Powertrain Forecast and Analysis:

What is Coming and What Are the Implications for the Specialty Equipment and Performance Aftermarket Industry

by

AUGUST 2009

The statements, findings, and conclusions herein are those of the authors and do not necessarily reflect the views of the project sponsor.

Acknowledgements

As with any project, this report is the result of many people contributing in a number of ways. The authors of this report would like to thank those in industry who assisted in this effort by sharing their vision of the future powertrain technologies. Their willingness to participate, and enthusiasm for the topic, made this project possible. The generous time provided by industry experts was a critical aspect of the research. CAR would like to thank those that contributed their thoughts, ideas, and direction.

Thanks also to Wendy Barhydt who contributed editing review, and Denise Semon who contributed her document preparation expertise.

The authors would like to especially thank the Specialty Equipment Markets Association (SEMA) for their support and sponsorship of this project. Chris Kersting, President and CEO, and the SEMA Board demonstrated vision in believing that, while their member companies are facing significant near-term tactical challenges, it is equally important for the Association to offer guidance on the rapidly changing strategic challenges member companies will face in the coming years. John Waraniak, Vice President of Vehicle Technology provided leadership, enthusiasm and insights to ensure this effort would be valuable and relevant to SEMA member companies and the performance aftermarket.

Brett Smith,
Director, Automotive Analysis Group

And
Zachery Adams,
Research Assistant

Jennifer Wong,
Research Assistant

Center for Automotive Research
1000 Victors Way, Suite 200
Ann Arbor, MI 48108
734/662.1287
www.cargroup.org

Executive Summary

The Specialty Equipment Market Association (SEMA) and the Center for Automotive Research (CAR) have engaged in a multi-phased project to create vehicle technology planning and business strategy guideposts for SEMA members. This, the Phase II second report—Powertrain Forecast and Analysis: What is Coming and What are the Implications for the Specialty Equipment and Performance Aftermarket Industry—addresses the rapidly changing powertrain paradigm in the U.S. market.

Part 1: U.S. Powertrain Forecast: 2011 and 2015

The first section of the report presents results of a targeted survey of powertrain experts from vehicle manufacturers, powertrain suppliers, and powertrain engineering services firm. The survey was conducted during the second quarter of 2009. Results of the survey are presented in a data table that includes baseline data where possible (actual data from previous years) and a forecast for two gasoline prices ($2.50 per gallon and $6.00 per gallon) for two years (2011 and 2015). The authors believe these scenarios offer very different market challenges, and thus create differing technology solutions.

The spark-ignited internal combustion (i.e. gasoline) engine has been the dominant automotive power-source in the United States for over a century. Given a gas price of $2.50, respondents do not see that dominance changing by 2015. However, given a gasoline price of $6.00 per gallon, respondents indicate diesel and to a far lesser extent, electricity (battery electric vehicles—BEV) will make in-roads into the U.S. market. *Hybrid electric vehicles (HEV) are forecast to gain an 11.1 percent (2.50 per gallon) and a 20.5 percent ($6.00 per gallon) share by 2015. Thus, given the higher price for fuel, the panel indicates that about a third of the vehicles sold in 2015 could utilize alternative powertrain technology.* Such a shift in powertrain technology would be a significant challenge for the industry and a great opportunity for SEMA members.

No technology has seen a more rapid reversal in expectations than gasoline direct injection (GDI). GDI technology was viewed as the most likely to see both rapid and effective application in the coming years. Although GDI has been offered in other markets, until recently, the expectation for penetration in the U.S. market has been muted. The respondents expect a large increase in GDI penetration rates by 2016

According to the results of the survey, respondents believe the parallel hybrid system will continue to be the dominant HEV technology. There is an important exception: given the $6.00 per gallon scenario, the respondents indicate they believe the belt-alternator starter (BAS--or stop/start system) will make significant in-roads. In fact, respondents forecast higher penetration rates for both of the lower cost solutions (BAS and integrated motor assist (IMG)) as gasoline prices rise. This may indicate a willingness on the part of consumers to look for the most cost-effective—not necessarily the most technologically advanced—solutions.

It is important for specialty equipment suppliers—even those that do not directly supply powertrain components—to be aware of the changes in powertrain. This forecast presents a vision for what may

happen. It is valuable to be reminded that this forecast is merely one possible outcome. It is incumbent upon each organization to consider the issues presented in this survey and use it as one piece of their scenario and strategic business planning processes.

Part 2: The Electrification of the Vehicle: A Positive Opportunity

The electrification of the vehicle is happening—maybe not as fast as some in the press and public office might suggest—but it is happening. In many ways, it offers a great opportunity for specialty equipment suppliers. It is important for specialty equipment suppliers—even those that do not directly supply powertrain components—to understand the changes in powertrain technology as well as the changes in who is manufacturing and marketing these vehicles.

The shift toward electrification can be separated into four distinct types of technology: hybrid electric vehicles (HEV), plug in hybrid electric vehicles (PHEV), extended range electric vehicles (EREV) and battery electric vehicles (BEV). These technologies present (in order) an increasing reliance on electricity. The last three can be classified as plug-in electric vehicles (PEV).

The very low initial market volumes for PEVs offer opportunity for specialty equipment suppliers. Vehicle manufacturers are not interested in (nor capable of) manufacturing ultra-low volume powertrain vehicles. Several SEMA companies have already developed products to convert HEVs to PHEVs. These companies are filling an important step in the evolution of the technology. There are currently customers interested in PHEV technology, yet demand has not risen to the point that would justify a purposed production vehicle from a major manufacturer. Thus, SEMA companies are serving to introduce a technology to the market place. This is in some aspects, a transitional activity, filling the void until vehicle manufacturers can address the demand.

Much like the automotive industry of 1909, the current industry is going through revolutionary change—only part of which has to do with the powertrain. The electrification of the vehicle has created an avenue for smaller, faster, entrepreneurial companies to compete—at least in the short run—with the industry giants. Over the coming years, some of these start-ups will make it to market with great products that capture market share and the imagination of a segment of buyers. Many will also fade away. The electrification of the vehicle has created two new avenues for specialty equipment suppliers. First, and most obvious, is that of a new powertrain paradigm. HEVs and PEVs bring new vehicle technologies and with them new opportunities. This change opens the door for a new generation of SEMA members. It also opens new markets for traditional powertrain member companies. Second, the launch of new car companies and OEMs—however small—presents additional opportunities for new relationships, partnerships and innovative business, revenue and organization models. The information in this report is intended to help SEMA and its members understand and monitor the developing business strategies of the PEV automakers

Introduction

The Specialty Equipment Market Association (SEMA) and the Center for Automotive Research (CAR) have engaged in a multi-phased project to create vehicle technology planning and business strategy guideposts for SEMA members. The first Phase I report in the program—The Specialty Equipment Company of the Future: Guideposts for Technology Forecasting and Strategic Planning—was released in the third quarter of 2008. This, the Phase II second report—Powertrain Forecast and Analysis: What is Coming and What are the Implications for the Specialty Equipment and Performance Aftermarket Industry—addresses the rapidly changing powertrain paradigm in the U.S. market.

The Phase I report stated "the automotive industry—both original equipment and aftermarket—is experiencing rapid and dramatic structural changes and is currently in a state of significant upheaval." It further stated, "Due to this upheaval, many industry participants are experiencing what can best be described as tactical tunnel vision. These companies, faced by severe near-term market vehicle technology and product development challenges and uncertainties, have been actively addressing tactical operational concerns, often at the expense of strategic long-term planning. While this is understandable—even necessary—it does present potential risk and opportunity costs for these companies." The authors believe that statement to be even more relevant today.

The SEMA--CAR industry research project is part of SEMA's Vehicle Technology strategy and is intended to assist SEMA member companies by investigating strategic concerns, challenges and opportunities and provide the most up-to-date information that is relevant and important to helping members sustain and grow their businesses.. The project is specifically designed to illustrate and communicate these coming challenges and create a forum for discussion (both within companies and between stakeholders) as well as provide a framework for effective scenario planning and bridging strategic thinking with operational business planning.. Individual companies will most certainly respond differently to these strategic challenges and scenarios. That creativity and innovation is the essence of SEMA members' entrepreneurial spirit and drive. The goal established by the CAR-SEMA project is to look ahead at what is coming down the road and provide advance notice of industry and vehicle changes in order to help member companies understand and prepare for those strategic challenges and opportunities.

Powertrain Challenges

In the past 18 months the automotive industry has seen, in essence, two energy directives (EISA of 2007, and the CAFE directive presented in May by President Obama), a ruling by the Environmental Protection Agency (EPA) stating that CO2 is a harmful pollutant, and Congress now debating a 2009 energy bill which could severely limit CO2 emissions. The consumers have seen gasoline prices vary from $1.50 per gallon to over $5.00 per gallon. Needless to say, the powertrain of the future is greatly uncertain.

In the automotive industry, uncertainty in the market (and policy) can be devastating. Thus, these are difficult times for all manufacturers. With these challenges comes opportunity—for automotive manufacturers, specialty equipment suppliers and, most importantly, the consumer.

Over the past fifty years, the automotive industry has become risk averse. Given the enormous investment required for development and manufacture, this is understandable. Yet, the current uncertainty makes almost all powertrain actions—even inaction—risky.

The introduction of any new technology presents several risks. First and foremost, there is the risk of introducing a technology which does not perform to the expectations of consumers and the marketplace. Examples of this are many, including the General Motors diesel engines of the late 1970s, and the Honda Accord HEV—biased for performance instead of fuel economy. The widespread adoption of a technology that does not meet customer expectations for performance and reliability (even if forced by regulation) can hurt a manufacturer's reputation, and also delay the technology implementation.

Second, there is the risk of a choosing the wrong technology, or one with a very short market life. In these rapidly changing times, companies may chose what appears to be a viable technology, only to discover that advancement in another technology (or even a policy change) can drastically alter the playing field. Some suggest the diesel engine may be an example of the latter. In the first half of 2009, several manufacturers cancelled or delayed light-duty diesel engine programs. These changes were brought on in part by the economic turmoil, but equally as much by the uncertainty surrounding the Obama administration's emissions regulation objectives.

With regard to the automotive industry, it is clear there are currently too many technology options. The multitude of options, each with unknown future costs and technology synergies, presents a strategic planning nightmare. However, this variety offers enormous opportunity for SEMA members.

Product Development in the Automotive World

While SEMA member companies are renowned for their speed in product development, it is valuable to understand the process vehicle manufacturers undertake as they develop a new vehicle—and related powertrain.

Business Case Development (6-12 months): Manufacturers must first develop a business case. A number of factors need to be considered in this business case including return on investment (ROI), market surveys, forecasts of market size, sales, fuel costs, and, future consumer preferences. The company must also assess capacity on existing manufacturing lines and, of special importance for this discussion, powertrain availability and readiness.

Product Development Engineering (18 months): Once a vehicle business case has been approved, the vehicle must be engineered. The length of time required to engineer the vehicle is highly dependent upon the number of components that will be re-used from previous generations. This factor is especially relevant when considering the addition of a new powertrain technology.

Plant Preparation and Launch (additional time dependent): During product development, the manufacturing facilities must be prepared for the vehicle launch.. This includes tooling, assembly processes, and supplier manufacturing coordination. While production ramp-up time has been greatly

reduced over the past few decades, the start of production for a new vehicle or powertrain is an enormous undertaking.

In the 24 or more months between concept and customer, many market factors will change (gas prices, consumer preferences, etc.). In many ways, it is remarkable when a company launches a new vehicle that consumers want—at the exact time they want it. While the timeline seems inexcusably long, it is useful to note that many of the start-up vehicle manufacturers that have garnered a lot of recent press, have not been capable of significantly improving on that timeline.

This Phase II report will be presented in two parts. The first part will present results from a survey of automotive powertrain experts. This survey focuses on expectations for powertrain portfolios and the mix in the United State over the first half of the next decade, from a panel of highly knowledgeable industry participants. It is intended to paint a picture of what may happen. In a real sense, this is a benchmarking study that enables any organization to compare (benchmark) its vision of the future to an industry consensus vision. It is important for all SEMA readers to understand the issues that surround the forecast, and incorporate those issues into their own scenarios, strategies and business plans.

The second part of this report will draw from the information gathered in the survey, and investigate implications for SEMA members. The effect the electrification of the vehicle may have on SEMA members—those that supply powertrain as well as those that do not supply powertrain components—will be of special interest. The electrification of the vehicle will undoubtedly create changes in design, engineering, manufacturing, architecture, accessorization and customization of vehicles and the industry as well. This report will address some of the implications of these changes and their impact on today's performance aftermarket and the specialty equipment company of the future.

Part 1: U.S. Powertrain Forecast: 2011 and 2015

This section of the report presents results of a targeted survey of powertrain experts from vehicle manufacturers, powertrain suppliers, and powertrain engineering services firm. The survey was conducted during the second quarter of 2009. However, as agreed in the survey process, no company nor individual will be identified—either to the funder, or any other individuals.

Seventeen individuals participated in the survey. The majorities of these respondents' have engineering backgrounds, and were selected based on their wide range of expertise in both technical and market issues. This topic is highly complex in nature. As such, CAR believes there is a very small group of individuals capable of responding to such questions. We believe those who participated in this project represent an important segment of that small group.

The data is presented as the mean of all responses. Statistical analysis of such a small sample is not helpful. All respondents had the opportunity to compare their estimates to the survey mean and make additional comments. Occasionally, there was some disagreement from the respondents upon review of the data. When there was disagreement, we have noted it, and presented the differing viewpoints.

For this survey, all questions were asked in reference to the U.S. light duty vehicle market with a Gross Vehicle Weight (GVW) of under 8,500 pounds. The estimates are for the given calendar year.

Results of the survey are presented in a data table that includes baseline data where possible (actual data from previous years) and a forecast for two gasoline prices ($2.50 per gallon and $6.00 per gallon) for two years (2011 and 2015). The authors believe these scenarios offer very different market challenges.

The authors have attempted to condense and classify the answers from the respondents. These considerations are intended to reflect the tenor of the interviews, and are not meant to be exhaustive statements of critical issues. The authors have further added strategic depth to each topic.

Fuel and Powertrain Type

The spark-ignited internal combustion (i.e. gasoline) engine has been the dominant automotive power-source in the United States for over a century. Given a gas price of $2.50, respondents do not see that dominance changing by 2015 (Table 1.1). However, given a gasoline price of $6.00 per gallon, respondents indicate diesel and to a far lesser extent, electricity (battery electric vehicles—BEV) will make in-roads into the U.S. market. It is important to note that this question was intended to identify expectations for fuel sources. *Hybrid electric vehicles (HEV) are forecast to gain an 11.1 percent (2.50 per gallon) and a 20.5 percent ($6.00 per gallon) share by 2015 (Table 1.6). Thus, given the higher price for fuel, the panel indicates that about a third of the vehicles sold in 2015 could utilize alternative powertrain technology.* Such a shift in powertrain technology would be a significant challenge for the industry.

Table 1.1
Powertrain Type (Gasoline, Diesel, and Battery Electric) Percent of Vehicles Sold, 2011 and 2015

	2007	$2.50/ gallon (gasoline)		$6.00/ gallon (gasoline)	
		2011	2015	2011	2015
Gasoline	97.6%	96.5%	93.8%	95.0%	89.0%
Diesel	2.4%	3.0	5.0	4.0	7.5
Battery Electric (BEV)	0%	0.1	1.0	0.5	2.5
Total	**100%***	**100%**	**100%**	**100%**	**100%**

Source: R.L Polk: Includes GVW 1 and 2—Light Duty Vehicles

*(Medians may not add to 100 percent)

The two gasoline prices scenario presents very different market situations. A price of $2.50 per gallon will likely lead to a policy-pushed response in the marketplace. That is, to meet fuel economy (and emission) standards, vehicle manufacturers will likely have to discount fuel economy technologies to ensure market penetration levels required to meet federal standards. Given the alternative ($6.00 per gallon forecast), consumers will likely value fuel economy and be willing to pay for fuel economy saving technologies or downsize their vehicle selections or some combination of the two.

The authors believe the responses present a best case scenario for diesels—especially for 2011. Several manufacturers have cancelled or postponed light duty diesel programs. Uncertainty remains regarding the Obama administration's emissions regulation objectives. It is clear that the electrification of the vehicle is a high priority for the new administration. However, the diesel engine may be better suited for some applications (e.g. pickup trucks, larger SUVs and CUVs) than hybrid powertrains.

Economics will be a critical driver/barrier for diesels—or any other technology. Accordingly, the most important issue for the consumer may be dollars per mile: what is the lowest cost-effective technology. The caveat for diesel technology, of course, is the lowest cost—while still meeting emissions standards. Curiously, the 'dollars per mile' equation may be different for city, suburban and rural driving cycles. For this reason, it is possible that the U.S. market may see different powertrain paradigms depending on the location. For example, in the coming decade, vehicles driven in city/urban settings may rely on electricity—BEVs (or plug-in hybrid vehicles)—while highly efficient gasoline engines or HEVs might be better suited for suburban driving, and diesel products might be ideal candidates for long distances (rural) driving.

Gasoline Engine

Clearly, the gasoline engine presents a rapidly moving target. The respondents suggest that, even at $2.50 per gallon, fifty percent of gasoline engines sold in 2015 may be at least 20 percent more efficient than similar 2009 engines. Whether via downsizing and turbocharging, gasoline direct injection (with or without turbocharging), or even homogeneous charge compression ignition (HCCI), the gasoline engine will not be an easy target for other powertrain technologies.

Table 1.2
Gasoline (Spark-Ignited) Engines: Percent of Engines Significantly Improve
(i.e. 20 Percent Better Fuel Economy vis-à-vis Current Technology), 2011 and 2015

	$2.50/ gallon		**$6.00/ gallon**	
	2011	**2015**	**2011**	**2015**
Percent significantly improved vis-à-vis current technology	10.0%	32.5%	10.0%	55.0%

There was some disagreement regarding the percent of engines improved by 2015. Although many of the respondents forecast change around the medians presented, there were several that had significantly higher estimates. As noted, there continues to be a great deal of development work being done on gasoline engines. The extent to which those developments reach the market will be something to closely monitor on the coming decade.

Ethanol

Few topics are more polarizing than ethanol. There are those who believe ethanol presents a very strong option, and are pursuing it with great vigor. There are others who believe it shows some promise, and is worth monitoring. There are still others that believe ethanol to be a poor fuel option—both economically and environmentally—and an overall bad strategy. The survey respondents forecast increased penetration of flex-fuel capable vehicles (Table 1.3).

Table 1.3:
Gasoline (Spark Ignited) Engines: E85 (Flex Fuel) Capable
(as a percent of total gasoline engines), 2011 and 2015

		$2.50/ gallon		**$6.00/ gallon**	
	2007	**2011**	**2015**	**2011**	**2015**
E85 Capable	8.0%	10.0%	10.0%	16.0%	8.0%

Estimated from Alliance of Automobile Manufacturers, R.L. Polk and other sources.

In the current economic situation, flex-fuel vehicle (FFV) share is entirely dependent on CAFE credit: most companies will sell only if they will get CAFÉ credits. Under the proposal from the current administration, FFV credits will end after 2015. There remains uncertainty about what the regulations for 2016 and beyond will be regarding FFV. The higher estimates for 2015 reflect the expectation that E85 could be economically enticing if gasoline reaches $6.00 per gallon.

Regardless of the viewpoint, there is a growing understanding that corn-based (or any food-based) ethanol will not likely be a viable solution. Increasingly, there is agreement among industry participants that if ethanol is to be cost/energy-viable, it will have to be cellulose-based.

Beyond the economic and environmental questions regarding the viability of ethanol as a widely implemented fuel, there is also disagreement as to what blend is most effective. One argument is for E85, or even E100 mixed at regional—even local—blending stations and delivered via truck to special pumps. Others believe that it may be most effective to push an E10 (or E15 or E20) blend for all gasoline sold.

Widespread implementation of E85 will require significant infrastructure investment (e.g., building bio-fuel refineries, increased trucking, and additional pumps). It would also require vehicles to be 85 capable, at an additional cost of approximately $100 per vehicle. However, it could *potentially* present an economically viable substitute for oil in the next decade—especially if oil prices rise or gasoline taxes increase drastically (either at the pump, or via carbon taxation).

Supporters of the lower-level blends suggest it would be a more effective way (no change in vehicle technology, and minimal change in infrastructure) to increase ethanol penetration. There is general agreement that current (non-flex fuel) vehicles may tolerate up to E15. However, it is also important to note that the current gasoline fuel delivery infrastructure supplies gasoline to non-automotive applications as well. It is likely that having low-level ethanol blends across all distributions will have safety implications for several non-automotive applications. Many of those non-automotive applications (e.g., off-road vehicles, boats) are of special interest to SEMA members. The flex fuel discussion is in many ways important to all SEMA members that make fuel delivery products.

Because of the difference in energy vis-a-vis gasoline, flex-fuel is illogical for the consumer at current fuel prices. However, if ethanol costs (and prices) reach $2.00 per gallon but gasoline (E10) goes to $6.00 (assuming that E85 is substantially cheaper), it could drive higher penetration perhaps even higher than what is indicated in the table.

If the long term goal is significant reduction in GHGs ,advanced biofuels may play a role. According to one respondent, a 45% market share of second generation bio-fuels could reduce the transportation sector GHG output by 80%. Such reductions would be a substantial leverage for the implementation of E85. However, there is some disagreement on the overall effectiveness of ethanol as a greenhouse gas reduction strategy.

Turbo and Supercharging

The automotive industry has spent a great deal of effort in recent years making big engines seem smaller. They have been selling larger engines, usually V-8s, which can run on fewer cylinders (using cylinder deactivation). In essence, they are making a big V-8 operate as a four cylinder under certain load conditions. This cylinder deactivation has proven to be an effective way to make a big engine more fuel efficient. But over the next few years, many automakers will go the other way--making a very small engine seem bigger. By doing this, they are hoping for the fuel efficiency of a small engine while delivering the performance of a larger one. Turbocharging is one way of achieving this goal. The respondents see some growth in turbocharged PFI engines in the coming decade (Table 1.4).

Table 1.4: Gasoline (Spark Ignited) Engines: Percent of Port Fuel Injection (PFI) with Turbochargers, 2011 and 2015

		$2.50/ gallon		**$6.00/ gallon**	
	2007*	**2011**	**2015**	**2011**	**2015**
Turbo-Charged	2.2%	3.5%	7.0%	4.5%	10.0%
Super-Charged	0.26%	0.3	0.3	0.3	0.3

Source: Wards Yearbook 2008 *2007 Model Year Installation Rates

The respondents differentiated two important markets for turbocharger performance and fuel economy. Most vehicles equipped with turbochargers available in the U.S. market are performance oriented—sold as high-end offerings, in part to cover the cost of the turbocharging technology. In other markets, turbochargers are offered as a means of increasing fuel economy. Fuel economy can be increased by downsizing the engine and increasing airflow into the cylinder via turbo charging. While a fuel economy strategy has been accepted in other markets, it has not seen similar success in the U.S. market.

A common theme in the industry is the need to increase efforts to develop and refine new turbocharger technologies (e.g. variable geometry). There continues to be great opportunity in this segment. Many of the larger SEMA member companies involved in developing turbochargers are leading in the development of VGT. The market for turbocharged PFI engines may be grown by VGT, as well as those SEMA members working to refine VGT

There was very little expectation that superchargers would see large market growth in the next few years. This is due, in part, to an expectation that new turbocharging technology would be able to match the power attributes of superchargers (specifically low-end boost) without the parasitic losses.

However, the authors offer two caveats: First, one respondent suggested that a supercharger combined with other technology to allow significant downsizing and 'downspeeding'of the engine could offer both performance and fuel economy gains. Second, there are several SEMA members that make outstanding

high performance superchargers. The forecast for low original equipment installations for superchargers means these companies will likely continue to have a strong market performance in the coming years.

Gasoline Direct Injection (GDI)

No technology has seen a more rapid reversal in expectations than gasoline direct injection. GDI technology was viewed as the most likely to see both rapid and effective application in the coming years. Although GDI has been offered in other markets, until recently, the expectation for penetration in the U.S. market has been muted. This change was in large part due to the agreement that engines could operate in the stoichiometric range, without emissions issues. The respondents expect a large increase in GDI penetration rates (Table 1.5).

Table 1.5:
Gasoline Engines: Percent with Direct Injection (GDI), and Percent GDI with Turbocharger, 2011 and 2015

		$2.50/ gallon		**$6.00/ gallon**	
	2007	**2011**	**2015**	**2011**	**2015**
Gasoline Direct Injection	<1.0%	5.0%	10.8%	6.0%	15.0%
Percent GDi with Turbo	N/A*	5.0	17.5	9.0	33.3

*Not Available

GDI alone will not significantly increase fuel economy. To get the full value of direct injection, the engine must be downsized. Further downsizing (or performance increase) can be achieved by incorporating a turbocharger. While turbocharging is an excellent technology to partner with GDI, the results indicate that manufacturers might offer a larger portion DGI engines without turbochargers. It is clear that manufacturers will have different strategies with regard to turbochargers and GDI. For example, Ford has made a very public commitment to incorporate turbo GDI into a broad range of offerings, while most initial offerings from GM have been normally aspirated. It is worth noting that forecast for percent of GDI engines with turbo varied greatly.

GDI offers the ability to increase the segment application range of the engine: that is, to make it capable of serving several different segments. This could allow the manufacturer to decrease the number of engine programs, relying on fewer programs to cover the entire range. It may also permit specialty equipment suppliers more room to tune the base engines

The rapid increase in computing power and speed has been an enabler for GDI. Current powertrain control software allows nearly constant monitoring of the injection and combustion process. This, in turn, allows GDI to meet emissions testing criteria. The ability of the powertrain controllers to monitor and react to the combustion process is critical to GDI technology—more so than with PFI engines. For

SEMA members, this is not an overwhelming barrier but must be considered when adding components to the powertrain.

Further advancement of GDI may lead to a new generation of head design. Current GDI technology uses wall guided stoichiometric fuel injection. There is some expectation that center mounted spray technology, which will enable stratified charge combustion, may be the design strategy for DGI engines in the coming decade. However, it is likely that side-mounted strategy will be used for some time because it is an easier (and less costly) engineering change, and a stratified charge presents some emissions concerns.

The panelists raised two final points with regard to GDI: first, it was that GDI is seen by some as a threat to increased diesel application. It offers increased fuel economy and the driving attributes of diesel, while being lower in cost. And second, the combination of turbocharged GDI, with a low cost stop/start hybrid system, may provide a very attractive cost/fuel economy

Hybrid Electric Vehicles

There continues to be great excitement surrounding hybrid vehicles. There also continues to be enormous uncertainty. The respondents forecast a steady, albeit relatively slow, increase in HEV market share over the next three years at $2.50 per gallon (Table 1.6). However, the forecast for 2015 (at $2.50 per gallon and at $6.00 per gallon) shows some expectation that HEVs will gain a strong market position in the U.S. Manufacturers are rapidly increasing their HEV offerings. However, it is likely that even with increased HEV market share forecasted, there will be winners and losers in the HEV segment. There was general agreement among panelists regarding the near term forecast for HEV penetration. However, there was some variance on the 2015 forecast.

Table 1.6
Hybrid Electric Vehicles (HEV): HEVs as a Percent of Total Vehicles sold, 2011 and 2015
(includes all forms of HEV technology)

		$2.50/ gallon		**$6.00/ gallon**	
	2008	**2011**	**2015**	**2011**	**2015**
% HEV	2.4%	5.0%	10.0%	6.0%	20.0%

Source: R.L Polk: Includes GVW 1 and 2—Light Duty Vehicles

According to the results of the survey, respondents believe the parallel hybrid system will continue to be the dominant HEV technology (Table 1.7). There is an important exception: given the $6.00 per gallon scenario, the respondents indicate they believe the belt-alternator starter (BAS--or stop/start system) will make significant in-roads. In fact, respondents forecast higher penetration rates for both of the lower cost solutions (BAS and integrated motor assist (IMG)) as gasoline prices rise. This indicates a willingness on the part of consumers to look for the most cost-effective—not necessarily the most technologically advanced—solutions.

Table 1.7
Hybrid Electric Vehicles (HEV): HEV Drivetrain Type (*as a percent of HEV sales*), 2011 and 2015 (does not include battery electric vehicles)

		$2.50/ gallon		$6.00/ gallon	
	2008	**2011**	**2015**	**2011**	**2015**
HEV(Non-Plug-in)					
Belt-alternator starter (stop/start with assist)	2.2%	5.0%	8.0%	6.0%	9.0%
Integrated motor generator	9.8%	12.0	15.0	12.0	18.0
Parallel (including dual mode)	87.7%	80.0	70.0	68.0	34.0
Plug-in capable	-				
Parallel 'plug in'	N/A	1.0	1.0	1.0	3.0
Series (extended range) 'plug-in'	N/A	0.7	1.1	1.0	3.0
	100%*	**100%**	**100%**	**100%**	**100%**

- Source: Estimated from manufacturer data and various other sources.
- (Medians may not add to 100 percent)

The belt alternator system presents an interesting alternative to the full HEV technology. To the hardcore environmentalist, it is not even considered a 'real' hybrid. Yet it may offer a cost-effective means of decreasing fuel consumption—and one that can be rapidly integrated into current production and sold at high volumes. The data indicate the stop/start system presents an opportunity for a wider application in a short period of time. The estimate of nearly 20 percent of all HEV being BAS in 2015 is indicative of the system's low cost. The BAS is relatively uncomplicated, and may present an interesting specialty equipment opportunity—especially if gas prices rapidly increase, and remain high. There was some disagreement with regard to the BAS and parallel systems for the 2015. Some of the respondents believed the BAS system would be widely applied by 2015, thus they had a much higher percentage for BAS, and a subsequent lower percentage for parallel systems. Others forecasted continued dominance of the parallel system

One manufacturer (Honda) has chosen the integrated motor generator technology as the core technology. The system offers reduced cost vis-à-vis the parallel system, but delivers slightly lower fuel economy. The recently introduced Insight presents the first real attempt to offer full HEV application at an entry level price. Again, the respondents view the lower cost associated with the IMG as a potential

customer satisfier. There is also indication Honda may be considering parallel type systems for larger vehicles in the future.

The parallel system (Toyota, Ford, GM, Nissan) is currently the most common form of HEV powertrain. This dominance is driven in large part by Toyota's dominant market position. The system has become perceived as the gold standard by consumers, media and environmentalists. It has also become a favorite of SEMA member companies for conversion to plug-in electric capability.

The respondents forecast plug-in electric vehicles (PEV) to account for about 4 percent of the total HEV market in 2011. Although the PEV has become the new poster child for how to save the industry, it is a long way from being economically viable. Several manufacturers will have PEVs on the road by 2011, but, these will be heavily reliant upon government subsidies.

The plug-in hybrid continues to be completely dependent on battery technology development. While range extended type plug-in technology has gained much press recently, it is important to note that work on parallel plug-in technology continues and will be the first of the two technologies to market. There is also some concern that plug-in technology is currently being oversold. It is worth noting this new energy paradigm is entirely dependent upon an effective battery—which to date has not been delivered. While policy and public relations may give the impression that the technology is easily achievable, economics will drive the solution.

Powertrain Survey Conclusions

The automotive industry is going through a paradigm shift in powertrain technology. There are numerous technologies which are close (e.g. Lithium Ion battery, cellulosic ethanol) —but not quite ready for primetime. There has been much discussion as to whether many of these technologies have moved past the 'invention' stage, and into the development phase. While there have certainly been advancements, a great amount of uncertainty remains. Contrary to popular press, there are still no sure bets.

It is important for specialty equipment suppliers—even those that do not directly supply powertrain components—to be aware of the changes in powertrain. This forecast presents a vision for what may happen. It is valuable to be reminded that this forecast is merely one possible outcome. It is incumbent upon each organization to consider the issues presented in this survey and use it as one piece of their scenario and strategic business planning processes.

Part 2: The Electrification of the Vehicle: A Positive Opportunity

The electrification of the vehicle is happening—maybe not as fast as some in the press and public office might suggest—but it is happening. In many ways, it offers a great opportunity for specialty equipment suppliers. It is important for specialty equipment suppliers—even those that do not directly supply powertrain components—to understand the changes in powertrain technology as well as the changes in who is manufacturing and marketing these vehicles.

The shift toward electrification can be separated into four distinct types of technology: hybrid electric vehicles (HEV), plug in hybrid electric vehicles (PHEV), extended range electric vehicles (EREV) and battery electric vehicles (BEV). These technologies present (in order) an increasing reliance on electricity. The last three can be classified as plug-in electric vehicles (PEV).

Gauging the actual PEV volumes in the coming years is exceptionally dangerous. After listening to media—and even the public relations announcements from some vehicle companies—a consumer could imagine the market for PEVs might soon reach well into the hundreds of thousands (even millions) per year. President Obama has set a goal of 1 million PEVs by 2015. Table 1.8 offers a potential scenario for PEV penetration based on the survey presented earlier in this report. Using percentages of PEVs (as a percent of HEVs) and BEVs, with sales volumes of 12,000,000 for 2011 and 14,000,000 for 2015, and the two gasoline scenarios, we can derive an estimate of PEV sales. The estimate should be viewed with caution, but does present an interesting approximation of potential volumes.

One caveat: certainly a $6.00 per gallon price would likely have a strong negative impact on vehicles sales. Although vehicle sales have been held constant between the two gasoline price scenarios for this exercise, it is highly likely that a higher gas price—either through increased oil prices, a gas tax, or some form of carbon tax—would likely lead to a lower overall market, and thus lower volumes, for all segments.

Table 1.9
Traditional Vehicle Manufacturers with Announced PEV Offerings

	$2.50/ gallon		**$6.00/ gallon**	
	2011	**2015**	**2011**	**2015**
U.S. vehicle sales	12, 000,000	14,000,000	12, 000,000	14,000,000
PHEV/EREV sales	10,200	29,400	14,400	168,000
BEV sales	12,000	140,000	60,000	350,000
Total PEV sales	**22,200**	**169,400**	**74,400**	**518,000**

The very low initial market volumes for PHEV offer opportunity for specialty equipment suppliers. Vehicle manufacturers are not interested in (nor capable of) manufacturing ultra-low volume powertrain vehicles. Several SEMA companies have already developed products to convert HEVs to PHEVs. These companies are filling an important step in the evolution of the technology. There are currently customers interested in PHEV technology, yet demand has not risen to the point that would justify a purposed production vehicle from a major manufacturer. Thus, SEMA companies are serving to introduce a technology to the market place. This is in some aspects, a transitional activity, filling the void until vehicle manufacturers can address the demand.

Yet, to view this as a transitional strategy would be a mistake. According to the forecast presented earlier in this report, there will be an increasing fleet of hybrids in service over the coming years. While battery life to date for these vehicles has not been a major problem, the ability to convert an HEV to plug-in ready could be an interesting market position—especially if lithium ion batteries become cost effective.

CAR has identified four different PEV manufacturer groupings—each with a unique opportunity for the specialty equipment supplier: 1) The traditional vehicle manufacturers, 2) The new automotive manufacturers, 3) The U.S.-based venture capital start-ups, and 4) the international independent start-ups. Each of these groups will view the specialty equipment market differently. One key differentiator for SEMA members will be the retail structure of these companies. This section highlights the differences between the groups, and identifies some companies. The list should not be considered comprehensive. The difficult economic times have made starting a car company difficult. In recent years, there have been numerous entities which have announced plans to build PEVs. Many of those have struggled with financing—and product.

The traditional automotive industry will enter this sector with caution and clout (Table 1.9). While much has been written about the Chevrolet Volt, it will not be the first plug-in vehicle to reach the market (expected introduction in fourth quarter 2010). The Mini E has already been leased in limited markets and very limited quantities. Toyota will have demonstration PHEVs on the road by the end of this year, but has clearly stated they will be in very low volumes. Toyota has also publically questioned the cost/benefit of PHEV technology. Nissan has very publically made the case that they would be a leader on BEV technology, and are expected to have a product on the road in late 2010.

Table 1.9
Traditional Vehicle Manufacturers with Announced PEV Offerings

Manufacturer
BMW-Mini
Fiat-Chrysler
Ford
General Motors
Honda
Hyundai
Nissan
Toyota

It is likely that the specialty equipment opportunities for these vehicles will mirror the experiences with current offerings from the vehicle manufacturers. The first CAR-SEMA report (*The Specialty Equipment Company of the Future: Guideposts for Technology Forecasting and Strategic Planning*) addressed the opportunities of supplying the vehicle manufacturers. The PEVs offered by these companies will likely be highly optioned—an attempt to make them more upscale to further justify the high cost of the vehicles. Thus, at least initially, they do not present a strong specialty equipment opportunity.

The new automotive manufacturers with limited automotive manufacturing histories—primarily Chinese (with Indian firms expected to also address this segment)—are also moving to develop PEV products Table 1.10. These products will enter the U.S. market in the inexpensive range of PEV offerings. Therefore, there will likely be very limited options offered from the manufacturer. Also, the distribution and retail system for these manufacturers is still very much under development. SEMA member companies should very closely monitor these efforts. SEMA companies should also consider the

opportunity to work directly with the manufacturers—or maybe more accurately, the retailers—to develop accessories for these vehicles.

Table 1.10
The New Vehicle Manufacturers with Announced PEV Offerings

Manufacturer
BYD
Chery

The electrification of the vehicle has created an enormous amount of interest throughout the world. The U.S.-based venture capital (VC) sector has certainly taken notice (Table 1.11). These companies have brought creativity, passion and excitement to the vehicle industry. They have also created new business models and pushed technology development. Although there will be success stories that arise from this influx of capital, there will certainly be numerous failures—an expected and acceptable element of the venture capital world. In fact, it is reasonable to think that a positive end-game for the VC start-ups would be a sale to an established vehicle manufacturer—in essence offering the vehicle manufacturer a turn-key PEV program, and the investors an opportunity to cash-out.

Table 1.11
The U.S. based venture capital start-up Manufacturers with Announced PEV Offerings

Manufacturer
AC Propulsion
Fisker
Miles
Phoenix
Tesla

Many of the U.S.-based VC start-ups have targeted the luxury end of the PEV market. Given the cost of the technology, this is understandable. It also suggests, similar to the traditional industry, it is likely the PEVs offered by these companies will be highly optioned. However, unlike the traditional vehicle manufacturers, this may be great opportunity for SEMA members. The small VC companies are much more willing to look beyond the usual supply base for innovative solutions. While the aftermarket opportunities (powertrain and accessory) may be somewhat limited for these vehicles, it is likely the manufacturing and retail structures of these new manufacturers may be an opportunity for SEMA suppliers.

The new international-based venture capital start-ups (Table 1.12) are varied in product and strategy. These products will enter the U.S. market in the inexpensive range of PEV offerings. It is reasonable to assume that those business strategies that include leveraging low-cost manufacturing and assembly bases will likely position their product similar to that of the new automotive manufacturers—in the

inexpensive range. Again, it is expected this business model will look to leverage specialty equipment as a means of up-fitting vehicles.

Table 1.12
The International-Based Venture Capital Start-up Manufacturers with Announced PEV Offerings

Manufacturer
Blade
Bollare
Flybo
Imperia
Lightning Car Company
Morgan
Reva
Venturi

Table 1.13 presents a partial list of the plug in electric vehicles that have either been announced, or are expected, for the U.S. market in the next few years. The variation among product and producers is almost overwhelming. As has been stated often in this report, it is likely many of these products (and even companies) will not make it to market. It is also likely that most of the listed vehicles will be low volume in the next three to five years. However, it is also clear there is an enormous amount of development in this area, and it should be monitored closely.

Table 1.13

The International-Based Venture Capital Start-up Manufacturers with Announced PEV Offerings

Model	Type of Vehicle	Range (Electric Drive)	Announced Volume	Start of Production	Battery Supplier
Ford					
Cargo Van	BEV	100+ Miles	NA	2010	Johnson Controls-Saft
Focus	BEV	100+ Miles	NA	2010-2012	Johnson Controls-Saft
Escape Hybrid	PHEV	10 Miles	Demonstration Program	2008	Johnson Controls-Saft
General Motors					
Chevrolet Volt	PHEV	40 Miles	40,000-60,000	2010	LG Chem
Cadillac Converj (expected)	PHEV	40 Miles	NA	NA	LG Chem (expected)
Saturn Vue (will be rebadged)	PHEV	10 Miles	NA	2010	NA
Chrysler/Fiat					
Town & Country EV	PHEV	40 Miles	NA	2010	A123 Systems
200c (expected)	PHEV	40 Miles	NA	NA	A123 Systems
Toyota					
Prius	PHEV	10 Miles	500	2009	Panasonic Energy Company
FT-EV	BEV	50 Miles	NA	2012	Panasonic Energy Company
BMW Mini E	BEV	100 Miles	500-1000	2010,2011	AC Propulsion
Mitsubishi MiEV	BEV	100 Miles	NA	2010	Mitsusbshi Motors, GS Yuasa, & Mitsubishi Trading Corp.
Nissan NA	BEV	100 Miles	NA	2010;2011	Automotive Energy Supply Corporation
Hyundai Blue-Will	PHEV	38 Miles	NA	2012	NA
BYD E6	BEV	250 Miles	NA	2009	BYD
Fisker Karma S	PHEV	50 Miles	5,000	2009	NA
Tesla					
Model S	BEV	150-300 Miles	NA	2011	Tesla/Daimler
Roadster	BEV	100 Miles	5,000	2008	Tesla/Daimler

The Electrification of the Vehicle: Conclusions

Much like the automotive industry of 1909, the current industry is going through revolutionary change—only part of which has to do with the powertrain. The electrification of the vehicle has created an avenue for smaller, faster, entrepreneurial companies to compete—at least in the short run—with the industry giants. Over the coming years, some of these start-ups will make it to market with great products that capture market share and the imagination of a segment of buyers. Many will also fade away. The electrification of the vehicle has created two new avenues for specialty equipment suppliers. First, and most obvious, is that of a new powertrain paradigm. HEVs and PEVs bring new vehicle technologies and with them new opportunities. This change opens the door for a new generation of SEMA members. It also opens new markets for traditional powertrain member companies. Second, the launch of new car companies and OEMs—however small—presents additional opportunities for new relationships, partnerships and innovative business, revenue and organization models. The information in this report is intended to help SEMA and its members understand and monitor the developing business strategies of the PEV automakers.

Yet, like one hundred years ago, the internal combustion engine remains a very difficult target (at least for the coming decade). As the forecast presented in this report highlights, the gasoline engine is not going away. It will be the focus of continuing development and innovation in the coming decade—and thus remain a major powertrain driver in the SEMA model and specialty equipment company of the future