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THEME

Powertrain: The New Profit Engine

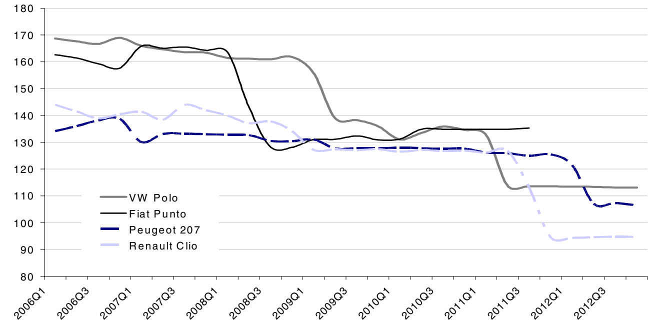
- **A new 'profit cycle':** Soaring fuel-efficiency demand looks set to entrench powertrain technology as a key driver of automotive profits, potentially more than model cycle. In a co-study with A.T. Kearney, we assess the powertrain cycles of Europe's OEMs. We look to buy innovation leaders with sufficient scale to cope with increasing complexity demands, notably **BMW and Daimler (Outperform)**. We avoid technology laggards in key segments including **PSA, Renault and Fiat (Underperform)**.
- **Innovation leaders should prevail:** We reject the notion of 'Buy mass, sell premium' as a strategy to exploit fuel-efficiency trends. In our view, this over-simplifies the complex relationship between fuel efficiency, performance and price. We firmly believe that technology leaders will prove more profitable, regardless of vehicle size or class. Ultimately, we think customers will only pay for the additional utility provided by advanced technology, not simply smaller or slower cars. Marketing and pricing the major 'cost-of-ownership' advantages of fuel efficiency is becoming a crucial factor, in our view.
- ***'Fill it up'* or '*Plug it in'*?** Gas stations will remain a familiar sight for drivers as rapid improvements in conventional engine technology lead fuel-efficiency efforts. Longer-term, we expect battery technology to win out over hydrogen thanks to superior infrastructure cost and energy storage capabilities. Battery system providers/integrators will become key technology gatekeepers but currently yield few liquid pure-play investment opportunities.

Credit Suisse and A.T. Kearney powertrain analysis
We have conducted a detailed analysis of engine product plans and CO2 output by OEM and segment between now and 2015. Key findings include:

- **BMW leads the powertrain race**: We believe BMW has a clear powertrain advantage over Mercedes thanks to its early adoption of gasoline direct-injection (56% versus 11%). Mercedes should catch up by 2012E, but the 250bp differential between Mercedes and BMW 2008E–09E margins is likely to narrow as a result. Well-known near-term challenges may weigh on BMW shares short-term, but its more efficient fleet should avoid a major downturn.
- **Megane likely to lose battle against new Golf:** Renault's 2009E earnings rely heavily on the success of the new Megane (launched this week). We think the car is likely to disappoint due to strong competition from VW's Golf, which offers 10–15% superior fuel economy at a 10% lower total cost of ownership. Peugeot's 308 is equally likely to struggle. We estimate closing the gap with VW could cost PSA and Renault c€200–300 per vehicle, consuming planned restructuring cost savings at both firms.
- **Powertrain scale is critical:** Mercedes lacks scale in small car engines relative to both Audi (thanks to VW) and BMW (thanks to PSA). Unless Mercedes finds a small car engine partner soon, we are highly cautious on A and B class margin potential. Both BMW and Mercedes could benefit from joint purchasing, notably in larger-capacity engines.

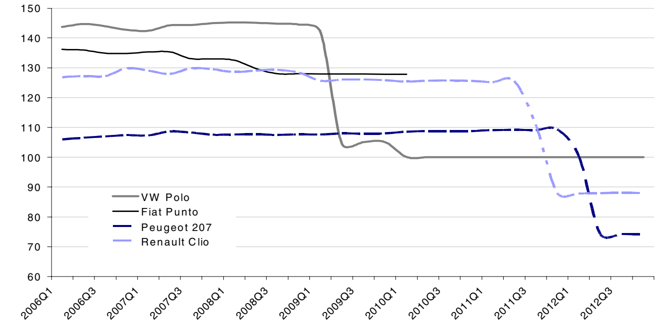
Powertrain cycles: Estimated CO2 by segment (g/km)

Figure 1: Compact gasoline—Normalised on 60kW



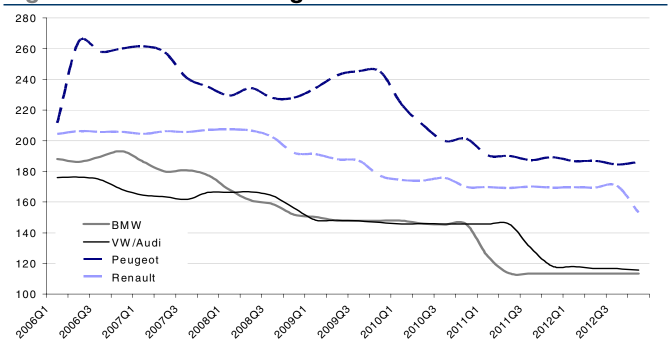
Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

Figure 2: Compact diesel—Normalised on 60kW



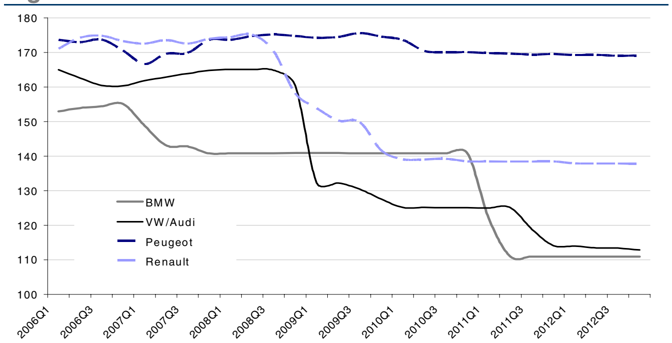
Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

Figure 3: Lower-medium gasoline—Normalised on 100kW



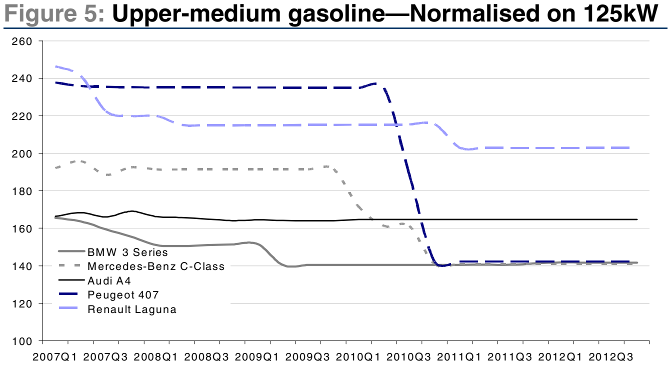
Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

Figure 4: Lower-medium diesel—Normalised on 100kW



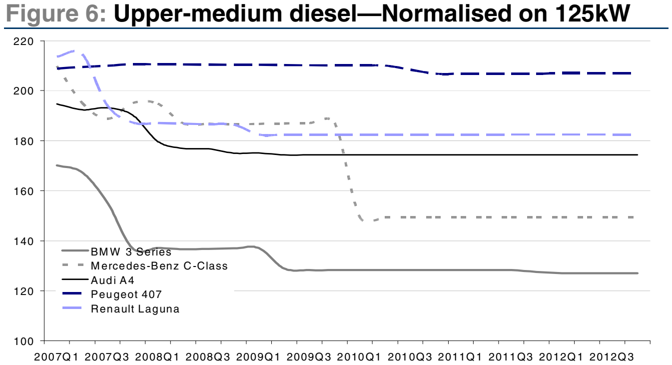
Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

Figure 5: Upper-medium gasoline—Normalised on 125kW



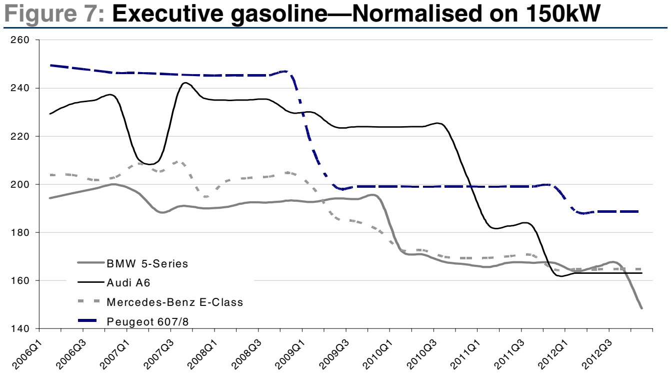
Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

Figure 6: Upper-medium diesel—Normalised on 125kW



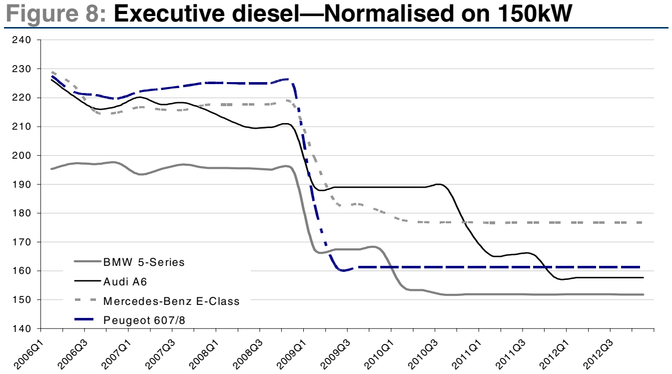
Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

Figure 7: Executive gasoline—Normalised on 150kW



Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

Figure 8: Executive diesel—Normalised on 150kW



Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

Key views and findings

- **Powertrain a key competitive advantage:** We see powertrain technology as potentially as (or even more) powerful than model cycle. High fuel costs, together with environmental legislation and awareness, are driving booming customer demand for fuel efficiency. Those OEMs introducing new technology ahead of the competition look set to gain from higher market share and improved pricing. Traditional 'model cycle' analysis may become less meaningful, instead superseded by 'powertrain cycles'.

- **It's not just about fuel efficiency:** We reject the notion of 'Buy mass, sell premium' as a strategy to exploit fuel-efficiency trends. This over-simplifies the complex relationship between fuel efficiency, performance, pricing and technology. We firmly believe that technology leaders will prove more profitable, regardless of vehicle size or class. Customers demand fuel efficiency **AND** performance, not less space or worse performance. Ultimately, we believe customers will only pay for the additional utility provided by advanced technology. **We see the winners as those offering the best combination of fuel efficiency and performance at a given price**.

Powertrain benchmarking results

- **Buy technology leaders**: BMW has a clear powertrain efficiency advantage over Mercedes thanks to its early adoption of gasoline direct-injection technology (56% versus 11%). Mercedes should catch up by 2012E, but the 250bp differential between Mercedes and BMW 2008–09E margins is likely to narrow as a result. Pricing power should determine whether BMW margins rise to meet Mercedes or vice-versa, but either way BMW looks an increasingly attractive play.

- **Avoid technology laggards:** Renault's 2009E earnings rely heavily on the success of the new Megane (launched this week). **We think the Megane is likely to disappoint** due to strong competition from VW's Golf, which offers 10–15% superior fuel economy at a 10% lower total cost of ownership. Peugeot's 308 is equally likely to struggle against more efficient competition. We estimate closing the gap to VW could cost PSA and RNO c.€200–300 per vehicle, thus consuming planned restructuring savings at both firms.

- **Look for scale:** Mercedes also lacks scale in small car engines relative to both Audi (thanks to VW) and BMW (thanks to PSA). Unless Mercedes finds a small car engine partner soon, we are highly cautious on A and B class margin potential. We would like to see significant engine cooperation between BMW and Mercedes in large engines.

Powertrain of the future

- **Fuel-efficient performance:** In the short-to-medium term, we expect optimising existing internal combustion engine technology to dominate efficiency efforts. We expect gasoline direct-injection and turbo-charging penetration to reach c.30% in Europe by early next decade, with VW and BMW leading the roll-out. We expect fuel-efficiency improvements **without** sacrificing performance to become the main goal in engine development. BMW's EfficientDynamics is a good example of this.

- **Gas stations will thus remain a familiar sight** for drivers as rapid improvements in conventional engine technology lead fuel-efficiency efforts. However, longer term, more radical changes in powertrain technology will be required to meet ever tightening emissions standards (culminating in zero tailpipe emissions).

- **We expect battery technology to win out over hydrogen** alternatives thanks to superior infrastructure cost and energy storage capabilities. Battery system providers/integrators will likely become key technology gatekeepers but currently yield few liquid pure-play investment opportunities.

Rating summary

We believe the external environment is likely to drag down auto stocks further from here. Higher input costs, Financial Services risks and slowing consumer sentiment are clearly severe threats for 2009 earnings. Nevertheless, we regard the fundamental analysis of innovation leadership in fuel efficiency and performance as crucial elements for future investment decisions and are thus adjusting our ratings accordingly.

Favour technology and replacement markets

- **BMW (Outperform, TP €32)**—BMW is the clear leader in fuel efficient/driving performance engines. This strength should help BMW to bridge a very challenging year in 2009 and to outperform the market from 2010 onwards. We have upgraded BMW to Outperform from Underperform, with a revised TP of €32 (from €22) in a separate report, also published today, entitled *BMW*: *Protected by technology,* in which we give full details plus our earnings estimates.

- **Porsche (Outperform, TP €110)**—We believe the fundamental value of VW within Porsche is underestimated at this stage. Based on our analysis, investors can buy VW within Porsche for c€56 (stripping out Porsche core at BMW multiples), far below the average price Porsche has paid for its stake in VW. We believe that VW is set to benefit from some of the best powertrain technology in the industry.

- **Daimler (Outperform, TP €52)**—We think Mercedes clearly has work to do in fuel efficiency, but the launch of the new E-Class in 2009 should herald significant cost savings. Lower operational leverage and significant net cash also make Daimler the defensive choice in the sector, in our view.

- **Michelin (Outperform, TP €58)**—We continue to prefer Michelin's replacement market exposure and self-help restructuring potential. The recent pullback in fuel prices should help mileage trends recover, allowing replacement markets to recover (also aided by falling OE car sales).

Avoid powertrain laggards and operational leverage

- **Renault (Underperform, TP €44)**—We have downgraded Renault from Outperform to Underperform with a revised TP of €44 (from €66) in a separate report, also published today, entitled *Renault: Swimming against the tide,* in which we give full details plus our earnings estimates. The downgrade is based on i) what we consider an inferior powertrain offering in the new Megane; ii) what we see as unrealistic volume and margin targets for 2009; and iii) slowing eastern European and Russian sales that will likely limit Logan growth and profitability.

- **PSA (Underperform, TP €32)**—Lack of scale, high operating leverage and heavy dependence on Europe make PSA still one of our least preferred stocks in the sector. Valuation attractions are somewhat misleading, in our view, as lowly EV multiples could significantly worsen on working capital outflow in a deteriorating volume environment.

- **Fiat (Underperform, TP €10)**—We remain concerned that Fiat's 2009 targets are overly ambitious in basically all divisions. Despite the great success of the new 500, we regard Fiat Auto's product line-up to be ageing. IVECO is facing the challenges of falling European truck volumes, and CNH is unlikely to report historical peak margins at a time when the US market for construction equipment is moving down.

Avoiding opaque special situations

- **Continental (Neutral, TP €70)**—Despite our belief that Schaeffler's €75 offer fundamentally undervalues the company, Conti's agreement with Schaeffler to limit the latter's holding to 49.99%, and Schaeffler's agreement with banks to hold excess shares, effectively places a €75 ceiling on the stock, in our view. With too many technical 'unknowns' driving the shares (i.e. bank lending behaviour), investors are best advised to utilise capital elsewhere, in our view.

- **Volkswagen (Underperform, TP €115)**—We view this as the most opaque situation in the autos space, with a host of technical factors driving increasingly extreme volatility in the shares. Clearly overvalued on fundamentals, in our view, we think investors should avoid VW ordinary shares and seek to capitalise on VW strengths (scale, powertrain technology) via purchasing shares in controlling shareholder Porsche instead.

Powertrain as a profit driver

We see powertrain technology becoming potentially as powerful as model cycle in driving market share, pricing, and hence profit over the coming decade. **We believe that OEMs introducing new technology ahead of their peers stand to gain significant competitive advantage in the medium term.** It is powertrain that in our view will form an automaker's best defence against downward mix and volume trends that have accelerated rapidly in 1H08 following the spike in fuel prices (see Figure 9).

Fuel efficiency: Two-stage impact on demand

We believe that customer demand for improved fuel efficiency will shape demand in two stages, starting with **i) a sudden downward shock to mix** as buyers seek out better fuel efficiency before technology has time to adapt; and **ii) a long-term powertrain race** amongst OEMs as technology development reacts to changing customer demands.

1) Sudden shock to mix hurts almost all

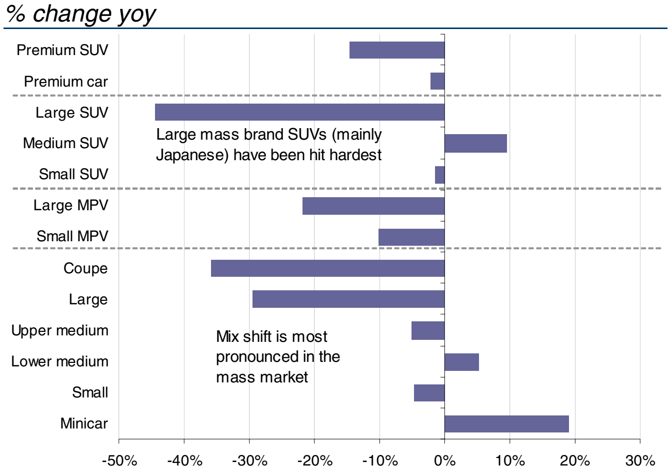
Europe and the US have already seen a significant mix shift away from heavy SUVs and MPVs as drivers grapple with record fuel prices. A common misconception of this mix shift, however, is that it favours mass brands over premium. This misses the point that mass makers can also earn high margins in larger cars, notably MPVs (indeed, Renault's Commitment 2009 plan looks for more volume in larger cars). It also overlooks the relatively higher sensitivity of mass brand customers to fuel prices and taxation.

Data for Europe for 1H08 (see Figure 9) highlights the severity of the mix shock already seen in Europe. However, it also shows that mass market segments have been as hard hit as (if not harder hit than) premium segments. The biggest declines have been seen in mass brands in large SUVs and MPVs, as well as coupes and large sedans. Premium SUVs have lost ground also, but not to the same extent as large mass SUVs. We thus believe very few OEMs can survive this mix shock unscathed, as only Fiat has a mix sufficiently biased towards small cars to capitalise on the demand shift.

A widespread view amongst analysts and investors that rising fuel prices and CO_2 taxes will simply lead to a shift of demand from premium to mass does not then appear to be borne out by the data in H1. Instead, the mix shift has hit mass and premium earnings alike. Even in France, where CO_2-linked taxation has exaggerated the mix shift, BMW has proven that premium brands need not necessarily lose share (see Figure 10).

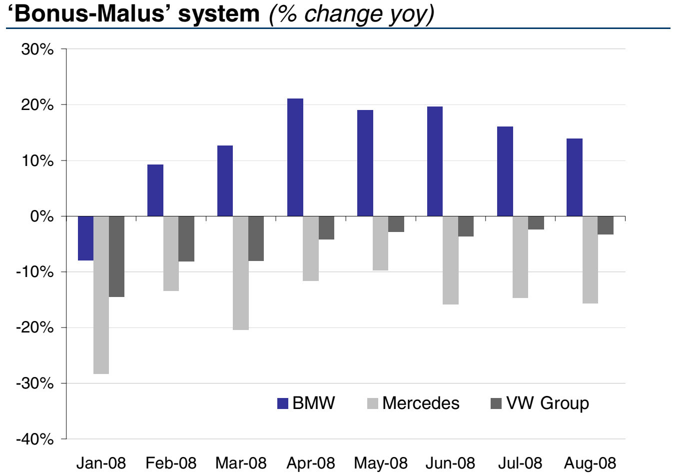
Figure 9: **1H08 European mix shift**

% change yoy



Source: JATO dynamics, Automotive News Europe

Figure 10: **French car sales since introduction of 'Bonus-Malus' system** *(% change yoy)*



Source: CCFA

In fact, **BMW has been growing sales by c.10% in France**, while Mercedes sales have declined by a similar amount. **This is the opposite trend one would expect from model cycle analysis** (Mercedes benefits from a stronger product cycle than BMW). Instead, BMW's powertrain advantage has been helping protect volumes from the decline we would otherwise expect, given its weak product cycle.

2) A powertrain race to offer the best fuel-efficiency technology

BMW's performance in France underlines our belief that powertrain technology will become a more powerful driver of market share than model cycle going forward. As has proved historically, we believe those with the best technology will prevail. In this case, OEMs are faced with a simple choice as a result of rising fuel prices and taxation:

- **Accept a weaker mix**—Accepting that consumers will buy either smaller vehicles and/or less powerful engine variants i.e. mix dilution; **OR**
- **Spend on advanced technology**—Improving fuel efficiency of their fleet so that a future BMW 540i, for example, improves to the fuel efficiency of a current 530i.

In our view, automakers would much prefer to spend on new technology than accept permanent mix dilution. While both scenarios will see margins squeezed in the short term (as per BMW's Efficient Dynamics programme), in the longer term only new technology provides any utility that OEMs can hope to charge customers for. Furthermore, technology costs will quickly decline as volumes rapidly increase.

To illustrate the choice facing an OEM, we highlight in Figure 11 the different contribution margins of various BMW models and the likely technology cost required to reduce emissions of the larger sized or larger engine model down to that of its smaller alternative. For example, BMW could simply accept that a 540i driver will trade down to a 530i for its lower emissions and better fuel economy. Or BMW could spend c.€2,400 to close the efficiency gap (or improve performance of the 530i and raise its price).

Figure 11: Between a rock and a hard place: Mix versus technology costs

Profit impact of weaker mix versus improved technology costs using BMW as an example

			←---------- Downsizing	
	320i	**330i**	**530i**	**540i**
CO2, g/km	146	173	182	250
CO2 'gap' to lower alternative, g/km	-	27	9	68
CO2 reduction cost, €/g	-	35	35	35
CO2 reduction cost, €/vehicle	-	945	315	2,380
Sale price, €	29,500	39,000	49,600	59,400
Contribution margin*, €	**5,900**	**7,800**	**10,000**	**12,000**
Less technology cost, €	-	(945)	(315)	(2,380)
Margin headwind	-	(250)bp	(60)bp	(400)bp
New contribution margin, €:				
- assuming 0% pass-thru	**5,900**	**6,855**	**9,685**	**9,620**
- assuming 25% pass-thru	5,900	7,091	9,764	10,215
- assuming 50% pass-thru	5,900	7,327	9,843	10,810

*Source: Company reports and Credit Suisse estimates. *Based on constant 20% contribution margin for all models. In reality, this number will likely be materially higher for high-end models, thus further incentivising OEMs to spend on technology rather than accept a lower mix.*

Even before assuming any cost pass-through to the customer, both solutions result in roughly equal contribution margin. However, in our view, only by spending on new technology can an OEM hope to improve that contribution margin over time through cost improvement and potentially an element of cost pass-through to the customer.

Ultimately, we believe margin prospects for the sector will hinge on OEMs' ability to reduce and pass through technology costs to the customer. This ability remains to be proven.

Nevertheless, on a relative basis, we believe those OEMs leading adoption of new technologies (and thus may have already seen the margin pain) are in a stronger position than those still needing to play catch-up.

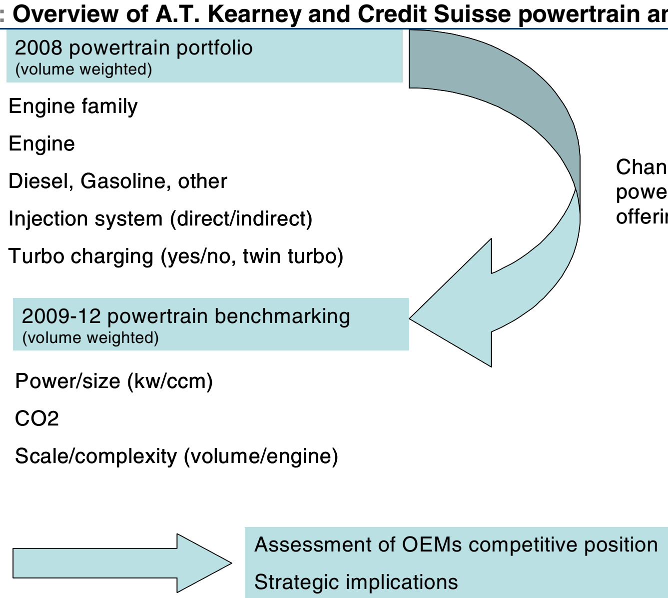
A.T. Kearney and Credit Suisse powertrain benchmarking

This in-depth analysis of carmakers' future powertrain technologies is the logical continuation of our work on the impact of CO2 regulation and the general need for more fuel efficient mobility. While in 2007 the debate was largely driven by longer-term legislative action (EU CO2 regulation), soaring fuel prices and environmental awareness have now made fuel efficiency a business critical issue today. **We thus regard the competitive landscape of fuel efficient mobility as the most important business driver for the automotive industry over the next decade.**

Our joint work with A.T. Kearney focuses on the analysis of a highly detailed database of future engine launches and powertrain technologies of the global automotive industry. Our analysis focuses on three key areas.

- **Powertrain benchmarking—**We analyse engine introduction schedules of the major OEMs, critically assessing performance and fuel efficiency characteristics. We use engine launch and CO2 data to build 'powertrain cycles', showing the evolution of CO2 (normalised for a given power output) for Europe's major segments and models. We also show global technology trends, including OEM by OEM adoption rates of key technologies, including gasoline direct fuel-injection, turbo-charging and hybrids.
- **Powertrain scale analysis**—As with platform strategy, scale is critical to powertrain efficiency and leadership. Meeting the fuel-efficiency challenge will require significant R&D and add-on technology costs. We thus compare 2012E engine volumes across different engine power bands to identify those OEMs with sufficient scale to invest heavily in new technology. We also identify in which power segments OEMs currently lack scale and thus may seek out JVs in order to remain competitive (e.g. BMW/PSA).
- **Powertrain of the future—**We examine long-term powertrain technology options and analyse likely powertrain mix by region under various scenarios. The oil price plays a key factor in the relative economics between alternative technologies, and hence future mix. Ultimately we believe the electrification of the car appears increasingly inevitable, with plug-in hybrids providing the bridge technology to fully electric vehicles. GM's Volt will provide a critical mass-produced test-bed for the technology.

Figure 12: **Overview of A.T. Kearney and Credit Suisse powertrain analysis**



Source: A.T. Kearney, Credit Suisse research

Powertrain benchmarking: Premium brands

German premium makers are clearly early adopters of new technologies and thus innovation leaders. However, we believe Mercedes and BMW are both in a dilemma: they need to be innovation leaders in terms of fuel efficiency yet they also need to offer 'fun to drive' vehicles. The combination of the two requires investment in R&D and adds variable costs to the engine. At the same time, both players are lagging economies of scale from too few engines per engine family.

We see a striking industrial logic for a merger of BMW/Mercedes engine production:

- Both players lack critical size in conventional engine manufacturing. New powertrain technologies are adding to complexity/costs.
- BMW and Mercedes have to be innovation leaders in order to keep their brand image strong. Stand-alone, the required resources are simply too large.
- Differentiation of engine performance can be achieved via electronic engine management in order to support the different brand identities (sporty versus classic).
- And as a side effect, both players could finally ramp up engine manufacturing in the US together

We are highlighting the total cost of ownership (TCO) advantages of BMW models compared to its peer group models. In this respect, we find it **difficult to understand why BMW is not pricing its better fuel efficiency**, marketing fuel cost advantage and residual value benefits to its customers. For instance, we estimate owning a BMW 3 Series for three years is c17% cheaper than a Mercedes C Class (17.5% cheaper compared to a Peugeot 407; see Figure 36).

Audi is clearly benefiting from scale within the VW group, which is becoming a more important competitive advantage alongside increasing powertrain complexity.

At the moment, BMW is clearly the leader in efficient (small) gasoline engines. Compared to Mercedes and Audi, BMW has by far the highest penetration of turbo-charged, GDI (gasoline direct injection) engines. We believe Mercedes will need until 2011/12 to close the gap to BMW. Audi has the highest penetration of gasoline direct injection and turbo-charged engines, plus, the brand should be expected to increasingly exploit the VW group network.

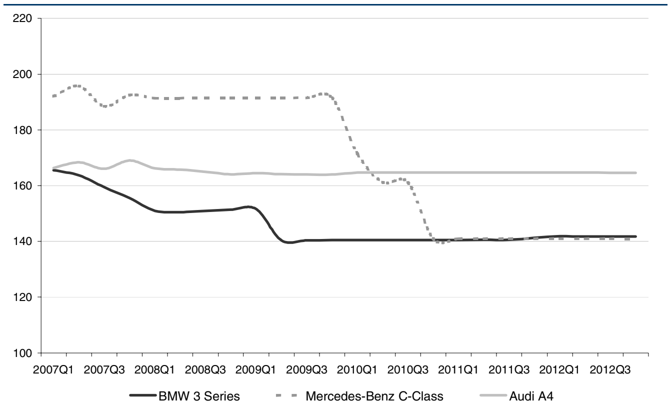
BMW and VW groups are the clear early adopters of GDI, with Audi already using the technology in some 71% of its gasoline vehicles. Mercedes looks to be the laggard, but will roll out the technology rapidly over the next few years and we believe will close the gap with BMW by 2011E/12E. The question is, of course, at what cost?

Based on our analysis, BMW is leading the field with respect to CO2 emissions relative to power (i.e. environmentally expectable and fun to drive). In our view, Mercedes needs until 2011E/12E to close the gap and Audi, despite high penetration of GDI and turbo charging, remains above BMW and Mercedes in the performance of its mid-size engines (both diesel and gasoline) for the time horizon of our analysis.

The following charts show the results of our analysis for the players' volume models in the mid-size and upper-medium segments.

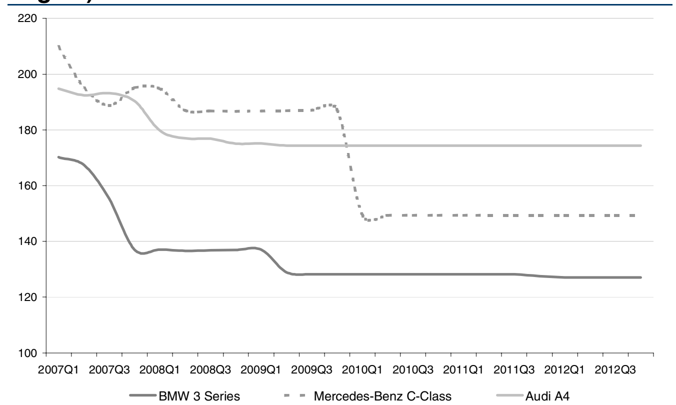
For instance, based on our analysis, BMW's 3 Series has a normalised CO2 advantage of c25% compared to the Mercedes C Class gasoline-powered model (in 2009). Mercedes will have to wait until its new Phoenix engine will be introduced in large size, which we expect with the model's facelift in H2 2009. We see similar advantages in the upper-medium segment, where BMW is increasingly benefiting from the implementation of "Efficient Dynamics".

Figure 13: CO2 emissions (normalised 125kw gas. engine)



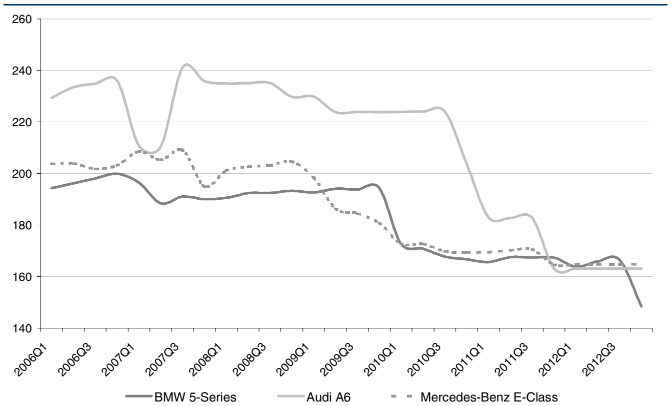
Source: Company data, Credit Suisse estimates. All years estimates.

Figure 14: CO2 emissions (normalised 125kw diesel engine)



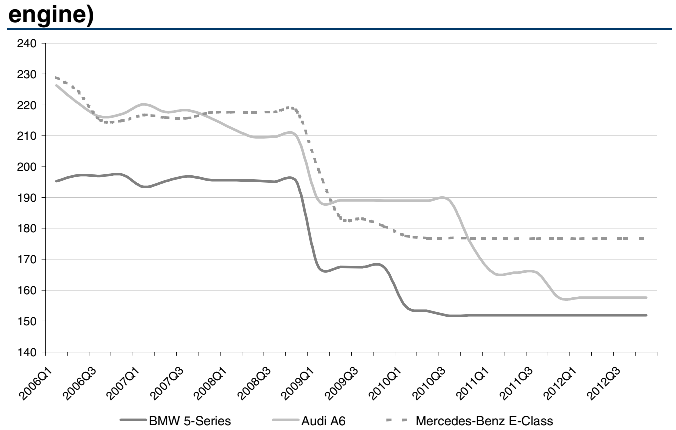
Source: Company data, Credit Suisse estimates. All years estimates.

Figure 15: CO2 emissions (normalised 150kw gas. engine)



Source: Company data, Credit Suisse estimates. All years estimates.

Figure 16: CO2 emissions (normalised 150kw diesel engine)

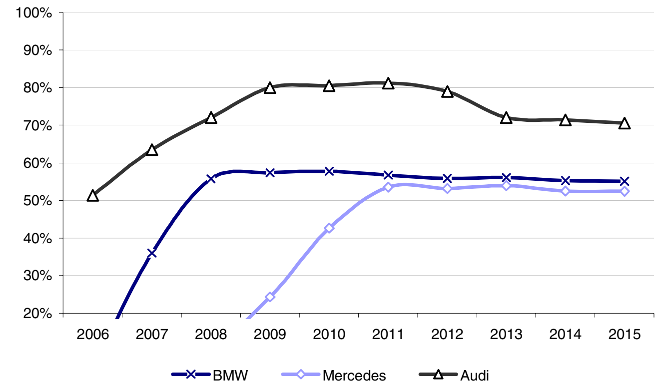


Source: Company data, Credit Suisse estimates. All years estimates.

The VW group (and thus Audi) is by far the leader with respect to the usage of GDI and turbo charging. We estimate that almost 80% of all Audi gasoline models will be equipped with direct injection and more than 50% will be turbo charged.

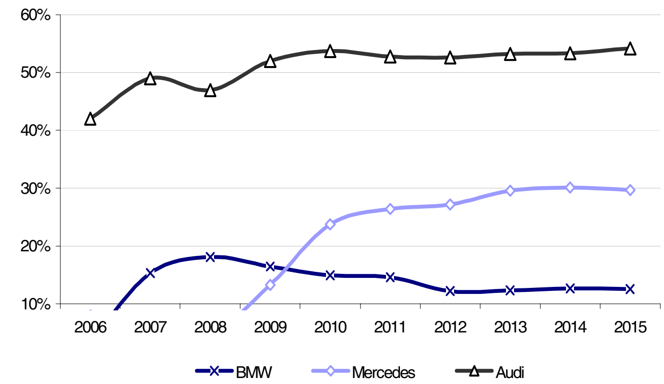
Mercedes is lagging behind its peers. GDI and turbo charging should reach the level of BMW in 2009E (turbo charging) and 2011E (GDI). This should enable Mercedes to close the gap with BMW. In the meantime, BMW should be in a position to benefit from more fuel-efficient engines.

Figure 17: Gasoline engines: direct injection penetration



Source: Company data, Credit Suisse estimates. All years estimates.

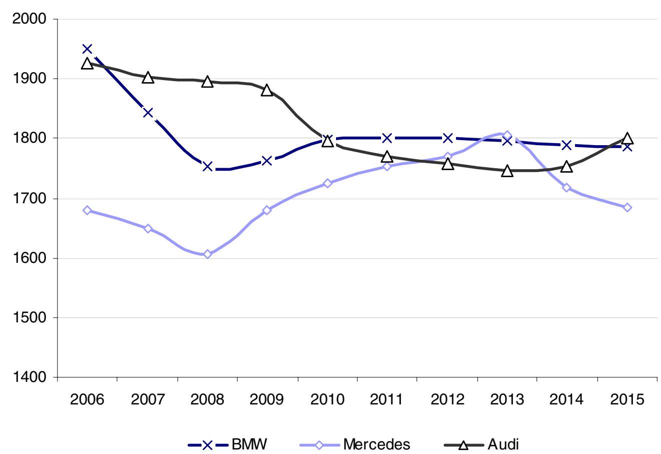
Figure 18: Gasoline engines: turbo charging penetration



Source: Company data, Credit Suisse estimates. All years estimates.

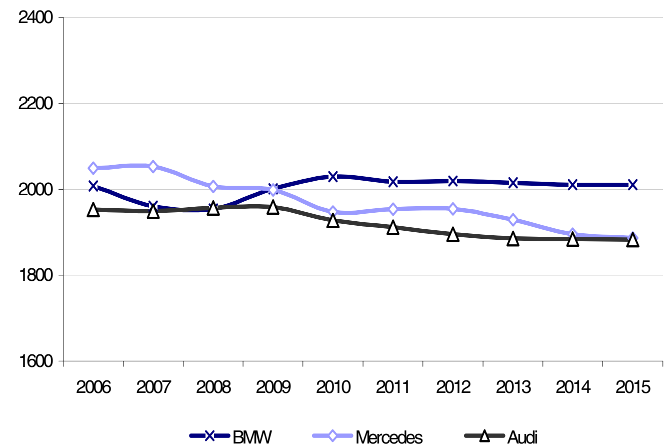
The average volume-weighted engine size does not differ much between the different German premium brands. The average engine displacement (cc) of gasoline engines stands at 1,800cc and for diesel engines at 2,000cc.

Figure 19: Gasoline engines: displacement (cc)



Source: Company data, Credit Suisse estimates. All years estimates.

Figure 20: Diesel engines: displacement (cc)

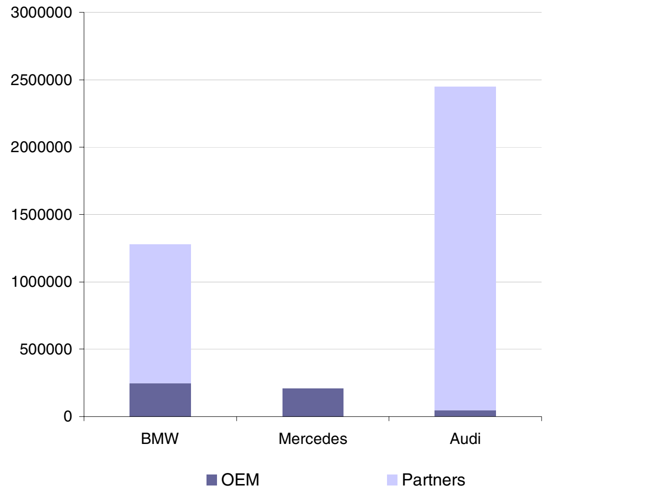


Source: Company data, Credit Suisse estimates. All years estimates.

Comparing the number of engines in certain power segments highlights the competitive advantage of Audi arising from its tie-up within the VW group. Especially in smaller gasoline engines and larger diesel engines, we believe Audi has considerable scale advantages. BMW has decided to team up with PSA in smaller gasoline engines, and Mercedes is clearly lagging scale in this segment.

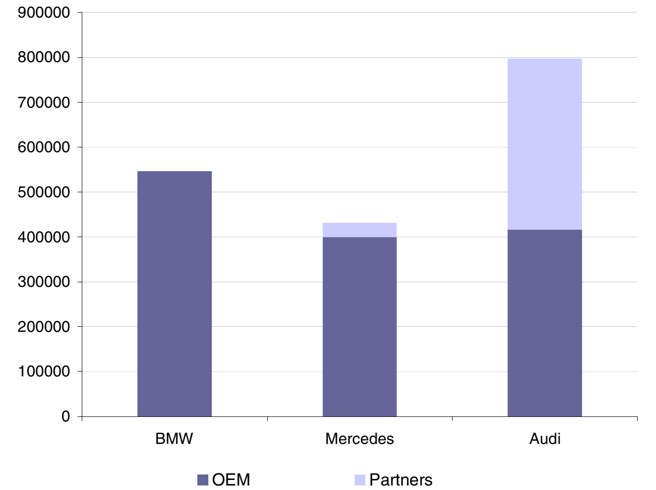
Even in larger diesel engines, the largest engine family for the likes of BMW and Mercedes, we concluded that both brands are lagging critical size. Mercedes, for instance, has only 50% of the volume in larger diesel engines compared to Audi/VW.

Figure 21: Gasoline Engine scale BMW / Mercedes / Audi (engines below 150hp), 2012E



Source: Company data, Credit Suisse estimates.

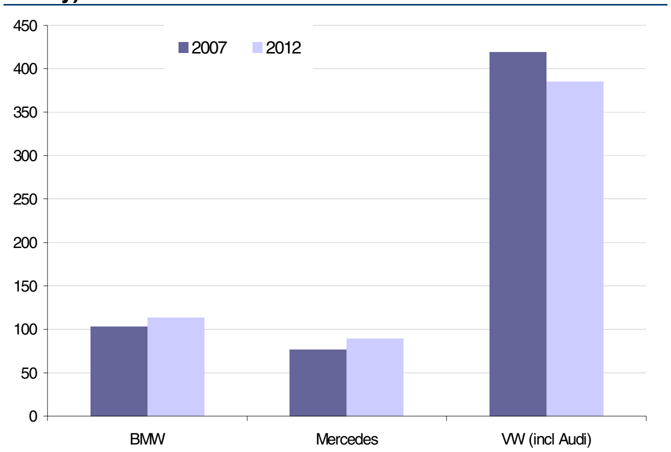
Figure 22: Diesel Engine scale BMW / Mercedes / Audi (engines >150hp), 2012E



Source: Company data, Credit Suisse estimates

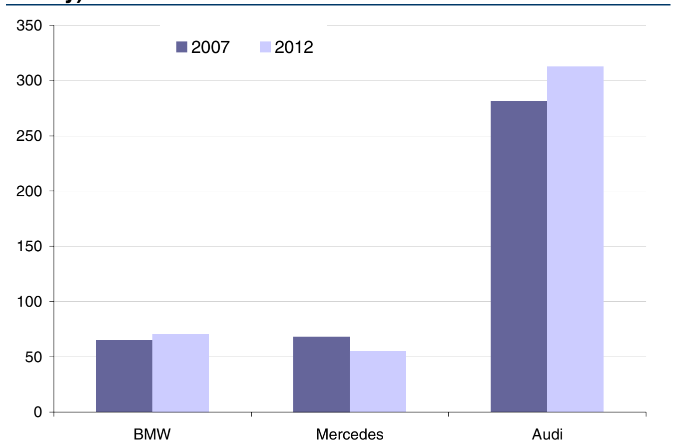
The absolute scale of diesel and gasoline production alone is not the only crucial factor determining economies of scale. The number of different engine families relative to volume is another driving force of profitable engine manufacturing. We are thus comparing the unit sales relative to the number of diesel and gasoline engine families. Again, Mercedes and BMW appear to have a major disadvantage compared to the VW group (and thus Audi).

Figure 23: Diesel economies of scale (engine / engine family) 2007A and 2012E



Source: Company data, Credit Suisse estimates

Figure 24: Gasoline economies of scale (engine / engine family) 2007A and 2012E



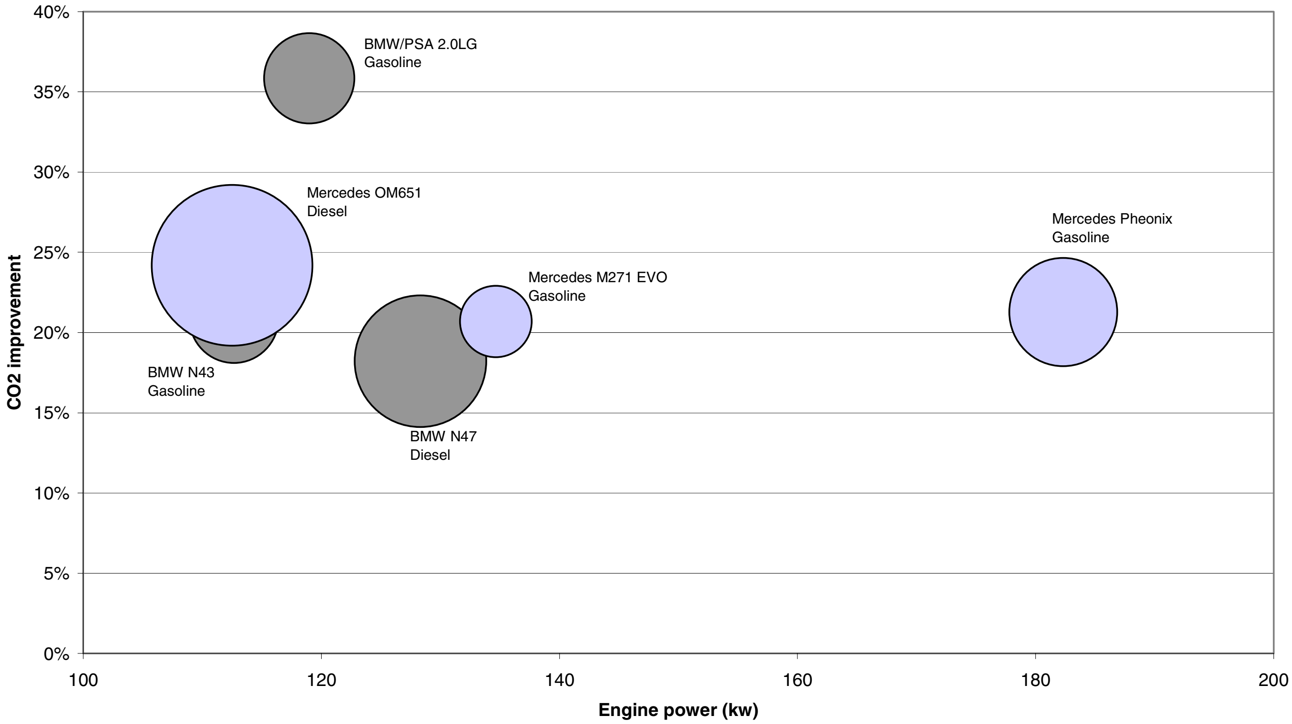
Source: Company data, Credit Suisse estimates

BMW has launched the majority of new engines in 2007. The next major new engine introduction is scheduled to be the new diesel engine in 2009 and the new gasoline engine in 2010. Both engines will be used in the new version of the 5 Series.

Daimler is renewing the majority of its engines in 2009, alongside the introduction of the new E Class. The new 77kw diesel engine is by far the major renewal, lowering emission by an estimated 24% versus its predecessor.

The VW group has done a major job replacing its gasoline engines with new direct injection, turbo charged versions. The introduction of new common rail diesel engines will be the final renewal for the group.

Figure 25: Major engine launches and CO2 improvement (BMW and Mercedes)



Source: A.T. Kearney, Credit Suisse estimates

Figure 26: Major engine launches

DIG = Direct –injection gasoline; T = Turbo; Volume = peak units, thousands

BMW	Fuel Type	KW/litre	Volume	DIG	T	2007	2008	2009	2010	2011	2012
N43	G	78	170	Y	N	1,3,5					
N54	G	103	30	Y	Y	1,5					
N53	G	85	180	Y	N	5	1				
N55	G	108	75	Y	Y			1,3	5		
BMW/PSA 2.0L G	G	85	170	Y	N				1,5	3	
BMW/PSA 2.0L G	G	120	5	Y	Y				1		
N47	D	83	370	N	Y	1,3,5					
N57	D	81	290	N	Y			3,5			

Mercedes	Fuel Type	KW/litre	Volume	DIG	T	2007	2008	2009	2010	2011	2012
M273	G	73	125	N	N	C					
M271 EVO	G	102	110	Y	Y			E	C		
Phoenix	G	95	90	Y	Y			E	C		
Phoenix	G	81	160	Y	N			E	C		
OM651	D	72	550	N	Y			C,E		A	
OM611/2/3	D	55	140	N	Y	E	C				

VW	Fuel Type	KW/litre	Volume	DIG	T	2007	2008	2009	2010	2011	2012
EA111	G	94	500	Y	Y	A3			A4		
EA888	G	93	280	Y	Y	A3, A4, Passat	A6, Golf,				
EA188CR	D	70	2255	N	Y	A4	A3, Golf, Passat	A6, Polo			

Source: Company data, Credit Suisse estimates

BMW—“Efficient Dynamics”

BMW has made fuel-efficient individual mobility a core brand value. We believe the company is thus the role model with respect to addressing the need for more sustainable and socially acceptable mobility. Unfortunately, BMW is thus far failing to transfer its early mover advantage into profitability. The company still argues that consumers are unwilling to pay extra for the additional technologies and the improved performance. However, we believe that technologies are getting cheaper with more players using them and that the entire industry will take a more prudent stance towards pricing for fuel efficiency.

BMW’s “Efficient Dynamics” implies engine downsizing in combination with additional turbo charging, better fuel injection and start-stop functions. So far, BMW has almost fully equipped its 3 and 1 Series products with the Efficient Dynamics package.

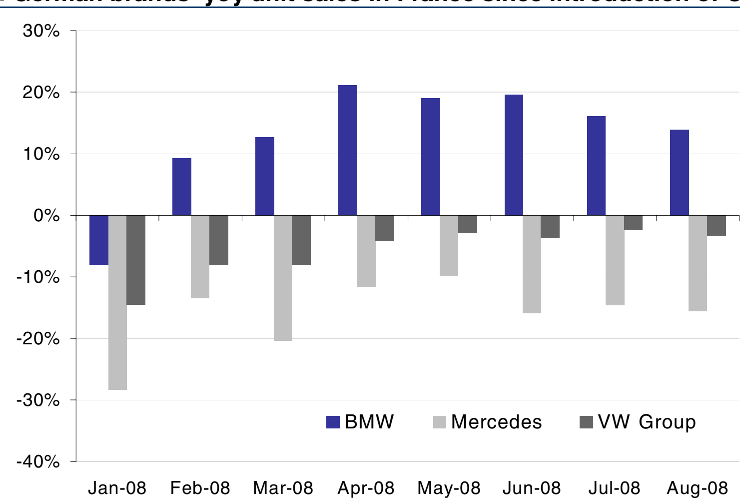
Figure 27: BMW Efficient Dynamics technologies and product penetration
in €, unless otherwise stated

	Cost (€ per engine)	3 Series	1 Series	5 Series	X3	7 Series	X5	Z4	6 Series
High precision injection	150	X	x	x					x
Lean-burn operation	400	X	x	x					x
Twin turbo technology	450	X	x						
VALVETRONIC	350	X	x	x	x	x	x	x	x
Variable twin turbo technology	325	X	x	x	x		x		x
Brake energy regeneration	350	X	x	x			x		x
Auto start stop function	250	X	x						
Shifting point indicator	50	X	x	x					x

Source: Company data

In France, which has introduced a “bonus/malus” system in December 2007, BMW reports strong demand for its more fuel-efficient, smaller models. Whether this has a positive impact on volume and mix has to be seen, but we believe it is definitely a promising development which should encourage BMW to expand these technologies to its bigger vehicles.

Figure 28: German brands’ yoy unit sales in France since introduction of CO2 tax



Source: Market data

Unfortunately, the German government is still debating whether to implement a CO2-based taxation system, which theoretically remains on the agenda for the start of 2009. We expect Ireland to link its road tax to CO2 emissions from July this year.

Powertrain benchmarking: Mass makers

- **French makers appear to us competitive only in the smallest of segments. From 308/Megane upwards, their engine technology appears to lag German peers.**
- **VW benefits from superior fuel efficiency and performance credentials thanks to early adoption of turbo-charger and direct fuel injection technology. We expect the new Golf to dominate its segment thanks to significant TCO advantages.**
- **We expect this to compromise PSA's and Renault's market share potential. We estimate that closing the technology gap with VW could cost up to €200–300 per vehicle, equivalent to some 40% of typical medium-car profits.**

New Golf likely to dominate its segment

Lower-medium segment = c.20% of EU car sales;

Lower-medium segment mix = 40/60 gasoline/diesel

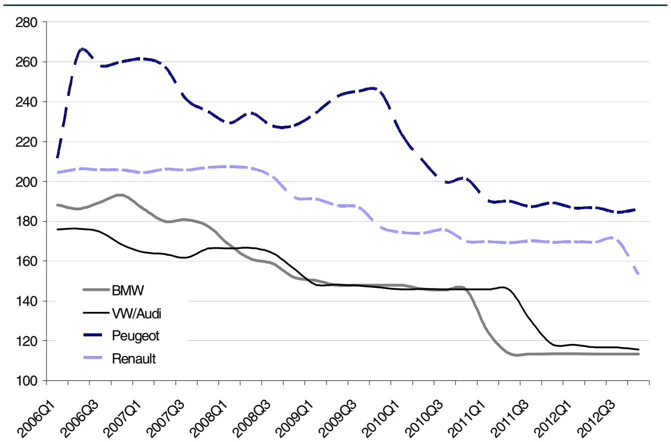
Based on our analysis, VW looks set to strengthen its dominance of the critical lower-medium segment with its new Golf, thanks to class-leading powertrain technology and compelling total-cost-of-ownership (TCO) benefits. We are pessimistic on prospects for the new Megane, new Astra and current 308, which are slow to see a broad roll-out of key GDI and turbo-charging technology.

To illustrate the Golf's relative advantage, Figure 29 (gasoline) and Figure 30 (diesel) below show CO_2 output by model based on our analysis of powertrain mix and new engine introductions between now and 2012. We show CO_2 output normalised on a typical power output of 100kW for this segment.

Our analysis suggests that the Golf and 1-Series have a normalised CO_2 advantage in gasoline engines of c.30% relative to the 308 and 20% relative to the new Megane. In diesel, revised Renault engines help the Megane keep pace with the 1-Series, but VW's new Golf will likely set the standard with a 10% normalised CO_2 advantage over the Megane, on our analysis. Peugeot's 308, which to date has been on a par with the outgoing Golf and Megane, looks set to fall significantly behind the pace from Q4'08E as new models and engines arrive in these competitor models.

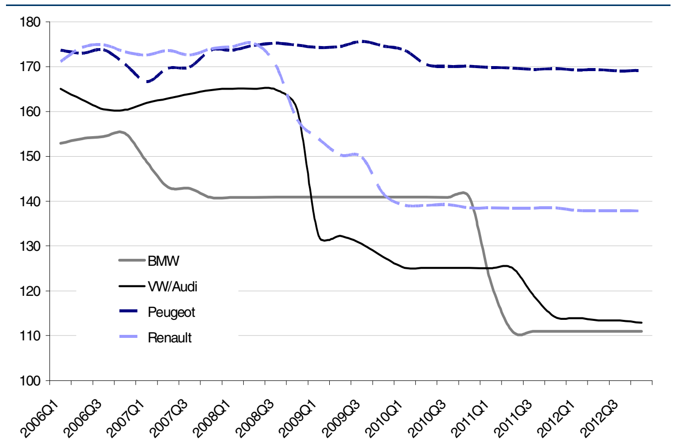
As a result, we expect 308 sales momentum to slow markedly in 2009E. Renault's new Megane is also unlikely to perform sufficiently to drive ambitious 2009E margin targets, in our view.

Figure 29: **Lower-medium gasoline—CO_2 (g/km) Normalised on 100kW**



Source: Company data, Credit Suisse estimates. All years estimates.

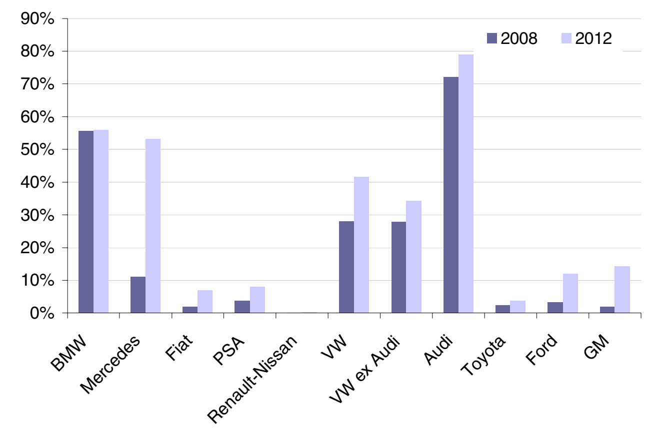
Figure 30: **Lower-medium diesel—CO_2 (g/km) Normalised on 100kW**



Source: Company data, Credit Suisse estimates. All years estimates.

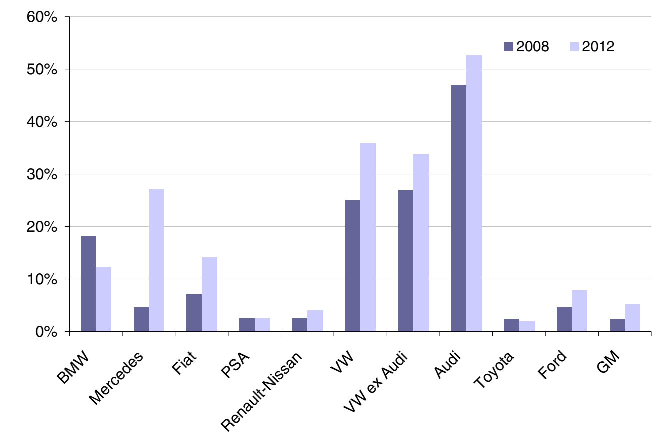
We believe that VW's and BMW's early adoption of engine downsizing, turbo-charging and direct fuel-injection is establishing the firms with a real lead in gasoline engine technology. Figure 31 and Figure 32 illustrate this lead: in 2008E, VW (ex-Audi) already uses GDI and turbo-charging on close to 30% of gasoline engines. For BMW, GDI is already used in over 50% of gasoline vehicles and in over 90% of 1-series gasoline output. By contrast, PSA and Renault barely use the technologies, with little rise in penetration likely by 2012E on current planning.

Figure 31: GDI penetration (of gasoline) by OEM



Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

Figure 32: Gasoline turbo-charging penetration (of gasoline) by OEM



Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

We believe Renault's new Megane will benefit from the introduction of new turbo-charged 1.4-litre gasoline engines, but these are likely to account for less than 100k units of combined Megane and Scenic volume (of c.600k units). The Megane does not benefit from any new diesels, although an improved range of K and M9R engine families should help it close the gap with BMW and take a lead on PSA in the segment.

Superior fuel-efficiency and residuals hand TCO advantage to Golf

However, VW's engines look set to maintain their advantage with the arrival of the new Golf, which benefits from the EA888 turbo-charged, GDI gasoline engine. PSA's 308 is also available in GDI guise on top-end versions, but volumes are likely to be limited to just c.20–30k. In contrast, some 50% of new Golf gasoline output will be turbo-charged with GDI technology. As a result, we expect the Golf to have a fuel efficiency advantage of c.15% over the 308 and Megane.

Together with stronger residual values, we estimate that this provides the Golf with a 10% total cost-of-ownership (TCO) advantage over the 308 and a 5% advantage over the Megane (see Figure 33). BMW's 1-Series runs the VW close despite its higher selling price thanks to stronger residuals (although these are currently under pressure).

For PSA and Renault, we estimate closing the gap with VW and BMW would cost c.€200–300 per vehicle at current costs (based on the incremental cost of GDI in smaller engines), potentially hitting unit profits of c.€500 per vehicle hard. For these makers, the challenge is to raise unit selling prices to close to Golf levels in order to pay for GDI technology, or to cut costs, either in GDI, or elsewhere in the vehicle. In the meantime, we expect these models to lose market share to the new Golf.

Figure 33: Gasoline engine performance and cost of ownership metrics

Figures show data and estimated costs for mid-range gasoline engine for each model

	Golf VI	1-Series	308	2008 Megane	2009 Astra
Engine metrics					
Engine capacity (cc)	1,390	1,596	1,598	1,598	1,598
Power (KW)	89	90	88	85	84
KW/1000cc	64	56	55	53	53
Turbo	Yes	No	No	No	No
GDI	Yes	Yes	No	No	No
CO2	**139**	**139**	**159**	**c.140**	**155**
Acceleration: 0-100km/h (secs)	9.5	10.1	10.8	c.10	10.9
Top speed: km/h	198	205	195	c.200	c.190
Fuel economy: l/100km	5.80	5.80	6.69	c.6.0	6.57
Total Cost of Ownership					
Purchase price	16,500	18,205	15,795	c.16,000	c.15,800
3-yr residual value	45%	49%	39%	40%	35%
Depreciation (over 3 yrs)	9,075	9,284	9,634	9,600	10,270
Fuel bill (15k km p.a. for 3yrs)*	3,132	3,132	3,613	3,240	3,547
Purchase tax (France)***	0	0	200	0	0
TCO**	**12,207**	**12,416**	**13,447**	**12,840**	**13,817**

*Source: Company reports, Autocar, Auto motor und Sport, Credit Suisse estimates. *Assuming €1.2/litres gasoline. **Excludes insurance, circulation tax and any finance or maintenance costs. ***From Dec-09 tax bands will reduce by 5g/km, meaning penalties kick in from 156g/km, rather than 161g/km today.*

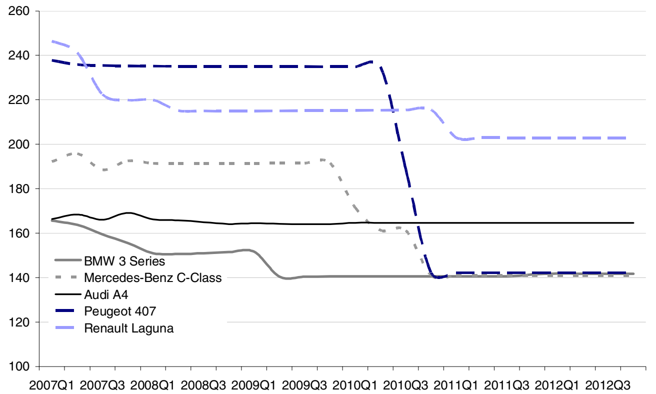
Mass makers struggle to compete in larger segments

We are even more cautious on mass maker potential in the upper-medium segment (i.e. 407, Laguna, 3-Series). The fact that the Laguna has been a relatively poor performer in volume terms is no secret. However, this has not been so much a Laguna issue, in our view, but rather a segment issue. The upper-medium mass-brand segment has been in terminal decline for some years, losing share to MPVs, SUVs and premium brands (notably the 3-Series). We think mass brands simply do not have the scale in this segment to compete with growing competition from premium makers. The latter benefit from scale in larger vehicle engines that in our view PSA and Renault are unlikely to be able to match without JVs (see powertrain scale charts later in this report).

The results in engine performance are plain to see, notably in gasoline engines, where our analysis suggests Renault and PSA lag class leader BMW by c.35% in terms of normalised CO2 output (based on typical 125kW output for this segment). PSA potentially solves this issue by using BMW's 2.0-litre gasoline engine for the 408, but this is not due to arrive until 2010/11. Renault currently appears to us to have no answer to this technological battle, despite its increasing use of shared powertrain with Alliance partner Nissan (GDI only makes a limited appearance from 2011 onwards).

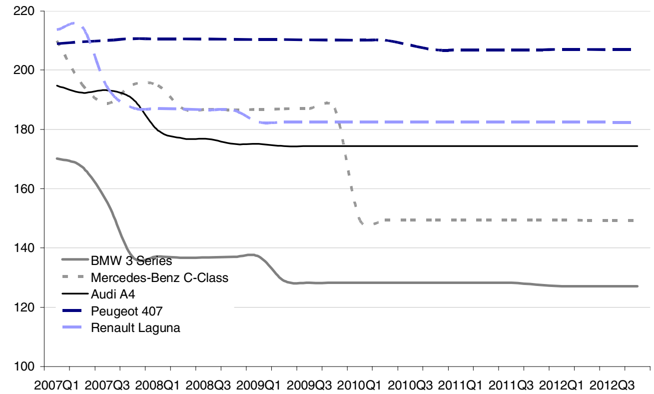
The picture is much the same in diesel (c.60% of segment sales), where PSA and Renault may match Mercedes in fuel-efficient performance, but significantly lag the latest diesel offerings available in the BMW 3-Series. We also expect Mercedes to pull ahead of its French rivals from late 2009 with the arrival of the OM651 diesel engine family.

Figure 34: **Upper-medium gasoline—Normalised on 125kW**



Source: Company data, Credit Suisse estimates. All years estimates.

Figure 35: **Upper-medium diesel—Normalised on 125kW**



Source: Company data, Credit Suisse estimates. All years estimates.

The TCO benefits of a 3-Series are illustrated in Figure 36 below. We estimate that the BMW is almost 20% cheaper to own over three years than a Peugeot 407. Stronger residual values (which may improve with the 408) account for half this difference, while lower fuel bills and the avoidance of CO2 taxation (in France) account for the rest. In our view, this calculation helps explain BMW's strong sales performance over the past 12 months. PSA need not be too concerned, however, as we believe the use of BMW engines in the 408 should help resolve this issue. However, we think Laguna looks destined to see deteriorating sales unless it can significantly advance its current engine technology.

Figure 36: **Gasoline engine performance and cost of ownership metrics**

Figures show data and estimated costs for mid-range gasoline engine for each model

	407	Laguna	3-Series	C class
Engine metrics				
Engine capacity (cc)	1,997	1,997	1,995	1,796
Power (KW)	103	103	125	135
KW/1000cc	52	52	63	75
Turbo	No	No	Yes	Yes
GDI	Yes	No	Yes	No
CO2 (g/km)	**192**	**185**	**146**	**169**
Acceleration: 0-100km/h (secs)	8.8	9.1	7.9	8.3
Top speed: km/h	211	210	228	233
Fuel economy: l/100km	8.31	7.90	6.14	7.24
Total Cost of Ownership (Euros)				
Purchase price	25,650	25,450	29,500	33,000
3-yr residual value	35%	38%	50%	48%
Depreciation (over 3 yrs)	16,673	15,779	14,750	17,160
Fuel bill (15k km p.a. for 3yrs)*	4,487	4,266	3,316	3,910
Purchase tax (France)***	750	750	0	750
TCO	**21,910**	**20,795**	**18,066**	**21,820**

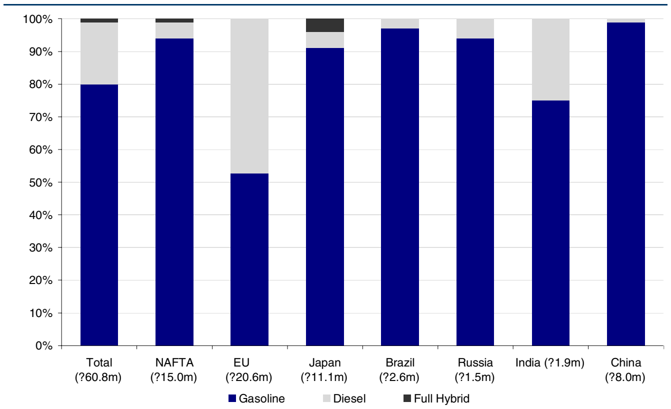
*Source: Company reports, Autocar, Auto motor und Sport, Credit Suisse estimates. *Assuming €1.2/litres gasoline. **Excludes insurance, circulation tax and any finance or maintenance costs. ***From Dec-09 tax bands will reduce by 5g/km, meaning penalties kick in from 156g/km, rather than 161g/km today.*

Where next? The future is electric

Why today's mix must change

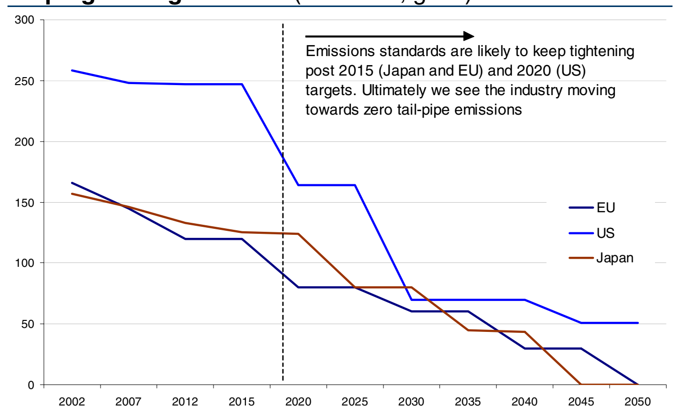
The world's automotive powertrain mix is currently heavily skewed towards gasoline-fuelled, internal-combustion engine (ICE) technology. While in the short-to-medium term improvements in ICE technology could herald significant CO_2 savings at a relatively low cost, this will not be sufficient to meet longer-term goals, in our view. EU and Japanese standards for 2015 (and US for 2020) will not be the end of the CO_2 debate: we expect a constant tightening of legislation, supported by consumer demand, to drive the industry towards zero tailpipe emissions in mature markets by 2050. For automotive executives, transferring the issue of CO_2 from the automotive industry to the power generation industry is the ultimate goal.

Figure 37: Global fuel mix, 2007A



Source: A.T. Kearney, Credit Suisse estimates

Figure 38: Global emissions standards are unlikely to stop tightening in 2015E (CO_2 limit, g/km)

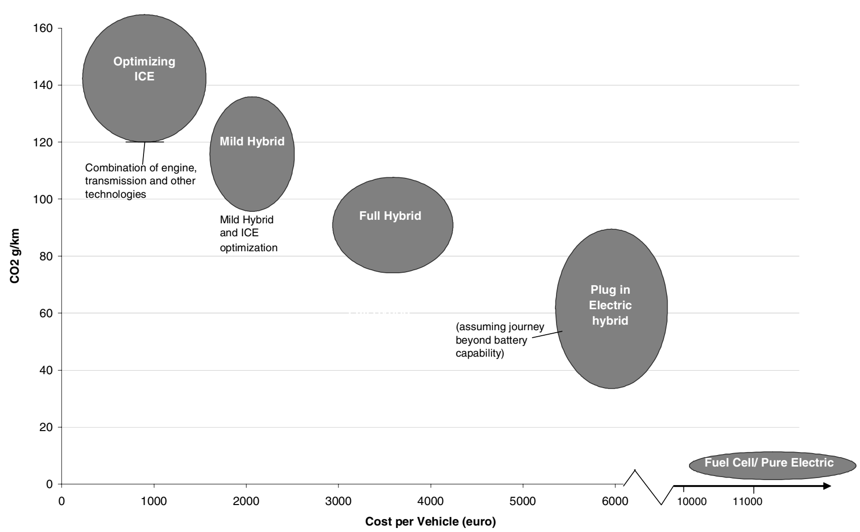


Source: Company data, Credit Suisse estimates

At present, we estimate that key ICE technologies allow the possibility to reduce CO_2 emissions by a maximum of c.30% at a cost of c.€1,500. Adding mild and full hybrid technology could further reduce emissions by c.50%. However, further improvement from here will likely require more radical powertrain alternatives.

Figure 39: Where are the limits of powertrain technology?

CO_2 potential (g/km, EU fleet) versus cost per vehicle (€)



Source: Company data, Credit Suisse estimates

Longer-term, battery technology likely to prevail

Longer-term, we believe that powertrain solutions lie in areas other than traditional combustion-engine-based systems.

The main alternatives at this stage are i) hydrogen fuel cells, and ii) the electrification of the car.

Battery development is currently at the forefront of all electric powertrain research. Hybrids that have been released to date incorporate nickel metal hydride batteries. Longevity and reliability are advantages of this technology, but their weight, cost (nickel costs are high) and relatively poor efficiency have led to the search for better chemistries. The future, it seems, lies in lithium ion batteries. Lithium ion batteries will be used in the production of the GM Volt which aims to be the first mass-produced plug-in hybrid when production begins in 2010 (see later). In the following section, we therefore compare technical, CO2 and cost characteristics of fuel-cell and pure-electric (based on lithium-ion) technologies.

1) Technology advantages

Both fuel-cell and electric vehicles offer the potential for zero tailipipe emissions in a still 'fun-to-drive package'. However, both have significant technical issues that need to be overcome. For electric vehicles, extending battery life and reducing charging time are the key parameters. For fuel cells, the main issue remains storage and distribution of hydrogen fuel. Infrastructure costs could run into tens of billions of dollars to support the rollout of this technology. In comparison, electric vehicles can make use of existing electricity infrastructure, especially in urban centres (e.g. Project Better Place).

Figure 40: Technology comparison

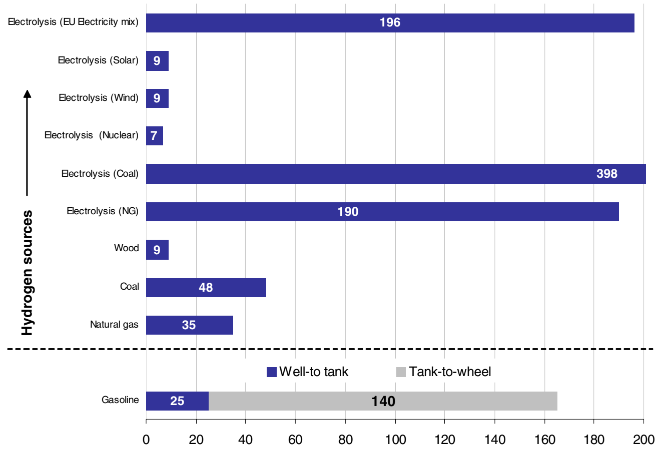
	Advantages	Disadvantages
Hydrogen Fuel Cells	Potential for a zero-emissions vehicle, if hydrogen can be generated through renewable energies	H2 Storage—liquid storage leads to fuel loss, limited vehicle range with compressed gas and reversible solid state not yet feasible
	Smooth, quiet driving experience	Very high cost with current technology; not yet ready for mass market
	Reasonable vehicle range (Honda FCX Clarity claims up to 270 miles)	New infrastructure needed alongside conventional infrastructure (high cost)
		Fuel starvation problem
		Limited reliability and durability under extreme conditions
Li-ion	Smooth, quiet driving experience	Low vehicle range between charges
	Electricity infrastructure already in place	Long charging cycle of several hours
	Zero tail-pipe emissions potential	Safety still an issue (overheating)
	Strong well-to-wheel CO2 credentials	Currently heavy, bulky and expensive system

Source: Company data, Credit Suisse research

2) CO2 performance

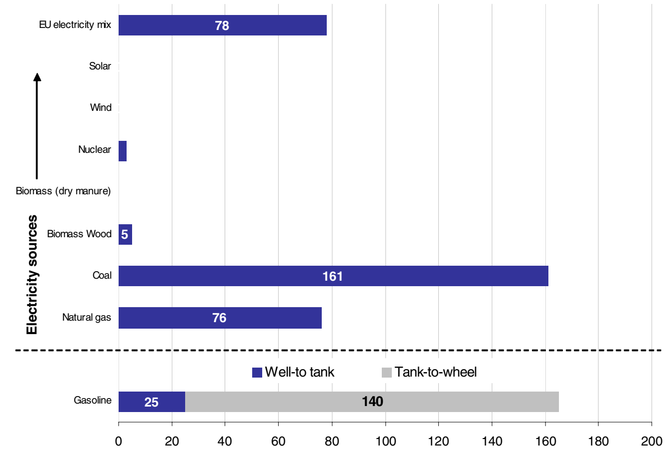
Given that both pure-electric and fuel-cell vehicles have zero tailpipe emissions (i.e. tank-to-wheel), it is well-to-tank parameters that matter in terms of CO2 performance. Figure 41 and Figure 42 illustrate CO2 equivalent output for both technologies under various energy-source scenarios. In most scenarios, EVs appear to superior to fuel-cells on a well-to-wheel CO2 basis and, based on the EU electricity mix, are more than twice as 'green' as fuel-cells. The picture may look slightly different in markets heavily dependent on coal for their energy mix (e.g. the US), under which scenario fuel-cells may prove cleaner. We expect electric vehicles to gain share fastest in urban centres supplied with a high proportion of clean energy (e.g. Project Better Place in wind-power rich Denmark).

Figure 41: **Fuel cell (g CO2 equivalent/km)**



Source: A.T. Kearney, Credit Suisse research

Figure 42: **Pure electric vehicle (g CO2 equivalent/km)**

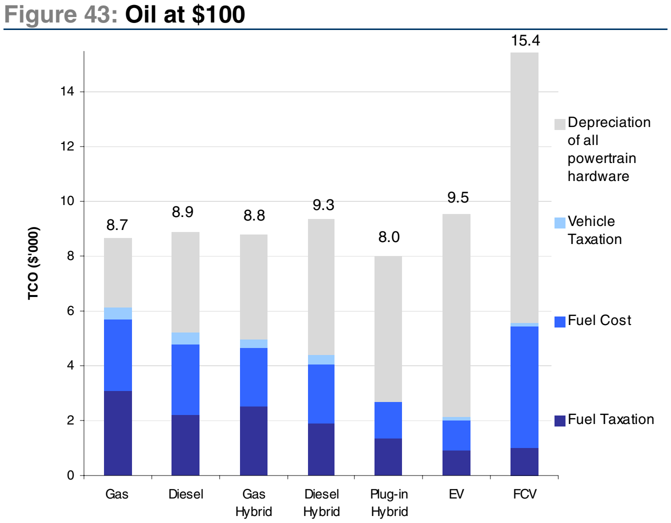


Source: A.T. Kearney, Credit Suisse research

3) Total cost of ownership (TCO)

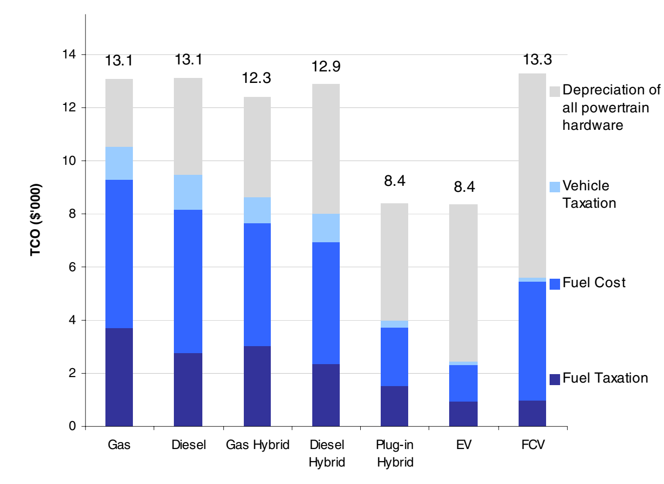
Comparing total cost of ownership over a typical four-year period of the different technologies strengthens the case for electric powertrains. Our analysis assumes cost improvement of c.5% annually for fuel-cell and battery technology, and c.1% for ICE technology. Assuming oil prices remain at c.$100, plug-in hybrids look to be the lowest-cost technology, even including gasoline and diesel. Pure electric vehicles appear as, but no more economical than, conventional technologies. However, under our $200 oil-price scenario, we estimate that pure-electric and plug-in hybrid technologies benefit from a TCO advantage of c.35% relative to fuel-cells and ICE technology.

Figure 43: **Oil at $100**



Source: A.T. Kearney, Credit Suisse estimates

Figure 44: **Oil at $200**



Source: A.T. Kearney, Credit Suisse estimates

The two scenarios have the following assumptions for TCO (total cost of ownership over four years): Average crude oil price ($/bbl) 100/200; Fuel cell CIP rate (%) 4/6, Battery CIP rate (%) 5/7.5; ICE CIP rate (%) 1.5/1.5; Annual mileage 15,000km

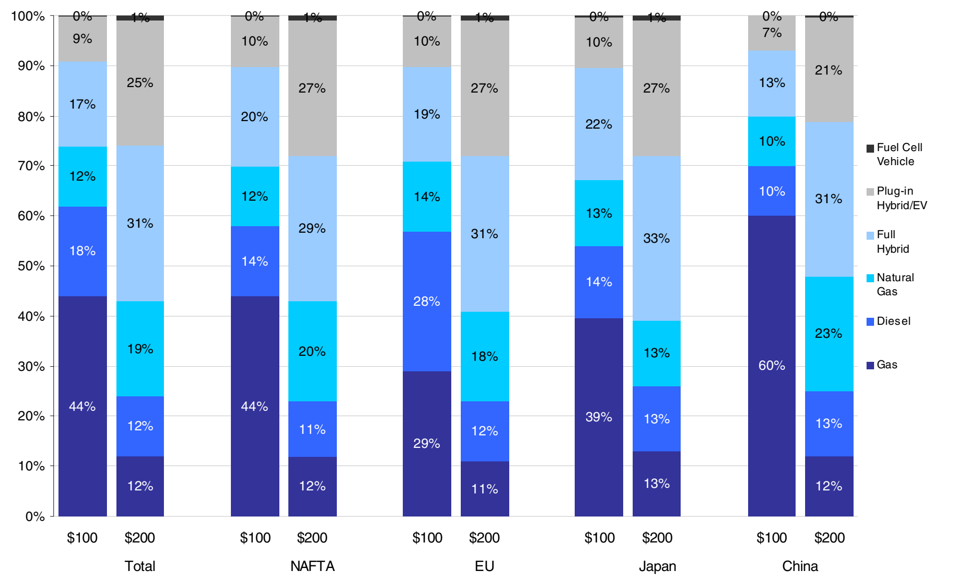
The 2020 powertrain landscape

Clearly, the oil price plays a key factor in the relative economics between alternative technologies and hence future mix. Ultimately, given compelling TCO and technical advantages, we believe the electrification of the car appears increasingly inevitable, with plug-in hybrids providing the bridge technology to fully electric vehicles. GM's Volt should provide a critical mass-produced test-bed for the technology.

It is no surprise then, that A.T. Kearney's scenario analysis of the powertrain of the future predicts EV penetration of close to 10% by 2020 under an oil at $100 scenario, rising to c.25% if oil prices rise to $200. Together with 'conventional' hybrid technology, battery penetration in vehicles would thus reach over 25% with oil at $100 and to over 50% of the market with oil at $200. Beyond 2020, prospects for ICE technology appear grim, in our view, barring an unexpected sharp decline in the price of oil.

Figure 45: 2020 powertrain landscape: Oil at a) $100/bbl; and b) $200/bbl

Global powertrain mix, %age shares



Source: A.T. Kearney, Credit Suisse estimates

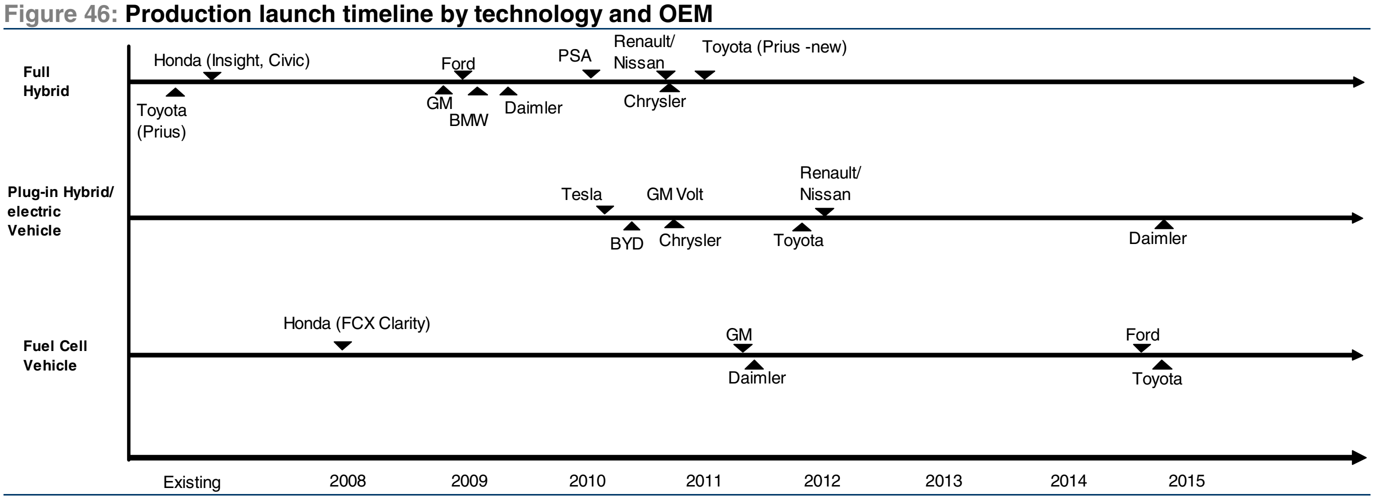
Total includes Brazil, Russia and India. The two scenarios have the following assumptions for TCO (total cost of ownership over four years): Average crude oil price ($/bbl) 100/200; Fuel cell CIP rate (%) 4/6, Battery CIP rate (%) 5/7.5; ICE CIP rate (%) 1.5/1.5; Annual mileage 15,000km

Who is doing what, when?

With so much at stake, car makers are investing heavily in alternative powertrains, with most spreading investment across multiple solutions in order to avoid becoming the 'Betamax' of the 21st century (which became obsolete as VHS video format gained critical mass). We believe electric vehicles are starting to win the lion's share of R&D budgets, and, critically, public recognition. A plethora of electric concept-vehicles are revealed almost every week, and low-volume plug-in hybrids should reach the market as early as next year.

It is little surprise, then, that OEM activity appears increasingly heavily concentrated on battery solutions, with almost every major OEM planning some form of EV before 2011 (see Figure 46). Despite decades of development, fuel-cell technology has only just reached the market, albeit in very limited volume, through the FCX Clarity, which Honda leases to customers in California. Beyond this model, we find only very limited production launch plans for this technology, with no models planned (that we know of) until 2011 at the earliest.

Figure 46: Production launch timeline by technology and OEM

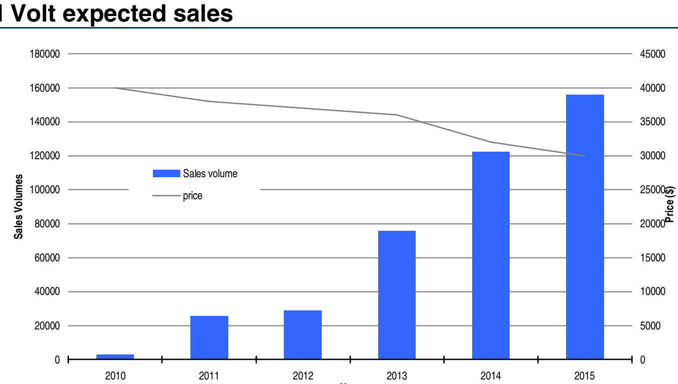


Source: Company data, A.T. Kearney, Credit Suisse estimates

GM Volt the testbed for plug-in technology

The GM Volt, to be launched in November 2010, looks set to be the world's first mass-produced plug-in electric vehicle. The specification claims 40 miles of power from a lithium-ion battery which is fully re-charged in 6.5 or 3 hours (110V as per US, or 220V in EU, respectively). For journeys longer than 40 miles, there is an additional gasoline tank. Research provided by GM indicates that 78% of Americans drive 40 miles a day or less.

Figure 47: GM Volt expected sales



Source: Global Insight, Credit Suisse estimates

The Volt is purely driven by the battery, with a small gasoline engine used only to recharge the battery in order to extend range. At the time of writing, two companies have been awarded development contracts for the lithium-ion batteries to be used in the Volt: Compact Power Inc., a unit of LG Chem, and A123. The winner has yet to be disclosed.

Costs and prices are also yet to be disclosed, but we expect the price will initially start at near $40,000 for base versions. As with most 'first-movers' in technology, the initial version is likely to be loss-making. GM will partly subsidise the Volt, but says it is hoping for tax credits to make it more marketable to consumers. Senate legislation could make tax credits available to plug-ins with at least six kilowatt-hours of electric power. Credits could reach $7,500 for light-duty vehicles and could benefit not only the GM Volt but also other electric vehicles such as those produced by Nissan, Mitsubishi and Tesla.

Figure 48: **Volt specifications**

Cost	c$35,000–40,000 subsidised by GM, and c$30,000 including tax credits/other subsidies
Battery Range	40 miles
Recharge Time	6.5 hours (220V source), 3 hours (110V)
Fuel Economy—mpg	100–150mpg
Running costs	US: $0.80/day to charge, $0.02/mile to run
0-60mph	8–8.5secs
Top speed mph	120 (limited duration)

Source: Company data, Credit Suisse research

Who will own the key intellectual property?

The electrification of the automobile has the potential to revolutionise the structure of the industry. Automakers have long maintained powertrain development as a key core competence, critical to the welfare of their brands. However, the shift to electric vehicles could lead to an outsourcing of powertrain technology, with core powertrain knowledge held outside the OEM. This may undermine the current business model of many carmakers, and we would thus not be surprised to see OEMs invest heavily in, or acquire, key battery makers and/or battery system integrators.

We identify the key automotive battery players in Figure 49 below. This list is not exhaustive, but covers the main companies of which we are aware. Unfortunately, at this stage, we think it is difficult to find any liquid, pure-play auto battery investment opportunities. Specialised companies operating in this segment include Saft, Ener1 and A123 Systems, which has recently declared plans to raise capital by issuing equity (any deal will likely be relatively small in size, however).

Figure 49: **Key battery supplier and partners**

Supplier	Partner/Investors	Contracts	Listed (ticker*)
Johnson Controls	SAFT, Conti	BMW, Mercedes, Chery	Y (JCI.N)
Saft	JCI, Conti	Mercedes	Y (S1A.PA)
A123	GE, P&G, AllianceBernstein, Conti	THINK, Volvo Trucks, Mercedes Buses, GM*	N
Continental	A123, JCI, Saft	Mercedes, VW	Y (CONG.DE)
Ener1 (EnerDel)	Ener1 / Delphi JV	THINK	Y (HEV.A)
Compact Power	LG Chem	GM, Hyundai	Y (051910.KS)
Sanyo	—	VW, Honda, Ford	Y (6764.T)
AESC	Nissan / NEC JV	Nissan, Renault	N
HVE	Hitachi, Shin-Kobe Machinery Co	GM	N
PEVE	Toyota / Matsushita	Toyota	N
GS Yuasa	Mitsubishi Corp	Mitsubishi	Y (6674.T)

*Source: Company data, Credit Suisse research. *Reuters ticker*

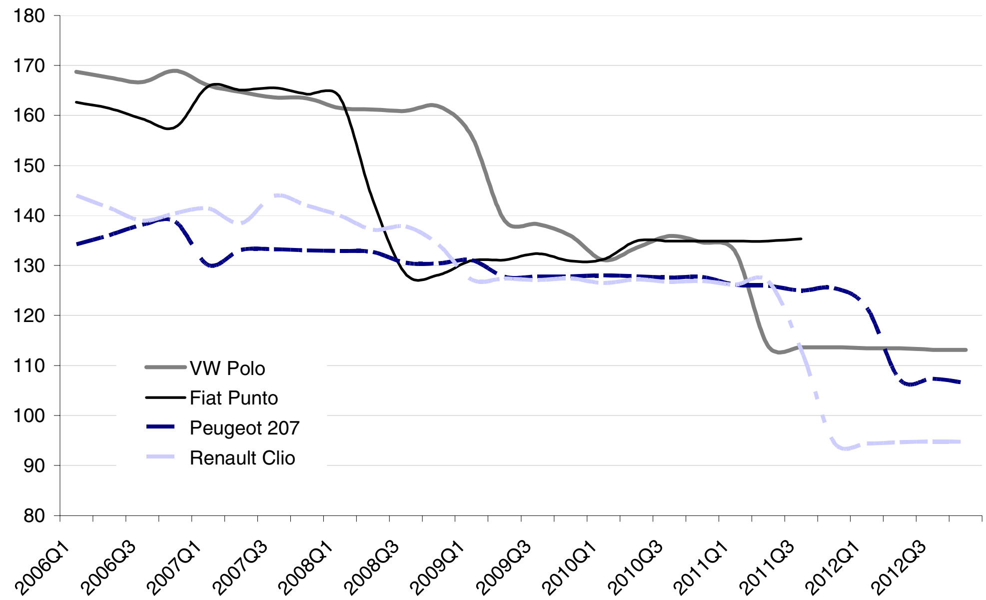
CO2 leaders: Segment by segment

Compact segment

(e.g. Polo, 207, Clio)

Gasoline

Figure 50: **Compact gasoline—CO2 (g/Km) Normalised on 60kW**

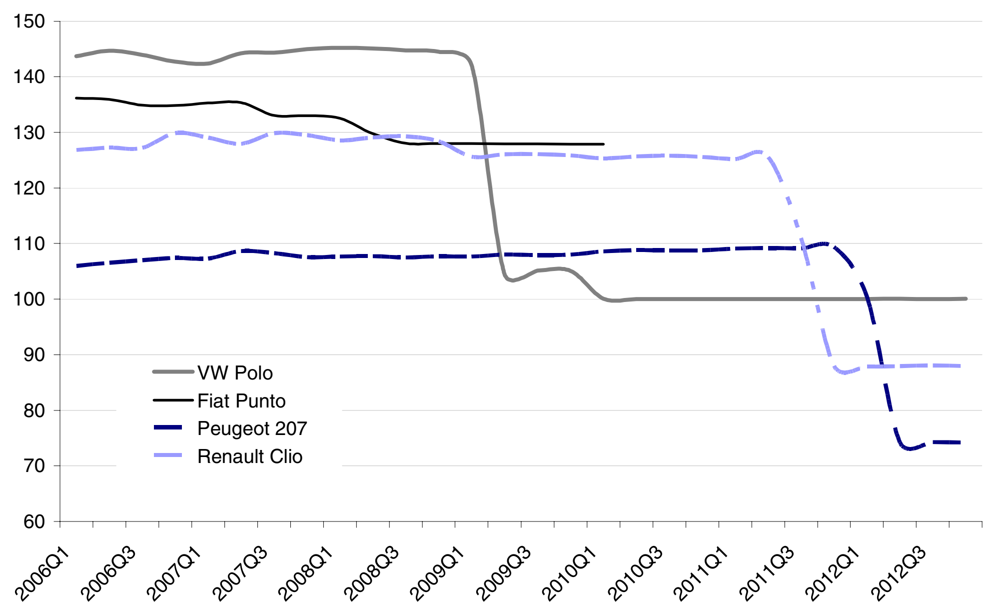


Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

PSA and Renault have enjoyed a lead in small gasoline engines, but Fiat and VW are catching up fast

Diesel

Figure 51: **Compact diesel—CO2 (g/Km) Normalised on 60kW**



Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

New engines should help VW join PSA as the leader in small-car diesel technology

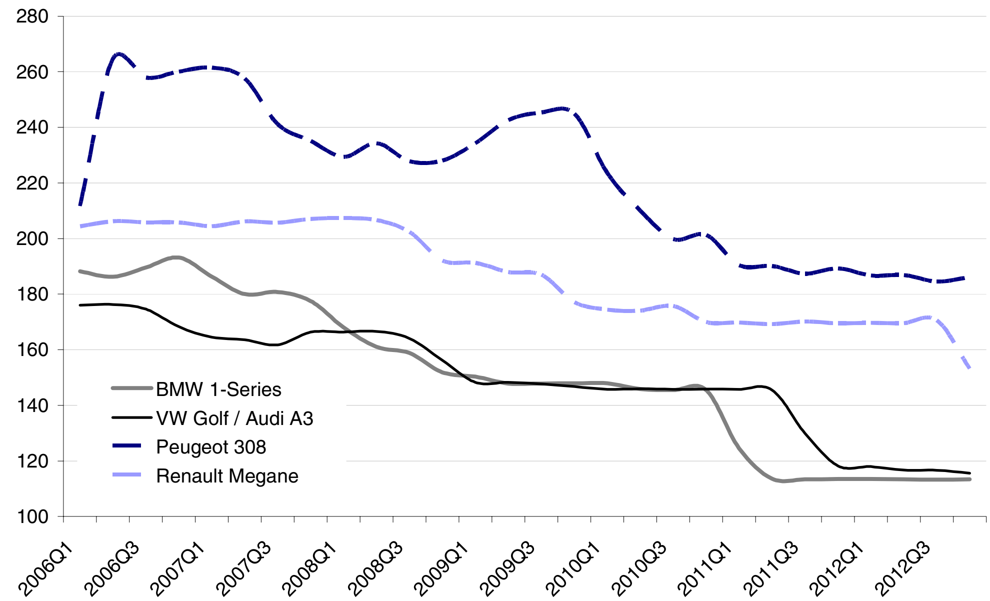
Lower-medium segment

(e.g. Golf, Megane, 308)

Gasoline

Figure 52: **Lower-medium gasoline—CO2 (g/Km) Normalised on 100kW**

BMW and VW look set to maintain their lead over French rivals in the critical Golf lower-medium segment (20% of EU sales)

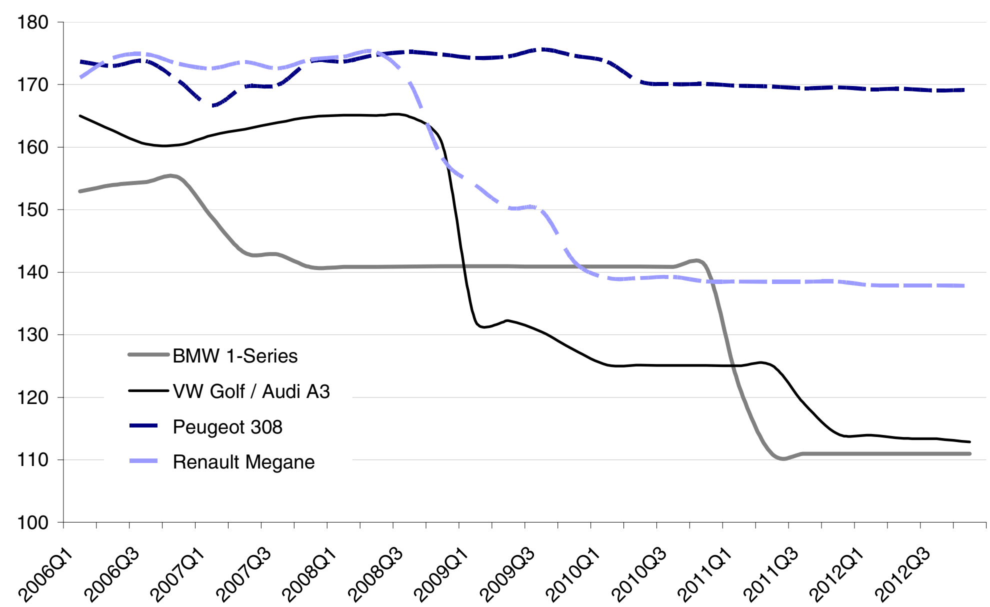


Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

Diesel

Figure 53: **Lower-medium diesel—CO2 (g/Km) Normalised on 100kW**

Revised Renault diesel engines should help Renault's Megane to close the gap to the Germans; PSA appears the laggard



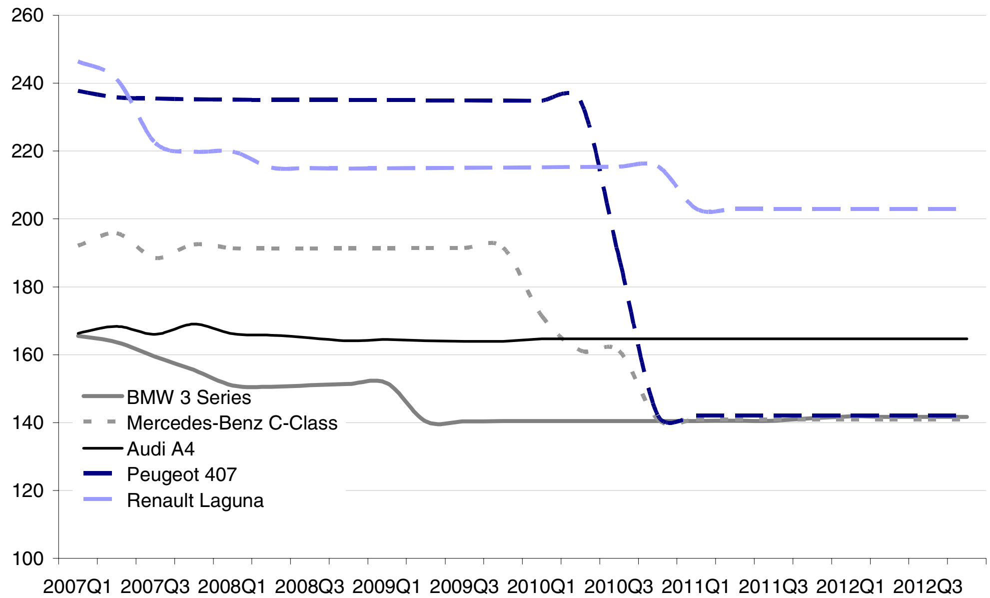
Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

Upper-medium segment

(e.g. 3-series, Laguna)

Gasoline

Figure 54: **Upper-medium gasoline—CO2 (g/Km) Normalised on 125kW**

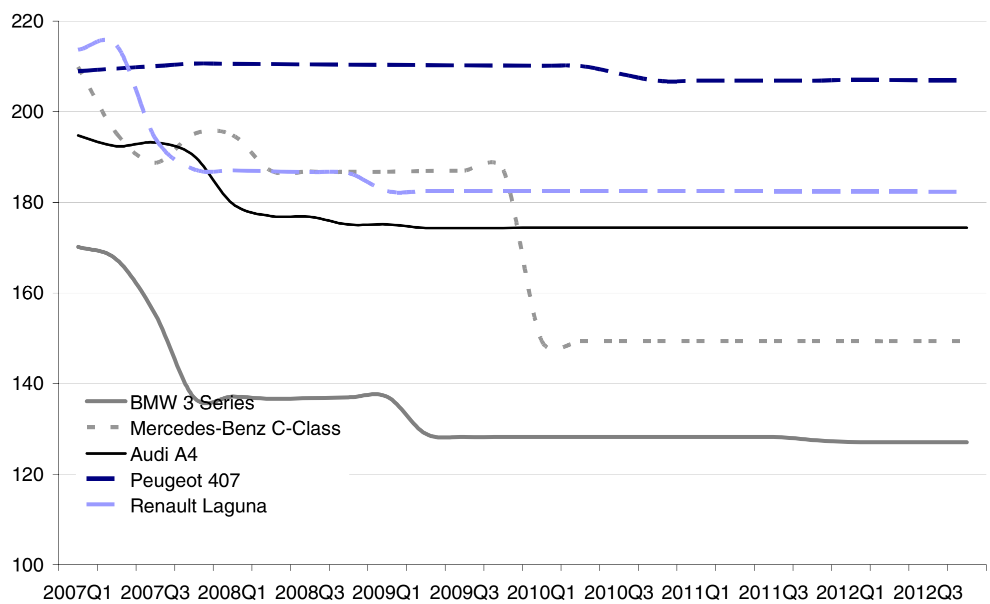


Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

Mass makers lack scale and pricing power to develop leading large-car engines; PSA is set to solve the issue by adopting a BMW engine from 2010 for the 408

Diesel

Figure 55: **Upper-medium diesel—CO2 (g/Km) Normalised on 125kW**



Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

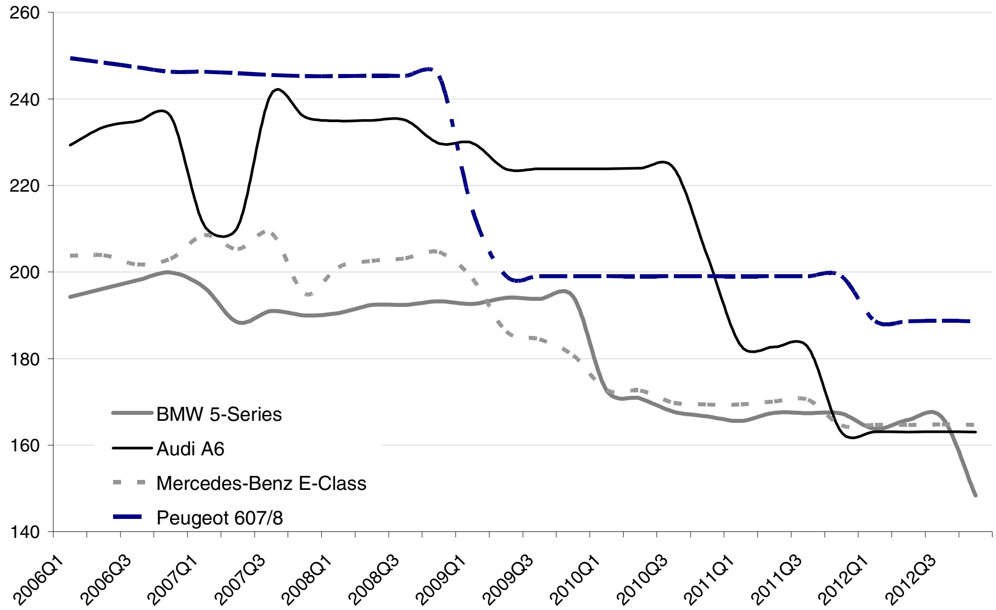
BMW's lead in upper-medium segment diesels appears insurmountable

Executive segment

(e.g. E-Class, 5-series)

Gasoline

Figure 56: **Executive gasoline—CO2 (g/Km) Normalised on 150kW**

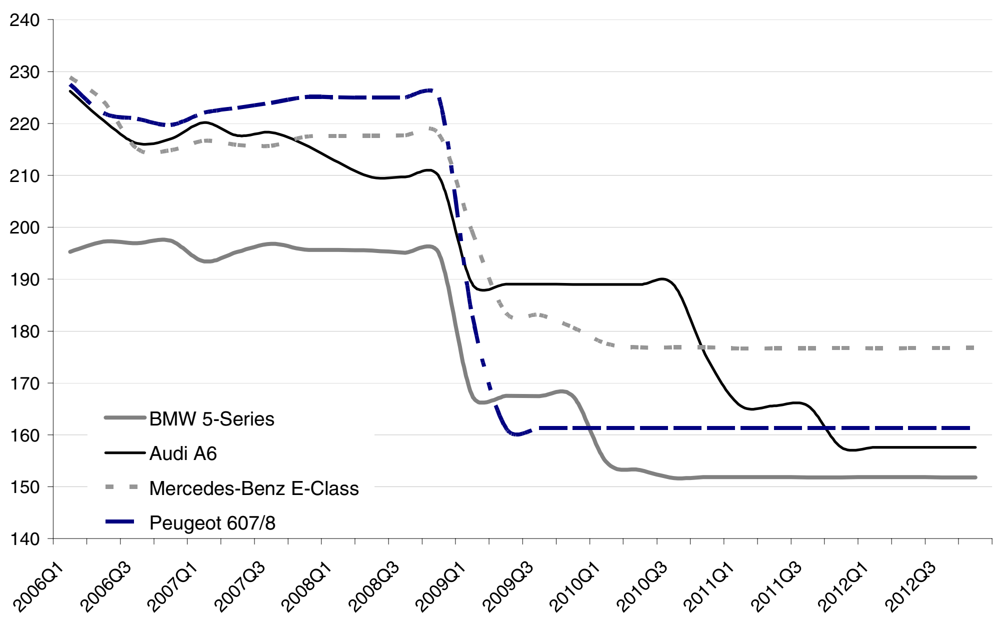


Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

Surprisingly, Audi gasoline engines lag BMW and M-B in the executive segment; this may reflect lack of scale in this segment elsewhere in the VW group

Diesel

Figure 57: **Executive diesel—CO2 (g/Km) Normalised on 150kW**



Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

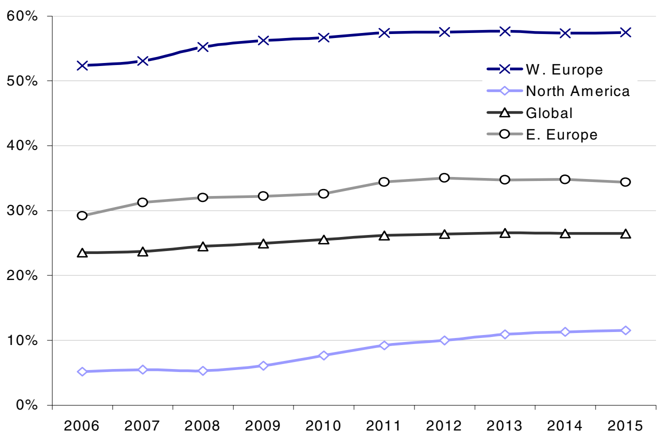
Little to call between OEMs in executive diesels, though BMW's recent advantage is likely to be eroded in 2009 with the arrival of the new M-B E-Class, in our view

Technology adoption

Diesel share in Europe close to its peak

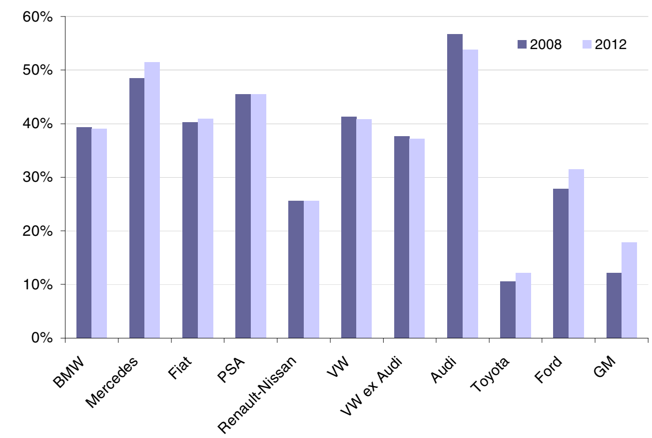
We believe diesel share has peaked in Europe but should continue to see a very modest increase in share globally. However, our database shows an increase in North American penetration of diesel to over 10% by 2013E—this may prove too rich if hybrid and pure-electric vehicles continue to dominate publicity and entrench the technology as the 'green choice'. European diesel leaders will likely see little change in diesel/gasoline mix by 2012E, but we expect Japanese and US makers to slowly increase their diesel offering.

Figure 58: **Diesel market share (2008–15 estimates)**



Source: A.T. Kearney, Credit Suisse estimates. . All years estimates.

Figure 59: **Diesel mix by OEM (2008A and 2012E)**

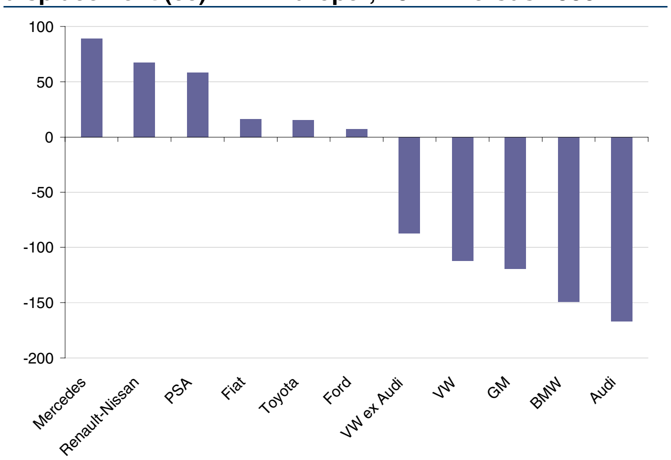


Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

BMW and VW lead engine downsizing

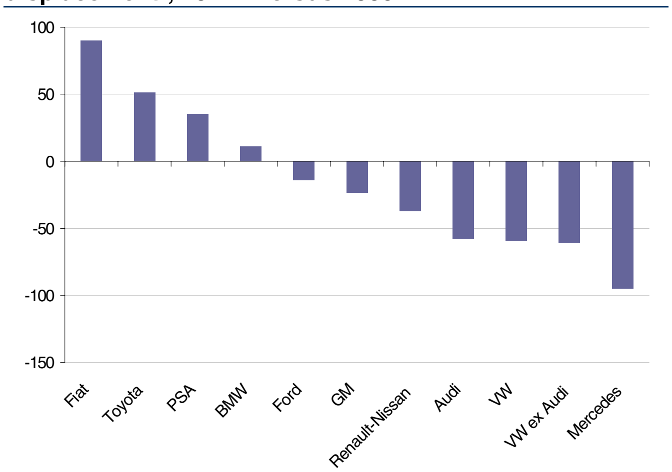
After decades of 'displacement culture', the auto industry is now instead turning to smaller-capacity engines to help improve fuel-efficiency. Engine downsizing helps reduce weight and friction in the engine, and works closer to peak efficiency for more of the time, thus improving fuel economy. BMW and VW are leading this trend, notably in gasoline engines, while Mercedes appears to be leading in diesel downsizing. Clearly, mix trends play a role in this evolution, but we fully expect engine downsizing, notably in gasoline, to continue to gain momentum over the next few years.

Figure 60: **Change in average gasoline engine displacement (cc) in W. Europe*, 2012E versus 2006**



*Source: A.T. Kearney, Credit Suisse estimates. *Up to 2500cc*

Figure 61: **Change in average diesel engine displacement*, 2012E versus 2006**

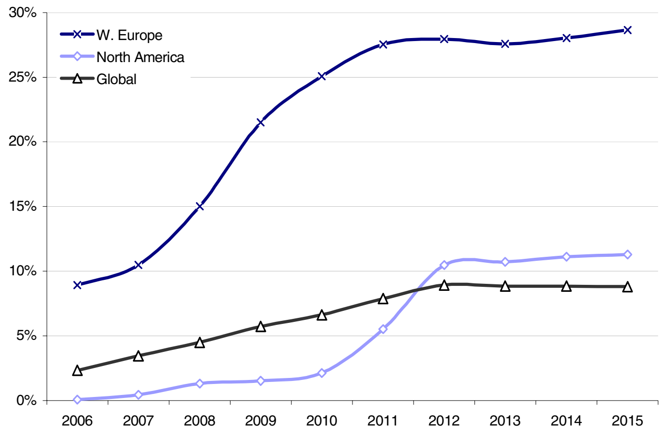


*Source: A.T. Kearney, Credit Suisse estimates. *Up to 2500cc*

GDI adoption follows downsizing trends

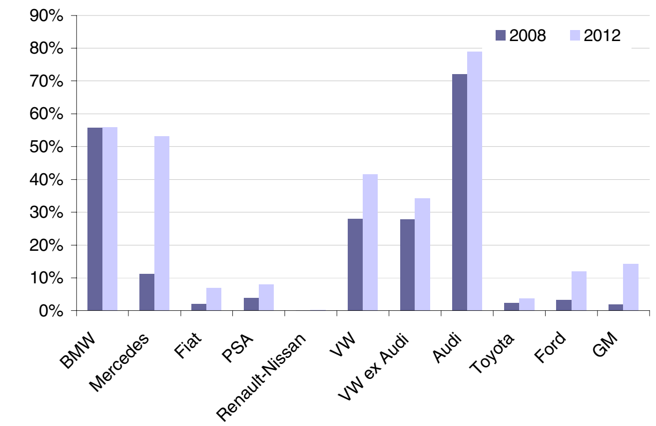
Downsizing data tells only half the story: it is easy to make a smaller, more efficient engine by sacrificing performance (e.g. Renault 1.5dci). But improving efficiency while maintaining performance requires investment in additional technology. For gasoline engines, this means direct fuel-injection and turbo-charging. We expect penetration of GDI in Europe to reach close to 30% by early next decade. North American take-up looks set to be slower, though it should still exceed 10% within five years. **BMW and VW groups will likely be the clear early adopters of GDI**, in our view, with Audi already using the technology in some 71% of its gasoline vehicles. Mercedes looks to be the laggard, but should roll out the technology rapidly over the next few years and close the gap with BMW by 2012E.

Figure 62: **GDI penetration (of gasoline) by region**



Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

Figure 63: **GDI penetration (of gasoline) by OEM**

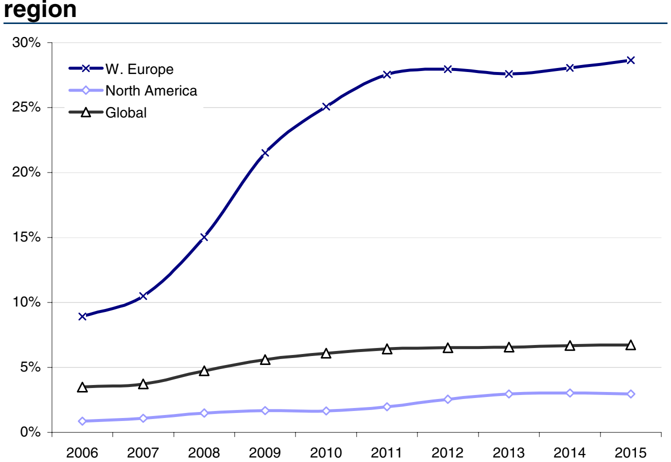


Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

Gasoline turbo-charging to accelerate in 2009E

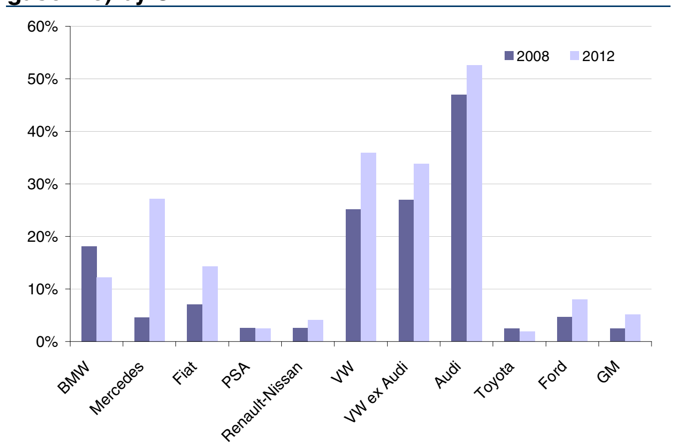
Gasoline turbo-charging should echo the trend in GDI, reaching European penetration of close to 30% by early next decade also. BorgWarner has reported booming demand for turbo-charging technology in Europe, with demand so strong that both Bosch and Continental plan to enter the business from a standing start. North America again looks slow to adopt the technology, but we would expect these plans to change as more European products reach US shores (on demand for smaller vehicles). VW and BMW again look to be the early adopters, though Mercedes should catch up fast.

Figure 64: **Turbo-charging penetration (of gasoline) by region**



Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

Figure 65: **Gasoline turbo-charging penetration (of gasoline) by OEM**



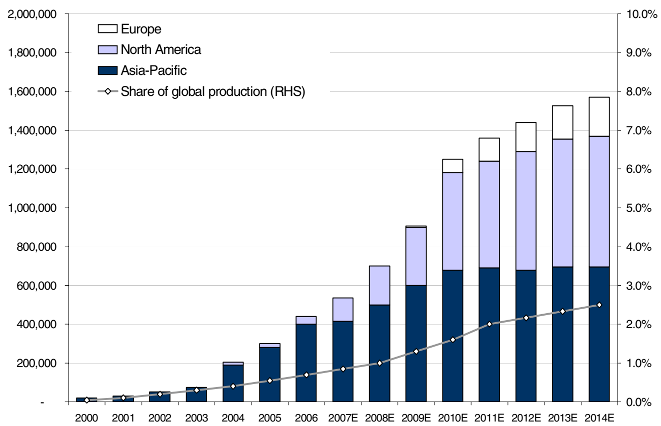
Source: A.T. Kearney, Credit Suisse estimates. All years estimates.

Full-hybrids remain a niche market

Full-hybrids make most sense only on very large and heavy cars, in our view. Though savings of c.20% are substantial, these come at a significant cost of €3–4k per unit on our estimates. We estimate that an equivalent saving can be achieved at roughly half the cost by optimising existing ICE technology (e.g. via direct injection, variable valve timing and turbo-charging). Full-hybrids will thus remain a niche product in the mid-term, in our view, found predominantly in range-topping variants where pricing power is sufficient to cope with the additional cost.

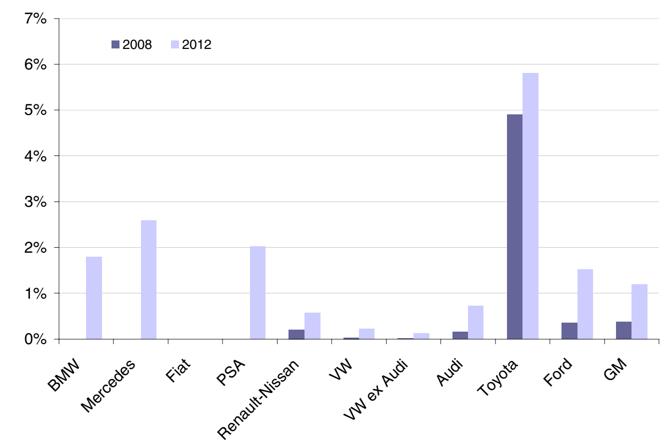
Clearly, Toyota has established a dominant position in hybrid technology with the Prius, which we expect to ultimately be rolled out to a range of Prius-branded vehicles (developing a new "green premium" segment). Other mass makers will likely follow, notably in the US, where hybrid technology appears to be winning the battle (over diesel) for the hearts and minds of US drivers. BMW and Mercedes will also launch hybrids over the next few years, with these concentrated in high-end, larger vehicles (e.g. X5, S-Class).

Figure 66: Full-hybrid sales by region



Source: PwC Automotive Institute. All years estimates.

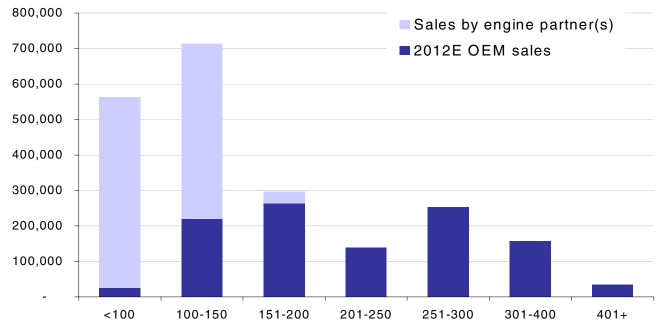
Figure 67: Full-hybrid penetration by OEM



Source: Company data, Credit Suisse estimates. All years estimates.

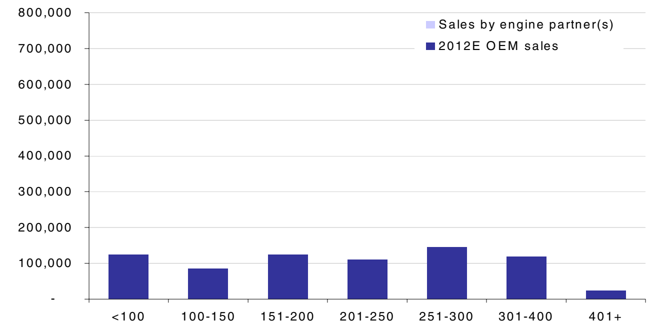
Powertrain scale—Gasoline

Figure 68: BMW—Sales by power output (hp), 2012E



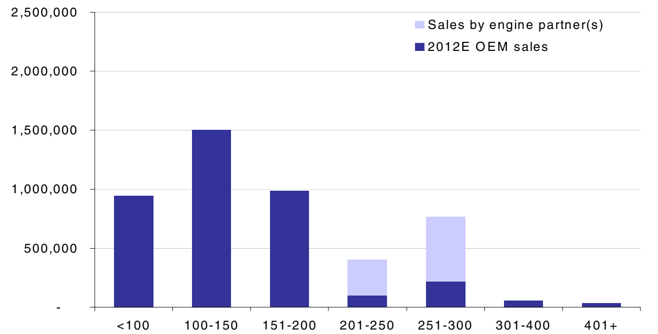
Source: Company data, Credit Suisse estimates

Figure 69: Mercedes—Sales by power output (hp), 2012E



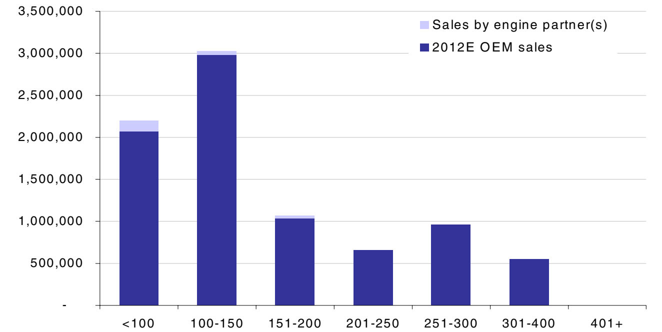
Source: Company data, Credit Suisse estimates

Figure 70: VW—Sales by power output (hp), 2012E



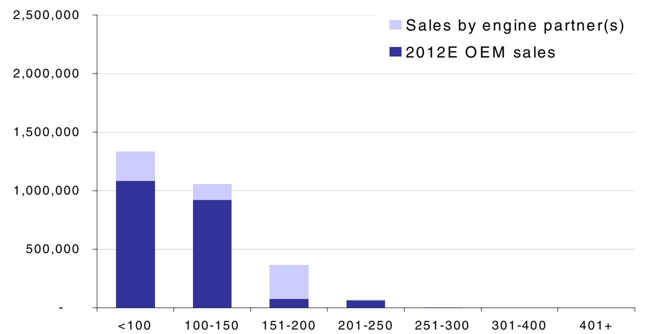
Source: Company data, Credit Suisse estimates

Figure 71: Toyota—Sales by power output (hp), 2012E



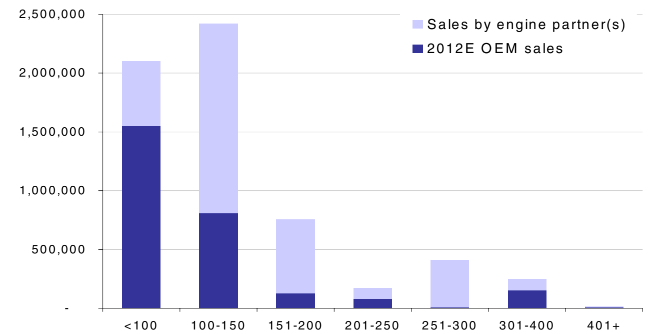
Source: Company data, Credit Suisse estimates

Figure 72: PSA—Sales by power output (hp), 2012E



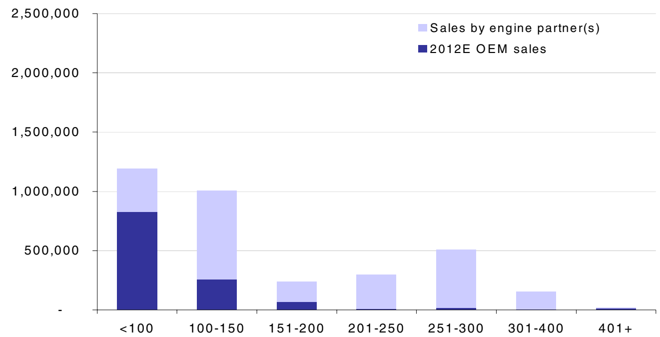
Source: Company data, Credit Suisse estimates

Figure 73: RNO/Nissan—Sales by power output (hp), 2012E



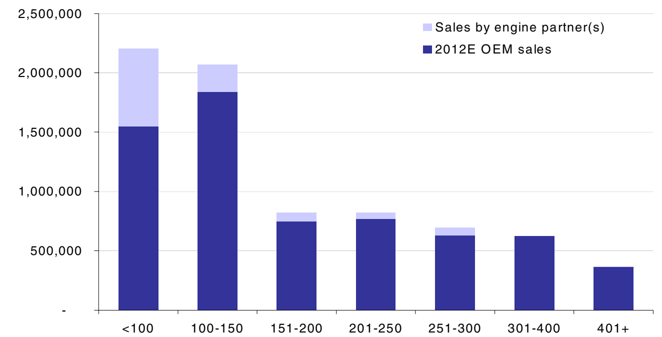
Source: Company data, Credit Suisse estimates

Figure 74: Fiat—Sales by power output (hp), 2012E



Source: Company data, Credit Suisse estimates

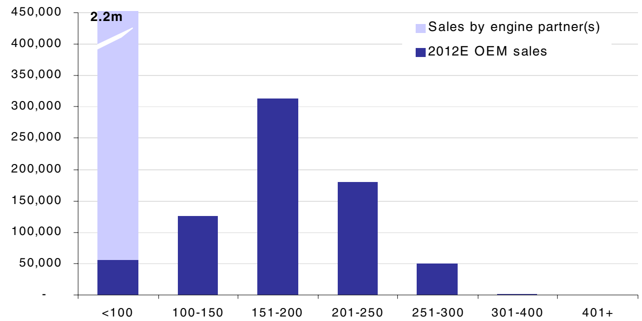
Figure 75: GM—Sales by power output (hp), 2012E



Source: Company data, Credit Suisse estimates

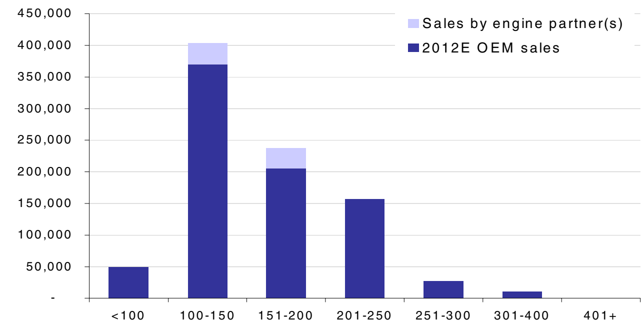
Powertrain scale—Diesel

Figure 76: BMW—Sales by power output (hp), 2012E



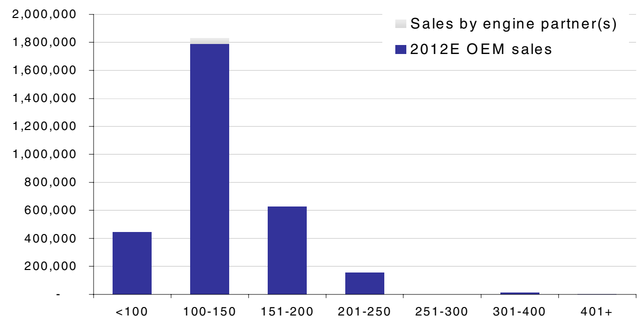
Source: Company data, Credit Suisse estimates

Figure 77: Mercedes—Sales by power output (hp), 2012E



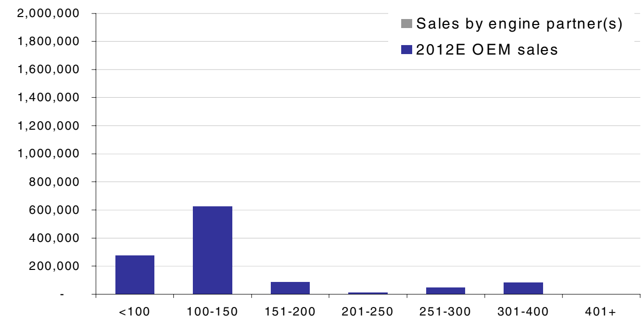
Source: Company data, Credit Suisse estimates

Figure 78: VW—Sales by power output (hp), 2012E



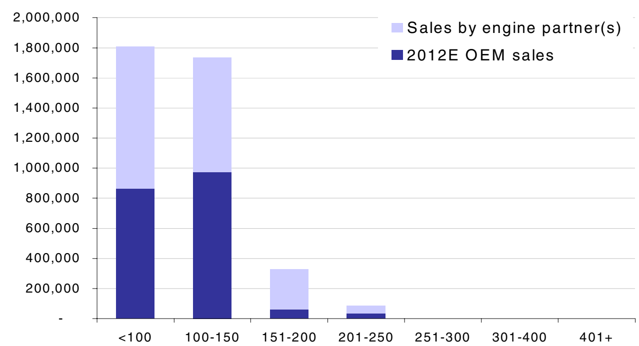
Source: Company data, Credit Suisse estimates

Figure 79: Toyota—Sales by power output (hp), 2012E



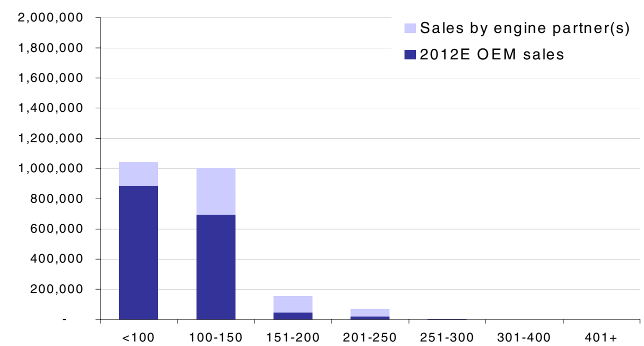
Source: Company data, Credit Suisse estimates

Figure 80: PSA—Sales by power output (hp), 2012E



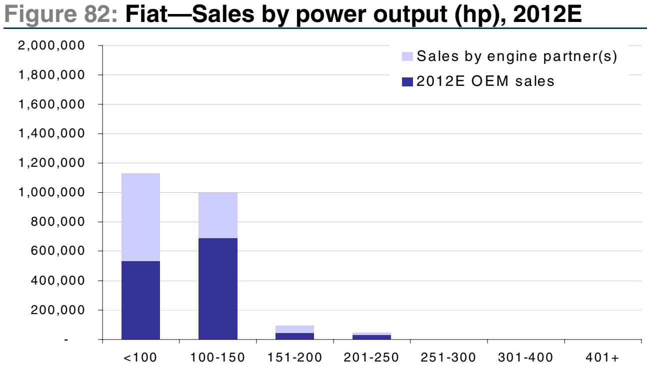
Source: Company data, Credit Suisse estimates

Figure 81: RNO—Sales by power output (hp), 2012E



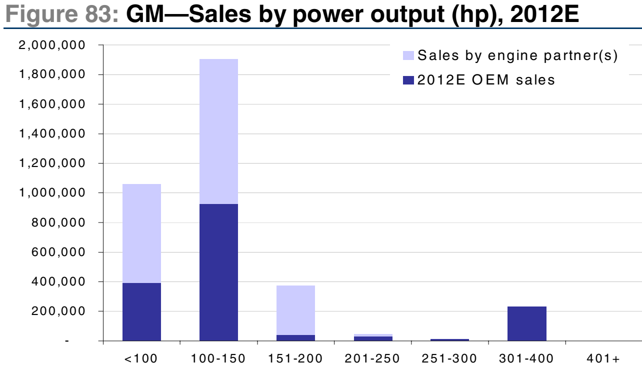
Source: Company data, Credit Suisse estimates

Figure 82: Fiat—Sales by power output (hp), 2012E



Source: Company data, Credit Suisse estimates

Figure 83: GM—Sales by power output (hp), 2012E



Source: Company data, Credit Suisse estimates

Powertrain launch schedules

Figure 84: European major engine programme introductions by OEM, by engine family and model introduction date

DIG = Direct –injection gasoline; T = Turbo; Volume = peak units, thousands

BMW	Fuel Type	KW/litre	Volume	DIG	T	2007	2008	2009	2010	2011	2012
N43	G	78	170	Y	N	1,3,5					
N54	G	103	30	Y	Y	1,5					
N53	G	85	180	Y	N	5	1				
N55	G	108	75	Y	Y			1,3	5		
BMW/PSA 2.0L G	G	85	170	Y	N				1,5	3	
BMW/PSA 2.0L G	G	120	5	Y	Y				1		
N47	D	83	370	N	Y	1,3,5					
N57	D	81	290	N	Y			3,5			

Mercedes	Fuel Type	KW/litre	Volume	DIG	T	2007	2008	2009	2010	2011	2012
M273	G	73	125	N	N	C					
M271 EVO	G	102	110	Y	Y			E	C		
Phoenix	G	95	90	Y	Y			E	C		
Phoenix	G	81	160	Y	N			E	C		
OM651	D	72	550	N	Y			C,E		A	
OM611/2/3	D	55	140	N	Y	E	C				

Peugeot	Fuel Type	KW/litre	Volume	DIG	T	2007	2008	2009	2010	2011	2012
PSA/BMW Prince EP	G	66	1100	N	N	308					208
PSA/BMW Prince EP	G	95	65	Y	Y	308					208
PSA EW	G	70	225	N	N		308	608			
BMW/PSA 2.0L G	G	77	110	Y	N				408		608
Volvo SI6	G	69	10	N	N			608	408		

Renault	Fuel Type	KW/litre	Volume	DIG	T	2007	2008	2009	2010	2011	2012
Nissan MR	G	71	625	N	N	Laguna	Megane				
Nissan MR	G	89	35	N	Y		Megane	Espace		Laguna	
Nissan HR	G	68	830	N	N					Laguna	Megane
Nissan HR	G	93	25	N	Y						Megane
Renault K Gasoline	G	90	100	N	Y		Clio, Megane				
Renault K Diesel	D	56	1020	N	Y	Laguna					
Renault V Series	D	74	60	N	Y			Laguna	Espace, MAV		

Fiat	Fuel Type	KW/litre	Volume	DIG	T	2007	2008	2009	2010	2011	2012
Fiat New I4/I5 TD	D	75	420	N	Y		159	Bravo, 149			
Fiat B/C Diesel	D	70	320	N	Y	Bravo					
Fiat SDE	D	63	470	N	Y	Bravo, 500					
Fiat Fire	G	56	900	N	N	500, Bravo					
Fiat Fire	G	103	100	N	Y	Bravo	500	149		159	

VW	Fuel Type	KW/litre	Volume	DIG	T	2007	2008	2009	2010	2011	2012
EA111	G	94	500	Y	Y	A3			A4		
EA888	G	93	280	Y	Y	A3, A4, Passat	A6, Golf,				
EA188CR	D	70	2255	N	Y	A4	A3, Golf, Passat	A6, Polo			

Source: AT Kearney, Company data, Credit Suisse estimates

Appendix I—Key technologies

a) Gasoline direct fuel injection (GDI)

CO2 potential: c.10%

Unit cost: €200–500

Key players:
Conti (VDO)
Bosch
Denso
Magneti Marelli
Delphi
Keihin
EPCOS

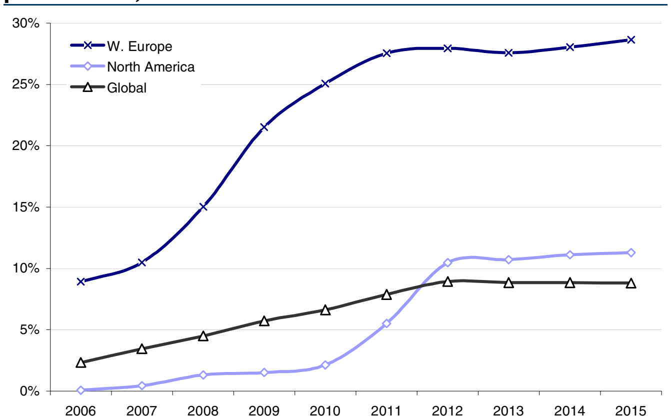
How does it work?

Approximately 24% of energy losses in a gasoline engine relate to inefficiencies in the fuel-injection process. Improved control over the fuel/air mixture and injection timing allows different combustion modes for different engine loads, thus improving fuel efficiency. Multiple injection cycles also improve the combustion process and are enabled by the enhanced reaction time of injector actuators (e.g. piezo injectors).

Technology adoption

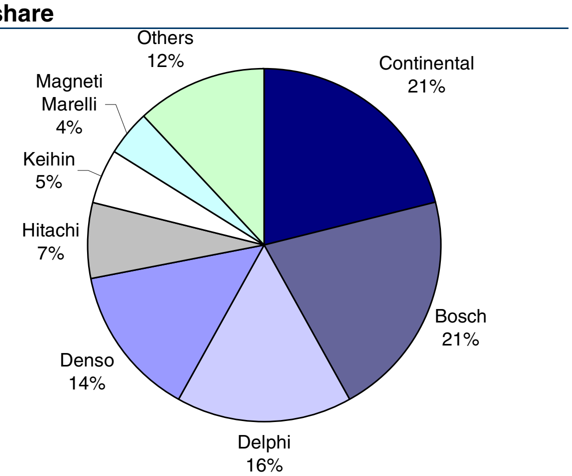
Latest-generation GDI technology offers CO2 savings of up to 10% at a cost of c.€200-500. BorgWarner has said it expects demand for direct-injection fuel systems to grow by +3.8m units for diesel engines and +2.6m units for gasoline engines by 2011. Of this total 6.4m unit increase, some 3m units should come from within Europe. In terms of market value, we calculate that this would equate to growth from €5.2bn in 2006 to c.€8bn by 2012, a CAGR of 7.5% p.a.

Figure 85: **Global gasoline direct-injection engine penetration, 2006–15E**



Source: A.T. Kearney, Credit Suisse estimates

Figure 86: **Gasoline direct-fuel-injection systems, 2007A market share**



Source: Continental.

Key technology suppliers

Bosch and Conti dominate the market for direct-injection systems, with a 2007 share of 21% each. Delphi and Denso each control approximately 15%, meaning that over 70% of the market is in the hands of four players. We expect faster growth rates in piezo systems, where Bosch and VDO are pioneers (Bosch has a 25% global share; VDO's is likely to be slightly lower). EPCOS should be a key beneficiary of this trend, supplying both Bosch and VDO with piezo injectors. EPCOS has a 95% share of the piezo-injector supply market. Furthermore, lean-burn combustion cycles will likely drive demand for exhaust-gas treatment systems, where Tenneco and VDO are well positioned to capitalise on a market growing at an annual rate of c.6%.

b) Downsizing and turbo-charging

CO2 potential: 10–12%

Unit cost: €200–500

Key players:
Honeywell
BorgWarner
IHI
Conti (VDO)
Bosch / Mahle

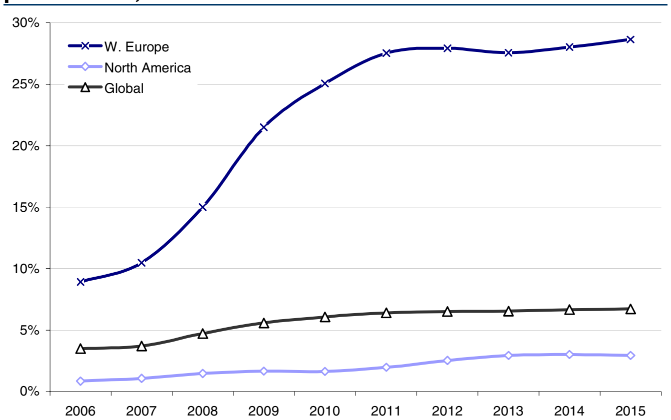
How does it work?

Engine downsizing helps reduce weight and friction in the engine, thus improving fuel economy. A downsized engine has to work at a higher load for a given power and hence works closer to peak efficiency more of the time. For peaks in power, forced induction is required, usually achieved through turbo-charging. Although already prevalent in diesel engines, this process is in its infancy in gasoline engines. Turbo-chargers are increasingly being combined with smaller, direct-injection gasoline engines to provide improved fuel efficiency but without reducing power output. Dual-stage systems are also gaining traction, where another turbo-charger, or supercharger (e.g. VW TSI), is used at different points in the engine range. This allows very small engine designs with low CO2 emissions.

Growth potential

Strong engine downsizing with turbo-charging costs €400–500 per unit and offers CO2 reduction potential of 12%. Medium downsizing costs slightly less, at €200–300 per unit, but reduces CO2 by 10–12%. Honeywell and BorgWarner have indicated they expect 25% of gasoline engines to be turbo-charged by 2010. Meanwhile, Volkswagen says it expects 50% of gasoline VW and Audi brand cars sold in Germany to be fitted with turbo-chargers by 2010. In Europe, PwC forecasts annual volume growth of some 26% p.a. over 2007–12, with growth predominantly focused on engine sizes beneath 1.6 litres. However, we expect prices to trend down as new players enter the market, meaning revenue growth should lag that of volumes. Globally, we expect the market for turbo-chargers to grow from €5.6bn in 2006 to c.€7bn by 2012, a CAGR of 4% p.a. Growth within Europe, however, should be somewhat faster.

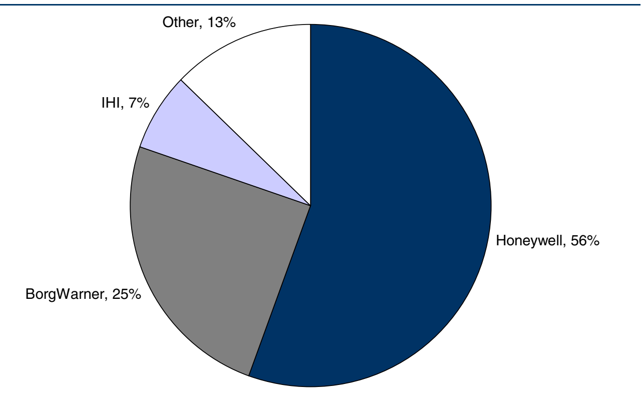
Figure 87: **Global gasoline turbo-charging engine penetration, 2006–15E**



Source: JD Power, Strategy Analytics, Roland Berger

N.B. Based on number of systems supplied. . All years estimates.

Figure 88: **Gasoline direct-fuel-injection systems, 2006A market share**



Source: PwC Automotive Institute

Key players

Honeywell/Garret currently dominates the market for turbo-chargers with a 56% market share. BorgWarner commands another 25% of the market, meaning two players control over 80% of the market. Our revenue-growth assumptions assume price declines as new entrants arrive. For example, Conti and Bosch/Mahle have said they may enter the market, seeing turbo-charging as good fits to complement their existing product portfolios. Furthermore, variable geometry turbo-chargers and two-stage turbos require advanced control systems, a potential opportunity for Conti.

c) Hybrid technology

Full-hybrids are distinguished by their ability to allow (albeit limited) drive with the electrical engine only. A variety of hybrid layouts are possible (parallel, series, powersplit) and can be mated to either gasoline (e.g. Prius) or diesel engines. However, the cost/benefit ratio of a diesel hybrid is impacted by the combination of two expensive technologies (diesel engines are already expensive to produce). CO2 savings of c.20% are possible but at a cost of some €3,000–4,000 per unit on our estimates.

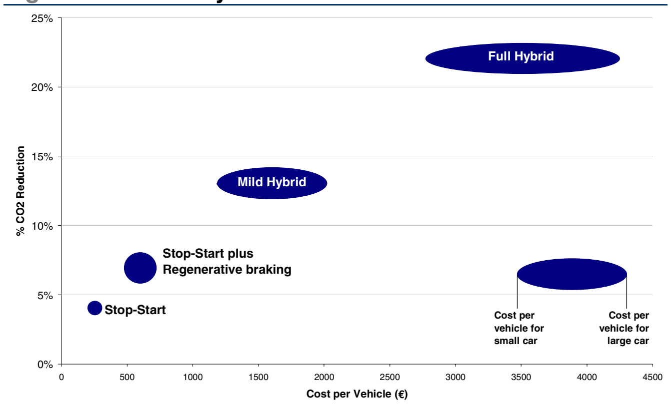
Figure 89 and Figure 90 below illustrate the cost/benefit ratios for various forms of hybrid system for both gasoline and diesel engines. It should be noted, however, that the claimed efficiency savings are heavily contingent on the type of usage. Hybrids are most efficient in the stop-start traffic of inner cities. Outside urban areas, hybrids lose their advantage to traditional diesel technology. The substantial energy required to produce the battery itself is also not considered in these 'tank-to-wheel' efficiency estimates.

CO2 potential: 15–20%

Unit cost: €3,000–4,000

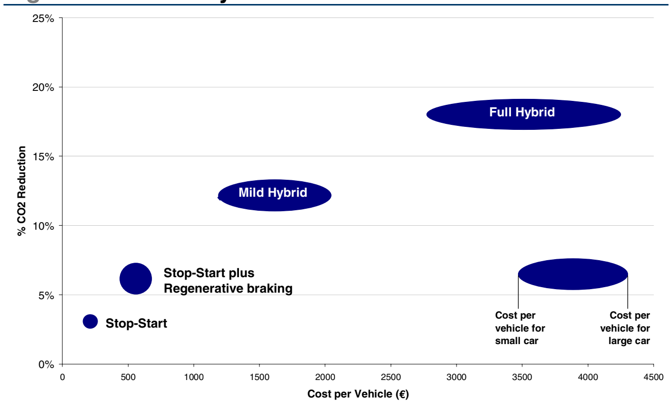
Key players:
Continental / ZF
Bosch
Valeo
Denso
Johnson Controls
Tomkins

Figure 89: Petrol hybrid—Cost/benefit ratios



Source: TNO, IEEP, EU Commission

Figure 90: Diesel hybrid—Cost/benefit ratios



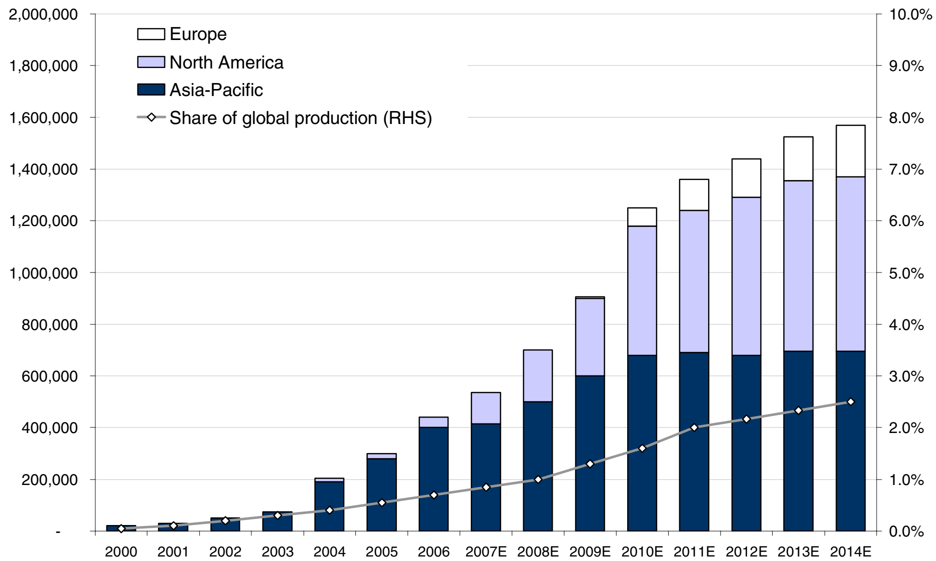
Source: TNO, IEEP, EU Commission

Growth potential

We expect hybrids to become a mainstream technology over the coming decade, with simple start-stop systems gaining close to full penetration in Europe by 2015 due to their low cost. Regenerative braking systems should also enjoy strong growth and reach close to 50% penetration by the same time horizon. However, full-hybrids make most sense only on very large and heavy cars, in our view. Though savings of c.20% are substantial, these come at a significant cost of €3–4k per unit on our estimates. We estimate that an equivalent saving can be achieved at roughly half the cost by optimising existing ICE technology (e.g. via direct injection, variable valve timing and turbo-charging). Full-hybrids will thus remain a niche product, in our view, found predominantly in range-topping variants where pricing power is sufficient to cope with the additional cost.

The PwC Automotive Institute forecasts global hybrid volume of close to 1.6m units by 2014, equivalent to just 2.5% of global production. Furthermore, very few of these are expected to be assembled in Europe (Figure 91). Continental has offered a slightly more bullish view of full-hybrid volume, predicting 2.1m units by 2013, with over 50% expected to be sold in North America and 22% in Europe. Conti has also indicated a more linear growth profile than the one shown in Figure 91, which picks up significantly from 2010. However, we think 'back-end loaded' growth more likely, given the high cost of the technology and that global emissions standards have deadlines not until 2012 and beyond.

Figure 91: Global full-hybrid production (by region of assembly), units



Source: PwC Automotive Institute

Key players

Following the marketing success of the Toyota Prius, a number of suppliers and OEMs are developing hybrid technology. Leaders in this area include Bosch, Continental, Valeo and Denso. Toyota develops its hybrid system in-house, in conjunction with Denso and Panasonic EV. GM, Daimler and BMW are also cooperating on hybrids (in conjunction with key suppliers). Batteries are arguably the key limiting factor to full-hybrids, accounting for up to €1,000 of the system cost (for a lithium-ion battery). Key players in hybrid battery development include Panasonic EV, Sanyo, A123 Systems and Johnson Controls.

Appendix II—Major players in fuel efficiency

Figure 92: **Listed global auto suppliers with fuel-efficiency exposure**

Company	2008E Emissions Revenue	% of Total***	System Content per Vehicle*	Key Technologies	Emissions Potential	Main Competitors
BorgWarner (BWA)	€5.8bn	c.100%	€300–500	Turbo-chargers	CO2: c.10%	IHI, Honeywell
			€700	Dual-clutch Transmission	CO2: c.5%	Getrag, ZF, Valeo
			€300–400	Variable Cam Timing	CO2: c.7%	Denso, Conti, Valeo
			-	Diesel Cold-start	Demand driven by rising diesel penetration in the US.	
			-	EGR	NOx	Denso
Continental	€7-8bn	c.30%	€200–500	Direct fuel injection	CO2: c.10%	Bosch, Delphi, Denso
			€200–250	Micro-Hybrid	CO2: 3-4%	Valeo, Bosch
			€1200–2000	Mild-Hybrid	CO2: 12%	Bosch, Denso, Valeo
			€3000–4000	Full-Hybrid	CO2: 20%	Bosch, Denso
			€100	Low rolling-resistance tyres & TPMS	CO2: 3-4%	Conti, Bridgestone, Goodyear, BorgWarner
Denso	Yen2,200bn	c.50%	€200–500	Direct fuel injection	CO2: c.10%	Bosch, Delphi, Denso
			€1200–2000	Mild-Hybrid	CO2: 12%	Bosch, Valeo
			€3000–4000	Full-Hybrid	CO2: 20%	Bosch, Denso
			€300–400	Variable Cam Timing	CO2: c.7%	BWA, Conti, Valeo
			c.€300	Diesel Particulate Filters	PM: 95%	Faurecia, Tenneco
ElringKlinger	€450m**	c.70%	NA	Specialty gaskets	CO2, NOx	
EPCOS	€430m	c.30%	€50	Piezo injector (supply Bosch, VDO)	CO2: c.10%	Kyocera, but EPCOS share close to 95%
Faurecia	€3bn**	c.23%	c.€300	Diesel Particulate Filters	PM: 95%	Tenneco, Bosch/Denso JV, Ar
GE (Honeywell)	Negligible	Negligible	€300–500	Turbo-chargers	CO2: c.10	BorgWarner, IHI
Michelin	NA	NA	€50	Low rolling-resistance tyres	CO2: 3-4%	Conti, Bridgestone, Goodyear
			€50	TPMS	Part of above	Schrader (Tomkins), Conti, BWA, Pirelli
Rheinmetall	€1.2bn	c.25%	NA	Air supply / emission control	c.5%	
Tenneco	$4bn	64%	c.€300	Diesel Particulate Filters	PM: 95%	Faurecia, Bosch/Denso
				Exhaust treatment	NOx: 90%	ArvinMeritor, Delphi, Emitec
Tomkins	€370m**	c.12%	€50	TPMS (via Schrader)	CO2: 3-4%	Conti, Michelin, BWA, Pirelli
			€50	Micro-hybrid	CO2: 3-4%	Supplier to Valeo
Valeo	€2.6bn**	c.25%	€200–250	Micro-Hybrid	CO2: 3-4%	Conti, Bosch, Denso
			€1200–2000	Mild-Hybrid	CO2: 12%	Bosch, Conti
			€700	Dual-clutch Transmission	CO2: c.5%	Getrag, ZF, Conti

*Source: Company data, TNO, IEEP, Credit Suisse estimates and, where indicated (**), Reuters consensus estimates. *Content for total system at current prices. Listed supplier may only provide one portion of the system. **Based on company reported revenue split for 2006A applied to consensus 2008E revenues. *** Based on company reported revenue split for 2006A*

Appendix III—Global emission regulations

Figure 93: Global emission regulations

Location	Scheme	Metric	Tax system	Who pays?	Introduction date (p =proposed)	System mechanism / Comment
Regional Legislation						
Europe	EU CO2 Proposal	CO2	Ex-post	OEM	2012 p	Proposal: EU fleet average target of €120g/km by 2012 (25% below 2007 level of 161g/km)
						Specific target set for each OEM according to vehicle weight.
						CO2 target by model = 130 + 0.0457 x (vehicle weight (Kg) - 1,289)
						Penalties: 2012 = €20/g; 2013 = €35/g; 2014 = €60/g; 2015 = €95/g
Europe	Euro V	NOx, PM	Regulated standard	NA	Sep-09	Petrol: NOx = 0.06g/km; PM = 0.005g/km
						Diesel: NOx = 0.2g/km; PM = 0.005g/km
Country Legislation						
US	CAFE	mpg	Ex-post	OEM	2020	Increase fuel economy by 40% from 25mpg to 35mpg by 2020. Fines for non-compliance (tho modest).
						Equivalent to CO2 cut from 219g/km to 156g/km
France	"Bonus / malus"	CO2	Purchase tax	Consumer	Dec-07	Tax rebate (bonus): <100g = €1000; 101-120g = €700; 121-130g = €200
						Cars between 131-160g = no bonus or penalty
						Tax penalty (malus): 161-165g = €200; 166-200g = €750; 201-250g = 1600; >250g = €2600
Spain	"Impuesto de matriculacion"	CO2	Purchase tax	Consumer	Jan-08	PREVER scrappage incentives stopped and replaced with CO2 linked registraton taxes. Cars under 120g = no tax; 121-161g = 4.75%; 161-200g: 9.75%; >200g = 14.75%
UK	Vehcile Emission Duty	CO2	Annual registration	Consumer	2001	Tax linked to CO2 band (A-G).
			Company car tax	Consumer	Jun-05	Company car taxation linked to CO2 band (A-G).
Germany	Circulation tax	CO2	Annual registration	Consumer	Jan-09 p	Plans to link annual car tax to CO2 in political limbo… In theory should start from Jan 2009
Italy	Scrappage incentive	CO2	Scrappage incentive	Consumer	Renewed annually	Scrappage incentive of up to €700 on new car purchase (if <140g) when pre-1997 car scrapped.
Netherlands	Registration tax	CO2	Annual registration	Consumer	Feb-08	Tax incentives up to €1400 (Band A); Tax penalties up to €1600 (Band G). Bands linked to CO2
Ireland	VRT	CO2	Purchase tax	Consumer	Jul-08	Move from engine capacity to CO2 tax scheme: <120g = 14%; 121-140g = 16%; 141-155g = 20%; 156-170g = 24%; 171-190g = 28%; 191-225g = 32%; >225g = 36%
	Road Tax	CO2	Annual registration	Consumer	Jul-08	Road tax linked to CO2: <120g = €100; 121-140g = €150; 141-155g = €290; 156-170g = €430; 171-190g = €600; 191-225g = €1000; >225g = €2000
Japan	ECCJ Targets	l/km	Regulated standard	NA	2015	Increase fuel economy by 29% from 13km/l to 16.8km/l by 2015. Weight based standards.
						Equivalent to CO2 cut from 179g/km to 138g/km
China	Fuel Consumption Limits	l/100km	Regulated standard	NA	2008	Weight based fuel economy standards, varying by transmission type. 2008 target equivalent to 170g/km.
S. Korea	Average Fuel Economy (AFE)	km/l & mpg	Regulated standard	NA	2006	Based on engine size: <1500cc = 39.9mpg (115g/km CO2); >1500cc = 26.6mpg (170g/km). OEMs given 6 year grace to fix non-compliance, otherwise 'named and shamed'.
Australia	Fuel economy standard	l/100km	Voluntary	NA	2010	CO2 average target of 180g by 2010
Canada	Company Avg. Fuel Consumption	l/100km	Voluntary	NA	2005	Tougher regulations under negotiation.
Local Legislation						
London	Congestion charge: Current	NA	Road-tax (daily use)	Consumer	2003	£8 per day; Cars <120g exempt.
	Congestion charge: Proposed	NA	Road-tax (daily use)	Consumer	Oct-08	<120g = exempt; 121-225g = £8 per day; >225g = £25 per day; N.B. May be scrapped by new mayor
	Truck CO2 charge: Current	PM	Road-tax (daily use)	Consumer	Feb-08	£100 per day; trucks non-EURO III compliant.
Milan	"Ecopass"	NA	Road-tax (daily use)	Consumer	2008 (1yr trial)	€2-10 per day charge linked to engine size
Berlin, Koln, Hanover	Environmental zones	PM	NA	NA	Jan-08	Excludes older vehicles from entering congested zones unless retro-fittted with e.g. particulate filter
California	CARB Phase I	mpg	Regulated standard	OEM	2009-2012	CO2 average target of 195g by 2012 (for light vehicles <3750lbs); Being challenged in court by OEMs
	CARB Phase II	mpg	Regulated standard	OEM	2013-2016	CO2 average target of 170g by 2016 (for light vehicles <3750lbs); Being challenged in court by OEMs

Source: ACEA, country governments, EU Commission, Credit Suisse research

Companies Mentioned *(Price as of 23 Sep 08)*
BMW (BMWG.F, Eu28.71, OUTPERFORM, TP Eu32.00, UNDERWEIGHT)
BorgWarner, Inc. (BWA, $35.07, OUTPERFORM, TP $47.00)
Bosch Limited (BOSH.BO, Rs3951.40, OUTPERFORM, TP Rs4166.10)
Continental (CONG.DE, Eu68.30, NEUTRAL, TP Eu70.00, UNDERWEIGHT)
Daimler (DAIGn.DE, Eu38.72, OUTPERFORM, TP Eu52.00, UNDERWEIGHT)
Denso Corp (6902, ¥2,660, NEUTRAL, TP ¥3,400, MARKET WEIGHT)
EPCOS (EPCGn.DE, Eu17.85, NEUTRAL, TP Eu17.85, OVERWEIGHT)
Fiat (FIA.MI, Eu10.73, UNDERPERFORM, TP Eu10.00, UNDERWEIGHT)
Ford Motor Co. (F, $4.86, NEUTRAL [V], TP $4.00)
General Electric (GE, $24.95, NEUTRAL, TP $25.00)
General Motors Corp. (GM, $10.72, NEUTRAL [V], TP $7.00)
Honda Motor Corp. (7267, ¥3,500, NEUTRAL, TP ¥4,000, MARKET WEIGHT)
Honeywell International Inc. (HON, $43.18, OUTPERFORM, TP $52.00)
Michelin (MICP.PA, Eu46.15, OUTPERFORM, TP Eu58.00, UNDERWEIGHT)
Nissan Motor Co. (7201, ¥803, NEUTRAL, TP ¥900, MARKET WEIGHT)
Porsche (PSHG_p.F, Eu83.70, OUTPERFORM, TP Eu110.00, UNDERWEIGHT)
PSA Peugeot Citroen (PEUP.PA, Eu29.19, UNDERPERFORM, TP Eu32.00, UNDERWEIGHT)
Renault (RENA.PA, Eu49.11, UNDERPERFORM, TP Eu44.00, UNDERWEIGHT)
Rheinmetall (RHMG.F, Eu41.30, OUTPERFORM, TP Eu58.00, OVERWEIGHT)
SAFT (S1A.PA, Eu29.60)
Tenneco Inc. (TEN, $14.75, OUTPERFORM, TP $24.00)
Tomkins (TOMK.L, 159.00 p)
Toyota Motor Corp. (7203, ¥4,870, OUTPERFORM, TP ¥6,500, MARKET WEIGHT)
Volkswagen (VOWG.F, Eu267.17, UNDERPERFORM, TP Eu115.00, UNDERWEIGHT)

Disclosure Appendix

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