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CHANGING DRIVERS

The Impact of Climate Change on Competitiveness and Value Creation in the Automotive Industry

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Executive Summary

The purpose of this report is to help investors make better informed decisions regarding automotive company stocks in light of emerging "carbon constraints"—policy measures designed to mitigate climate change by limiting emissions of carbon dioxide (CO_2) and other greenhouse gases. This report explores how carbon constraints in global automotive markets may affect value creation in 10 leading automotive companies between now and 2015, a timeframe in which major technological and policy changes are possible. The Original Equipment Manufacturers (OEMs) assessed are BMW, DaimlerChrysler (DC), Ford, GM, Honda, Nissan, PSA, Renault, Toyota and VW—the world's largest independent automotive companies. The geographical scope of the assessment is the United States, European Union and Japanese markets, which together account for nearly 70 percent of current global sales.

This report is the result of collaboration between SAM Sustainable Asset Management (SAM)—a Zurich-based independent asset management company specializing in sustainability-driven investments—and the World Resources Institute (WRI)—an environmental research and policy organization based in Washington D.C. Drawing on the respective strengths and expertise of the two organizations, the report analyzes both the risks and opportunities of carbon constraints, and then estimates the combined implications for OEMs' future earnings. The report is explicitly forward-looking, focusing on the main factors affecting OEMs' exposure to carbon constraints, and drawing on the latest publicly available information about the 10 assessed OEMs.

MAIN FINDINGS AND CONCLUSIONS

Emerging carbon constraints could significantly impact the automotive industry, primarily through pressure to increase the fuel economy or lower the CO_2 emissions intensity of vehicles. As carbon constraints take hold, OEMs able to produce vehicles with lower carbon emissions could see global market share increase and financial performance improve. In contrast, OEMs that produce more carbon-intensive vehicles may have diminished ability to compete in global markets with adverse consequences for their shareholder value.

Carbon constraints are already in place in major automotive markets. The European Union and Japan have both made strong commitments to lower the CO_2 emissions rates of vehicles. To date, the United States has made less of a commitment. However, debate over federal Corporate Average Fuel Economy (CAFE) standards continues, while a 2002 California law seeks to regulate vehicle CO_2 emissions for the first time. As an indicator of growing pressure in this area, over 60 percent of global vehicle sales in 2002 occurred in countries that have ratified the Kyoto Protocol.

A large number of lower-carbon technologies are emerging that may transform the industry. Further modifications to the conventional internal combustion engine (ICE) platform to improve carbon performance will be introduced but diesel engines, hybrid electric vehicles (HEVs), and fuel cell vehicles (FCVs) are all set to challenge the traditional gasoline-ICE vehicle. However, there is much uncertainty regarding which technology(ies) will emerge as winner(s). OEMs face a considerable challenge not only in developing new technologies, but also in devising an innovation strategy that is robust across multiple possible technology pathways. Developments in lower-carbon technologies over the next decade have the potential to alter significantly the competitive balance within the industry.

OEMs are differently positioned to respond to the challenges of carbon constraints. This is because of differences regarding:

- segment mix (e.g., 49 percent of DC's 2002 sales in US, EU and Japanese markets were light trucks compared to only 3 percent for VW).
- carbon intensity of models (e.g., the average GM sports utility vehicle (SUV) emits 41 percent more carbon emissions per kilometer (km) traveled than the average Honda SUV).
- geographic distribution of sales (e.g., GM and Ford are dependent on sales in the United States while PSA and Renault primarily sell vehicles within the European Union).

The structure of each OEM's product portfolio largely determines its current "carbon intensity of profits." OEMs with a high carbon intensity of profits rely on high carbon-emitting vehicles to generate profits and create shareholder value, and face a harder task in responding to carbon constraints.

OEMs are also differently positioned by virtue of their innovation and R&D choices and their overall management quality regarding carbon constraints. Through internal development choices and external partnerships and alliances, OEMs have different access to new technologies that may come to dominate the market. Carbon constraints could accelerate the need for lower-carbon technologies, raising the significance of OEMs' plans for developing these technologies.

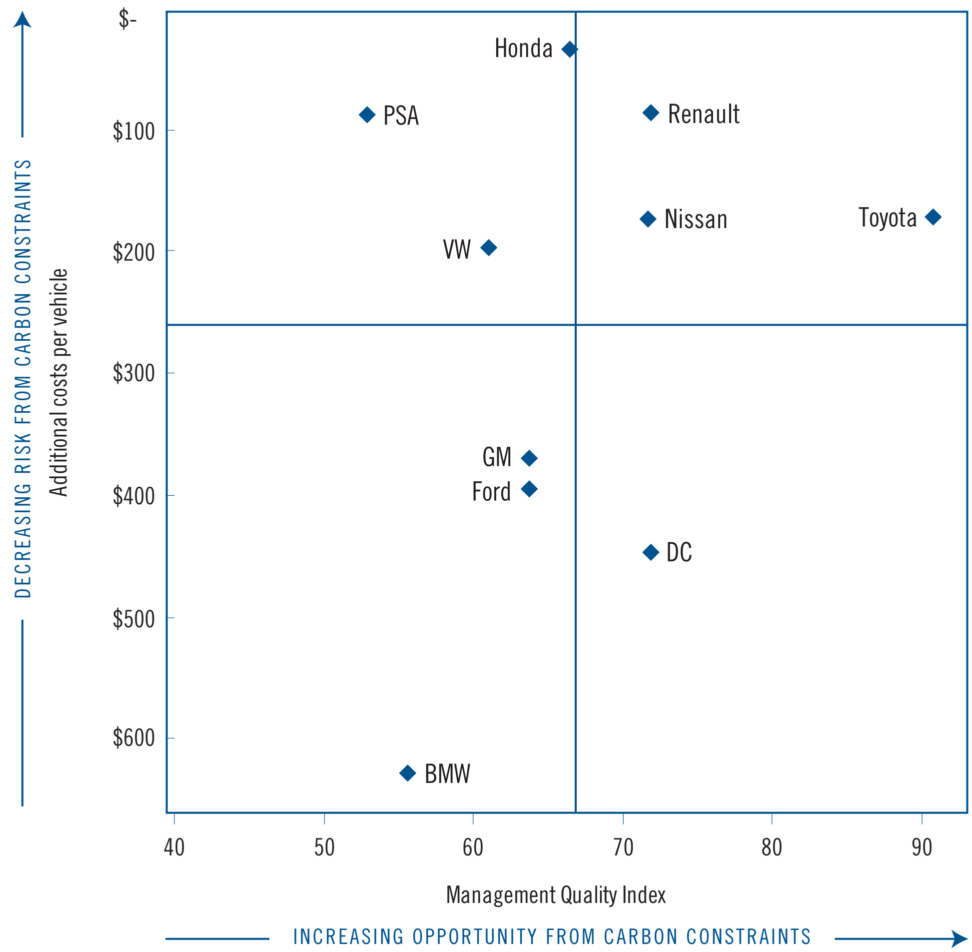
ANALYSIS AND RESULTS

For this report, we performed two complementary analyses:

- A **Value Exposure Assessment** identifies the risks of carbon constraints in terms of the estimated costs for each OEM to meet new CO_2 emissions standards by 2015.
- A **Management Quality Assessment** identifies the opportunities for OEMs to capitalize on carbon constraints and enhance their competitiveness, by virtue of their superior management quality and focus on lower-carbon technologies.

The results of the separate assessments are illustrated in Figure ES.1. Risks are presented in terms of average additional cost per vehicle in 2015 (lower costs are better). The upside strategy opportunities are expressed as a qualitative score between 0 and 100 (higher scores are better). OEMs in the top right quadrant can be considered “lower carbon leaders” with below average exposure to risks and above average management quality with regard to lower carbon technologies.

FIGURE ES.1. QUANTIFICATION OF THE RISKS (Value Exposure) AND OPPORTUNITIES (Management Quality) OF CARBON CONSTRAINTS



Note: The lines indicate industry averages in each category.

Several findings are of note:

- OEMs vary considerably with respect to both value exposure and management quality around carbon constraints. This indicates that carbon constraints have the ability to influence competitive balance within the industry.

- Honda is the OEM that has the lowest value exposure. It faces the least immediate risk from carbon constraints as the current high fuel efficiency of its vehicles implies only minimal costs to meet new standards. Toyota emerges as the clear leader on carbon-related management quality with a strong position in all three technologies that will be key for long-term competitiveness.

- Renault and Nissan are also strongly positioned with better than average management quality scores and lower than average expected costs from carbon constraints.

- PSA and VW are two other OEMs that have lower than average value exposure, while DC has above average management quality with regard to carbon constraints.

- BMW stands out as having the greatest value exposure, though this may be somewhat misleading. BMW is the smallest of the 10 OEMs reviewed and produces exclusively premium (and high cost) vehicles. Consequently, BMW should have a greater ability to pass on those costs to consumers than do other OEMs.

- PSA has the weakest management strategy regarding carbon constraints, which may limit its ability to exploit opportunities even though it faces low expected costs.

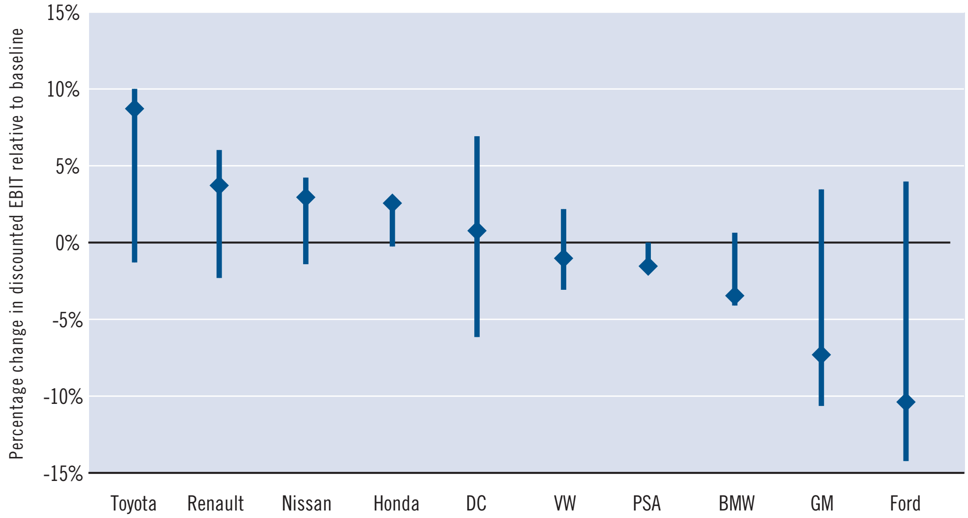
- Ford and GM both have above average value exposure and below average management quality regarding climate risks. Their value exposure is driven principally by the relatively low fuel efficiency of their current vehicle mix. While much of this is due to their leadership in the carbon-intensive segments of the US market, which may not face immediate constraints, their current bias towards heavy vehicles coupled with below average positioning on hybrid and diesel technology may limit their near-term competitiveness in non-US markets.

A key challenge for analysts is to determine the implications of these findings for shareholder value creation. Consequently, we translate the results of both the Value Exposure and Management Quality assessments into changes in forecasted EBIT (Earnings before Interest and Taxes) for the period 2003 through 2015. EBIT is a foundation for valuation estimates in this sector and so changes in an OEM's EBIT offer useful insight into possible changes for overall Return on Invested Capital (ROIC) and thus shareholder value.

Converting our cost estimates and management quality scores into EBIT figures sets our results in the context of existing and projected business performance. Though this adds confounding factors to our initial results (e.g., differences in existing EBIT margins across OEMs), it nonetheless represents the basic challenge facing investors: to understand the additive effect that carbon constraints may have on each OEM's financial position.

The combined results presented in Figure ES.2 show the range of possible effects on EBIT, in terms of percentage changes from business-as-usual EBIT projections. The upper limits reflect the results from the Management Quality Assessment alone, which captures the opportunity for OEMs, while the lower limits are results from the Value Exposure Assessment alone, which reflect risks. The points indicate the combined impact of both assessments on EBIT.

FIGURE ES.2. POTENTIAL IMPACT OF CARBON CONSTRAINTS FOR DISCOUNTED EBIT (2003–2015) BASED ON VALUE EXPOSURE AND MANAGEMENT QUALITY ASSESSMENTS



Combining value exposure and management quality scores into a single EBIT measure (shown as points in ES.2) again reveals wide variety in values across OEMs—from a possible increase in discounted EBIT of 8 percent to a decrease of 10 percent. Toyota appears best positioned, while Ford has the weakest result.

While the findings refer primarily to carbon constraints, they also shed light on how OEMs may perform in response to other pressures that would lead consumers or regulators to value fuel economy more highly (e.g., energy price rises or renewed energy security concerns). Indeed, consumer and policy responses to energy market shocks may play out considerably more rapidly than the steady progress in carbon regulations envisaged in this report, potentially making manufacturing adjustments more awkward. If so, the impacts on OEMs—whether positive or negative—may be more extreme than reported here.

SECTION I THE CONTEXT

Climate change is a relatively new issue for the automotive industry, and one that may have significant financial impacts for the sector. Climate change policies are already in place in several major automotive markets and appear likely to spread, forcing OEMs to lower the carbon emissions profile of new vehicles. At the same time, new technology options in various states of development offer the potential to meet new carbon constraints while increasing profitability. Carbon constraints thus create a combination of risk and opportunity for OEMs.

Chapter 1 describes recent developments and policy impacts around the climate change issue in the United States, the European Union and Japan. The chapter also explains how climate change may impact important value drivers and create new management challenges.

Chapter 2 outlines the most likely technology options available to OEMs to respond to carbon constraints. Because it is not clear which technology option(s) will emerge as winner(s), this chapter also identifies strategic partnerships between OEMs that might point to future changes in the industry's structure.

Chapter 1

Climate Change and the Automotive Industry

SUMMARY

Efforts to prevent climate change have already led to policies in the European Union and Japan to constrain carbon dioxide (CO_2) emissions from vehicles. Similar restrictions look likely in other markets, including potentially the United States. Over the next decade, these carbon constraints will become a defining force for the automotive industry. Carbon constraints are likely to influence conventional value drivers within the automotive sector and will create significant challenges for senior managers. OEMs well-positioned to deal with new carbon constraints could find themselves with a competitive advantage over those who are unable to adapt to new rules and market conditions.

1.1 CLIMATE CHANGE AND EMERGING CARBON CONSTRAINTS

Carbon constraints are emerging in major automotive markets…

Several of the world's major automotive markets are adopting policies to reduce vehicle-related carbon dioxide (CO_2) emissions. These "carbon constraints" will push automotive Original Equipment Manufacturers (OEMs) to produce vehicles that emit fewer CO_2 emissions per kilometer (km) traveled. The European Union and Japan already have programs in place that call for significant CO_2 reductions over the next decade. Even in the United States, which has resisted raising fuel economy standards through most of the 1990s, there are signs that vehicle sales will be affected by carbon constraints in the future. A 2002 California law seeks to regulate vehicle CO_2 emissions and other states have indicated an interest in following California's lead.

The emergence of carbon constraints in automotive markets reflects ongoing concerns about the threat of climate change and the scale of vehicles' contribution to the atmospheric buildup of CO_2, the principal greenhouse gas (GHG).

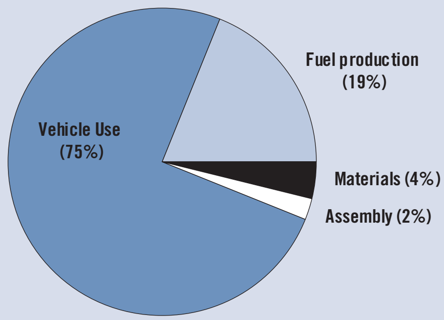
… because of concerns about climate change…

The latest scientific evidence indicates that human activities are leading to increased accumulations of greenhouse gases in the atmosphere, which are altering the Earth's climate patterns at unnatural rates. The Intergovernmental Panel on Climate Change (IPCC) has found that global average temperatures rose by 0.6° Celsius over the last century,[1] and that "most of the warming observed over the last 50 years is attributable to human activities."[2] The IPCC predicts further increases in the Earth's average surface temperature ranging from 1.4° to 5.8° Celsius by 2100.[3] A changing climate could lead to unpredictable and costly consequences, including rising sea levels, spread of infectious diseases into new areas, and altered incidence and location of extreme weather events such as hurricanes, monsoons, and droughts.

BOX 1.1. Cars and Climate Change: Tracing the Connection

While CO_2 emissions arise at nearly every stage of a motor vehicle's life—including extraction of raw materials and manufacturing of component parts—it is the combustion of gasoline and diesel fuels during vehicle use that accounts for the greatest share of vehicle-related CO_2 emissions. (See Figure.)

EMISSIONS FROM THE LIFE CYCLE OF A TYPICAL VEHICLE



Source: Derived from Weiss et al., 2000.

Consequently, emissions from vehicle use are where effective climate policies are most likely to focus and where OEMs have the greatest scope to establish a competitive advantage over their rivals. While CO_2 emissions can be reduced at the assembly stage—as some OEMs are showing—potentially much greater reductions are possible in the "use phase." Based on a 1996 Toyota Camry rated at 28 mpg, a 5 percent reduction in use phase emissions will save 3.75 metric tons of CO_2 over the vehicle's lifetime (3 metric tons from avoided gasoline combustion and 0.75 metric tons from avoided fuel production). In contrast, a 5 percent reduction in assembly-related emissions will save only 0.1 metric tons of CO_2 per vehicle.

The figure is also revealing of the different approaches taken by regulators around the world. Climate-related policies in the European Union, Japan, Canada, Australia and California have targeted the 94 percent of emissions directly or indirectly associated with vehicle use. In contrast, the US Administration's voluntary climate program encourages OEMs to reduce assembly-related emissions that make up just 2 percent of overall life-cycle emissions.

Though much uncertainty remains regarding climate trends and the severity of potential impacts, the threat of climate change has prompted concern and action at national and global levels. The most conspicuous policy step has been the Kyoto Protocol, which is intended to initiate a long-term process of reducing global GHG emissions.[4] As of October 2003, 111 countries had ratified the Protocol, including those responsible for 60 percent of 2002 global vehicle sales.[5] A notable exception is the United States, which has rejected the Protocol out of concerns about the economic costs it may impose and because it fails to cover key developing countries that will be major emitters in the future.[6]

Regardless of the Kyoto Protocol's fortunes, concern about climate change is unlikely to abate. Economic growth in the near term will increase emissions of CO_2 and other GHGs, while increasing prosperity will intensify demand for environmental protection. As business leaders at the World Economic Forum in Davos noted in 2000, "climate change is the greatest global challenge facing humankind in the 21st century."[7]

… and because of vehicles' contribution to the climate change problem.

The automotive sector is a major source of CO_2 emissions and thus an obvious target for policy efforts. Emissions of CO_2 result primarily from the burning of fossil fuels, including gasoline and diesel. The transportation sector accounts for 30 percent of CO_2 emissions in the industrialized economies of the OECD (Organization for Economic Cooperation and Development) and about 20 percent worldwide.[8] In the United States, which leads the world in total CO_2 emissions from the transport sector, light-duty vehicles (i.e., cars and trucks) contribute about 20 percent of all US CO_2 emissions.[9] (See Box 1.1 for the sources of CO_2 emissions over the life cycle of a vehicle.)

Projections indicate that emissions from vehicles will grow significantly. The global fleet has been growing at a rate of about 16 million vehicles per year since 1970 and by 2025 is expected to reach 1 billion vehicles on the road.[10] Energy demand for transportation is projected to grow by 2.5 percent per year between 1999 and 2020, a higher pace than is expected for energy demand overall.[11]

The automotive industry is increasingly aware of the need to lower the carbon emissions of its vehicles. The World Business Council on Sustainable Development's Mobility Project identifies as one of the "grand challenges" for a sustainable future the need to "drastically reduce carbon emissions from the transportation sector."[12] All but two of the OEMs analyzed in this report are members of the Project.[13]

The most significant carbon constraints target emissions generated during vehicle use.

The bulk of automotive-related CO_2 emissions occur during vehicle use. Thus, fuel economy and CO_2 emissions standards offer the best prospect for reducing vehicles' contribution to climate change. (See inside back cover for details on the relationship between fuel economy and CO_2 emissions standards.) This type of carbon constraint is already in place in some of the world's major automotive markets.

- In the **European Union**, dialogue between regulators and the automotive industry trade association (Association des Constructeurs Européens d'Automobiles, or ACEA) inspired a voluntary commitment from the industry to reduce CO_2 emissions from passenger cars by 25 percent relative to 1995 levels by 2008. This would bring emission rates to a level of 140 g CO_2 per km traveled, or approximately 39 miles per gallon (mpg). Depending on early progress, ACEA may extend the target to 120 g CO_2/km (or 46 mpg) by 2012.

- In **Japan**, new legislation requires fuel economy improvements in cars of 23 percent beyond 1995 levels by 2010. Specific targets vary with vehicle weight but extend to 125 g CO_2/km (44 mpg).

- In **Canada**, the government has proposed a target of improving vehicle fuel efficiency by 25 percent by 2010 as part of its Climate Change Plan.[14]

- In **Australia**, the automotive industry has responded to the government's challenge to improve fuel economy by announcing a voluntary commitment to improve fuel economy by 18 percent by 2010.[15]

To date, the **United States** has taken no comparable action to regulate vehicle emissions in response to the climate change challenge. Although the Corporate Average Fuel Economy (CAFE) standard for light trucks was moderately tightened in 2003 – to improve light truck fuel economy by 7 percent by 2007 – the fuel economy standard for cars remains fixed at the 27.5 mpg (201 g CO_2/km) level first set in 1990. Moreover, the US Congress has repeatedly rejected bills proposing higher fuel economy standards and has shown no willingness to take action on climate change.

However, carbon constraints may emerge in at least parts of the US automotive market over the next decade. A 2002 California law requires the Californian Air Resources Board to adopt rules to achieve the "maximum feasible reduction" in GHG emissions from cars and light trucks. The regulations will go into effect in 2006, but will give OEMs until 2009 to comply. Though not a national law and still subject to challenge in court, this initiative could have profound implications for OEMs. California accounts for one out of eight new US vehicle registrations[16] and other states, most notably New York, have expressed an interest in following California's lead.

Other policies may reduce automotive-related GHG emissions.

Though fuel economy or CO_2 emissions standards offer the best prospect for reducing carbon emissions from the automotive sector, a wide range of complementary policies designed to lower the climate change impact of cars could affect OEMs. Placing a price on CO_2 emissions through direct taxation of emissions or by instituting a carbon cap-and-trade program would increase fuel costs and encourage consumers to purchase more fuel-efficient vehicles. Tax credits or penalties based on a vehicle's fuel economy or technology are another policy option for reducing GHGs. For instance, the United States now imposes certain tax penalties on "gas-guzzlers," while some local jurisdictions give preferential treatment to cleaner-technology vehicles in various ways, including lower taxes as well as access to road space (e.g., high occupancy lanes) and parking. Many governments have sought to advance automotive technology through government-industry partnerships. Such partnerships could help new lower-carbon technologies become viable in the marketplace.

Carbon constraints overlap with energy security concerns and energy price risks.

Carbon constraints also interact with well-established efforts (e.g., CAFE) to improve vehicle fuel economy that have been motivated by energy security concerns and questions about the long-term supply of hydrocarbons. In this report, we focus on the impetus to improve fuel economy for reasons of climate change. However, the findings are also relevant for considering how OEMs would perform in response to other pressures that would lead consumers or regulators to value fuel economy more highly (e.g. significant energy price rises or enhanced energy security concerns). Indeed, while carbon regulations can be expected to develop at a measured pace (as regulators pay heed to OEMs' operating constraints), history has shown that movements in energy markets can be more sudden. Steep price rises may lead to rapid changes in consumer preferences, as occurred in the 1970s, and accelerate policy developments. In such circumstances, the possible impacts on OEMs, whether positive or negative, may be more extreme than those reported here.

Will emerging markets embrace carbon constraints?

While this report focuses on automotive markets in developed countries, a key issue for the industry is whether other countries that constitute major emerging automotive markets will embrace carbon constraints as part of their development path. Though the mature automotive markets of the United States, European Union and Japan accounted for nearly 70 percent of global vehicle sales in 2002, emerging markets will account for most of the growth in the industry in coming years, given the pace of income and population growth.[17] Developing countries' share of global automotive sales is projected to rise from 24 percent in 2000 to 49 percent by 2020.[18] Consequently, emerging markets hold the key for sales and profit growth over the next two decades and OEMs wanting to be global players will need to ensure that they are positioned to sell appropriate models.

Of all emerging markets, China captures the most attention. Vehicle sales have been surging in recent years alongside rising personal incomes. Recent sales growth rates have exceeded 56 percent per year.[19] Moreover, there is extraordinary growth potential. In 2001, vehicle ownership in China was 13 vehicles per 1,000 persons, compared with 779 per 1,000 in the United States.[20]

Though the Kyoto Protocol, which China has ratified, does not require China to make CO_2 reductions before 2012, the growing prominence of the Chinese economy means that it will almost certainly face future CO_2 reduction obligations. However, a number of more immediate factors suggest that fuel economy will be an important feature of the developing Chinese vehicle market. First, China has relatively small domestic oil reserves. The country is already a net importer of oil even though its car ownership rates are 1/60th of those in the United States. This should encourage a focus on fuel-efficient vehicles as a way to minimize future energy dependency. Second, low average income of less than $1,000 per year will steer Chinese consumers towards smaller vehicles and will ensure that a relatively high value is placed on fuel economy.[21] Third, in a bid to alleviate China's serious air quality problems, the government has set a goal of matching European vehicle emissions standards for conventional air pollutants by 2010.[22] Improving fuel economy will help to meet this goal. Finally, high population density and crowded cities should support demand for the small, or "smart", cars increasingly seen in Japanese and European cities.

While it remains to be seen exactly how China and other emerging markets develop, OEMs will need to be mindful of influences that directly or indirectly encourage more fuel-efficient and less carbon-intensive vehicles.

Investors will need to monitor the development of carbon constraints.

The likely cumulative effect of the above developments suggests that concern about climate change will exert a significant influence over the industry in the next decade. This influence will increasingly be felt in all major markets, with key uncertainty about developments in the United States. As concerns about climate change mount, so too will investors' attention to companies' management of new carbon-related risks and opportunities. Companies well-positioned to handle these constraints will find themselves with a competitive advantage over those who are unable to adapt to new market conditions and rules.

Given the growing importance of climate-related policies, automotive analysts may follow other financial market actors in wanting to know more about the risks and opportunities of emerging carbon constraints. Under the recent Carbon Disclosure Project, 35 major institutional investors (representing over $4 trillion in assets) signaled their concern about the possible impacts of climate change for companies' financial performance by asking the world's 500 largest quoted companies to disclose investment-relevant information on their GHG emissions.[23] The project concluded that carbon constraints could have a differential impact on companies' financial performance. It also found that most investors currently suffer from a significant information deficit on the topic.

1.2 CARBON CONSTRAINTS AND VALUE CREATION IN THE AUTOMOTIVE SECTOR

Carbon constraints will affect the industry's traditional value drivers.

Carbon constraints constitute new sources of risk and opportunity that investors and managers will have to consider alongside existing industry fundamentals. In particular, carbon constraints could influence OEM competitiveness and profitability by affecting the industry's traditional value drivers. Conventional valuation models will need to be updated to reflect these new pressures.

The traditional value model for the automotive industry is based on supply and demand forces, which in turn determine sales volumes, pricing, margins and profitability.[24] (See Figure 1.1.) In addition to these tangible drivers, a number of intangible value drivers—such as brand, innovation and product quality—are increasingly viewed as important sources of competitive advantage and value creation. Intangible assets may represent as much as 50 percent of an OEM's market value.[25]

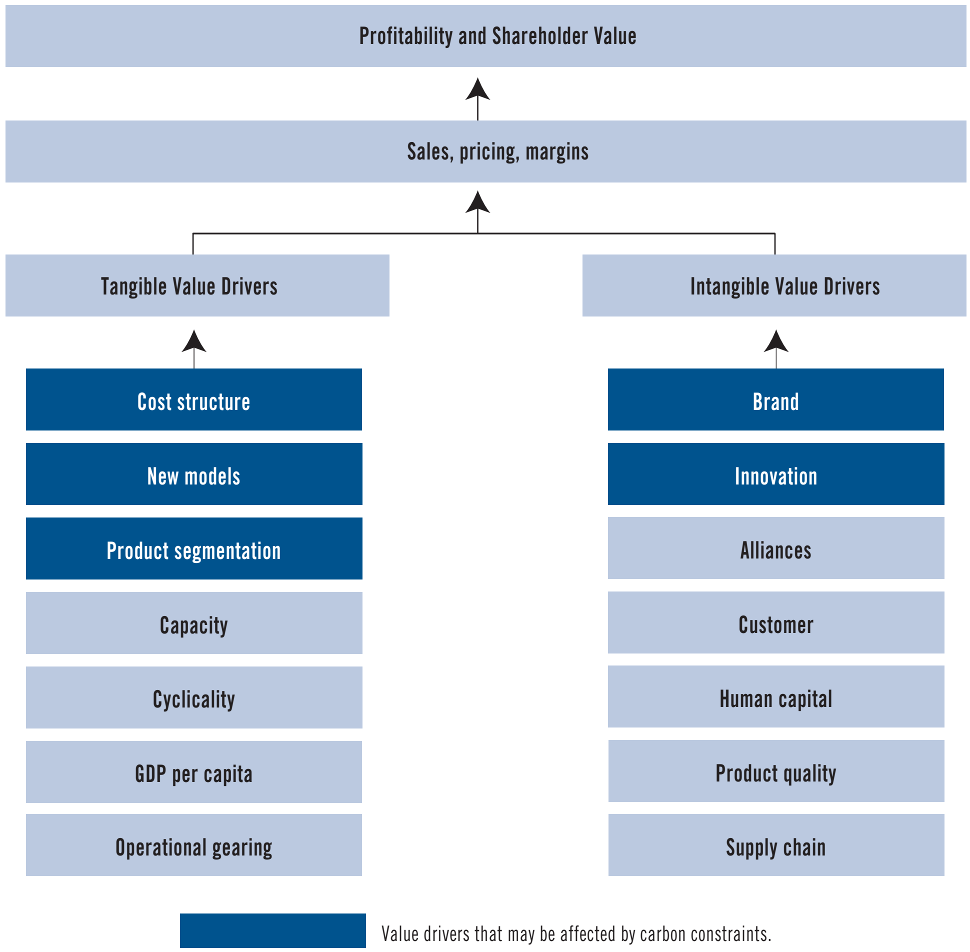
The automotive sector is a mature, low-growth industry.

Automobile manufacturing is a mature industry with current annual growth rates averaging around only 2 percent per year across all global markets. The sector's transition into a stable, low-growth industry is evident in the consolidation of 52 OEMs in 1964 into 12 today,[26] with further consolidation expected due to fundamental structural problems, such as production overcapacity.

The automotive industry is highly capital-intensive. To compete, OEMs must achieve significant economies of scale, which in turn raises barriers to entry and exit. The combination of low sales growth and high entry/exit barriers ensures marked rivalry and competitive pressure within the sector. This manifests itself in excessive additions to overall capacity, as each OEM tries to recoup large fixed costs through high sales volumes. The result is global production overcapacity, currently at around 30 percent, which puts pressure on pricing and margins, and erodes OEM value.

In mature, low-growth markets, OEMs can increase sales only by taking market share from another firm. In this "zero-sum game" environment, competitive advantages tend to be temporary. An important means of securing short-term advantage is through innovation. Successful innovation in the form of new models or technologies allows first-mover advantages, such as pricing power and higher margins. As a result, maintaining innovation capacity is essential for competitiveness in the automotive industry.

FIGURE 1.1. THE INFLUENCE OF CARBON CONSTRAINTS ON VALUE DRIVERS IN A TYPICAL AUTOMOTIVE SECTOR VALUATION MODEL



Source: Adapted from Deutsche Bank (2002).

Carbon constraints will complicate existing industry dynamics. While the influence of carbon constraints could permeate throughout the business, the following are some of the ways in which carbon constraints could affect key value drivers, positively or negatively:

Innovation

Maintaining innovative capacity is critical in the automotive industry as new models and technologies are a source of differentiation and competitive advantage. Carbon constraints add a new element to the innovation challenge. Leadership in lower-carbon technologies could translate into first-mover advantages of stronger pricing power and higher margins and create handsome payback on R&D outlays. New technologies could also be sold or licensed to others in the industry. Alternatively, falling behind in the development of lower-carbon technologies could see R&D expenditures go unrewarded. This awareness has led to a genuine race within the industry to develop lower-carbon technologies and bring them to market.

Brand

As homogenization of vehicles increases, OEMs compete more and more on non-manufacturing factors such as brand. Strong brands induce higher consumer loyalty, support higher prices and generate higher margins. Environmental quality can be an important component of brand and being viewed as a leader on climate change could enhance brand equity. Alternatively, losing ground to rivals in the development of lower-carbon technologies could undermine an OEM's brand value.

New models

The development and launch of new models is key for maintaining the sales volumes required to recoup the industry's high capital costs. OEMs increasingly employ "platform strategies" (i.e., use a common platform and powertrain for several different vehicle models) to enhance economies of scale and provide flexibility. Key components of platforms, such as engine design, remain stable for many years. To accommodate increasingly strict emission standards across all markets, OEMs must anticipate and address concerns related to climate change at multiple stages of production, including R&D, design and pre-production. Failure to address carbon constraints at these early stages could compromise a new platform's long-term viability in markets that subsequently adopt carbon constraints. In turn, this could harm sales growth and profitability.

Product segmentation

OEMs rely to varying degrees on different segments of the automotive market for their sales and profits. OEMs that depend on market segments featuring carbon-intensive (i.e., fuel-inefficient) vehicles, such as sports utility vehicles (SUVs), may be more exposed to emerging carbon constraints. Subsequent pressure to differentiate into less carbon-intensive segments to reduce the overall carbon intensity of the company's product portfolio could diminish profitability, given that most OEMs have derived less profit from the less carbon-intensive segments.[27] However, OEMs that can generate profits in lower-carbon (i.e., fuel-efficient) segments could benefit from this transition.

Cost structure

Carbon constraints could raise costs across all stages of the business, from R&D and design to production. OEMs may have to make changes to vehicle manufacture, from relatively minor changes to engines and transmission systems to potentially more radical changes such as moving to new powertrains. The recent CAFE increase for light trucks of 1.5 mpg over 3 years is expected to cost DC, Ford and GM $1.57 billion in aggregate.[28] Moreover, the race to develop lower-carbon technologies will put further pressure on R&D budgets. Overall, cost increases associated with rising fuel economy requirements could lead to higher retail prices and lower sales relative to a business-as-usual scenario. However, even if new standards impose absolute costs across the industry, some OEMs may gain competitive advantage by facing smaller cost increases than their competitors.

Carbon constraints create new management challenges.

Given these influences, carbon constraints also constitute a critical new management challenge for OEMs. Senior managers will have to consider the new dynamics created by carbon constraints alongside current industry trends. (See Box 1.2 for an example of how carbon constraints may exacerbate current trends in the US light truck market).

BOX 1.2. Carbon Constraints as a Competitive Factor in the US Light Truck Market

Over the last decade, light trucks, including sports utility vehicles (SUVs), have been a crucial source of profits for DaimlerChrysler (DC), Ford and GM (collectively known as the "Big Three"). However, the light truck segment is becoming increasingly competitive as other OEMs develop models and as segment sales plateau. Moreover, given the high CO_2 emissions of light trucks, the segment provides a good example of how carbon constraints pose an additional challenge for OEMs over and above existing industry dynamics.

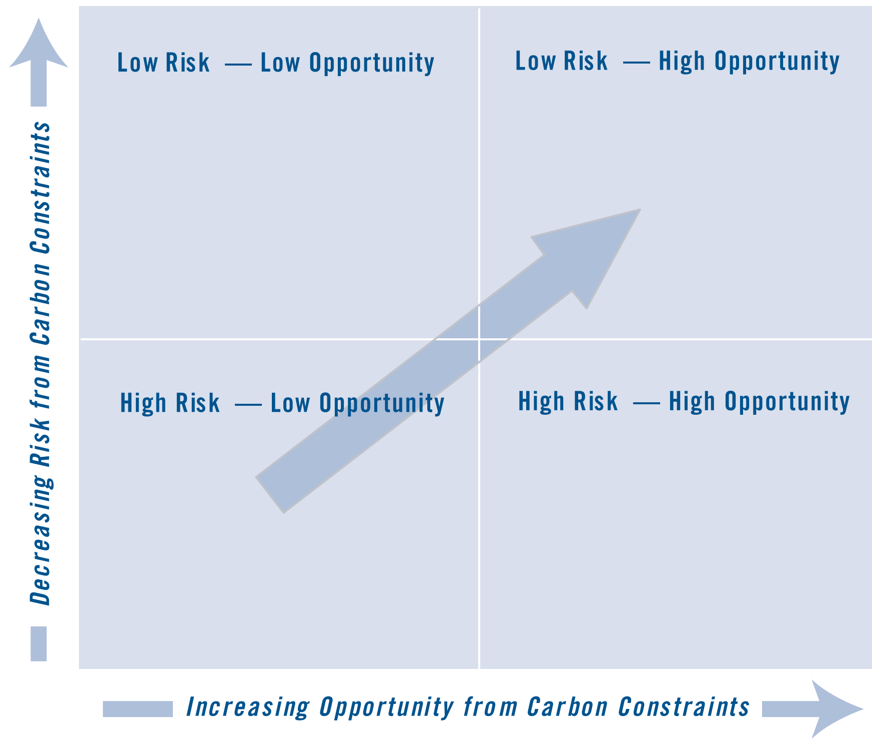
In the early 1990s, DC, Ford and GM introduced new lines of light trucks—the SUV and the minivan—especially designed as passenger vehicles. Because these passenger vehicles were classified as light trucks by the Corporate Average Fuel Economy (CAFE) program, they only needed to meet an average fuel economy of 20.7 mpg, permitting more powerful engines and progressively greater weight and size. American consumers quickly adopted these vehicles and light truck sales grew from 34 percent of the US market in 1990 to approximately 50 percent in 2001.

The Big Three enjoyed significant pricing power and high margins as consumers gravitated towards these larger vehicles. Moreover, high margins and profitability from these segments persisted for an unusually long period, as foreign OEMs initially dismissed demand for SUVs as a passing fad. Crucially, profits from the light truck segment concealed a structural weakness in the businesses of the Big Three—a growing inability to earn profits on small and medium passenger car segments, owing to stiff competition from non-US OEMs.

The Big Three's advantage in the light truck segment is now disappearing. The apparent permanence of demand for SUVs, minivans and pickups has drawn in other OEMs, even as demand growth starts to plateau. The result is growing capacity, increased competition and inevitable erosion of market share for the segment's pioneers. Worse, the strong bias towards light trucks in their product portfolios leaves the financial outlook of the Big Three particularly exposed to developments in these segments. Deutsche Bank estimates that over 70 percent of Ford's and GM's profits come from these segments. With their passenger cars earning little or no profits, the Big Three have resorted to aggressive efforts to maintain light truck sales by offering ever larger incentives and discounts, further eroding profitability.

On top of these existing industry dynamics, dependence on light trucks leaves the Big Three unusually exposed to carbon constraints. While margins and profitability in the light truck segment are expected to fall, the overall carbon intensity of these vehicles is expected to remain relatively unchanged in the near future. As a result, these OEMs are particularly exposed to the recent tightening of CAFE standards for light trucks or to proposals to harmonize CAFE standards for passenger cars and light trucks. Moreover, even if US regulators do not require further CO_2 reductions before 2015, the Big Three may find it challenging to compete in foreign markets that are increasingly adopting carbon constraints or value fuel economy for other reasons. The particular circumstances of the US market—high average income, low fuel prices and low fuel economy standards—has encouraged design and engineering choices that may make it harder for US OEMs to compete in global markets, even as non-US OEMs account for a growing share of US sales.

FIGURE 1.2. THE MANAGEMENT CHALLENGE OF CARBON CONSTRAINTS



A successful business strategy in a carbon-constrained market will be one that can maintain or enhance profitability from sales of progressively less carbon-intensive (more fuel-efficient) vehicles. Invariably, the management challenge will require both minimizing the risks and capitalizing on the opportunities noted above. Schematically, delivering value to shareholders in a carbon-constrained world will require that OEMs move into the top right quadrant ("low risk/high opportunity") of Figure 1.2. Indeed, under carbon constraints, this would be the only sustainable position for OEMs in the long term.

Not only are OEMs at different positions today with regard to this challenge, but the direction of immediate business plans may be inconsistent with moving to a more sustainable position. OEMs whose current business models envisage further growth in high carbon-emitting vehicles may face growing tension between profit goals and pressures to meet carbon constraints. In contrast, other OEMs may have plans for sales growth, product development and branding that are consistent with the demands of carbon-constrained markets. The management challenge for all OEMs is to incorporate carbon reduction plans into the business and ensure that they are aligned with traditional profitability goals. In turn, this requires that carbon concerns become central to mainstream business planning.

Chapter 2

Lower-Carbon Technologies and Competitiveness in the Automotive Industry

SUMMARY

In carbon-constrained markets, OEMs face the twin challenge of producing vehicles that emit less carbon while continuing to create value for shareholders. To meet carbon constraints, OEMs can turn to a wide range of "lower-carbon technologies" including alternative fuels, improvements to existing combustion engines (gasoline and diesel) and development of new engine types (e.g., hybrid and fuel cell technology). These technologies vary in terms of their carbon reduction potential and the degree to which they can penetrate the market by 2015. We find that "incremental technologies", diesel and hybrids will be the key technologies to deliver CO_2 reductions up to 2015.

In addition, some lower-carbon technologies have the potential to alter the long-term competitive balance within the industry, as OEMs that are early movers on these technologies could develop important market niches, reap the benefits of brand differentiation and establish de facto standards that competitors will have to follow. The key technologies in this regard are diesel, hybrid, and fuel cell technology.

A complicating factor is the uncertainty regarding which technology(ies) will become the market standard(s). Consequently, OEMs face not only the R&D challenge of producing lower-carbon technologies, but also the management challenge of being prepared to succeed no matter which technologies emerge as most important. The latter in particular puts pressure on R&D budgets. To control expenditures, many OEMs are now engaged in research partnerships and alliances around lower-carbon technologies. If carbon constraints accelerate the emergence of new standard technologies in the industry, OEMs could win or lose depending on the expertise developed internally or through partnerships.

2.1 LOWER-CARBON TECHNOLOGY OPTIONS

Lower-carbon technologies differ in their implications for OEMs' financial performance.

Developing and introducing lower-carbon technologies will be vital for meeting carbon constraints, but lower-carbon technologies differ in their implications for OEMs' financial performance. While some technologies represent only minor modifications to vehicle design and production, other lower-carbon technologies could exert a strong influence on the long-term competitive dynamics in the sector.

BOX 2.1. Reducing Carbon Emissions through Alternative Fuels

Numerous programs around the world have sought to introduce less carbon-intensive, or "alternative" fuels into automotive markets, including ethanol, methanol, propane (LPG), compressed natural gas (CNG), and biofuels. While the use of these fuels could lower CO_2 emissions by as much as 30 percent compared to gasoline, such fuels constitute only a miniscule proportion of the transport fuel market. Alternative fuels made up less than 0.2 percent of overall transport fuel use in the United States in 2002. An obvious problem is the enormous advantage enjoyed by gasoline and diesel, with an established refining, transport and delivery infrastructure. This will continue to make it difficult for alternative fuels to enter the marketplace. Even by 2025, alternative fuels are expected to contribute only 1.5 percent of light-vehicle fuel consumption within the United States. Internationally, 97 percent of transport fuel is expected to be oil-based in 2020.

Moreover, OEMs in the automotive industry are unlikely to be able to derive competitive advantage from fuel choice per se, so much as from the in-vehicle technology that will have to accompany any significant fuel switch. This may require coordination and collaboration with energy companies and several such research partnerships have already been formed.

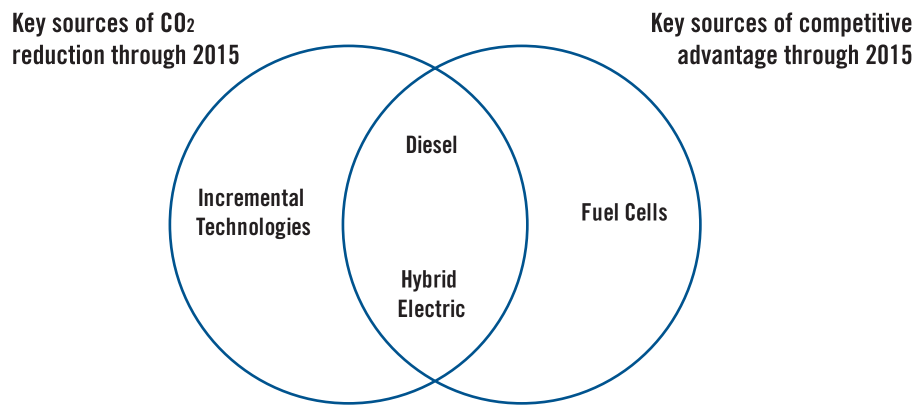
Sources: M.Q. Wang (2001); US Energy Information Administration (EIA), Alternatives to Traditional Transportation Fuels (2000); EIA, Annual Energy Outlook, 2003 (2003); and International Energy Agency, World Energy Outlook 2002 Forecast (2002).

In seeking to reduce vehicle CO_2 emissions, OEMs can pursue two complementary strategies: (i) produce vehicles that use lower-carbon "alternative" fuels; or (ii) increase vehicle fuel economy for a given fuel type. In practice, important barriers to adoption of alternative fuels (including lack of infrastructure) make it unlikely that fuel switching will yield significant carbon reductions between now and 2015. In addition, switching to alternative fuels is not an area where automotive manufacturers have particular expertise or the ability to derive competitive advantage, which lies more with fuel producers. (See Box 2.1 for more information on alternative fuels.)

Instead, a more natural focus for OEMs is to develop new technologies—particularly engine technologies—that are capable of reducing carbon emissions. Using the traditional gasoline-ICE platform as the baseline for today's new vehicles, we group into four main categories the main lower-carbon technologies that are expected to be developed between now and 2015:

- "Incremental technologies" (including advanced gasoline-ICE technologies)
- Diesel (or compression-ignition) technology
- Hybrid technology
- Fuel cell technology

FIGURE 2.1. CONTRIBUTIONS OF LOWER CARBON TECHNOLOGIES TO CO_2 REDUCTIONS AND COMPETITIVE ADVANTAGE THROUGH 2015



These technologies differ in the degree to which they permit OEMs to meet carbon constraints and/or serve as the basis for competitive advantage. (See Figure 2.1.) For example, while incremental technologies may play a significant role in helping OEMs to meet carbon constraints, they offer little scope for enhanced profitability. In contrast, while fuel cells may deliver few actual carbon reductions through 2015, they represent a major and potentially disruptive advance in the automobile's evolution that could reward technology leaders with competitive advantage. Hybrid and diesel technologies lie somewhere in between these extremes. Investors need to be aware of both how technologies can contribute to near-term carbon reductions and whether they can confer long-term competitive advantage.

2.1.1 Achieving CO_2 Reductions through 2015

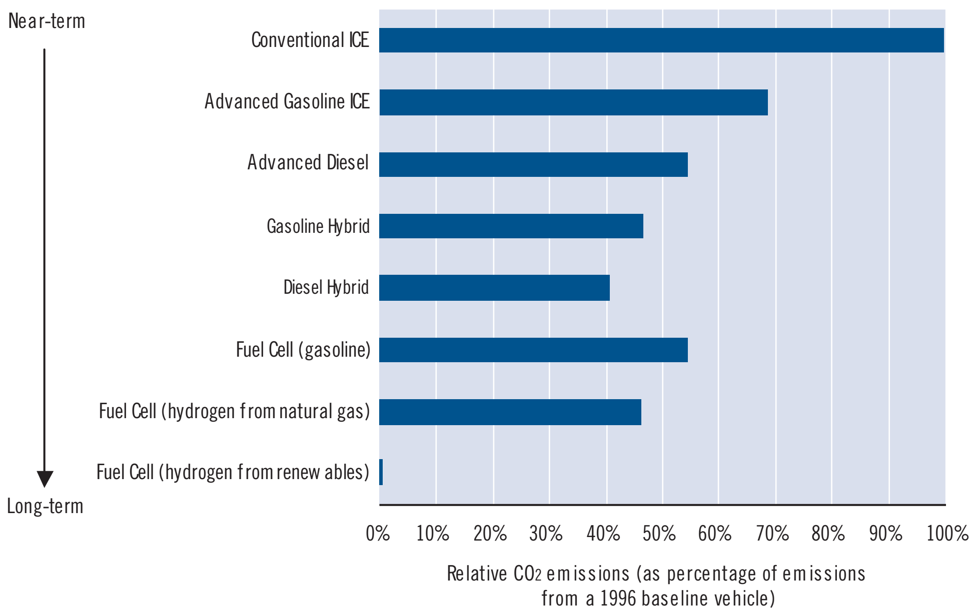
Lower-carbon technologies differ in their potential to reduce vehicle CO_2 emissions before 2015.

Failure to meet voluntary or mandatory carbon constraints could result in diminished sales or even financial penalties for OEMs. Consequently, investors will need to monitor whether and to what extent OEMs are introducing technologies that will permit them to meet carbon constraints on schedule. Figure 2.2 shows the relative potential for "well-to-wheel" reductions in CO_2 emissions of key lower-carbon technologies.[29]

Adding incremental technologies to the standard gasoline-ICE platform reduces carbon emissions to 70 percent of those from a 1996 reference vehicle.[30] Beyond that, the hybridization of either gasoline or diesel engines leads to savings of a further 25 to 30 percent. CO_2 savings from fuel cells depend on fuel choice. Gasoline-based fuel cells that permit on-board conversion of gasoline into hydrogen and which are likely to be the only viable option before a hydrogen fueling infrastructure can be established, yield less well-to-wheel savings than hybrids. Using hydrogen derived from natural gas offers small further reductions, but only if fuel cells use hydrogen derived from renewable energy will the well-to-wheel CO_2 emissions effectively be eliminated.

Not all of these technologies will be immediately available. In practice, the smaller gains associated with incremental technologies could penetrate the market relatively quickly to

FIGURE 2.2. WELL TO WHEEL CARBON EMISSIONS FROM LOWER CARBON TECHNOLOGIES



Source: Weiss et al. (2003).

generate significant carbon savings across an OEM's product portfolio through 2015. In contrast, while diesel hybrids and hydrogen-based fuel cells could ultimately generate much greater carbon reductions per vehicle, the lower expected penetration of these technologies by 2015, especially for fuel cells, implies less carbon reductions from these sources during the timeframe of this study.

In addition, though this assessment considers the technologies in isolation, the viability of the more advanced technologies is sensitive to the success or failure of nearer-term improvements. The greater the fuel savings are that can be achieved through near-term advances (e.g., incremental technologies or gasoline hybrids), the smaller are the incremental benefits from moving on to fuel cells subsequently.

2.2.2 Deriving Competitive Advantage through 2015

Some lower-carbon technologies could create enduring competitive advantage for OEMs.

Engine technology is a key component of global platforms and therefore can be an important source of competitive advantage. Certain lower-carbon technologies based on new engine types offer the potential for significant change in global automotive markets that could create important and enduring competitive advantage for leading OEMs, for several reasons:

- **Brand differentiation.** Leadership in a key lower-carbon technology could enhance brand equity, thereby lifting pricing power and margins.

TABLE 2.1. Lower Carbon Technologies as a Source of Competitive Advantage through 2015

	Incremental Technologies	*Diesel (CI) Technology*	*Hybrid Technology*	*Fuel Cell Technology*
Potential for brand differentiation	○	●	●	●
Potential to set de facto standards	○	◐	●	●
Disruptive potential	○	○	◐	●

○ Low potential ◐ Limited potential ● Strong potential

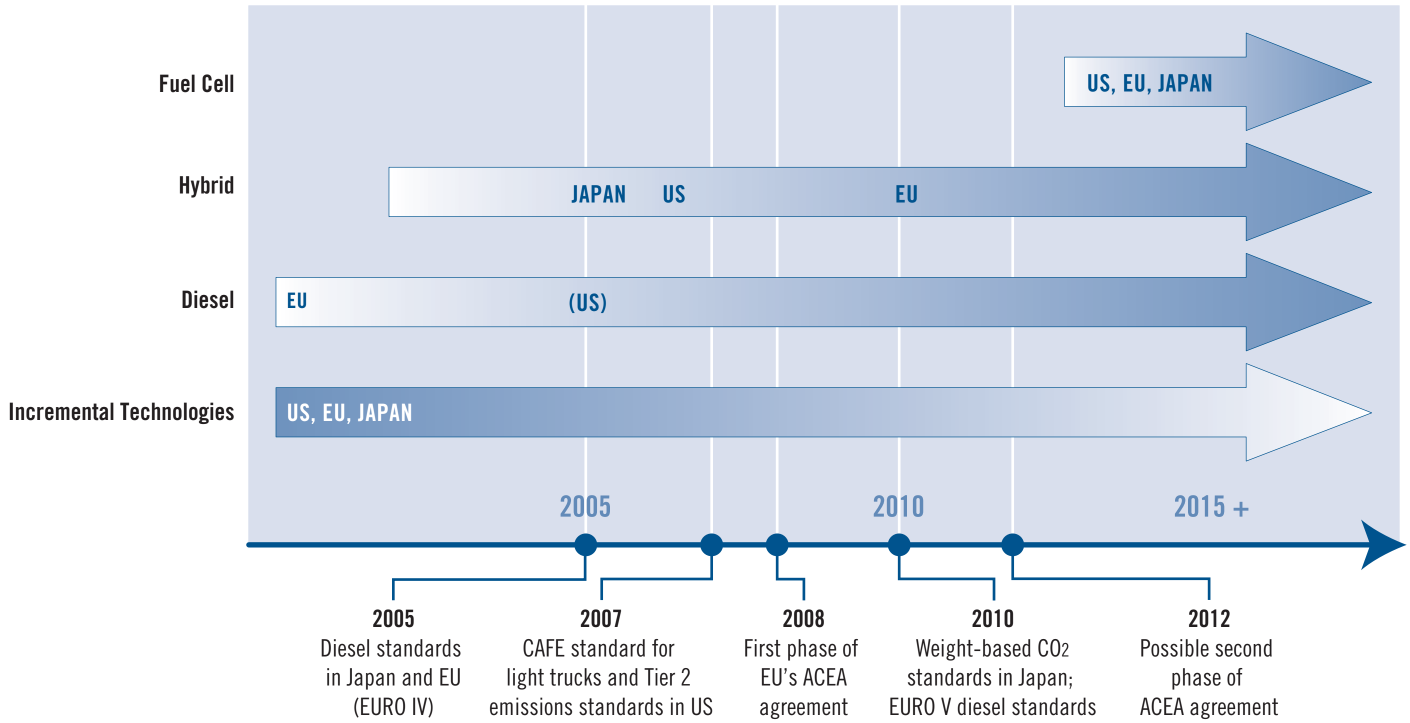
- **De facto standards.** First movers in lower-carbon technologies may define industry standards and be in a strong position to capitalize on this advantage through technology licensing, early profits and a proprietary learning curve.
- **Disruptive potential.** Some lower-carbon technologies hold the potential to alter fundamentally the competitive balance in the automotive industry. A key example would be fuel cell technology, which could lead to a convergence of transport and energy industries.

Based on these criteria, Table 2.1 identifies diesel, hybrid and fuel cell technology as the lower-carbon technologies that hold most potential to become a source of competitive advantage for OEMs through 2015. Even if these technologies yield fewer actual CO_2 reductions through 2015, they could influence competitive balance within the industry for many years after.

2.2 REVIEW OF KEY LOWER-CARBON TECHNOLOGIES

The following section reviews key lower-carbon technologies in more detail. Not all of the technologies will be relevant in all markets at all points in time. (See Figure 2.3.) The internal combustion engine is likely to continue to be the dominant platform through 2015 across all markets, with scope for diesel to grow further in the European market and to penetrate the US market. Facing carbon constraints, many OEMs will steadily "hybridize" their product portfolio over time, coupling electric motors and batteries with both gasoline and diesel engines. Given the technological and economic challenges, fuel cells are unlikely to emerge as a significant technology option before 2015, but remain the long-term goal for the industry as a whole. Policy developments in different markets will influence technology decisions.

FIGURE 2.3. LOWER CARBON TECHNOLOGY ROADMAP



"Incremental technologies" offer immediate low-cost opportunities for fuel economy gains.

2.2.1 Incremental Technologies

Context

A number of incremental technologies could be introduced to raise fuel economy beyond the level associated with the standard gasoline-ICE vehicle. In many cases, these technologies are already developed and well understood.[31] The technologies likely to be introduced include:

- Engine technologies such as direct fuel injection, variable valve timing and cylinder deactivation
- Transmission technologies, such as improved automatic and continuously variable transmissions
- Vehicle technologies, such as drag reduction, integrated starter-generators and weight reduction

OEMs are already introducing these technologies and touting the fuel economy benefits. For example, GM claims that its new "Displacement on Demand" cylinder deactivation technology will improve fuel economy by 8 to 25 percent.[32]

CO_2 Reduction Potential

The individual impact of many incremental technologies is small. Continuously variable transmissions may reduce fuel consumption by 4 to 8 percent; variable valve timing by 1 to 8 percent.[33] However, the combined effect of introducing several of these technologies into a vehicle model could quickly add up. In addition, some imminent technologies could have a larger impact. By operating at high pressure, advanced direct-injection gasoline engines increase energy efficiency and can reduce CO_2 emissions by 20 percent compared to standard gasoline engines. Direct injection engines are likely to become standard over the next decade.

Potential for Competitive Advantage

Incremental technologies, including advanced gasoline engines, are unlikely to be the foundation for competitive advantage for OEMs because of their piecemeal nature and the fact that they are broadly understood in the industry. Thus, there is limited potential for brand differentiation or to set de facto standards. Some technologies may generate specific customer appeal, such as continuously variable transmission with its ability to deliver a smoother ride, but it will be difficult for an OEM to establish or maintain a competitive advantage on the basis of such a technology.

2.2.2 Diesel (Compression Ignition) Technology

Context

Diesel technology is well understood but faces challenges outside Europe.

The compression-ignition engines used to combust diesel fuel allow OEMs to produce more powerful and durable vehicles with potentially lower carbon emissions. Diesel engine vehicles are already commonplace in the European automotive market, where they make up nearly 40 percent of current sales, largely on the back of preferential tax treatment for diesel fuel.[34] Again, the technology is relatively well developed with key suppliers (e.g., Bosch and Delphi) set to introduce third-generation diesel systems in 2006. Operating at even higher pressures than today's diesel engines, these systems will further enhance the combustion process and reduce CO_2 emissions.[35]

The key challenge for diesel manufacturers will be their ability to meet clean air standards. The United States, European Union and Japan are all committed to stricter air quality standards for emissions of nitrogen oxides (NOx) and particulate matter (PM), which diesel engines emit in greater quantities than gasoline engines. Stringent Japanese air pollution regulations, coupled with strong government support of hybrid technology, make it unlikely that diesels will make significant inroads into the Japanese market. In the United States, pending Tier 2 emissions regulations could similarly restrict OEMs' ambitions to introduce diesels, though the introduction of low-sulfur fuel in 2006 may make diesels a feasible option. Even in Europe, where the current standard is more lax, the new EURO IV standards may challenge OEMs.

Another obstacle for the US market is winning consumers over to diesel. Consumers familiar with the loud and sooty diesel cars of the 1970s may be skeptical and OEMs will likely have to invest resources to educate and persuade consumers that the modern diesel engine is significantly more sophisticated than its predecessors. DC and VW are currently marketing diesel engine vehicles in the United States. Nonetheless, it remains to be seen whether regulators and consumers will favor diesel outside of the European market.

CO_2 Reduction Potential

As a fuel, diesel is more carbon-intensive than gasoline on a per unit basis. However, diesel can be used with compression-ignition (CI) engines, which are 20 to 40 percent more efficient than the spark-ignition (SI) engines required to combust gasoline.[36] As a result, a diesel vehicle emits 10 to 30 percent fewer CO_2 emissions per km traveled than a comparable gasoline-fueled vehicle.

Potential for Competitive Advantage

The competitive importance of diesel will be determined by a variety of factors, including growth in the European market and uncertainty about diesel introduction in North America. Currently, some 90 percent of global diesel sales are in Europe.[37] Diesel sales accounted for 40 percent of total European vehicle sales in 2002, up from 35 percent a year earlier, due to high fuel prices and improved affordability.[38] Diesel may reach an estimated 50 percent market share in Europe by the end of this decade. This makes diesel crucial for access to and profitable growth in the European market. Importantly, diesel already offers OEMs a source of differentiation, which is reflected in a pricing premium of approximately €200 per engine over gasoline-based vehicles.[39] In the United States, if clean diesel technology can meet regulatory standards and win over consumers, early movers could gain a competitive advantage.

2.2.3 Hybrid Technology

Context

Hybrid technology will become mainstream over the next decade.

Hybrid electric vehicles (HEVs) have drivetrains that combine an electric drive (consisting of an electric motor and some form of electricity storage, typically a battery) with a fuel-based engine (e.g., an internal combustion engine). However, HEVs may use onboard electrical power to varying degrees. “Full hybrids” permit some actual propulsion using electric power, whereas “mild hybrids” may limit use of the electric motor to regenerative braking or vehicle idling.[40]

HEVs are already being sold in Japan and the United States. US sales are likely to reach 54,000 in 2003 and could rise to 872,000 by 2013.[41] Moreover, given stricter emissions regulations and energy security concerns around the world, HEVs could potentially account for 10 percent of global market share by 2010.[42] Genuine competition around HEVs is already appearing. DC, Ford and GM have all announced plans to introduce HEVs—some of which will only be mild hybrids—even as Toyota and Honda are bringing their second-generation hybrids into the marketplace.

The key challenges for OEMs seeking to mainstream HEVs will be to overcome higher costs and ensure profitability. HEVs currently sell for $3,000 to $4,000 more than conventional equivalents, which impedes efforts to benefit from economies of scale at this stage.[43]

CO_2 Reduction Potential

HEVs have the potential to reduce well-to-wheel CO_2 emissions by 50 percent compared to today's diesel and gasoline engines.[44] HEVs could also benefit from the difficulties diesel may confront in meeting clean air regulations and overcoming negative perceptions in the United States. There is less ambiguity about HEVs' environmental impact. Even in Europe, where diesel is a mainstay technology, hybridization will probably be necessary as OEMs approach the 140 g CO_2/km target and the 120 g CO_2/km target that may follow. Incentives in Japan look certain to accelerate hybrid uptake in that market.

Potential for Competitive Advantage

The combination of promising growth prospects, the potential to set de facto industry standards and enhanced brand equity is expected to turn HEVs into a key for competitiveness across major automotive markets through 2015. The eagerness with which the Big Three have publicized plans for hybrid models in response to the pace-setting by Honda and Toyota signals this as an area where OEMs will compete in the future.

2.2.4 Fuel Cell Technology

Context

Fuel cells represent the long-term goal, but face formidable economic and technological obstacles.

Fuel cells are electrochemical devices that convert a fuel's energy directly into electrical energy. They represent the long-term goal for the industry. The prospect of highly efficient vehicles consuming hydrogen and emitting only water constitutes a major advance in vehicle technology that could greatly shrink the environmental footprint of the automobile.

However, given the technology's complexity, fuel cells remain extremely costly. To compete with existing technology, costs for fuel cells will have to fall from their current cost of $2,500 per kilowatt produced to $50 per kilowatt.[45] Despite significant investments and the fast pace of development, it is highly uncertain whether OEMs will be able to bring costs down to this level within the next decade. Similarly, the development of a hydrogen infrastructure will face considerable physical and regulatory challenges. The cost of establishing a large-scale hydrogen infrastructure in the United States comparable to current gasoline networks is estimated at over $100 billion, and will require significant collaboration between OEMs and energy companies.[46]

CO_2 Reduction Potential

Fuel cells powered by hydrogen offer the promise of zero-carbon vehicles, if the hydrogen can be produced from renewable sources of primary energy, such as solar or wind. Currently, however, more than 90 percent of hydrogen is produced by industrial processing of natural gas, a fossil fuel.[47] Hydrogen can also be derived from on-board conversion of traditional fuels, but this too generates CO_2 emissions. With significant hydrogen production from renewable sources unlikely over the next decade, well-to-wheel CO_2 reductions from fuel cell vehicles (FCVs) will be comparable to those promised by hybrids for the foreseeable future.[48]

Potential for Competitive Advantage

Having raised unrealistic market expectations in the late 1990s, OEMs are now understandably cautious about prospects for large-scale introduction of fuel cells. However, they cannot afford to discount the possibility that such an important and potentially disruptive technology will eventually enter the marketplace. Therefore, establishing a strong position in fuel cells is a key strategic challenge for OEMs today and one that is expected to grow in importance through 2015. The potential to recoup development costs sooner than competitors by setting industry standards has triggered a genuine race in the automotive industry around fuel cell technology. As a result, leadership in fuel cell technology may be central for long-term competitiveness in the industry.

2.3 TECHNOLOGICAL UNCERTAINTY AND THE ROLE OF PARTNERSHIPS

OEMs are already taking different positions on lower-carbon technologies, which could influence how they fare under carbon constraints.

While carbon constraints exert significant influence on current innovation within the industry, there is great uncertainty regarding the engine technology(ies) that will emerge as market standard(s) in the coming years. Uncertainty is compounded by the fact that emission standards, technology and fuel preferences differ across markets. The choice of which technologies to pursue is a vital one for OEMs.

To maintain a competitive position in an environment of uncertainty, OEMs have an incentive to explore a broad range of technologies and pursue different learning paths. Doing so, though, places a significant burden on innovation capacity and R&D budgets. Each OEM will have to pursue and manage a minimum of three main technology pathways that provide scope for competitive advantage—diesel, hybrid and fuel cell technology—as well as keep up with incremental advances.

Partnerships permit innovation at lower cost.

To reduce innovation costs, OEMs are increasingly engaged in research partnerships, or alliances, around lower-carbon technologies. Given the strategic importance of lower-carbon technologies for the industry in general, these “tie-ups” are of increasing significance and could signal the shape of future industry consolidation.[49]

Alliances and partnerships help OEMs in several ways:[50]

- **Enhanced cost competitiveness through economies of scale and cost leadership**

Some partnerships seek to generate economies of scale to improve the cost basis of lower-carbon technology, thus reducing the time needed to cover development costs and/or to improve the operating margin of new vehicles. A good example is the recent tie-up between Toyota and Nissan around HEVs. The partnership aims to put Toyota and Nissan in a strong position to be able to recover development costs and bring down production costs through economies of scale earlier than competitors. As an initial project, Nissan will be installing a hybrid system currently under development by Toyota into its vehicles to be sold in the United States in 2006. Volume is expected to reach approximately 100,000 units within the 5-year period that follows. The Nissan tie-up is expected to contribute to Toyota’s global sales objective of 300,000 HEVs annually through its dealerships by 2007. If successful, this partnership would be a significant milestone for mass-commercialization of HEVs.

Enhanced access to technology and markets through partners

Some partnerships aim to fill a gap in an OEM's technology portfolio without relying solely on its own R&D resources. With key markets increasingly displaying preferences for lower-carbon technologies, this type of partnership allows an OEM to retain market access, or position itself for future growth. US and Japanese OEMs are increasingly partnering with European OEMs that have diesel expertise to grow market share in Europe through diesel technology. For instance, Toyota has teamed up with PSA in the Czech Republic to develop a joint vehicle platform, including small diesel engines supplied by PSA. This strengthens Toyota's access to the growing European diesel market.

Enhanced ability to set de facto standards

Increasingly, OEMs strive to establish de facto standards for lower-carbon technologies. This type of partnership holds potential for reducing costs and enhancing brand differentiation. Establishing de facto industry standards helps to bring down development and component costs by allowing for economies of scale. In addition, setting de facto standards allows OEMs to capitalize on a first-mover advantage, including enhanced pricing power and setting the pace of technology development. New technologies can also be licensed to other OEMs. For example, as early as 1993, DC forged an alliance with fuel cell producer Ballard to build up a leading position in fuel cell technology. Ford subsequently joined the alliance in 1998. The partnership covers a broad range of technology options, including fuel cells that operate directly on hydrogen rather than fossil fuels as well as reformer technology to enable hydrogen storage on board the vehicle, one of the key obstacles to commercialization of fuel cell technology in automobiles. The DC-Ford-Ballard alliance holds significant potential to establish industry standards and thereby establish a strong competitive position in the emerging market for fuel cell technology.

Partnerships can also be a challenge. Among other things, partnerships involve revealing strategically important know-how, learning to cooperate effectively despite crucial differences in corporate culture, and managing conflicts of interest arising from multiple partnerships among OEMs. Nonetheless, partnerships have become a feature of the modern automotive industry. (See Table 2.2.)

TABLE 2.2. Selected OEM Partnerships in Key Lower Carbon Technologies

Technology	Partnership Members		Possible Benefits of Partnership		
	Lead Technology Developer	Partner OEM(s)	Access	Economies of Scale	De facto Standards
Diesel	PSA	Ford	x	x	
	Renault	Nissan	x	x	
	Toyota	BMW	x	x	
Hybrid	Toyota	Nissan (DC)	x	x	x
Fuel Cell	Toyota	GM	x	x	x
	Ballard	DC/Ford	x	x	x

Notes: Brackets indicate possible future partnerships.

Critically, through their internal innovation and external partnerships, OEMs have taken different positions with regard to new technologies. Some have hedged their bets, while others have chosen to specialize and develop expertise in one particular area. Table 2.2 gives an overview of internal expertise and key partnerships around lower-carbon technologies. With the notable exception of Honda, all OEMs have entered into a partnership on at least one of the key lower-carbon technologies, but some companies have developed considerably broader portfolios than others. The implication of these different positions is explored further in Chapter 5.

SECTION 2 THE ANALYSIS

In view of the growing carbon constraints on automotive markets, a key challenge for sector investors and OEM managers is to quantify the impact of carbon constraints on competitiveness. In Chapters 3 to 6, we analyze how carbon constraints could affect the shareholder value creation of 10 leading OEMs: BMW, DC, Ford, GM, Honda, Nissan, PSA, Renault, Toyota and VW. The geographical focus is the US, EU and Japanese markets, which account for nearly 70 percent of current global sales. The time period analyzed is from 2003 to 2015.

Carbon constraints create both risks and opportunities for OEMs. Risks principally take the form of possible increases in costs to meet new standards and/or loss of market share to more fuel-efficient producers. Opportunities lie in the potential to develop successful strategies to reduce carbon emissions that translate into technological leadership, enhanced market share and greater profits.

Risks and opportunities for OEMs are analyzed in the ensuing chapters as follows:

Chapter 3 quantifies the Current Carbon Profiles of OEMs. With distinctive product portfolios and geographical focuses, each OEM starts from a unique position in responding to carbon constraints.

Chapter 4 presents the results of a Value Exposure Assessment, which quantifies the possible costs to OEMs of meeting new carbon constraints.

Chapter 5 presents findings from a Management Quality Assessment, which analyzes each OEM's potential ability to benefit from carbon constraints by developing and commercializing the lower-carbon technologies that will be key for long-term competitiveness.

Chapter 6 aggregates the findings and explores their implications for OEMs' future earnings.

Chapter 3

Current Carbon Profiles of Leading OEMs

SUMMARY

In producing different vehicles for different markets, OEMs vary substantially in the carbon emissions associated with their product portfolios. Some OEMs rely heavily for sales and profits on vehicles that emit relatively high amounts of CO_2, while other OEMs derive the bulk of their profits from vehicles that are less carbon-intensive. By measuring the "carbon intensity" of current sales and profits, it is possible to assess each OEM's initial exposure to emerging carbon constraints. All else being equal, OEMs that earn a relatively large proportion of their profits from carbon-intensive segments will find carbon constraints more challenging. Of course, differing consumer preferences and regulatory attitudes to carbon constraints across major markets must also be taken into account.

PSA, Renault and VW stand out as deriving over 90 percent of current profits from vehicles of low or medium carbon intensity. On the other hand, GM and Ford currently earn over 70 percent of total profits from vehicles that emit more than 270 g CO_2/km (less than 20.5 mpg).

3.1 FACTORS AFFECTING THE CARBON INTENSITY OF OEMS

OEMs whose profits come primarily from carbon-intensive segments will be more challenged by carbon constraints.

OEMs rely to differing extents on sales of high carbon-emitting vehicles to generate current profits. Hence, the "carbon intensity of profits" varies across the industry. All else being equal, OEMs with high carbon intensity of profits will find carbon constraints more challenging than OEMs with lower carbon intensity of profits.

The assessment in this chapter provides a snapshot of where OEMs are today with regard to light-duty vehicle carbon emissions. It is based on the latest publicly available information about sales volumes and carbon intensity of each OEM's light vehicle models. (See Box 3.1 for information on data sources.) The data highlight that OEMs are starting from different points when it comes to addressing carbon constraints. Past business decisions and current product mix give each company its own unique carbon intensity of sales and profits, and hence exposure to carbon constraints.

BOX 3.1. Data Sources

The analysis in Chapter 3 is based on a dataset developed by SAM and WRI for this report. Sales data are from US and European editions of *Automotive News* and the Japan Automobile Dealers Association, which only includes domestic production in Japan. Data on fuel efficiency were obtained from the US Environmental Protection Agency and Department of Energy for US sales, from the German Federal Motor Transport Authority for EU sales, and from various company and industry data sources for Japanese sales.

OEM sales data include sales from subsidiaries in proportion to their ownership stakes. Hence, for example, a share of Mitsubishi's sales are included in DC's sales and similarly for Mazda and Ford. In addition, the figures reflect the current cross-ownership between Renault and Nissan. Renault owns 44 percent of Nissan while Nissan owns 15 percent of Renault. Hence, in some of the charts, Renault is shown as having sales in the United States and Japan, which essentially reflect Renault's share of Nissan's sales.

Finally, CO_2 emissions rates and fuel economy figures refer to "on road" rather than test results. On road levels are considered to be a more accurate representation of the emissions rates and fuel economy realized in practice compared to official tests, which tend to underestimate emissions levels and overestimate fuel economy performance.

A number of overlapping factors influence the carbon emissions associated with OEMs' product portfolios:

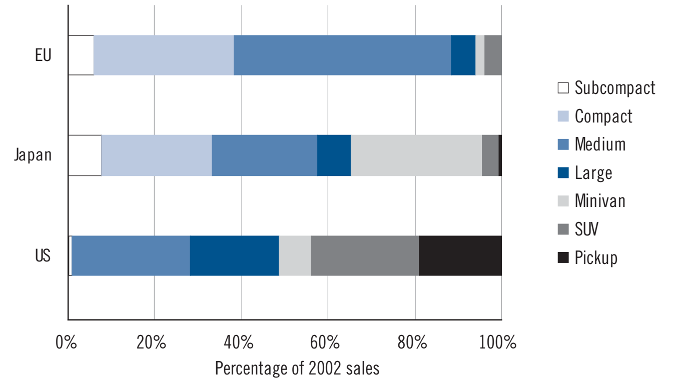
- **The three main automotive markets demand different vehicle types.** Regional differences in government regulations, demographics, transport infrastructure and consumer preferences create differential demand in the various markets. (See Figure 3.1.) For example, in Europe and Japan, high fuel prices and smaller, more congested roads result in a strong consumer preference for small and midsized vehicles. In the United States, a greater share of light duty vehicle sales is made up of larger vehicles, including SUVs and pickups.

- **OEMs' sales are differently distributed across the three main markets.** For example, PSA's sales are exclusively in Europe while the primary market for DC, Ford and GM is the United States. The Japanese companies are heavily invested in both Japan and the United States. (See Figure 3.2.)

- **OEMs produce different mixes of vehicles.** With different geographical focuses, OEMs concentrate on different vehicle segments. Nearly half of the vehicles that the US-based OEMs sell are light trucks, such as minivans, SUVs and pickups. In contrast, cars make up more than 90 percent of sales for PSA, VW and BMW. (See Figure 3.3.)

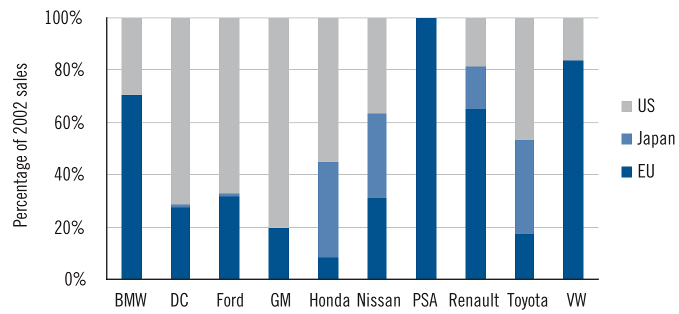
- **CO_2 emissions rates vary across segments according to vehicle size and weight.** The global average CO_2 emissions rate for a midsized car was 198 g CO_2/km (28 mpg) in 2002, while the average SUV emitted more than 300 g CO_2/km (less than 18 mpg). (See

FIGURE 3.1. SHARE OF MARKET SALES BY SEGMENT, 2002



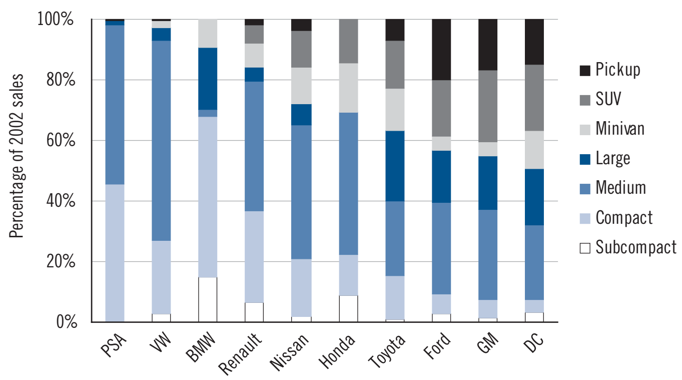
Note: Based on sales of the OEMs analyzed in this report.

FIGURE 3.2. OEMS' SALES BY MARKET, 2002



Notes: Sales for each OEM include ownership share of their subsidiaries' sales. Excludes sales outside of US, EU and Japan.

FIGURE 3.3. SHARE OF GLOBAL SALES BY SEGMENT, 2002



Note: OEMs ordered by increasing share of light truck sales.

FIGURE 3.4. AVERAGE CO_2 EMISSIONS RATES BY SEGMENT, 2002

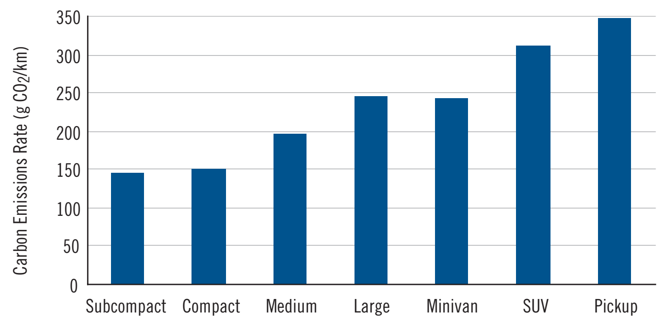


FIGURE 3.5. RELATIVE CO_2 INTENSITY OF OEMS IN MIDSIZED CAR SEGMENT

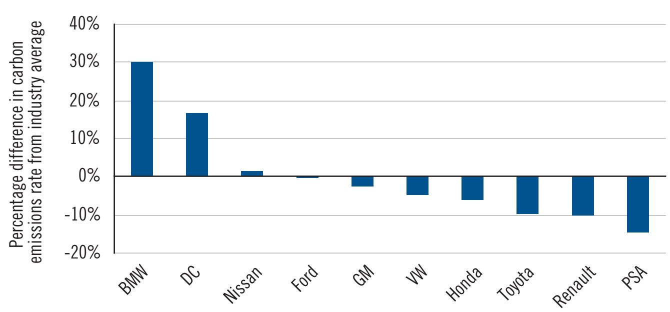


FIGURE 3.6. RELATIVE CO_2 INTENSITY OF OEMS IN SUV SEGMENT

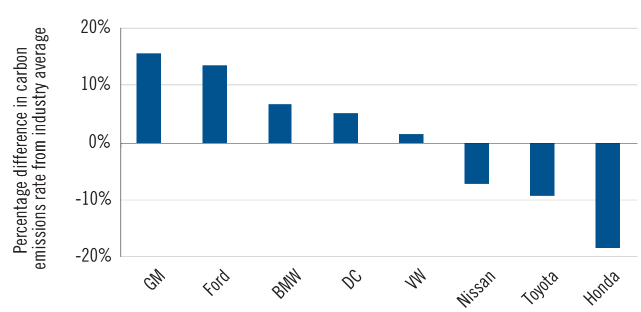


Figure 3.4.) On average, the emissions rates of SUVs and pickups are approximately twice those of subcompact and compact vehicles.

- **CO_2 emissions rates can also be substantially different within segments.** Emissions rates for midsized cars vary by 50 percent across OEMs and by 40 percent for SUVs. (See Figures 3.5 and 3.6.) In the midsized car segment, BMW and DC's vehicles have the highest carbon intensity, reflecting the luxury vehicles that the two OEMs produce in this segment. Within the SUV segment, Ford and GM's models are currently the most carbon-intensive, while Nissan, Toyota and Honda produce SUVs of lower than average carbon intensity. Some of this difference is due to the greater concentration of the former OEMs in the full-size SUV market, and may change as the latter release larger and heavier SUVs.

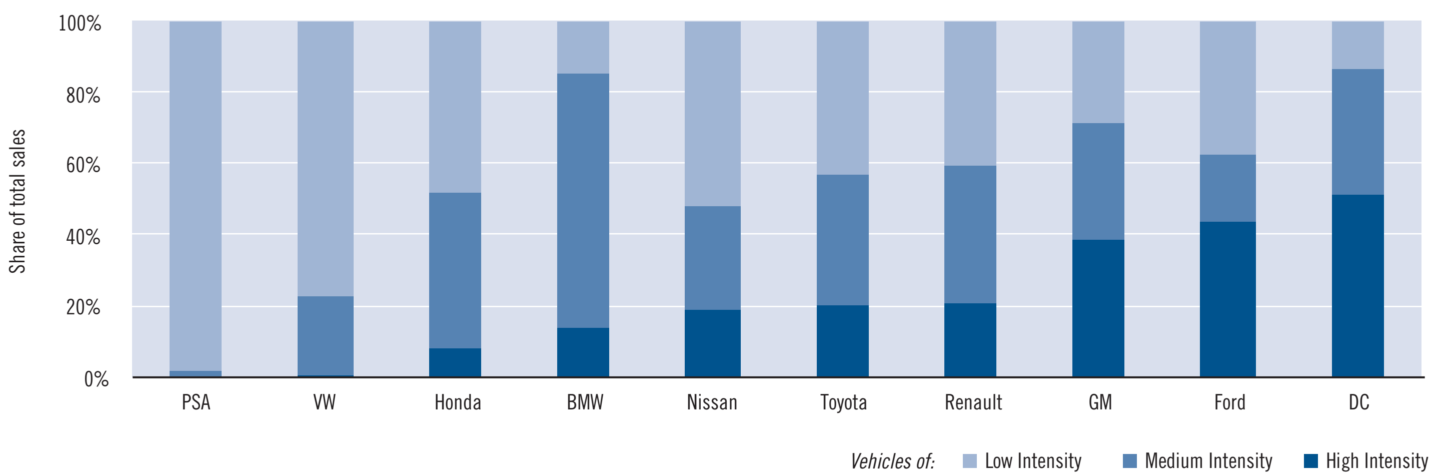
3.2 THE CARBON INTENSITY OF SALES

The carbon intensity of sales differs among OEMs.

Given the above factors, vehicles sold by OEMs in 2002 exhibit markedly different average CO_2 emissions rates. In other words, OEMs had different levels of "carbon intensity of sales". (See Figure 3.7.) Virtually all of PSA's sales consist of vehicles whose carbon emissions are less than 200 g CO_2/km (greater than 27.5 mpg). In contrast, DC, Ford and GM are the main sellers of high carbon-intensity vehicles.

Not all of the difference in carbon intensity of sales is due to the concentration of OEMs in different markets. For example, DC and Ford are among the top four OEMs by vehicle carbon intensity in all three markets. (See Table 3.1.) Similarly, Honda's and Nissan's fleets have below average carbon intensity in all three markets.

FIGURE 3.7. CARBON-INTENSITY OF OEM'S SALES, 2002



Notes:
High: Greater than 270 g CO_2/km (less than 20.5 mpg).
Medium: 200 - 270 g CO_2/km (20.5 - 27.5 mpg).
Low: Less than 200 g CO_2/km (greater than 27.5 mpg).
Boundaries for high, medium and low categories were informed by the current CAFE standards for cars and light trucks, rounded slightly for convenience.

TABLE 3.1. Average CO_2 Emission Rates per Vehicle for Each OEM by Region, 2002

	United States		European Union		Japan	
OEM	g CO_2/km	Mpg	g CO_2/km	Mpg	g CO_2/km	Mpg
BMW	251	22.0	214	25.8	—	—
DC	282	19.6	234	23.6	230	24.0
Ford	295	18.7	196	28.2	212	26.0
GM[a]	293	18.8	181	30.6	143	38.6
Honda	214	25.8	174	31.8	174	31.7
Nissan	242	22.8	159	34.8	185	29.8
PSA	—	—	166	33.2	—	—
Renault[b]	242	22.8	149	37.1	185	29.8
Toyota	245	22.5	180	30.7	200	27.6
VW	220	25.1	179	30.7	—	—

Notes: Increasing CO_2 emissions rates (g CO_2/km) correspond to decreasing fuel economy (mpg).
a. GM's sales in Japan represent less than 8,000 sales of Suzuki and Isuzu vehicles, which reflect GM's ownership stakes in these companies.
b. Renault's figures for the United States and Japan represent sales of vehicles by Nissan, in which Renault has a 44 percent ownership stake.

3.3 THE CARBON INTENSITY OF PROFITS

OEMs differ in their reliance on carbon-intensive segments to generate profits.

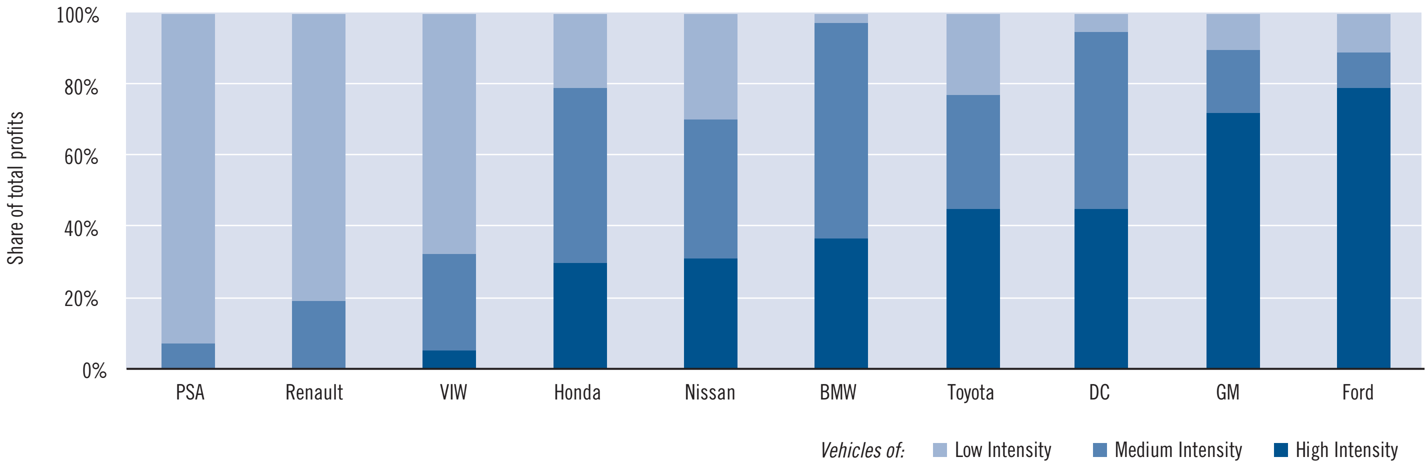
Because some segments of the vehicle market are more profitable than others, the carbon intensity of profits differs from the carbon intensity of sales. However, attributing profits to market segments is complicated by the large fixed costs in the industry and by significant general expenditures on such things as R&D and advertising. Table 3.2 presents estimates of the profitability of segments for each OEM.[51]

TABLE 3.2. Estimated Share of Profits by Vehicle Segment for Leading OEMs

	BMW	DC	Ford	GM	Honda	Nissan	PSA	Renault	Toyota	VW
Subcompact	2	1	1	1	1	—	—	6	1	3
Compact	39	4	2	1	5	5	32	27	6	16
Medium	3	30	10	9	46	34	61	48	16	68
Large	34	39	9	17	—	18	3	9	23	10
MiniVan	—	3	5	—	21	3	4	10	11	2
SUV	22	18	33	30	26	28	—	—	23	1
Pickup	—	5	40	42	—	12	—	—	20	—

Source: SAM Research based on WestLB, Deutsche Bank Research, Goldman Sachs, Lehman Brothers and Schroder Salomon Smith Barney.

FIGURE 3.8. CARBON-INTENSITY OF OEM'S PROFITS, 2002



Notes:
High: Greater than 270 g CO_2/km (less than 20.5 mpg).
Medium: 200 - 270 g CO_2/km (20.5 - 27.5 mpg).
Low: Less than 200 g CO_2/km (greater than 27.5 mpg).
Boundaries for high, medium and low categories were based on the current CAFE standards for cars and light trucks, rounded slightly for convenience.

Using these profit figures and the CO_2 emissions rates of the different segments, we can illustrate the relative carbon intensity of profits. (See Figure 3.8.) Again, PSA and Renault are least dependent on more carbon-intensive vehicles to generate profits, but Ford and GM derive more than 70 percent of their profits from high carbon-emitting vehicles, because their profits are disproportionately attributable to light truck sales.

The assessment in this chapter is a snapshot of where OEMs find themselves today. Naturally, data on current sales and fuel economy only indicate the current status of where companies are—not how they can, and will, respond to carbon constraints. The next two chapters contain forward-looking assessments that take account of different possible development paths in different markets and the abilities for companies to respond to carbon constraints through innovation and strategic decision-making.

Chapter 4 Value Exposure Assessment

SUMMARY

It will cost OEMs different amounts to produce the less carbon-intensive vehicles required to meet emerging carbon constraints in the three main automotive markets. By combining OEM-specific data on sales and fuel economy with cost estimates for incremental technologies, hybrids and diesels, we estimate the overall cost each OEM will incur to meet alternative potential standards for fuel economy or carbon emissions between now and 2015.

Because OEMs' product mixes differ with respect to carbon-intensity levels, the costs incurred in meeting new standards will vary across the industry. WRI estimates that costs per vehicle will range from $650 for BMW to less than $25 for Honda.

OEMs could see returns on these costs in two ways. First, some OEMs will have to spend less than others and so should become more price-competitive in the marketplace and enjoy higher sales. Second, consumers may perceive additional value from the introduction of lower-carbon technologies, independent of impacts on CO_2 emissions. For instance, diesel and hybrid technologies both offer non-carbon-related attributes that consumers may be willing to pay extra for. In addition, the fuel savings generated by most of the technologies referred to in this chapter outweigh the incremental manufacturing costs. If consumers were to value these fuel savings at the time of purchase, OEMs could recover their full costs.

4.1 OVERVIEW

The Value Exposure Assessment seeks to answer the following question:

- What costs do OEMs face in meeting higher fuel economy standards in 2015, given their initial sales levels and vehicle mix?

In all three main automotive markets covered in this report—the United States, European Union and Japan—governments have committed to higher fuel economy or CO_2 emission standards in the coming years. These standards will require OEMs to make potentially costly changes to vehicle specifications and sales mix. The costs incurred by each OEM will vary depending on its product portfolio and the current sales-weighted average fuel economy of its fleet, and on the costs of achieving CO_2 reductions for different vehicle types. The Value Exposure Assessment aims to quantify the range of costs that carbon constraints may impose on OEMs over the next 12 years.

This chapter gives an overview of the analysis. More details on the methodology and assumptions are available in a separate Appendix accompanying this report.[52]

4.2 METHODOLOGY

We developed a methodology to estimate the cost that each OEM will incur to meet different possible carbon constraints between now and 2015. In our analytical model, each OEM is characterized by its 2002 sales and fuel economy levels and has access to three main categories of lower-carbon technologies—incremental technologies, diesel, and hybrid technology. Fuel cell technology is ignored in this analysis because it is unlikely to contribute to actual CO_2 reductions before 2015.[53]

The model calculates the lowest-cost combination of technologies that an OEM must add to its existing vehicle fleet to ensure that it meets the specified new standards. Separate analyses are done for the US, EU and Japanese markets and then aggregated to produce an overall cost estimate for each OEM.

Because of uncertainties about the future regulatory environment, we assess sensitivity to different levels of carbon constraint that may emerge by 2015. In addition, we explore different market penetration rates for diesel and hybrid technologies because of uncertainties regarding their technological development and acceptance by regulators and consumers.

Though the main analysis does not take into account inevitable changes in sales and vehicle mix over the next decade, it provides a quantitative insight into the magnitude of costs that each OEM might face in order to improve the carbon intensity of its vehicles. In addition, Section 4.4 describes potential changes in sales that might arise from efforts to lower carbon intensity.

4.2.1 Carbon Constraint Scenarios

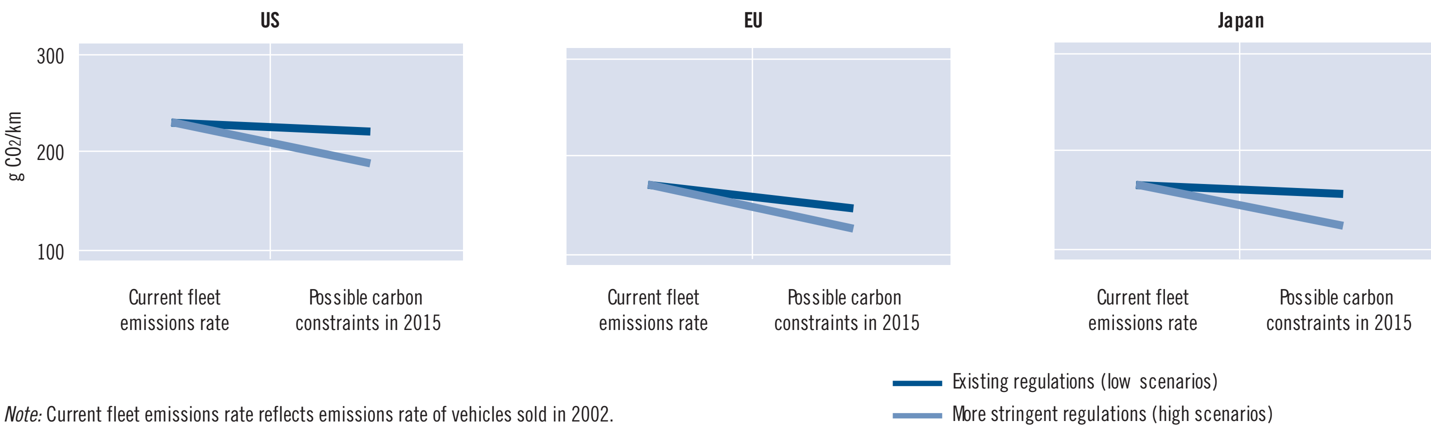
While significant carbon constraints are in place in Europe and Japan, the outlook for the United States is more uncertain.

To reflect uncertainty about future carbon constraints, we analyzed two different levels of emissions standards (“high” and “low”) for each market for 2015. (See Figure 4.1.) These scenarios aim to bracket possible developments in each market.

For the European Union and Japan, future standards have already been signposted through voluntary agreements and regulations. In the United States, scenarios reflect much greater uncertainty. The United States recently tightened its CAFE standards for light trucks to 22.2 mpg (249 g CO_2/km) from 20.7 mpg (267g CO_2/km). However, fuel economy standards for passenger cars may not change before 2015. Bills proposing tighter standards for passenger cars have repeatedly been rejected by the US Congress, while both the Administration and Congress have shown little willingness to introduce policies to address climate change. On the other hand, some recent developments argue for the possibility of significantly tighter carbon constraints for passenger cars by 2015. California has passed a law that will regulate CO_2 emissions from vehicles by 2009, and other states have shown interest in emulating this approach. In addition, continued energy security concerns may advance CAFE standards by 2015.

The details of the scenarios used for each market are described in Section 4.3. Predicting which of these, or other, scenarios is likely to occur is inherently difficult, given the many factors that may influence the setting of carbon constraints between now and 2015. Consequently, we weigh high and low scenarios equally. We also report results for individual scenarios in the figures in Section 4.3.

FIGURE 4.1. CURRENT AND FUTURE CARBON CONSTRAINTS IN THE UNITED STATES, EUROPEAN UNION AND JAPAN



Note: Current fleet emissions rate reflects emissions rate of vehicles sold in 2002.

OEMs may be limited in their capacity to adjust segment mixes in response to carbon constraints.

4.2.2 Characterization of OEMs

Each OEM is characterized in terms of vehicle sales in seven separate segments for each of the three main markets. OEMs have different initial levels of carbon intensity for each segment in each market. One limitation of the analysis is that vehicle sales by company and by segment are kept constant at 2002 levels. This assumes that consumers will continue to buy the same types of vehicles from the same OEMs. In practice, of course, an obvious response to carbon constraints is for OEMs to adjust segment mix to produce relatively more low-emissions vehicles.

However, there are a number of reasons to expect that OEMs may be constrained in changing their segment mix. First, decisions about vehicle type are dominated by expectations regarding the use of the vehicle, such as passenger and load requirements, type of driving, etc. This limits substitution possibilities. Second, even where there is interest in fuel efficiency, survey results show that consumers would prefer to buy more fuel-efficient versions of their current vehicle rather than to switch to a more fuel-efficient vehicle type.[54] Third, the commitment to platforms and the time lags associated with production changes limit OEMs' ability to move rapidly in or out of segments.

In addition, a review of OEMs' near-term production plans reveals that some OEM fleets will become more carbon-intensive in the near future as they move to larger or more luxurious vehicles. Hence, holding segment mix constant at 2002 levels may underestimate cost impacts for some OEMs. Finally, some implications for sales and margins are reviewed in Section 4.4.

4.2.3 Technology Costs

Costs of lower-carbon technology will vary across segments and OEMs.

Between now and 2015, OEMs will have access to three core types of CO_2-reducing technologies (incremental technologies, diesel and hybrid technology). These technologies will have different costs in terms of dollars required to generate a given reduction in CO_2. In addition, the costs of a given technology will vary across different vehicle segments (e.g., hybridization may be more expensive in pickups than smaller cars) and in some cases by OEM (e.g., Toyota and Honda should be able to add hybrid technology at lower cost than other OEMs).

Cost information on incremental technologies forms the basis of our estimates. We used cost data from a recent National Academy of Sciences (NAS) study addressing both existing and emerging technologies that should be readily available by 2015.[55] The underlying cost data reflect both capital and operating costs required to improve fuel economy. For such technologies, capital expenditures are expected to account for approximately one third of total costs. For incremental technologies, costs are assumed to be equal across all OEMs, given the well-understood and relatively well-developed nature of those technologies. In practice, though, some OEMs may have small near-term advantages in this area because of existing expertise in conventional ICE technology.

These cost curves are modified in certain sub-scenarios by introducing diesel and hybrid powertrains as additional CO_2-reducing technologies. For most OEMs, costs are lower in scenarios where diesel and hybrid technology is available.[56] Availability of diesel and hybrid technologies differs by market. For example, diesel, which is already established in Europe, appears in all sub-scenarios for the European Union but is ignored in Japan. Also, while it is assumed that incremental technologies can be applied to all vehicles, ceilings are placed on the adoption rate of diesel and hybrid technologies, reflecting likely production and market constraints on their penetration over a 12-year period. (See Table 4.1.)

TABLE 4.1. Maximum Assumed Diesel and Hybrid Penetration Rates in 2015, by Market

Market	Diesel penetration rate (%)	Hybrid penetration rate (%)
US	20	15
EU	65	15
Japan	—	30

Moreover, for hybrid and diesel technology, we assume that manufacturing costs vary among OEMs according to level of expertise with these technologies. Using results from the Management Quality Assessment in Chapter 5, we ranked OEMs in terms of their expertise with diesel and hybrid technologies. Leaders in each group were assumed to be able to implement the new technology at a 5 percent cost reduction, while laggards were assumed to incur a 5 percent cost penalty. (See Table 4.2.)

TABLE 4.2. Ranking of OEMs by Technological Leadership

Technology	Leader (5% cost reduction)	Neutral	Laggard (5% cost penalty)
Diesel	PSA, VW	DC, Renault (Nissan), Toyota, BMW	Ford, GM, Honda
Hybrid	Honda, Nissan (Renault), Toyota	DC, Ford, GM	BMW, Peugeot, VW

Source: Management Quality Assessment. See Chapter 5.

4.3 MARKET-SPECIFIC RESULTS

Costs for each OEM were determined for the United States, European Union and Japan. Results from each market are described below.

4.3.1 United States

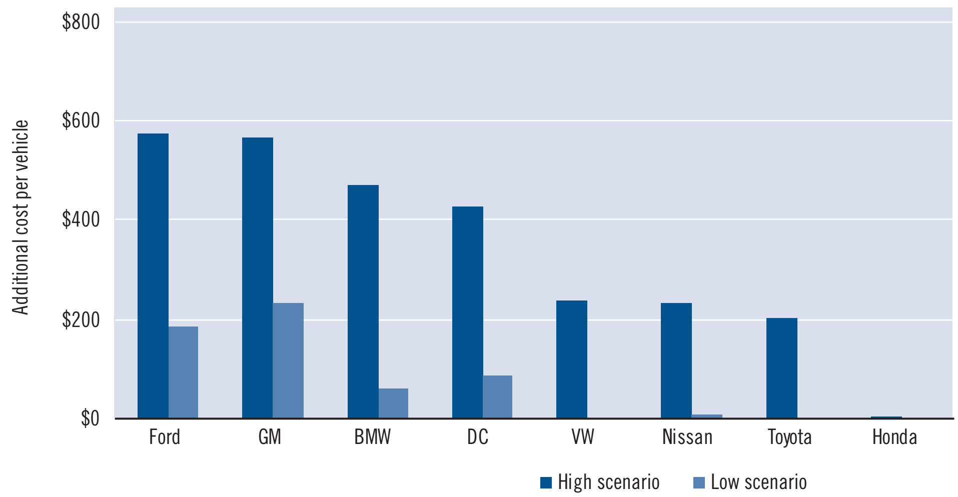
For the United States, we evaluated two scenarios of equal weight. The low scenario was based on the conservative assumption that no further changes are made to CAFE standards over the next 12 years beyond the recent tightening for light trucks. This raises standards by 1.5 mpg for light trucks by 2007 to 22.2 mpg (249 g CO_2/km).

In the high scenario, fuel economy standards rise to 33 mpg and 25 mpg (167 g CO_2/km and 221 g CO_2/km), respectively, for cars and light trucks. These represent standards that the NAS finds will maximize net economic and social benefits and can be achieved using available or nearly available technologies.[57] Though a significant increase over today's standards, they still fall well below current standards in the European Union and Japan. Furthermore, these standards are in line with the levels that would be achieved in 2015 if the current CAFE increase of 1.5 mpg over 3 years for light trucks were extended at the same rate for all vehicles over this time frame.

Though there has been debate about the future structure of the CAFE program, we assumed that the distinction between imported and domestic vehicles disappears by 2015 for both scenarios. In addition, we assumed that the distinction between cars and light trucks would persist, but that the light truck category would expand upwards to include several large models of SUVs and pickups that currently are exempt from CAFE standards.

The costs of meeting a stricter CAFE standard vary widely among companies, because of the different vehicle mix and initial levels of average fuel economy. (See Figure 4.2.) Costs also vary significantly between the high and low scenarios. Ford, GM, BMW and DC incur the greatest additional costs per vehicle. Honda is virtually unaffected in either scenario.

FIGURE 4.2. COST PER VEHICLE OF MEETING HIGHER CAFE STANDARDS IN THE UNITED STATES



Notes: OEMs not shown do not have sales in the United States. Figures represent the costs of altering today's vehicles to meet the standards assumed for 2015.

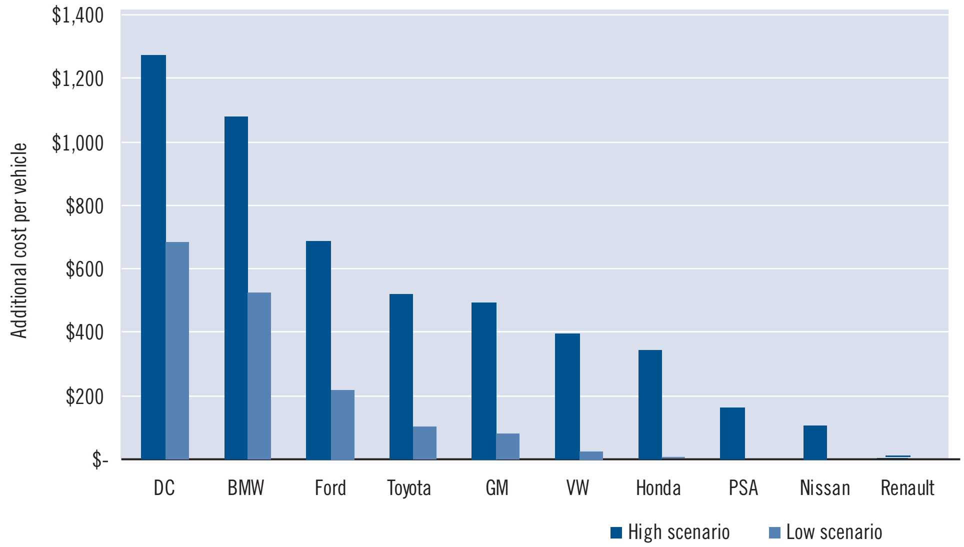
4.3.2 European Union

For Europe, we evaluated a low scenario reflecting the first step of the ACEA agreement (140 g CO_2/km) and a high scenario in which CO_2 emissions standards are tightened to the 120 g CO_2/km rate that is the potential next phase of the agreement.

To date, the industry has not disclosed the working structure of its voluntary commitment, creating marked uncertainty for investors about its financial implications. For this analysis, we assumed in both scenarios that the target would eventually be binding on each OEM's fleet. A binding target reflects the strong interest of EU regulators in seeing the agreement succeed and their likely willingness to step in if it does not. If so, it is plausible to imagine a system that places equal responsibilities on individual OEMs, whether it requires each to meet the standard through emissions reductions in its own fleet or whether the standard can be met through some form of trading among OEMs of CO_2 reduction credits. However, until the structure of the agreement is fully disclosed, investors will remain uncertain about the financial consequences for OEMs: while a CAFE-like structure of a single target for each OEM would reward companies currently producing vehicles that are the least carbon-intensive, a structure based on proportionate reductions from current starting points would have the opposite effect.[58]

An important feature of the European market is the already high level of market penetration of diesel vehicles. In 2002, diesels accounted for 40 percent of sales and in the diesel scenario, this level could increase to as much as 65 percent by 2013. This preference for diesel is due mainly to favorable tax treatment.

FIGURE 4.3. COST PER VEHICLE OF MEETING LOWER CO_2 EMISSIONS STANDARDS IN THE EUROPEAN UNION



Note: Figures represent the costs of altering today's vehicles to meet the standards assumed for 2015.

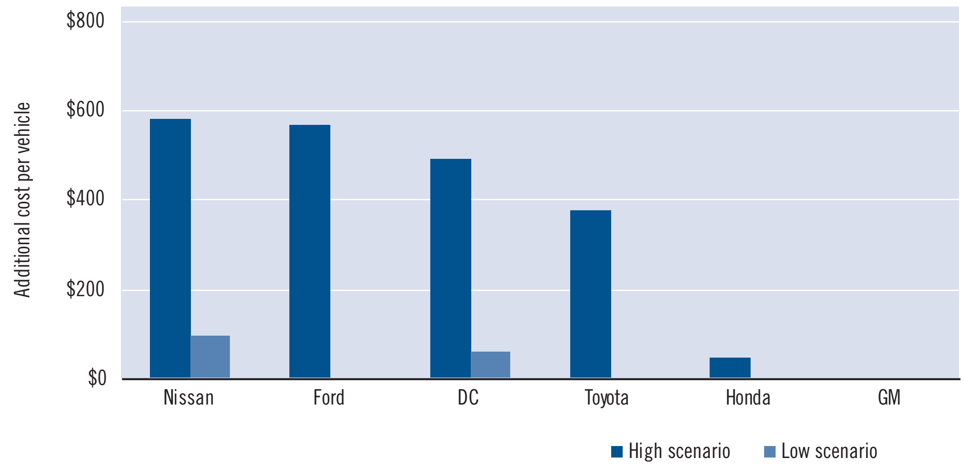
Again, costs vary significantly by OEM. (See Figure 4.3.) DC and BMW have the highest additional costs per vehicle in both scenarios. Renault, Nissan and PSA stand out as having little or no new additional costs in either scenario. Note that the high figures represent manufacturing costs only. If OEMs rely on diesel technology to lower carbon intensity—as is expected—it is likely that they could recoup all or most of these costs given the price premium that currently exists for diesel technology.

4.3.3 Japan

For Japan, we evaluated a low scenario based on the 2010 standards, which a majority of vehicles are already in compliance with. In the high scenario, the recent rate of mandated fuel economy improvements was extended to 2015. This implies a 46 percent increase in fuel economy by 2015 relative to 1995 levels. Although this standard seems quite stringent, the implied trajectory of improvement is below that required to achieve the government's goal of fleet average fuel economy of 48 g CO_2/km (115 mpg) by 2025. Moreover, given the number of vehicles that exceed the 2010 standard already, such a target seems feasible.

The Japanese government has established a clear preference for hybrid over diesel technology. Thus, we assume that only incremental and hybrid technologies will be adopted by 2015. Again, costs fall on OEMs to different degrees. (See Figure 4.4.) Ford and Nissan would incur the greatest additional costs if more stringent CO_2 emissions standards were enacted in Japan. There are virtually no costs incurred in the low scenario.

FIGURE 4.4. COST PER VEHICLE OF MEETING LOWER CO_2 EMISSIONS STANDARDS IN JAPAN



Notes: OEMs not shown do not have sales in Japan. Figures represent the costs of altering today's vehicles to meet the standards assumed for 2015.

4.4 AGGREGATE RESULTS AND FURTHER IMPLICATIONS

4.4.1 Aggregate OEM Costs to Meet Carbon Constraints

Total costs to meet carbon standards in the major global automotive markets differ substantially among OEMs.

The financial impacts for the separate markets were aggregated to identify the overall cost for each OEM to meet new standards in the markets in which it competes. (See Figure 4.5 and Tables 4.3 and 4.4.) Because OEMs have different product mixes with different carbon-intensity levels, the costs incurred in meeting new standards will vary across the industry. Our analysis shows that costs of compliance per vehicle will range from nearly $650 for BMW to less than $25 for Honda.

Although mid- to long-term competitiveness in the industry will rest heavily on the successful development and commercialization of diesel, hybrid and fuel cell technologies, our analysis indicates that the majority of the near-term carbon reductions are achieved by less-heralded incremental technologies that are already available.

It is uncertain to what extent OEMs will be able to pass on cost increases to customers. In the current atmosphere of highly competitive pricing, the scope to pass on costs may be significantly limited. Consequently, cost increases could translate directly into lower EBIT margins. This is the simplest interpretation of these results and the one that is used to analyze overall findings in Chapter 6.

However, while production cost increases are the most immediate manifestation of new carbon constraints, two related impacts discussed below may affect OEMs' value creation potential: (i) scope for relative cost changes to influence sales volumes (up or down); and (ii) potential for all OEMs to benefit from perceived extra value of vehicles that are more fuel-efficient.

FIGURE 4.5. ESTIMATED COSTS PER VEHICLE TO MEET CO2 EMISSIONS STANDARDS BY 2015

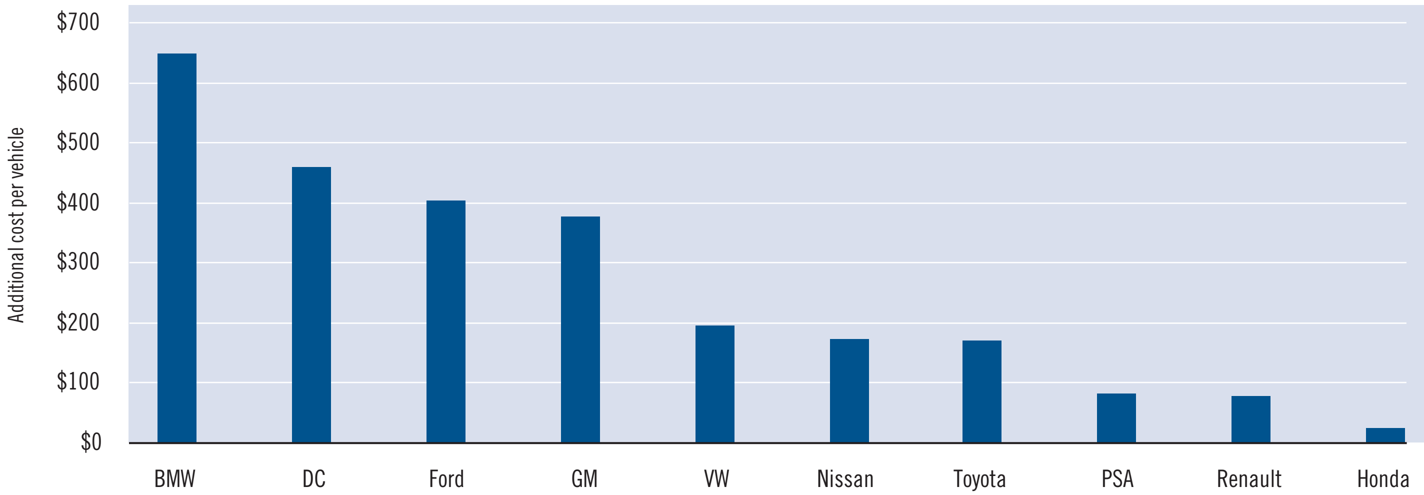


TABLE 4.3. Estimated Costs per Vehicle to Meet CO_2 Emissions Standards by 2015, by market

	BMW	DC	Ford	GM	Honda	Nissan	PSA	Renault	Toyota	VW
US	$267	$257	$380	$399	$2	$122	—	$122	$102	$119
EU	$807	$984	$455	$289	$175	$54	$82	$3	$314	$210
JP	—	$279	$287	—	$23	$340	—	$340	$190	—
Average	**$649**	**$459**	**$403**	**$377**	**$24**	**$172**	**$82**	**$79**	**$170**	**$195**

Notes: Average costs per vehicle reflect sales-weighted averages of costs in individual markets. Renault is attributed sales in US and Japan because of its 44 percent stake in Nissan.

TABLE 4.4. Estimated Total Costs to Meet CO_2 Emissions Standards by 2015, by market ($millions)

	BMW	DC	Ford	GM	Honda	Nissan	PSA	Renault	Toyota	VW
US	$69	$642	$1,333	$1,869	$3	$50	—	$40	$177	$59
EU	$502	$957	$757	$336	$32	$19	$170	$3	$202	$554
JP	—	$10	$18	—	$18	$123	—	$98	$254	—
Total	**$571**	**$1,609**	**$2,107**	**$2,205**	**$53**	**$192**	**$170**	**$141**	**$634**	**$613**

Note: Renault is attributed sales in US and Japan because of its 44 percent stake in Nissan.

Fuel economy improvements could alter demand patterns for vehicles.

4.4.2 Implications for Sales

Though vehicle pricing is currently very competitive, if the industry as a whole is facing pressure to lower carbon intensity, it is likely that average vehicle prices will rise as OEMs try to recoup costs. Moreover, over a 10-year period, there is ample scope for OEMs to raise vehicle prices: since 1970, the average amount that US consumers have been willing to spend on a new vehicle has increased by $229 each year.[59]

However, the combined efforts of OEMs to recover costs through higher prices may create new incentives for customers to switch to new vehicle segments and/or manufacturers. For example, if the full costs are passed on to consumers with a markup to cover overheads and dealer margins, we found that efforts to improve fuel economy in the US might lead to a $540 increase in the average price of an SUV, but only a $280 increase in the average price of a compact car. Though customers' choice of vehicle type is influenced by many factors, changes in relative price could alter relative sales growth in segments over time.

Similar effects hold for consumers' choice among models produced by different OEMs. For example, the price of an average vehicle sold in the United States by Ford (which had the lowest fleet average fuel economy in 2002) would rise by $800 in the high scenario, while the price of an average vehicle sold by Honda (which has the highest average fuel economy) would rise by a mere $5. To recoup costs, Ford will have to raise the price of its vehicles by more than the average OEM, while Honda will have to raise its price by only a negligible amount, and by considerably less than the average OEM. Consequently, one would expect Ford's sales to suffer, while Honda's might increase. These sales impacts would further influence OEMs' earnings and profits.

4.4.3 Scope for Higher Margins from Enhanced Fuel Economy

Fuel economy improvements create more valuable cars.

Though fuel economy improvements initially entail higher production costs, these improvements generate fuel savings that more than offset those costs. For example, for US sales as a whole, meeting fuel economy standards in the high scenario leads to an average sales price increase of $587 per car in the US market. However, improved fuel economy produces fuel cost savings of $913 in the first 5 years of ownership (the typical ownership period for new vehicle buyers), more than offsetting the increase in vehicle purchase price.[60] If consumers were to recognize the full value of fuel savings, they would perceive vehicles with improved fuel economy as more valuable than existing models that are otherwise comparable. In turn, this might offer OEMs an opportunity to capture some of the value created by fuel savings in the form of higher prices, thereby increasing margins. The challenge for OEMs is to find ways to effectively market fuel savings in a carbon-constrained world. In the United States, OEMs have long maintained that consumers do not value fuel economy highly. However, in countries where fuel prices are higher and/or incomes are lower, fuel economy is a more important component of the buying decision.

Even if consumers do not value fuel economy, consumers may value some of the other attributes offered by major new technologies, such as the durability of diesel or the advanced safety systems that hybrids may permit. Diesel engines in Europe already command a price premium of €200 above the additional costs of diesel engines relative to gasoline engines. It is conceivable that hybrid-related features will offer similar non-environmental benefits to consumers. If so, this would create additional opportunities for OEMs to lower overall costs or derive profit through meeting carbon constraints.

Chapter 5 Management Quality Assessment

SUMMARY

Offsetting the risks, emerging carbon constraints create opportunities for OEMs to enhance their competitiveness by developing vehicles that produce fewer carbon emissions. The degree to which OEMs succeed in this depends on the quality of management decisions made with regard to lower-carbon technologies. One challenge for managers is to establish leadership in one or more lower-carbon technologies that may be vital for future profits. In addition, given that most OEMs compete in more than one of the three major automotive markets, each of which has its own technology preferences, another challenge is to ensure that the strategy for reducing carbon emissions is robust, or balanced, across the multiple technology pathways outlined in Chapter 2.

In this chapter, we analyze each OEM's strategic positioning and quality of management with regard to carbon constraints. The strength and robustness of an OEM's strategy for lowering carbon emissions depends on a set of six key management competencies. Toyota, DC and Renault-Nissan have the strongest overall management quality scores across all lower-carbon technologies, though some other OEMs have strong positions in individual technologies.

5.1 OVERVIEW

The Management Quality Assessment seeks to answer the following question:

- Which OEMs have the strongest potential to capitalize on their investments in lower-carbon technologies and so benefit from carbon constraints?

In Chapter 2, we identified diesel, hybrid and fuel cell technology as key sources for future competitive advantage. The actual development of these technologies is only part of the challenge facing OEMs. OEMs also have to commercialize, market and mass produce these technologies if they are to reap the full rewards. Consequently, an OEM's ability to capitalize on carbon constraints depends on a wide range of management attributes regarding lower-carbon technologies, beyond just technological development capabilities.

By virtue of their market exposure, past management decisions and financial resources (among other factors), OEMs exhibit different levels of management quality with respect to lower-carbon technologies. The stronger an OEM's overall management capabilities in this area, the more likely it will be able to benefit from carbon constraints. While some OEMs have strong capabilities in one or two lower-carbon technologies, a few exhibit strength across all three technologies. Given uncertainties about the development of these technologies, and their acceptance by consumers and regulators in different markets, a strong management strategy across all three technologies may be advantageous.

This chapter gives an overview of the analysis. More details on the results for individual OEMs can be found in Section 3.

5.2 METHODOLOGY

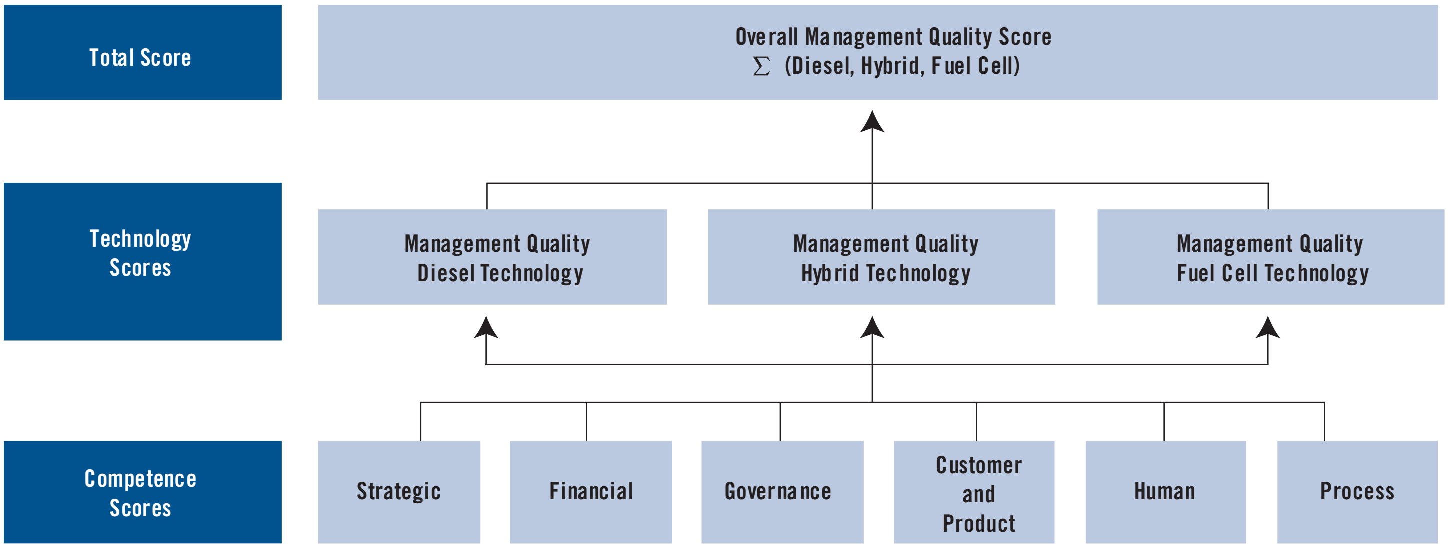
The analytical framework we used to assess lower carbon management quality is based on a management competence model developed by SAM Research. For the purpose of this report, SAM Research's standard competence model was adapted to focus on OEMs' ability to derive competitiveness through strategies to achieve lower carbon intensities (or "lower-carbon strategies"). The quality of such strategies is driven by a core set of management competencies, including strategic, financial, governance, customer and product, human, and process. (See Table 5.1.)

The Management Quality Assessment focuses on the three technologies—diesel, hybrid and fuel cell technology—that are most likely to form the basis for long-term competitive advantage. We believe that there is less scope for an OEM to establish a competitive edge

TABLE 5.1. Management Competencies Relevant for Assessing Lower Carbon Strategies

Competence	Business Case	Core Indicators
Strategic	Alignment of lower carbon strategy to business strategy enhances strategic co-ordination and is essential to derive competitiveness from lower carbon technologies	Level of strategic commitment Level of strategic coordination Targets Milstones
Financial	Ability to fund development and commercialization of lower carbon technologies is a key driver for turning lower carbon strategy into a competitive advantage	Cash position Level of R&D Expenditure Capital structure Access to capital Investor relations
Governance	Setting de facto standards in lower carbon technologies allow OEMs to capitalize on first mover advantages, such as enhanced pricing power	Ability to set de facto standards Market share License to operate
Customer & Product	Introducing a lower carbon technology ahead of competition holds strong potential for competitiveness, including brand equity.	Ability to derive brand equity Margins Market share Cross-selling Customer feedback
Human	Access to technology and ability to capitalize on intellectual capital through partnerships is essential for deriving competitiveness from lower carbon technologies	Number of patents R&D headcount Partnerships
Process	The ability to generate economies of scale allows to compensate development costs ahead of peers	Economies of scale Process efficiency Production flexibility Industrial ecology

FIGURE 5.1. STRUCTURE OF MANAGEMENT QUALITY ASSESSMENT



through lower-carbon technologies based on advanced gasoline engines and incremental technologies, given the mature stage of development of these technologies and widespread understanding of these technologies.

The full set of competencies was assessed and evaluated for each of the three lower-carbon technologies. The six competencies were scored for each technology using a simple scoring system of 0 (Low), 1 (Medium), and 2 (High). The scores for the individual competencies were then aggregated (equally weighted) into a management quality score for each lower-carbon technology. In turn, the technology-specific scores for diesel, hybrid and fuel cell technology were aggregated (equally weighted) into an overall management score to provide an indication of overall management strength. (See Figure 5.1.)

Finally, though Nissan and Renault are treated as separate OEMs elsewhere in the report, they received the same management quality scores. This reflects their close alliance and the expected increasing level of integration and strategic coordination between the two OEMs over the next decade.

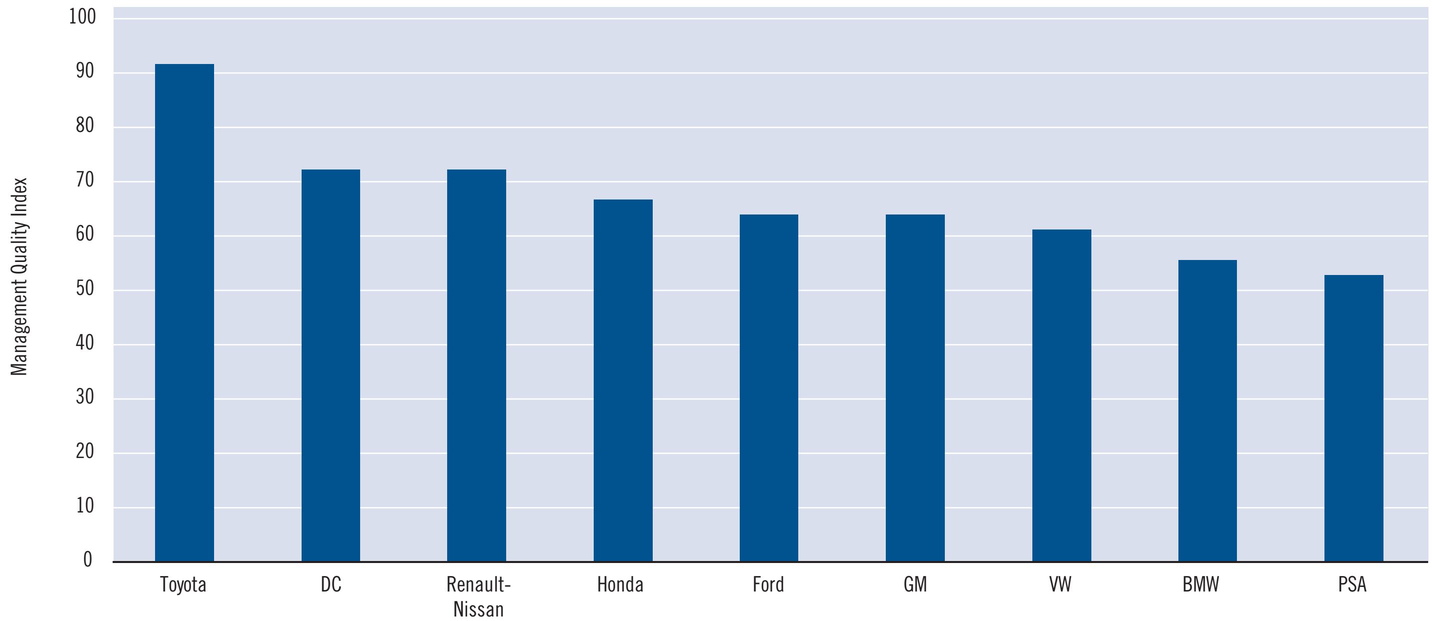
5.3 MAIN RESULTS

Company-specific information on management quality and strategic positioning can be found in Section 3 of this report. The following provides an overview of relative strategic positioning with regard to lower-carbon technologies.

OEMs differ in the overall strength of their lower-carbon strategies.

By combining scores across technologies, we derive an overall score for lower-carbon strategy for each OEM. (See Figure 5.2.) Toyota, DC and Renault-Nissan appear to have the strongest current management quality with regard to lower-carbon technologies. At the

FIGURE 5.2. MANAGEMENT QUALITY ASSESSMENT: ALL LOWER-CARBON TECHNOLOGIES



Note: Management quality score for BMW reflects its activities regarding the hydrogen-powered internal combustion engine.

other end of the scale, PSA and BMW display the weakest management positioning regarding lower-carbon technologies.

OEMs display different strengths in different technologies.

Besides overall strength, an OEM's current strategy with regard to carbon constraints may be more or less robust (or balanced) across alternative technology pathways. Based partly on prevailing regulatory regimes in their most important markets, OEMs have developed different preferences for lower-carbon technologies. Figure 5.3 reflects the strategic choices made by OEMs. While most European OEMs display a strategic bias toward diesel, US-based OEMs focus on fuel cell technology. Toyota and Honda show most bias toward hybrid technology. Renault-Nissan stands out among OEMs as having one of the more balanced lower-carbon strategies, reflecting the alliance's strategic fit and competitive potential.

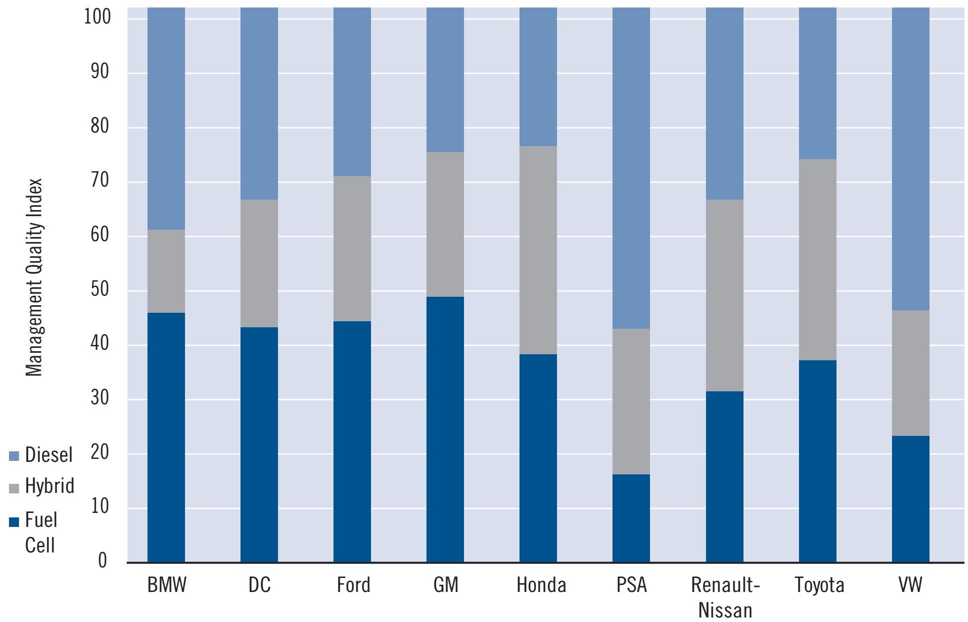
5.4 TECHNOLOGY-SPECIFIC RESULTS

5.4.1 Management Quality in Diesel Technology

Process competence and customer competence will be crucial for capitalizing on diesel technology.

Diesel is a relatively cheap and well-established lower-carbon technology. As a result, financial and technology development competencies are of increasingly less competitive relevance. Rather, the management challenge will be to maintain margins in the face of increasing competition through strong reputation, economies of scale, and flexibility of production. Consequently, management quality is reflected in a strong diesel sales base, high diesel margins, and cost leadership.

FIGURE 5.3. RELATIVE ROBUSTNESS OF MANAGEMENT QUALITY ACROSS LOWER-CARBON TECHNOLOGIES



Note: Management quality score for BMW reflects its activities regarding the hydrogen-powered internal combustion engine.

European OEMs are more competitive in diesel.

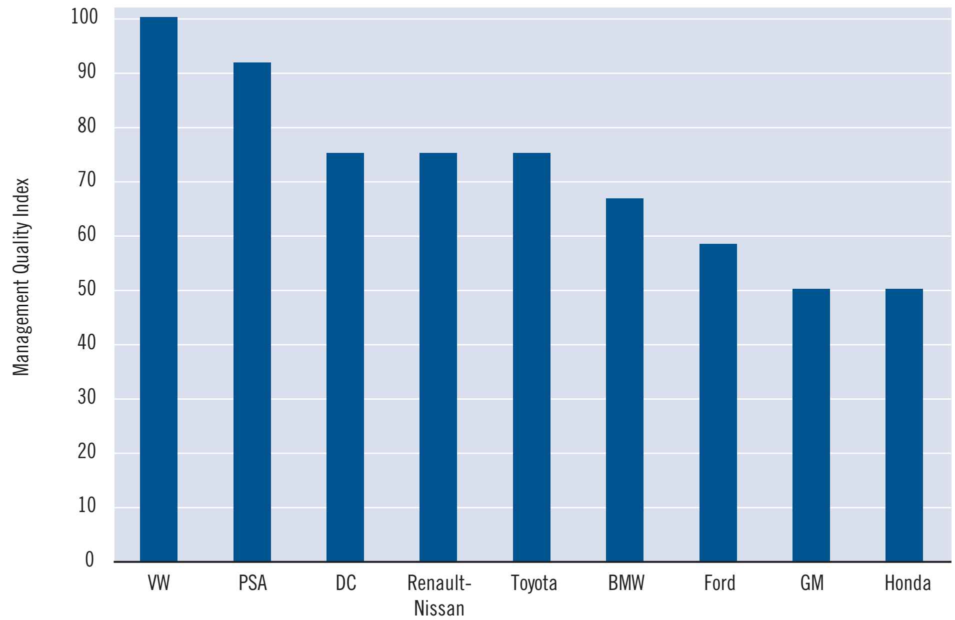
VW's and PSA's market leadership in diesel is clearly reflected in their high management quality scores. (See Figure 5.4.) Among the non-European OEMs, Toyota and Ford appear to be the most interesting. Toyota has recently stepped up its efforts in diesel due to a more aggressive push into Europe, where diesel is key for growth, and in preparation for meeting new Tier 2 air quality standards in the United States from 2007 onwards. By cooperating with PSA, Ford may have an opportunity to improve its diesel capabilities quickly by leveraging economies of scale. As a result, Ford's process competence regarding economies of scale is a key driver for its management quality score.

The following examples highlight some of the factors explaining OEMs' different positions on diesel technology:

Leading edge: VW

Diesel has been a strategic priority for VW for some time, and accounts for nearly 50 percent of the OEM's European sales.[61] This puts VW in a strong position to benefit from further diesel market growth over the next decade, especially in Europe. Moreover, VW´s European market leadership in diesel provides the company with significant brand equity. As a result, VW commands a higher price premium on its diesel sales relative to peers. Large global platforms and a modular strategy will provide for economies of scale and put VW in a strong position to strengthen margins.

FIGURE 5.4. MANAGEMENT QUALITY ASSESSMENT: DIESEL TECHNOLOGY



Note: Renault and Nissan receive the same management quality assessment scores to reflect the expected level of integration and strategic coordination between the two OEMs over the next decade.

Catching up: Ford

Ford is quickly expanding its diesel sales base, especially in Europe. Given that Ford is catching up with peers rather than leading, the company is unlikely to derive differentiation and brand equity from diesel technology. While this may limit upside potential of margins for diesel options, Ford may benefit from cost advantages due to the recent partnership with PSA that aims to establish a low-cost diesel platform.

Low profile: Honda

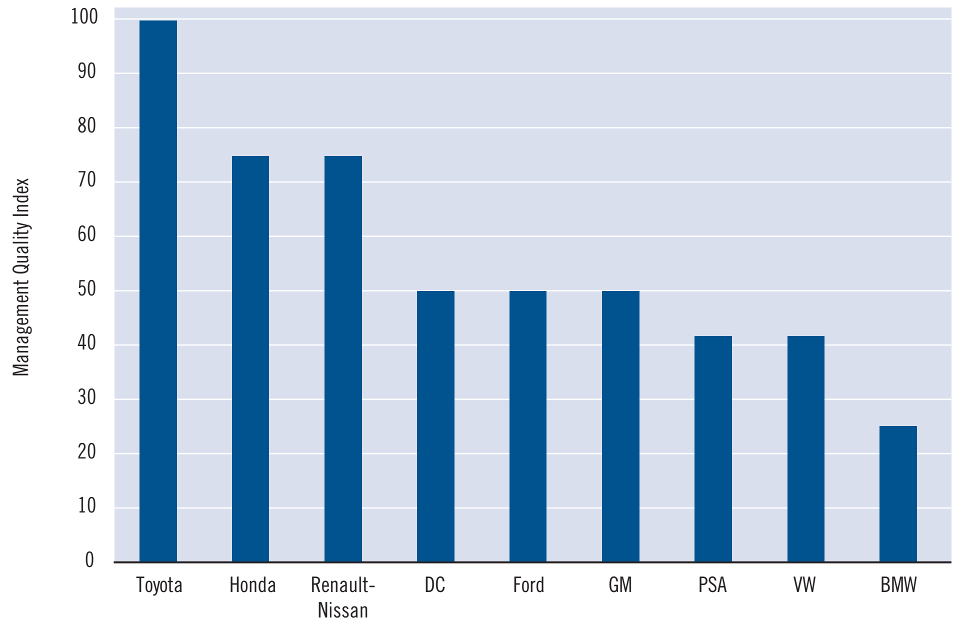
Realizing that diesel is a prerequisite for profitable growth in the European market, Honda only recently introduced a diesel option. Honda may temporarily offset its lack of scale through flexibility but may be at a structural disadvantage in the longer run. This is compounded by the fact that Honda avoids working through partnerships. This might limit Honda's ability to generate a competitive advantage in diesel.

5.4.2 Management Quality in Hybrid Technology

Financial, governance, and customer competencies will be important for capitalizing on hybrid technology.

Given the nature of HEVs as a relatively immature, emerging lower-carbon technology, the main challenges center around high development costs and lack of customer acceptance. As a result, the strategic management challenge is to quickly recoup development costs and to grow a strong customer base. Accordingly, key characteristics of management quality are the ability to forge strategic partnerships as well as moving faster up the learning curve. These factors increase the potential to set de facto standards.

FIGURE 5.5. MANAGEMENT QUALITY ASSESSMENT: HYBRID TECHNOLOGY



Note: Renault and Nissan receive the same management quality assessment scores to reflect the expected level of integration and strategic coordination between the two OEMs over the next decade.

Japanese OEMs have a strong strategic position in hybrid technology.

In contrast to Europe, the Japanese government has long expressed a preference for hybrid technology over diesel. This has allowed Japanese OEMs to establish early-mover advantages that are reflected in their management quality scores. (See Figure 5.5.) In addition, because of uncertainty regarding future technology pathways in the United States, US-based OEMs have recently stepped up their hybrid development. This is reflected in the slightly above average level of management quality. However, their ability to derive competitiveness from hybrid technology is still limited compared to their Japanese counterparts, who are the dominant players in this technology.

Leading edge: Toyota

Past management decisions have allowed Toyota to keep key technological knowledge in-house while at the same time establishing partnerships that could generate economies of scale. As a result, Toyota has established a unique competitive position in hybrid technology, which is reflected in its current 90 percent share of the global market for HEVs. In particular, the recent tie-up with Nissan indicates that Toyota is close to setting a de facto industry standard in hybrid technology. Having been the first to market with HEVs, Toyota is well ahead of competition in terms of organizational learning. Moreover, by building up a strong customer base for advanced vehicle technology, Toyota is starting to capitalize on its early market experience. Toyota can be expected to continue to invest aggressively in hybrid technology, further separating the company from its rivals, including Honda. While Honda's engineering expertise in hybrid technology is among the strongest in the industry, its reluctance to enter into partnerships similar to the Toyota-Nissan tie-up may limit its ability to capitalize fully on investments in lower-carbon technologies, for example through setting de facto standards and economies of scale.

Catching up: GM

GM has only recently changed its strategy on hybrid technology. By introducing a wide range of hybrid or near-hybrid options, GM seems to be building up an opportunistic hedge position against a potential uptake of HEVs, especially in the US market. While GM is well positioned to bring down costs for hybrid technology by virtue of its size, the lack of market experience with hybrid technology may turn out to be a structural disadvantage relative to the early movers.

Low profile: BMW

Reflecting the company's cautious position on hybrid technology, BMW has not taken any visible strategic steps regarding HEVs. While BMW´s strong cash flow in principle provides a comfortable position from which to fund hybrid technology development, resource allocation seems to be limited to research activities rather than a systematic commercialization strategy. Moreover, lack of scale may put BMW at a structural disadvantage to generate a premium on capital-intensive hybrid options.

5.2.4 Management Quality in Fuel Cell Technology

Financial, governance and human competencies will be key for capitalizing on fuel cell technology.

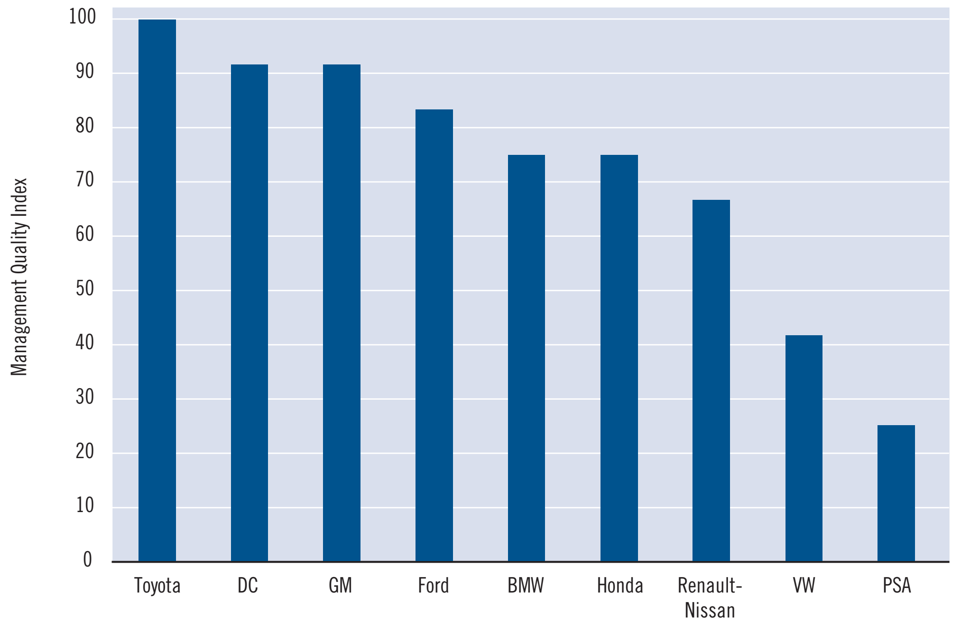
Because it is still early days for fuel cells, a range of technology issues remain to be resolved. This will require continued financial and R&D commitment. Importantly, the challenge is to bring the technology to the market ahead of rivals in order to recoup development costs and benefit from first-mover advantages. The key aspects of management quality on fuel cells are strong institutional and human R&D capacity, resource allocation and the ability to work through strategic partnerships.

Two key partnerships are advancing fuel cell technology.

As a result of these challenges, relative strategic positioning with respect to fuel cells is determined primarily by two main partnerships that have developed: DC-Ford-Ballard and Toyota-GM. These tie-ups are designed to provide partners with a head start as the market for FCVs emerges. (See Figure 5.6.) Their strategies differ slightly. While DC and Ford are outsourcing development and future production of fuel cells to Ballard Power Systems, Toyota is working on a proprietary technology. If successful, this could be the source of valuable licensing revenue as other OEMs utilize the technology.

Based on the competence evaluation, the two dominant OEMs in this area are Toyota and DC. Given that BMW is not visibly pursuing fuel cell technology as a powertrain option, we have considered their efforts to commercialize a hydrogen-powered internal combustion engine. In an environment of uncertainty around the emergence of fuel/technology pathways, a hydrogen-powered ICE could prove a viable alternative to fuel cells. This explains the relatively high score of BMW in Figure 5.6.

FIGURE 5.6. MANAGEMENT QUALITY ASSESSMENT: FUEL CELL TECHNOLOGY



Notes: Renault and Nissan receive the same management quality assessment scores to reflect the expected level of integration and strategic coordination between the two OEMs over the next decade. Management quality score for BMW reflects its activities regarding the hydrogen-powered internal combustion engine.

Leading edge: DC

DC has made fuel cell technology a cornerstone of its technology leadership strategy, forging an early partnership with Ballard, a leading supplier of fuel cells. This alliance, which now includes Ford, holds considerable potential to set de facto technology standards. This puts DC in a strong position to capitalize on its development costs through first-mover advantages. Moreover, DC has centralized its fuel cell R&D activities at the corporate level, strengthening strategic coordination and efficiency of resource allocation.

Catching up: Renault-Nissan

Nissan is aggressively pursuing fuel cell technology. Through its alliance with Renault, Nissan is in a good position to leverage its technology expertise (reflected in a large number of patents) with significant funding. Moreover, industrial synergies and the emergence of joint global platforms may put Renault-Nissan in a strong position to commercialize fuel cell technology in the longer term.

Low profile: PSA

Having reviewed its strategy on fuel cells, PSA has decided that it is too early for a strategic engagement. This suggests that PSA is significantly reducing resource allocation to fuel cell technology. As a result, PSA works mainly through publicly sponsored European research programs. This approach diminishes opportunities for PSA to derive competitive advantage from fuel cell technology.

Chapter 6 Aggregate Results and Implications for Value Creation

SUMMARY

This chapter outlines the implications of the separate risk and opportunity assessments described in Chapters 4 and 5 for OEM profitability and value creation. We translate the previous findings into changes in discounted EBIT (earnings before interest and taxes), a foundation for financial valuation in the sector.

Results show that OEMs are very differently positioned with respect to both the risks and opportunities presented by carbon constraints. Toyota emerges as the most strongly positioned company, while Ford and GM appear least well placed to respond to carbon constraints.

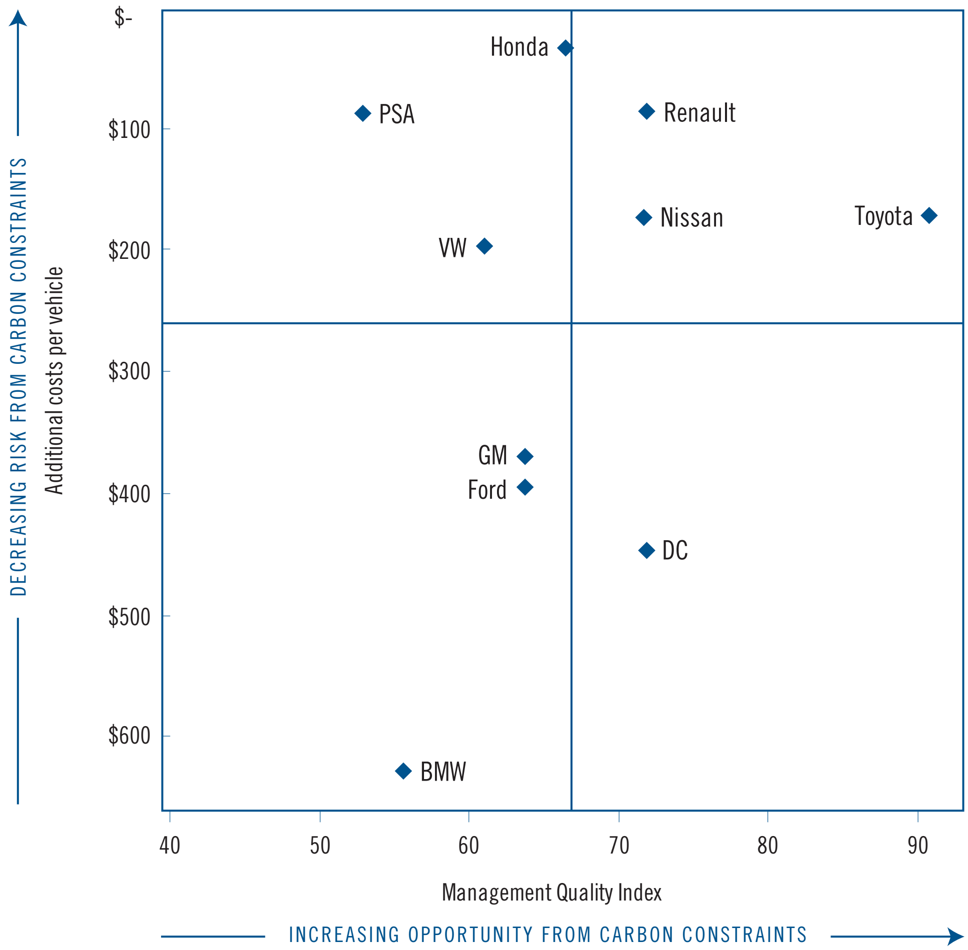
6.1 AGGREGATE RESULTS

Chapters 4 and 5 respectively assess OEMs' positioning regarding risks and opportunities from new carbon constraints. The Value Exposure Assessment in Chapter 4 estimates the costs in dollars that carbon constraints could impose on OEMs. The Management Quality Assessment in Chapter 5 ranks OEMs on their potential to capitalize on carbon constraints. Combining the two results provides a two-dimensional matrix upon which OEMs can be mapped. (See Figure 6.1.) Risk reflected by the Value Exposure Assessment is measured on the vertical axis, while opportunity captured by the Management Quality Assessment is measured on the horizontal axis. The top right quadrant (low value exposure – high management quality) represents better than average performance on both criteria.

Several findings are of note:

- OEMs vary considerably with respect to both value exposure and management quality around carbon constraints. This indicates that carbon constraints have the ability to influence competitive balance within the industry.
- Honda is the OEM that has the lowest value exposure. It faces the least immediate risk from carbon constraints as the current high fuel efficiency of its vehicles implies only minimal costs to meet new standards. Toyota emerges as the clear leader on carbon-related management quality with a strong position in all three technologies that will be key for long-term competitiveness.
- Renault and Nissan are also strongly positioned with better than average management quality scores and lower than average expected costs from carbon constraints.

FIGURE 6.1. QUANTIFICATION OF THE RISKS (Value Exposure) AND OPPORTUNITIES (Management Quality) OF CARBON CONSTRAINTS



Note: The lines indicate industry averages in each category.

- PSA and VW are two other OEMs that have lower than average value exposure, while DC has above average management quality with regard to carbon constraints.
- BMW stands out as having the greatest value exposure, though this may be somewhat misleading. BMW is the smallest of the 10 OEMs reviewed and produces exclusively premium (and high cost) vehicles. Consequently, BMW has a greater ability to pass on costs to consumers than do other OEMs.
- PSA has the weakest management strategy regarding carbon constraints, which may limit its ability to exploit opportunities even though it faces low expected costs.
- Ford and GM both have above average value exposure and below average management quality regarding climate risks. Their value exposure is driven principally by the relatively low fuel efficiency of their current vehicle mix. While much of this is due to their lead-

ership in the carbon-intensive segments of the US market, which may not face immediate constraints, their current bias towards heavy vehicles coupled with below average positioning on hybrid and diesel technology may limit their near-term competitiveness in non-US markets.

Section 3 of the report contains more details on each OEM's position.

6.2 THE IMPLICATIONS OF CARBON CONSTRAINTS FOR SHAREHOLDER VALUE CREATION

A key challenge for analysts is to determine the implications of these findings for earnings, return on invested capital (ROIC) and thus shareholder value creation. In this section, we translate the results of the Value Exposure and Management Quality assessments into changes in forecasted EBIT (earnings before interest and taxes) for the period 2003 to 2015. EBIT is a foundation for valuation estimates in this sector and so changes in an OEM's EBIT offer useful insights into possible changes for overall shareholder value.

Converting our cost estimates and management quality scores into EBIT figures sets our results in the context of existing and projected business performance. Though this adds confounding factors to our initial results, it nonetheless represents the basic challenge facing investors: to understand the additive effect that carbon constraints may have on each OEM's financial position.

Value Exposure translates into reductions in EBIT.

As the results of our Value Exposure Assessment are denominated in dollars, it is relatively easy to integrate these into existing financial valuation models. Carbon-related costs will increase the costs of goods sold and so reduce EBIT.

We developed a simple model based on the SAM Sustainability DCF (Discounted Cash Flow) model to forecast the impacts of value exposure for each company's discounted EBIT from the period 2003 to 2015.[62] (See column 1 of Table 6.1.) Information on recent years' cost and EBIT margins was combined with SAM and Deutsche Bank forecasts for sales growth and changes in EBIT margins to derive a baseline EBIT forecast. This baseline reflects important differences in OEMs' fundamental business performance. For example, some OEMs, like GM and Ford, are expected to see slower than average sales growth in the coming years as others compete for their profitable SUV segment. Additionally, some OEMs, such as BMW and Toyota, are expected to retain higher EBIT premiums because of such factors as brand and quality.

We then applied our cost estimates to see how they would alter the baseline discounted EBIT value. Translating cost estimates into EBIT changes the rankings of companies with regard to risks. BMW improves its performance notably. While BMW faces the highest estimated cost per vehicle to meet carbon constraints, as a premium OEM that enjoys higher than average price margins, it should have a greater ability to tolerate new costs than do other OEMs. This ensures that the EBIT implications of its value exposure are less damaging than the cost-only figures would suggest.

In contrast, GM and Ford's slightly higher than average cost per vehicle estimates lead to significant reductions in their EBIT forecasts. As noted above, this is driven in part by underlying assumptions about the current financial position of these OEMs. With both OEMs' sales growth and EBIT margins currently lower than the industry averages, GM and Ford can tolerate additional costs less well.

Management Quality could affect multiple financial metrics.

While management quality is extensively analyzed by investors, it is a very difficult concept to integrate into financial valuation models. In practice, good management quality will tend to permeate throughout the income statement and balance sheet rather than appearing discretely in certain places. Each analyst has their own preferred method of reflecting management quality within valuation models.

Good management quality regarding carbon constraints could have a positive impact on a number of financial variables, including increases in:

- EBIT margin (e.g., if a successful carbon strategy leads an OEM to produce new vehicles that confer higher pricing power)
- return on invested capital (ROIC) (e.g., if a successful development strategy allows an OEM to recover its R&D costs more quickly)
- sales (e.g., if an OEM can be first-to-market with a new lower-carbon technology that has mass customer appeal).

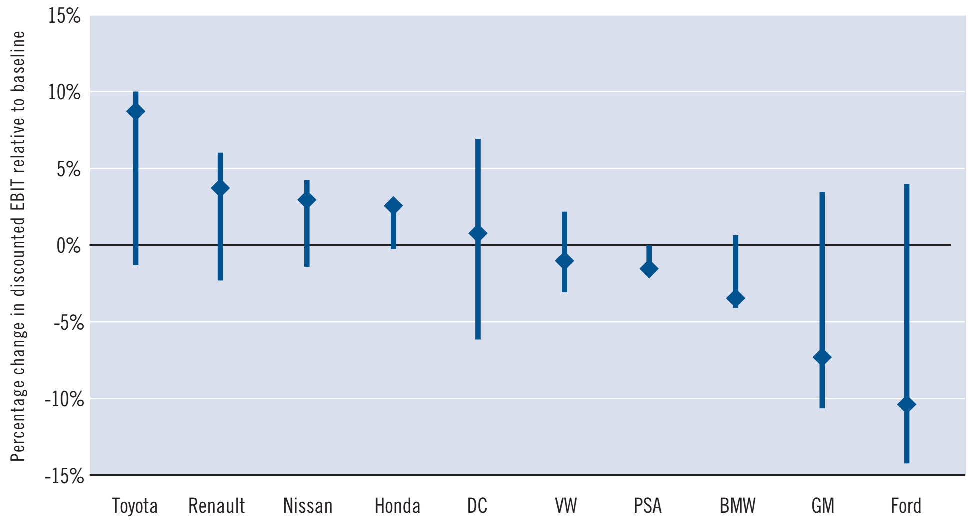
Though it is possible to identify such links, it is difficult to gauge the magnitude of impact that good management quality might have on specific variables.

As an indication of how analysts might use these results, we translate scores from the Management Quality Assessment into changes in EBIT margins in order to integrate them with the results of the Value Exposure Assessment. We assumed that the OEM with the strongest management quality (i.e., Toyota) would see its projected EBIT margin increase by 20 percent, while the OEM with the weakest management quality (i.e., PSA) would see no

TABLE 6.1. Potential Impact of Carbon Constraints for Discounted EBIT, 2003–2015 (percentage change from baseline EBIT forecast)

	Impact of Value Exposure Assessment (risk)	Impact of Management Quality Assessment (opportunity)	Combined Impact
BMW	-4	1	-3
DC	-6	7	1
Ford	-14	4	-10
GM	-11	3	-7
Honda	0	3	3
Nissan	-1	4	3
PSA	-2	0	-2
Renault	-2	6	4
Toyota	-2	10	8
VW	-3	2	-1

FIGURE 6.2. POTENTIAL IMPACT OF CARBON CONSTRAINTS FOR DISCOUNTED EBIT (2003–2015) BASED ON VALUE EXPOSURE AND MANAGEMENT QUALITY ASSESSMENTS



change in its projected EBIT margin. For the remaining OEMs, changes in EBIT margin lay in between these two extremes based on their relative management quality scores.[63] Integrating this strategy premium into the EBIT forecast reveals a significant upside effect, reflecting the potential to establish a competitive advantage through lower-carbon strategies. (See column 2 of Table 6.1.)

These combined results are presented in Figure 6.2 to show the range of possible effects on EBIT, in terms of percentage changes from business-as-usual EBIT projections. The upper limits reflect the results from the Management Quality Assessment alone, while the lower limits are results from the Value Exposure Assessment alone. The points indicate our estimate of the combined impact of both assessments on EBIT.

Combining value exposure and carbon strategy scores into a single EBIT measure demonstrates once again that carbon constraints could significantly affect the competitive balance within the industry. Changes in EBIT forecasts range from a 8 percent increase to a 10 percent decrease. Toyota appears best positioned, while Ford has the weakest result.

6.3 MAIN CONCLUSIONS

Though the shape of future carbon constraints and the stringency with which they will be enforced are uncertain, there is every indication that they could have a profound effect on the competitive balance in the industry.

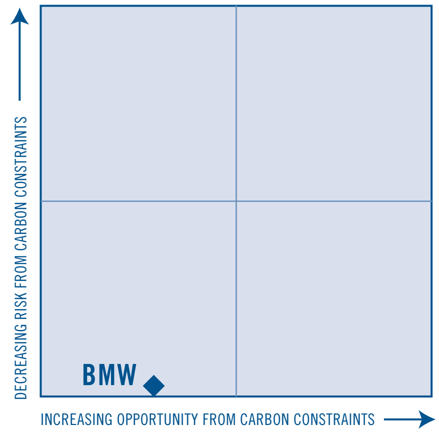
In the short term, carbon constraints could present the industry with new cost burdens that vary among OEMs. In particular, we find that BMW (with estimated costs of $649 per vehicle) may have to spend twenty-five times more per vehicle to meet carbon constraints than Honda ($24 per vehicle). Some of these costs could be recouped by price premiums for diesels and hybrids, both of which offer additional attributes that drivers may value. Even more of these costs could be recouped if more consumers were to account properly for fuel cost savings, though this tendency varies from market to market.

In the mid- to long term, carbon constraints will also create opportunities by raising the competitive significance of vehicle and engine technologies that offer improved fuel efficiency. This is an area in which OEMs are very differently positioned. Toyota stands out as best-positioned on these issues overall. In contrast, BMW and PSA are in the weakest positions. Certain OEMs show additional strengths and weaknesses with respect to particular lower-carbon technologies.

While the findings refer primarily to carbon constraints, they also shed light on how OEMs may perform in response to other pressures that would lead consumers or regulators to value fuel economy more highly (e.g., energy price rises or renewed energy security concerns). Indeed, consumer and policy responses to energy market shocks may play out considerably more rapidly than the steady progress in carbon regulations envisaged in this report, potentially making manufacturing adjustments more awkward. If so, the impacts on OEMs—whether positive or negative—may be more extreme than reported here.

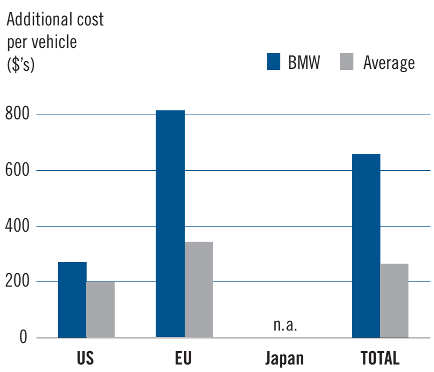
SECTION 3 THE COMPANIES

BMW Group



BMW faces the highest value exposure of the OEMs and a lower than average management quality score. These results translate into changes in estimated EBIT of -3% through 2015. The combined impact on EBIT is muted compared to other OEMs with similar value exposure results because of the high margins BMW commands as a premium brand. This will make it easier for BMW to recoup costs.

FIGURE 1
Value Exposure Relative to Peer Average

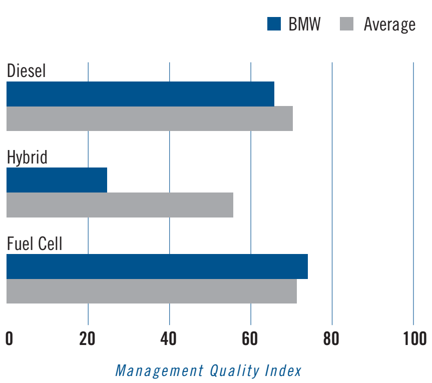


VALUE EXPOSURE

Premium strategy generates high carbon intensity.

BMW faces the highest costs in the industry for its 2002 fleet to meet higher fuel economy standards in the European Union and United States. (See Figure 1.) However the impact of these costs on EBIT is muted due to the higher margins BMW earns as a premium brand. BMW currently derives an estimated 37 percent of global profits from vehicles that emit more than 270 g CO_2/km (less than 20.5 mpg), with an estimated 30 percent of total profits coming from the US market, especially in larger cars. In light of the increasing importance of the US market for BMW, especially in the light truck segment, carbon intensity of profits is on the rise. Recently, BMW started to diversify into smaller, lower-carbon segments. However, the potential to reduce carbon intensity of profits through sales in smaller cars such as the Mini or the forthcoming 1-series is limited due to strong sales in larger cars, with the 3-series continuing to be the top-selling model. Plans to introduce hydrogen options for some selected models face significant market barriers. BMW's hydrogen-based cars are not expected to be profitable over the next decade and hold little potential to lower the carbon intensity of profits.

FIGURE 2
Management Quality on Lower-Carbon Technologies Relative to Peer Average



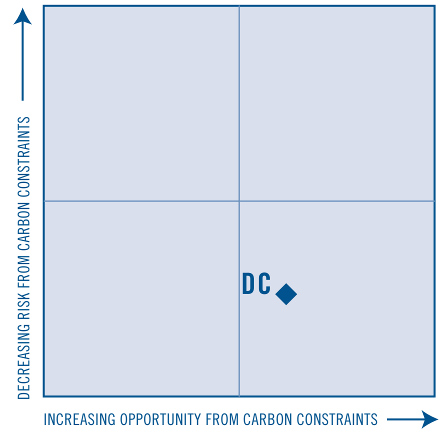
MANAGEMENT QUALITY*

Investments in lower-carbon technologies hold potential to create brand equity.

BMW shows above average management quality in hydrogen-powered internal combustion engine technology, a lower-carbon technology equivalent to fuel cells. (See Figure 2.) In particular, BMW is set to derive significant brand value from its focus on the hydrogen-powered internal combustion engine due to strong alignment with its premium strategy. Given the combination of a high cash position, strong cash flow and high R&D spending, BMW would be generally well placed to allocate resources to the development and commercialization of lower-carbon technologies. However, it seems that BMW lacks hedging in hybrid technology and fuel-cell propulsion technology, which could prove a disadvantage. Moreover, lack of scale may prove a structural challenge for the commercialization of lower-carbon technologies in general.

* Since BMW is not visibly pursuing fuel cell technology as a powertrain option, the evaluation in this category reflects the company's efforts regarding the commercialization of a hydrogen-powered internal combustion engine.

DaimlerChrysler



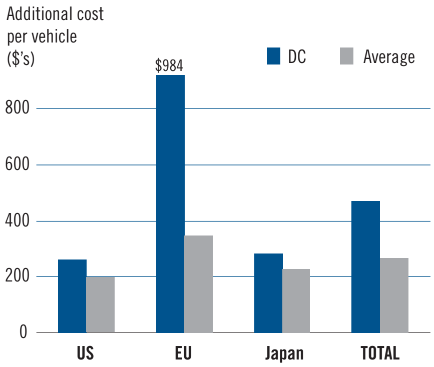
High sensitivity to carbon constraints combined with high potential to derive competitiveness from diesel and fuel cell technology translates into changes in estimated EBIT of +1% through 2015.

VALUE EXPOSURE

Chrysler turnaround is driving carbon intensity.

DC faces the second highest costs in the industry for its 2002 fleet to meet higher fuel economy standards in the United States, European Union and Japan. (See Figure 1.) The cost exposure is created mainly by light trucks in the US market, which account for an estimated 80 percent of profits at Chrysler. Overall DC currently derives an estimated 45 percent of global profits from vehicles that emit more than 270 g CO_2/km (less than 20.5 mpg). The challenge for DC is to combine a turnaround at both Chrysler and Mitsubishi with lower carbon growth in its main markets. However, DC's profitability continues to be dominated by Chrysler, where turnaround is dependent on the SUV and pickup segment, which will increase carbon intensity of profits. At the same time, margins will come under pressure from increased competition in this segment. In addition, DC's plans to steer Chrysler from the mainstream market into the premium segment is likely to further heighten carbon intensity of profits.

FIGURE 1
Value Exposure Relative to Peer Average

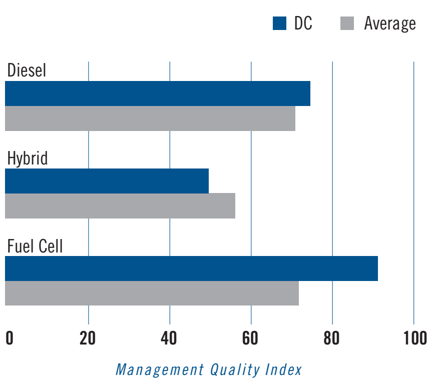


MANAGEMENT QUALITY

Ability to streamline global platforms is a challenge.

Lower-carbon technology is a key aspect of DC's overall technology leadership aspirations and a cornerstone of its global strategy. DC is among the leading OEMs in both diesel and fuel cell technology and is looking to strengthen its management focus on hybrid technology. (See Figure 2.) In particular, DC's investment in fuel cell technology offers strong potential to derive competitiveness through setting de facto standards as well as brand equity. A key for translating technology leadership into competitive advantage will be DC's ability to streamline its global platforms by turning around both Chrysler and Mitsubishi. However, weak cash flow and turnaround efforts at Chrysler and Mitsubishi might limit resources available for development of key lower-carbon technologies.

FIGURE 2
Management Quality on Lower-Carbon Technologies Relative to Peer Average



Ford Motor Company

A high sensitivity to carbon constraints combined with below average potential to derive competitiveness from non-fuel cell technologies translates to a change in estimated EBIT of -10% through 2015. The low EBIT value is also influenced by poor current financial conditions.

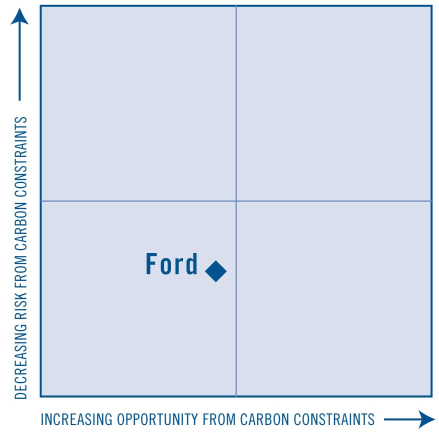
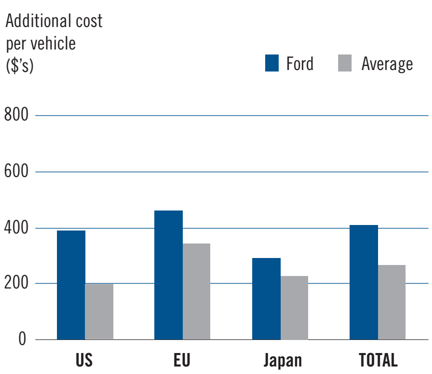


FIGURE 1
Value Exposure Relative to Peer Average

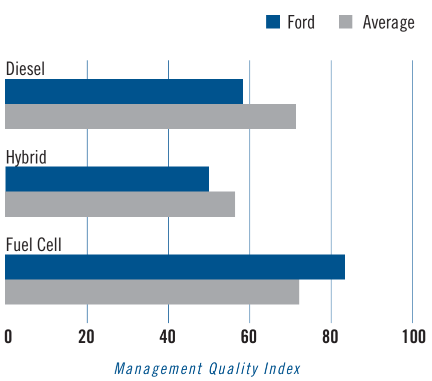


VALUE EXPOSURE

Revitalization features a carbon-intensive product line-up.

Ford faces relatively high costs for its 2002 fleet to meet higher fuel economy standards in the United States, European Union and Japan. (See Figure 1.) Accounting for an estimated 70 percent of profits in 2002, the United States is Ford's most important market. The US market also determines Ford's carbon intensity of profits, with an estimated 80 percent of US profits derived from sales of light trucks. This structural bias in the higher-carbon segments leaves Ford exposed to both carbon constraints and shrinking margins in the light truck segment. The carbon intensity of its product portfolio is not expected to change soon since the revitalization plan is largely built around increased sales of SUVs and pickups. Apart from light trucks, Ford expects a 30 percent contribution to its profitability target of $7 billion by mid-decade from its Premier Automotive Group (PAG), which includes Volvo and Land Rover, among others. As with light trucks, profits derived from these premium and luxury segments are expected to remain relatively carbon-intensive. This situation is compounded by the fact that Ford is currently not in a position to offset carbon-intensive profits in light trucks with its passenger vehicle business, which shows low or negative profitability.

FIGURE 2
Management Quality on Lower-Carbon Technologies Relative to Peer Average



MANAGEMENT QUALITY

Scale and strategic alignment of lower-carbon technologies will be critical.

Ford is among the leading OEMs in fuel cell technology and, along with GM and DC, is catching up with peers in hybrid technology. (See Figure 2.) Ford's management quality in fuel cell technology is largely dictated by its alliance with Ballard and DC and the potential for this partnership to generate economies of scale. However, to fully capitalize on key lower-carbon technologies, Ford will have to realize better economies of scale from its large platforms. Moreover, Ford's broad portfolio of lower-carbon technologies contrasts with increasingly limited resources due to weak cash flow and restructuring efforts. As a result, Ford will have to enhance strategic coordination by further rationalizing its portfolio of lower-carbon technologies.

General Motors

A high sensitivity to carbon constraints combined with below average potential to derive competitiveness from non-fuel cell technologies translates to a change in estimated EBIT of -7% through 2015.

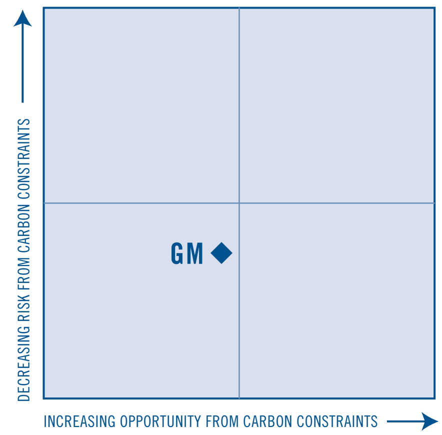
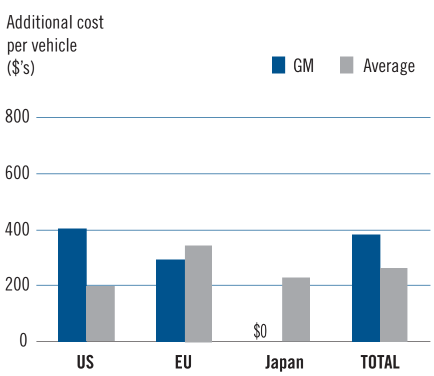


FIGURE 1
Value Exposure Relative to Peer Average

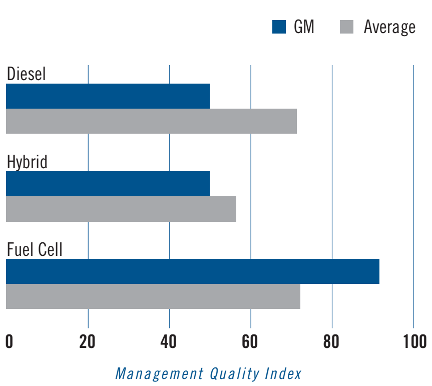


VALUE EXPOSURE

Profitability focuses narrowly on carbon-intensive segment.

GM faces above average costs for its 2002 fleet to meet higher fuel economy standards in the United States, while in the European Union and Japan it faces lower than average costs. (See Figure 1.) Although the United States and European Union are GM's main markets, the United States accounts for virtually all profits. GM's strong bias in the light truck segment is reflected in its carbon intensity of profits as well as carbon intensity of sales in the US market. Over 70 percent of GM's profits are derived from vehicles that emit more than 270 g CO_2/km (less than 20.5 mpg). GM's dependence on a very narrow and carbon- intensive segment of the market (SUVs and pickups) makes the company vulnerable to both tighter emissions standards and increased competition in the light truck segment. Similar to Ford and DC, GM's margins are expected to come under further pressure while the structure of the product line-up and thus carbon intensity of profits remain unchanged. GM would be in a better position than Ford and Chrysler to turn around its passenger vehicle business because of a more favorable cost structure. However, it is unclear whether GM can derive much profitability from its lower-carbon segments.

FIGURE 2
Management Quality on Lower-Carbon Technologies Relative to Peer Average



MANAGEMENT QUALITY

Capitalizing on a strong bet on fuel cell technology will be key.

GM's efforts on lower-carbon technology focus primarily on fuel cell technology. While GM recently started to catch up with its peers in hybrid technology, strategic alignment and organizational integration seem to be lacking compared to fuel cell technology. Despite strong access to all key lower-carbon technologies through affiliates, suppliers and partnerships, GM's ability to capitalize on its expertise in diesel technology appears to be significantly lower than its peers. (See Figure 2.) Given the strong strategic bet on fuel cell technology, the challenge for GM will be to fully capitalize on its investment through setting de facto standards, brand equity and economies of scale.

Honda Motor Company

Very low sensitivity to carbon constraints combined with high potential to derive competitiveness from hybrid and fuel cell technology give Honda an estimated EBIT change of +3% through 2015.

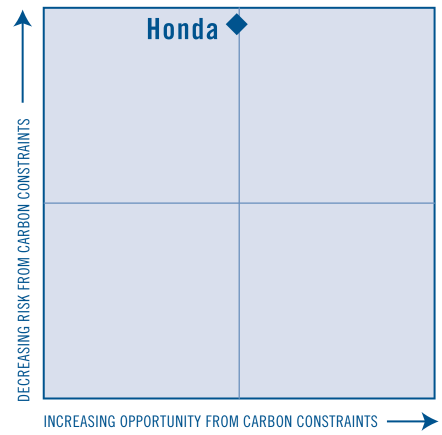
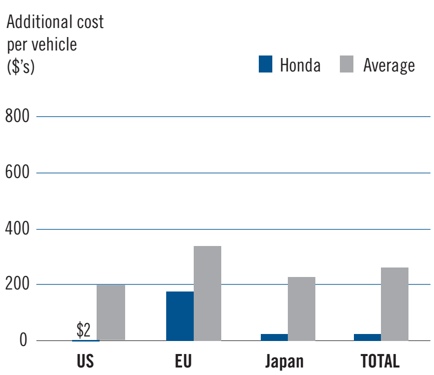


FIGURE 1
Value Exposure Relative to Peer Average

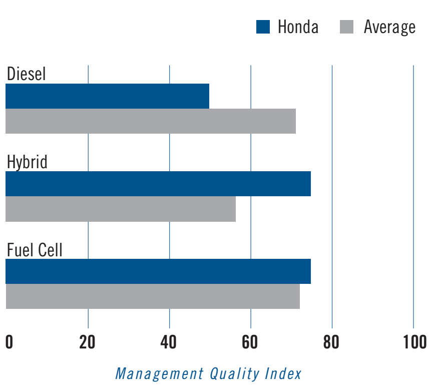


VALUE EXPOSURE

Top-class fuel efficiency enhances corporate brand and global competitiveness.

Honda's costs to meet higher fuel economy standards across its fleet are the lowest of the 10 OEMs assessed. (See Figure 1.) Honda's main markets are the United States and Japan, with the former contributing an estimated 90 percent of global profits in 2002. While Honda is expected to continue to depend heavily on the US market, the company aims to expand in Europe and especially Asia. Honda has taken the view that top-class fuel efficiency contributes significantly to its corporate brand and enhances its global competitiveness. This is clearly reflected in relatively low carbon intensity across all segments. In 2002, Honda derived an estimated 70 percent of profits from vehicles that emitted less than 270 g CO_2/km (greater than 20.5 mpg). In contrast to peers with significant presence in the US market, Honda has no plans yet to push into the highly carbon-intensive segment of large pickups. In combination with Honda's diesel-based expansion in Europe, this will help to further decarbonize profits relative to its peers.

FIGURE 2
Management Quality on Lower-Carbon Technologies Relative to Peer Average



MANAGEMENT QUALITY

Leveraging expertise in lower-carbon technology will be crucial.

Honda systematically aligns lower-carbon technologies with its global expansion strategy. Honda's lower-carbon technology strategy is underpinned by a very strong cash position and high R&D spending. While Honda shows a low profile in diesel technology, it is among the leading OEMs in hybrid technology. (See Figure 2.) Moreover, Honda is aggressively pushing into fuel cell technology. While Honda's engineering expertise across all key lower-carbon technologies is among the strongest in the industry, its reluctance to enter into partnerships may limit its ability to capitalize fully on investments in lower-carbon technologies, for example through economies of scale or setting de facto standards. Still, Honda is deriving significant brand equity from lower-carbon technologies, in particular from its early commercialization of HEVs.

Nissan Motor Company

High sensitivity to carbon constraints combines with high potential to derive competitiveness from diesel and hybrid technology thanks to its alliance with Renault and its tie-up with Toyota. This position translates into an increase in estimated EBIT of +3% through 2015.

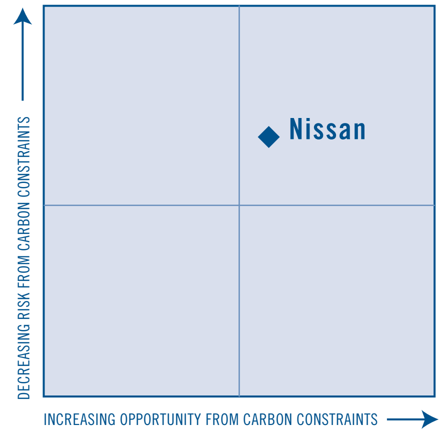
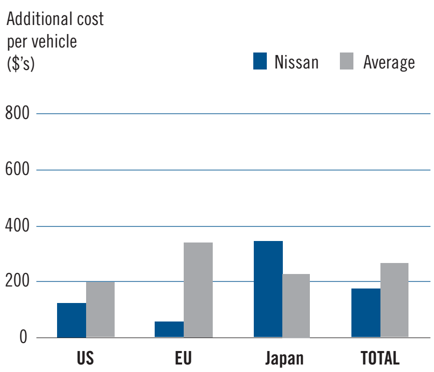


FIGURE 1
Value Exposure Relative to Peer Average

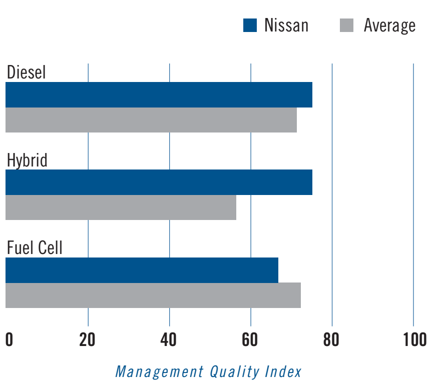


VALUE EXPOSURE

"Nissan 180" increases carbon intensity.

Nissan faces lower than average costs for its 2002 fleet to meet higher fuel economy standards in the United States and Europe, but higher than average costs in Japan. (See Figure 1.) In 2002, Nissan derived an estimated 75 percent of its profits from sales in the United States. However, less than a third of global profits are from vehicles that emit more than 270 g CO_2/km (less than 20.5 mpg). Following the launch of the Renault-Nissan alliance in 1999, Nissan embarked on a Revival Plan, based on cost reduction and restructuring, which has been successfully completed. Since 2002, Nissan has been implementing a new 3-year business plan, the "Nissan 180", aimed at 1 million unit sales, 8 percent operating margin, and zero automotive debt. The "Nissan 180" depends heavily on further growth in the United States, which is expected to be driven largely by sales in the light truck segment. In June 2003, Nissan laid the foundation for this expansion by opening a new plant dedicated to production of the Titan, its first full-size pickup. Increased US sales in light trucks are expected to alter the distribution of global profits across segments in favor of pickups and SUVs. As a result, Nissan's global profits will become more carbon-intensive in the near term.

FIGURE 2
Management Quality on Lower-Carbon Technologies Relative to Peer Average



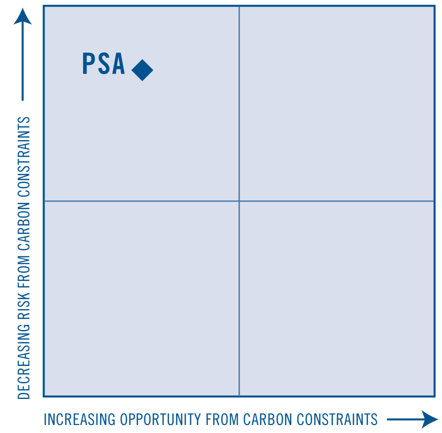
MANAGEMENT QUALITY*

Industrial synergies are likely to leverage technology expertise.

Recent strategic moves show Nissan's ability to align its expansion strategy with a lower-carbon technology strategy. For instance, the recent tie-up with Toyota regarding hybrid technology holds strong potential for Nissan to capitalize on its investment in this key lower-carbon technology. Moreover, Nissan is well positioned to benefit from further growth in the diesel market through alliance partner Renault. (See Figure 2.) The alliance with Renault puts Nissan in a strong position to establish a competitive advantage by leveraging considerable in-house technology expertise through industrial synergies and improved cash situation. Further, global joint platforms should enable Nissan to bring down costs for key lower-carbon technologies.

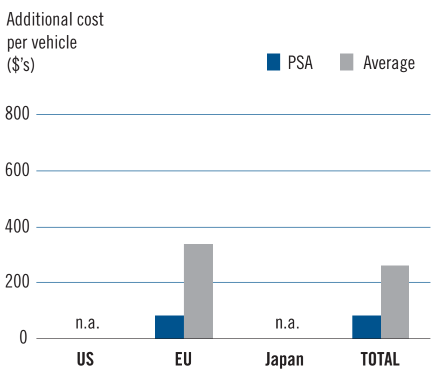
* To reflect the expected increasing level of integration and strategic coordination over the next decade, we treat alliance partners Renault and Nissan as one organization for assessment of management quality in key lower-carbon technologies through 2015.

PSA Peugeot Citroen



PSA faces the third lowest value exposure of the OEMs assessed. However, aside from expertise in diesel, the company exhibits below average management quality in non-diesel technologies. This translates into a change in estimated EBIT of -2% through 2015.

FIGURE 1
Value Exposure Relative to Peer Average

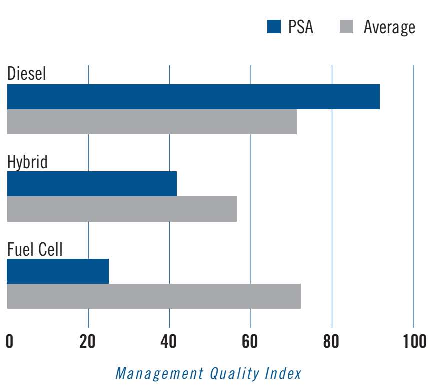


VALUE EXPOSURE

Diesel focus keeps carbon intensity low.

PSA displays low sensitivity to carbon constraints. (See Figure 1.) Europe is PSA's most important market, accounting for an estimated 90 percent of profits. The carbon intensity of profits is low, with an estimated 93 percent of profits derived from vehicles that emit less than 200 g CO_2/km (more than 27.5 mpg). Increasingly, growth is expected to come largely from emerging markets in Central Europe, Asia, and Latin America. In addition, a re-entry into the US market cannot be ruled out. A strong diesel bias combined with a broad model line-up in the smaller segments provide the basis for low carbon intensity of profits. Further European growth in diesel is expected to translate into higher margins for PSA as it enjoys a higher diesel price premium than most European competitors. Increasing sales of smaller cars jointly developed with Toyota will further help to reduce the carbon intensity of profits. In addition, PSA has no plans to strengthen its position in the carbon-intensive luxury segment. As a result, PSA's carbon intensity can be expected to remain at the low end of the peer group.

FIGURE 2
Management Quality on Lower-Carbon Technologies Relative to Peer Average

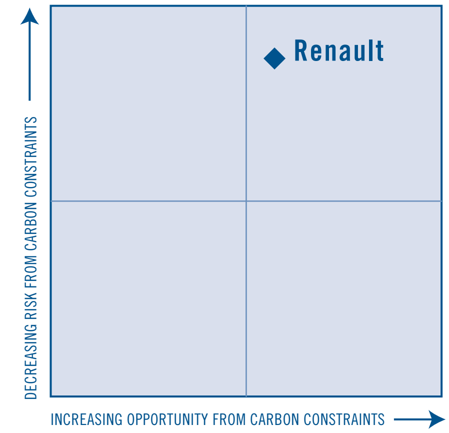


MANAGEMENT QUALITY

Partnerships are essential.

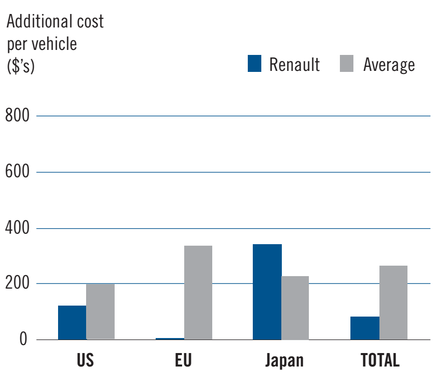
Although it recently announced plans to commercialize hybrid technology, PSA's lower-carbon technology strategy is very focused on diesel. As a result, PSA shows above average potential to derive competitiveness from its investment in diesel technology. (See Figure 2.) PSA has already established a temporary lead over its competitors in particulate filter technology. A key for PSA's ability to achieve its longer-term goal of cost leadership in diesel technology will be management of partnerships that provide economies of scale. While PSA has started to catch up on hybrid technology, it remains to be seen whether it will manage to forge a partnership that can strengthen its position. Moreover, PSA displays a low profile in fuel cell technology. Relatively low R&D spending and cash position may also constrain PSA's competitive position in lower-carbon technologies.

Renault



Low sensitivity to carbon constraints combined with high potential to derive competitiveness from diesel and hybrid technology from its alliance with Nissan translates into a projected impact on estimated EBIT of +4% through 2015.

FIGURE 1
Value Exposure Relative to Peer Average



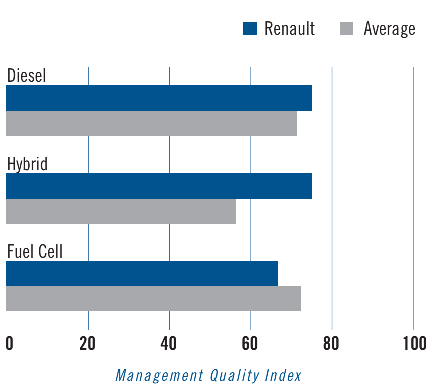
Note: Renault's exposure in the US and Japan are a result of its 44 percent ownership in Nissan.

VALUE EXPOSURE

A European focus contributes to a low-carbon product line-up.

Renault faces virtually no costs to meet higher CO_2 emissions standards in Europe. (See Figure 1.) With an estimated 90 percent of profits, Europe is Renault's most important market. However, the company aims to produce 50 percent of vehicles outside Western Europe by 2010, with a focus on emerging markets. The alliance with Nissan is expected to boost international expansion of the Renault brand while improving the cost basis through sharing of platforms, technology and capacity. Renault starts from one of the lowest carbon profiles in the industry, with an estimated 81 percent of global profits derived from vehicles that emit less than 200 g CO_2/km (more than 27.5 mpg). This profile complements Nissan's line-up, which is somewhat more carbon-intensive due to its exposure in the US light truck segment. The low carbon profile of Renault's product line-up is driven by its European focus and a strong presence in the small, compact, and midsized segments, which include Renault's most popular models (such as Twingo, Kangoo, and Clio) and account for approximately 50 percent of sales. Since profits are expected to continue to be generated largely from lower-carbon segments, Renault shows low sensitivity to carbon constraints.

FIGURE 2
Management Quality on Lower-Carbon Technologies Relative to Peer Average



MANAGEMENT QUALITY*

Strategic coordination with alliance partner generates low-carbon benefits.

While high management quality in hybrid technology is largely provided by alliance partner Nissan, Renault contributes management quality in diesel. (See Figure 2.) Thanks to a relatively high sales base and price premium in diesel technology, Renault is well placed to benefit from further growth in the diesel market. Meanwhile, the alliance with Nissan gives Renault strong access to other important lower-carbon technologies, such as hybrid and fuel cell technology. Together, Renault and Nissan are in a strong position to establish a competitive advantage by leveraging considerable in-house technology expertise through industrial synergies. Starting in 2006, joint global platforms with Nissan will enable Renault to generate economies of scale in lower-carbon technologies.

* To reflect the expected increasing level of integration and strategic coordination over the next decade, we treat alliance partners Renault and Nissan as one organization for assessment of management quality in key lower-carbon technologies through 2015.

Toyota Motor Company

Below average sensitivity to carbon constraints combines with high potential to derive competitive advantages from investments across the full range of lower-carbon technologies to translate into changes in estimated EBIT of +8% through 2015.

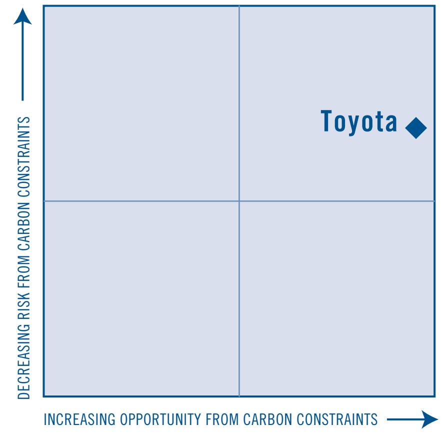
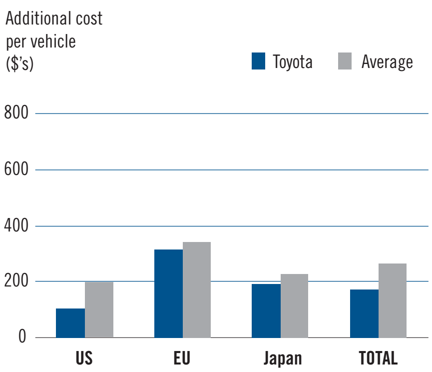


FIGURE 1
Value Exposure Relative to Peer Average

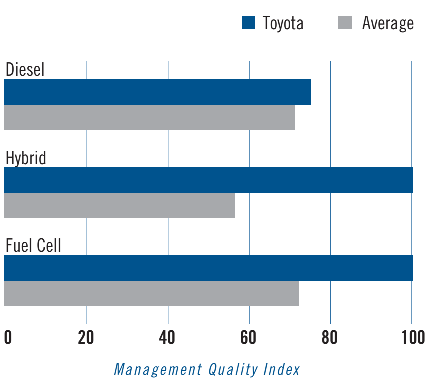


VALUE EXPOSURE

Carbon intensity of global profits is on the rise in the near term.

Toyota faces below average costs to meet higher fuel economy standards in all three main markets. (See Figure 1.) Toyota's 2010 Global Vision aims to increase worldwide market share from 10 percent today to 15 percent over the next decade. Growth is expected to be generated by a continued focus on its core markets of the United States and Japan, combined with a push into emerging markets such as China. In the short term, Toyota's expansion in the United States will be dominated by increased sales in full-size light trucks, and the company is currently building up production capacity for this segment. Given an aggressive push into this segment, light trucks are likely to account for a larger share of Toyota's future profitability than the current estimated 45 percent. Consequently, carbon intensity of Toyota's global profits is on the rise in the near term. However, Toyota has the potential to partly offset this rise in carbon intensity by expanding its small-vehicle business in Europe, especially through highly efficient diesel vehicles.

FIGURE 2
Management Quality on Lower-Carbon Technologies Relative to Peer Average



MANAGEMENT QUALITY

Strong diversification in lower-carbon technologies creates unique competitive potential through 2015.

Toyota's potential to capitalize on the full range of lower-carbon technologies clearly distinguishes it from its peers. (See Figure 2.) Early on, Toyota systematically aligned its lower-carbon technology (Eco-Project) with its global expansion strategy. Given its strong capital structure, Toyota is in a unique position to continue to invest aggressively in lower-carbon technologies. Past strategic moves put Toyota in a particularly strong position in fuel cell and hybrid technologies, where its dominance could impact competitive balance across the automotive industry. Toyota is also quietly emerging as a leader in diesel technologies. As a result, the company is well positioned to derive a higher return on investments in key lower-carbon technologies. Also, its strength in all three technologies will give Toyota flexibility in adapting to future regulatory and consumer preferences in different markets.

VW Group

A low downside exposure to carbon constraints combined with management quality weakness in non-diesel technologies translates into an estimated EBIT change of -1% through 2015.

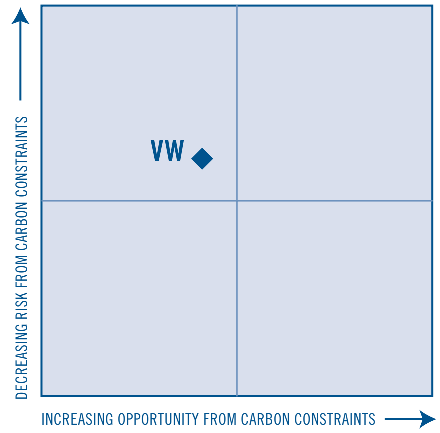
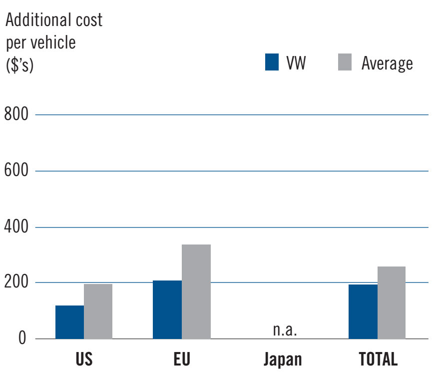


FIGURE 1
Value Exposure Relative to Peer Average

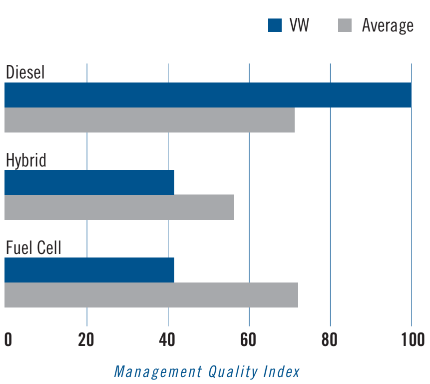


VALUE EXPOSURE

A low-carbon product line-up holds strong potential for balanced growth.

VW faces below average costs to meet lower carbon emissions standards in the US and EU automotive markets. (See Figure 1.) With a product structure that is fuel-efficient relative to peers across market segments, VW is well positioned to build up a balanced portfolio of growth without increasing carbon intensity. In 2002, an estimated 67 percent of global profits were derived from vehicles that emitted less than 200 g CO_2/km (greater than 27.5 mpg). While expansion in the United States will be largely driven by SUVs such as the Touareg, increased carbon intensity of US-derived profits is expected to be offset by a strong structural sales base in the midsized and compact segments in Europe. Moreover, expansion plans include a systematic introduction of highly efficient, direct-injection diesel and gasoline engines throughout all segments. By 2005, VW plans to have completed the introduction of direct-injection options throughout all engine families. This systematic incremental approach holds strong potential to keep carbon intensity stable while growing the business across all segments.

FIGURE 2
Management Quality on Lower-Carbon Technologies Relative to Peer Average



MANAGEMENT QUALITY

Strengthening position beyond diesel will be key.

VW´s lower-carbon technology strategy focuses on advanced internal combustion engines, with a historic priority on diesel. As a result, management quality is clearly dominated by VW's industry-leading position in diesel technology. (See Figure 2.) This strong position in diesel not only generates significant brand equity and market leadership in Europe, it also will help enable VW to capitalize on diesel technology in other markets, including the United States, where the company is pursuing a first-mover strategy. Leadership in diesel contrasts with VW's cautious position in hybrid and fuel cell technology. While this stance reduces short-term costs, the need to catch up with peers at a later stage might put VW at a competitive disadvantage. If it can overcome this challenge, VW would be well positioned to generate economies of scale in lower-carbon technologies by virtue of its high-volume global platforms.

NOTES

1. Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2001: The Scientific Basis—Summary for Policymakers: A Report of Working Group I of the Intergovernmental Panel on Climate Change* (Geneva, Switzerland: IPCC, 2001 p.2).
2. IPCC (2001) p.10.
3. IPCC (2001) p.13.
4. *The Kyoto Protocol to the United Nations Framework Convention on Climate Change.* At http://unfccc.int/resource/docs/convkp/kpeng.pdf.
5. Based on data from Automotive News, 2003 *Global Market Data Book* (Detroit: May 26, 2003).
6. Letter from President Bush to Senators Hagel, Helms, Craig, and Roberts. At http://www.whitehouse.gov/news/releases/2001/03/20010314.html.
7. "Business leaders say climate change is our greatest challenge," Davos Annual Meeting 2000 (January 27, 2000). At www.weforum.org.
8. Malcolm Weiss, et al., On the Road in 2020: A Lifecycle Analysis of New Automobile Technologies (Cambridge MA: MIT, October 2000).
9. US Environmental Protection Agency (EPA), *Light Duty Automotive Technology and Fuel Economy Trends: 1975 through 2001* (Washington D.C.: Office of Transportation and Air Quality, September 2001 p.i). These refer to "vehicle use" emissions only.
10. American Automobile Manufacturers Association (AAMA), *World Motor Vehicle Data 1993* (AAMA, Washington, D.C., 1993 p. 23) and AAMA, *Motor Vehicle Facts and Figures 1996* (AAMA, Washington, D.C., 1996 p. 44).
11. US Energy Information Administration (EIA), *International Energy Outlook, 2003* (Washington D.C.: US Department of Energy, DOE/EIA 0484).
12. World Business Council on Sustainable Development, *The Sustainable Mobility Project: July 2002 Progress Report* (Geneva, Switzerland: WBCSD, 2002 p.15). At http://www.wbcsdmobility.org/publications/progressrpt_july2002.asp.
13. The exceptions are BMW and PSA.
14. *Climate Change Plan for Canada*. At http://www.climatechange.gc.ca/plan_for_canada/plan/summary.html.
15. Federal Chamber of Automotive Industries, *Voluntary Code of Practice - Reducing the Fuel Consumption of New Light Vehicles* (Canberra, Australia: April 15, 2003). At http://www.autoindustries.com.au/code_reducing_fuel.php.
16. Ward's Communications, *Ward's Motor Vehicle Facts & Figures 2002* (Southfield, Michigan: 2002 p.38).
17. Automotive News (2003) p. 47 and UNEP/SustainAbility, *Driving Sustainability — Can the Auto Sector Deliver Sustainable Mobility?* (London: 2001 p. 21).
18. Autelligence, "Weekly Insight: The Expanding Global Market" (London: September, 27 2003). At http://www.autelligence.com.
19. Asia Pulse, "China's Car Sales Growth Expected to Last for 5 Years," (Sydney: September 22nd, 2003).
20. EIA (2003) p. 34.
21. World Bank, *World Development Indicators 2003* (Washington D.C.: World Bank) and Kelly Sims Gallagher, "Foreign Technology in China's Automobile Industry: Implications for Energy, Economic Development, and the Environment" *China Environment Series* (Washington D.C.: Woodrow Wilson International Center for Scholars, Issue 6). At http://wwics.si.edu/topics/pubs/2-feature_1.pdf.
22. National Academy of Sciences, *Personal Cars and China* (Washington D.C.: National Academies Press, 2003 p. 4).
23. Carbon Disclosure Project, *Carbon Finance and the Global Equity Markets* (London: February 2003). At http://www.cdproject.net.
24. See, for example page 14 of Deutsche Bank AG, *The Drivers: How to navigate the auto industry* (Frankfurt: July 2002).
25. P.C. Kalafut, *Invisible Advantage: How intangibles are driving business performance* (Perseus Publishing: 2003).
26. Deutsche Bank (2002) p. 13.
27. Deutsche Bank (2002) p. 28.
28. Environmental Protection Agency, *Economic Analysis of New CAFE Standards for Light Trucks* (Washington DC: April, 2003).
29. "Well-to-wheel" analysis considers energy use and GHG emissions on a total systems basis, from well to tank (i.e., fuel production) and tank to wheel (operation of the vehicle itself).
30. Malcolm Weiss et al, *Comparative Assessment of Fuel Cell Cars* (Cambridge, MA: MIT, 2003 p. 29).

31. National Research Council, *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards* (Washington D.C.: National Academy Press, 2002 p. 42).

32. General Motors, "Displacement on Demand" on their website at http://www.gm.com/automotive/gmpowertrain/tech/dod/overview.htm.

33. National Research Council (2002).

34. Lee Schipper, et al, "Diesels in Europe: Analysis of Characteristics, Usage Patterns, Energy Savings and CO_2 Emissions Implications," *Journal of Transport Economics and Policy* (Bath, UK: May 2002, vol. 36 Part 2 pp. 305-340).

35. Edmund Chew, "Siemens, Bosch Fuel Diesel War," *Automotive News Europe* (June 2nd, 2003).

36. M.Q. Wang, *GREET 1.6 (beta) Fuel Use and Emissions Model* (Argonne Illinois: Argonne National Laboratory, Center for Transportation Research, 2001).

37. Deutsche Bank (2002), p. 63.

38. Schroder Salomon Smith Barney, "Diesel Market Update," *Equity Research: Europe* (2002 p. 4).

39. Deutsche Bank (2002), p. 63.

40. David Friedman, *A New Road: The Technology and Potential of Hybrid Vehicles* (Cambridge, MA : The Union of Concerned Scientists, 2003).

41. J.D. Power and Associates, "Hybrid Electric Vehicle Sales Expected to Increase Dramatically Over the Next Decade", Press Release, May 28th, 2003.

42. Cambridge Energy Research Associates (CERA), *The Hydrogen Economy: How Far and How Fast?* (Cambridge MA: 2003 p. 18).

43. David L. Greene and Andreas Schafer, *Reducing Greenhouse Gas Emissions from U.S. Transportation* (Arlington, VA: Pew Center for Global Climate Change, 2003 p. 17).

44. Weiss et al. (2003).

45. Greene and Schafer (2003) p. 27.

46. Lance A. Ealey and Glenn A. Mercer, "Tomorrow's Cars, Today's Engines," *The Mckinsey Quarterly* (2002, Number 2). At http://www.mckinseyquarterly.com.

47. CERA (2003) p. 5.

48. Weiss et al. (2003).

49. McKinsey (2002).

50. NikkoSalomonSmithBarney, *Auto Industry: 2000 Global Equity Research — Auto Manufacturers* (June 27, 2000).

51. SAM Research based on WestLB, Deutsche Bank Research, Goldman Sachs, Lehman Brothers and Schroder Salomon Smith Barney.

52. *Appendix to Changing Drivers: Details on the Methodology, Assumptions and Results for the Value Exposure Assessment* (Washington, D.C.: World Resources Institute, 2003). At http://capmarkets.wri.org.

53. The position that OEMs have developed with regard to fuel cells for the period following 2015 will of course be an important determinant of competitiveness in the long term and forms part of the Management Quality Assessment in Chapter 5.

54. JD Power and Associates, *Interest in Hybrid Technology is High, Especially Among Women* (Agora Hills, CA: March 6, 2002).

55. National Research Council (2002).

56. For some OEMs, the presence of diesel and hybrid technologies makes no difference because their vehicles are already very efficient and need only minor modifications to meet new carbon constraints.

57. National Research Council (2002).

58. This issue is explored in more detail in the Appendix available at http://capmarkets.wri.org.

59. John DeCicco, Feng An and Marc Ross et. al, *Technical Options for Improving the Fuel Economy of U.S. Cars and Light Trucks by 2010-2015* (Washington D.C.: The American Council for an Energy-Efficient Economy, 2001 p. 49). The figure is in real 2000$.

60. This is for an assumed gas price of $1.45 per gallon over the period of 2003 through 2008.

61. Schroder Salomon Smith Barney (2002), p. 7.

62. The simple discounted cash flow model used to generate these results is available for download at either http://capmarkets.wri.org or http://www.sam-group.com/changingdrivers.

63. Sensitivity to these assumptions can be tested in the simple DCF model available for download.

ACKNOWLEDGMENTS

We would like to thank the many individuals who helped in the production of this report. We are grateful to a number of financial analysts who reviewed the report or provided helpful comments including: in the United States, Steve Girsky and Maryann Keller; in Europe, Kamran Baig, Thomas Besson, Christian Breitsprecher, Clive Wiggins, Henrik Lier and Lars Ziehn; and in Japan, Kunihiko Shiohara and Tatsuo Yoshida. We also received helpful comments and advice from Feng An, KG Duleep, David Friedman, David Greene, Jason Mark, Martina Otto and Robert Repetto. We particularly thank Justin Adams for his fresh perspectives and feedback.

The SAM authors would like to thank their colleagues Alois Flatz, Thilo Goodall, Davide Rima and Markus Moor for their helpful contributions.

The WRI authors are grateful for the generous input of their colleagues Phil Angell, Andrew Aulisi, Liz Cook, Navroz Dubash, Suzy Greenhalgh, David Jhirad, Nancy Kete, Chris Lagan, Bill LaRocque, and Lee Schipper. We also thank Moeko Saito and Anand Rao for their research assistance. We are also grateful to the SC Johnson Foundation, the Oak Foundation and the Surdna Foundation for their generous financial support. Finally, we thank Hyacinth Billings, Kristina Bonner, Karen Holmes, Donna Lomangino and Maggie Powell for their help with the editing and production of the report.

While recognizing the contributions of those mentioned above, the authors bear sole responsibility for the opinions expressed in this report.

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A Note on Metrics and Terms

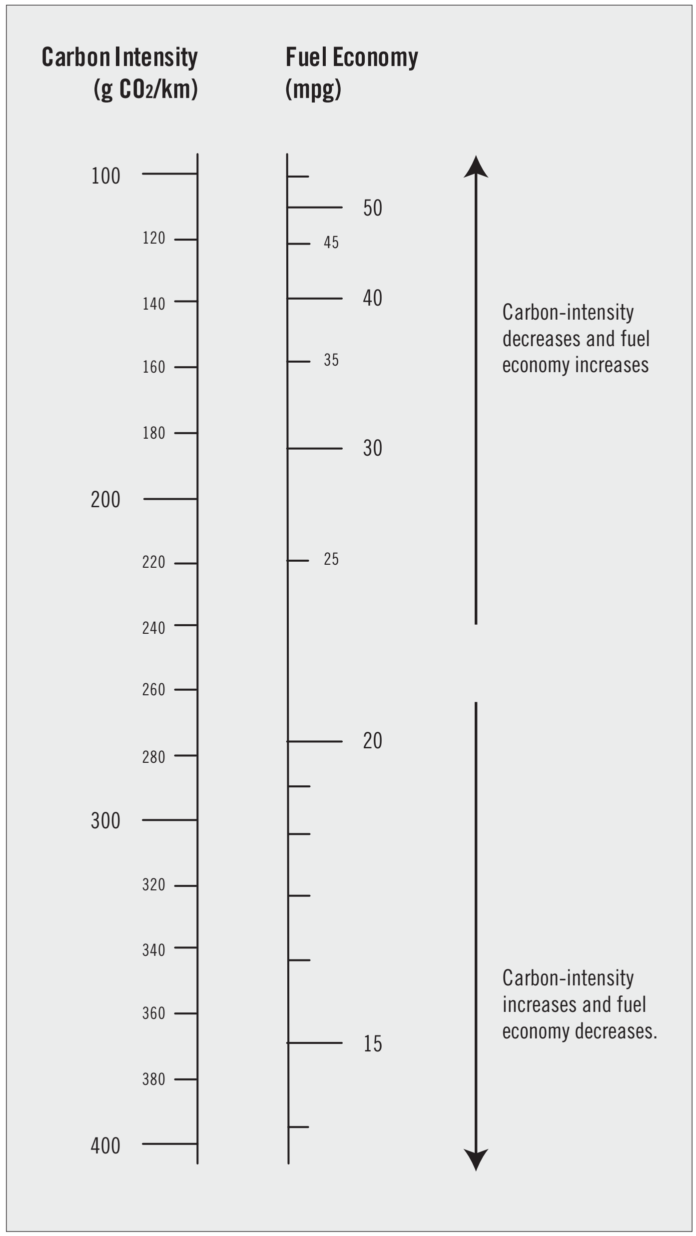
Different markets use different metrics to capture the emissions rates and fuel economy of vehicles. European and Japanese standards are expressed in terms of grams of CO_2 per kilometer (g CO_2/km), while US CAFE standards are expressed in terms of miles per gallon (mpg).

Because all carbon embodied in a vehicle's fuel is emitted as CO_2, *for a specific fuel* a given emissions rate implies a given fuel economy level, and vice-versa. The figure shows the conversion between carbon-intensity and fuel economy metrics for a gasoline-fueled vehicle.

As one of the metrics (mpg) has distance as a numerator and the other (g CO_2/km) has distance as a denominator, the two have an inverse relationship. A higher fuel economy (in terms of mpg) translates into a lower emissions rate (in terms of g CO_2/km).

Because this report focuses on the climate impact of vehicles, we generally use g CO_2/km as our primary metric, though we revert to mpg when explicitly referring to policies based primarily on fuel economy (e.g., US CAFE standards). In all cases, the alternative figure is provided in parentheses afterwards. Similarly, in referring to vehicle performance, we primarily use "carbon-intensive" and "carbon-emitting" terms rather than "fuel-efficient". With the inverse relationship a "more carbon-intensive" or "high carbon-emitting" vehicle is a "less fuel-efficient" one.

Equivalence of Fuel Economy Levels (in miles per gallon) and Carbon Emissions Rates (in grams of CO_2 per kilometer) for Gasoline-fueled Vehicles



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ISBN 1-56973-558-1
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