The Oil Drum: Australia & New Zealand
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

The Air Car - A Breath Of Fresh Air Or A Waste Of Breath ?

Posted by Big Gav on December 17, 2007 - 7:18pm in The Oil Drum: Australia/New Zealand
Topic: Alternative energy
Tags: air car, mdi, transportation [list all tags]

The primary impact of peak oil will be felt on our transportation systems. As road transportation is the primary consumer of oil, this is where we will need to make the most changes in order to adapt to less available oil. There are a number of ways of adapting - most, if not all, of which have been discussed at length in the peak oil blogosphere. These include expanding mass transit systems, redesigning cities and towns to make them easier to walk or cycle around (or combining both of these approaches in "transit oriented development"), making greater use of electric cycles (or mopeds), using lightweight materials in vehicle construction, and - most commonly - switching to electric vehicles (particularly, in the medium term, plug-in hybrids).

One variation on the oil free car alternative is the "air car", which is powered by compressed air. The Age recently reported that IT MDI-Energy will be setting up a manufacturing plant in Melbourne, with cars expected to go on sale next year for less than $8000 and with running costs "80% lower than current comparable vehicles" (2 L per 100 km).

All of this sounds very promising (and the company promotes it as the solution for both peak oil and global warming). The question is - is it for real ?

The company is claiming that the vehicles will be able to attain speeds of up to 110 kilometres an hour, and travel 150 kilometres on compressed air alone. The Age article also mentions another (hybrid) mode of operation where the air is heated using a fuel source, such as ethanol or diesel, which would make it "possible to travel from Perth to Brisbane without refuelling".

The car is refuelled by plugging it into the compressed air supply found at most service stations, and founder Louis Arnoux is claiming that the "engine technology could also be used to power homes". In other words, it is another way of implementing the vehicle to grid (or V2G) concept - which would be an interesting development as one of the main obstacles for this idea (once plug-in hybrids appear in significant numbers) is the impact of constantly discharging and recharging on battery lifespans (though recent developments in this area are promising too).

Compressed air is similar to hydrogen - it is an energy storage medium, not an energy source. Critics point out that using compressed air simply shifts energy production from oil based engines to power stations - usually coal fired ones, particularly in Australia. On the other side of the ledger, compressed air is a safe, well-known storage mechanism (already in large scale use to store power produced by wind farms, for example), and the energy generation infrastructure can (and hopefully will) be converted from fossil fuel based sources to cleaner alternatives over time.

The Air Car was created by MDI (Moteur Developpement International) which is headquartered in Luxemburg, while the prototype factory is in the south of France. Originally conceived by former Formula 1 engineer Guy Negre back in 1991, the official names for the “Air Cars” are the OneCAT, CityCAT and MiniCAT. The OneCAT is expected to sit three or five people, with the MiniCAT and CityCAT models expected to follow.

MDI recently signed a deal with India’s Tata Motors, to build the air-powered vehicles in India. Zero Pollution Motors is looking to market the car in the US, and the Thai government has also invited Tata to manufacture the car in Thailand. A Colombian company (MDI Andina S.A) is also looking to produce the cars and sell them in Latin America.

The company has been talking about producing cars since at least 2000, so it is worthwhile remaining skeptical until cars start rolling off a production line somewhere.

WebHubbleTelescope had a brief look at the Air Car back in 2004.

> The Air Car has gotten the press excited on and off over the years. The French design, which has received the most publicity, uses compressed air as an energy delivery mechanism. It has the potential for providing a clean-burning solution, but as usual it takes net energy to compress the air. No free lunch, unless wind or solar energy are involved to run the air compressors. And even there, we require energy to make the windmills and solar conversion devices.
>
> As a sanity check here are two ways to calculate the energy value of 1 liter of compressed air. Remember that the gold standard is 1 GJ/30 liters for gasoline (or 33,000,000 joules/liter). First, if you compress air completely you actually get liquid. So we take the energy value of liquid nitrogen (air consists of 70% nitrogen by volume).
>
> 1. Energy Density/Specific Energy of liquid nitrogen = 320 KJ/l or 320,000 joules/liter
> 2. Heat of Vaporization of liquid nitrogen = 161 KJ/l or 161,000 joules/liter (to double-check the above value)
>
> Looking at specific energy, this is at best 100 times less energy content than gasoline. On the plus side, the transfer to mechanical power is better than for gasoline (burning gas generates much wasted heat). Granted that advantage, we still have to generate the compressed air by using energy, and to top it off, we also have much worse energy density (i.e. energy per volume) than gasoline. You understand why consumers and corporations like gasoline (little energy overhead to extract a free lunch).

James Fraser at The Energy Blog had a look at the air car earlier this year when the Indian deal was announced, coming to the following conclusion:

> This technology competes with the electric car. The claimed advantage of compressed air over electric storage is that it is less expensive, has a faster recharge time and pressure vessels have a longer lifetime compared to batteries. Both technologies have hurdles to overcome, demonstrating that the air engine/compressed air system is as light, efficient and cheap as available electric motors/batteries. The main issues to me are that the air engine has not been proven to be dependable and advanced batteries are still too expensive. ...
>
> A discussion of the energy efficiencies of an air engine vehicle vs an electric vehicle would breakdown into the efficiency of the air compressor and air engine vs the efficiency of batteries and motors in the electric car, which I am sure the electric car would win. However because of the potentially low initial cost, low maintence cost and low operating cost compared to a fossil fueled vehicle the "air car" could find a niche market if it could be marketed before low cost batteries are available.

The Australian operation, IT-MDI Energy Pty Ltd, is a merger betweeen MDI and IT Mondial, Louis Arnoux's IT business. The IT MDI-Energy venture has other ambitions besides transport, with its (in my mind, very confusing) website detailing plans to provide home power generation (shades of the key to Richard Smalley's "distributed energy grid" idea) and even broadband internet services in a "green" manner, using a combination of solar power and some sort of cogeneration technology. While the air car idea seems to have quite a lot of history behind it, much of the rest smells a lot like vapourware based on the information on the website.

When the article in The Age came out, Kyle Schuant posted a few back-of-the-envelope calculations to The Bullroarer comparing the air car to a small petrol fuelled car in terms of fuel costs and carbon emissions, in which the air car fared pretty well.

> If I remember my high school physics and chemistry right, the energy E required to compress air at 25C is,
>
> E = 110,000 x ln (P1/P2) /m3/mol
>
> There are about 45mol air in 1m3, so,
>
> E = 110,000 x ln (P1/P2) /m3
>
> This howstuffworks article tells us that an air car tank might have 300lt at 4,561psi, which is 29,999,087.707 - call it 30,000 kPa. Atmospheric pressure is 101.3kPa. 300lt at 30,000kPa will be 90,000lt at atmospheric pressure, or 90m3. And so we get,
>
> E = 110,000 x ln (30,000 / 101.3) x 90
> = 110,000 x 5.69 x 90
> = 56,331,000J
> which is 15.6kWhr
>
> However, a company which supplies air compressors tells us that "Most systems typically waste 25 to 50 percent of the energy required to generate compressed air that actually provides useful work."

> Let's be optimistic and assume that with lots of air cars zooming around, service stations will buy the most efficient (expensive) compressors. So we get just a 25% loss. This brings us to 20.9kWhr.
>
> Let's round it up to 21kWhr to refill the tank. Again, this isn't the air car referred to in the article, but it gives us an idea of the order of magnitude.
>
> 21kWhr to travel 200km.
>
> A regular small city car gets about 10km/lt. Petrol costs about $1.30/lt, and causes 2.32kg CO2e/lt. So to go 200km in a regular car would cost $26 and cause 46.4kg CO2e in emissions.
>
> Electricity from coal cost $0.1355/kWh and 1.21kg CO2e/kWh, so the 200km journey would cost $2.85 and cause 34.9kg CO2e in emissions.
>
> Electricity from wind costs $0.19/kWh and causes 0.04kg CO2e/kWh. So the 200km journey would cost $3.99 and cause 0.84kg CO2e in emissions.
>
> The average Australian car is driven 15,000km annually. That'd be 75 refills, or 1,575kWh energy in all. That's not bad when the average household uses 6,000kWhr annually.
>
> Presumably service stations could do things better than we could at home, since they can buy the big heavy and efficient equipment; if service stations supply so much compressed air, they'll start charging more for it, more than the power costs. Still, it seems that running it on compressed air will be significantly cheaper in money terms.
>
> However, if the air is compressed by electricity got from coal, the greenhouse gas emissions will be comparable to simply burning petrol in the car.
>
> Again, not perfect calculations, but the best we can do with the data we've got, and they give us an order of magnitude idea of the numbers involved.

There is another Australian company pursuing air powered vehicles - the Di Pietro Rotary Air Engine, which doesn't seem to have made much progress commercialising their technology, though it still appears in the press from time to time. From a recent ABC interview:

> BLANCH : As the world wakes up to global warming, petrol prices rise and greenhouse gases pollute the atmosphere, what better than a car that creates zero pollution by running on nothing but compressed air? The dream started seven years ago for a Melbourne engineer, Angelo di Pietro, to advance his innovative air-driven 'Engineair' vehicle that he conceived, designed and developed and which could have an enormous impact on future motor-driven applications. I asked Angelo to list after zero-pollution, what he considered to be important improvements that his engine delivered over other motors.
>
> ANGELO DI PIETRO : Our motor delivers high torque and low rpm, very high efficiency, low noise and it's a fraction of the weight of a traditional piston motor. It is cheaper to produce and is better for the environment, as less material and energy is used in its production.
>
> BLANCH : So your motor is based on a rotary piston. How does your engine design

differ from existing rotary engines?

ANGELO DI PIETRO : Uses a single rotary piston and pivoting dividers which runs almost frictionless.

BLANCH : Your motor's seven times smaller than the piston air motor currently in use, so what power does the engine develop with what about of compressed air?

ANGELO DI PIETRO: Although our motor is seven times smaller than the piston air motor, we develop much more power with considerable less energy, even by using our early motor's testing results of 2002, conducted by Monash University, we only use 770 litres per minute per horse power compared with the piston motor's 896 litres. We have advanced our technology today enormously and our scientific model predictions suggest that the new motor could be made at least four times more efficient for the same power output, compared to its commercial competitors.

BLANCH : So how do you get your motor to operate at a higher torque or with greater efficiency?

ANGELO DI PIETRO : By regulating air pressure and timing or manipulating the compressed air to perform the reverse function from when it was compressed.

BLANCH : You've designed the engine to be suited to a variety of applications and these range from commercial vehicles and motor scooters, buses, boats, trains and cars. Well that's a whole spectrum of transport, isn't it? So how does your engine adapt to such a range of vehicles?

ANGELO DI PIETRO : The engine can be scaled up or down in its size and will be built from different materials specific to each use, for example, carbon fibre or other plastics or even stainless steel for marine use. Our engine is best suited to a new generation of vehicles that can be built lighter as the need to build current heavier structures to support large heavy motors and all that goes with them is no longer required. This reduction in the weight of the engine and the elimination of many other components translates into fuel efficiency and economic benefits. ...

Cross posted from Peak Energy