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DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

The Air Car Part 2 - Q & A With Louis Arnoux of IT-MDI

Posted by Big Gav on January 19, 2008 - 3:00pm in The Oil Drum: Australia/New Zealand
Topic: Alternative energy
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Update: I received responses to my follow up questions from Louis - see the end of the Q&A section.

In the wake of my last post on The Air Car (The Air Car - A Breath Of Fresh Air Or A Waste Of Breath ?), IT-MDI's Louis Arnoux made a lengthy comment at the tail end of the commenting period, arguing that we had been overly harsh in questioning the practicality of the vehicle(s).

> It's great to feel the excitement, interest and intrigue about the MDI "air car" as posted on The Oil Drum – Australia and New Zealand. However, a large number of those comments are in my view mistaken and made without the required knowledge and expertise. In this posting I wish to clarify a few matters.
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> To call the MDI vehicles an "air car" is a misnomer. It is no more an "air car" than a "gasoline car", or a "diesel car" or an "ethanol car" or a "rapeseed oil car" or a "what-have-you car." The point being that the MDI engines (there is a whole series of them) are being designed to accept a very wide range of primary energy inputs including fossil fuels, bio fuels, waste heat recycling from other processes and thermal solar energy. Transport is only on aspect of the applications of the MDI technology. Power generation at the point of use, on customer premises is another. Power generation applications are at least as important as the transport applications.
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> "Is it for real?" many people ask. ...

As few people were likely to be following the comments at that point, I asked Louis if he would like to do an interview to answer some of the questions we had about the MDI technology.

Question: What equipment would be required for fast refills at service stations ? How much would the equipment cost, and how much to you estimate it will cost to refill the car ? What are the power requirements for the compressors ?

> **Answer:** In the Australasian applications we do not intend to use compressed air refilling point to any significant extent. It is important to realise that the main version of the MDI engine is designed to run in multi-fuel mode. That is to say that (1) it makes it's own compressed air through the burning of a fuel that takes place inside a heater/combustor located outside the engine. Because the primary energy input takes

place outside the engine, it is possible to use any fuel, petrol, diesel, natural gas, LPG, or preferably "green" biofuels like rapeseed oil, ethanol from sugarcane, and so on.

Because the system (compressed gas engine and external heater/burner) is much more energy efficient than an internal combustion engine the amount of biofuel required per 100 km is considerably reduced. The present system is capable of running on 2 litres per 100km. As far as I know no other engine can achieve this.

In cases where a compressed air refilling station is to be used, such as possibly for a fleet of taxis or mini buses operating in a CBD, the compressor is a standard commercial unit combined with a bank of compressed air bottles. The refilling station is very similar to that used for CNG (Compressed Natural Gas) used to operate converted cars or buses, except that in our case the gas is air instead of being methane. It takes 2 to 3 minutes to refill the bottles in a MDI car. I am not prepared to provide cost or power requirement information as this, of course, is commercially sensitive. Simply, as MDI likes to stress, the cost of operating the first commercial model, code named for now the OneCAT, is expected to be €1 per 100 km, i.e. about AU$1.70 or NZ$1.90 per 100 km.

Question: When will construction of the manufacturing facility in Melbourne commence?

Answer: That depends on investment levels and MDI's delivery timetable. At present rate I am expecting establishing a first manufacturing facility during the second half of 2008 and being in full production in 2009. Initially, our focus is going to be on producing power generators, then we plan to move on the automotive applications.

Question: When will air cars first appear on Australian roads ?

Answer: MDI plans to unveil its OneCAT before the end of January 2008. I plan to show case one in Australia towards July 2008.

Question: Is the Melbourne plant the only one planned ? Some articles have mentioned three manufacturing plants in Australia / New Zealand.

Answer: The joint IT MDI business model is to manufacture at or close to the point of sale in small networked factories. We are planning a substantial number of such factories distributed throughout Australasia. We plan to complement this network of factories with a few hubs. We plan to establish the first of those hubs in Melbourne.

Question: How long do you believe it will take to obtain approval from the various Australian state vehicle licencing Authorities ? Has crash testing been undertaken and approved by Australian authorities ? What would happen if an air tank is ruptured ?

Answer: MDI is constantly monitoring regulations world wide and designing each feature of its vehicle to meet the most exacting of all specifications. So I do not expect any significant issue to obtain approval in Australia. The OneCAT will have very

innovative design features concerning crash safety. Nothing much would happen in case of a tank rupture. The tanks are underneath the car floor, built within the chassis frame and design to bleed towards the ground in case of a rupture; so just a big "pshiiiit".

Question: How well does the vehicle handle strong cross winds given its light weight ? Has any testing been carried out in this area ?

Answer: It works very well. Weight is only one of many factors affecting handling in cross winds.

Question: If the car can drive up to 4500kms on one tank and the stated economy is 2litres/100km the implied tank capacity is 90litres. This is somewhat larger than the standard fuel tank. Where is this situated in the Australian models?

Answer: Several pieces of information are conflated in the above query. MDI is designing more than one car. The above refers to a bigger model and to our plans to demonstrate the capabilities of the technology, for example, by driving from Perth to Brisbane on one tank full, possibly with an adapted tank.

The OneCAT is being designed to have an autonomy of about 150km when run purely on air within an urban centre and an autonomy similar to that of a contemporary small car when run in multi-fuel mode.

Question: There have been many reports over the years that production of the Air Car will begin shortly - for example, in 2000 this BBC report (http://news.bbc.co.uk/2/hi/africa/988265.stm) claimed cars would soon be rolling off production lines in France then South Africa, with a raft of countries to follow afterwards - what obstacles were encountered back then and have these all been overcome ?

Answer: In my view, the two main obstacles have been (1) that some parties do not like the prospect of a revolutionary energy and automotive technology and have been keen to stop it, slow it down, or take it over, and (2) low investments levels because parties able to provide larger levels of funding by and large did not know how to evaluate an initiative that was so out of what they were use to (so-called change agent or disruptive technology) and/or wanted to take it over. As is often the case and up to 2007, both MDI and my own company IndraNet technologies (the IT in IT MDI - Energy Ltd) have progressed entirely with the financial support of relatively smaller investors and small individual investments. Both factors combined has meant many delays and much slower progress than would have been the case if the companies had been left to do their work in peace and had been suitably funded. The first commercial models could have been on the roads at least 2 years ago. However, we are resilient people and now things are getting very exciting.

Question: It is stated that the car has a top speed of 110kph. It is implied this is achieved using only compressed air as the power source - is this correct ?

Answer: The 110 km/hour speed is by choice to fit within speed regulations for the small market entry model. This is not the maximum speed that can be achieved. Where regulations allow it, it is expected that subsequent larger models will be produced matching speed performance of contemporary cars. Running purely on air within a CBD, the car is designed to cruise at around 50 km/hour and will be able to go to 110 km/hour (obviously at such higher speed the air reserves get used more quickly). It is important to note that the MDI engines have very flat torque and energy efficiency curves, meaning that torque and efficiency are similar at around 200 revs and 4,000 revs. From this it ensues that an MDI car equipped with a 40kW MDI engine can have the same acceleration feel as that of a mainstream car with a 150 kW internal combustion engine and a complex and heavy clutch and gear box assembly.

Question: The Age mentions a range of 150km using compressed air. Is that at a specific speed, and if so, what is this speed? What range would the car have if it was used on freeways at a speed of 110kph?

Answer: As noted above the 150 km is for in town driving at a moderate speed around 50 km/hour. The actual range depends very much on people's driving patterns. People who very often accelerate and stop abruptly would use up their reserves much faster than less aggressive drivers. However, at any time, the car can be switched back to multi-fuel mode and run burning a fuel and while driving it can recharge its compressed air storage. In other words the cars are being designed to never run out of compressed air.

Question: How noisy is the car compared to a normal passenger car ?

Answer: The commercial version are expected to be similar to current passenger cars or less noisy. The prototypes that have been shown on numerous TV shows were not muffled to any significant extent, simply for ease of running tests. They are not representative of the final noise levels in commercial series products.

Question: How noisy is the onboard air compressor when it is being used to refill the tanks from an electrical power outlet at home ?

Answer: The system is being designed to be very quiet. In the main version the system (that includes a variable speed reversible power generator/electrical motor) reverses as a compressor. There is no separate compressor.

Question: The article in The Age talks about a hybrid mode where "the air is heated externally and incorporated with a fuel source, such as ethanol or diesel" - can you explain how this works ? Could you also explain the 'MDI thermodynamic cycle' and how it creates the claimed efficiencies ?

Answer: This refers to what I outlined above. The engine takes air from the outside and compresses to 30 bar. It pushes this 30 bar compressed air through the external

heater/combustor where the air is heated at constant pressure by a flame. A gas heated in this fashion expands. So through the application of heat, each cubic centimetre of air at 30 bar injected in the heating module is expanded to 3 to 5 times.

This expanded air is then returned to the engine where it pushes the pistons. The overall energy balance is very positive (power available at the crankshaft less power used to compressed the air intake). The design of the engine itself makes it twice more energy efficient than an internal combustion engine. The external combustion takes place in a steady fashion (no explosions and in internal combustion engines), at much lower temperatures (less than 8600C instead of around 2000 oC) and in an excess of oxygen (which means a very lean and clean combustion that does not produces any significant levels of uncombusted particulates or NOx pollutants).

The fact that the combustion is external means that one has a wide choice of fuels without having to change the engine, only the fuel supply parameters to operate the burner require adjusting when changing from one fuel to another. This is done through a computerised system.

Question: Could you explain the relevance of 'advanced magneto-caloric quantum mechanic effect' and how it is used to 'reduce intake temperature and further enhance energy efficiency'.

Answer: This concerns the next upgrades of the system. What governs the amount of power an engine can produce is the temperature difference between the hot and cold side. In the case of the MDI technology, since the combustion takes place outside the engine one has a much better and easier control of both the hot and cold sides. One can use and advanced heat pump (which is what the magnetocaloric effect is used for) to substantially cool the air intake.

This means that one can also lower the top temperature to be achieved on the hot side. This makes it substantially easier to recycle waste heat from other processes (e.g. in industrial applications for distributed power generation) and/or from thermal solar energy including from ambient heat in the atmosphere (hence calling this version "solar augmented"). Through such upgrades MDI expects to bring fuel consumption to 1 litre/ 100 km or less.

Question: Given that a large number of patents have been secured, are there plans for the technical details of the car to be made publically available ?

Answer: Patents that have been granted are accessible to anyone. However, patent applications into actual commercial products entail a considerable amount of know how that is commercially sensitive. Details will be unveiled over time, having in mind such sensitivity.

While there have been many incremental improvements or variations to internal combustion engines (e.g. various petrol, diesel, or rotary engines) since they were invented over a century ago, during all that time there has not been a single major new breakthrough. In my view MDI is one. There amy be others in the future. However, I do not know of any in sight capable of achieving what the MDI system is already achieving and at similar extremely low costs.

> I hope the above will assist in gaining a better understanding of the MDI technology, in addition to what I have already posted.

Louis' responses indicate that the first product IT-MDI will be marketing is actually a power generator, with cars to follow at a later stage, so I suspect we won't be seeing air cars on Australian roads in the near future.

I've sent through some follow up questions, in particular asking for a roadmap indicating which products will be available when and what their capabilities will be. At this stage I haven't received a response.

Update 20 Jan - responses received

Question: Tata have been reported as saying it will be at least 2 years before they produce an air car. Do you expect to get to the market before Tata ?

> Yes. We are in a joint venture with MDI.

Question: Could you give me a "roadmap" outlining the dates of the product releases you are planning and a brief description of each product. I think some of the confusion generated by the press coverage is due to a range of different products being described without any clear differentiation between the different versions.

> We have entered the productisation phase, i.e. the use of new technology to generate new products. With pioneering technologies, timetable must remain very flexible as one cannot rely on the same support systems as in the case of well established products. We aim to have a first manufacturing facility established in Australia in 2008. Our plan is to first produce power generators for distributed point-of-use electricity generation (such as for emergency back up units, and replacing UPSs, remote locations, farms, recycling of waste heat in industrial settings, and communities aiming towards sustainable independent lifestyles). We then plan to begin producing a small market entry vehicle code named for now OneCAT by MDI. Over the ensuing five years we intend this to lead to production of an expanding range of vehicles, including family cars, utility vehicles, tractors, forklifts, trucks, buses, boats and light aircrafts.

Question: Can you describe the target market for the power generators you plan to manufacture first - and the expected capabilities and price for these ?

> Please see above. The pricing is to be set up to be competitive with existing products or services in each instance. for commercial reasons I cannot expand on this at this stage.

Question: Can you describe how the external heat source is integrated into the design and how the multi-fuel version increases the range of the car?

> We plan to post soon on our www.itmdi-energy.com website a small video clip showing a multi-fuel MDI engine in operation that hopefully will make clear how the external heat

source is integrated with the MDI engines.

The range of a vehicle is governed by the amount of energy stored on board in whatever form. A fuel has a much greater energy density than stored compressed air. By burning a fuel, preferably renewable, the MDI system makes its own compressed air. The system is currently capable of achieving around 2 litres of petrol per 100km. So on a suitably sized tank (e.g. 60l) one can drive for about 3,000 km versus about 150km on stored compressed air.

Question: Can you describe how the engine is used in refilling the air tanks both in a stationary and mobile mode?

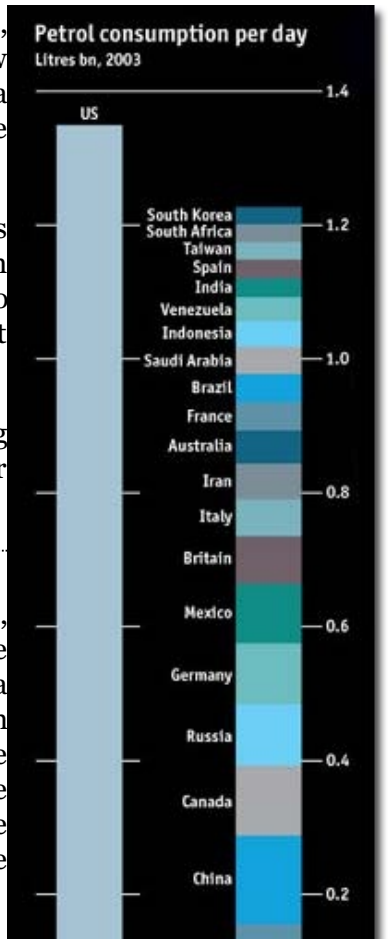
The new MDI engines have a set of pistons built in that are used to compress air in three stages to recharge the compressed air bottle(s) at around 300 bar.

End update

Nevertheless, the Air Car continues to get a lot of press, with sites like TreeHugger, AutoBlogGreen and Celsias pointing to this BBC video on the vehicle. Plenty Magazine also has a report.

Tata are the MDI licencee that tends to get the most press attention - however the company recently released a very cheap petrol fueled vehicle - the Tata Nano (or "Peoples Car") - and have been reported as saying it will be at least 2 years before they produce an air car.

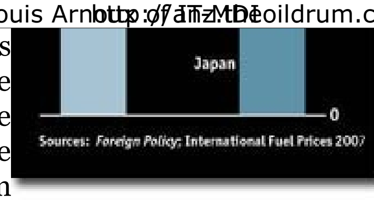
The Tato Nano has come in for a lot of criticism since its release, with people expressing concern that if hundred of millions of new vehicles appear on the roads, as the emerging middle classes of Asia can now afford their own cars, we will rapidly accelerate the problems of peak oil and global warming.



Pavithra Sankaran at Celsias had a look at some of the issues surrounding the Nano, and pointed out "If the Nano does jam traffic, people will demand better road networks. If petrol prices go up, they will use public transport. As for rising emissions, I cannot see people caring as long this graph stays the way it is."

WorldWatch has some interesting thoughts about those criticising the potential impact of the Nano while ignoring the much greater impact cars are having elsewhere.

One car gets 46 miles per gallon, features fancy accessories, and sports two engines with a combined 145 horsepower. The other car reportedly gets 54 miles per gallon, runs on a diminutive 30-horsepower engine, and is positively spartan in its interior trimmings. The first is a darling of the environmentally conscious. The latter is reviled as a climate wrecker. These two vehicles are the Toyota Prius and the newly unveiled Tata Nano, dubbed “the people’s car.” Is there a double standard?



Advertised as the world's cheapest car, the Nano is a no-frills automobile designed by Indian conglomerate Tata to be affordable for millions, possibly hundreds of millions, of people who are newly joining the middle class in India and elsewhere in the developing world. Such mass sales might overwhelm halting efforts to ward off catastrophic climate change. As Indians (and others) join the love affair with the private automobile, many in the West are suddenly aghast at the prospect of Nano becoming a household term like Chevy or Mercedes. The German weekly Der Spiegel termed it an "eco-disaster."

Indeed, transportation has the fastest growing carbon emissions of any economic sector. Proliferating numbers of automobiles are a key reason. More than 600 million passenger cars are now on the world's roads, and each year some 67 million new ones roll out of manufacturing plants.

But amid the finger pointing, let's remember who has driven the planet to the edge of the climate abyss. People in Western countries and Japan—less than 15 percent of the world's population—own two-thirds of all passenger and commercial motor vehicles in the world. Although they are rapidly expanding their fleets, India and China, with a third of the world's population, so far account for only about 5 percent of vehicles. In 2005, China's ratio of motor vehicles to population was at about the level the United States had reached some 90 years earlier. India's ratio is less than half that of China.

Westerners not only have far more cars, but the distances they drive are also 3–4 times longer on average than those of Indians and Chinese. The United States alone—where monster SUVs roam and driving is considered a birthright—claims about 44 percent of the world's gasoline consumption. Fuel economy has stagnated for a quarter-century as cars grew larger, heavier, and more muscular. Here in New York, a Nano might be mistaken for a golf cart.

So if it's true that Asia's (and Latin America's and Africa's) teeming billions can't indulge in the same reckless habits as Westerners, then neither can Americans, Europeans, or Japanese. Delhi and Beijing know hypocrisy when they encounter it. Nonetheless, they have good reason to take action irrespective of what Western countries say or do. Residents of many Asian cities are exposed to a lethal brew of sulfur and nitrogen oxides, particulates, and toxics from motor vehicles of all stripes. Breathable air is every bit as important as climate stability.

Leaner engines and cleaner fuels are essential. The Nano may well be a cleaner option than the highly polluting motorcycles, motor rickshaws, and diesel buses (and many of the Western-designed cars) already clogging India's roads. But the mass market that Tata is hoping for will render putative gains ephemeral.

All countries need to seriously rethink their transportation policies. Such an effort has to go far beyond the pursuit of alternative fuels and even beyond making cars more efficient. Denser cities and shorter distances reduce the overall need for motorized transportation and make public transit, biking, and walking more feasible. Those who will never be able to afford a car will have more options instead of being marginalized by the onslaught of private automobiles. ...

Moving back to the topic of the Air Car, Tyler Hamilton from Clean Break has the best review of the vehicle that I've seen, published in MIT Technology Review.

A French-designed car that's propelled by compressed air and claims speeds of more than 60 miles per hour is expected to go into commercial production as early as this summer, although skeptics of the technology aren't holding their breath.

Using compressed air, they argue, may mean zero tailpipe emissions, but it's unlikely to provide enough range or speed to appeal to the masses, particularly in North America. "Compressed air does not contain much energy--that's the killer," says Larry Rinek, senior research analyst for automotive technologies at consultancy Frost & Sullivan. "This is more a nice garage project for a Popular Science subscriber." ...

The Air Car was supposed to hit the streets years ago, but its release always seems just around the corner. MDI announced in 2002 that the cars would be used to replace taxis in Mexico City, but nothing resulted.

Tata's involvement this time around, combined with the fact that oil recently hit $100 a barrel, could change the game. India's largest automaker announced last February that it had struck a deal with MDI to further develop and refine Negre's compressed-air engine technology, with the intention of producing and selling the emission-free cars in India. It has since been reported that Tata invested nearly $30 million in MDI as part of the agreement. ...

The Air Car may do better than fuel-cell cars, but experts say that using grid power to charge a battery-powered electric vehicle is much more efficient than using electricity to compress and store the same amount of energy in a tank. "The main problem is that air gets hot when you compress it, so much of the energy input goes into raising the temperature of the air as you try to raise the pressure," explains Doug Nelson, a professor of mechanical engineering and an expert on advanced vehicle systems at Virginia Polytechnic Institute. ...

At the core of all CAT models is a four-piston engine powered by compressed air that is stored in tanks at 4,500 pounds per square inch. The lightweight tanks, a thermoplastic container surrounded by a carbon-fiber shell, are made by Airbus Industries and hold nearly 3,200 cubic feet of air.

To propel the vehicle, compressed air from the tanks is injected into a small chamber, where it expands and cools. This expansion drives a downstroke of the piston. But as the ambient temperature begins to reheat the air in the first chamber, that air is forced into a second neighboring chamber, where it expands again to drive an upstroke. Using ambient heat helps capture more of the energy in the compressed air, ultimately improving the efficiency and expanding the range of MDI's Air Car. And compared with four-stroke combustion engines, in which half of the strokes are wasted to pull air and fuel into the chamber, the air engine makes use of every stroke.

Ulf Bossel, a mechanical engineer consulting in Switzerland and organizer of the European Fuel Cell Forum, is cautiously optimistic. "I think there's something to it," says Bossel, one of the few who has performed a comprehensive analysis of MDI's approach. Even though one of MDI's compressed-air tanks would carry the energy equivalent of just one gallon of gasoline, the use of that air in the engine is 90 percent efficient.

The energy balance would improve substantially, he argues, if the compressed-air systems located at filling stations or in car owners' garages were designed so that any waste heat during compression could be captured and used to produce domestic hot water, for example. If the compressors could interact with the grid and be programmed to only compress and store air during off-peak hours, or when solar and wind energy are in greater supply, the emissions profile of the Air Car would also improve.

"If you use clean electricity, it's an absolutely clean system," says Bossel, adding that compressed-air systems, despite being less efficient than battery-powered cars, have the advantage of being simple, cheaper to manufacture, and unconstrained by the degradation problems associated with current battery systems. "Still, there are some thermodynamic tricks you have to do," he says.

To increase the range of the vehicle, MDI is also coming out with an optional dual-mode system that allows the car to run on fossil or biofuels--either when its speed exceeds 35 miles per hour or when the compressed-air tanks are empty. When in fuel mode, the car's moto-alternator refills the tank with compressed air as the vehicle moves. ...

The first CAT car to be produced is called the OneCAT, a "utilitarian" car for urban and rural driving that's specifically designed for use in overcongested cities and priced in a range ($5,100 to $7,800) within reach of consumers in a developing economy, such as India.

The ultralight bodies of the vehicles would be made of glued-together fiberglass and injected foam, and the aluminum chassis would also be glued, not welded, to simplify manufacturing.

Before production of the CAT can begin in India, likely followed later by Spain and Australia, MDI says that it must start mass production of the cars at its factory in France. A spokeswoman at MDI's marketing office in Barcelona says that this will likely happen in September 2008.