Powertrain Strategies for the 21st Century: Revolution and Evolution

“Focus on the Future”
UM Automotive Research Conferences

WELCOME!

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Automotive Futures
University of Michigan
Transportation Research Institute

Funding

Affiliate Program
- Supporting Members
- Research Partners

Research
- Globalization
- Powertrains
- IT

Conferences
- 5 Annual Conferences
Automotive Futures
Affiliate Program

Affiliates Members and Research Partners

**IT Organizations**
Oracle Corporation
IBM
HP
Siemens-PLM

**OEMs**
General Motors
Toyota Tech Center
Nissan Tech Center
Ford Motor Company
Chrysler LLC

**Government/NGOs**
NREL / EPA
NSF
Motor Carrier
Energy Foundation
The Hewlett Foundation
National Resources Defense Council
Union of Concerned Scientists
CALSTART
Argonne National Labs

UMTRI

AF AUTOMOTIVE FUTURES
# Automotive Futures Affiliate Program

## Affiliates Members and Research Partners

<table>
<thead>
<tr>
<th>Suppliers</th>
<th>Suppliers</th>
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</thead>
<tbody>
<tr>
<td>Chevron</td>
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<td>Denso</td>
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<td>Dana</td>
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<td>Peterson Spring</td>
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<tr>
<td>Continental</td>
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<tr>
<td>TRW</td>
<td>Dow</td>
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<tr>
<td>Valeo</td>
<td>Bosch</td>
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[UMTRI Logo]
Automotive Futures
Affiliate Program

New Affiliates Members

Argonne National Labs
BorgWarner
Valeo
ITS America

Thank you for your support!
Automotive Futures
Current Research Programs

• Powertrains
  • 2014 Powertrain Strategies for the 21st Century Survey (Sponsor: Affiliates)
    • Survey continuing

• Total Cost of Ownership: Comparing Diesel and Gas Vehicles (Bosch)
  • Based on resale value of 30K vehicles sold through Mannheim auctions in 2012 / 2013
Automotive Futures
Current Research Programs

• ITS
  • Integrated Mobile Observations: Micro-level weather reporting using cell phones in MDOT vehicles (Sponsor: MDOT and FHWA)
    • Continuing data collection through October, 2015
  • Roadway Evaluation Project: Measuring road roughness via accelerometers in cell phones mounted in MDOT vehicles
    • Final report available
  • Deploying Safety Technologies in Commercial Vehicles
    • Familiarity and penetration currently and in the future of: Forward Collision Warning / Lane Departure Warning / Blind Spot Detection / ESC / Vehicle Communications
    • Final report available (Sponsor: ITS America)
Upcoming UMTRI-AF Conferences

- September 16, 2015: *The Business of IT: The Future of IT in the Organization and the Vehicle.* Our annual IT conference will examine the future of IT as it changes how global organizations operate as well as how vehicles will function in the future.

- November 11, 2015: *Inside China: Understanding China’s Current and Future Automotive Industry.* Our 8th annual conference provides insight into the Chinese auto industry from experts in specific areas of the industry including the Chinese market, suppliers, trade, Chinese manufacturers, labor, and marketing.

- February 17, 2016: *New Mobility: The Future of Freight.* A new conference that examines the major changes IT-enabled goods movement will have on the freight movement industry.
Upcoming UMTRI-AF Conferences

• April 13, 2016: *Globalization of the Automotive Industry: The 2016 Update.* A new conference that brings everyone up to date on the trends in the globalization of the automotive industry from a manufacturer and supplier perspective.

• July 20, 2016: *Powertrain Strategies for the 21st Century.* Our 8th annual conference will provide an overview of all the electrification progress that has been made in the global auto industry.
Upcoming UMTRI-AF Conferences

The UM Alumni Discount
Alumni who sign up in advance for five conferences in a row receive a $250 discount
9am  Bruce Belzowski, Managing Director, Automotive Futures, UM Transportation Research Institute

- Jeff Jowett, Manager, North and South America Powertrain Forecasting, IHS Automotive
- John Shutty, Chief Engineer, Advanced Controls and Simulation, BorgWarner Inc.

10:30-10:45am  Break

- Bryan Krulikowski, Vice-President of Transportation and Technology, Morpace Market Research and Consulting
- AM Panel Q&A
PM Presenters

12:00-1:30pm  Lunch

1:30pm  Paul Whittaker, Director of Product Technologies, AVL
  • Walter McManus, Principal, McManus Analytics
  • Therese Langer, Transportation Program Director for the American Council for an Energy-Efficient Economy

2:55-3:05pm  Break
  • John DeCicco, Research Professor, University of Michigan Energy Institute
  • PM Panel Q&A

4:00pm  Adjourn
Company Powertrain Strategies Information

- Highlights the powertrains for each of the manufacturers
- Company level EPA MPG rating
- Engine displacements
- Engine type and its associated vehicle models
- North American engine production
- Current and future directions for each manufacturer
- Sources include EPA, WardsAuto.com, and company information
Conference Questions

• How are the different powertrains currently being used by manufacturers helping them meet their CAFE goals?
• How big a role will alternative powertrains have in helping manufacturers meet their 2025 CAFE goals?
• How are manufacturers using the supply base for new powertrain technologies?
• How challenging will system engineering be for the development of new powertrains?
Conference Questions

- What new powertrain technologies seem the most likely to be implemented over the next 10 years?
- Are some of the new powertrain technologies more important than others in meeting 2025 CAFE goals?
- How are consumers valuing new powertrain technologies in their new vehicle purchases?
- How are lower fuel prices affecting consumer attitudes towards fuel economy?
Conference Questions

• What role are the powertrain consulting companies playing in supporting manufacturers in meeting 2025 CAFE goals?
• Are there new powertrain technologies the powertrain consulting companies are developing?
• What do independent assessments of new powertrain technology say about the ability of manufacturers to meet their 2025 powertrain goals?
• How are credits used by manufacturers to help meet their CAFE goals?
Conference Questions

• What types of credits are currently available and being used by manufacturers? Will different types be available in the future?

• What role are alternative fuels currently playing in the U.S. and what role will they play in near future?

• What are the net carbon impacts of motor fuels and how are the impacts modeled for policy purposes?
Total Cost of Ownership:
A Diesel Versus Gas Comparison (2012-2013)

Bruce M. Belzowski
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Managing Director-Automotive Futures
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## The Slow Growth of Alternative Fuels/Technologies

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>Percent of Sales</th>
<th>2014</th>
<th>Percent of Sales</th>
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<tbody>
<tr>
<td>Clean Diesels</td>
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<td>2.83%</td>
<td>Clean Diesels</td>
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<tr>
<td>Hybrids</td>
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<tr>
<td>Compressed Natural Gas (CNG)</td>
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<td>0.03%</td>
<td>Compressed Natural Gas (CNG)</td>
<td>0.02%</td>
</tr>
</tbody>
</table>
The Slow Growth of Alternative Fuels/Technologies

• Our analysis of the number of models available in the U.S. market in 2014 showed that of the 381 models available, 124 models (33 percent) offered alternative powertrains. This is a significant increase over the 11 percent reported for 2011.

• A recent purchase intention study reported that consumers considered hybrids (49 percent) and clean diesels (19 percent) as their first and second choices for their next purchase. (Morpace, 2014)

• But this has not translated directly to sales.
Total Cost of Ownership: Project Goal

• Project Goal: To objectively measure the value ($) of comparable gas and diesel light and medium duty vehicles over 3 and 5 years through an analysis of the Total Cost of Ownership (TCO). Sponsor Bosch Corporation

• TCO Includes: Vehicle depreciation, fuel, insurance, license/fees, maintenance, repairs

• We developed our own models for resale value and depreciation as well as fuel costs

• Future estimates of comparable gas/diesel vehicle costs generated by Vincentric
Total Cost of Ownership: Data Sources

• 2012 and 2013 Mannheim auction data to estimate the vehicle resale value/depreciation and Blackbook data for the original MSRP (28,239 vehicles) (Model Years 2000-2013)

• Energy Information Administration for annual fuel cost estimates, Department of Transportation vehicle survival rates/annual miles driven, and EPA vehicle MPG to measure fuel costs

• Vincentric data to estimate annual taxes and fees, insurance, repairs, and maintenance
Total Cost of Ownership: Equation and Assumptions

• The equation for TCO includes:
  • Depreciation (MSRP-Resale Value) + Fuel Costs + Fees and Taxes + Insurance + Maintenance + Repairs

• All values are in 2013 dollars.

• Assuming 15K miles driven per year for our model.

• Estimates are for 3 years / 45,000 miles and 5 years / 75,000 miles
## Total Cost of Ownership: Diesel/Gasoline Vehicle Pairs

### Passenger Cars
- Audi A3
- Mercedes E Class
- VW Jetta
- VW Sportwagen
- BMW 3-Series
- VW Golf
- VW Passat

### SUVs
- Audi Q7
- Mercedes GL Class
- VW Touareg
- BMW X5
- Mercedes M Class

### Medium Duty Pickup Trucks
- Chevrolet Silverado 2500
- Ford F-250
- Ram 2500
- GMC Sierra 2500
Total Cost of Ownership: Vehicle Sample

Number of Vehicles

Gasoline  Diesel

0  250  500  750  1,000  1,250  1,500

Audi A3  BMW 3 Series  Mercedes-Benz E Class  VW Golf  VW Jetta  VW Jetta Sportwagen  VW Passat  Audi Q7  BMW X5  Mercedes-Benz GL Class  Mercedes-Benz M Class  VW Touareg  Chevrolet Silverado 2500  Dodge Ram 2500  Ford F250  GMC Sierra 2500

Passenger Cars  SUVs  Medium Duty  Pickup Trucks
Total Cost of Ownership: Miles Per Gallon Differences

- Audi A3: +36%
- BMW 3 Series: +31%
- Mercedes-Benz E Class: +32%
- Golf: +29%
- Jetta: +30%
- Sportwagen: +25%
- Passat: +27%
- Audi Q7: +38%
- BMW X5: +24%
- Mercedes-Benz GL Class: +38%
- VW Touareg: +15%
- Chevrolet Silverado 2500: +17%
- Dodge Ram 2500: +15%
- Ford F250: +15%
- GMC Sierra 2500: +15%
Total Cost of Ownership: Vehicle Price Differences (MSRP)
Total Cost of Ownership: Resale (Auction) Price Differences

GMC Sierra 2500: Gasoline

Mileage/15,000

Sale Price (2013 Dollars)

Low Trim
Medium Trim
High Trim
Total Cost of Ownership: Resale (Auction) Price Differences @ 5 Years
Total Cost of Ownership: Depreciation Differences @ 3 Years
Total Cost of Ownership: Depreciation Differences @ 5 Years
Total Cost of Ownership: Fuel Cost Differences @ 3 Years

- Audi A3: -17%
- BMW 3 series: -22%
- Mercedes-Benz E Class: -20%
- VW Golf: -20%
- VW Jetta: -23%
- VW Jetta Sportwagen: -23%
- VW Passat: -27%
- Audi Q7: -12%
- BMW X5: -18%
- Mercedes-Benz GL Class: -23%
- VW Touareg: -17%
- Chevrolet Silverado 2500: -8%
- Dodge Ram 2500: -7%
- Ford F250: -8%
- GMC Sierra 2500: -4%

Categories:
- Passenger Cars
- SUVs
- Medium Duty Pickup Trucks
Total Cost of Ownership: Fuel Cost Differences @ 5 Years
Total Cost of Ownership: Vincentric Differences @ 3 Years

Insurance, Fees and Taxes, Maintenance, Repairs

Gasoline vs Diesel Differences @ 3 Years

- Audi A3: +2%
- BMW 3 Series: +1%
- Mercedes-Benz E Class: +10%
- VW Golf: +2%
- VW Jetta: +7%
- VW Jetta Sportwagen: +10%
- VW Passat: +7%
- Audi Q7: -1%
- BMW X5: +4%
- Mercedes-Benz GL Class: +4%
- Mercedes-Benz M Class: +10%
- VW Touareg: +12%
- Chevrolet Silverado 2500: +10%
- Dodge Ram 2500: +10%
- Ford F250: +10%
- GMC Sierra 2500: +10%

- Passenger Cars
- SUVs
- Medium Duty Pickup Trucks
Total Cost of Ownership: Vincentric Differences @ 5 Years

[Bar chart showing differences in cost of ownership for various vehicles at 5 years.]
Total Cost of Ownership @ 3 Years

- A3 (G) vs A3 (D)
  - Δ=$4,977
- 3-Series (G) vs 3-Series (D)
  - Δ=$2,287
- E-Class (G) vs E-Class (D)
  - Δ=$1,091

Passenger Cars

Legend:
- Black: Depreciation
- Pink: Fuel
- Red: Repairs
- Green: Fees & Taxes
- Blue: Insurance
- Yellow: Maintenance
Total Cost of Ownership @ 3 Years

Passenger Cars

- Depreciation
- Fuel
- Repairs
- Fees & Taxes
- Insurance
- Maintenance

- Golf (G): $798
- Golf (D):
- Jetta (G):
- Jetta (D): $2,687
- Sportwagen (G):
- Sportwagen (D): $1,583
- Passat (G):
- Passat (D): $7,289
Total Cost of Ownership @ 3 Years

SUVs

- Q7 (G)
- Q7 (D)
- X-5 (G)
- X-5 (D)
- GL Class (G)
- GL Class (D)

Cost Categories:
- Depreciation
- Fuel
- Repairs
- Fees & Taxes
- Insurance
- Maintenance

Cost Differences:
- Δ-$929
- Δ-$6,938

Total Cost Difference: Δ-$7,319
Total Cost of Ownership @ 3 Years

- M Class (G)
- M Class (D)
- Touareg (G)
- Touareg (D)

Depreciation, Fuel, Repairs, Fees & Taxes, Insurance, Maintenance

Δ-$3,525
Δ-$4,358
Total Cost of Ownership @ 3 Years

Medium Duty Pickup Trucks

- Silverado (G)
- Silverado (D)
- Ram (G)
- Ram (D)
- F-250 (G)
- F-250 (D)
- Sierra (G)
- Sierra (D)

Cost differences:
- △-$4,250
- △-$2,281
- △-$1,319
- △-$3,378
Total Cost of Ownership @ 5 Years

Passenger Cars

- **Golf (G)**
  - Depreciation: $10,000
  - Fuel: $5,000
  - Repairs: $2,000
  - Fees & Taxes: $1,000
  - Insurance: $1,000
  - Maintenance: $1,000
  - Total: $20,000

- **Golf (D)**
  - Depreciation: $12,000
  - Fuel: $6,000
  - Repairs: $3,000
  - Fees & Taxes: $2,000
  - Insurance: $2,000
  - Maintenance: $2,000
  - Total: $31,000

- **Jetta (G)**
  - Depreciation: $15,000
  - Fuel: $7,000
  - Repairs: $4,000
  - Fees & Taxes: $3,000
  - Insurance: $3,000
  - Maintenance: $3,000
  - Total: $44,000

- **Jetta (D)**
  - Depreciation: $17,000
  - Fuel: $8,000
  - Repairs: $5,000
  - Fees & Taxes: $4,000
  - Insurance: $4,000
  - Maintenance: $4,000
  - Total: $55,000

- **Sportwagen (G)**
  - Depreciation: $20,000
  - Fuel: $10,000
  - Repairs: $6,000
  - Fees & Taxes: $5,000
  - Insurance: $5,000
  - Maintenance: $5,000
  - Total: $76,000

- **Sportwagen (D)**
  - Depreciation: $22,000
  - Fuel: $12,000
  - Repairs: $7,000
  - Fees & Taxes: $6,000
  - Insurance: $6,000
  - Maintenance: $6,000
  - Total: $94,000

- **Passat (G)**
  - Depreciation: $25,000
  - Fuel: $15,000
  - Repairs: $8,000
  - Fees & Taxes: $7,000
  - Insurance: $7,000
  - Maintenance: $7,000
  - Total: $117,000

- **Passat (D)**
  - Depreciation: $27,000
  - Fuel: $18,000
  - Repairs: $9,000
  - Fees & Taxes: $8,000
  - Insurance: $8,000
  - Maintenance: $8,000
  - Total: $138,000

- **Total**
  - Depreciation: $90,000
  - Fuel: $45,000
  - Repairs: $30,000
  - Fees & Taxes: $20,000
  - Insurance: $20,000
  - Maintenance: $20,000
  - Total: $205,000
Total Cost of Ownership @ 5 Years

- Depreciation
- Fuel
- Repairs
- Fees & Taxes
- Insurance
- Maintenance

$0 - $70,000

M Class (G) vs. M Class (D)
- Δ-$4,153

Touareg (G) vs. Touareg (D)
- Δ-$5,637

SUVs

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Total Cost of Ownership @ 5 Years

Medium Duty Pickup Trucks

Depreciation: Red
Fuel: Green
Repairs: Orange
Fees & Taxes: Yellow
Insurance: Light Blue
Maintenance: Navy

Silverado (G) $1,810
Silverado (D) $2,289
Ram (G) $945
Ram (D) $952
F-250 (G)
F-250 (D)
Sierra (G)
Sierra (D)
# TCO: Diesel vs. Gas Comparisons

Passenger Cars 3 Years 45,000 Miles | 5 Years 75,000 Miles
---|---
Audi A3 | -$4,977 | -$5,828
BMW 3 Series | -$2,287 | -$4,308
Mercedes E Class | -$1,091 | -$3,643
VW Golf | +$798 | +$2,034
VW Jetta | -$2,687 | -$4,342
VW Sportwagen | -$1,583 | -$1,102
VW Passat | -$7,289 | -$7,688
## TCO: Diesel vs. Gas Comparisons

<table>
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<tr>
<th>SUVs</th>
<th>3 Years 45,000 Miles</th>
<th>5 Years 75,000 Miles</th>
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<td>Audi Q7</td>
<td>-$929</td>
<td>-$3,134</td>
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<tr>
<td>BMW X5</td>
<td>-$6,938</td>
<td>-$19,505</td>
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<tr>
<td>Mercedes GL Class</td>
<td>-$7,319</td>
<td>-$13,426</td>
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<tr>
<td>Mercedes M Class</td>
<td>-$3,525</td>
<td>-$4,153</td>
</tr>
<tr>
<td>VW Touareg</td>
<td>-$4,358</td>
<td>-$5,637</td>
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## TCO: Diesel vs. Gas Comparisons

<table>
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<th>3 Years 45,000 Miles</th>
<th>5 Years 75,000 Miles</th>
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</thead>
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<tr>
<td>Chevrolet Silverado 2500</td>
<td>-$4,250</td>
<td>-$1,810</td>
</tr>
<tr>
<td>Dodge Ram 2500</td>
<td>-$2,281</td>
<td>-$2,289</td>
</tr>
<tr>
<td>Ford F-250</td>
<td>-$1,319</td>
<td>+$945</td>
</tr>
<tr>
<td>GMC Sierra 2500</td>
<td>-$3,378</td>
<td>-$952</td>
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Conclusions

• The increase in diesel and other models in the US continues to grow, though the sales of these models is increasing very slowly.

• Since the previous 2010-2011 study, the market for diesels has grown with the introduction of diesel versions of the Audi A6, A7, A8, and Q5, BMW 3, 5, 7 Series and X3, Chevrolet Cruze, Ford Transit, Jeep Grand Cherokee, Porsche Cayenne, Ram Promaster, Ram 1500, and Volkswagen Beetle.

• There have also been some recent announcements of diesel versions of the Audi A4, Chevrolet Colorado, GMC Canyon, Mazda 6, Mercedes C-Class, Nissan Titan, Porsche Macan, and the Range Rover.
Conclusions

• Companies use different strategies in pricing their diesel versions of similar vehicles
  • This may be because manufacturers have matured the processes for developing and manufacturing diesel engines, lowering their costs.
  • This may also be because the diesel engine is a global commodity, and its costs can be spread across many more markets, lowering its cost
• Some companies may be urging the adoption of diesel vehicles in order to improve their fuel economy ratings
Conclusions

• Diesel vehicles tend hold their value despite a higher initial purchase price, providing buyers with $4K-$5K savings over gas versions of the same models.
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Link to Presentations Will Be Emailed This Weekend