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62nd International Motor Show Cars

Environmental Highlights of the 2007 Frankfurt Motor Show

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The Frankfurt Auto Show is always interesting; it is the biggest show in the world and European manufacturers try to make the best impression. This year was especially interesting from an environmental perspective because everyone, even the luxury carmakers, boasted about (or defended) their efforts to be cleaner and more efficient. And manufacturers continued the tone from the Paris show last fall – stressing the point that environmental technology is an integral part of their product plans.

But they are somewhat cautious despite the overwhelming ‘green’ message. Manufacturers obviously feel pressured to look progressive and develop innovative technologies, yet they are bound by shareholders to make conservative business decisions – and not rush to adopt new technologies that do not have a clear advantage for the customer and the company. So the show is full of examples of companies trying to show their heritage in technology development while not being exactly sure what technology to bet on. For example, many manufacturers display a fuel cell concept vehicle at every major motor show, but tell the press that engine improvements are the key to environmental success.

Despite the uncertainty, the decision to go hybrid is getting easier because suppliers are joining forces to develop components and share the investment risk. With the statements of intent to produce so many hybrids in the next few years, commitments to suppliers have apparently been made, and it appears that most passenger cars will transition to some form of hybrid propulsion over the next decade. So hybrids are a given ... but what type of hybrid?

Manufacturers are not willing to give up performance and cannot afford to add a substantial price premium while investing to meet emissions regulations (EU5 and EPA Tier II-Bin5). So hybrid technology is being adopted strategically and in a manner consistent with the risk. It turns out that ‘micro’, ‘mild’ and ‘full’ hybrids are named appropriately in terms of investment risk as well as propulsion system configuration – so that is the order technology is being introduced. Stop-start technology is already offered on some cars and regenerative braking will be included in some ‘conventional’ 2008 models. Mild and full hybrids apparently will be phased in as their economics improve and confidence in the technology, as well as customer demand, builds.

















The messages from the motor show can be clearly summarized:

- Improved internal combustion engines will be the most crucial factor in lowering fuel consumption and emissions,
- Environmental technologies (e.g., engine improvements, multi-fuel capability, after-treatment technology and hybrid systems) are an integral part of their product plans and
- Every major (high volume) manufacturer plans to integrate hybrid technology as long as it does not compromise vehicle performance or customer expectations.

Suppliers are critical to the technology development and application engineering process. Some important alliances between Tier 1 suppliers have recently occurred – strongly supporting the

manufacturers' stated intentions regarding hybrid production – and they are summarized in “Suppliers Gearing Up for Hybrids”, the last section of the report.

The overall environmental interest (and posturing) at the show can be sensed from the table of (selected) displays by major manufacturers and notations below.

	LATEST GENERATION HYBRID MODULE	Diesel technology key to reducing fossil fuel consumption; hybrid efficiency must rival best diesel TDI technology to be introduced.
	CONCEPT X6 ACTIVEHYBRID	X6 probably first hybrid platform; significant enhancement of efficiency plus improved driving dynamics required for introduction.
	URBANHYBRID CONCEPT C-CACTUS CONCEPT	Corporate environmental strategy; Stop&Start technology spreads; hybrid without a cost premium
	PANDA ARIA CONCEPT	Small car leadership and environmental models emphasized; Holistic environmental vehicle approach
	NEXT GENERATION CLEAN DIESEL	Latest diesel engine with innovative NOx reduction comes to Europe in new Accords; news expected in Tokyo
	I-BLUE FCEV CONCEPT	First ground-up fuel cell vehicle design; real news in Tokyo?
	ECO_CEE'D CONCEPT LATEST FCEV PLATFORM	“Eco-friendly” performance; real news in Tokyo
 Mercedes-Benz 	E-, M- & S-CLASS HEVs SMART ED, MHD B-CLASS FCV F700 RESEARCH VEHICLE	Extensive environmental vehicle product plan revealed (ranging from mild with latest diesel to full hybrid with two-mode transmission); ‘Diesotto’ engine technology in vision of the ‘future luxury’
	CONCEPT-CX	Next generation diesel technology; news expected in Tokyo
	MIXIM CONCEPT	EV with Li-ion from NEC joint venture; news expected in Tokyo
	FLEXTREME CONCEPT	New body GM E-Flex platform; ‘ecoFlex’ low CO ₂ models
	308 HYBRIDHDI ‘DEMONSTRATOR’	Diesel-powered hybrid to be produced in 2010
	HYBRID CAYENNE CONCEPT	Response to Greenpeace; Cayenne HEV planned; hybrid Panamera rumored;
	RECHARGE CONCEPT	(Very preliminary) plug-in concept tests the waters
	BLUEMOTION TECHNOLOGY	‘Blue’ is the new green in Wolfsburg; extensive line-up of low CO ₂ models



Audi clearly states that the combustion engine will remain the major drive system for the foreseeable future. They say that diesel technology, more than any other current power system, can help to reduce the consumption of fossil fuels – citing a 35% advantage of TDI (turbocharged direct injected diesel) over the fleet average for gasoline engines in the US. TDI still has considerable potential for reducing fuel consumption and their ultra low emission system makes it “future-proof”. TFSI (turbocharged direct injected spark ignition gasoline) and the Modular Efficiency program will significantly reduce CO₂ emissions for all new models. And with respect to hybrid propulsion, Audi says the technology will be employed in specific markets with TFSI engines, but the efficiency must compete with their latest TDI technology – that’s a challenge!

Audi presented concepts at the IAA they called “technology of the near future ... virtually ready for series production”. And they will expand the range of ‘e-model’ (efficiency) products in the future, offering TDI, FSI and TFSI in the high-volume model series. By 2012, they say, CO₂ emissions will be reduced from all their models by around 20%.

A4 2.0 TDI e Concept – 4.9 l/100 km (129 gCO₂/km) on the EU cycle

The A4 2.0 TDI e Concept combines an updated engine and after-treatment, more efficient accessories, a new low-friction gearbox and micro-hybrid features to reduce emissions below the EU fleet target for 2014. Some improvements are already in series production on the ‘08 A4 and the start/stop and energy recuperation features will be introduced in the ‘near future’.



2.0 TDi engine - Common rail injection replaces the unit injection pumps and piezo-electric injectors supplying fuel pressure of up to 1,800 bar. Modified piston geometry, reduced internal friction and improved temperature management contribute to increased fuel efficiency. The result is 105 kW / 143 bhp output and 320 Nm of torque in the 1,750-2,500 rpm speed range. The ultra low emission system (AdBlue injector, DeNOx converter, oxidation catalyst, diesel particulate filter and sensors) results in 90% NOx reduction making the TDI the “world's cleanest diesel”. It goes into production in 2008 as an option on the new A4 3.0 TDI – meeting European requirements for 2014 and LEV II BIN 5 in the US.

Low-friction gearbox – A newly developed six-speed manual gearbox has been specially tailored for the high-torque of the TDI engine – its transmission ratios are slightly longer in third to sixth gears – and has reduced internal friction. The driver information system encourages economical driving by recommending the appropriate gear.

Start/stop system – According to Audi, much daily travel is made up of trips less than 10 km with numerous stops, so they employ a special starter motor that spins the engine in about 0.2 seconds to allow for smooth starting after the engine has been turned off at a stop (by the gear lever being moved to neutral and the driver taking his foot off the clutch).

Regenerative braking – A ‘robust’ gel battery and a dc-dc converter are combined to convert kinetic energy during coasting and braking into electrical energy.

Improved hydraulic power steering – A demand-controlled vane-cell pump has improved efficiency by around 50%.

Improved automatic air conditioning – A thermostatically controlled refrigerant circuit with an internal heat exchanger and improved components reduce associated fuel consumption by 20%.

Latest generation hybrid module – more power, higher efficiency

For certain markets, Audi will complement their engine technology with a hybrid module – designed to be fitted to any model with a longitudinal engine. Audi will put its hybrid concept into production ‘as soon as this provides decisive benefits for the customer’ and it rivals the efficiency of TDI technology.



The Audi hybrid module is configured as single-shaft parallel, with the electric motor/generator integrated into the drive train between the SI engine and gearbox. The system can run on the engine, the electric motor or both and take advantage of regenerative braking energy. The additional weight of the hybrid system is 100 kg.

According to Audi, the combination of components on display (described below) provides the performance of a high-displacement, naturally-aspirated 6-cylinder engine, but with fuel consumption about 30% lower. Audi says a 1,850 kg vehicle – corresponding to a luxury passenger car or a medium size SUV – would consume 6.4 l/100 km on the standard cycle.

Engine: Audi 2.0 TFSI (155 kW / 210 bhp, 300 Nm torque)

Electric motor: Permanent magnet synchronous (32 kW / 44 bhp, 230 Nm torque)

Gearbox - The electric motor replaces the torque converter in the housing of a new eight-speed tiptronic gearbox, requiring no additional space. A dual-mass flywheel absorbs vibrations from the Audi hybrid module, while a wet multi-plate clutch takes care of coupling and decoupling the combustion engine and the electric motor.

Electric mode – The hybrid drive is configured for pure electric driving at speeds up to about 50 km/h and a range of about 3 km.

Li-ion battery – A Sanyo Li-ion battery was displayed and was described as half the size and weight of a nickel metal hydride with comparable performance. The 264 volt, 39 kWh battery displaces 26 litres and is intended to be placed below the floor of the luggage compartment.

Electric accessories - The hydraulic power steering pump, air conditioning compressor and vacuum pump for the brake booster (shown in orange in the photo) are electrically driven.



X6 Probably BMW's First Hybrid Platform

The **Concept X6 ActiveHybrid** was presented along with the new X6 platform and apparently it is a candidate for near-term production. It is based on the dual-mode transmission from the BMW-DCX-GM venture and they say the car has 20% better fuel consumption and emissions than a comparable conventional car. The news is not related to the technology – the dual-mode system has been adequately described previously – but that the X6 will likely be first BMW available as a hybrid (probably in a couple of years) and it will not require its customers to sacrifice performance or features they expect.



EfficientDynamics Strategy Implemented Across Product Lines

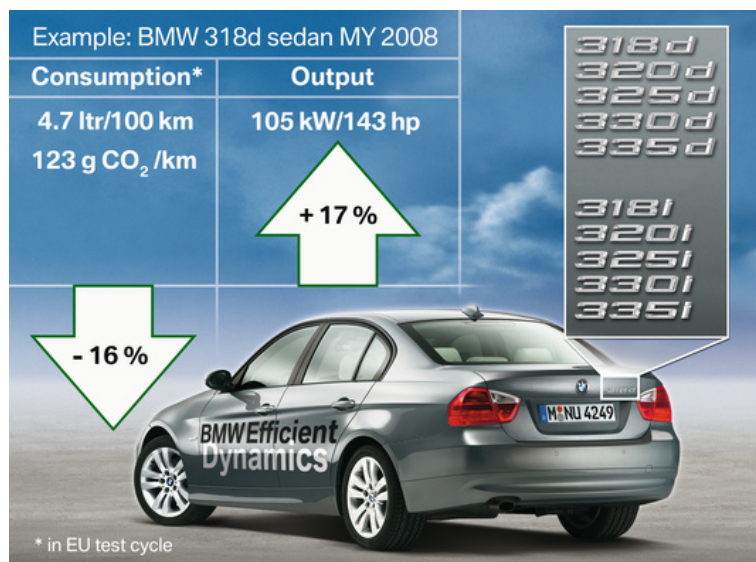
In addition to their new models presented in Frankfurt, BMW focused attention on their overall strategy; how it is an inherent part of vehicle design and that it is being deployed in every model series from the 1 Series through the X. BMW defines the strategy as “all improvements serving on BMW cars to consistently reduce fuel consumption, CO₂ and other emissions harmful to the environment while at the same time enhancing the car's driving dynamics”. The objective is to optimize efficiency in all vehicle segments, while balancing dynamics and economy. BMW apparently takes the position that it is not necessary (or its customers are not willing to) sacrifice performance for environmental benefits.

They went to great lengths (and used a lot of trees in the process) to explain the strategy and the implementation is summarized below because it demonstrates their commitment. It is a timely subject since organizations such as Greenpeace are labeling luxury cars producing CO₂ levels well above the proposed standards as ‘climate pigs’ (see Porsche section).

BMW presented an example of the improvements in the 3 Series (right) as well as the broad range of models where new technologies have been applied.

In addition to the X6 hybrid, BMW cited specific results of their strategy for 2008:

- BMW 635d @ 6.9 l/100km (~34 mpg)
- 19 models (1, 3 and 5 Series) < 140 gm CO₂/km
- BMW 123d is the first production car over 200 bhp with < 140 gm CO₂/km



Contributions from the various technologies BMW includes in their strategy and the relative contribution to fuel economy are listed below:

High Precision Injection (jet guided direct petrol injection) with lean operation ... 10%

All-aluminum diesel engines with 3rd generation common-rail fuel injection (below) ... 8%



Brake Energy Regeneration – All 1, 3, 5 and 6 Series and the X models ... 3%

Auto Start Stop Function – All 4-cylinders (gasoline and diesel) and manual 1 and 3 Series ... 3%

Electric Power Steering – All 1 and 3 Series, except 335i, 335d and all-wheel models ... 3%

Varioserv steering assistance pump – X3, all 5 Series and 630i, 635d

On-demand Electric Coolant Pump – All 4- and 6-cylinders in the 1, 3, 5 and 6 Series plus X3 and X5 (except X3 2.0i)

On-demand A/C Compressor – All 1, 3, 5 and 6 Series plus X5, except 335i, 330d and 325d

Gearshift Point Indicator – All manual gearbox versions of the 1, 3, 5 and 6 Series

These improvements are expected to spread throughout the product line in the near term, with further electrification of the drivetrain (including hybridization) in the medium term. But they say that a significant enhancement of efficiency in addition to improved driving dynamics is the only way a full hybrid vehicle will fulfill all the requirements and standards of EfficientDynamics. BMW still says that the long term focus is hydrogen-fueled combustion engines – with the hydrogen coming from renewable sources.



Citroën's portfolio of small vehicles, combined with its engine control and after-treatment technology, yields an impressive environmental record for production vehicles.

55% of all their vehicles emit less than 140 g/km CO₂ and 24% produce less than 120 g/km. They have 11% of the European market for vehicles emitting less than 141 g/km CO₂ and 500,000 of their vehicles have been sold with a particulate filter. To emphasize their environmental commitment, they have established a signature to identify the vehicles with the best environmental credentials: **airdream**

To qualify for the designation vehicles must meet the following criteria:

- CO₂ emissions < 130 g/km or
 < 158 g/km for diesel with DPFS (Diesel Particulate Filter System)
 < 200 g/km for E85 (=120 g/km on well-to-wheels basis)
 - No CO₂ emissions and no noise when stationary (Stop & Start vehicle)
 - 20% < petrol engine (CNG vehicle)
- Manufactured in a plant that is ISO 14002 certified
- Designed to be 95% recoverable (recycling and energy recovery) by weight at end-of-life

The 28 qualifying production models are listed individually in the press release and include gasoline and diesel versions of the C1, gasoline (with Stop & Start) and diesel versions of the C2, gasoline (with Stop & Start), diesel and CNG versions of the C3, diesel and biofuel versions of the C4 and C5 plus the CNG version of the Berlingo.



'UrbanHybrid' Technology in the C5 Airscape Concept

The Airscape combined Stop & Start (already in production on the C1 and C2) and regenerative braking; this is not much of a stretch for the technology to be added to the production C5 in the near future.

Hybrid without a Cost Premium?

The **C-Cactus HybridHDI** appeared to be a styling exercise due to the extreme styling and other features, but Citroën apparently sees it as much more significant. It uses the diesel hybrid system of the C4 HybridHDI concept (covered in the 2006 Paris report). By the way, they named the C-Cactus after the plant because of its overall efficiency the use of a 'significant portion' of recycled or recyclable materials.

The significance is the claim by Citroën that it could be sold for no more than an entry-level C4. They attributed its low production cost to the use of new materials and a design that drastically reduces the parts count (e.g., half the parts for the 'cabin'). It uses a lot of molded plastic – with obvious benefits in consolidating functions (i.e., lowering parts count) as well as the potential to use recycled materials. The implication though is that cost-cutting elsewhere is necessary to afford hybridization. And are they implying that the plastic, entry-level ambience may be good enough for the environmentally-minded buyer, but not



<i>C-Cactus HybridHDI</i>	
Platform	C4 running gear
Hybrid Drivetrain	70 bhp HDi diesel and DPFS, 5-speed automatic transmission; 30 bhp e-motor in clutch housing; ZEV mode
Weight	1,180 kg (includes batteries)
Fuel Consumption	2.9 l/100 km (81 mpg); Combined cycle test results
CO ₂ emissions	78 g/km

necessarily for their mainstream customers?

FIAT Small Car Leadership and Environmental Models

Fiat says they have always been an environmental vehicle builder and have taken pre-regulatory environmental actions. It leads Europe in the production of compact cars (they define as “inherently environmentally friendly”). The Fiat 500 is being launched with Euro 5 engines (petrol and diesel) two years ahead of the deadline. And they will introduce Euro 5 engines on the majority their products before 2010. Fiat is the leading manufacturer of CNG vehicles and is the first to offer dual fuel methane-petrol vehicles. They also lead the world in technologies that employ vegetable-based fuels. 95% of Fiat’s car offerings in Brazil are Flex Fuel and can run on mixtures of pure bio-ethanol and gasohol (22% ethanol).

Fiat is using down-sizing by adding new generation turbochargers and getting higher performance with lower fuel consumption and emissions. The new 2-cylinder (SGE 900 cc Turbo used in the Aria concept) equipped with the Multiair® system is an example of this strategy and it meets future Euro 5 and Euro 6 (proposed) emissions standards.

Each of the Fiat Group’s manufacturing facilities is certified by ISO 14001 standards and all the vehicles in the Fiat range are already 95% recoverable, anticipating the homologation deadline imposed by Directive 2005/64/CE, which will become obligatory for newly homologated models in December 2008 and for new registrations from July 2010.

Holistic Environmental Approach

This is not a typical concept car. Fiat’s idea was to ‘synergistically associate sustainable technologies already in existence or soon to be industrialised as a practical demonstration of Fiat’s commitment to the environment’.

The **Panda Aria Concept** combines their new small engine technology (with Multiair®), automated manual gearbox and Stop&Start with eco-compatible materials in the body (i.e., recycled, recyclable or of natural origin). The interior is upholstered with natural fibres (cotton and linen), woven coconut fibre and biodegradable elements, while the exterior panelling is made of semi-transparent eco-resin and the structure is treated with opaque ‘totouch’ paint.

The Multiair® system controls the air without the throttle valve; rather the air intake is controlled using variable electro-hydraulic activation of the inlet valve.

This allows the valve rise to be modified in response to the request for air from the engine and speed. Early inlet valve closing (EIVC), late inlet valve opening (LIVO) or multi-lift strategies can be used to optimise combustion efficiency, with benefits in power output, torque, consumption and emissions. And the constant air pressure upstream of the valves combines with the high speed valve actuation (partial to full load in one engine cycle) to produce increased torque response of the engine – on both the aspirated and turbocharged engines.

And finally, the Aria is also uses a telematic system, based on the Blue&Me architecture, and original software that allows the consumption and emissions of each trip to be recorded on a USB



<i>Panda Aria Concept</i>	
Engine	80 bhp, 900cc 2-cylinder turbo; Multiair with electro-hydraulic valve actuation;
Transmission	MTA (manual transmission automated); Stop&Start;
Fuel	Gasoline or 70/30 methane/hydrogen
Body	Eco-compatible materials
CO2 emissions	69 g/km

pen drive; the driving style can be analysed later on a computer the driver can learn how to make his driving more 'eco-friendly'.



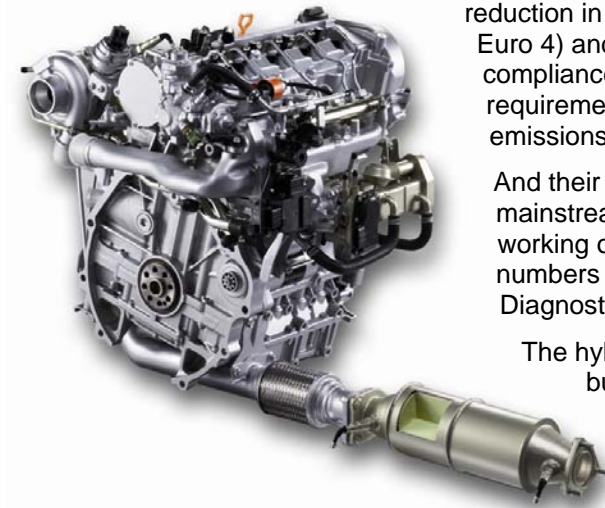
Concept Precedes New Accords

Honda presented the Accord **Tourer Concept** as a prelude to the European debut of the new Accords in Geneva next year. The significance is that they will be available with Honda's latest clean diesel engine technology that meets foreseen European regulations.



Next Generation Clean Diesel

The engine and its innovative NOx reduction technology was covered in the 2006 Paris report, but production confirms that they comply with Euro 5 (80% reduction in particulates and 28% reduction in NOx versus Euro 4) and their report that they have achieved compliance with the US EPA Tier II/Bin 5 emissions requirements as well means that they have satisfied the emissions levels in the Euro 6 proposals.



And their diesels appear to be on their way to the mainstream US market; Honda says that they are working on handling diesel fuels with different cetane numbers as well as meeting the US On-Board Diagnostic requirements.

The hybrid and fuel cell line-up was also presented, but the (relatively) new entry was the **Small Hybrid Concept** (below). It uses the same IMA hybrid technology as the other hybrids, but it was designed at their technical center in Offenbach, Germany.





HYUNDAI

i-Blue Fuel Cell Electric Vehicle Concept Debuts

The **i-Blue FCEV** is a ground-up design based on a 2+2 crossover vehicle platform and their third-generation fuel cell technology. The stack is apparently more compact than the earlier generations and Hyundai says they are “making tremendous efforts to reach mass

production of hydrogen-powered fuel cell vehicles a reality in the next decade”. The i-Blue is powered by a 100 kW fuel cell-capacitor system. Fueled with compressed hydrogen (700 bar) stored in a 115 liter tank, the range is said to be more than 600 km before refueling and it has a maximum speed of 165 km/h.

As shown in the graphic below, the fuel cell stack is housed under the passenger compartment. Recall that the second-generation fuel cell was in the engine compartment of the Tucson FCEV. Of course the weight distribution is greatly improved – now 50:50. But it also allows more space in the engine compartment for the electric drive components and thermal management system.

Hyundai’s first-generation Santa Fe and second-generation Tucson FCEVs have both been tested at the Fuel Cell Partnership’s facility in Sacramento, Calif. In addition, Hyundai FCEVs have successfully completed five Partnership-sponsored Road Rally events covering nearly the entire state of California.



<i>I-Blue Fuel Cell Electric Vehicle</i>	
Length	4,850 mm
Width	1,850 mm
Height	1,600 mm
Wheelbase	2,850 mm
Tires	285/50 R20
Powertrain	100kW Fuel Cell 450V/11.3F Capacitor
Fuel Cell Output	100 kW
Fuel Tank Pressure	700 bar
Fuel Type	Compressed Hydrogen
Fuel Tank Capacity	115 liters
Vehicle Range	600km

Hyundai is currently operating fleets at Hyundai America Technical Center in Chino, Calif.; California Air Resources Board in Sacramento, Calif.; AC Transit in Oakland, Calif.; Southern California Edison in Rosemead, Calif.; and the U.S. Army TACOM facility in Warren, Mich.





KIA MOTORS

“Eco-Friendly” Performance Concept

Kia showcased the **eco_cee'd** (right) in addition to their latest fuel cell platform and the Rio hybrid. The eco_cee'd is based on their popular hatchback with the 1.6-liter diesel engine. By making several relatively minor changes, they cut the fuel consumption by 0.8 l/100km (17%) and the CO₂ emissions by 20 g/km. The body changes included lowering the suspension by 15mm, covering the underside, aerodynamic tweaks around the wheel openings, a low-drag front grill and Michelin ultra-low rolling resistance tires. The vehicle is fitted with their new ISG (Idle Stop&Go) system and the 5-speed manual transmission has been replaced with a 6-speed (an ECU-controlled ‘shift indicator’ to recommend when to shift).



KSH

Latest generation fuel cell platform

The platform is intended for a Sorento-size SUV. Configured much like the Hyundai system, with a 100 kW fuel cell, an ultra/super-capacitor and twin hydrogen tanks at 700m bar, the Kia version is four-wheel drive with electric wheel motors on the rear in addition to the front motor. The latest version of the fuel cell system reportedly has the ability to cold-start at -30°C.

Kia has been operating a fleet of 34 fuel cell vehicles in Korea since August 2006. Five more stations will be added in 2008, to expand utilization of the fleet over the 5-year evaluation period.

The Rio mild hybrid did not include any new technology – it uses a 12 kW motor with a 144v Nickel Metal Hydride battery. It consumes 5.3 l/100km and emits 129 g/km CO₂.



KSH

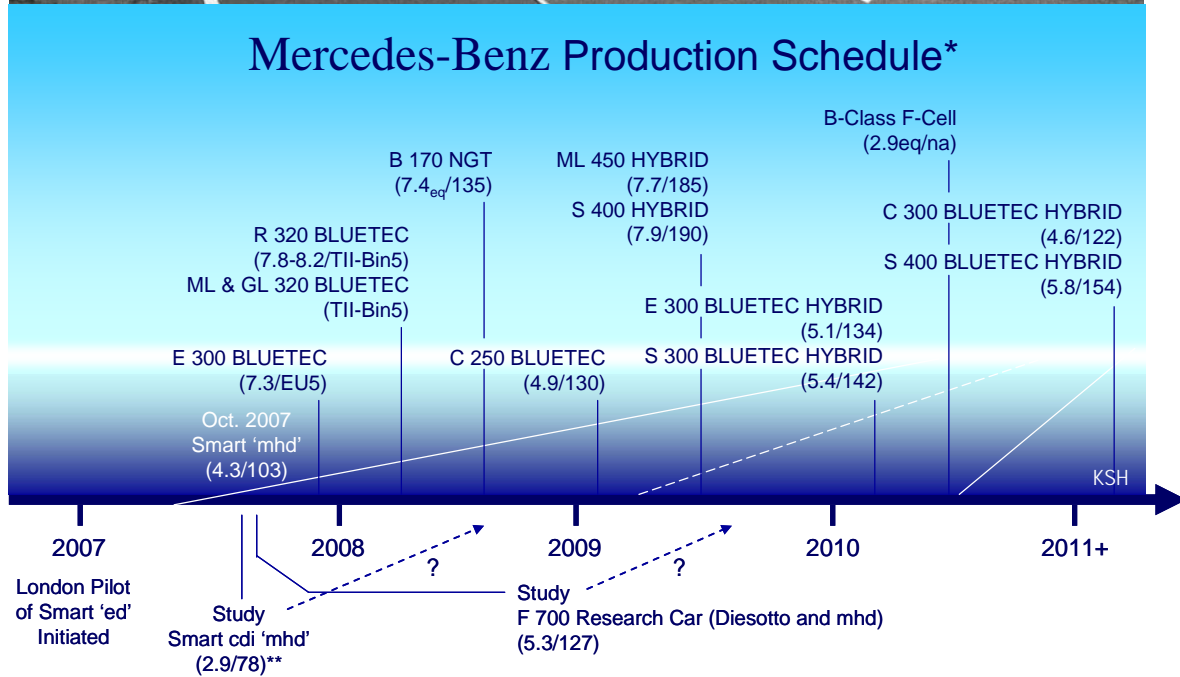
Fuel Cell Platform	
Acceleration*	0-100 km/h in 10 s
Top Speed*	170 km/h
Range*	600 km
Powertrain	100 kW Fuel Cell (Metal Bipolar Plates); Super-capacitor
Fuel Type	Compressed Hydrogen
Fuel Tank Capacity	2x 76 liters
Fuel Tank Pressure	700 bar
Electric Motors	100 kW (front) 2 x 20 kW (rear wheel motors)
* Simulation results; Sorento SUV body	



Daimler's theme this year, "Road to the Future" means "fuel-efficient and environmentally compatible premium automobiles that do not compromise on safety, comfort or supreme driving pleasure". In pursuit of this objective, their development priorities include modular drive technologies, "first and foremost, optimized combustion engines with individually configured hybrid solutions that can be used singly or in combination, depending on the class, usage and customer".

Nine new Models Including Seven Hybrids

Demonstrating their commitment, they presented many new models from five model series, including and many 'CO₂ world champions'. The vehicles included E-, M-, and S-Class hybrids, Smart electric and hybrid vehicles, their latest B-Class fuel cell vehicle and the F700 research vehicle in addition to higher efficiency versions of their gasoline and diesel engine-powered models. They reinforced their intentions by describing their production plans for these vehicles – the graphic below the photo is an attempt to consolidate the plans for vehicles with electric or hybrid propulsion systems, Bluetec or those fueled with CNG or hydrogen.

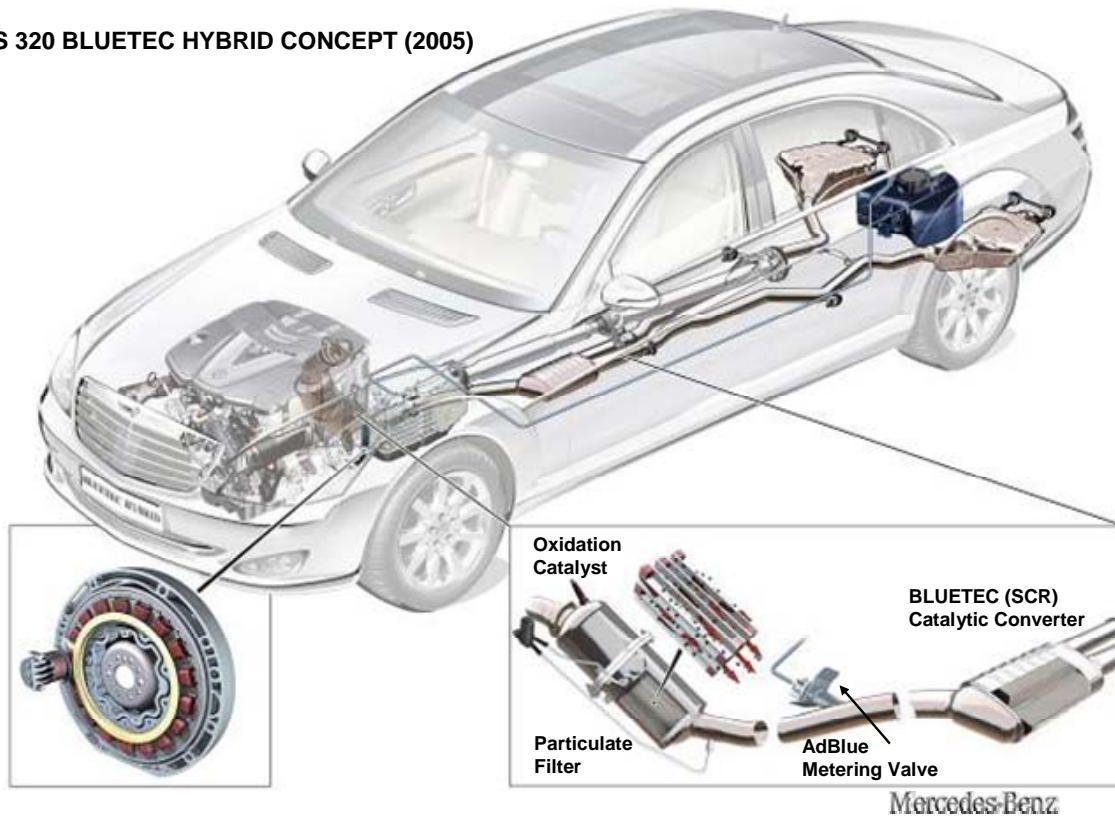


* Includes electric, hybrid, BLUETEC, CNG and hydrogen – based on information provided at IAA 2007
 ** (x.x/y.y) = fuel consumption (l/100km) / CO₂ emissions (g/km) or regulatory compliance level

The key to the strategy is modular component development by Daimler and their suppliers. The BLUETEC after-treatment system does not require major engine modifications (i.e., redesign) and therefore can be applied when appropriate to all of their diesel engines. Similarly, hybrid drive components have been developed to be compatible with their engines and vehicle layout, e.g., the mild hybrid drive fits within the housing of the transmission and the two-mode system for a full hybrid replaces the transmission on their vehicles with a longitudinal drivetrain configuration.

BLUETEC - The first wave of new technology to spread throughout the fleet is exhaust after-treatment based on selective catalytic reduction (SCR), which was described in the IAA 2005 report . The graphic below of the S 320 BLUETEC HYBRID concept serves as a reminder of the system components and the brief explanation that follows summarizes the functionality.

S 320 BLUETEC HYBRID CONCEPT (2005)



The oxidation catalyst reduces CO and HC, particulates are reduced in the filter and the SCR system reduces NOx by 80% - leading to what Mercedes calls the cleanest diesel in the world. Note the small AdBlue tank in the center of the spare tire in the trunk. Mercedes estimated (in 2005) that the vehicle consumed 0.1 liters/100 km, which implies that the 22-liter tank would last for about 22,000 km (adequate for scheduled service intervals). The E 320 BLUETEC was launched in the States in 2006 – when low-sulfur diesel was introduced throughout the US.

2007 –The E300 BLUETEC that will be introduced in December is EU5 compliant and Mercedes says that the NOx values are so good that it shows potential to meet the EU6 standard.

2008 – The BLUETEC models of the R, ML and GL 320s (V6 engines) will be launched – all meeting USTII-Bin5, with the possibility of meeting the planned EU6 standard.

2009 – The significance of the C 250 BLUETEC launch is that is based on the new generation 2.2-liter, 150 kW, 4-cylinder engine – with performance similar to previous 3-liter diesels. With BLUETEC, it is as clean as gasoline engines and will comply with EU6.



HYBRID - Daimler exhibited micro, mild and full hybrid configurations – with all three targeting production before the end of the decade.

2007 – The Smart fortwo will be introduced this year with a ‘micro hybrid drive’ (mhd) that provides engine stop-start functionality, reducing fuel consumption of the 3-cylinder gasoline engine by 8.5% (4.7 to 4.3 l/100km) and CO₂ emissions to 103 g/km. It uses a belt-driven motor-generator that supplies 42 Nm torque and a 12v ‘gel’ battery (by AGM) to absorb or supply energy.



A ‘study’ vehicle – the Smart fortwo cdi mhd – has demonstrated fuel consumption of 2.9 l/100km (78 g/km CO₂), which they claim as a world record. The combination of stop-start and closed-trap diesel particulate filter results in emissions that easily satisfy EU5.

2008 – Production version of the Smart diesel hybrid?

2009 – Mercedes calls the 2009 ML 450 HYBRID “the most economical hybrid SUV in its class”, consuming 7.7l/100km gasoline and emitting 185 g/km CO₂. The full hybrid configuration uses the two-mode hybrid module out of the BMW-Daimler-GM venture coupled to a 205 kW V6 engine, combining for 236 kW and 480 Nm. The explanation of the electric drive was somewhat confusing (in English and German), but it *appears* that the two motors in the transmission produce 120 kW and a 288v battery (likely Li-ion) is employed.



The S 400 HYBRID will be launched as a mild hybrid, combining the 205 kW V6 gasoline engine with a ‘compact hybrid module’ (a 15 kW, 160 NM motor/generator sandwiched between the engine and transmission) to produce 220 kW and 375 Nm. The expected fuel consumption is 7.9 l/100 km with CO₂ emissions of 190 g/km due to the torque boost, stop-start and regenerative functions of the hybrid module. Regenerative energy is stored in a Li-ion battery in the engine compartment. Mercedes says it is the most efficient luxury sedan in the world

2010 – The new E-Class will be launched with the same 2.2-liter 4-cylinder engine as the '09 C250 BLUETEC, the 15 kW compact hybrid module and a 7-speed automatic transmission (7G-TRONIC). The performance should be impressive; the combined torque of 560 Nm surpasses many 6-cylinder, 3-liter diesels. The consumption of 5.1 l/100km (with 134 g/km CO₂) could make the E 300 BLUETEC HYBRID the cleanest and most efficient vehicle in its class when it reaches production.

The S 300 BLUETEC HYBRID will be launched at the same time with the same technology as the E 300 BLUETEC HYBRID. The resulting fuel consumption of 5.4 l/100 km (with 142 g/km CO₂) is 30% less than the best vehicle in the S-Class segment.

2011 – The C 300 BLUETEC HYBRID will round out the trio using the same technology set, but it will perform a little better (its lighter) and consume only 4.6l/100 km (122 gm/km CO₂).

In the same timeframe, Mercedes will launch the S 400 BLUETEC HYBRID by substituting their reliable 180 kW V6 for the 4-cylinder; the consumption is expected to be 5.8 l/100 km with 154 g/km CO₂ emissions.

NATURAL GAS – Mercedes will introduce the B 170 NGT next summer (**2008**), joining the E 200 NGT that has been on the market for a couple of years, with the same basic advantages; 20% lower CO₂ emissions compared to the gasoline-powered model. They describe the use of natural gas as “an important milestone along the way to more widespread use of synthetic fuels from biomass”.

HYDROGEN FUEL CELL – Low volume production of the B-Class F-Cell will begin in early **2010** to support a summer launch. The fuel cell is reportedly 40% smaller, 30% more powerful and 16% more fuel efficient than the previous generation. Cold starting is supposedly improved due to an electric turbocharger to control the air supply and a new ventilation and dehumidification system. The electric drive delivers 100 kW and 320 Nm (peak ratings). They say the consumption is equivalent to 2.9 l/100 km diesel.



F 700 RESEARCH VEHICLE – This is an extremely interesting car with many advanced features unrelated to economy or emissions (above), but it appears to support the Mercedes claim that they can achieve luxurious touring, performance and economy. The vehicle combines a new 4-cylinder, 1.8-liter diesel engine with a two-stage turbocharger and mild hybridization to achieve the same performance as a 3.5-liter naturally aspirated V6 gasoline engine or 3.0-liter V6 turbo-diesel; it consumes 5.3 l/100 km (44 mpg) with 127 g/km CO₂ – very low for a luxury vehicle.

DIESOTTO Engine – This engine was designed to combine the advantages of the low-emission gasoline engine with the consumption advantages of the diesel engine. In addition to downsizing and hybridization, this engine uses controlled auto ignition – a diesel principle – during part of its load cycle. The following explanation was provided by Mercedes:

“On starting and at full load, the air-fuel mixture is not ignited by a sparkplug as in a conventional gasoline engine. The controlled auto ignition (homogeneous ignition) to which the DIESOTTO automatically reverts within its working cycle occurs during partial load conditions, i.e., at low and medium engine speeds.

“As a result of homogeneous combustion at reduced reaction temperatures, very low emissions of nitrogen oxides are produced. The rest of the emission control work in the DIESOTTO drive is handled by a standard three-way catalytic converter. In addition, in order to combine the individual subsystems into one drive concept, a highly efficient engine management and control system has been implemented.

One could argue that reducing the consumption of a luxury car to ‘only 5l/100 km’ is not that significant, but that’s over 60% higher than the average fuel economy in the US. And the reality is that they have determined that most customers buy the level of performance and luxury they can afford – from the manufacturer that provides it.



Their latest technology is traditionally unveiled in Tokyo in October. So Mitsubishi presented the corporate environmental strategy that addresses all aspects of vehicle design, manufacturing and recycling – and they are in line to comply with coming directives in Europe. In addition, they emphasized that powertrain solutions are applied on a regional basis considering short term needs, e.g., their EU5 engines for Europe and electric vehicles for Japan. Examples of both were presented, the Concept cX and the iev, respectively.

Concept Showcases Next Generation Clean Diesel

Mitsubishi's 100 kW, 1.8-liter, 4-cylinder Clean Diesel engine was featured in the **Concept-cX** and will be launched in Europe in 2009. It features a variable geometry turbocharger, diesel oxidation catalyst (DOC) and diesel particulate filter (DPF). The engine is coupled to their transmission with 'Twin Clutch SST' technology, an automated manual with efficiency comparable to a conventional manual and sporty gear changing is possible without a clutch pedal.



They also touted the use of 'Green Plastic' in the Concept-cX, based on their proprietary plant-based resin technology, which is made from bamboo and other plant-based resins. They use it for interior trim materials such as floor mats, door trim, tail gate trim and seat back panels.

The **iev** is a typical electric vehicle, with a PM synchronous motor (47 kW) on the rear and Li-ion battery (330v, 16 kWh) located beneath the floor of the passenger compartment. The total weight of the 4- passenger car is 1,080 kg and the range target on the Japan 10-15 mode test of 160 km.





The Nissan Green Program was announced in late 2006, covering all aspects of vehicle manufacturing from design through recycling. Like all major vehicle manufacturers, they believe that the IC engine will continue to serve as the primary power source for the foreseeable future, so they continue to improve the efficiency of conventional powertrains and address regional needs. For example an E100 (100% ethanol) vehicle will be launched in Brazil in 2009. A

3-liter car, next generation clean diesel engines (for Japan, the US and China) and a hybrid that uses original Nissan technologies will be launched in 2010. Fuel cell and electric vehicles will come 'early in the next decade' with their own technology and "accelerated development of plug-in hybrid technology" is noted in the plan as well. Nissan will likely present concepts or technology displays covering the program in Tokyo in October.

Electric Vehicle Powered by Li-ion Battery from Joint Venture with NEC

The only new technical concept presented in Frankfurt was the **MIXIM** electric vehicle, but it is consistent with their Green Program (technical content and timing). It uses their 'super motor' on each axle for four-wheel drive and the Lithium-ion battery their new joint venture with NEC, the Automotive Energy Supply Corporation. Both technologies were covered in the 2003 Tokyo Motor Show report; the motor was in the Effis concept and the battery was in the X-Trail FCV prototype.



The 'super motor' features dual rotors inside and outside a single stator coil and can provide different power levels on each shaft at the same time – so the right and left wheels can be driven independently. Because of the flexibility, Nissan sees their motor/generator as being applicable to hybrid drives as well.

The AESC Li-Ion battery uses thin laminated cells and has fewer components overall – compared to a cylindrical cell. They say that power is 50% higher and the volume is reduced by half. The flat construction allows for a thin modular design, better thermal efficiency and packaging benefits. MIXIM uses two laminate Li-Ion batteries, each developing 50 kW, located under the floor.

Nissan says that the higher power output results from material improvements in the lithium manganate positive electrode and carbon negative electrode. The apparent improvement in internal resistance contributes to its ability to accept a fast charge, i.e., completely recharged in 20-40 minutes. The battery is expected to provide up to 250 km range.



Opel presented a range of concepts based on the GM E-Flex architecture (e.g., the Volt) as well as a range of efficient and clean vehicles that will be in production soon. The most relevant to recent DOE activities is the Flextreme plug-in hybrid concept. A more near-term approach was presented in the Corsa (micro) hybrid concept that uses a starter generator and stop/start automatic transmission with the 1.3-liter diesel engine, resulting in an average consumption of 3.6 l/100 km with 95 g /km CO₂. The Vectra Flexpower, with a 2.0-liter turbo engine designed for operation on bioethanol/gasoline debuted as well.

With respect to near-term production, Opel will soon offer new 'ecoFLEX' variants (i.e., producing less than 140 g/km CO₂) of the Corsa, Meriva and Astra, as well as CNG versions of the Zafira and Combo. An example is the 55 kW Corsa 1.3 CDTI ecoFLEX with a diesel particulate filter that will be available to order from December – it consume 4.5 l/100km and emits 119 g/km CO₂.

Flextreme Plug-in Hybrid Concept

This incarnation of the GM E-Flex platform is capable of 55 km electric range and can travel up to 715 km without stopping to recharge or refuel its 1.3-liter turbo-diesel engine. Based on the European test cycle (ECE R101), its emissions are expected to be less than 40 g /km CO₂.

Flextreme is a series hybrid (same as the Volt) always operating as an electric vehicle with the engine on-board to charge the battery and extend the operating range. The advantage is that the engine can always operate in an optimum rpm range and its cylinder pressure-based closed loop control minimizes emissions. The disadvantage is no mechanical connection between the engine and drivetrain for long trips on the highway (i.e., the energy takes a less efficient path through the battery before supplying power to the wheels).

A standard 220 V circuit is used to recharge the Li-ion battery in about 3 hours. According to Opel, the average commute in Europe is less than 50 km, which implies that charging overnight and during the day would be required to drive over 100 km each day without producing any CO₂ emissions.

The Flextreme also conceals two Segways for personal transportation in areas that cars cannot enter – providing additional mobility and up to 38 km electric range.



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<i>Flextreme Concept</i>	
Vehicle configuration:	Electric FWD with range extender
Battery system:	
Type:	Lithium-ion (Nanophosphate)
Energy:	16 kWh (minimum)
Peak power:	136 kW
Voltage:	320 to 350
100% recharge time:	
220-volt outlet:	3.0 to 3.5 hours
Electric traction system:	
Max. electrical power:	120 kW
Max. mechanical power:	120 kW
Continuous electrical power:	45 kW
Continuous mechanical power:	40 kW
Torque :	370 Nm
Generator:	
Power:	53 kW peak power output
Drive:	Direct
Range extender:	
Type:	4-cyl. CDTI diesel engine
Size:	1.3 L
Peak engine speed:	3200 rpm
Fuel tank:	26 L
Charger:	
Type:	Plug-in
Voltage / amp:	220 / 20
Pure electric mode range:	55 km
Measured CO ₂ release (g/km)*	< 40g CO ₂ (ECE R101)
Full driving range :	715 km
0 to 100 km:	ca. 9.5 seconds
Top speed :	ca. 160 km/h



PEUGEOT

Diesel-Powered 308 Hybrid to be Produced in 2010

The first hybrid to be produced by Peugeot will be based on the new 308 platform that premiered at the Frankfurt show. The **308 HybridHDI** will be produced in a parallel configuration, derived from the 307-based hybrid demonstrator (covered in the 2006 Paris report).

Fuel consumption of the 308 hybrid 'demonstrator' at the show is reported to 38% lower than the equivalent conventional diesel, i.e., 3.4 l/100 km on the combined cycle and 90 g/km CO₂. But Peugeot apparently anticipates less impressive performance in the production version due to compromises necessary to meet the packaging, safety, regulatory (safety and emissions) and cost constraints of the new platform. An unexpected statement found in the press materials reads. "The new demonstrator offers technological advances in an arrangement similar to that of



the production model, but with a more efficient power train providing extremely low levels of fuel consumption".

More specifications are shown in the table, but the propulsion system is an 80 kW diesel engine coupled to a 6-speed automated manual and a 16 kW motor powered by a 200v, 5.5 Ah Nickel Metal Hydride battery pack.

The control strategy is straightforward, i.e., the electric motor is used to start and drive at low speeds; the engine is used for higher speeds and when higher

acceleration is demanded. Minimal pure electric range (i.e., 3 km) is provided in anticipation of regulated urban centers.

	308 HybridHDI	Reference 308 HDI
Diesel Engine	1.6-liter HDI DPFS	2.0-liter HDI DPFS
Power	80 kW (110 bhp) @ 4000 rpm	100 kW (136 bhp) @ 4000 rpm
Torque	240-260 Nm @ 1750 rpm	320-340 Nm @ 2000 rpm
Electric Motor	PM Synchronous	
Continuous Power	16 kW (22 bhp)	
Torque	80 Nm	
Temporary maximum	23 kW , 130 Nm	
Gearbox	6-spd elec. contr. manual	6-spd manual
Emissions	EU5	EU4
Curb weight	1460 kg	1426 kg
Hybrid components	110 kg	
Fuel tank	60 l	60 l
Battery range	3 km	
Fuel Consumption		
MVEG/CEE (combined cycle)	3.4 l/100km	5.5 l/100km
Urban	90 g/km CO ₂	146 g/km CO ₂
	3.0 l/100km	7.2 l/100km
	80 g/km CO ₂	191 g/km CO ₂
Performance (1/2 load)		
Acceleration: 0-1000 m	33s	32.5s
0-100 km/h	12.2s	11.0s
In-gear: 30-60 km/h	3.0s (automatic mode)	4.9s (in 3 rd)
80-120 km/h	7.4s (automatic mode)	9.5s (in 5 th)
Specific Components		
Brakes	Controlled hydraulic brakes and electric motor	
Inverter	150-260v, liquid cooled	
High voltage battery	200v, 5.5 Ah Ni-MH	
dc-dc converter	200vdc-12vdc	



PORSCHE

Hybrid Cayenne Planned; Panamera Rumored

The hybrid Cayenne is on its way – probably by 2009 – based on technology shared with the corporate members, Audi and VW. Apparently it has the same configuration as the Audi Q7 hybrid, i.e., a typical SUV parallel drive integrated in the longitudinal transmission – the basic layout is below and there is a video on the Porsche website.

The vehicle was anticipated by the press since the Q7 came out and its fuel consumption target of around 9 l/100 km (~26 mpg) is not revolutionary, but it is a big improvement over the current Cayenne – rated about 17 mpg combined. That is not likely to appease Greenpeace.

The story apparently wasn't covered in the States, but Greenpeace called Porsche vehicles 'climate pigs', then staged a protest at the Stuttgart-Zuffenhausen plant in July. Porsche management welcomed them with their own large banner, *"Done It!*

Greenpeace Demonstration at Porsche. Now We Have Really Made It!" Porsche also delivered a statement similar to the press release at IAA regarding their efficiency improvements over the years. They finished by rolling out another banner that read, *"Dear Friends from Greenpeace: Porsche is Better than You Think. But the Good News is that David taking on Goliath was Underestimated, too . . ."*

There are rumors about the highly anticipated 2009 Panamera model coming out at the same time as the Cayenne with the same hybrid powertrain. It would be interesting, but that's probably not the magnanimous gesture that Greenpeace is hoping for. Anyway, the overall situation needs to be considered from a positive perspective ... the fact that Porsche is even in a report on environmental technology is commendable.



Photo adapted from German Auto Blog



Volvo Presents Plug-in Hybrid Concept

The Volvo strategy for dealing with emissions and efficiency is similar to the other manufacturers, a mix of continuous improvement of combustion engines, adaptation to multiple fuels and innovation; and all the while meeting the demands of your customers and shareholders.

Volvo's presentation included all these aspects of their program; new 2-liter, 4-cylinder gasoline and diesel engines, a 4.5 l/100 km version of the C30 and 'Flexifuel' engines for biofuels, including E85. These technologies and vehicles will be available this model year in various markets globally and have an immediate environmental impact

The most interesting innovation from the DOE perspective is the **Volvo ReCharge Concept**, a plug-in hybrid electric vehicle (PHEV) with individual electric wheel motors and batteries that can be recharged via a regular electrical outlet. However, this concept will not begin to have an environmental impact for some time yet. The barrier is no different for Volvo than other manufacturers – batteries that are large, expensive and unverified in a PHEV duty cycle and harsh automotive environment.



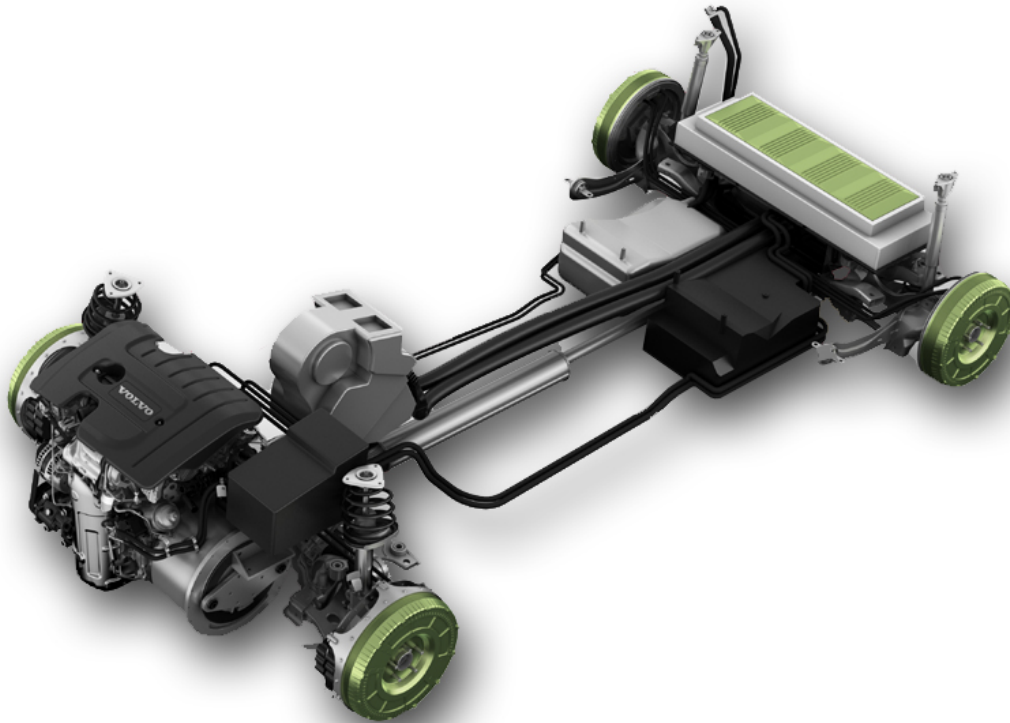
The technical objective of the ReCharge is challenging; drive 100 km on battery power alone before starting the engine to power the car and recharge the battery. To illustrate their approach to the challenge, Volvo packaged one potential solution (i.e., an electric vehicle with wheel motors and an on-board generator for range extension) in a cutaway of the C30 platform for the Frankfurt show. If the development activity is successful, then plug-in hybrid technology could be in Volvo products by 2015 or so, according to President and CEO, Fredrik Arp, in comments following the press conference.

The ReCharge Concept was developed at the Volvo Monitoring and Concept Center (VMCC), the Volvo Car Corporation's think-tank in Camarillo, California. Ichiro Sugioka, project manager, provided insight into why the concept was introduced so long before the potential market introduction – to gauge public interest (outside of the States) and foster communication in the technical community regarding issues such as standard global test procedures.

The reason test procedures are so critical can be extracted from Volvo's comments regarding benefits to the customer, "When driving beyond the 100 km battery range, fuel consumption may vary from 0 to 5.5 litres per 100 km depending on the distance driven using the engine." The fact that PHEV fuel economy varies substantially with trip length (a fact that has been confirmed in government testing) implies that current EPA test methods are not applicable to PHEVs. Conventional vehicles do not exhibit this extreme variation in consumption as a function of

distance and current procedures use prescribed cycles that are generally representative of typical consumer use. Another notable implication of the Volvo comment is that the ReCharge could (depending on trip length) actually use more fuel than its conventional counterpart, the C30 'Efficiency', which consumes only 4.5 liters of diesel per 100 kilometers.

The Volvo ReCharge Concept combines new technology in a series hybrid configuration, where there is no mechanical connection between the engine and the wheels. The layout is shown and the components are explained below.



- The Lithium-ion battery is integrated in the luggage compartment and requires 3 hours for a full charge. It is intended to last the life of the vehicle; this is a major development if it has actually been demonstrated. Li batteries in the DOE program have demonstrated up to 300,000 shallow cycles (for power-assist hybrids), but there is no public information that supports a service life of 3,000-5,000 deep cycles.
- Four electric wheel motors, developed by PML Flightlink, can provide independent traction power. If the economics (i.e., four sets of motors and power electronics versus one), packaging (integrating brakes) and the dynamic implications (additional unsprung mass) are resolved, then this is promising approach – plus it provides 4-wheel drive..
- High-efficiency Michelin tires are specially designed to accommodate the wheelmotors.
- A 4-cylinder, 1.6-litre Flexifuel engine drives a generator (also developed by PML Flightlink) that powers the wheel motors when the battery is depleted. The engine starts automatically when 70% of the battery energy is depleted, though the driver could start the engine at any time to preserve battery capacity.



'Blue' is the new 'green' for Volkswagen

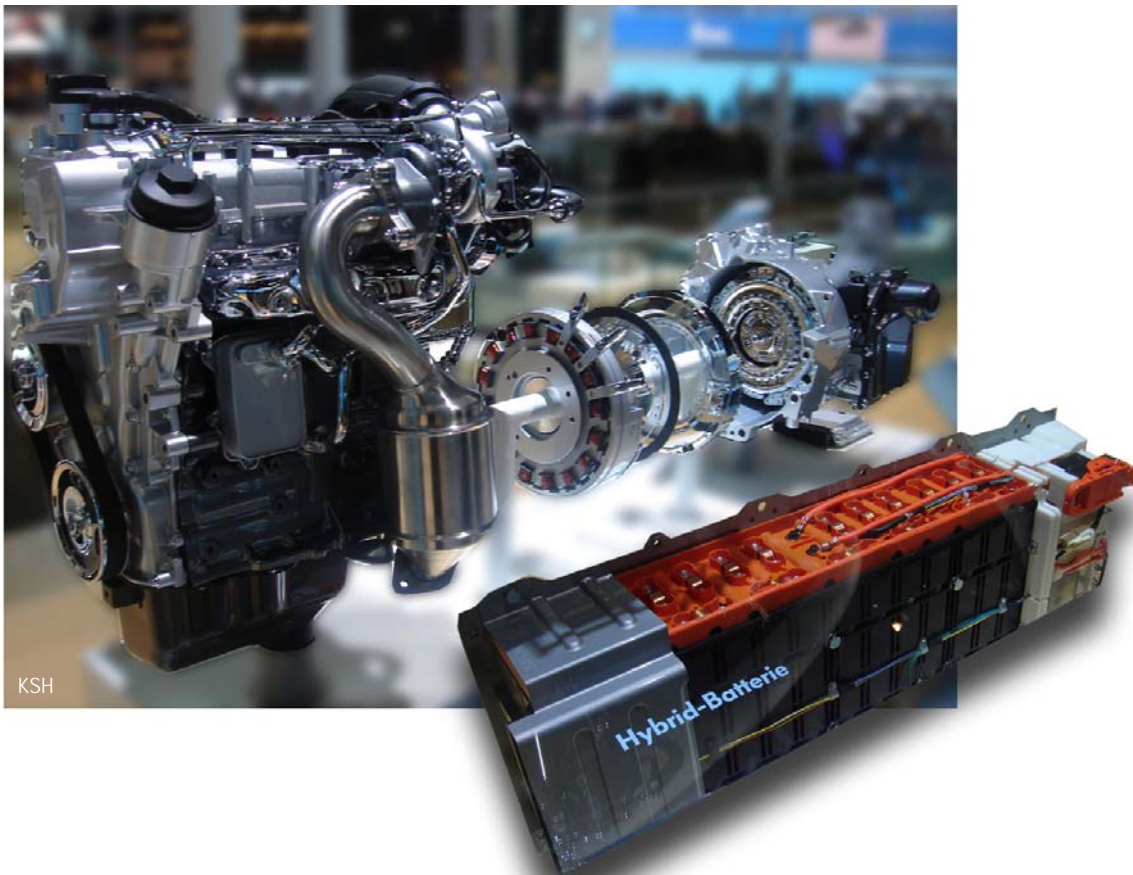
'BlueMotion' designates the most economical model of a series as well as overall brand activities related to cost-efficient powertrain technologies and environmentally friendly fuels. Six new BlueMotion versions of the Golf, Golf Plus, Golf Variant, Jetta, Touran and Caddy Life were introduced in Frankfurt.

Starting in 2008, Volkswagen will offer a BlueMotion model in nearly all of its model series. VW calculates that together they have the potential, in Germany alone, of saving four million liters of fuel and 10,600 metric tons of CO₂ annually. The line-up of BlueMotion designated model introductions and their 'scores' follow.

Golf	4.5 l/100km, 119 g/km CO ₂
Golf Variant	4.6 l/100 km; 122 g/km CO ₂
Golf Plus	4.8 l/100 km; 127 g/km CO ₂
Jetta	4.6 l/100 km; 122 g/km CO ₂
Touran	5.5 l/100 km; 146 g / km CO ₂
Caddy	5.8 l/100 km (41 mpg); 154 g/km CO ₂



Various components and systems supporting their environmental strategy were displayed in the **BlueMotion Park**. The example below is the typical parallel hybrid component stack between the engine and transmission of a front wheel drive vehicle – along with the associated Sanyo Li-ion battery. The longitudinal arrangement is shown in the Audi section.



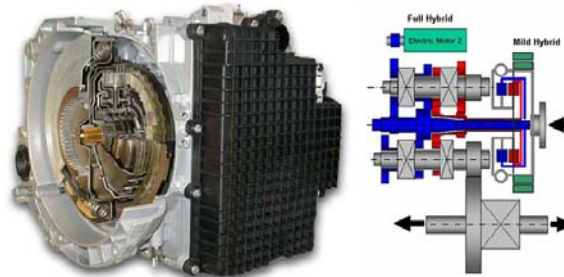
Suppliers Gearing up for Hybrids



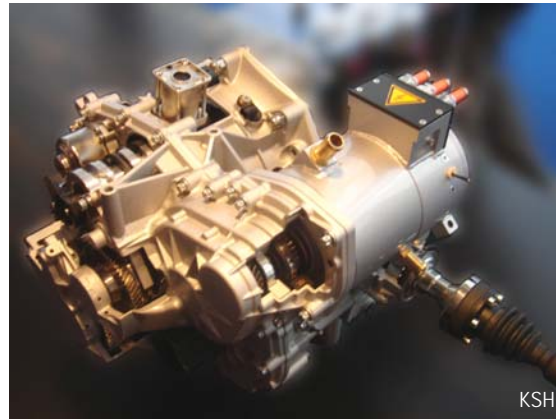
The most significant supplier news is the announced partnering between major German manufacturers of electrical/electronic components and mechanical drive trains to supply

hybrid propulsion systems; apparently they have their orders and this substantiates the vehicle manufacturers' claims regarding pending production of hybrid vehicles. It was reported in the 2006 Hannover show report that ZF was planning to supply turnkey hybrid drive systems. ZF's experience with production systems for the Nissan Cabstar, in addition to development vehicles for MAN, was certainly a factor in the OEM decisions to proceed to production.

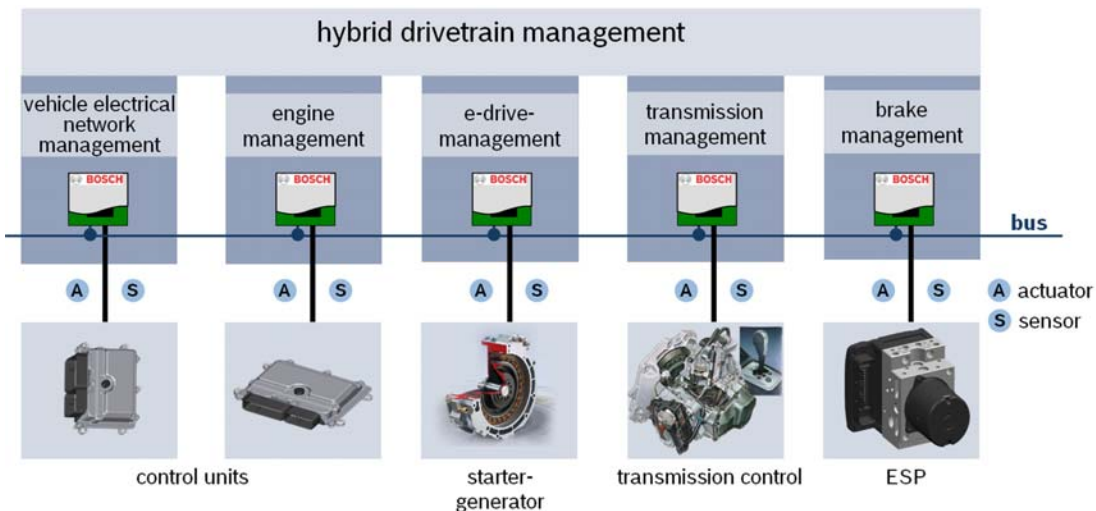
Bosch + Getrag – These suppliers support OEMs throughout Europe and Asia with components that can be modified for hybrid applications. For example, the Powershift from Getrag was described in the Frankfurt '05 report. It is a 6-speed, dual clutch transmission that can handle up to 450 Nm torque and is easily configured for mild or full hybrid drive trains because of the lay shaft arrangement.



They have commitments from 8 OEMs that require annual production to increase from 227,000 units in 2008 (Ford and Volvo are the first users) to almost 2 million in 2014, with hybrid versions of the Powershift available from 2010. Thus any of the target vehicles could be transitioned to hybrid in subsequent model changes. Their new hybrid concept is a dry dual-clutch version (start of production 2009) linked to an electric rear axle (right).



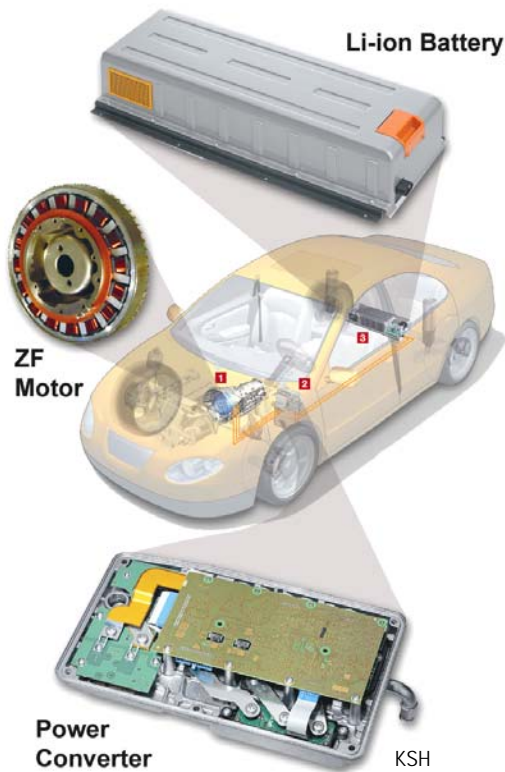
Bosch is focusing on modular components and control of parallel systems as well as the necessary electric auxiliary systems. They see the primary hybrid market in NAFTA and only 1% production in Europe by 2015.



Continental Automotive Systems + ZF Friedrichshafen – The latest technology introduced by ZF is the 8-speed automatic transmission, a modular design that can be combined with various input and output drives (e.g., 4WD), including hybrid systems. ZF prefers the parallel configuration, with their estimates of fuel savings ranging from 5-8% for a micro to 30% with a full hybrid. ZF is a Tier 1 BMW supplier and apparently agrees totally regarding the features of driving dynamics such as direct engine integration and agility, precise shifting quality and comfortable handling – even that they can be improved through hybridization.



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Li-ion Battery

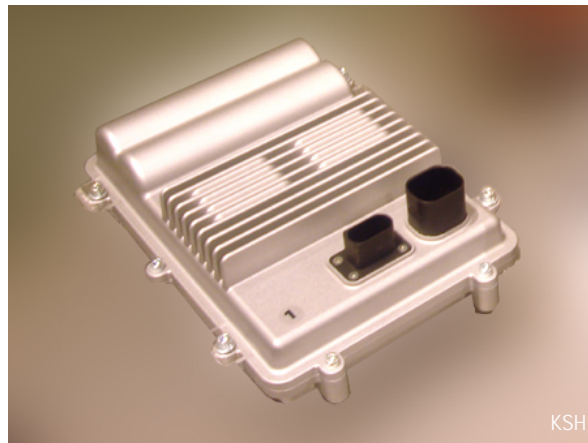
ZF Motor

Power Converter

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With Continental, ZF is able to offer complete hybrid solutions, including power electronics, software integration, energy management, and electronic brakes. It was reported in the 2006 Hannover show report that ZF was planning to supply turnkey hybrid drive systems. ZF's experience with production systems for the Nissan Cabstar, as well as developmental hybrid systems with all the major German manufacturers, was certainly a factor in the OEM decisions to proceed to production.

Continental even showed a Li-ion battery and an associated control system (apparently for a mild hybrid), but that has not been one of their core competencies. They also displayed an 'advanced energy storage' device (below) with no more explanation than it is rated at 30A.



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