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The Transformation of the Automotive Industry: The Environmental Regulation Effect

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Executive Summary

The global automotive industry is undergoing a fundamental transformation due to increasing consumer preferences toward vehicles with a lower carbon footprint. Governments throughout the world have responded to these market forces and other geo-political factors by imposing stringent environmental regulations on original equipment manufacturers (OEMs) for emissions control and fuel economy. These regulations vary markedly from one part of the world to the other, adding complexity to the mix of vehicles offered by OEMs worldwide. As a result, global OEMs and suppliers are being challenged to constantly update their product portfolios to meet numerous regional regulatory requirements, which are expected to add significantly to their manufacturing costs.

Globally, road transport (passenger cars and commercial vehicles) contributes 14 percent of total man-made carbon dioxide (CO_2) emissions.[1] Although new cars now emit significantly less CO_2, road transportation remains one of the few sectors where emissions keep rising. This is due to the growth of freight transportation, vehicle ownership, and increased mileage. In the European Union (EU), for example, motorists increased their annual mileage by 16.4 percent between 1995 and 2003. For conventional vehicles, only 15 percent of the energy from fuel put in the tank is used to move the vehicle with the rest wasted in friction losses.[2] This suggests that tremendous opportunities still exist to improve fuel economy.

OEMs have made reducing the amount of CO_2 emissions a priority. To significantly reduce the carbon footprint of their model lines, OEMs are focusing on the most cost-effective technologies capable of being deployed on mass-produced models, in line with their strategy of offering "everyone an environmentally friendly vehicle." To pursue this objective, most OEM strategies are focused on:

- Improving fuel efficiency and reducing carbon and pollutant emissions
- Developing of alternative fuel vehicles, powered by fossils (natural gas) or renewables (biofuels)
- Electrification technologies by enhancing the cost-effectiveness of hybrid and electric vehicles.

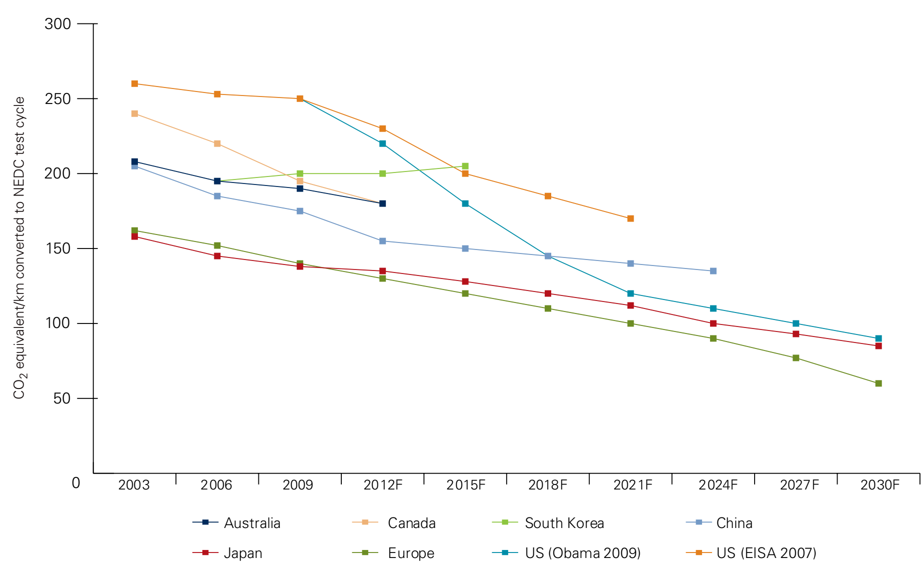
Source:
[1] www.globalwarmingart.com
[2] CSM Auto

Government incentives are expected to play a huge role in accelerating the mass adoption of these technologies, but the government response has been very different across the world. While the United States government has recently been proactive acting as a venture capitalist by funding new ventures in automotive battery and electric vehicles, the Japanese government has only indirectly funded these ventures by temporarily providing subsidies for fuel-efficient vehicles. The Chinese government has become an ardent supporter of New Energy Vehicles (NEV) and battery development because Chinese OEMs and suppliers understand they cannot catch up to or move ahead of Western manufacturers by developing traditional internal combustion engine (ICE) technologies.

Given the variance of regulatory frameworks around the world and the lack of will and direction to harmonize the regional standards into a single global standard, companies may choose to develop multipronged strategies to minimize risks and maximize returns. While all OEMs are exploring a wide variety of green technologies, regional preferences dictate the choice of solution offered in specific markets. For instance, stop-start technology is expected to see widespread adoption in Japan and Europe but limited uptake in North America. Similarly, Chinese OEMs have shifted focus to more small-car production, which could make them the largest producer of NEVs by 2013.

The degree of influence that consumers, government agencies, and automotive companies have in reshaping the structure of the industry varies significantly across the globe. The combination of a global recession, overcapacity, and pressure from stiff environmental regulations has led to widespread sector consolidation that could continue to increase for years to come. As discussed in more detail in section 3, the findings of KPMG LLP (U.S. member firm of KPMG International Cooperative) suggest that the most attractive M&A transactions may be between North America and Asia, followed by Europe and Asia, and North America and Europe. These potential trends are in line with recent cross-border mergers and alliances between Volkswagen and Suzuki, Bosch and Samsung, PSA and Mitsubishi, and many more. These trends are expected to pick up steam as companies seek more opportunities for horizontal and vertical integration.

Regional CO_2 Emission Regulations



Note: EDC – New Europe Drive Cycle

Source: The International Council on Clean Transportation, Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update

Regional Fuel Economy and GHG Emission Standards

Region	Standard	Measure	Structure	Targeted Fleet	Test Cycle	Implementation
North America-U.S.A.	Fuel	mpg	Single standard for cars and size based standard for light trucks	New	US CAFÉ	Mandatory
European Union	CO_2	g/Km	Single Standard	New	NEDC	Voluntary
Asia-Japan	Fuel	km/l	Weight-based	New	JC08	Mandatory
Asia-China	Fuel	l/100-Km	Weight-based	New	NEDC	Mandatory
South America-Brazil	No local standards as the majority of vehicles run on ethanol mix					

Source: The International Council on Clean Transportation, Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update

In the future, the hardest-hit suppliers may be those with undifferentiated products that do not meet the demand for increased fuel economy or emission control. On the other hand, numerous others that are savvy enough to reposition themselves today could benefit from regulations that threaten to become increasingly stringent in the future. As the industry innovates its way towards a new business model with alternative powertrains and fuel-efficient technologies, it is clear the map of the industry will look very different from the one today.

This KPMG white paper presents an overview of the governmental regulations in North America, Europe, Asia, and Latin America and analyzes the impact of these regulations on the global automotive industry.

"OEMs and suppliers should embrace emission regulations and technologies… and use them as competitive advantages"

– Dr. David Cole, Chairman
Center for Automotive Research

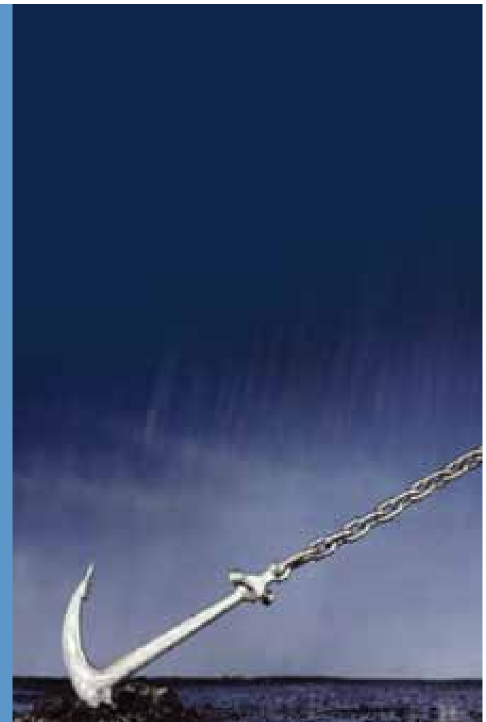


Table of Contents

Executive Summary

1. Governmental Regulations and Incentives 1
   - North America – U.S.A.
   - European Union
   - Asia – Japan
   - Asia – China
   - Latin America – Brazil

2. OEM and Supplier Strategies to Meet the Regulations 16
   - North America – U.S.A.
   - European Union
   - Asia – Japan
   - Asia – China
   - Latin America – Brazil

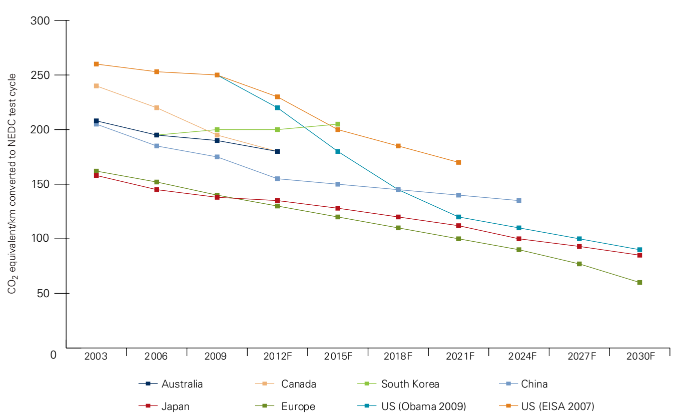
3. Impact of the Regulations on the Industry 29

4. Conclusion 33

Governmental Regulations and Incentives

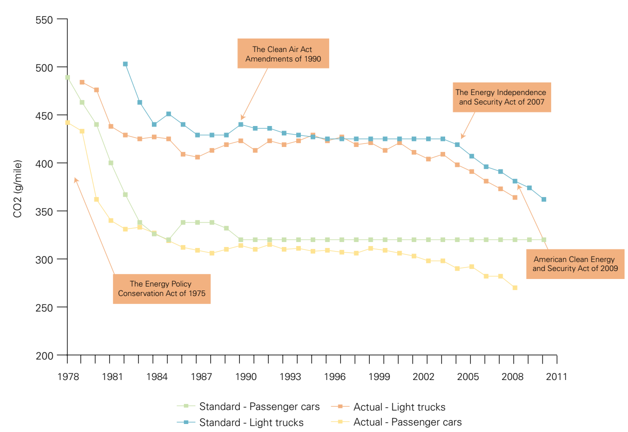
North America – U.S.A.

United States Fuel Efficiency



Source: "Summary of Fuel Economy Performance," March 30, 2009, United States Department of Transportation

United States CO_2 Emissions



Source: The emission amounts are based upon a conversion calculation of mpg to CO_2 g/mile as provided by the EPA.

Current Regulations

CAFÉ (Corporate Average Fuel Economy[3]) standards were established in 1975 by the National Highway Traffic Safety Administration (NHTSA) for passenger cars[4] and light trucks.[5] CAFÉ (pronounced café) is the sales-weighted average fuel economy in miles per gallon (mpg) of an OEM's fleet of passenger cars or light trucks with a gross vehicle weight rating of 8,500 lbs or less. The standards apply to all vehicles manufactured for sale in the United States. The Environmental Protection Agency (EPA) is responsible for calculating the average fuel economy for each OEM.

The Energy Independence and Security Act of 2007 currently regulates environment standards for the North American automotive industry. The act increased current CAFÉ standards from 27.5 mpg to 35 mpg (14.8 km/l) by model year (MY) 2020 for OEMs

[3] Fuel economy or efficiency is defined as the average mileage traveled by a vehicle per gallon of gasoline (or equivalent amount of other fuel) consumed.
[4] "Passenger car" is a 4-wheel vehicle not designed for off-road use that is manufactured primarily for use in transporting 10 people or fewer.
[5] "Truck or light truck" is a 4-wheel vehicle, designed for off-road operation (has 4-wheel drive or has a gross vehicle weight rating of more than 6,000 lbs) or transports more than 10 people; or provides temporary living quarters; or transports property in an open rear bed; or permits greater cargo-carrying capacity than passenger carrying volume; or can be converted to an open bed vehicle by removal of rear seats.

combined passenger car and light truck fleets. The Act also took steps to include government incentives and subsidies to OEMs for research and development costs associated with attaining the 35 mpg standard by 2020. In addition, the Act provided funding for increased production of biofuels. The total amount of biofuels added to gasoline is required to increase from 4.7 billion gallons in 2007 to 36 billion gallons by 2022. The Act specifies that 21 billion gallons of the 2022 total must be derived from non-corn starch products (e.g. sugar or cellulose).

According to the NHTSA, in the "Summary of Fuel Economy Performance" published March 30, 2009, the average MY 2009 passenger cars and light trucks fleets sold in the United States both met the required CAFÉ standards. The MY 2009 passenger car fleet averaged 32.6 mpg and surpassed the CAFÉ standard of 27.5 mpg. The MY 2009 light truck fleet averaged 24.2 mpg and also exceeded the CAFÉ standard currently in place of 23.1 mpg. OEMs that did not meet the MY 2009 CAFÉ standards were Daimler (light truck), Ferrari (import passenger car), Ford (import passenger car), Jaguar and Land Rover (import passenger car and light truck), Maserati (import passenger car), and Porsche (light truck).

The EPA is responsible for calculating the fuel efficiency for each OEM's passenger and light-duty truck fleets for each MY. If the fleet does not meet the CAFÉ standard, the penalty is U.S. $5.50 per tenth of a mile per gallon for each tenth under the standard amount multiplied by the total volume of vehicles in the fleet manufactured in the MY. Penalties can be paid by the OEMs, offset by CAFÉ credits, or eliminated based upon an agreed-upon change in fleet mix for the following year

OEMs can earn CAFÉ credits when the fuel efficiency level of a fleet exceeds the standard in a given MY. The amount of credits is calculated the same way as a penalty. The credits may be applied in any three consecutive MYs immediately prior to or subsequent to the MY in which the credits are earned. Credits cannot be passed between OEMs or fleets.

If the OEM does not have credits available, the OEM can pay the fine or submit a carry-back plan to the NHTSA. The carry-back plan describes how the OEM plans to meet and exceed CAFÉ standards in the following three years. The NHTSA reviews the plan and, once approved, the future expected credits are used to offset the current penalties.

Proposed Regulations

In the United States, new legislation such as the American Clean Energy and Security Act of 2009 is currently under debate to propose new fuel efficiency standards for the automotive industry. The legislation, along with proposed programs from the Department of Transportation (DOT) and EPA, proposes that OEMs build a single, light-duty (passenger car and light trucks) national fleet that meets all federal requirements, California standards, and those of other states. The proposed legislation includes a combined CAFÉ standard for passenger and light truck fleets of 35.5 mpg in MY 2016 and a combined average emission level of 250 grams of CO_2[6] per mile. This would be the first-ever national emissions standards set by the EPA.

Incentive Programs

A number of United States government incentives exist as a result of the Energy Independence and Security Act (EISA) of 2007. These programs include:

- *Domestic Manufacturing Conversion Grant Program* – The program includes the refurbishment of manufacturing facilities and retraining of skilled workers. An unspecified amount of funds is appropriated to carry out the program.

[6] CO_2 emissions: The United States historically has not regulated CO_2 emissions. The United States CO_2 emissions chart is based upon a calculation to convert fuel efficiency standards to CO_2 emissions.

- *Advanced Battery Loan Guarantee Program* – Provides guarantees of loans for the construction of facilities for the manufacture of advanced vehicle batteries and battery systems that are developed and produced in the United States.
- *Advanced Technology Vehicles Manufacturing (ATVM) Incentive Program* – A $25 billion direct loan program to provide debt capital to the United States automotive industry for purposes of funding projects that help vehicles manufactured in the United States meet higher mileage requirements and lessen U.S. dependence on foreign oil. The program provides loans to OEMs and component suppliers to re-equip, expand, or establish a manufacturing facility in the United States to produce advanced technology vehicles or components of advanced technology vehicles.
- *Energy Storage Competitiveness* – The program provides $295 million a year (from 2009 to 2018) for research and development of energy storage systems for electric drive vehicles such as batteries, compressed air energy systems, thermal management systems, and hydrogen as an energy storage medium.
- *Lightweight Materials Research and Development* – The program provides $80 million (in total from 2008 to 2012) to be allocated for the development and demonstration of weight reducing materials in vehicles to improve fuel efficiency.

On October 27, 2009, the United States Department of Energy (DOE) announced a $24 million loan for Tenneco Inc. to develop fuel-efficient emission control components for advanced technology vehicles. Tenneco is the first component manufacturer to receive a conditional loan commitment under the DOE's ATVM program. Tenneco will use the proceeds of the loan to design, engineer, and produce emission control components for gas, hybrid, and diesel-powered vehicle engines. More than 2 million automobiles and light trucks built in model years 2010 to 2014 will be equipped with Tenneco's emission control technology. Electric Transportation Engineering Corporation (eTec), a leader in clean electric transportation and storage technologies, signed a contract with the DOE for a grant of $99.8 million to undertake the largest deployment of electric vehicles (EVs) and charging infrastructure in history. Kemet Corp., a Tier 2 capacitor maker, has won a $15.1 million DOE grant to expand its Simpsonville, SC, plant to make more hybrid components. The expansion will enable the factory to make capacitors for up to 100,000 electric-drive vehicles.

On August 6, 2009, the government announced 48 grants totaling $2.4 billion issued to companies to develop next-generation electric cars and recreational vehicles. Grants were distributed for the following:

- $1.2 billion for cell, battery, and materials manufacturing facilities
- $245 million for advanced battery supplier manufacturing facilities
- $465 million for electric drive component manufacturing facilities
- $32.3 million for electric drive subcomponent manufacturing facilities

On June 23, 2009, President Obama awarded $8.5 billion in auto loans through the DOE under the ATVM Incentive Program. Ford Motor Company received $5.9 billion to assist in the transition from internal combustion engines to electrified vehicles. The loan will also be used to convert two truck plants to passenger car production plants. Nissan received $1.6 billion to assist in the production of electric cars and battery packs at a manufacturing complex in Tennessee. The loan will also be used for the construction of a new battery manufacturing plant and modification necessary at an existing plant. Tesla Motors received $465 million in loans to help finance a manufacturing facility that produces the Tesla Model S sedan, which is expected to get the equivalent of 250 miles per gallon. Production of the Model S will begin in 2011 and ramp up to 20,000 vehicles per year by the end of 2013. Later, Fisker Automotive received a total of $528 million to complete the engineering of its first EV, called the Karma, and to develop a less expensive EV model, called the Nina, to be assembled at a shuttered General Motors plant in Delaware.

In April 2009, the DOE announced $41.9 million in funding to accelerate the commercialization and deployment of fuel cells and create jobs in fuel cell manufacturing, installation and maintenance, and support services. On December 3, 2008, the DOE announced up to $29.3 million in funding for R&D projects related to improving battery material performance, developing improved manufacturing processes to increase performance and decrease cost of plug-in hybrid EV, developing thermoelectric (TE) systems that provides the heating, ventilation, and air conditioning (HVAC) in vehicles to reduce engine load and increase fuel efficiency, and for advanced aerodynamic trailers to reduce fuel consumption for heavy-duty tractor trailers.

The increasing role of the United States government as a venture capitalist (VC) in the automotive industry is impacting private VCs, which have pledged less than a tenth of government funding for the automotive industry in 2009. Private VCs now look for government funding of ventures in the automotive sector as a signal to invest while the government aims to fund new ventures already backed by private capital. The result is an intertwining of public and private-sector interests in an arena where politics is never far from the surface.

Despite the increased technology and regulatory push, commercializing these investments at a level consumers will support may be difficult to sustain. According to Dr. David Cole, Chairman of the Center for Automotive Research, consumers may not be encouraged to change their driving or purchasing habits while gasoline remains a relatively low-cost fuel. At this point, there is no serious discussion in the United States of enacting a floor on gasoline prices, which Dr. Cole believes to be the most effective means of ensuring that less expensive alternative energies emerge and get commercialized.

European Union

Current Regulations

Higher fuel prices in the EU (compared to those in the United States) have dictated the mix of models with smaller engines and more efficient diesel engines that OEMs have developed and offered in the European market. Although no mileage standards exist in the EU, the high fuel tax acts as a floor on fuel prices and has a powerful moderating effect on the number of miles driven by an average driver.

EU emission standards define the acceptable limits for exhaust emissions of new vehicles sold in EU member states. The emission standards are defined in a series of European Union directives staging the progressive introduction of increasingly stringent standards. Regulations cover vehicles of categories M1, M2, N1, and N2, with a reference mass not exceeding 2,610 kg. This includes, among others, passenger vehicles, vans, and commercial vehicles intended for the transport of passengers or goods or certain other specific uses (ambulances, for example), which should have positive-ignition engines (petrol, natural gas, or liquefied petroleum gas (LPG)), or compressed ignition (diesel engines).

Currently, emissions of nitrogen oxides (NOx), total hydrocarbon (THC), non-methane hydrocarbons (NMHC), carbon monoxide (CO), and particulate matter (PM) are regulated for most vehicle types, including cars, trucks, trains, tractors and similar machinery, and barges, but excluding seagoing ships and airplanes. Different standards apply for each vehicle type. Compliance is determined by running the engine at a standardized test cycle. Noncompliant vehicles cannot be sold in the EU, but new standards do not apply to vehicles already on the road. No use of specific technologies is mandated to meet the standards, although available technology is considered when setting the standards. New models introduced must meet current or planned standards, but minor life cycle model revisions may continue to be offered with precompliant engines.

A. CO and NOx Emission Standards

Emission standards for passenger cars and light commercial vehicles are summarized in the following table. Since the Euro 2 stage, EU regulations introduced different emission limits for diesel and gasoline vehicles. Diesels have more stringent CO standards but are allowed higher NOx emissions. Gasoline-powered vehicles are exempted from PM standards through to the Euro 4 stage, but vehicles with direct injection engines will be subject to a limit of 0.005 g/km for Euro 5 and Euro 6. A particulate number standard (P) or (PN) is part of Euro 5 and 6, but is not final. The standard is to be defined as soon as possible and at the latest upon entry into force of Euro 6.

All dates listed in the tables refer to new type approvals. The EC Directives also specify a second date—one year later—that applies to first registration (entry into service) of existing, previously type-approved vehicle models.

European Emission Standards for Passenger Cars (Category M) & Light Commercial Vehicles**

Tier	Date	CO	THC	NMHC	NOx	HC+NOx	PM
Diesel							
Euro 1†	Jul-92/ Oct 94*	2.72 (3.16)	-	-	-	0.97 (1.13)	0.14 (0.18)
Euro 2	Jan-96/ Jan-98*	1	-	-	-	0.7	0.08
Euro 3	Jan-00	0.64	-	-	0.5	0.56	0.05
Euro 4	Jan-05	0.5	-	-	0.25	0.3	0.025
Euro 5	Sep-09	0.5	-	-	0.18	0.23	0.005
Euro 6 (future)	Sep-14	0.5	-	-	0.08	0.17	0.005
Petrol (Gasoline)							
Euro 1†	Jul-92/ Oct-94*	2.72 (3.16)	-	-	-	0.97 (1.13)	-
Euro 2	Jan-96/ Jan-98*	2.2	-	-	-	0.5	-
Euro 3	Jan-00	2.3	0.2	-	0.15	-	-
Euro 4	Jan-05	1	0.1	-	0.08	-	-
Euro 5	Sep-09	1	0.1	0.068	0.06	-	0.005**
Euro 6 (future)	Sep-14	1	0.1	0.068	0.06	-	0.005**

** For Light Commercial vehicles*
*** Applies only to vehicles with direct injection engines*
**** A number standard is to be defined as soon as possible and at the latest upon entry into force of Euro 6*
Note: CO = carbon dioxide, HC = hydrocarbons, NOx = nitrogen oxides, PM = particulate matter
Source: euroactiv.com.en/transport/cars
† Values in brackets are conformity of production (COP) limits

B. CO_2 Emission Standards

The Commission has set a CO_2 emission limit on vehicle manufacturers for new cars registered in the EU in order to achieve an average community-wide objective of 120 g CO_2/km from 2012 onwards.

On December 17, 2008, the European Parliament and Council approved new CO_2 emission rules for passenger cars. These are set out in Regulation 443/2009 dated April 23, 2009 and have the following main provisions:

- The Regulation sets the average CO_2 emissions for new passenger cars at 130 g CO_2/km complemented by additional measures to reduce emissions by a further 10 g CO_2/km.
- Manufacturers have to ensure that average CO_2 emissions for each calendar year from January 1, 2012 do not exceed a specific formula-driven emissions target based on 130 g CO_2/km adjusted for mass for each new vehicle produced.
- Sixty-five percent of new cars will have to comply with the emission requirements in 2012, 75 percent in 2013, 80 percent in 2014, and 100 percent in 2015.
- EU targets include super-credits for vehicles with emissions below 50g CO_2/km. This allows vehicle manufacturers to count these cars 3.5 times for their overall car fleet in 2012 and 2013—although this will be phased out in 2016.
- A reduction of 5 percent will be applied to the specific manufacturer emissions target for each vehicle capable of running on E85 (15 percent petrol/85 percent ethanol) mix up to 2015 depending on the availability of filling stations in member states where these vehicles are registered.
- An application can be made for Eco-innovations, or "the presence of innovative technologies," to reduce the emissions target by up to 7g CO_2/km.
- There are special provisions for niche manufacturers registering less than 10,000 vehicles in the European Community.
- Manufacturers (other than those adopting the "niche" exemption) may also choose to pool their obligations subject to meeting certain registration requirements.
- A new objective of just 95 g CO_2/km was fixed for 2020. This will be conditional on an impact assessment.
- Penalties from 2012 onwards will be imposed on a sliding scale. Manufacturers that exceed their target by more than 3 grams will pay 95 Euros per excess gram per vehicle. Lesser transgressions will be charged between 5 and 25 Euros. From 2019, penalties will always be 95 Euros (with a review in 2013).
- In 2014, there will be an evaluation of the average mass (weight) development of cars over the previous three years
- Member states are responsible for collating the relevant data for each new passenger car registered in their territory commencing January 1, 2010.

C. Biofuels Standards

Biofuels are produced from biomass such as plant material or biodegradable waste. Presently, the most commonly used biofuels (known collectively as "first-generation biofuels") are:

- FAME (Fatty Acid Methyl Ester) blended in diesel and produced from either one or a mixture of different vegetable oils such as rape seed oil, sunflower seed oil, soybean oil or animal fats

- Ethanol blended in petrol (in the EU, ethanol is mainly produced from grains with wheat as dominant feedstock; in Brazil, the preferred feedstock is sugar cane, while in the United States, it is corn).

In the EU, diesel and gasoline may contain up to 5 percent FAME and ethanol, respectively, and these blends are compatible with vehicle models sold in the market. Such blends are referred to as B5 for 5 percent FAME blended into diesel and E5 for 5 percent ethanol blended into petrol. The "neat" biofuels (i.e. 100 percent FAME or 100 percent ethanol) are governed by their own international quality standards.

Companies are currently working on R&D to make the production processes for "second-generation" biofuels commercially viable. Second-generation biofuels are mainly produced from non-food crops, wood, or agricultural waste such as straw. Compared to first-generation biofuels, the second generation is expected to cut down further on greenhouse gas (GHG) emissions. Since second-generation biofuels are essentially a hydrocarbon product, just like petrol and diesel, they will be far more compatible for use in vehicles.

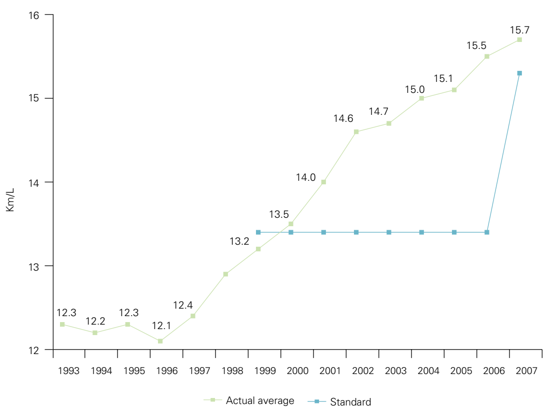
By 2010, all new European car models are expected to run on B7 (7 percent FAME and 93 percent diesel) and E10 (10 percent ethanol and 90 percent gasoline). The European Parliament's Environment committee supports a plan for renewable sources in transport to 4 percent of total fuel consumed by 2015. A thorough review would be required in 2015 before the EU could progress to an 8-10 percent mark by 2020.

Asia – Japan
Current and Proposed Regulations

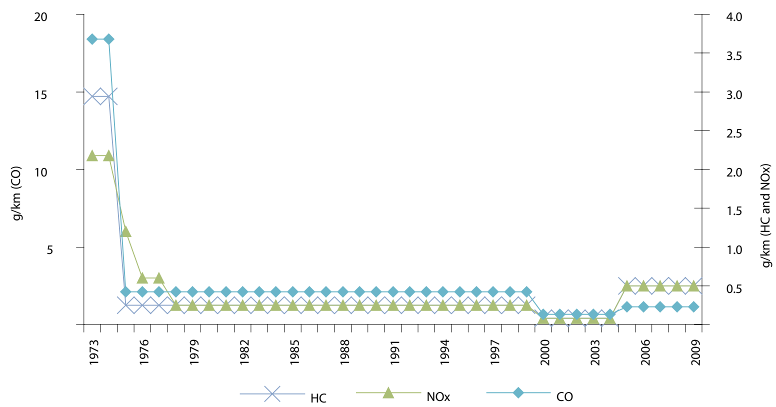
Fuel Efficiency

As the host of the 1997 Kyoto convention on climate change, the Japanese have a relatively high level of awareness towards environmental issues. From recycling efforts to anti-idling campaigns, the country is making significant strides to comply with the Kyoto targets—a 6 percent reduction of greenhouse gas emissions from the 1990 level by the year 2012.[7]

Gasoline Passenger Car Fuel Efficiency – Japan



Passenger Car Emissions Standards – Japan



Source: Fuel efficiency – Ministry of Land, Infrastructure, Transport and Tourism. http://www.mlit.go.jp/jidosha/jidosha_mn10_000001.html

Emissions

1. *The Motor Industry of Japan 2009. Japan Automobile Manufacturers Association, Inc.*
2. *Ministry of Land, Infrastructure, Transport and Tourism http://www.mlit.go.jp/hakusyo/transport/shouwa50/index.html, http://www.aia-net.jp/gaskisei48.html, http://www.env.go.jp/air/car/gas_kisei/kisei.pdf*

Note

1. *In Japan, the standard is essentially the target fuel efficiency and is determined by vehicle weight class. We have assumed the average vehicle weight as the standard. Fuel efficiency standards prior to 1999 were not available.*
2. *In Japan, a passenger car is defined as a vehicle seating ten or fewer people, which includes SUVs and "kei" cars (minicars), a category of small vehicles under 660cc, which is extremely popular in Japan due to the compact size as well as the tax and insurance advantages. According to JAMA, in 2008, 33.8 percent of all new passenger car registrations in Japan were kei cars. The prevalence of kei cars is a key contributor to the high average fuel efficiency in Japan.*
3. *Test cycles used to calculate emissions standards were changed with the introduction of the "new long-term" standards in 2005.*
4. *Emissions standards shown are the average regulatory value.*

In order to meet the target, Japan has established rigid fuel efficiency standards beginning with the introduction of the "Top Runner" program in 1999. The program was introduced nationally as a result of amendments to the Energy Conservation Act, and was intended to increase energy efficiency in various products, ranging from automobiles to consumer electronics. With regard to the automotive sector, it entails identifying the most efficient vehicle currently available in the market and mandating that vehicle as the minimum requirement for future products. The most recent standards for passenger cars as well as trucks and buses were introduced in July 2007, with the target year set at 2015.

[7] United Nations Framework Convention on Climate Change. http://unfccc.int/cop3/fccc/info/indust.htm

The following table shows Japan's current fuel efficiency standards by vehicle type and by gross vehicle weight:

Fuel Efficiency Standards - 2015 Target

	Gross Vehicle Weight (kg)																
	Test cycle	Under 600	601-740	741-855	856-970	971-1080	1081-1195	1196-1310	1311-1420	1421-1530	1531-1650	1651-1760	1761-1870	1871-1990	1991-2100	2101-2270	2271+
Gasoline/diesel passenger cars (km/L)	JC08	22.5	21.8	21.0	20.8	20.5	18.7	17.2	15.8	14.4	13.2	12.2	11.1	10.2	9.4	8.7	7.4
	Gross vehicle weight (ton)																
		3.5-7.5	**7.5-8**	**8-10**	**10-12**	**12-14**	**14-16**	**16-20**	**20+**								
Truck (km/L)	Heavy	8.12	7.24	6.52	6.00	5.69	4.96	4.15	4.04								
		3.5-6	**6-8**	**8-10**	**10-12**	**12-14**	**14-16**	**16+**									
Bus (km/L)	Heavy	9.04	6.52	6.37	5.70	5.21	4.06	3.57									

Source: Ministry of Land, Infrastructure, Transport and Tourism

If the 2015 target is met, i.e., the weighted average fuel efficiency of cars produced exceeds standards, it is estimated to yield a passenger car fuel efficiency of 16.8km/L, or a 23.5 percent improvement from the 13.6km/L level in 2004.[8] Small trucks are expected to achieve 15.2km/L by 2015, a 12.6 percent improvement from the 13.5km/L in 2004.

As the 2015 target year approaches, Japan is expected to further increase its fuel efficiency standards post-2015. Japan recently made a declaration during the UN Climate Change Conference in Copenhagen to reduce CO_2 emission by 25 percent by 2020 compared to the 1990 level, subject to other countries agreeing on the global framework. Since this would be a significantly higher commitment than the Kyoto protocol, it is expected that a more strict fuel efficiency standard may be imposed in the future. According to Asahi Shimbun, the government reportedly is currently considering a possible fuel efficiency target of 21km/L by 2020, although nothing has formally been announced yet.

Emission Standard

Japan began regulating automotive emissions in 1966. The mandatory installment of on-board diagnostics (OBD) systems along with the "new short-term" standards implemented from 2000 have significantly tightened emission regulations surrounding CO, HC and NOx. In 2005, the "new long-term" standards were introduced, which altered the emissions test cycles for both gasoline and diesel vehicles. Furthermore, the "post-new long-term" regulations introduced in 2009 further tightened standards to make it the world's most stringent emissions level.[9] The table on the right shows Japan's current emissions standards.

In addition to national legislation, Japan has several local environmental regulations. For instance, the NOx-PM Law, introduced in 2001, set more stringent emissions standards for new buses and trucks in major urban areas such as Tokyo and Osaka. Non-compliance may result in the failure to register the vehicles in the applicable area. In addition, the Local Ordinance on Diesel Vehicles was announced in 2003. This regulation banned heavy-duty diesel trucks and buses that were noncompliant with PM emission standards from driving in certain urban areas—mainly in the greater Tokyo metropolitan region.

[8] Note that the 2004 level of 13.6km/L is calculated using the JC08 test cycle which was only introduced in 2009.
[9] Ministry of Land, Infrastructure, Transport and Tourism. http://www.mlit.go.jp/jidosha/jidosha_tk10_000001.html

Motor Vehicle Emissions Regulations in Japan

Vehicle Type	Emission	New Short-term Standard (2000–04)			New Long-term Standard (2005)			Post-new Long-term Standard (2009)		
		Test Cycle	Gasoline/ LPG	Diesel	Test Cycle	Gasoline/ LPG	Diesel	Test Cycle	Gasoline/ LPG	Diesel
Passenger Cars	CO NMHC NOx PM	10/15 (g/km)	0.67 0.08 0.08	0.63 0.12 0.30 0.056	10/15M+ 11M (g/km)	1.15 0.05 0.05	0.63 0.024 0.15 0.014	JC08 (g/km)	1.15 0.05 0.05 0.005	0.63 0.024 0.08 0.005
Light duty truck/bus (GVW<1.7t)	CO NMHC NOx PM	10/15 (g/km)	0.67 0.08 0.08	2.10 0.08 0.13	10/15M+ 11M (g/km)	1.15 0.05 0.05	0.63 0.024 0.12 0.013	JC08 (g/km	1.15 0.05 0.05 0.005	0.63 0.024 0.08 0.005
Medium-duty truck/bus (1.7t<GVW<3.5t)	CO NMHC NOx PM	10/15 (g/km)	2.10 0.08 0.13	0.63 0.024 0.25 0.015	10/15M+ 11M (g/km)	2.55 0.05 0.07	0.63 0.024 0.25 0.015	JC08 (g/km	2.55 0.05 0.07 0.007	0.63 0.024 0.15 0.007
Heavy-duty truck-bus (GVW>3.5t)	CO NMHC NOx PM	G13M (g/km)	16.0 .58 1.40	2.22 0.87 3.38 0.18	JE05 (g/kWh)	16.0 0.23 0.70	2.22 0.17 2.00 0.027	JE05 (g/kWh)	16 0.23 0.70 0.01	2.22 0.17 0.70 0.01

Note:
1. *Amounts shown are the average regulatory value*
2. *Only heavy-duty trucks and buses use the JE05 test cycle for both standards, which is measured in g/kWh.*

Source: "The Motor Industry of Japan 2009." Japan Automobile Manufacturers Association, Inc.
Ministry of Environment. http://www.env.go.jp/air/car/gas_kisei/kisei.pdf

Current legislation in Japan does not entail direct penalties or fines towards OEMs that do not meet government regulated emissions standards. However, under Japan's mandatory vehicle inspection program, any vehicle that does not comply with government standards is not permitted to be driven on public roads. There is an indirect sales impact on new cars that do not meet government emission standards: they will be ineligible for government subsidies, effectively making their car prices less attractive.

Incentive Programs

In recent years, the government has made a significant push in promoting eco-friendly vehicles through subsidies and tax incentives. The policy creating the biggest buzz in Japan is the subsidy offered to buyers of new eco-friendly cars. The policy was introduced in April 2009 and is effective for 12 months, ranging from 100,000 yen for passenger cars to 900,000 yen for large bus/trucks meeting the requirements. The subsidy increases if the buyer trades in a car older than 13 years, resulting in subsidies of 250,000 yen for passenger cars and 1.8 million yen for large bus/trucks.[10]

In addition, there are varying degrees of automobile purchase and tonnage tax reduction on qualifying new vehicles, depending on their level of fuel efficiency and emissions ("next-generation cars" such as electric and hybrids are fully exempt). Used cars are also eligible for tax and/or price reduction, provided they meet the standards. Nonetheless, it should be noted that unlike other developed nations such as the United States, Japan has not yet implemented funding programs or direct subsidies to the OEMs to promote the growth of eco-friendly cars.

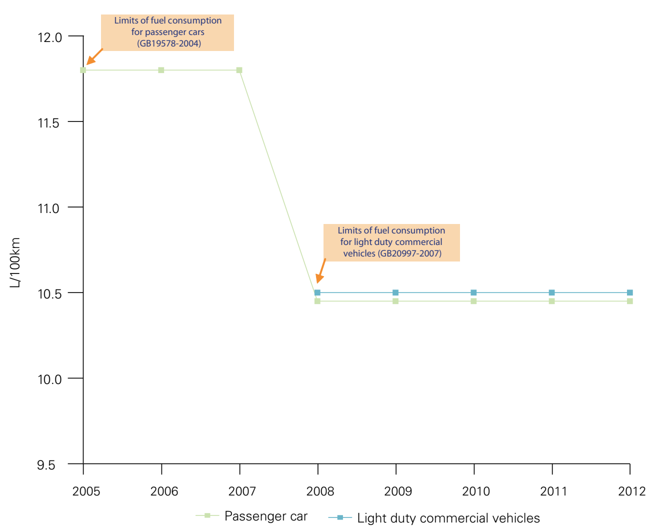
[10] "The Motor Industry of Japan 2009." p45–46. Japan Automobile Manufacturers Association, Inc.

Many Japanese OEMs have mixed views regarding the government's increasing focus on environmental regulations. In the short term, tighter emissions regulations have resulted in lower sales of larger vehicles (trucks, SUVs, etc.), which normally have higher margins. Recent government incentives that promote eco-friendly cars have encouraged sales, but OEMs are afraid this may not continue for long, especially if such incentives are terminated. In the long run, however, the majority of manufacturers agree that these environmental regulations will benefit the industry as vast sums of money are invested into the technology and infrastructure to promote the next-generation vehicles.

Asia – China

Fuel Efficiency

Fuel Consumption Standards for Light-duty Vehicles in China 2005–2012



Note:

a. For passenger cars, fuel consumption standards are divided into 32 sub-classes based on the complete vehicle kerb mass, type of fuel and various characteristics of the vehicle. Only heavy-duty trucks and buses use the JE05 test cycle for both standards, which is measured in g/kWh.

b. For light-duty commercial vehicles, fuel consumption standards are divided into 22 sub-classes based on the maximum design total mass, type of fuel and engine displacement of the vehicle

c. Figures in the graph indicates the midpoint of the fuel consumption standards applied to different sub-classes for the specific vehicle class

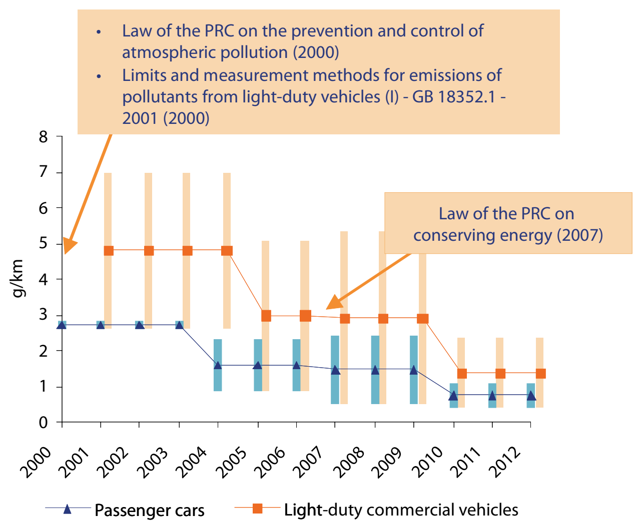
d. Enforcement dates indicated in the graph apply to newly designed vehicles only; enforcement dates for licensed vehicles under production are one year after the corresponding dates for newly designed vehicles

Source:

1. Limits of fuel consumption for passenger cars - GB19578-2004

2. Limits of fuel consumption for light-duty commercial vehicles - GB20997-2007

Carbon Monoxide (CO) Emission Standards for Light-duty Vehicles in China 2000–2012



Note:

a. Carbon monoxide emission standards are divided into various sub-classes based on the type of engine, type of fuel and the relevant mass of the vehicle

b. The shaded areas indicate the range of the carbon monoxide emission standards based on different sub-classes for that particular year

c. Enforcement dates indicated in the graph apply to newly designed vehicles only; enforcement dates for licensed vehicles under production are one year after the corresponding dates for newly designed vehicles

d. The first regulation regarding limits for emissions of pollutants from light-duty vehicles was first issued in 1989; the first revised version was issued in 1993.

The figures for previous regulations in 1989 and 1993 were not listed as they are based on different methodologies and are no longer comparable

Source:

3. Limits and measurement methods for emissions of pollutants from light-duty vehicles (GB 18352.1-2001)Limits of fuel consumption for light-duty commercial vehicles - GB20997-2007

4. Limits and measurement methods for emissions of pollutants from light-duty vehicles (GB 18352.2-2001)

5. Limits and measurement methods for emissions of pollutants from light-duty vehicles (GB 18352.3-2001)

In China, fuel economy is expressed as fuel consumption instead of fuel efficiency and is defined as liters of gasoline (or equivalent amount of other fuel) consumed per 100 kilometers traveled by a vehicle. The China fuel consumption standard is divided into two segments: passenger cars[11] and light-duty commercial vehicles.[12]

Historically, China has not regulated CO_2 emissions, but there are standards that govern emissions of exhaust pollutants, including CO, HC, NOx, and PM. The regulatory standards have been implemented in various phases, with each succeeding phase requiring a stricter guideline or standard.

There is a lack of publicly available statistics on the actual CO_2 emissions. However, the recent draft of proposed CO_2 emission standards indicated that more than 75 percent of vehicles during the review process have a fuel consumption level which is 5 percent or more below the required standard. According to a recent study by CATARC, overall passenger vehicle (including SUV) fuel efficiency (converted from fuel consumption) averaged 28.4 mpg in 2006.

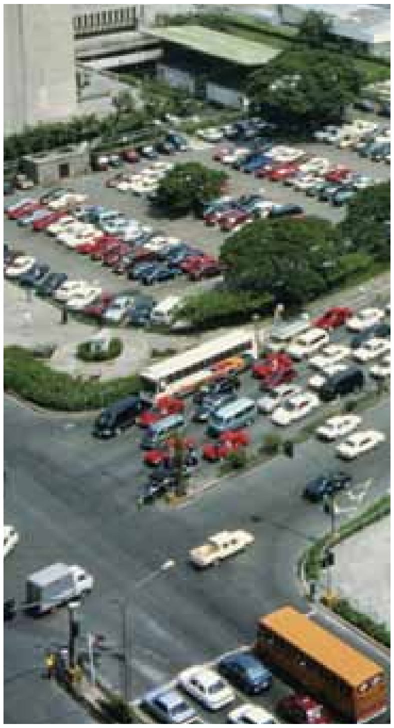
Current Regulations

The current laws regulating fuel consumption standards are the "Limits of fuel consumption for passenger cars" and "Limits of fuel consumption for light-duty commercial vehicles," which were enacted in 2004 and 2007, respectively. In addition to the fuel consumption limits, the standards also include the procedures and methodologies for conducting sample tests through which the certificates of the corresponding standards will be issued to the manufacturers, provided all of the criteria are met.

Regarding the emission standards for other exhaust pollutants such as CO, the current regulation is the "Limits and measurement methods for emissions of pollutants from light-duty vehicles," which was enacted in 2005. The standard addresses the emission limits for exhaust pollutants in phase I (from year 2007 to 2009) and phase II (starting in 2010) for both passenger cars and light-duty commercial vehicles in China.

[11] A Passenger car is a 4-wheel vehicle (or 3-wheel if the maximum total mass>1,000 kg) with a positive or compression ignition engine, a maximum speed ≥50 km/h, a maximum total mass≤3,500 kg, and a maximum number of passenger seats (except driver) ≤8.

[12] Light-duty commercial vehicle is a minimum 4-wheel (or 3-wheel if the maximum total mass>1,000 kg) cargo-holding vehicle with maximum total mass≤3,500 kg or passenger-holding vehicle with maximum total mass≤5,000 kg and a maximum number of passenger seats (except driver) >8.



Proposed Regulations

The Chinese government recently drafted a set of standards for CO_2 emissions to improve fuel efficiency. The draft is currently under review and is likely to be implemented in the near future.

Proposed CO_2 Standards for Passenger Cars in China

Complete vehicle kerb mass (CM)/kg	Normal types (g/km)	Special types (g/km)
CM≤750	140	149
750<CM≤865	147	156
865<CM≤980	158	167
980<CM≤1,090	170	181
1,090<CM≤1,205	183	194
1,205<CM≤1,320	194	206
1,320<CM≤1,430	208	222
1,430<CM≤1,540	219	233
1,540<CM≤1,660	231	244
1,660<CM≤1,770	242	256
1,770<CM≤1,880	251	267
1,880<CM≤2,000	260	276
2,000<CM≤2,110	269	285
2,110<CM≤2,280	278	294
2,280<CM≤2,510	296	314
2,510<CM	314	332

Note:
Special types are passenger cars with any of following characteristics:
1. *With automatic transmission*
2. *Number of rows of seats ≥3*
3. *Off-road vehicles which meet certain criteria regarding CM, climbing capacity and angles between vehicle and ground level*

Source: Technical requirements for environmental labeling products – Light-duty Vehicles (Draft)

In addition, the Chinese government has also proposed to enact a regulation that requires information regarding the fuel consumption level to be labeled on each vehicle that is manufactured and/or sold in China.

Currently, there are no fines that would be imposed on manufacturers that do not meet the government's environmental regulations in the automotive industry. However, in order to manufacture and/or sell vehicles in China, a manufacturer must obtain various types of certificates through which the environmental standards on automotives are being regulated. Under the current government regulated standards, each manufacturer must conduct testing for each of their car models based on the testing methodologies and procedures listed in the corresponding standard.

Incentive Programs

The Chinese government strongly supports the development of environmental technology for the automotive industry and has been focusing on the development of new energy vehicles (NEV). The State Council has listed low-energy consumption and NEVs as priority areas of development in its "Program for science and technology development" since 2006.[13] The National Development and Reform Commission (NDRC) has further set out "Rules on the production, admission and administration of NEVs" that govern NEV development, including production testing in 2007.

In January 2009, the Chinese government released the "Automotive industry readjustment and revitalization plan," which granted CNY10 billion special funds for automotive sector R&D support. It also provides incentives for the public to purchase passenger cars with low fuel consumption by reducing the vehicle purchase tax from 10 percent to 7.5 percent starting on January 1, 2010 for passenger cars with displacement below 1.6L.

In addition, the government recently released the "Interim administration of fiscal subsidies to energy-efficient and new energy automotive sample scheme" to provide fixed subsidies for the purchase of hybrid, electric, and alternative fuel vehicles in 13 pilot cities. The plan targets the deployment of 60,000 NEVs in China by 2012. Local governments tend to direct the subsidies to support Chinese automobile manufacturers. For example, Dalian purchased 100 NEVs from FAW with a subsidy that amounted to CNY20 million; Wuhan purchased 100 EVs from DFM with a three-year subsidy valued at CNY160 million; and Beijing purchased 800 NEVs from Foton with a subsidy worth CNY500 million.[14]

The Ministry of Science and Technology, along with cooperation from other government departments, is also taking measures to further support R&D in NEVs, including expanding investments to promote sustained technological development, organizing nationwide demonstrations to increase penetration of NEVs, and using international experiences to adopt appropriate stimulus policies. Chinese auto brands are also strongly participating in NEV development and have included plans in long-term strategies. Some examples of these developments include:[15]

- SAIC: Invested CNY2 billion for NEV development
- Chang'An: Established NEV JV and plans its first hybrid car for 2009
- FAW/DFM: Currently has hybrid buses in pilot operation
- Chery: Introduced plans for a hybrid and an electric car
- BYD: Introduced plans for a dual-mode electric car

Another initiative that supports the development of new technology is the "National high-tech R&D program," commonly known as the "863 program." It was launched to boost innovation in the high tech sector across different industries. One of the key recent supports in the automotive industry is a grant of CNY 3.1 million to China BAK Battery, one of the largest lithium-ion battery cell manufacturers in the world, for its "Electric Vehicle Lithium-phosphate Power Battery Industrialization Project."[16]

Latin America – Brazil

Similar to most developing regions of the world, Latin American countries have not historically been very active in regulating vehicle emissions or fuel efficiency. Brazil has been

[13] Gerson Lehman Group, "China Auto Trend 4: Investment in New Energy Vehicles & Related Infrastructure," 22 Aug 2009

[14] China CBN.com, "NEVs sample program in 13 pilot cities", 13 May 2009, available in Chinese at http://www.china-cbn.com/s/n/015/20090427/000000113694.shtml

[15] Gerson Lehman Group, "China Auto Trend 4: Investment in New Energy Vehicles & Related Infrastructure," 22 Aug 2009

[16] The Autochannel, "China BAK Funded by National 863 Program for its Electric Vehicles Battery Project", 29 Dec 2008

the most aggressive in the legislation of alternative fuels, namely the blending of ethanol and gasoline, through initiatives started in 1975. Although Latin American countries are generally not viewed as being aggressive about environmental protection, recent evidence suggests that climate change is beginning to impact how natural resources are protected. In Brazil, which significantly relies on products sourced from the Amazon region, climate change has become a threat to the economy and thus the country is expected to manage emissions more aggressively. In response to this impact, Brazil has initiated or adopted increasingly more stringent emission standards. Apart from subsidies to OEMs and consumers, Brazil has also limited the number of imported used vehicles, despite large demand for used vehicles in the country.

Current Regulations

The National Alcohol Program began in 1975 in reaction to the oil crisis and the country's exclusive dependence on imported fuel. The Brazilian government adopted the Alcohol Program (PróÁlcool) with two objectives in mind: 1) to reduce external dependence on oil; and 2) to produce renewable and environmentally friendly energy. In reality, the widespread use and production of ethanol in Brazil has historically been led primarily by the desire to subsidize sugar cane growers, reduce dependence on foreign oil, and improve trade balances rather than address environmental concerns. Starting in 1975, 25 percent alcohol was mixed with gasoline throughout the entire country. Between 1985 and 1990, around 90 percent of all automobiles manufactured in Brazil were powered by alcohol. In the early '90s, an alcohol shortage in the country resulted in a downturn for PróÁlcool. However, by the year 2000, alcohol cars came back into favor with consumers, who were drawn to the fact that they cost less than gasoline-powered vehicles, and that new technologies for flex-fuel vehicles (FFV) allowed cars to run on gasoline, pure alcohol, or a mixture of both.

In 1986, the National Council on the Environment (CONAMA) developed the Program for the Control of Air Pollution by Motor Vehicles (PROCONVE) to provide emissions targets for automakers. However, the first emission limits for cars and heavy vehicles were only defined by law in 1992. These regulations, now in their sixth generation under proposal for 2012 (PROCONVE L-6), identified levels of pollutants for vehicles in different weight classes.

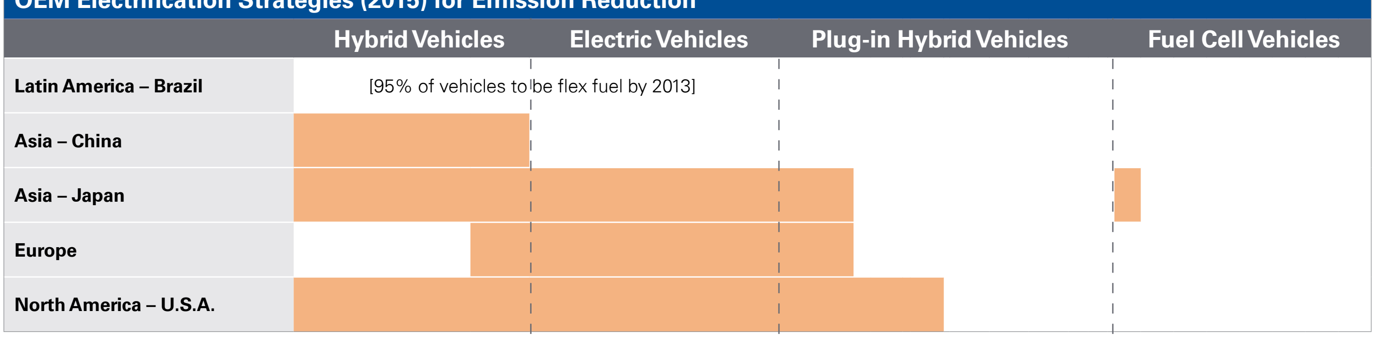
The Brazilian government has traditionally used a mixture of government mandates and tax incentives to drive consumer behavior. One of the original legislations mandated that diesel fuel be used in buses and trucks that were responsible for the majority of cargo and passenger transportation. This mandate remains to this day: trucks and buses run on diesel, while light vehicles run on gasoline (mixed with alcohol; E25) and pure alcohol (E100). Although E25 is the country's standard, E100 is popular because ethanol is cheap in Brazil. Although there are consumer incentives to switch to pure alcohol (E100), including fewer taxes for alcohol-fueled vehicles and lower fuel prices, there are also drawbacks to using E100 in cold weather. But the upside is that, due to the considerable use of alcohol to power vehicle fleets, Brazil's CO_2 emissions are very low at 124 g/km in 2004, according to a study by the Center for Clean Air Policy. As a result, vehicle fuel economy standards do not exist in Brazil due to the country's high use of ethanol and related low level of CO_2 emissions. Recently, however, there have been proposals for a voluntary vehicle window-sticker program that would identify fuel economy as well as other emissions and vehicle information in all new vehicles, comparable to what already exists in the United States and EU.

OEM and Supplier Strategies to Meet the Regulations

Interestingly, regional solutions to meet fuel economy standards vary across the world. North America and Japan appear to be experimenting with a mix of electrification technologies in mild, serial, and parallel hybrids, PHEVs and EVs. Europe is still heavily focused on advanced diesel powertrains, while Latin America is focusing on ethanol-powered flex-fuel vehicles. Local market and geopolitical forces appear to influence the choice of solutions that OEMs and suppliers offer in a region. While it may seem that EVs may not be economically attractive options today, by 2020 the payback period for an EV would be less than six years, indicating a high likelihood of increased market adoption. Other technologies, such as turbo-charging with direct injection, are economically viable today outside North America, but they could soon be attractive globally as the cost of the technology drops.

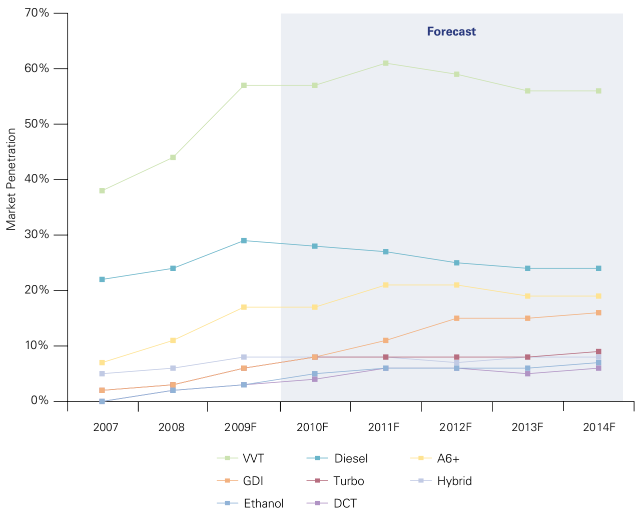
Besides the electrification options being offered globally, a suite of fuel efficiency enhancement technologies for conventional internal combustion engines are expected to see widespread adoption. Most notably, variable valve technology (VVT) is expected to become standard in North America and some other developed countries by 2015. Others, such as gasoline direct injection (GDI), turbo-charging, and dual-clutch transmission (DCT), are also expected to see dramatic growth.

OEM Electrification Strategies (2015) for Emission Reduction



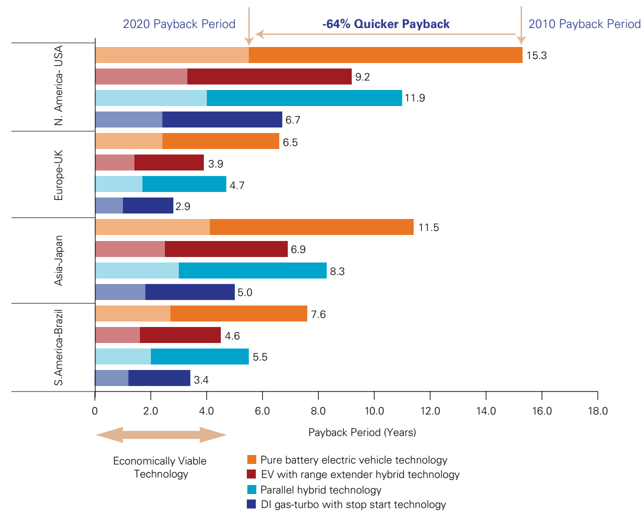
Source: CSM, Wards Auto

Installation of Fuel Efficiency Technology – Global



Source: CSM

Payback Period of Fuel Efficiency Improvement Technologies (2010–20)



Note:

1. *Additional technology cost per vehicles is assumed to be $1,000 for pure battery electric vehicles, $3,000 for parallel hybrid vehicles, $10,000*
2. *Technology driven efficiency gain (% additional miles per gallon gas) is assumed to be 10% for Pure battery electric, 20% for Parallel Hybrid*
3. *Cost for each technology is assumed to reduce by an average annual rate of 15%*
4. *It is assumed that gas prices will remain unchanged between 2010 and 2020 on a real dollar basis*
5. *Average miles driven per gallon is assumed to be 27.5 in 2010 and 40.0 in 2020*
6. *Average distance traveled is assumed to be 15,000 miles per year, other than Asia-Japan which is assumed to be 10,000 miles per year*

Source: CSM

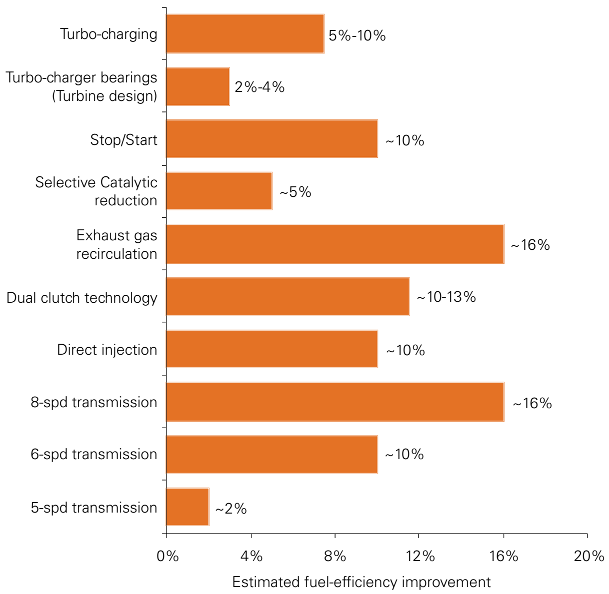
North America – U.S.A.

Available technologies may allow United States OEMs to meet the CAFÉ mandate in 2016. According to the automotive trade publication Ward's Auto World, the estimated United States fleet efficiency of 30.5 mpg in 2009 could be as high as 42.7 mpg by 2015 with the adoption of these technologies. The challenge remains the value for cost and whether consumers would be willing to absorb the costs of these add-ons. As seen before, the payback period for some of these solutions, like GDI with turbo and start-stop (cylinder deactivation), is still fairly high in the United States, which affords them niche status. With a drop-off in cost, however, these solutions are expected to become more prevalent in future models. Hybridization of these powertrains could result in an additional 20-40 percent improvement in fuel economy.

Emerging Technology Expected to Increase Fuel Efficiency of U.S. Vehicle Fleet by 2015

Various Technologies Under Development are Expected to Increase Fuel Efficiency Between 2% and 16%.

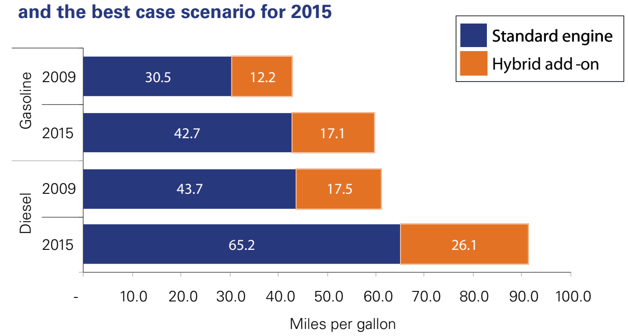
Estimated Fuel Efficiency Improvement from Various Technologies



(a) Improvement indicated represents relative improvement over 4-speed transmission.
Source: 1) Ward's Auto, July 2009; (2) "How Dual-clutch Transmissions Work," HowStuffWorks.com; (3) DetroitDiesel.com.

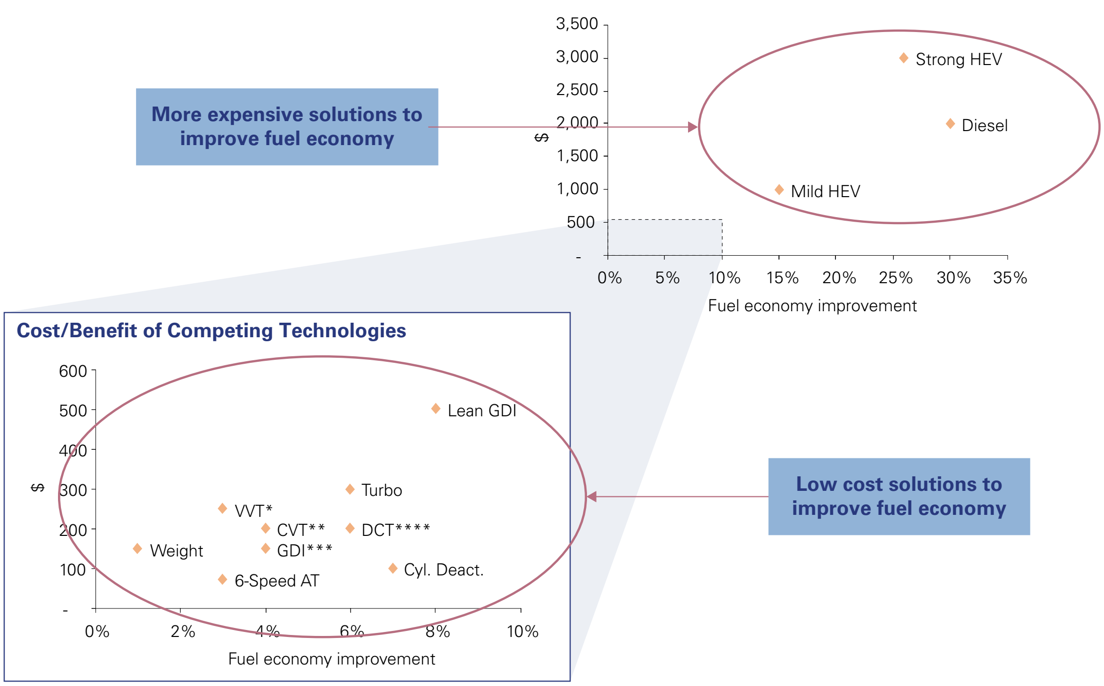
Implementation of Fuel Efficient Technology may Allow Manufacturers to Comply with CAFÉ Standards by the 2016 Deadline.

Fuel Efficiency of U.S. Vehicle Fleet in 2009 and the best case scenario for 2015



Source: Ward's Auto, July 2009

Cost/Benefit of Competing Technologies



Note:
** Variable valve timing*
*** Continuously variable transmission*
**** Gasoline direct injection*
***** Dual clutch transmission*

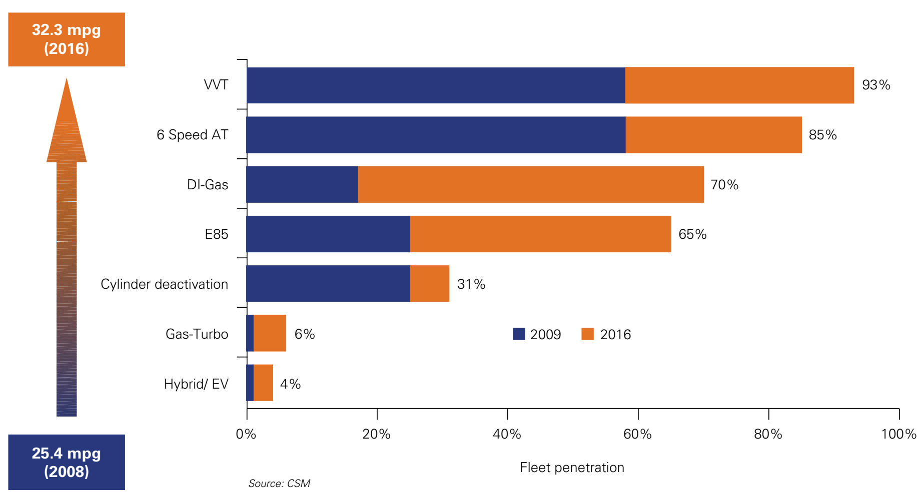
Source: CSM and Ward's Auto 2008

According to a recent report by the EPA, Ford Motor Company has improved in fuel economy more than any other major United States automaker. As a result of its efficiency improvement programs, Ford's fleetwide emissions at 270 g CO_2/km in 2009 have improved more than any other auto maker. These improvements are the result of a variety of engineering solutions such as:

- *Six-speed automatic transmissions* – Ford expects to transition its entire fleet to six-speed transmissions by 2013.
- *Eco-boost gasoline turbo-charged direct injection technology* – Results in 20 percent better fuel economy and 15 percent fewer CO_2 emissions. Ford expects to increase the penetration in its models from 20 percent to 90 percent as an option.
- *Improved aerodynamics*
- *Weight reduction* – Replacing heavier material with lighter material is nearly as important as hybrid technology according to a recent study.
- *Electric power assist steering (EPAS)* – Powering the steering with an electric motor rather than a hydraulic pump results in 3 percent improvement in fuel economy.
- *Electrification* – Ford plans to bring battery system design and development and manufacturing in-house as a core competency. Ford is partnering with Azure Dynamics to build a pure battery electric Ford Transit Connect van for the United States and Canadian markets in 2010. Additionally, Johnson Controls-Saft is the supplier of the Lithium-ion battery cells and battery packs for the Transit Connect.

Other OEMs, such as GM, are similarly relying heavily on VVT and advanced transmissions to meet the fuel efficiency goals set out by the federal agencies with phenomenal growth expected in the build-out of models with GDI and flex-fuel (E85) options.

General Motors – Road Map for Fuel Efficiency Improvement



Source: CSM

OEMs are making significant efforts up front in the initial development and design phase to make future vehicles more fuel efficient, versatile (across multiple fuel sources), and advanced enough to employ the latest fuel technology. Even the manufacturing process is becoming more "green" with the increased use of renewable resources. Manufacturers include higher portions of recycled materials in the various automotive components, while reducing heavy metals and cabin volatile organic compound (VOC) emissions. These initiatives also include reducing waste and water consumption and increasing the amount of recycling.

GM has partnered with Goodyear to use a new energy-saving tire (Goodyear Assurance Fuel Max Tires) that allows for approximately one extra mile on an EV on a fully charged battery. Goodyear states that these tires with Fuel-Saving Tread Compound help reduce energy loss as the tire rolls to save 2,600 miles worth of gas over the life of the tire.

While most OEMs may overlook energy savings in components, such as the electronic safety systems and the factory-installed sound systems, some such as GM are making that extra effort to find efficiencies in every aspect of a vehicle. Bose has developed an energy efficient sound system that is 30 percent smaller, 40 percent lighter, and requires 50 percent less energy than its conventional sound systems. Bose will release this product in GM's highly anticipated "Volt" electric vehicle. Under certain listening and driving conditions, the total energy savings from this sound system may be the equivalent of removing 50 pounds from the electric car.

Chrysler Group LLC plans to launch production of an advanced, fuel-efficient engine for the North American market with Fiat's innovative advanced technologies to reduce engine emissions and improve fuel economy. The 1.4-liter, 16-valve Fully Integrated Robotized Engine will be built at Chrysler's Global Engine Manufacturing Alliance (GEMA) plant in Michigan for use in its growing fleet of fuel-efficient vehicles.

Earlier this year Nissan North America, Inc. was approved by the DOE for a $1.6 billion loan under the ATVM Loan Program to modify its Smyrna, Tennessee, manufacturing plant to produce zero-emissions vehicles and lithium-ion battery packs that power them. In addition, Nissan is looking to partner with electricity companies. Recently announced was an agreement to advance zero-emission mobility in the United States with Reliant Energy of Houston, Texas, one of the major competitive electricity providers in the nation.

European Union

According to the European Automobile Manufacturers' Association, European OEMs have significantly reduced the environmental impact of vehicle production in recent years. Per unit produced, energy consumption, CO_2 emissions, waste, water use, and VOC emissions have all decreased. This is mainly due to the impact of a changing market structure, progress in R&D, the shift towards sustainability, and the regulatory framework instituted by national and international policy makers.

Achieving sustainable mobility has become the chief aim of R&D activities. A large share of the European automotive industry R&D expenditures (EUR20 billion) is directed towards environment-related improvements or features. By doing so, the European automotive industry has drastically reduced the impact of motor vehicles on the quality of air and the level of noise. Companies have made progress in the recycling of their products or have modernized and improved industrial processes, in terms of waste management and water and energy savings. Besides these strategies, the industry is also clearly committed to reducing CO_2 emissions.

Several initiatives underline the importance of a joint approach between the industry and policy makers. The Green Car Initiative by the European Commission and the European automotive industry aims to allocate additional EUR5 billion towards a breakthrough in the use of renewable and nonpolluting sources of energy, road safety, and traffic fluidity. The initiative covers passenger cars as well as trucks and buses and transport systems, intelligent infrastructure, and the availability of a fueling and/or charging infrastructure. The initiative concentrates on long-term R&D, largely combining existing projects under a clear policy focus.

European OEMs and suppliers have responded quickly to the backdrop of tighter environmental regulations and changing consumer preferences. Reducing the environmental impact of manufacturing processes has become a commitment of European companies. In recent years, European manufacturers have started focusing on the environmental impact of their products over the entire life cycle, from development and production to service use and recycling. For example, Volkswagen awards environmental commendations based on life-cycle assessments. These commendations are awarded to vehicles and technologies that demonstrate ecological progress compared to their respective predecessors or reference models.

OEMs like Volvo follow three main tracks for reducing the environmental impact of their vehicles—fuel efficiency (stop/start), renewable fuels (bio-fuels), and electrification (plug-in hybrids, serial hybrids, battery electric vehicles). This is now the key driver of medium-term product plans.

As a result, a number of trends are emerging including:

- OEM consolidation or collaboration. The recent acquisition by VW of Porsche and the alliance with Suzuki are examples at either end of the product spectrum. Together VW and Porsche can exploit synergies and share leading edge technology. The Suzuki investment is designed to deliver a new low-cost car. The acquisition of Volvo by Geely will also enable both companies to share environmental technology. Niche luxury vehicle producers have the potential to "pool" emissions and thereby avoid EU penalties through partnering with larger volume players. This may result in some interesting future alliances along the lines of the Aston Martin Cygnet city car being developed in conjunction with Toyota.
- An increase in number of joint ventures and alliances to exploit new technologies and pool resources. For example, the recent announcement by Bosch, DEUTZ, and Eberspächer to set up a joint venture for diesel exhaust after-treatment.
- A focus on research into lightweight structure. For example, BMW has announced a joint venture with the SGL Group for the production of carbon fibers and textile semi-finished products for use in vehicle production. This is aimed at reducing vehicle weight and hence emissions.
- Cross-border alliances have emerged to develop battery technology. For example, SB LiMotive (Bosch – Samsung joint venture) being used by BMW for its Project i electric vehicle program.
- Increased supply of vehicles with alternative powertrain technology suitable for everyday increased use. For example, SmartForTwo electric drive from Mercedes based on lithium iron battery technology, the LPG range from Opel, and electric Mini E. PSA unveiled the idea of a deeper alliance with Mitsubishi, which was based on a bet on electric engines and volume sales of smaller combustion engines in emerging markets. This strategy is to compete with Toyota Motor and Honda Motor of Japan and Daimler's Mercedes of Germany.

- Collaboration by utility companies, car manufacturers, and governments to create the infrastructure required to support electric vehicles. This could be provided via publicly available charging stations or hydrogen filling stations. To support the wider use of electric vehicles and plug-in hybrids, PSA Peugeot Citroen formed a partnership with French power utility EDF in 2008, covering such areas as the definition of the business models capable of driving the commercial development of electric vehicles; energy storage technologies, such as lithium-ion batteries; and the standardization of recharging systems and protocols to enable vehicles and the network to communicate during recharging. A joint venture project between Volvo Cars and energy supplier Vattenfall will develop plug-in hybrid cars and an energy infrastructure.
- Automotive manufacturers are increasingly using green energy sources such as wind to reduce air pollution caused by their manufacturing plants. For example, Nissan introduced a wind power facility in its plant in the United Kingdom as part of its initiative to increase its use of renewable sources. This is expected to generate five percent of the site's electricity requirements and reduce CO_2 emissions as well as energy costs
- A commitment to environmental standards and sustainability. Most major OEMs now publish a sustainability report and have other strategies to highlight "green credentials;" should be for example the CO_2 offset program of LandRover. Daimler has set up a central management committee for sustainability that coordinates significant sustainability measures throughout the group and supports the operating units as they put solutions into practice. Similarly, suppliers highlight their environmental and ecological strategies as a key part of Websites
- Branding of vehicles to highlight their environmental or eco-credentials examples include Fiat's Eco-Drive and VW's BlueMotion concepts. BMW launched the "Efficient Dynamics" program to highlight the potential to combine environmental awareness and efficiency without compromising on performance or driving experience. French OEMs (Renault and Peugeot) have demonstrated their environmental credentials by selling vehicles emitting less than 140 g CO_2/km (over one million for Peugeot-Citroën in 2008 and one million for Renault in 2008) and their commitments to producing more environmentally friendly cars by taking appropriate measures to meet the European Union's target of limiting average emissions by new vehicles in Europe to 120 g CO_2/km by 2015.
- Government initiatives to encourage low carbon technology. The U.K. government has committed some £400 million to support a range of initiatives.
- Under EU legislation passed in December 2008, their new vehicles have to be 85 percent recyclable. OEMs assume responsibility for their vehicles at the end of their lifetime and ensure that the majority (e.g. BMW promises 95 percent recyclability) of vehicle components can be recycled. Daimler's recycling management system (MeRSy) helps to ensure that a growing number of end-of-life parts are recycled on a voluntary basis, thus reducing the volume of waste. The company is also establishing a take-back network for end-of-life vehicles in cooperation with local importers and national disposal companies in all EU countries. PSA Peugeot-Citroën facilitates the collection and processing of end-of-life vehicles and components by specialized providers of decontamination, recycling, and resource recovery services.

Since the internal combustion engine will remain the dominant propulsion technology for the foreseeable future, there is a focus on improving engine efficiency. This is being achieved through a range of mechanical and electronic innovations ranging from transmission technology, fuel pump monitoring, steering mechanisms, exhaust systems, and "stop-start." Peugeot has committed that almost every Peugeot Citroën model will feature stop-start technology, which shuts down the engine when the car is idling (resulting in a 15 percent carbon emissions decrease in city driving). Suppliers such as Bosch are working with OEMs to combine internal combustion technology with electric drive. The improvement in 4-cylinder engine performance has been dramatic over recent years and similar progress in 3-cylinder technology is anticipated. This means that relatively small 3-cylinder engines may produce the equivalent power of today's larger 4-cylinder engines.

European Union – Technology Matrix by OEM

OEM	2006 CO_2 Rating	Sustainability Initiative	Stop-Start	GDI Turbo	Diesel	DCT, CVT, A6+	Bio-Fuel	Hybrid
BMW	184	EfficientDynamics	✓	✓		✓		✓
Daimler	188	BlueEFFICIENCY	✓	✓	✓	✓		✓
Fiat	144	Natural Power Multijet + Multiair	✓	✓	✓			✓
Ford	162	Econetic	✓	✓	✓	✓	✓	
General Motors	157	ecoFLEX		✓	✓		✓	
PSA	142	Hybride HDI BioFlex	✓				✓	✓
Renault/Nissan	157	ECO_2		✓			✓	
Toyota	153	EVAS			✓			
Volkswagen	166	BLUEMOTION	✓	✓		✓		✓

Key: ✓ Key technology focus
Source: OEM interviews

Asia – Japan

Japanese automakers have been coping with various new environmental and safety regulations, both domestic and foreign. This is especially relevant for OEMs, since half of Japanese cars sold worldwide are produced in Japan. Furthermore, of the 11.6 million vehicles produced domestically in 2008, 6.7 million vehicles were ultimately exported to foreign countries.[17] This dependence on overseas demand has forced Japanese OEMs to be more attentive towards foreign legislation. As a result, the majority of OEMs have adopted a global strategy with necessary adjustments made to comply with local legislation.

According to Japanese OEMs, powertrain technology has been most impacted by the recent environmental regulations. Today, Japanese OEMs are attempting to survive this highly competitive industry through energy diversification, addressing conventional gasoline, diesel, and alternative fuel engines as well as EV and fuel cell technologies. For example, Toyota[18] has been developing each of these powertrains and aims to use its hybrid systems for further enhancement of these systems. Mazda[19] has been developing a gasoline engine with a start-stop system and a hydrogen rotary engine with a hybrid system. Nissan[20] and Honda[21] have been developing efficient gasoline and diesel engines as well as EV, HEV, and fuel cell vehicles.

[17] "The Motor Industry of Japan 2009." Japan Automobile Manufacturers Association, Inc.
[18] Toyota Motor Corporation company Web site
[19] Mazda Motor Corporation company Web site
[20] Nissan Motor Co., Ltd. company Web site
[21] Honda Motor Co., Ltd. company Web site

Interestingly, Suzuki appears to continue to focus on the conventional gasoline engine to dominate the "Kei" niche, or minicar segment, which, along with other minicar brands, accounts for approximately one third of all new passenger cars sold in Japan. Their rationale is that instead of developing a high-cost hybrid car, they are better off improving and continuing to provide cheap "Kei" cars, which already have above-average fuel efficiency.

Depending on the strategy and stage of development, each company has prioritized different powertrains for commercialization. Currently, Toyota and Honda lead in the hybrid segment with Prius and Insight, respectively. EVs from Nissan (Leaf), Mitsubishi (i-MiEV), and Subaru (Stella) are either being sold or expected to begin selling to the general public in 2010. According to a leading OEM, "in order to comply with new standards in future, implementation of next-generation vehicles (that do not rely on gasoline) will become indispensable."

Suppliers in Japan, under constant pressure from OEMs to reduce parts costs and weight, have been instrumental in realizing new technologies in the powertrain and other parts. For example, Aisin Seiki[22] has developed a water pump for cooling the new Prius engine, which operates electrically rather than on gasoline. This improves fuel efficiency by reducing engine weight and eliminating the friction inherent in belt-driven pumps. The company has also developed innovations such as the 2-motor hybrid system, 2-motor hybrid transmission, 8-speed automatic transmissions, and light-weight frame construction (by die quench method).

One of the suppliers we interviewed commented that trends in tightening environmental regulation may negatively affect the interior parts suppliers because the production cost of high value-added products may not necessarily be passed on to the OEMs. However, "the industry change, driven by technology development, may also create opportunities for suppliers to form alliances with other OEMs," the interviewee added. The majority of OEMs are uncertain about the level of premium that consumers are willing to pay for a "greener" vehicle. One manufacturer commented that customers may be willing to pay two to five percent more for an environment-friendly product, while another supplier commented that such a premium may be as high as 10 percent. But the majority of other respondents were unsure if they can dictate higher prices for greener vehicles, especially after the current incentive and tax savings programs expire.

Due to the current industry challenges, there appear to be various integration and consolidation opportunities. Prospects abound for horizontal integration as some incumbents may fail to make a successful transition to a "greener" automotive industry. OEMs may merge to realize synergies from their partner's expertise in a particular segment. Cross-sector integration is widely expected as well, especially between OEMs and major suppliers in the electrical, power, and battery industry. Furthermore, as the industry transitions, the traditional "keiretsu" alliance between Japanese OEMs and their suppliers may become less evident. New suppliers may enter the market, which may ultimately define a new OEM-supplier landscape.

With prospects rising for the EV, OEMs are realizing the importance of developing a battery with capabilities similar to internal combustion engines. The majority of OEMs have established joint ventures or strategic alliances with major electronics companies in the past decade. For example, Toyota has a joint venture with Panasonic while Nissan has a partnership with NEC. Likewise, Honda has a partnership with GS Yuasa, a top

[22] Aisin Seiki company Web site

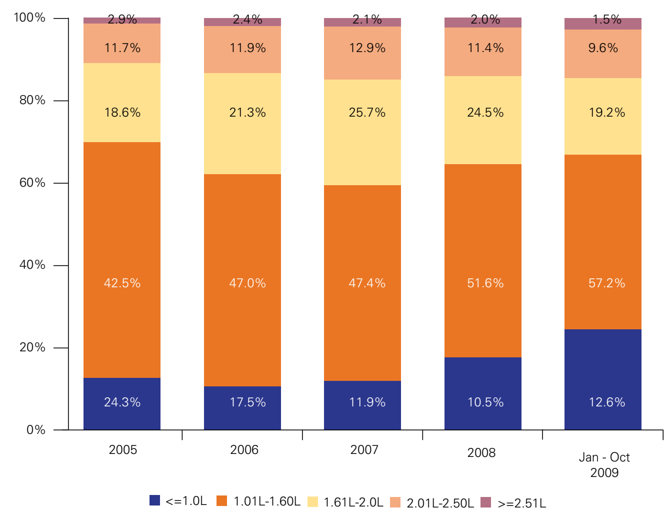
battery manufacturer. These strategic alliances are not limited to domestic companies. Many overseas OEMs are using Japanese electronics companies to supply parts for their EVs and HEVs. For instance, GM is currently using Hitachi batteries for its hybrid vehicles while Volkswagen and Sanyo have teamed up to develop lithium-ion batteries. PSA Peugeot-Citroën is reportedly considering investing in Mitsubishi Motors, with whom PSA has already collaborated on research in EV technology.

Cross-border alliances are expected to grow beyond battery development, especially with a view to penetrating the emerging markets. Volkswagen recently announced its plan to cross-hold a minority stake in Suzuki. The influx of cash allows Suzuki to spend more on R&D, especially in the "Kei" minicar segment, where it has established a niche, both domestically and overseas. Japanese OEMs have also entered the Chinese market, primarily through joint ventures with local manufacturers.

Asia – China

China is already one of the largest producers of vehicles in the world. It is forecasted that by 2030, China could replace the United States as the nation with the most vehicles on the road with over 330 million vehicles.[23] With the continuing automotive growth and growing environmental concerns, the Chinese government is seriously pushing for reducing vehicle emissions and promoting cars that run on renewable energy.

China's Automotive Sales by Engine Capacity



Source: Nomura, "Autos & Auto Parts – Beijing outlines auto stimulus package", Jan 15, 2009; Wind Database

On the renewable energy front, the government is providing subsidies on purchase of NEV and providing funding support for automotive R&D. To curb emissions (and stimulate sales), the government provided subsidies to rural farmers to trade in old vehicles for more efficient ones, and introduced tax cuts in 2009 that have been carried forward in 2010 for small engine vehicles, or those under 1.6 L.

OEMs and suppliers in China appear to be seizing upon the opportunities and aligning themselves with the direction of the environmental policy. Most car makers have implemented or have plans to increase small-car development. For example, SAIC-VW has added more small car capacity to its model line and is also launching smaller-engine versions of vehicles (e.g. Magotan, which has been a 1.8L vehicle, is expected to have a

[23] McKinsey Quarterly "China's Green Opportunity", May 2009

1.4L model in 2010).[24] Car makers such as Toyota, which has focused on larger cars, have seen relatively flat sales and are now tapping into the small-car segment for growth.[25]

To gain an advantage in the emerging NEV segment, OEMs have been investing heavily in R&D, rolling out NEVs in pilot test cities or showcasing their new model developments in automotive shows.

BYD has garnered headlines for its electric and hybrid vehicle programs, but in fact, other Chinese car manufacturers, including SAIC, FAW, Beiqi Foton, Chery, and Geely, are not far behind in their plans to launch hybrid vehicles. For example, SAIC (the partner of both General Motors and VW in Shanghai) is investing over USD1.8 billion in NEV projects with plans to launch its own brand of NEVs in 2010. In partnership with the Shanghai World Expo, SAIC will also be supplying the Expo's logistics with a variety of NEVs, ranging from sedans to buses.[26]

OEMs and suppliers have also focused on engines and energy sources for a number of new investments. For example, Chery has developed the S18 electric vehicle that is capable of 150km in range and a maximum speed of 120km/h. Chery also plans to make its hybrid technology standard equipment for its vehicle lineup. The Aviation Industry Corporation of China (AVIC) is also partnering with major domestic car manufacturers to develop and produce electric cars and engines, and is looking to invest around CNY20 billion between 2009 and 2020.[27]

While NEVs are a very small sliver of the Chinese market today, industry participants have commented that China could become the largest producers of NEVs by 2013. Roland Berger projects that 15 percent of vehicle powertrains in China will be EV or PHEV by 2020 (1.6 million units). According to a recent TNS Automotive survey, 75 percent of Chinese car buyers today are willing to pay a 10 percent premium for a NEV. Government policies are highly favorable to EV and PHEV, as Chinese OEMs and suppliers realize they cannot catch up to or move ahead of Western manufacturers by developing traditional ICE technologies. Similarly, dollars might be more productively employed to China's advantage by spending on PHEV or EV, rather than on bio-fuels, diesel technologies, LNG/LPG, and other energy sources. However, China and other countries still need to address the challenge of widespread implementation of NEVs by building the infrastructure necessary to support them. This is likely to require a greater coordination among the OEMs, government, and other infrastructure suppliers. The Chinese government and the SOE sector as "directed" fleet buyers in China could give added weight to the policy around PHEV and EV.

Recharging stations, including solar-powered ones, are being developed and put into use in pilot cities such as Shanghai, although these are mainly used by public and government transportation, which serve as the main audience for the NEV pilot testing programs. It is projected that by 2020, EV infrastructure could cover cities with GDP of USD1,000 per head or greater (more than 40 Chinese cities), or those that generate 46 percent of total PV sales. Interestingly, this has attracted investments from companies not traditionally associated with the automotive sector: the State Grid Corporation, China's largest electric power provider, has announced the construction of charging stations for buses and passenger vehicles in Beijing, Shanghai, and Tianjin,[28] and petroleum giant CNOOC is considering the possibility of building a network of battery-charging stations for EVs nationwide.

[24] China Economic Net "Small-displacement cars lead auto market", November 24 2009
[25] Global Times "Toyota to tap China's small car market for growth", September 30 2009
[26] China Daily "SAIC Group to invest 12b Yuan in new energy cars", July 7, 2009
[27] ChinaEV.org "AVIC establishes electric vehicle system base in Zhengzhou", 11 December 2009
[28] McKinsey Quarterly "China Charges Up: The Electric Vehicle Opportunity", October 2008

Nevertheless, for OEMs, battery capacity and recharging time are also likely to be another hurdle for the public rollout of EVs. One idea that has been designed by Better Place, an American start-up focused on providing infrastructure for electric cars, is to provide an infrastructure for renting and replacing batteries. Chery has also indicated that it may pursue a battery replacement business model.

Bringing the model one step closer to reality, the Renault-Nissan Alliance, a cooperative venture that has worked with Better Place, signed an agreement in April 2009 with the Ministry of Industry and Information Technology to develop an electric vehicle pilot project in 13 Chinese cities. The Alliance has signed a MOU with the Wuhan municipal government as a pilot city for zero emission vehicles, and is aiming to provide a "blue-print for a battery-charging network" and cars in China in early 2011.[29]

Policies should trend towards differentiated incentives based on energy savings, with pure EV probably receiving the highest subsidies, hybrid the least, and PHEV mid-level subsidies. The current leading players in PHEV and EV are BYD, Wanxiang, Chang an, SAIC, Chery, and Tianjin Qingyuan. However, others will rapidly join and new players will emerge. There are more than 25 companies that claim to have Li-Ion capability for EV applications.

China may become a technology hub for e-components, and Chinese suppliers may have some natural advantages such as low raw material costs, low manufacturing costs, the use of cheaper domestically produced tooling and other equipment, a significant existing manufacturing base for Li-Ion batteries, and vast resources being deployed for Li-Ion research and production ramp-up. China has 80 percent of global neodymium, a critical material for permanent magnets, and it is also the world's third largest country in lithium reserves. Chinese suppliers have already developed $LiFePO_4$ batteries; however, China lacks the capability for producing periphery and power/thermal management electronics and software. Future cross-border M&A transactions and partnerships could address this area.

Latin America – Brazil

The Brazilian government has increased its focus on environmental protection via emissions regulation, with the result being that OEMs in Brazil have been under greater scrutiny. In response to previous versions of PROCONVE standards, OEMs and suppliers were forced to include components and technologies such as catalytic converters, electronic fuel injection, and other components such as exhaust gas recirculation (EGR) valve, oxygen sensor, high-energy ignition, and secondary air injection in order to meet regulations.

The Brazilian Ministry of Environment recently issued a ranking of the pollution that certain model cars produce according to criteria adopted by the PROCONVE regulations. The list ranks 250 models with alcohol and gasoline engines, and compares their levels of CO_2 emissions, nitrogen oxide, carbon monoxide, and hydrocarbons, with the latter accounting for 99 percent of vehicle pollution.[30] Each model receives a so-called "Green Rating" on a scale of 0 to 10. The calculation of the Green Rating is based on the average emissions of the three greenhouse gases (carbon monoxide, hydrocarbons and oxides of nitrogen), measured in production tests and compared to the maximum emissions allowed in the PROCONVE legislation. Although the National Association of Automobile Manufacturers (ANFAVEA) took issue with the testing and ranking procedures, the news garnered

[29] China Economic Review "The Long March", June 2009
[30] "Consulta dos níveis de emissão dos veículos novos brasileiros", www.ibama.gov.br

significant public and media attention due to the government's creation of a Web site that allows consumers to see how their vehicles rank.

More recently, in response to increasing regulatory and public pressure, OEMs have accelerated the development of technologies focused on reducing vehicle emissions. Although emissions targets are similar to those in Europe, the fact that most vehicles sold in Brazil are flex-fuel and can potentially run on up to E100 fuel has meant that customized solutions must be implemented for the Brazilian market.

One example of the changes required by OEMs to meet the latest requirements can be seen in the 2009 Chevrolet Astra. The new 2.0L Flexpower engine introduced in the vehicle meets the new technical requirements in force since the February 1, 2009 enactment of the latest PROCONVE phase. Developments to the engine included weight reduction, changes to the torque curve, the usage of Low Friction Valvetrain, two catalytic converters that optimize the load distribution of precious metals for better system efficiency, and a second oxygen sensor that constantly analyzes the efficiency of the catalytic converters, readjusting the mixture when necessary.

Other OEMs introducing E100 are quickly addressing customer inconveniences, such as the need to maintain a second gasoline tank under the hood to provide adequate cold starts. Since ethanol vaporizes at higher temperatures than gasoline, E100 engines in Brazil start and run on gasoline for the first few minutes when the weather is below a certain temperature. This requires a separate gas tank that is traditionally mounted in the engine compartment.

Due to the nature of the Brazilian market and the number of vehicles the country produces, every major powertrain component supplier has local development teams focusing on meeting local standards as well as using Brazil as a test market for new technologies related to pure ethanol (E100) vehicles. Preheating the ethanol prior to vehicle starting has been one potential solution to resolving these issues; however, these systems have historically been inconvenient. Recently, a fuel injection system that preheats the ethanol has been developed by Bosch and Magneti-Marelli, where the glow plugs are located directly in the fuel rail. Although this still involves a slight delay before the engine can be started, it provides significant improvement over current systems. Magneti-Marelli has also developed the TetraFuel system that allows a vehicle's engine to function on four different fuel types: gasoline, ethanol mix, pure ethanol, or compressed natural gas.[31] Other suppliers have been working on new types of fuel injectors that incorporate a heating element within the injector itself.

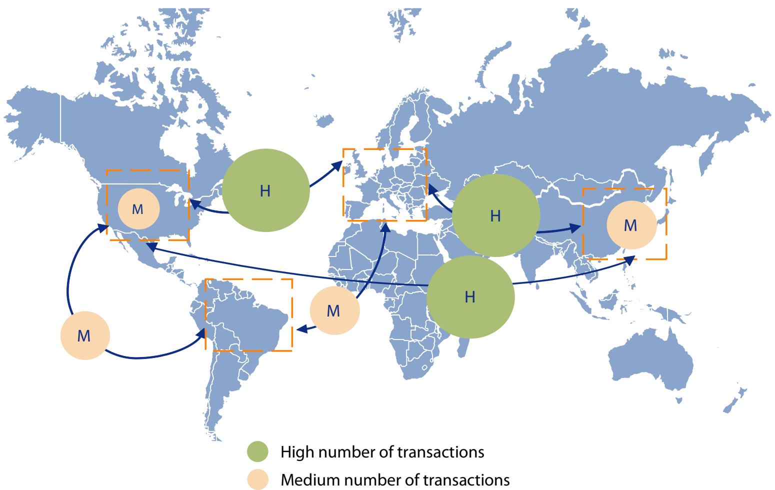
[31] Magneti-Marelli company website

Impact of the Regulations on the Industry

Local regulations and market dynamics may force many companies to consolidate, divest, or exit from some geographies or businesses altogether. Automotive companies may have to revisit their product portfolio and manufacturing footprint to remain competitive in the complex and changing global regulatory environment. For example, North American and European companies that are facing a high level of distress may choose to divest some of their assets to Asian or European counterparts to raise necessary capital for growth. Companies may also consolidate regionally to rebalance their product portfolio in light of new fuel efficiency and emission standards, and to reduce costs. The availability of private capital and government incentives, such as the United States government's funding of clean technologies or the Chinese government's push for acquiring foreign assets, may also play a key role in shaping the automotive industry's future.

KPMG LLP analyzed the regulatory forces and market dynamics across different regions to estimate the likelihood of intra-region and inter-region transactions at a macro level around the globe. Transactions include mergers, acquisitions, divestures, joint ventures, technology licensing, and the development of major supply relationships between two or more companies. Our analysis considered such factors as the present gap between existing emissions and government-mandated standards, the degree of regulatory enforcement, current market size, the number of distressed suppliers, clean technology capability, and the availability of capital, among other factors. Based on these considerations, we assigned a rating of "High", "Medium" or "Low" attractiveness for intra-and inter-region combinations to reflect our judgment of the propensity of transactions across regions.

Projected Automotive Transactions
(Mergers & Acquisitions, Divestitures, Joint Ventures etc.)



Note: Low number of transactions not shown on chart

Assessment Criteria				
Criteria	**North America**	**Europe**	**Asia**	**Latin America** (Brazil)
Regulatory pressure	◕	◕	◑	◔
Emission standards	◕	◕	◑	◑
Market size ($B)	150	200	100	5
Number of suppliers (No)	3500	3800	3700	250
% Distressed suppliers	50%	30%	10%	10%
Clean Tech capability	◔	◑	◑	◔
Capital availability	◔	◔	◑	◔

● = High ◑ = Medium ○ = Low

Source: Ward's Auto, OEM Interviews

Our findings, as presented in the map above, suggest that the most attractive transactions appear to be between North America and Asia, followed by Europe and Asia then North America and Europe, which is also aligned with our general understanding of the current industry trends.

In North America, a combination of factors such as a stringent regulatory environment coupled with slower market growth, a higher number of distressed suppliers, larger average vehicle size, and the relatively low experience of incumbents with clean technologies make the region predisposed to doing transactions with Asian and European companies. North American companies may increasingly look to shed unprofitable assets to companies that can benefit from their brand names, assets, and market reach. A recent example might be GM's divesture of the gas-guzzling Hummer model to a small Chinese company looking to capitalize on Hummer's increasing popularity in China. North American OEMs may also establish supply relationships or joint ventures with technology leaders in Asia or Europe. For example, GM and Ford have signed agreements with LG of Korea, an independent battery supplier. Ford licenses hybrid technologies from Toyota in exchange for Ford's diesel and direct-injection engines technologies. Aisin Seiki Co. Ltd., a Japanese automotive components supplier belonging to the Toyota Group, supplies the hybrid transmissions for some Ford hybrid models.

In such a dynamic environment, those suppliers that emerge as preferred partners may be able to leverage their global scale to further reduce technology costs and thus increase their industry influence. European companies that lead the development of diesel technologies and produce smaller and more fuel-efficient vehicles may be able to leverage their experience in other parts of the world where the demand for diesel-based small cars is rapidly increasing. Major European companies such as BMW, Audi, and Volvo are already making a strong push for diesel models in the United States market as the United States gradually warms up to diesel powertrains.

Asian companies with relatively higher growth rates, lower cost structures, and clean technology know-how may increasingly scoop up attractive assets from more mature markets. For example, India's Tata Motors acquired Norwegian electric vehicle maker Miljo Grenland Innovasjon and leveraged its technology to create the Electric Indica, an electric version of the Indian model to be sold in Norway. We might increasingly see similar transactions where a low-cost manufacturer acquires strategic assets abroad to enter those markets with new models. Similarly, Asian companies may make efforts to acquire auto parts manufacturers in the United States and elsewhere to increase technology know-how and expand their market reach. Mitsubishi Steel Mfg Co Ltd of Japan acquired a majority interest in Meritor Suspension Systems Co, a U.S. manufacturer and wholesaler of motor vehicles parts, in June 2009. The Asian advantage, stemming largely from capital availability and domestic market growth, may spark interest in more transactions in the foreseeable future. Asian automotive suppliers with expertise in one of the new technology areas may also choose to forward integrate to compete with the incumbent OEMs. A good example is BYD, originally a Chinese battery producer, which has started to produce low-cost electric vehicles to compete in the growing electric vehicles market in China.

Besides the inter-region transactions discussed above, North America and Europe are expected to continue to observe intra-region consolidations and divestures, as distressed companies try to restructure their business model. The timing could not be better for stronger companies with access to capital to assess struggling companies as potential targets. Equinox Group of Switzerland recently acquired a 96 percent interest in bankrupt Celette SA, a manufacturer of motor vehicle body repair parts. To quickly grow by capitalizing on this environment, smaller automotive companies may try to gobble up large distressed companies. In Asia, similar transactions are occurring; Alpha Design Co Ltd acquired the entire business of bankrupt Tonami Seisakusho Inc., a Japanese manufacturer and wholesaler of parts. Europe, too, is seeing similar activity. Volkswagen AG agreed to acquire Wilhelm Karmann GmbH, a German manufacturer of cars in November 2009 after it went bankrupt and started looking for a buyer.

Given the variance of regulatory frameworks around the world and the lack of will and direction to harmonize the regional standards into a single global standard, companies may choose to develop multi-pronged strategies to minimize risks and maximize returns. For example, Toyota is now planning to introduce clean diesel engines after having launched a successful hybrid program. Toyota also plans to introduce lithium-ion hybrid vehicles in some markets through a joint venture with their battery supplier, Panasonic. Companies may increasingly engage their suppliers, and sometimes their competitors, to bring best-of-breed technologies to the market at the lowest cost. Since technology costs highly correlate with manufacturing scale, a small number of suppliers with large footprints in a technology area may emerge as cost leaders with a significant competitive advantage. Some of these suppliers may also form regional clusters based on government incentives and other favorable business conditions. Federal funds introduced by the United States government for R&D in clean technologies and for re-tooling existing factories may motivate companies to increase their United States footprint.

Conclusion

The next 5 to 10 years may bring substantial structural changes to the automotive industry. Although a large portion of the global automotive industry is still in distress, companies have to look beyond their short-term survival challenges to become successful in the long run. A longer-term strategy will involve rebalancing product portfolios and shedding unprofitable assets, as well as investing in strategic growth areas through a complex web of global relationships. As a result, successful companies will increasingly become global, asset light, and responsive to market shifts. A clearly defined global M&A strategy will play a dominant role in separating winners from losers, and eventually shape the future of the global automotive industry.

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