Powertrain Strategies for the 21st Century

Bob Czarnowski
Business Development Manager

Our Beliefs
Respect
Collaboration
Excellence
Integrity
Community

July 15th, 2009
Outline

- BorgWarner at a Glance
- Framing the Future: Looking at the Past
- Future Strategies & Technologies
  - What will the Powertrain of 2020 look like?
BorgWarner at a Glance

- 2008 Sales: $5.3 Billion ($6.0B with NSK-Warner)
- Employees: 14,000
- Operations: 60 Locations
  18 Countries
- Products: Engine, Transmission
  & AWD systems
- Market Drivers: Fuel Economy
  Emissions
  Performance
We are Powertrain Focused

**Thermal Systems**
- Thermal Management Components and Systems
- Visctronic® Systems
- Fans / Fan Drives

**Chain Systems**
- Engine Timing Chain
- Variable Cam Timing
- Gemini™ Chain Systems
- HY-VO® Transmission Chain
- Oil Pumps / Drives

**Transmission Systems**
- DualTronic® Clutch Module
- Solenoids / Control Modules
- One-way Clutches
- Friction Plates
- Transmission Bands

**Turbochargers**
- Wastegate
- Variable Turbine Geometry (VTG)
- Regulated 2-stage (R2S™)

**Emissions Systems**
- Emission Controls
- Secondary Air Systems
- Actuators

**Beru Technologies**
- Diesel Cold Start Technology
- Electronic & Sensor Technology
- Gas Ignition Technology

**TorqTransfer Systems**
- AWD Systems
- 4WD Transfer Cases
- Synchronizer Rings
- Electronic Control Units

**Engine**

**Drivetrain**

BorgWarner

Powertrain Strategies for the 21st Century
U of M Conference 15JL09
BorgWarner = Efficient Gasoline

- Examples - 2010 Ford Fusion, VW Golf, BMW Mini Cooper, Honda Fit

- Transmission Modules, One Way Clutches, Friction plates
- Turbochargers
- Cam Torque Actuated VCT
- Engine Timing Systems, HY-VO® Chain
Examples - VW Jetta TDI, Mercedes C-Class & E-Class, BMW 1/3/5 Series, Mazda Atenza

VTG and R2S Turbochargers

Pressure Sensor Glow Plugs

One Way Clutches, Friction Plates

DualTronic™ Dual Clutch & Control Modules

Clean Diesel Examples
### BorgWarner = Hybrid & Electric Vehicles

BorgWarner has broad production experience with current products in hybrid and electric vehicle applications.

<table>
<thead>
<tr>
<th>Hybrid and Electric Vehicle Applications (A few examples)</th>
<th>Current Product Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart ForTwo hybrid</td>
<td>Engine Valve Timing System</td>
</tr>
<tr>
<td>BMW Mini</td>
<td>Cabin Heater (High Voltage)</td>
</tr>
<tr>
<td>Toyota Prius</td>
<td>HY-VO® Chain</td>
</tr>
<tr>
<td>Honda Insight and Civic</td>
<td>Engine Valve Timing comp.</td>
</tr>
<tr>
<td>Ford – Escape, Mariner, Tribute, Fusion, Milan</td>
<td>Engine Valve Timing System</td>
</tr>
<tr>
<td>GM/Saturn – Vue, Aura, Malibu</td>
<td>Transmission Components &amp; HY-VO® Chain</td>
</tr>
<tr>
<td>GM – Escalade, Tahoe, Yukon</td>
<td>Transmission Components</td>
</tr>
<tr>
<td>Tesla - Roadster</td>
<td>Tire Pressure Monitoring System &amp; eGearDrive™</td>
</tr>
<tr>
<td>Fisker Karma</td>
<td>Turbocharger</td>
</tr>
</tbody>
</table>

Powertrain Strategies for the 21st Century
U of M Conference 15JL09
What will strategies and technologies look like in 2020?
What will strategies and technologies look like in 2020?

Diversity!
OEM Views - Who’s Right?

VW CEO says electric vehicles are "very far away"

Mulally says electric vehicles to dominate Ford's future lineup

Mazda: Don't believe hot air being emitted by hybrid hype

Nissan may flip electric-vehicle switch early in U.S.

Hyundai plans plug-in for 2012 in U.S.
Automotive Technology - a history of start/stops – and some restarts

- **GDI**
  - Started in the 1950’s, really only took off in the 2000’s
- **LD Diesel**
  - Started in the 1940’s, really only took off in the 1990’s
- **Fuel Injection**
  - Started in the 1950’s, really took off in the late ‘80s
- **Electric Vehicles – started in 1890’s, still waiting**
- In general, the most rapid deployment of technology occurs in 10 years after significant numbers enter production. (provide there is a market driver). Normal time is 20 years
- The fastest known deployment was catalytic converters, starting in 1975. Due to regulation, robust technology and capital investment made in advance, these converters were in place within 5 years.
- **Bottom Line: Dominant Technology for 2020 is already known, just waiting to be sorted and deployed**
Rapid Technology change and outside forces will drive more Powertrain Diversity

- Energy Security/Fuel price
- Air Quality GHG Concerns
- Customer Buying Habits
- Infrastructure
- Political Uncertainty
- Price/Performance
- Regulation/Incentives
- Capital Investment

Automotive Industry

Powertrain Diversity

- Gasoline
- Hybrids
- Natural Gas
- Electric
- Diesel
Powertrain Market Shares: Carriages and Cars

Scenario VI: Unconstrained Fuel, Cost Driven, Clean Diesel Combustion

- Steam
- Horse and Carriage
- Electrical
- Diesel
- Fuel Cell
- Full Hybrids
- Natural Gas
- GDI
- Electrical

Years

Powertrain Strategies for the 21st Century
U of M Conference 15JL09
Powertrain Strategies for the 21st Century

Variable Valve Timing
Gasoline Direct Injection
6-speed AT
Lean GDI

Cost Benefit of Technologies

Cost/Benefit of Competing Technologies

- Turbo Charging
- Dual Clutch Transmissions
- Weight
- Cylinder Deactivation
- Continuously Variable Transmissions
- Variable Valve Timing
- Gasoline Direct Injection
- 6-speed AT
- Lean GDI

Source: CSM Worldwide
# ICE Technology Highlights - 2020

<table>
<thead>
<tr>
<th>Product Trend</th>
<th>IC Engine Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybridization</td>
<td>Stop/Start Hybrid</td>
</tr>
<tr>
<td>Variable Everything</td>
<td>Variable Valve Timing</td>
</tr>
<tr>
<td></td>
<td>Cyl. Valve Deactivation</td>
</tr>
<tr>
<td></td>
<td>Variable Compression Ratio</td>
</tr>
<tr>
<td>Combustion and downsizing</td>
<td>Turbochargers</td>
</tr>
<tr>
<td></td>
<td>HCCI</td>
</tr>
<tr>
<td>Electrification</td>
<td>Electric Valvetrain Actuation</td>
</tr>
<tr>
<td></td>
<td>Elect. P.S.</td>
</tr>
<tr>
<td></td>
<td>Elect. Water Pump</td>
</tr>
<tr>
<td>Modularization - Cost and weight reduction</td>
<td>One Example - Integrated manifolds</td>
</tr>
</tbody>
</table>
Hybrids & EV’s will Play an Increasing Role

- **Hybrids and Electric Vehicles**
  - Perform well in the City

- **Up-charge Somewhat Accepted**
  - Environmentally friendly
  - Trendy
  - Payback less of a concern for some
  - Battery & Power electronics cost still a big issue

- **Electric Vehicles**
  - Potential as commuter cars
  - Requires incentives due to cost
  - Will be a small niche through 2020

Source: WardsAuto.com Jan 16, 2009
Electrification Shifts the Focus

Impact on Carbon Emissions:
Shift Focus and Concentrate on Generation Sites

A shift to electricity-based vehicles would move the focus for addressing carbon emissions from millions of individual vehicles to far fewer centralized electricity-generating plants. Controlling emissions thus becomes an industrial task that is easier technologically.
Electric Vehicles will shift strategy to focus on efficiency of electrical generation & transport and storage.

Focus is on engine efficiency

Source: EIA, BorgWarner
Assumes primary energy sources of oil, coal and natural gas.
Diesels Should Play a Large Role

- **Diesels have their place**
  - Highways, Rural and Sub-urban driving
  - Technology is proven and can make immediate impact

- **Diesels are Proven to Achieve**
  - ~30% better fuel economy
  - ~25% better CO2 emissions
  - ~50% better torque for acceleration

- **Public Perception**
  - Only consider initial cost and fuel price
  - US Consumers and Policy Makers need to be educated
    - Environmental Statement as well as paying for itself
    - Reduce dependence on oil, further with Bio-diesel
Future Uncertainty of Regulation

- **Current CAFE Standard a good start (through 2016)**
  - Door open for a patchwork of regulations after 2016
  - Need to Set Standards through 2020 quickly
    - Facilitates Long Term Strategies & Global Competitiveness

- **Incentive Legislation Must be Technology Neutral**
  - Currently favors electrification with tax incentives
  - Must have a level playing field to encourage technology innovation
  - Varied Driving requirements dictate varied technologies
    - Give the American consumer the choices they want and deserve

- **CO2 & CAFE Calculations**
  - Should be based on real world driving:
    - 43% City / 57% Hwy
  - Currently based on:
    - 55% City / 45% Hwy

Source: EPA Fuel Economy Trends Report
BorgWarner Powertrain Strategies

- BW continues to develop new Engine and Drivetrain Products / Systems to further improve powertrain efficiency and emissions
- Additional new technologies will be focused on and support the increasing demand for Hybrid & Electric applications

- Cost effective Turbocharging Systems for Diesel and Gasoline Engines
- Air Management Modules
- Electrically assisted Turbocharging
- Dual Clutch Transmissions
- New Drivetrain Technologies for Hybrids
- Energy and Signal Management
- Variable Valve Duration Control
- Transmission for electric vehicles
Powertrain technologies summary -2020

- Stop/Start Technology will be widespread >60%
- Variable Valve Timing will be virtually on every engine
- Turbochargers will be on most all GDI and diesel engines
- Downsizing / Power Density up
- Lean Burn GDI will be restricted by emissions
- Alternative combustion will be here
  - HCCI/Miller/Atkinson
- Modularization
  - Integrated head / manifolds
- Electric accessories will be common place
- Transmissions will be most all 6+ speeds with growth in DCT and AMT
Summary

- The Internal Combustion Engine (ICE) will dominate in the foreseeable future
  - Fastest way to improve fleet fuel economy
- Engine technology choices will be more diverse than since the early 20th century
- All relative newcomers grow in market share
  - Diesel, hybrids and GDI will grow substantially
- Legislation & Regulation should be Technology neutral
- Stability and certainty of Future Standards improves chance for best solutions
Thank You

feel good about driving

better fuel economy
reduced emissions
great performance