L'Automobile MAGAZINE
Passion & Expertise

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GREEN TRENDS

ANOTHER (INTELLIGENT) HYBRID IDEA

LC SUPER HYBRID PROJECT

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A **hybrid powertrain** is **really good** at **lowering consumption,** but **it's expensive.** By making alternative use of the electricity recuperated during braking, the LC Super Hybrid consortium proposal **reduces** the on-cost **to almost a quarter.** L'Automobile Magazine tested it. The verdict: **it's rather attractive**.

Exclusive

The Mubéa belt tensioner is optimised to minimize friction and guarantee the tension needed for high power transmission.

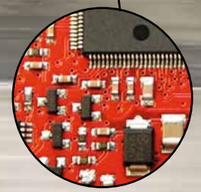
The starter-generator uses a switched reluctance electric motor, which is not expensive and gives high performance.

The "electric turbo" produces an additional 20 kW of transient power, while using just an additional 2 kW of electricity.

Photos Bruno Picault and CPT

The lead-acid battery has a carbon loaded anode for performance and low cost.

The fuel economy of a hybrid, but for a quarter of the additional cost.... An extremely attractive idea!



The integrated electronic control units allow precise control of these new components.

Over the last fifteen years that hybrid models have been developed, our tests carried out to the ISO 9001 standard have had time enough to prove the advantages that this technology brings in terms of fuel economy: around 30% in urban areas, 15% on highways, but practically nothing on motorways. However, despite these highly convincing results, hybrids have not taken off due to their high additional cost. It's true that in 15 years Toyota has sold over 3 million hybrid vehicles, but in relation to the global market, this is really very few. Last year in France, despite the large bonus which is generally given with them, they hardly exceeded 1% of the total volume of sales. In short, they have done nothing significant towards lowering the average consumption of the automotive parc, and therefore pollutant CO2 emissions.

Bruno Picault

HYBRIDS ARE TOO EXPENSIVE

To reach this aim, hybrids would have to be much more widespread, which means that they would have to be sold at a much more affordable price. This is exactly the long term aim of a consortium called LC Super Hybrid. The parties involved are mostly English, American and German, with some French. The key idea is that the hybrid components (electric motor, battery and electronic control unit) are too expensive to be widely used. Another solution must therefore be found, which is more affordable but no less effective, to store and intelligently use the energy recuperated during braking and deceleration.

The plan for this prototype which is based on a VW Passat 1.4 TSI (which was selected as it is a large saloon car powered by a small 1.4 engine) is based on three major innovations: a new-generation starter-generator which is more powerful and has an optimised belt tensioner, an innovative battery and more importantly, an electric supercharger. These components are connected to an integrated electronic control unit. Its promise – to offer the same improvements in fuel economy (thanks to downsizing the thermal engine as far as possible) as a Toyota Prius type hybrid (i.e. 30% reduction) but for a quarter of the cost! All this without affecting driving pleasure. A promise too far perhaps? After testing this prototype for a significant time, we don't think so.

But let's take a look at how it all works. The basic idea is that in certain vehicles (Peugeot and Citroen e-HDi, Smart...) there is an electric motor which could help with traction if it were boosted a little: the belt-driven starter-generator. Usually with a power rating between 2 and 3 kW, this component could, with doubled or quadrupled power, give assistance to the piston engine during starting off and acceleration. We have already tested similar prototypes which were very convincing at Valeo (see AM no 784 and 792) which transmit power, via a belt, up to 12 kW. In the LC Super Hybrid prototype this starter-generator is water cooled. It is supplied by CPT (Controlled Power Technology), an English engineering company which is at the forefront of the use of switched reluctance electric motors. With no expensive rare earth magnets, this technology uses coils for the stator and a single press-fitted steel rotor whose poles are naturally aligned to those of the stator. The advantage – apart from the highly attractive price, the rotor is very light and as it has low inertia it can quickly reach high rotation speeds, giving high power levels in a compact volume. The downside is that controlling this motor remains complex. But as the performance of electronics continues to improve and the components become cheaper, the equation begins to balance. Compact, rapid, powerful and not too expensive, this 2.7 kW starter-generator is also capable of recuperating a lot of energy during braking and deceleration, which it then converts to electricity to be stored.

	Micro-hybrid	LC Super Hybrid concept	Mild hybrid	Full hybrid	Rechargeable hybrid
Examples of models	Smart mhd, e-HDi		Honda Jazz, Insight	Toyota Prius, Auris	Opel Ampera, Volvo V60
Electrical power	2 to 3 kW	3 to 10 kW	10 to 15 kW	20 to 50 kW	60 to 70 kW
Electrical assistance	None	20 to 35 kW*	<15 kW	> 15 kW	> 60 kW
Electrical range	0 km	0 km	0 km	Approx. 2 km	30 to 50 km
Fuel eco. and CO2 saving	4 to 7%	15 to 25%	8 to 12%	15 to 20%	>20%
Overall additional cost	150 to 700 €	750 to 1500 €	1600 to 3000 €	3000 to 5000 €	6000 to 10000 €
Add. cost/fuel economy	35 to 100 € / %	50 to 60 €/%	200 to 250 €/%	200 to 250 €/%	300 to 500 €/%

*12-48V + starter-generator + electric turbo + engine remapping + taller gearing + lead-carbon batteries

CARBON ELECTRODE

A new type of lead-acid battery is also used, similar to ones currently used for starting our cars, apart from the fact that the negative electrode is partially made from carbon. And that changes everything. With this innovation, the lead-acid battery can now be used to store energy, without

Behind the wheel, we're enjoying an already attractive proposition, while we wait for the 48V version with improved fuel economy.

affecting its life, as quickly as supercapacitors, while retaining better energy density and above all at an acceptable cost level. Only 50% heavier and more expensive (when in series production) than the standard Passat battery it replaces, the carbon electrode battery can provide 9 kW of power and has a storage capacity of over 1 kWh. This is close to what is provided by a nickel metal hydride battery (used on hybrids such as the Prius) which costs five times more for identical performance and still requires a lead-acid battery and additional 12V starter to start on cold days.

This large amount of stored electricity is then reused in the third major innovation – the electric supercharger from CPT, now badged as Valeo since the French company bought the English innovation in November 2011. Driven by a high speed switched reluctance motor, this 2kW "electric turbo" is capable of providing 90% of its 1.45 bar maximum boost pressure in just 1 second. This provides an additional 20kW (27 bhp) to the combustion engine. Once more this allows the engine capacity to be reduced to improve fuel economy. In concrete terms, for this prototype, the original turbo on the 1.4 TSI is boosted to work harder and reach the performance levels of the 1.8 TSI, approximately 150 bhp and 275 Nm torque (compared with 122 bhp and 200 Nm originally). It's a development which increases the turbo response time and which could have made this 1.4 laggy and very unpleasant to drive, especially as it's a large saloon weighing in at 1505 kg. But this latency is fully compensated for by the "electric turbo" which the electronic control system operates when needed, for a full second, which is the time needed to start the conventional turbo as soon as the driver requests power. A clever idea, which offers impressive efficiency, without forgetting that an electric turbo can also create savings , for example by doing away with the costly variable geometry found on turbodiesels. With such levels of torque available so quickly, the gears on our prototype can be made longer, without affecting driving pleasure or performance (they are those of the Passat TDI 140) which improves fuel economy further still. An additional point of interest for this ultrarapid "stop & start" system is that the 4 cylinder engine remains off for longer while in town. As the starter-generator is so powerful (and perfectly unobtrusive) it only restarts the engine of the 1.4 TI when the driver's foot releases the brake pedal to move across to the accelerator. Current models, including the excellent PSA e-HDi, must start the engine as soon as the driver lets the clutch out to engage first gear.

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MORE ECONOMICAL WITH 48V

The technology we have exclusively unveiled here is promising but remains in development and won't be on the market until 2015. However, despite the fact that the prototype we have driven runs so well now, giving the feeling of a large atmospheric engine with full power at all engine speeds, its electrical system still uses 12V and the boost function of the starter-generator was not activated. It still gave significantly better performance than an original Passat with fuel consumption lowered by nearly 11%. A new prototype is currently being built with a 48V system which will allow even more deceleration energy to be recuperated and the starter-generator boost function to be activated (10 kW and 95 Nm torque available in 0.3 s !), while allowing the "electric turbo" to work even harder. This should improve performance and lower consumption even more. We will be able to verify this soon, with our ISO 9001 standard tests. L'AM is the only magazine to carry out such tests in Europe, which the managers of the LC Super Hybrid programme found valuable.

Text – Christophe Conrega