Gasoline S<500 ppm

Diesel S<500 ppm

Lead phase-out
Gasoline S<150 ppm
Aromatics, RVP...

Diesel S<350ppm
Cetane, T95 ...

Gasoline S<50 ppm
Aromatics < 35%

S<50 ppm and Sulphur free

Unleaded Gasoline

Lubricity

Gasoline S<50 ppm

Diesel S<350ppm
Cetane, T95 ...

S<50 ppm and Sulphur free

US ULSD

Sulphur free
**Vehicle Energy Loss Breakdown**

- **Efficiency = Work Output/Work Input**
  - 14% of Engine Shaft Work
  - 4% of Fuel Energy

- **Typical Losses**
  - 22% in Engine Friction and Pumping
  - 20% in Aerodynamic drag
  - 14% In Tire Rolling Resistance
  - 10% in Driveline/Brake Drag/Chassis
  - 10% in Transmission
  - 24% in Others

*Chevrolet Malibu*
**Efficiency**

**Mechanical Efficiency**

- Work Output
- Work Input

**Perceived Efficiency**

- Miles Traveled
- Cost
- MPG
- Miles Traveled
- Gasoline Consumed

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14
Chevrolet Volt / Opel Ampera

40 miles BATTERY Electric Drive + 400 miles EXTENDED RANGE Driving
Typical Daily Commute

40 miles Is the Key

Source: OmniStats Data by the US Bureau of Transportation
Perceived Efficiency with Electrification

- Perceived Efficiency = Cost/Mile

- 10¢ per mile
- 7¢ per mile
- 1¢ per mile off-peak (2¢ on-peak)
Vehicle Electrification

Future requirements drive a progression towards increasing electrification

Conventional Engine/Transmission
- Baseline
- SIDI
- 2-step valve
- HCCI
- Turbo boost
- 6 speed transmissions
- Active Fuel Management

Mild Hybrid
- Engine stop start
- Recoup braking energy
- Electric power assist

Full Hybrid
Baseline plus:
- Engine operating point optimization
- Electric launch
- Limited pure electric drive

Plug-in Hybrid
Baseline plus:
- Plug-in rechargeable
- Significant electric drive

Extended Range Electric Vehicle
Baseline plus:
- Full-function electric drive
- Initial pure electric range

Fuel Cell Electric Vehicle
- 100% pure electric range
- No exhaust emissions

Mechanical with Electric Assist

Electric with ICE Generator

All Electric

Increasing Level of Efficiency and Reduced Emissions
Summary

GM’s Advanced Propulsion Technology Strategy will...

- Reduce fuel consumption and GHG emissions
- Be sustainable through energy diversity
- Displace petroleum
- Enabled by partnerships
Panel Discussion – New Direction in Engine and Fuels – J. Gary Smyth

Passive NH3 SCR for Lean-Burn SIDI Engines – Wei Li

Engine and Reactor Evaluations of HC-SCR for Diesel Nox Reduction – Richard Blint

Development of Thermoelectric Technology for Automotive Waste Heat Recovery – Jihui Yang

Improving Automotive Energy Efficiency by Developing Components for Distributed Cooling and Heating Based on Thermal Comfort – Jihui Yang