The *Story* has been updated.

The Post Peak Car

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This is a guest post By Ugo Bardi and Pietro Cambi. Affiliations, ASPO- Italy and www.eurozev.org. It is a fantastic account of how a 1970s Fiat 500 has been retrofitted with batteries and an electric motor to create the Post Peak Car. Be sure to watch the videos linked to at the bottom of the page.

Fig 1. Chantal poses with the little 500 at the Ecoauto fair in Torino, Septamber 2007. It is not a toy car, it is Chantal who is a tall girl.

Fig 2. Nevertheless, Chantal can fit in, more or less. Picture taken at the Ecoauto fair, in Torino, September 2007.

It is always a shock when people understand that peak oil is about to arrive (or that it has already arrived). Reactions vary from utter despair to groundless optimism. Some people immediately jump to the conclusion that the great dieoff is just around the corner. Others, instead, are sure that some technological marvel will save us. In both cases, the bottom line is that there is nothing that can be done: either we are doomed, or someone will come up with the miracle solution at the last moment.

But passivity is never a good strategy. We can adapt; and if there are no perfect solutions for the incoming petroleum scarcity, there are at least some that may be good enough. That is why we built our retrofitted, battery powered Fiat 500. We don't claim it is the first retrofitted vehicle in the world, nor that it is the solution to all problems brought by peak oil. But we do believe that it is an example of a way for maintaining some low cost transportation for the troubled times ahead. It is a true "post peak car" that has the additional advantage that it can be used for focussing people's attention on the reality of the incoming peak oil

Let's go more in detail. Why use batteries? Why retrofitting an old car? There is a chain of reasoning that led us to that. As we know, our transportation system runs on liquid fuels obtained almost exclusively from crude oil. With oil becoming scarce, we'll have to cut on travelling and use more public transportation. But that can't be the definitive solution. No country of the world has a public transportation system that can completely replace private vehicles. Expanding public transportation to that level would be so fantastically expensive to be unimaginable, especially in the difficult period that will follow peak oil. And, of course, it will take a while before we manage to raze down the suburbs and relocate everyone in towns. Transporting people, then, is only part of the problem: we also need to carry merchandise. You can't use bicycles to bring food to supermarkets' shelves. So, we still need vehicles able to carry people and things around.

The rush, right now, is all for synthetic fuels and biofuels. But that's not the solution. Robert Hirsch showed in his, by now famous, 2005 report that we don't have enough time and we don't have enough money for building the infrastructure that would be needed to liquefy coal or gas. And even if we could somehow find the resources needed, that would be the perfect way to ruin an entire planet by generating a runaway greenhouse effect. Biofuels won't do, either, too inefficient and needing too much land; not a good strategy if we also want to eat. In any case, the old internal

combustion engine is so inefficient that we won't be able to afford to keep using it in the post-peak world. Hydrogen cars could be more efficient, but the technology won't be ready soon enough and the cost of the infrastructure that would be needed is out of this planet. In short, there is no technology available right now that could be used to make vehicles with the same performance and the same prices as those we have now.

But, if we can't have everything, we can at least have something. The post peak paradigm is to do things that work; not perfect, maybe, but good enough. We can have clean and efficient vehicles that don't depend on fossil fuels if we accept the limitations of battery powered electric vehicles. These vehicles won't have the range and the performances we are used to, but are efficient, non polluting, already exist, and don't need a specific infrastructure. The recent development of lithium batteries for traction is a small quantum leap that has greatly improved the energy/weight ratio of electric vehicles. But even the old lead batteries can propel a vehicle far enough to be interesting for an average commuter or for carrying goods around.

The strong point of battery powered vehicles in a post-peak world is their flexibility. Batteries can be recharged with anything that produces electricity. Normally, the existing power grid would be used and, in this case, electricity is still produced mainly by fossil fuels. But that is going to change: the energy that powers the grid will be increasingly produced by renewable sources. It is also possible to conceive stand-alone renewable plants dedicated to recharging vehicles' batteries. In both cases, the batteries of electric vehicles will also provide an energy storage system; something that renewables badly need.

Despite the advantages of battery powered vehicles, if you shop around for a purely electric car you'll find that a tiny, electric 2-seater costs more than a traditional compact car. Electric cars are expensive because they are made in small numbers and they are made in small numbers because they are expensive; a classic catch-22 situation. The big car companies never wanted to engage in making electric vehicles in numbers sufficient to escape this problem: surely you heard the story of the ill fated EV1, an electric car first created and then killed by General Motors.

The situation with prices may improve as electric cars gradually enter the market. But, in a post peak world, cars may never be again the inexpensive commodity we have grown used to. In a pre-peak situation, the common wisdom is that scrapping perfectly working cars for new ones is a good idea since, it is believed, it increases the GDP, creates jobs, etc. But in a post-peak world, you can't afford to throw away things that still work. So, there comes the idea of retrofitting old cars: you change what you must (the engine) and keep what you can still use (the body).

The job of retrofitting an old vehicle is relatively easy. You get rid of the old engine and replace it with an electric one. Coupling the new engine with the old transmission is not the optimum in terms of efficiency, but it is the easy way. Lithium batteries won't occupy much more space than the old fuel tank; lead batteries are bulkier and will need more creative solutions, but it can be done. Then you need a few more details: a voltage converter for powering the car's electric system (lights and the rest) and an inverter in order to be able to charge the batteries from an ordinary AC outlet. The result is a vehicle that runs and is much more efficient than the old one. It won't be able to do the same things that a standard internal combustion engine or hybrid car can do; it doesn't have the same speed, power or range. But you have a form of transportation that can carry people where they need to go: commute in and out of town and carry goods from the supermarket to home. Even more important than that, a battery retrofitted truck can still take food to a supermarket. Also, a battery retrofitted ambulance can carry patients to the hospital; all that even in the most difficult situation of fuel shortage.

Fig 3. The electric engine of the little 500. It fits easily in the much larger space left by the old engine. Note also the lack of fans and cooling. The electric engine is so efficient that it doesn't need to be cooled.

We experimented with these ideas using an old Fiat 500. It is a car designed in the 1950s that belongs to the generation of the "cars for the people," of which the Volkswagen "Beetle" is the best known example. These cars were efficient, light, and inexpensive; much different from the present generation of hormone fattened McCars. The Fiat 500, in particular, was a marvel of engineering. Not much larger than a toy car, it could nevertheless carry four people. It even had built-in air conditioned in the form of a foldable hardtop. They don't make them any more, but there are still at least two hundred thousands Fiat 500 running in Italy. Many are kept in tip-top shape by owners who are emotionally attached to their old "cinquino" ("the little five hundred" in Italian) but people also keep those cars because they are practical, inexpensive, and reliable. You can still easily find spare parts and, if you are careful to keep the body from rusting, the 500 can keep running forever, or almost so.

So, we took the old Fiat 500 (vintage 1970) which had belonged to Pietro Cambi's father. We exchanged the old gasoline engine with an electric engine of the same power. We replaced the fuel tank with a pack of lithium polymer batteries. The whole operation took a few hours of work in a mechanical workshop. The result is a car that reaches approximately the same top speed of the original one (around 90 km/h). The electric engine has a much higher torque at low speeds and therefore you don't need to use the transmission or the clutch pedal. Theoretically, with all this torque available, you could turn the little 500 into a mini-dragster, but the axles wouldn't survive for long. So, the best way to drive it is gently. If you do that, the car will run for a good 100 km before needing to be recharged. If you consider that the battery pack contains about as much energy as a liter of gasoline, that gives you some idea on how much more efficient an electric engine is in comparison to an internal combustion one. [Ed: 100 km/l = 282 mpg (Imperial), 235 mpg (US)].

Fig 4. The battery pack. These lithium polymer batteries contain as much energy as about one liter of gasoline. Nevertheless, the engine is so efficient that the car can run for 100 km, if driven gently.

Recharging the batteries of the 500 at a domestic outlet takes a few hours for a full recharge but, in normal use, you don't completely discharge the batteries, so that about one hour and a half is sufficient. At the present prices of electricity in Italy, a complete recharge costs about Eur 1.2. Since we have a range of about 100 km, it follows that the cost per km of running the car is about 1/5 of what was the cost using gasoline. We also have charged it using the energy produced by the PV panels on the roof of Ugo Bardi's home. In that case the cost of the recharge is strictly zero.

Our idea with building this car was not just to have fun building a prototype (well, that too!), but to explore a solution for a low cost everyday transportation. We think that what we did is already very promising. The cost of the first prototype was relatively high (more than 10,000 euros); about the same cost of a small electric two seater bought new. However, the main cost was that of the batteries, still in their early stage of commercialization. In the future, we see costs going down with those of lithium batteries. We think that a retrofitting kit for a small car could eventually cost as little as around Eur 6000 - 8000; much less than buying a new electric car. A further advantage with a retrofitted car is that you know that spare parts for it will be available for a long time; something that you can't be sure about in the case of a new car built by a small producer. In short, after this first prototype, we are already planning to make new ones.

The little retrofitted 500 is related to peak oil in more than one way. One of these is in terms of image. If you are involved with the peak oil movement, you are often accused of being a catastrophist interested only in seeing civilization collapse; of wanting people to return to rural times, only travelling by riding donkeys or camels. But the battery powered "500" is not a problem: it is a solution. Not the only, and not even the best solution to the incoming oil crisis but, at least, something that shows a

positive attitude. And we seem to have been doing something right. The retrofitted 500 has appeared in Italian newspapers and in the Italian TV. We also exhibited it at motor fairs and public events. When people ask us "why did you do that?" we mention peak oil and we are bringing people's attention the concept much more effectively than if we were going around showing bell shaped curves. That won't change the world, but it is at least something.

Technical data

Vehicle: FIAT 500 F, built in 1970
Engine: Separate excitation DC motor, 96 Volts. Nominal power 10 kW.
Batteries: Li-Polymer: 26 elements. Total energy stored 9.6 kWh (the same as approx 1 liter of gasoline).
Weight: ca. 65 kg
DC/DC converter 96/12 volts.

A little FAQ

"*Can I do it with my old car?*" In principle, you can retrofit any vehicle but the best is to do it with light, compact models.

"*How much does it cost?*" The answer is "it depends". The main cost at present is in the lithium batteries, but if prices keep going down as they have been doing during the past few years, we estimate that soon a complete retrofitting kit would cost around Eur 6000 - 8000.

"*Can I drive it on public roads?*" Again, it depends. We know that in Germany, Switzerland and in the USA it is easy to get a retrofitted car approved for road use. In other countries, such as Italy, it is nearly impossible because of the bureaucracy involved (ours runs on public roads because it is a prototype with a special permit). In other countries, you have to check with the local authorities.

"*How about insurance?*" We found no problems in insuring the electric 500 for a reasonable price.

"*Does it need special facilities for recharging?*" No, you can recharge it with any domestic power outlet. In some countries you can also use public recharging facilities along the road.

"*Is it safe?*" The retrofitted 500 doesn't have all the tricks that the last generation of cars have: airbags, reinforced body, etcetera. It wouldn't be safe to drive it on highways or at high speeds on any road. But this not a car that is designed to go fast. It is designed for urban or suburban transportation and, if you go slow, then it is safe.

"*How does it feel to drive it?*" Like an ordinary car, but the only noise you hear is a soft humming and the engine has a higher torque at low speeds. You still have the clutch pedal and the shift lever, but you don't need to use them, except for backing up.

"*How about maintenance?*" Almost zero. No oil to change, nothing to lubricate, no tune up needed. Lithium polymer batteries should last thousands of recharging cycles, that is for more than 100.000 km. An electric engine is normally supposed to run for the equivalent of a million kilometers. The rest of the car will last as long as you'll take care that it doesn't rust.

Fig 5. The electric 500 at the creativity fair in Firenze in October 2007. Pietro Cambi is the one at the back, discussing with the guy with the orange sweater.

Acknowledgment

The electric 500 was built with the help and the dedication of a group of people who contributed for free with their time, money, and expertise. Among the people who contributed: Pietro Cambi (commander in chief and owner of the old 500), Ugo Bardi (peak oil theorist and bard of the enterprise), Debora Billi (pasionaria and media manager), Riccardo Falci (electric racer and vehicle assembler), Massimo de Carlo (our battery man), Francesco Meneguzzo (our man in Rome), Corrado Petri (engineer extraordinary), and Ringo Reemberg (tester and international ladies' man). We also thank Chantal (we don't know her last name), professional model who agreed to pose with the retrofitted 500 at the Ecoauto fair in Torino in September 2007.

Where to learn more

See the site of the non-profit association called "Eurozev" www.eurozev.org

See the little 500 running at:
www.youtube.com/watch?v=KjIOb5m-DDU
www.youtube.com/watch?v=Ee4v7nlUM9M

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