ENGLISH

VALEO TECHNOLOGIES ON THE ELECTRIC VEHICLE SHOW CAR

valeo added

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Valeo presents its innovations for electric vehicles

On its stand at the Paris Motor Show, Valeo is presenting an electric show car that features its innovative technologies especially developed for electric vehicles.

Valeo already has a wide range of technologies that reduce CO_2 emissions from ICEVs, and is now expanding this offer to include high-performance, affordable solutions specific to electric vehicles and capable of being mass produced. These offers include the powertrain components and heat management systems, and comfort, driving and safety equipment.

Demand for personal transport is constantly on the rise, but society strongly disapproves of current solutions. Emissions from internal combustion engines vehicles (ICEVs) have been blamed for contributing to global warming and atmospheric pollution, and oil reserves will not last forever. An alternative to the internal combustion engine has therefore become indispensable, and electric vehicles are one of the realistic solutions.

They are a perfect fit for current challenges insofar as the electricity is largely generated by non-fossil sources. They therefore produce no local air pollution or greenhouse gases, and are particularly noiseless, easy to drive, with good acceleration. Only their range remains lower than that of ICEVs.

Electric vehicles have a battery in place of the tank on an ICEV, one or more electric motors in place of the engine, and an electronic control unit in place of the peripheral equipments like fuel injectors, ignition etc. The vehicle is easy to charge, being simply connected to the grid, either on a normal “slow” connection through a standard electric socket at home or at the office, or on a “fast” connection at a dedicated charge point like those found in cities. An electric vehicle can therefore offer the same levels of comfort, safety, driving pleasure and performance as an ICEV.

The greatest industrial challenge is not to produce an electrically powered vehicle, but to design a high-performance electric vehicle for an affordable cost, whose performance is comparable to ICEVs, range excepted. This is a vital precondition for making electric propulsion a realistic, tangible solution. Valeo has therefore joined five French industry leaders—Leroy-Somer, Johnson Controls, GKN, Michelin and Leoni—in a consortium, in order to pool their skills and expertise to offer automakers a complete electric driveline.

A consortium to promote an electric drivetrain industry for electric vehicles

• Development of the entire electric drivetrain

• Economical, lightweight and high performance drivetrain

Valeo has committed to developing new electric vehicles, and its ambition is to deliver innovative, avant-garde solutions. Its objective of offering automakers a complete electric drivetrain has led to the creation of a consortium of French technology leaders. The purpose is twofold: innovating in the best technologies, and developing every component with the aim of producing the best possible vehicle. All products share common specifications in terms of fuel economy, performance enhancement, and weight reduction throughout the drivetrain.

The consortium members are industry leaders specialized in each of the fields that cover the electric drivetrain.

- **Valeo** is involved in two major drivetrain functions: control electronics and the vehicle's heat management. The Group has expertise covering the operation of the motor, vehicle safety, battery autonomy and climate control for the passengers.
- **Leroy Somer** supplies the motor-generator that drives the vehicle and recovers energy during deceleration in order to recharge the battery. Its new generation synchronous motors are compact and reliable; they increase the vehicle's range and provide excellent driving performance.
- **Johnson Controls** is world leader in lead-acid batteries for vehicles and advanced batteries for electric and hybrid vehicles. The Johnson Controls-Saft joint venture is the first company in the world to product lithium-ion batteries for mass-produced hybrid vehicles, using a technology that has been optimized for safety, lifespan and cost in order to equip electric vehicles.
- **GKN** completes the drivetrain with an axle reducer and axle shafts. These components transfer the motor's power to the wheels with minimum loss, noise and vibrations.
- **Michelin** supplies tires with very low energy consumption that help to extend the range of electric vehicles, a performance that compromises neither vehicle safety nor tire lifespan. Via the Active Wheel project, Michelin will also contribute its expertise in running gear and wheel-mounted motors.
- **Leoni** develops high-voltage wiring that connects the various parts of the drivetrain—electric motor, battery, inverter, converter, etc. A wide range of products with optimized weight and cost, covers all the configurations and needs of electric vehicles.

Power control unit

- **Innovative combination of the inverter and the charger generates significant reduction in the cost of the electric drivetrain**
- **High-efficiency inverter boosts autonomy in electric only mode**
- **Failure tolerance, with electric motor able to function in degraded mode**

The power electronics unit includes three major parts: the inverter, charger and the DC/DC converter.

The inverter is responsible for supplying current to the electric motor according to the torque required by the driver. The electric motor and the inverter are inseparable, just like the ignition and injection systems controlling a gasoline engine. For a three-phase electric motor, the inverter transforms direct current (DC) from the battery into alternating current (AC) with variable frequency and intensity.

The charger allows the battery to be recharged, just as we fill the fuel tank of an internal combustion engine vehicle (ICEV). In electrical terms, it is the opposite of an inverter: the AC voltage is turned into DC voltage that is compatible with the battery. The charger performs this function within the safety constraints of lithium ion batteries, constantly communicating with the battery management system (BMS).

The DC/DC converter transforms the high voltage of the drivetrain battery into 14V for the car's comfort and driving systems. It is known as a DC/DC converter since it only converts DC voltage to other voltage levels. It performs a similar function to the alternator in a traditional engine, charging the vehicle's 12V battery.

Elements shared by the inverter and the charger

The inverter and charger have identical, albeit reversed, electric roles: transforming DC voltage into AC voltage at different levels. Reducing the cost of systems is one of Valeo's priorities, and the Group has developed a single architecture in which some elements are shared—elements that are never used at the same time and have an identical electrical structure, such as the inverter and its motor, which are not used when the battery is charging.

Valeo's innovation is to use the inverter and the electric motor windings when the battery is charging. It is the coils in the motor that provide the necessary induction (using their own inductance) to convert the energy that supplies the current to recharge the battery. This innovation cuts costs, as well as the size and weight of the electronics.

The inverter has a " triple H bridge " configuration, allowing the charging system to be connected to the end and to the central points of the motor phases. Another advantage of direct benefit to the user is that the operation of the three-phase motor is unaffected if one of the phases becomes inoperative. This is impossible with a conventional inverter using a three-phase full bridge, electric structure normally found in current electric cars. Valeo's system also uses a supply voltage that is adaptable to a range between 200 and 410 V.

Increased range

The range of an electric car depends not only on battery capacity and the energy required to move the vehicle, but also on the efficiency of its control electronics. Valeo's engineers have therefore sought to maximize the efficiency of the inverter to reduce electrical losses between the battery and the motor.

For example, the operating voltage of the motor has been raised, which reduces the current passing through the components. This lowers the maximum current from 550 A to just 70 A, reducing resistive losses so heat losses of the inverter therefore energy losses from the whole system. Intrinsic losses in the electric drivetrain are cut by 20%.

The right offer for the market

As a global supplier, Valeo must offer realistic solutions to electric car manufacturers, i.e. high-performance solutions that are applicable to mass production for an affordable cost.

For example, the quantity of silicon in the inverter has been cut by 40% compared to current models, mainly by raising the operating voltage. And in addition to the shared elements between the charger and the inverter, the converter shares the same heat exchanger. The close integration of the three power electronics components cuts assembly costs and increases reliability. It is made possible by a Valeo-developed power module that uses an innovative technology for bare-die assembly on copper lead frames. Valeo has already applied the principle of close integration in a product that is currently available on the PSA Peugeot Citroën e-HDI range—the i-StARS starter alternator, which offers a noise and vibration-free stop-start function, integrates both the rotating machine and its power electronics into a single unit.

THE SUPERVISOR

A program with the best compromise between range, performance and comfort

To limit fuel consumption in an ICEV, it is standard practice to manage electrical energy between the different functions—charging the alternator during deceleration, shutting off the de-icing of the rear window when fuel is low, shutting off the radio fifteen minutes after cutting the engine, etc.

In electric cars, it is even more important to optimize the use of energy in order to increase range. This role is attributed to the "supervisor", which acts as the brain of the vehicle, with a global vision of all onboard systems. At any time, it takes the right decision to reduce consumption, optimize battery charge, and provide passenger comfort.

The supervisor manages interactions between a great many components: the inverter, charger, converter, battery, braking system and comfort and driving functions. It takes account of the battery parameters, such as charge level and temperature, in order to authorize or restrict the operation of auxiliaries and to set priorities. It also interfaces between the energy recovery system and the braking loop to optimize battery charging while providing maximum vehicle safety. As another example, if the distance to be traveled is known, it manages the compromise between climate control (heating and air conditioning) and range.

Thermal management

- Cooling the driveline and heating the cabin
- High energy efficient air conditioning
- Battery thermal management

Electric vehicles have multiple thermal management needs which are more numerous and complex than those of an internal combustion engine vehicle (ICEV). The system must cool the electric motor and electronics and provide thermal comfort for passengers both in summer and in winter. It also impacts the range of the vehicle, and battery durability and reliability.

For Valeo, as a global expert in automotive thermal management, it is not enough just to offer a simple adaptation of the ICEV cooling and heating circuit. The Group has therefore designed a completely new architecture, with three fluid loops operating at different temperatures. The main water loop cools the drivetrain and heats the cabin, the refrigerant loop cools the cabin and the third loop, also a water loop, provides thermal management for the battery.

This global architecture optimizes energy flows in order to guarantee both the reliability of the drivetrain components and maximum range.

Cooling the drivetrain and heating the cabin

The main water loop cools the driveline and heats the cabin. This hot loop uses equipment that is standard on internal combustion engine vehicles (ICEVs). The front water radiator is adapted to a low coolant temperature flow and a fan located in front of it, turns on when necessary. Compared to the fan on an ICEV, it has been designed for a longer lifespan, since it is required to operate during battery charge. With its reduced speed and specially shaped blades, it is also totally silent, allowing the vehicle to be charged at night, for example.

However an electric vehicle must offer the same level of thermal comfort as a conventional vehicle. Since their highly efficient electric motors generate very little heat, it is essential to find a way to heat up the cabin without impacting the vehicle's range or cost.

Valeo has therefore developed a thermal accumulator that can store a considerable amount of heat when the vehicle is charging at the grid charging point. It is a thermally insulated box containing a special material which stores the heat and redistributes it through a water circuit connected to the vehicle's heating system. The complete system includes a heating resistance and a water pump. The thermal accumulator has been specially designed for easy integration into the vehicle. This ensures the cabin can be heated for a certain time without depleting the battery. As a result, the additional range generated by this concept represents about 10% in one urban journey at an outside temperature of around 0°C. Alternatively, for equivalent range, automakers can opt to reduce vehicle costs significantly by using fewer battery modules.

Valeo is also developing a range of innovations adapted to different types of vehicle and usage, to restrict the energy required for cabin heating. These solutions offer different trade-offs between the amount of energy recovered, the complexity of the solution itself and the additional cost incurred.

In the right conditions, the drivetrain cooling circuit can contribute additional heat to the cabin loop.

Some of the thermal energy contained in the cabin air can be recycled or recovered rather than being evacuated from the vehicle.

Valeo is also developing several architectures of heat pumps, which offer the advantage of extracting energy from the air.

High energy efficient air conditioning

The second thermal loop involves the A/C system.

Valeo has optimized the compressor's technology in order to meet the specific needs of electric and hybrid vehicles. Unlike ICEVs, it is driven by a dedicated electric motor, meaning that integration into the engine compartment is more flexible, and that the system can operate while the vehicle is stationary, which is not possible for an ICEV. The optimized scroll compressor is designed for achieving low noise and vibration level, a distinctive benefit in the light of the low noise levels in electric vehicle cabins. The scroll technology compact and highly efficient, as well as the performance of the brushless electric motor, result in reducing significantly current consumption. It also increases the overall efficiency of the climate system because of the presence of an oil separator. The compressor is compatible with the R1234yf refrigerant fluid in line with future EU regulations.

Battery thermal management

Thermal management of the lithium-ion battery is of paramount importance, since this is what determines the battery's capacity to store and deliver energy, its durability and reliability. The battery's optimal operating temperature is between 20°C and 30°C, whatever the conditions of use (charging, running) and outside temperature, and this temperature must be evenly distributed across all cells, in order to guarantee homogenous ageing.

In this architecture, the third loop ensures battery thermal control by circulating conditioned water through the box. Energy for heating is drawn from the main loop, and for cooling from the refrigerant loop.

Depending on the automaker's requirements and needs in terms of efficiency, cost or standardization, Valeo also offers alternative solutions such as cooling by air circulation, direct cooling, or a thermo-electric reversible hot-cold system.

LED lighting

- **Night range increased by 2%, and far more in heavy traffic**
- **Style signature for daytime running lights and low beams**
- **Great design freedom for all kinds of vehicle**

LEDs are everywhere in the modern environment—on TV screens, street signs and pocket torches. The inexorable displacement of incandescent lamps by this electronic light source has now reached the automotive industry. The low energy requirement of LEDs is particularly useful in electric cars, which offer the same levels of safety and comfort as ICEVs (internal combustion engine vehicles).

LEDs (Light Emitting Diodes) are electronic components that generate light when crossed by a current. They have many advantages, including very high energy efficiency. Halogen bulbs, for example, require 65W in low beam mode, but LEDs only need 12W to produce the same light. This reduces pressure on the battery, sparing more charge for propulsion. The instant power-saving from LED low beams and front and rear position lamps increases night range by 2%. In heavy traffic, with the vehicle moving slowly, the increase is even greater. At very low speeds, the intensity of the light can be optimized to reduce the power requirement even further, something impossible to achieve with halogen bulbs which emit reddish light in these circumstances. Moreover, for the equivalent quantity of light (in lumens), white LED light is closer to daylight, enhancing human perception by 25%.

Unlike halogen lamps, LED lighting is extremely compact and can be distributed across several light sources. This frees designers from space constraints and gives them full rein to express their talent. When the LEDs are lit, they can call on the multiple light sources to create a signature for their brand or model. LEDs also offer great design freedom by making it easier to adapt the lighting to the nature of the car—city driving or long-haul travel. The same applies to active functions such as bending light and speed-adjusted range, as well as city lighting which optimizes the width of the beam.

Safety is increased at the rear of the vehicle by the faster ignition of LED lamps. An LED brake light is visible 0.2 seconds earlier than a tungsten bulb, shortening braking distance by 6 meters at 120kmh. Designers will also appreciate the LED's ability to produce red or orange light without needing a colored bulb, which gives them significant freedom to define the colors of the rear lamps.

Finally, there is no need to replace LEDs since they last far longer than the car itself.

AquaBlade® system

- **No impairment of visibility during windshield washing**
- **2 kg weight saving**
- **Reduced washer fluid usage**

Despite countless changes since the early days of the automobile, no device has yet replaced the windshield wiper originally patented in 1907. Today Valeo is revolutionizing windshield washing by removing the nozzles which spray the washer fluid. The innovative AquaBlade® is fitted with one or two tubes which distribute the fluid evenly via a series of tiny holes along the length of the blade. As soon as it is deposited, the washer fluid cleans the windshield and is immediately wiped away by the blades.

One of the advantages of this new concept over the nozzle system is that it avoids wasting washer fluid. With nozzles, spray quality varies according to vehicle speed and wind, soaking the roof when stationary but failing to reach the upper part of the windshield at high speeds. AquaBlade® injects just the right amount of washer fluid in front of the blade, halving both fluid consumption and the size of the reservoir. In electric cars, this weight advantage of up to 2 kg helps increase the vehicle's range, and decreasing the consumption of washer fluid also helps reduce the vehicle's maintenance costs.

AquaBlade® also improves safety, both by ensuring that the windshield is perfectly cleaned at any speed, and by eliminating spraying which may temporarily reduce visibility. Since spraying can take up to 1.5 seconds, visibility is reduced for 21 meters at 50 kph and for 54 meters at 130 kph. AquaBlade®, however, maintains optimal visibility.

The system can use either one or two washer distribution tubes. The fluid is piped through one tube at a time in order to ensure instant wiping. Wiper position is therefore determined with precision, and the fluid pump, which is activated in a synchonized way with the wiper motor(s), sends the washer fluid through alternate tubes depending on the direction of the wiper blade.

AquaBlade® will be available on the market as of 2012.

Dual direct drive synchronized wiper motors

- **Weight advantage of up to 30%**
- **Noiseless wiper operation, in keeping with the low noise level of electric vehicles**
- **Extremely compact system offering new styling possibilities**

The drive system is the invisible part of the wipers, and it takes up considerable space in terms of integration into the vehicle. The Dual Direct Drive Motor is a completely new motorization concept for the windshield wipers. Most notably, it involves the separation of the two arms. Unlike a traditional system, in which they are connected by the linkage and driven by a single motor, each arm has its own motor, and the two are electronically synchronized. The second major innovation is the alternate movement of the arms, which is not produced by a traditional cam/rod system, but by the motor itself, which changes direction of rotation at the end of each sweep.

This ingenious arrangement has many advantages, some of which are especially useful in an electric vehicle. The elimination of the linkage and the replacement of the bulky drive motor with two smaller direct drive motors reduce the weight of the system by up to 30%, or 1.7kg, and any weight saving increases the electric vehicle's range. A new generation of motors will be out soon, shaving off an additional 300g, offering greater efficiency and higher torque. Since electric vehicles are particularly quiet, passengers will appreciate the noiseless wiping across the windshield. Most of this noise is generated by the slight tipping of the blades as they change direction, and since the motors are controlled electronically, they can slow down this action at the critical point in order to eliminate noise completely.

The absence of linkage and the compact motors facilitate the integration of the wiper drive system. In some extreme arrangements, this advantage is particularly useful. Cars with high windshields, for example, require the wiper axes to be as far apart as possible while in a car such as the Mercedes SLS AMG, the V8 6.3 engine of the takes up part of the space given to the wiper drive in the initial model (first application of this technology on parallel wipers). Electric cars are not suited for a conventional vehicle architecture, largely because of the compact nature of their driveline and the space required for the battery. Electric vehicle designers have greater freedom in windshield and hood styling; direct drive synchronized wiper motors will add to this.

In conventional systems, wiper speed can vary according to air speed and the quantity of water sprayed onto the windshield. With electronically managed motor speed, wiper speed remains constant at all times, offering greater user comfort and increased safety. The surface cleaned by the wipers is also increased, because the two end limits are calculated to within 0.5 degrees, which allows them to go as far as possible to the edge of the windshield. Electronic motor management also allows wipers to avoid jamming and change direction if they encounter a large obstacle, such as a block of ice on the windshield. This intelligent control system maintains wiper quality without affecting the movement of the other wiper, and preserves the system's working life.

Detection systems

- Targeted sound signal for pedestrians
- Assisted docking for automatic connection
- Saving energy by adapting to traffic flows
- Assistance with parallel, angle and perpendicular parking

New functions are needed for the specific requirements of electric vehicles, particularly in driving assistance and active safety. Valeo has a range of solutions based on ultrasonic sensors and cameras, tried and tested technologies that have now been widely adopted.

Targeted sound signal for pedestrians

The silent operation of electric vehicles is often quoted as a key advantage. Under 50 kph, the electric motor is practically the only source of noise, and is far quieter than an internal combustion engine (ICEV). This advantage is not insignificant, especially in built-up areas, but it can present a safety issue for pedestrians, who often cross the road without looking properly, reassured by the lack of engine noise. Valeo's smart solution is a pedestrian detection system that emits a warning sound towards their location. The advantage is that pedestrians on the vehicle's trajectory are alerted to its presence without generating unnecessary noise pollution. The detection system uses a camera facing forward at the level of the rearview mirror and ultrasonic sensors. The camera detects any pedestrians, the sensors confirm their presence, and a computer determines their position relative to the vehicle's trajectory.

This system can also work when the vehicle is in reverse using data supplied by a camera that can be located in the liftgate.

Assisted docking for automatic connection

Automatic connection allows the battery to be charged without the user having to use a cable and connect it to a charging point. An arm connects the charging point to the vehicle, but the system requires the vehicle to be very precisely positioned in front of the arm. The docking maneuver is made possible thanks to the fusion of the information received from the forward camera and ultrasonic sensors used by the vehicle for its forward parking assistance. As the vehicle approaches the charging point, the camera tracks the location and the target, and the ultrasonic sensors give the precision required to position the connector in front of the arm.

Saving energy by adapting to traffic flows

Both ICEVs and electric vehicles use considerably more energy with repeated speed variations. Valeo's forward camera, together with specific software, can reduce this consumption by adapting the vehicle's speed to that of the traffic. The camera takes account of the speed of the vehicle in front and the presence of traffic lights in order to warn the driver to release the accelerator immediately as soon as a braking action seems imminent.

Numerous new Driving Assistance solutions

A set of twelve ultrasonic parking assistance sensors, positioned as on the show car, offers a range of functions. There are four forward and four rear sensors, plus one in each corner for the Park4U® function, offering semi-automatic parking assistance for parallel, angle or perpendicular parking and assistance in leaving a parallel parking space. In addition to these functions, the forward camera allows the headlamps to switch automatically between high and low beams, BeamAtic® Premium (maximum high beam without glare), reading of speed limit signs and a lane departure warning. In conjunction with the rear ultrasonic sensors, a second camera placed on the liftgate detects pedestrians in the vehicle's trajectory when reversing.

Integrated man-machine control system

- **Improvement in perceived quality**
- **Design flexibility for very wide range of vehicles**
- **Electronic flexibility for easier integration and reduced costs**
- **Reduction in electric consumption**

An electric drivetrain may represent a different means of propulsion, but it is no different from other types of vehicle in that onboard comfort is of prime importance: a vehicle's perceived quality depends on the interior style and the ergonomics of the various man-machine interfaces on the dashboard. A good example of this approach is the production of a multifunction control panel that allows the electric architecture to be optimized and offers considerable design freedom.

This integrated control panel controls not only the heating and air conditioning systems, but also the audio equipment. Complementary functions such as navigation or any other new control can be added at the automaker's request, and its integrated screen can display such information as the level of air conditioning but can also be used for other purposes such as battery charge level.

Other Valeo-developed space-saving features can be added to the control panel, and the Group also offers additional switching solutions such as short-travel switches, and resistive or capacitive touch-sensitive surfaces, that not only enhance perceived quality but also offer innovative ergonomics and space-saving for greater design freedom.

These technologies help eliminate any issues involving alignment, sizing or gaps between switches. The use of touch sensitive surfaces gives designers increased freedom (the positioning of switches on complex surfaces), and enables a wide variety of materials to be used (increased perceived quality). Another advantage is a reduction in the number of physical parts, allowing a design freeze at a later stage in the development schedule.

This product uses modular electric architecture, which has the advantage not only of using standard technological bricks, but also of reducing development costs. This approach offers great freedom when it comes to managing product variants, while at the same time minimizing validation costs. Separating the calculator from the control panel also offers greater flexibility for integration in the dashboard. The use of the latest LED lighting technologies and a single display significantly cuts electric consumption.

Smart car key

- **Displays real-time battery level remotely**
- **Sets the cabin temperature remotely**

Today's car keys let you remotely control functions such as locking and unlocking the doors and activating the position lamps, but tomorrow's car keys will also be able to receive information from the vehicle. In an electric car, this extended function offers the driver information on the car's status. Is it connected to the charging point? What is the battery level? What is its current estimated range or its range within a given time? This precious information, specific to an electric car, lets drivers organize their trip or make sure that the battery is charging correctly.

Valeo's Smart Car Key provides this information via a color display of a modular size chosen by the automaker. Communication between the driver and the vehicle can also be reinforced by a beep or buzzer. To do this, the Smart Car Key uses a bi-directional radio channel that is more powerful than current remote controls. Depending on the environment, it can operate across a range of 500 meters, sufficient to communicate with the car from a home or office.

Another of the key's particularly useful functions is the ability to preset the climate control in the cabin before travel. Since heating and air conditioning are both highly energy-intensive, it makes sense to take energy directly from the charging point whenever possible, instead of getting it from the battery. The Smart Car Key can display current cabin temperature and reset it remotely shortly before departure. This offers the occupants cabin comfort from the beginning of the trip and extends the range of the car, especially if it has a heat storage system.

The Smart Car Key can also provide a wealth of additional information according to the specific demands of the automakers. This includes tire pressure and the remaining mileage before maintenance. The driver can also check whether the windows are closed properly.

The Smart Car Key also offers an additional service: it is a USB memory stick that lets you transfer files such as music or video from a computer to the car.