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The 40th
TOKYO MOTOR SHOW 2007

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平日10:00-18:00 土・休日9:30-19:00 特別招待日：10月26日(金) http://www.tokyo-motorshow.com
入場料：一般1,300円 中学・高校生600円 前売及び平日の15時以降入場料：一般1,100円 中学・高校生500円(消費税込) 小学生以下無料

Environmental Highlights of the 2007 Tokyo Motor Show

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The Tokyo Motor Show covers a broad range of vehicle technologies, e.g., commercial vehicles were incorporated this year, and many of the new concepts are either hybrid or electric (some examples above). But the high-level message is essentially the same as the other shows in the past year – environmental technology is an integral part of the major manufacturers' plans, including improved engines and after-treatment, lightweight materials, new propulsion systems and alternative fuels. And in response to the push in the States, plug-in hybrid electric vehicles (PHEVs) are being explored by several manufacturers. In fact, there is some interesting positioning underway due to Japan being caught off guard with respect to PHEVs. In fact, the statement by Honda's CEO Fukui that PHEVs don't make sense and don't reduce emissions could be at least partly due to the fact that their system requires a thorough redesign for use in a PHEV. And one manufacturer (with a PHEV on display at the show) commented that Honda had not done a thorough analysis if they concluded that PHEVs did not reduce emissions.

Previous motor show reports have typically focused on technology specific to electric or hybrid vehicles, but some remarks with respect to global engine development are due – inspired by the array of small engines and advanced technology on display in Tokyo as well as Frankfurt last month. Features that we call 'advanced', including precision fuel injection, variable valve timing, multi-stage turbo-charging, sophisticated after-treatment, etc, are in production engines ranging from less than one liter to several liters displacement in Europe and Asia. And since many of these features can be precisely controlled, they are particularly useful in hybrid systems.

Manufacturers and suppliers are working hard to improve engines and powertrain systems in preparation for more restrictive regulations in the future. But one conclusion that could be drawn from what is on display at the motor shows is that a substantial part of the development is focused on maintaining high performance in a more regulated environment versus optimizing performance and efficiency to maintain mobility in a fuel-constrained environment. Many hybrid vehicles utilize essentially the same engine (i.e., the same power) and use the hybrid components to add capability (e.g., 4-wheel drive or faster acceleration). Apparently the perception is that the majority of vehicle purchasers are unwilling to compromise in any way to save energy or reduce emissions. Smaller high-tech engines are being applied to cars that are small and relatively efficient already. Of course, the 'conventional' car that gets 40 mpg is still more efficient than the most sophisticated hybrid that gets 25 mpg – and it certainly costs less.

Transmission development is worth mentioning as well. Suppliers like Aisin, JATCO and ZF are developing manuals with up to 8 speeds, automated manuals and CVTs – for both front and rear wheel drive – designed to provide more control to keep the engine operating in a regime where it is best suited (or where it needs to operate to meet emissions regulations). Of course, this flexibility can be useful to hybrid systems as well.

Passenger Cars		Metro Project Quattro PHEV Concept	PHEV with 100 km range is theoretical, but shows awareness of public interest with straightforward 'through-the-road' parallel
		CR-Z HEV Sports Car Concept Puyo FCV Concept	Continued pursuit of young, performance-oriented market with next generation lightweight hybrid – likely headed to production; Inconsequential publicity exercise
		LF-Xh Concept LF-A Concept	Updated hybrid SUV with 'L-finesse' styling and latest hybrid powertrain; Debuted in Detroit, but confirms CFRP interest/Toray capabilities
		Premacy Hydrogen RE HEV 'Exhibition Model'	Leasing of the dual-fuel (gasoline also) van to government and corporations (who can afford it) will commence in 2008; leasing of H2 RX-8 expands
		i MiEV Sport Concept	Updated version of the MiEV that has been in demonstration programs in Japan, with front wheel motors and more appealing styling
		Pivo2 EV Concept	Publicity exercise, but it has their latest wheel motor and Li battery technology
		G4e Concept	Updated version of the R1e that has been in the TEPCO demo programs, with new 'nano-vanadium' Li-ion battery (2x energy of Manganese Li-ion)
		Kizashi 2 Concept Pixy + SSC Concepts MIO SeniorCar Concept	Crossover wagon that 'could be' hybrid in the future; Personal transportation (isolation?) concept for a crowded society Fuel cell powered electric cart refillable with methanol mix
		1/X Concept Hi-CT PHEV Concept Crown HEV Concept FT-HS HEV Concept	Plausible CFRP body and next generation hybrid powertrain Body style inconsequential, but further recognition of plug-in concept Expected upgrade of the 'mild' hybrid with 'full' Hybrid Synergy Drive Same young target market as Honda CR-Z hybrid sports car
Trucks		Canter Eco-D HEV Concept	Based on the Canter Eco Hybrid vehicle currently in (limited) production; new target market for hybrid vehicles
		HEV Powertrain	Continuing hybrid development – displayed latest 4-liter engine with in-line motor and battery pack
		Next Generation SCR System Concept	Combination of 2-stage turbo-charging, increased fuel injection pressure and EGR, improved catalyst, DPF and airless urea injection
		HEV Powertrain	Japanese premier of I-SAM hybrid concept – with mixed reviews
Motorcycles		Crosscage FC Concept	Air-cooled fuel cell by Intelligent Energy (UK) with NEC Li-ion battery
		FC-AQEL Concept FC-Dii Concept LUXAIR HEV Concept Tesseract HEV Concept	Yamaha hydrogen fuel cell system Yamaha direct methanol fuel cell system with 1 kW constant power Power assist hybrid 4-wheeler with parallel hybrid system that could be applied to small cars

This report covers the latest developments and their significance in the order of the previous summary table. The most significant (directional) developments are summarized below:

- Energy storage – Lithium-ion batteries (many types) are being aggressively pursued globally, but safety and recycling remain challenges
- Power electronics – Japanese suppliers are developing and producing impressive technology and moving toward more integrated systems
- Electric traction motors – Wheel motors are currently the rage, but economics have not yet been seriously considered
- Engines – Small engine technology development is making strides in precision control with variable valve timing, etc. that applies to hybrid propulsion
- Fuels – Alternate liquid fuels are being addressed widely (though availability is limited); Hydrogen is less popular at the moment, though impressive development continues
- Vehicle technology – Hybrids becoming 'conventional'; PHEVs gaining interest globally
- Vehicle efficiency technologies – The Toyota 1/X concept

Audi stated at the Frankfurt show in September that the combustion engine will remain the major drive system for the foreseeable future – citing diesel technology as the key to reducing fossil fuel consumption. But they are active in hybrid vehicle development and share components and systems with the other companies in the group, VW and Porsche. Their plug-in hybrid electric vehicle concept on display basically illustrated their awareness of trends/public interest as well as helped introduce their new small car concept. It is interesting, however, that they did not show this concept in Frankfurt. Perhaps they anticipated some confusion relative to the corporate parallel strategy that was presented for front- and rear-wheel drive systems. Or perhaps the decision was made to show that they are not 'behind' the main hybrid trendsetter, Toyota – on their turf. And it might have been difficult to defend the PHEV concept in light of their unambiguous statement that hybrid technology "will be employed in specific markets … but the efficiency must compete with their latest TDI technology". They certainly were not ready to imply that this concept could meet the challenge – there are too many uncertainties at this time. In short, it would have elicited many questions that Audi would not have been able to answer easily (the same reason it cannot be explained as an integral part of their strategy). In the end, Audi will draw from the corporate portfolio of components to effectively field a hybrid. Constructing this vehicle based on a platform that is coming anyway would not be a major challenge, but they have the same problem as everyone else, the battery.

Metro Project Quattro Concept

Audi's plug-in hybrid concept is more about the design of their next sub-compact vehicle than a technical statement about plug-in hybrids. In a discussion with an Audi representative, the message was clear that this is a "concept only" and drawing technical or programmatic conclusions might not be warranted. But the plug-in hybrid drive obviously draws the interest of those that might not be excited about a new body style – so their plan worked.

The vehicle is configured as a 'through-the-road' parallel hybrid, with coordination between the 1.4.litre TFSI engine and gearbox on the front axle and a 30 kW electric motor on the rear axle. A lithium-ion battery can theoretically provide a range of up to 100 km in pure electric mode.

Audi claims that the combination of start/stop functionality, regenerative braking and 'phases of purely electrical operation' reduce the fuel consumption and emissions by 'around 15% compared to when it is running exclusively on the combustion engine'. The result is that the vehicle would consume 4.9 liters/100 km and emit on average 112 g CO_2 /km. Since it is not likely capable of full performance on the 30 kW motor alone (continuous or peak rating not specified), the results are likely based on a blended strategy. KSH

Use of electric mode determined by conditions – Audi Driver Select is an option on the current A4, enabling the driver to choose one of two operating modes for the drivetrain and ride characteristics ('efficiency' or 'dynamic'). The default choice is the 'efficiency' mode with settings designed to 'respond gently' to driver commands, minimizing fuel consumption and emissions. In the PHEV concept this means that the electric motor is not used for power-assist, but is operated 'selectively as the sole power source to minimize fuel consumption' based on adaptive control. Audi explains that the navigation system can detect differences in altitude along a given route and regeneration as well as the increase in energy/power requirements on inclines can be computed before the (next) journey starts. They say the vehicle can travel up to 100 km in electric-only mode on predefined routes with access to a power socket at the destination (an unexplained caveat that brings up questions regarding their definition of range), with the engine turned on when the battery state-of-charge drops to 20%. The 'efficiency' mode also flashes messages in the display advising the driver to turn off energy-intensive systems, such as air conditioning, or close open windows.

In the 'dynamic' mode, the electric motor boosts performance and provides four-wheel drive, benefiting vehicle dynamics in high-performance operation.

Propulsion system based on the new 1.4 TDSI engine – This is an advanced version of the production engine that debuted recently in the Audi A3. This engine develops 110 kW (at 5,500 rpm) versus 92 kW in the A3 – with peak torque of 240 Nm available from 1,600 – 4,000 rpm. The integrated turbo can provide 80 percent of peak torque as low as 1,250 rpm (just above idle). Obviously, the vehicle can perform adequately on the engine alone and it is likely that the production vehicle will have a conventional configuration.

Audi says that the 'components of the electric motor' add around 70 kg to the overall weight (including battery?), but the reference is not clear since this is a new body style and the mass is not specified. Audi says that electric operation and recharging saves around €6.50 ($9.10) for every 100 km, or 70% based on the price of premium fuel.

Presents Concepts for Young Drivers; Shuns PHEVs

Honda presented a performance-oriented hybrid concept (the CR-Z) that uses their standard IMA system and is likely to go to production – with the primary target being young drivers. The fuel cell electric vehicle concept presented (the Puyo) was designed to fascinate the public with their creativity and entertain the home crowd, not provide technical information. But the opportunity to see the real thing is coming soon; Honda will unveil the new version of the FCX at the Los Angeles Auto Show in November.

Though PHEVs were not mentioned at the show, they were addressed in a statement by the Honda CEO just prior to the show. Apparently in response to announcements by Toyota and others, Takeo Fukui made the following statement according to the Wall Street Journal,

"My feeling is that the kind of plug-in hybrid currently proposed by different auto makers can be best described as a battery electric vehicle equipped with an unnecessary fuel engine and fuel tank. ... I'm not sure what kind of real advantages they [plug-ins] would have. ... I don't think that [plug-ins] will contribute to the global environment or to reducing carbon dioxide."

One manufacturer that displayed PHEVs at the show opined that Honda had not performed adequate analysis prior to making the comments. Their assessment of PHEVs shows substantial fuel displacement as well as benefits for the environment and utilities.

Another consideration is that their hybrid propulsion technology, designed for power-assist only, is not a good match for PHEVs. In contrast, GM's electric drive components in the Volt were developed for the fuel cell program and are capable of full performance in the electric mode. And Toyota can basically add more battery and use their power-sharing strategy with battery depletion to function as a PHEV. Volvo and others are considering approaches that rely on a series configuration with wheel motors. But Honda needs a new system with higher power motors and electronics in addition to a new battery (like everyone else) to produce an effective PHEV. And if they had presented yet another PHEV concept at the show, it would look like 'me too', a bow to peer pressure and it would get lost in the PHEV confusion. Honda has always been independent of the other Japanese manufacturers and, whether it was intentional or not, they made a statement that they are not going to be drawn into PHEVs without a good reason.

CR-Z Hybrid Sports Car Concept

"Compact Resistance Zero" was presented as the next generation lightweight sports car – with no explanation of 'lightweight'. There were features like mesh over frame seating, but look for something more substantial like CFRP when it debuts. Under the hood, it uses the Honda IMA (Integrated Motor Alternator) hybrid system.

Puyo Fuel Cell EV Concept

Puyo is designed to show Honda's freethinking attitude and appeal to the social interests of the populous – certainly not the design direction for fuel cell vehicles. The features are soft (gel skin), comfortable (gel seats), pleasing to the users and onlookers – it even communicates with skin that emits light as an indication of running conditions. I'm not sure the mass market is looking for a car 'that looks like it could be a pet". The fuel cell and electric drive are technically inconsequential; it merely allowed the designer to eliminate the engine compartment.

Updated Hybrid SUV and Carbon Fiber Sports Car

The concepts presented by Lexus did not provide any real technical surprises. Since they announced a few years ago that their core powertrain would be hybrid, hybrid versions of their line-up continue to roll out. The hybrid version of the LF-X (concept debuted at the 2003 New York show) reflects their current styling approach, L-Finesse, and incorporates the latest powertrain used in the hybrid passenger vehicles.

Perhaps a more interesting development is the LF-A concept that originally debuted in Detroit in 2005. Though billed as an exotic 'halo car' for Lexus, the car has undergone further development and the continuing development of carbon fiber reinforced plastic (CFRP) for automotive applications by Toray Industries is significant. Apparently their experience with the LF-A (as well as their extensive activities with Boeing) is being applied to other vehicles under the Toyota umbrella, such as the Toyota 1/X. Toray's recent announcements about increasing production capacity of CFRP components and the establishment of an automotive center in Nagoya points to the impending production of CFRP body components for automotive applications.

Sustainable ‘Zoom-Zoom’

Mazda’s long-term development vision was revealed in the Sustainable Zoom-Zoom plan they announced this past spring. The marketing title belies the seriousness of the content; they are spending their development resources on hydrogen engines rather than fuel cells in preparation for a hydrogen society. Their reasoning (paraphrased) is that they want to keep the ‘zoom-zoom’ in their products regardless of the fuel. Apparently they are less optimistic about fuel cells meeting the challenge.

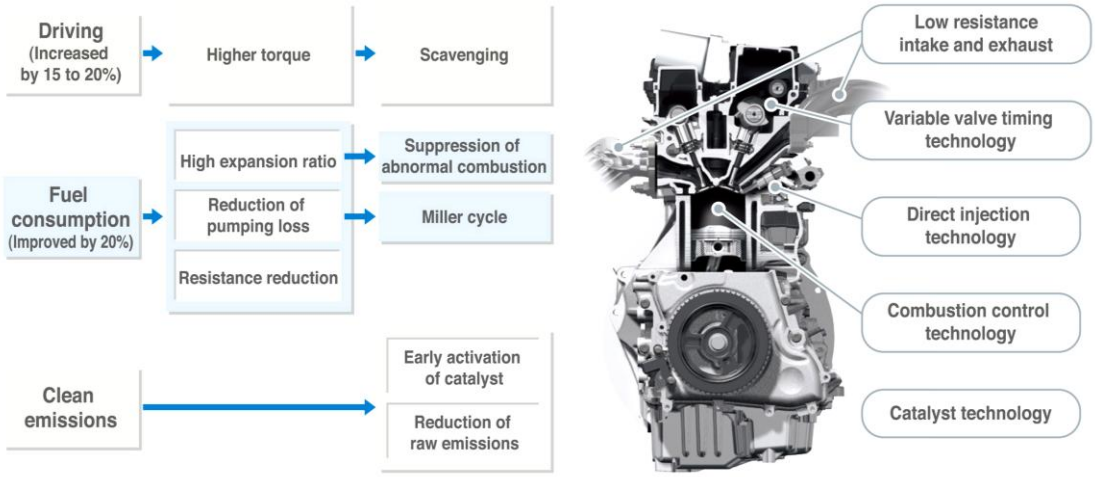
Though they are bucking the current fuel cell trend, it might be a good approach for them. They have many years experience with hydrogen engines, the technical risk is much lower than that of fuel cells and their rotary engine technology is particularly suited to hydrogen combustion (separate intake and combustion chambers, dual injectors, excellent mixing, etc.). Though their engines will not reach the (theoretical) efficiency of fuel cells, they can be economically produced whenever hydrogen fuel becomes available. And they are not in bad company – joining BMW – in deciding on a hydrogen engine development policy.

To put some meat on their environmental policy, they presented their latest environmental technology at the Tokyo show, including the next generation powertrains, the Premacy Hydrogen RE Hybrid and their plant-sourced ‘bioplastic’ for automotive applications.

Next-Generation Powertrains

The basic assumption is that impressive power is needed alongside excellent fuel economy and emissions control to keep the excitement in their products (not unlike BMW). Mazda plans to have a complete new line-up of powertrains in place for 2010 and beyond, which will be sequentially introduced in all their models. To accomplish this plan, Mazda is developing next-generation direct injection gasoline, clean diesel and rotary engines. In addition, they have developed a clever way to implement stop/start functionality without using the electric starter motor.

I-4 Direct Injection Gasoline Engine – Targeting a 15-20% improvement in dynamic performance with a 20 % lower fuel consumption (compared to their 2.0-liter gasoline engine), Mazda will have to reduce all engine losses and improve thermal efficiency. The high level approach (in the accompanying figure) is not unique to Mazda, but they bring some of their own technology to the challenge.



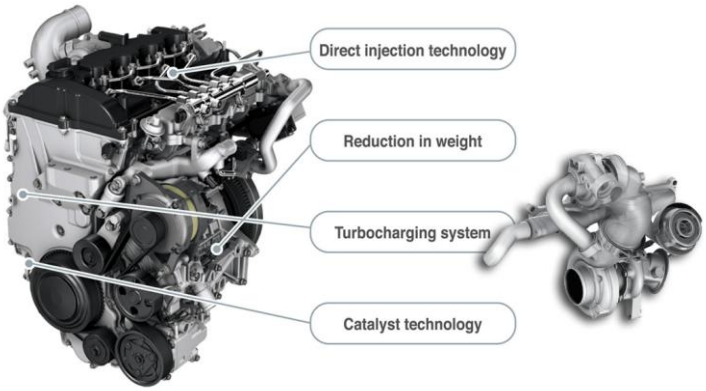
Direct injection – Improve fuel atomization and in-cylinder flow to cool the intake air; to suppress pre-ignition/knock caused by higher compression and increase air density (i.e., increase power).

Combustion control – Optimize combustion chamber shape to avoid unwanted occurrences associated with higher compression ratios.

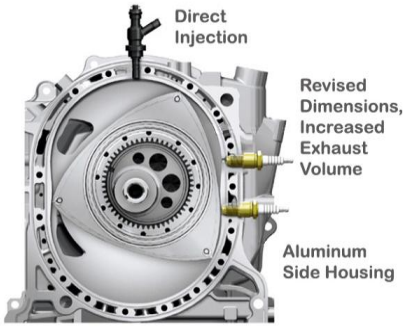
Variable valve timing – Mazda is investigating dual sequential-valve timing with a phase variable mechanism for both intake and exhaust as well as a continually variable lift mechanism.

Catalyst technology – Mazda has developed a new catalyst that uses 'single nano technology' and reduces the precious metal requirement by 70-80% without reducing purification efficiency.

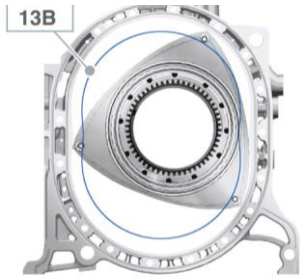
Clean Diesel Engine – A 10% percent improvement in emissions and fuel consumption is the basic objective of the Mazda development activities. Development direction is typical for modern diesel engines, including piezo-electric injectors, an aluminum block and lighter dynamic (reciprocating and rotating) masses, a two-stage turbocharger to flatten the torque curve, higher efficiency PM combustion catalyst with reduced precious metal and NOx reduction technologies (SCR, etc.).

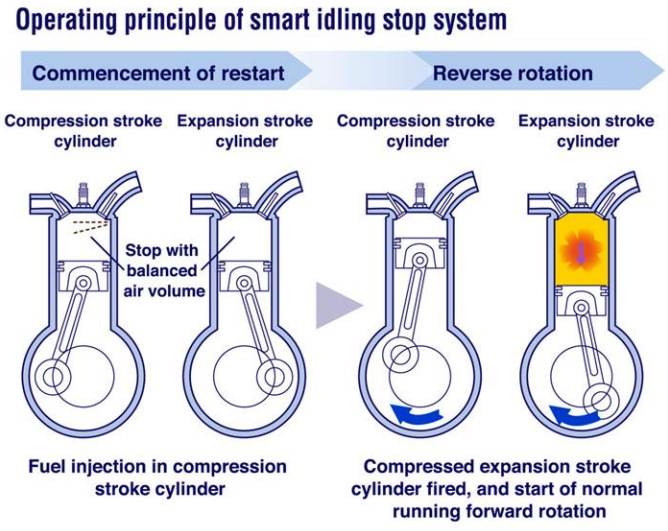


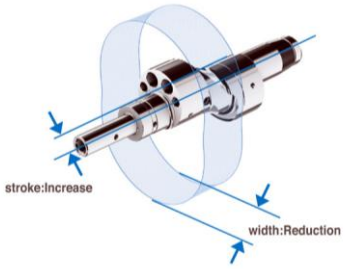
RENESIS Rotary engine 16X – Believe it or not, they have been developing rotary engines for 40 years and they are applying that experience to a new 1600 cc (800cc x 2) powertrain with a new trochoid chamber shape, gasoline direct injection technology inherited from the hydrogen rotary engine and an aluminum side housing. The combination of the new trochoid shape ('13B' in the figure outlines the previous shape), narrower rotors (resulting in a longer stroke) and more efficient intake and exhaust (due to the new side ports) has resulted in 40% more power than the RX-8 rotary.



SISS (Smart Idle Stop System) – Mazda says turning off the engine to stop idling on the Japan 10-15 mode tests reduces fuel consumption by about 10%, so they devised an approach for their piston engines that does not require an electric starter motor. When the engine would normally idle, they stop the pistons at the right point (i.e., the right air balance in the compression- and expansion-stroke pistons) to allow an injection of fuel while the engine is stationary and ignite the fuel – which they claim saves fuel and starts the engine quicker.

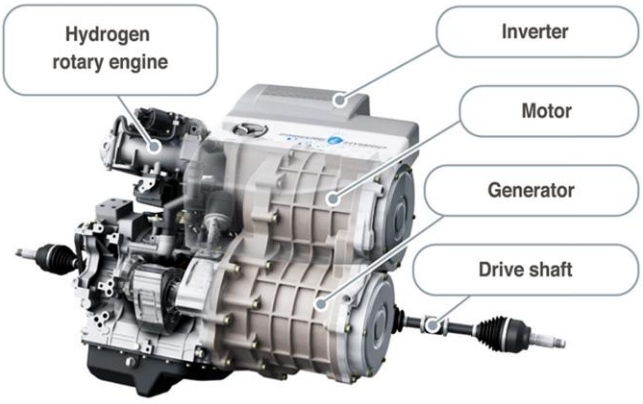






Premacy Hydrogen RE Hybrid

The Premacy hydrogen van uses the new RENESIS rotary engine and offers the same dual-fuel capability as the RX-8 Hydrogen RE that has been leased to corporations and local governments since 2006. But the Premacy offers increased range between refueling and increased seating capacity as well as a new hybrid system with better performance – and it will enter the lease program in 2008.



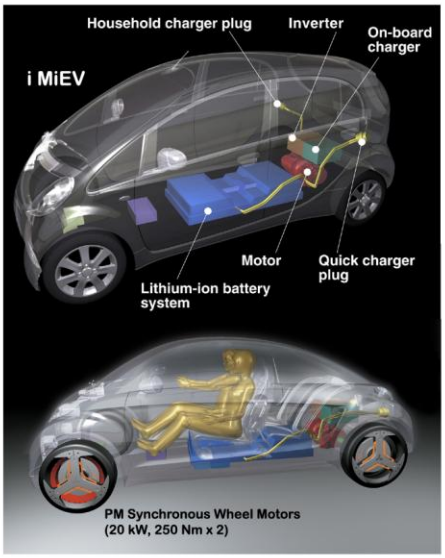
As shown in the figure, the engine has been changed to transverse mounting and the hybrid system has been designed specifically for this application. The hybrid system overcomes the typical hydrogen engine issues of low torque and poor combustion efficiency at low speed. In addition, the RX-8 engine produced roughly 80 kW with hydrogen fuel; the new Premacy engine produces 40% more power (roughly 110 kW) and the hybrid system with a 110 kW motor and Li-ion battery boosts performance substantially. The battery and fuel tank are beneath the floor (under the back seat) and the hydrogen tank is located behind the seat (figure above left).

Biotechmaterial – In a joint venture with Teijin Ltd. and Teijin Fibers Ltd., Mazda is the first in the auto industry to develop the a 100% plant-sourced biofabric made of polyactate fibers; and it has wear, fire and weather resistance that are adequate for seating. Kernels of corn are shown in the figures – that also illustrate the hard and soft forms of the material used in the Premacy – for interior trim and seat covers.

Bumper recycling – The Premacy also uses recycled plastic from a process that utilizes their unique optical sorting technology; resulting in plastic pellets from damaged bumpers that are 99.9% free of paint and can be reused in the same application.

i MiEV Sport EV Concept

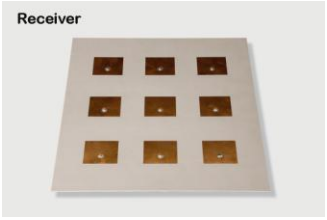
A concept for a more intriguing version of the i MiEV was showcased in Tokyo. The car uses the same electric components and rear wheel drive configuration as the i MiEV that has been successfully operating in Japanese demonstration programs for a couple of years. The obvious difference (shown in the figure below) is the addition of front wheel motors, providing E-4WD (Electric four-wheel drive). Mitsubishi has adapted the Super All Wheel Control (or S-AWC) principle used in their conventional 4WD vehicles to integrate control of the E-4WD, E-AYC (Electric Active Yaw Control), ABS and Active Stability Control (ASC) – aiming to "explode preconceptions about the drive qualities of electric vehicles". Use of the word "explode" is rare in automotive marketing materials, especially considering recent events with lithium batteries. But there is no doubt that vehicle dynamics improve with integrated powertrain and chassis control, especially with the low center of gravity and even weight distribution well.



Mitsubishi also conceived features (of debatable value) to maximize the use of 'natural energy', including a photovoltaic roof panel and small wind turbines in the grill to capture energy during deceleration.

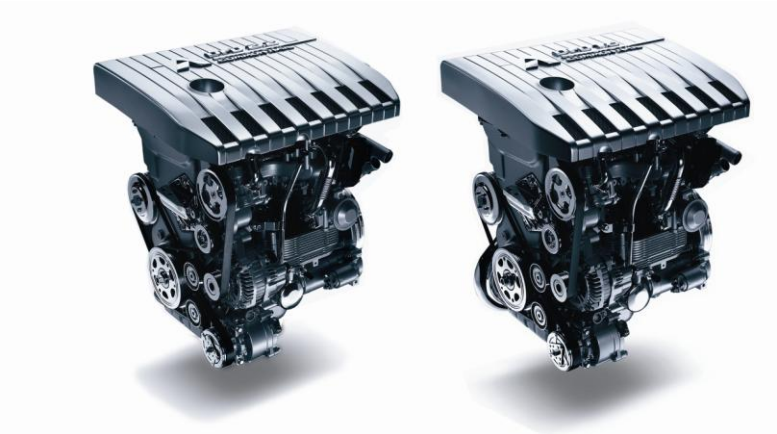
Infrastructure was considered as well, including wireless microwave recharging as well as Power Line Communications (PLC) to connect the vehicle with a home computer; enabling vehicle presets for recharging and air conditioning, updating navigation, e-mail, etc. The concepts of wireless charging and PLC seem to be contradictory, but they are obviously covering all the options. The microwave recharging hardware (below) was developed by Mitsubishi Heavy Industries in a study commissioned by NEDO (New Energy and Industrial Technology Development Organization).

Note that both the i MiEV and i MiEV Sport can be recharged with 100 or 200 VAC household outlets (full charge 14 and 7 hours, respectively) or quick-charged (30 minutes to 80% capacity) with 3-phase, 200 VAC.



Clean Diesel Engines

Mitsubishi introduced the Concept-cX in Frankfurt with their new 1.8-liter clean diesel engine, but they provided more information in Tokyo regarding the 1.8- and 2.2-liter versions. The key features are discussed and contrasted in the following paragraphs.



Models	**4N14-type**	**4N13-type**
Cylinders and valve gear	Inline 4-cylinder 16-valve DOHC	(Same)
Bore x stroke	86.0mm × 97.6mm	83.0mm × 83.1mm
Total displacement	2268cc	1799cc
Max. output (net)	140kW / 4000rpm	100kW / 4000rpm
Max. torque (net)	400Nm / 2000rpm	280Nm / 2000rpm
Fuel supply system	Common rail with piezo injectors	Common rail with solenoid injectors
Turbocharger	VD / VG turbo	VG turbo
Regulation Target	Compliance with Japan's Post New Long Term regulations	(Same)

High-pressure common rail – To improve combustion efficiency the two new clean diesel engines use a 200-MPa common rail injection system. Piezo injectors are used on the 2.2-liter (4N14-type) that produces a finer fuel spray and, along with a fast ceramic glow plug system, the result is acceptable emissions at a lower compression ratio than other diesel engines to date. And in turn, the lower combustion pressure allows an aluminum cylinder block that reduces weight.

Advanced turbocharger – The 4N13-type1.8-liter clean diesel engine uses a VG (Variable Geometry) turbocharger with a variable vane turbine, which provides optimal boost pressure control for different driving conditions. The 4N14-type 2.2-liter engine is fitted with a VG system plus a VD (Variable Diffuser) that uses both variable geometry vanes in the turbine housing and a compressor with variable vanes in the diffuser passage. Further improving combustion efficiency by allowing optimal boost at all engine speeds, the VD/VG turbocharger (shown) results in higher power with lower fuel consumption and emissions.

Crankshaft offset optimized – The clean diesel uses an offset angle crankshaft and tailoring for the particular engine substantially reduces friction.

New catalyst system – The new catalyst system combines an oxidation catalyst, NOx trap catalyst and diesel particulate filter to meet the requirements of Japan's Post New Long Term Regulations.

Nissan reinforced their position 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. But they are intensifying efforts to develop electric vehicle technology "to help advance the widespread use over the long term" and will introduce EVs in Japan in the next decade.

But at the Tokyo show, they showcased two extremes; the GT-R 'super-car' for the high-performance segment and the Pivo2 electric vehicle for (apparently) the fantasy segment, i.e., it is designed primarily to attract attention, but it has some interesting technology.

Pivo2 Too Cute, but Has New 3-D Disk Motors and the AESC Li-ion Battery

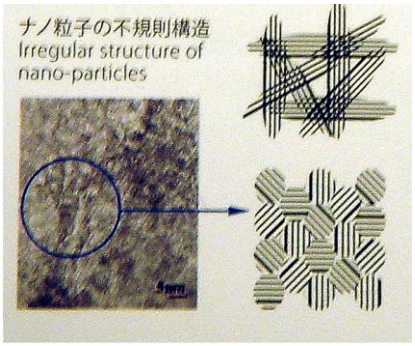
The application of wheel motors in this concept, which emphasizes independent control as a function of the operating mode (e.g., 4-wheel independent steering to park versus typical operation) shows that Nissan, like Mitsubishi, is attempting to justify the additional cost and complexity of wheel motors with perceived additional value. They are obviously exploring various motor technologies (e.g., the 'super-motor' in the MIXIM concept in Frankfurt) to cover potential electric vehicle configurations in the near- and mid-term. And they mentioned the possibility of a hybrid application of the super-motor in the Frankfurt press material, so it appears they are covering all the bases. And they reportedly are working on a significantly smaller inverter that can be integrated with the motor.

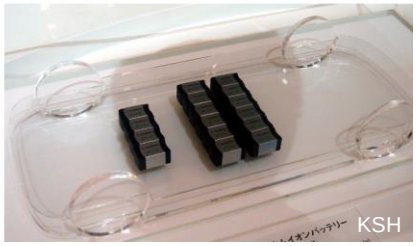
The AESC Li-ion battery from the joint venture with NEC debuted in Frankfurt, but you no longer have to envision the packaging of the thin laminated cells because they displayed a cutaway of a module. The battery is based on "chemically stable spinal-structured manganese for the electrode material" – apparently the enabler for the planar format. The battery reportedly has 50% higher power and energy in half the volume of a Li battery constructed with cylindrical cells. But there was an interesting comment in the press material; since the battery is "half a size of the conventional type but twice the power, the *development is being accelerated for practical use*". There may be something lost in the translation, but it could imply that a standard SLI (Starting, Lighting and Ignition) battery for the mass market is coming. That would be a game changer and would test the economics of large format Li batteries in high volume.

And Nissan is introducing variable valve timing in the Skyline Coupe in Japan this fall – the significance is that this capability was the enabler for Toyota to build the Prius. In combination with their motor technology, integrated inverter, Li batteries and widespread use of CVTs, a variety of hybrid propulsion systems could be envisioned.

Subaru has been developing EV technology in cooperation with Tokyo Electric Power Company (TEPCO) for several years and 40 EV R1e's have been operating within the utility and local government fleets. The vehicle is capable of 80 km range with its 346V Li-ion battery.

Their latest EV technology was showcased in the G4e ("Green for earth") concept vehicle. The motor power was increased from 40 kW to 65 kW and they hope for 200 km range based on their next generation Li-ion battery and more efficient vehicle characteristics. The key development is the "nano-vanadium" battery developed exclusively by Subaru. It capitalizes on a new "nano-particulated" structure and pre-doping technology to more efficiently load their original vanadium material – that can store two to three times more lithium ions than conventional materials on the positive electrode. According to Subaru, the result is energy density about double that of manganese Li-ion batteries of the same weight. The figure (right) shows the basic idea. Fully recharging at home takes 8 hours or it can be quick-charged to 80% in 15 minutes – through a universal charging socket.





The improved vehicle efficiency will supposedly come from the lightweight aluminium structure – though the final weight was not specified (the R1e weighs 920 kg). As in the case of the R1e, a single PM synchronous motor is on the front axle.

"Small Cars for a Big Future", Suzuki Automobile's theme this year, could easily be interpreted as 'small cars now lead to big cars in the future'. Their environmental direction must be a matter of internal debate or a result of their corporate lineage – the message was anything but clear. They are exploring environmental options, but their cars are growing larger. For example, they presented the Kizashi 2 concept vehicle with obvious Western influence and the highest-displacement engine ever used by Suzuki – from an environmental perspective an apparent case of counter-productive technology transfer. And at the same time they displayed their awareness of the personal transportation needs of a growing part of the population. Not 20 meters away from the Kizashi 2, they displayed their latest fuel cell-powered wheelchair and presented a new 'people-centred' concept called Sustainable Mobility – which focuses on one-person low-speed transport devices that can be coupled with 'sharing systems'. This is a noble

idea for those that cannot drive personal cars, but also could be interpreted as an attempt at personal isolation in a crowded environment. Suzuki describes the system of personal, shareable urban transportation as in line with the Japanese Ministry of Economy, Trade and Industry's Next-Generation Vehicle and Fuel Initiative, which is aimed at realizing the world's most people-centred motorized society. This would be good material for a sociological debate supported by adequate quantities of beer and/or sake.

Kizashi 2 Concept – Image Now, Efficiency Later

A crossover sports wagon was presented with an 'emotionally appealing shape that reflects a dual focus on status and vitality' and a 3.6-liter V6 engine – obviously targeting the up and coming professional that depends on his/her car to make the first impression. The only interesting aspect of this concept is that Suzuki is supposedly pursuing hybrid technologies for this vehicle "for superior environmental performance".

Sustainable Mobility – PIXY and SSC Concepts

This people-centered concept is included in this report because the propulsion system is electric and it provides a glimpse of transportation options being considered for urban environments in the rest of the world. The idea is simple – one-person vehicles designed for low-speed operation on sidewalks or inside buildings (PIXY) could be coupled with a variety of larger vehicles (with higher performance capability and range) that are shared with other one-person vehicles. Options include the SSC (Suzuki Sharing Coach), which was demonstrated with PIXY at the show (below), as well as sports car (SSF) and boat (SSJ) units that are left to our imagination.

MIO FC SeniorCar Reference Model

The latest version of Suzuki's electric cart replaces the lead-acid battery with a Direct Methanol Fuel Cell that provides capabilities well beyond that of the typical electric wheelchair. The range is increased to 60 km on 4 litres of 34% methanol-water solution. And a cartridge of methanol solution can be carried for emergencies.

“Harmonious Drive”; Dominant Technology

Toyota continued to support their environmental message – a future society where cars will be driven in harmony with people and the environment. And they are in a good position to influence the market; they lead in hybrid technology, enjoying the fact that ‘hybrid vehicle’ means ‘Prius’ to most potential customers. And in addition to the environmental mainstream Prius buyer, they lead in the premium hybrid market as well (with their Lexus brand). Their new ideas and continuing spread of environmental technology through their product lines illustrates that that they are not standing still while the competitors try to catch up; and they might even change the rules of the game in the meantime.

The Prius resulted from a loud bark (without much bite) about hybrid vehicles in the US. The same thing could happen with PHEVs if the Japanese take the lead in Li-ion battery technology. Since competitive energy storage technology is critical to a viable hybrid vehicle strategy, then *Toyota will spend whatever is necessary to develop/acquire the critical technology*. They were spending over $1B per year on environmental technology a decade before getting into the hybrid vehicle business. Most of their global competitors ridiculed them for producing non-profitable vehicles and said that it could not be sustained. Toyota has since become the No. 1 automaker and hybrids will become the standard over the next decade – mainly due to Toyota.

1/X Lightweight PHEV Concept

This ability to initiate and profit from the hybrid vehicle market has many wondering about the future prospects for their latest technology on display at the show – a mock-up of a lightweight Prius replacement with a carbon fiber reinforced plastic (CFRP) body – called the 1/X (pronounced one-xth as in a fraction of normal consumption). The light weight (1/3 of the Prius) hybrid would certainly be revolutionary if produced. Though their business case was likely based on their aircraft business, Toray Industries, part of the same keiretsu as Toyota (the Mitsui Group) and a Boeing supplier of aircraft body components, recently announced substantial expansion of its CFRP sheet manufacturing capability and established an automotive technology center in Nagoya, Japan. If they are able to develop technology and profit from the aircraft business, then expansion to automotive might be relatively incremental – this is certainly worth watching. The 1/X was described as a plug-in hybrid, as was the Hi-CT concept, and their press materials said that they had begun testing their PHEV in Japan, Europe and North America ‘as a step toward commercialization’.

Though a mock-up, the CFRP body displayed meaningful design intent, such as reinforced joints and thoughtful structural elements (e.g., floor and column interface details). The propulsion system represented a 2-cyl. 500 cc engine, electric motor and generator in one package beneath the floor. Toyota does not manufacture an engine this small, but Daihatsu (part of Toyota) is Toyota’s small engine technology leader. And one of the Yamaha hybrid motorcycle concepts had a similar propulsion system. The combination of the lightweight body (with essentially the same interior space as the Prius) and the hybrid propulsion system would weigh 420 kg, with a target of twice the fuel efficiency of the Prius.

Hi-CT PHEV Concept

The decal on the fuel filler door (inset) identifies this as a PHEV. The vehicle design is unusual, like a cross between an 18-wheeler and a Scion, but it is intended to make you think of a gorilla (they actually said that). But at least they recognized the importance of, or interest in, plug-in hybrids. Look for more serious PHEVs from Toyota in a couple of years.

Crown Hybrid Concept

This was the logical upgrade for the Crown. A conservative luxury sedan in Japan (essentially the same target market as the Cadillac Brougham in the US), it was available as a mild hybrid in the old body style; outdated when it was introduced considering other Toyota hybrid technology available. But with the updated body style (similar to the Lexus) and the very sophisticated hybrid propulsion system in the 600h, the perceived difference in these luxury hybrids was simply too great. And this could be a deal if it costs less than the $120,000+ price of the Lexus 600h.

FT-HS Hybrid Sport Concept

Toyota must build a hybrid that meets the needs of young, performance oriented drivers if they are going to get away from the Prius image (as a car for 'environmentalists' only) and, on a larger scale, avoid the reputation of a 'vanilla-flavored' car producer that market leaders have had in the past. And their primary competitor in this segment is Honda, with their independence and a history derived from motorcycles – very close to the image that the street racers (or wannabes) relate to. And now that Honda has anted up the CR-Z high-performance hybrid concept that appears very likely to make it to production, Toyota will have to match the bet. The Toyota concept is impressive from an image perspective – very aggressive and aimed directly at the same target market as the Honda. Technically, it will have a hybrid synergy drive that takes advantage of all the new engine and driveline technology that Toyota/Lexus has developed, but this vehicle will likely have a lightweight, high-power Li-ion battery (or perhaps a capacitor system).

Truck Technology

This is the first time in many years that passenger cars and commercial vehicles have been combined at the Tokyo Motor Show and most truck manufacturers were somewhat cautious, responding with fewer, smaller, less comprehensive displays than would have been prepared for a dedicated show. They probably expected to be overlooked by the public and journalists because the automotive press conferences and concepts are more exciting and all on the first press day – and they were right – many journalists did not stay for the second press day or make their way to the venue that combined suppliers, trucks and motorcycles.

However, Mitsubishi Fuso took the opportunity to present some new and interesting vehicle concepts (examples of models shown) to express their optimism about the future of trucks and demonstrate their environmental awareness. They are the designated corporate HEV Competence Center and, unlike the passenger car hybrid activity, were not affected by the DaimlerChrysler split.

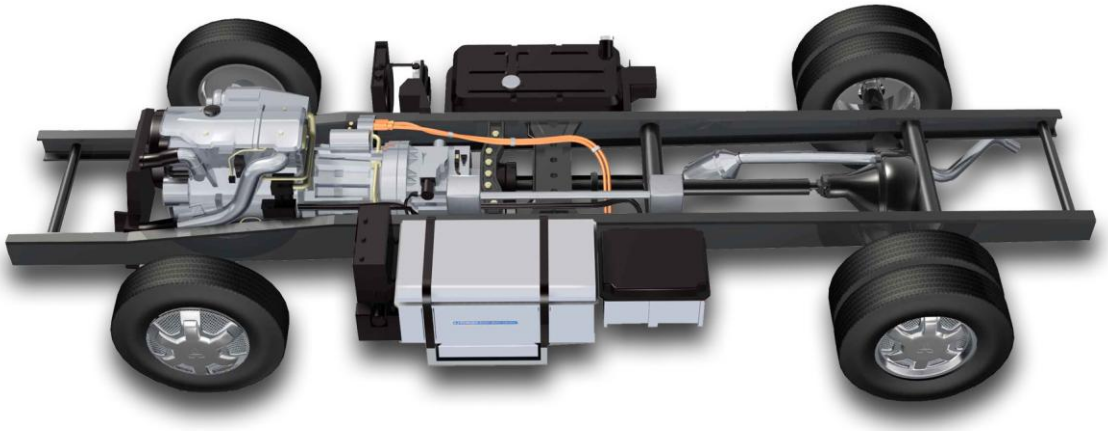
In addition, Isuzu displayed the limited production Elf Hybrid (50 vehicles per month), but it has been discussed in previous reports.

Canter Eco-D Concept

Mitsubishi expanded the perceived relevance of hybrid technology by applying it to a light-duty dump truck – pointing out the benefits in an urban setting, e.g., low noise levels and emissions when performing tasks such as road maintenance/repair, landscaping, etc. In fact, dump trucks are noticeable in Tokyo supporting many local road projects; it would enhance the image of the company or municipality that utilized it. Also, the impressive styling lends credence to their progressive approach to future trucking (i.e., the medium- and heavy-duty styling studies above).

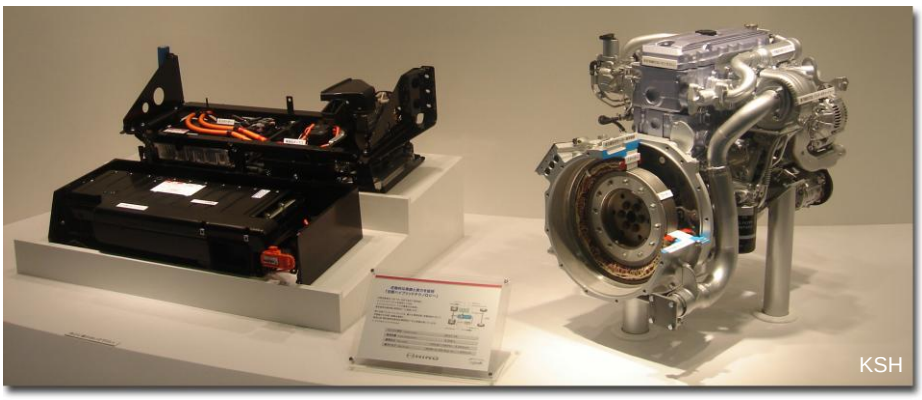
The Eco-D utilizes the same parallel hybrid configuration and power-assist control strategy as the Canter Eco Hybrid that has been in limited production since mid-2006. The primary technical difference is that the Eco-D utilizes the electric motor instead of the engine to provide power take off functions such as raising and lowering the dump body, which significantly reduces noise and emissions during this operation.

The basic layout of the powertrain system is shown below – typical of body-on-frame commercial vehicles – with the electric drive motor packaged in-line with the transmission and the battery box and control systems mounted outboard of the main frame rails. It is relatively easy to envision, as Mitsubishi has, the use of this chassis as the basic element of numerous commercial applications of hybrid technology, such as lifts or cherry pickers.



Fuso also showed their future heavy duty truck engine (12.8-15.6 liter displacements), with little detail other than the use of SCR, as well as a 12-speed mechanical automatic transmission. But the main point they made is that this is the first heavy duty 'global' engine, sharing 90% of the parts for US, European and Asian markets.

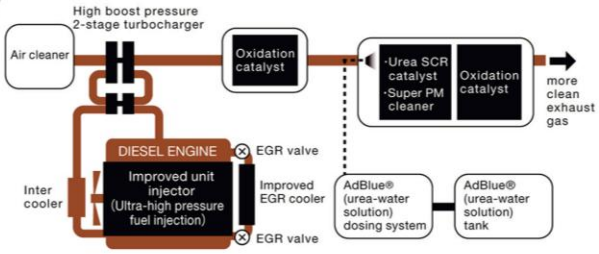
HINO



Hino is a member of the Toyota Group and benefits from the developments of Daihatsu, Aisin, etc. They have explored a variety of hybrid systems/components in the past, ranging from 'conventional' hybrid systems to hydraulic power assist and gas turbine series systems. But their hybrid technology display was somewhat conservative this year, choosing to display only their 4-liter engine and parallel drive system (shown in the figure above).

Their main technical exhibit was the new 8.9L A09C engine (right), which supposedly performs like a 10.5L engine. In addition, it meets the new 2015 ("new long-term") emissions regulations when combined with 'DPR', their Clean Diesel System.

UD NISSAN DIESEL



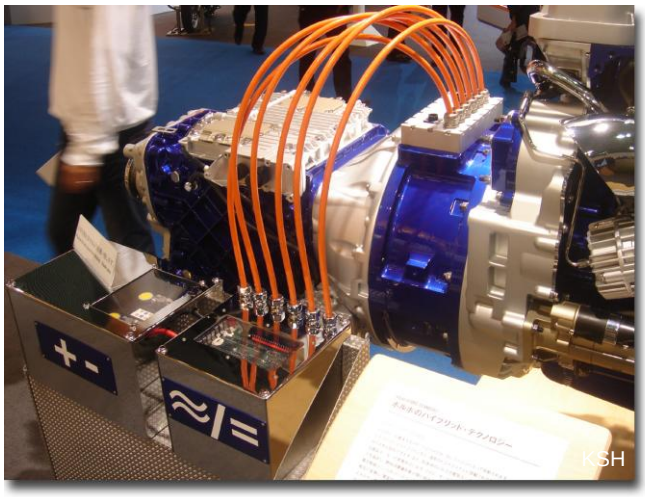
Their main focus, like most truck manufacturers, is emission control technology on their heavy-duty trucks, with the current approach being engine development for efficiency (with some PM and NOx reduction) and SCR after-treatment for NOx reduction.

Their plans for the next generation advanced emission control technology encompass improvements in the engine and after-treatment, as summarized in the graphic. Engine-out particulates are further reduced by increasing the fuel injection pressure. A 2-stage turbocharger and high levels of EGR are applied to reduce NOx in conjunction with the urea SCR system.

VOLVO

I-SAM, Volvo Truck's Integrated Starter-Alternator-Motor hybrid system was described in the Hannover 2006 report, but this was its Japan debut.

The technology, which is being tested with their 9-liter engines in Sweden, reportedly reduces fuel consumption and CO_2 emissions by up to 35%. However, in response to questions regarding the potential popularity of the concept in Japan, local representatives of Volvo Truck commented that it was not yet perceived as beneficial due to the loss in payload (due to the weight of the hybrid system). This does not have a significant environmental impact since there are only 2,500 trucks in Japan though Volvo has been selling directly in the market for about ten years.



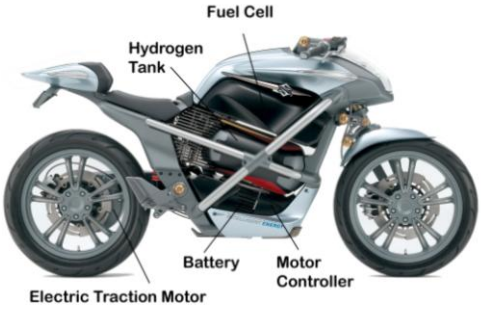
Small Engine/Motorcycle Technology

Suzuki says that if optimization of well-to-wheels energy is the objective, then efficient two-wheeled vehicles should not be overlooked; they can be major contributors to petroleum displacement and air quality. They pointed out that compact motorcycles use far less resources than automobiles to construct, alleviate congestion and cause less damage to road surfaces – in addition to the obvious efficiency advantages of small displacement engines. Some interesting environmentally friendly developments were presented at the show, including a fuel cell vehicle and a 3-dimensional-cam for variable valve lift – especially interesting since it can be readily utilized on a variety of their engines to improve efficiency.

Air-cooled Fuel Cell Hybrid 'Crosscage'

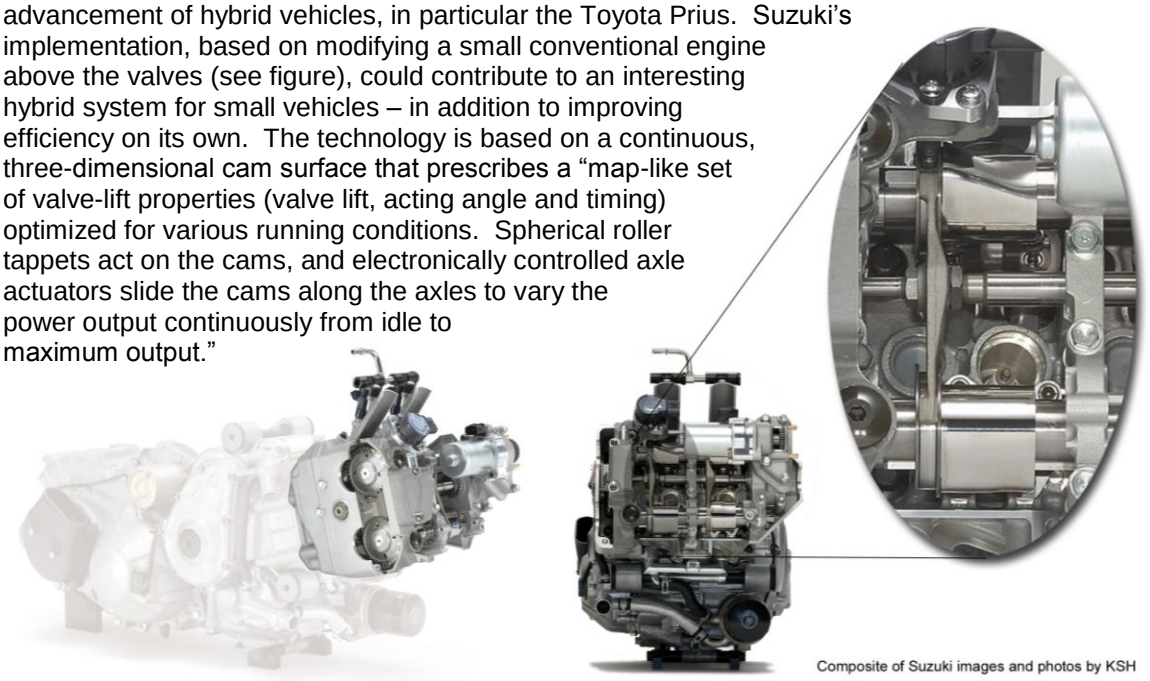
The key components of this system are the fuel cell by Intelligent Energy, a U.K. company, and the NEC Tokin-made lithium-ion battery. Intelligent Energy has been talking production for several years, announcing a partnership with Boeing to develop a fuel cell powered plane about 5 years ago and a slick motorcycle (called the ENV) was to be offered for sale to the public by 2006.

Despite the apparent delays, the fuel cell remains interesting because of the air cooling that eliminates the liquid cooling components as well as the design that does not require a humidifier or hydrogen pump – the only auxiliary component is a low-pressure blower fan. Start up supposedly takes only a few seconds. No details were provided for the fuel cell system in the Crosscage, but the ENV had a 1 kW unit.



3-D Cam for Variable Valve Lift

Variable valve timing has played a critical role in the introduction and advancement of hybrid vehicles, in particular the Toyota Prius. Suzuki's implementation, based on modifying a small conventional engine above the valves (see figure), could contribute to an interesting hybrid system for small vehicles – in addition to improving efficiency on its own. The technology is based on a continuous, three-dimensional cam surface that prescribes a "map-like set of valve-lift properties (valve lift, acting angle and timing) optimized for various running conditions. Spherical roller tappets act on the cams, and electronically controlled axle actuators slide the cams along the axles to vary the power output continuously from idle to maximum output."



Composite of Suzuki images and photos by KSH

At low-output, low-rpm range, the valve lift and acting angle are kept small and valve-closing timing quick for a Miller-cycle operation (compresison stroke shorter than expansion stroke) offering better fuel efficiency. At high-output, high-rpm range, the valve lift and acting angle are both larger than those for similar-sized conventional engines, making possible more power and torque output. Since the 3-D cam also varies timing, there is no need for a variable-valve-timing mechanism, resulting in the compact design.

In addition pumping losses are greatly reduced due to the elimination of the throttle. Suzuki has measured (in-house) 20% improved fuel consumption and up to 6% more torque throughout the speed range.

Paintless Technology to Reduce VOCs and Improve Recyclability

Though not quite as interesting as new engine technology, Suzuki has developed paintless plastic parts to reduce the output of volatile organic compounds and eliminate the need to remove the paint layer when recycling. This translates to developing compounds that have a durable, attractive surface despite years of exposure. Typical applications include the silver-metallic clutch cover on the Skywave as well as the Pallet and Address series motorcycles in Japan.

YAMAHA

Yamaha has produced electric bikes before, but their most relevant developments are hybrid systems, and applications of their integrated electric drive and Yamaha fuel cells.

Tesseract Multi-Wheeled Hybrid Concept

The liquid-cooled V-Twin engine and electric drive are interesting because they offer some insight into how small, lightweight (more conventional) environmental vehicles might be powered in the future. For example, this system is not too much of a stretch from that required for the Toyota 1/X concept vehicle. The engine could be transformed to an almost horizontal configuration (with parallel cylinders) to allow the below-floor mounting as in the 1/X.

Luxair Hybrid Concept

A more conventional motorcycle chassis was chosen for the Luxair hybrid concept, with the advantage that their YIPU (Yamaha Integrated Power Unit – flat brushless dc motor, controller, planetary transmission and drum brake packaged on the integrated swing arm and hub) can be utilized. The motor provides power assist, regenerative braking, reverse and for walking with the bike.

Plug-in Hybrid Fuel Cell Scooter Concepts

Yamaha showcased their accomplishments with direct hydrogen and methanol fuel cells. The FC-AQEL (left) uses hydrogen compressed at 35 MPa in two 4.7 liter tanks. The FC-Dii uses a 54% methanol mix to power a 1 kW DMFC system that is 30% efficient. A removable secondary Li-ion battery that can be removed for charging separately is used in both cases.