Zen and the art of electric car conversion

Some people get their thrills from extreme sports. Rod Dilkes get his from extreme DIY

It's not logic that leads one to attempt to convert a perfectly good car to run on electricity stored in batteries—it's a passion, or madness! One that seems to infect relatively few people at the moment. Some may say it comes from environmental idealism, but I have the same desire for speed and power as any revhead.

Rod's converted Suzuki Mighty Boy, complete with rooftop solar panels.

The electric car: an idea whose time has come

In 1900 there were many more electric cars on the road than internal combustion (petrol/diesel) cars. They were faster, more convenient and quieter. Petrol cars of the day were noisy, dirty, smelly, difficult to start and unreliable. So what happened to all the electric cars? In a word: range. Petrol cars could go further and were quick and easy to refill, with the new resource of oil abundant and cheap. So for 100 years we have put up with noise, grime, smell and global warming for the sake of convenience! All that is about to change.

Imagine a car that gets refuelled from just being parked in your garage. It is powered from solar panels on your house rooftop, or a wind farm off the coast. Indeed it has solar panels in its roof that power the air-conditioning when it is parked and give you extra kilometres of free transport. Acceleration to 100kmh is effortless and quiet in less than five seconds, and cruising at high speed is safe and enjoyable. Instant throttle response, regenerative electric braking, high efficiency, zero emissions, silence, virtually zero maintenance, recyclable components, easy and direct use of renewable energy resources, constant four-wheel-drive with instantaneous traction control on each wheel. All these things are possible with electric cars.

At least 90% of our daily commuting is done within a distance of 50 kilometres, so a battery powered car will suffice for most people. For the other 10% of occasional driving a simple, compact and efficient microturbine generator can be installed. By turbine I mean the type used in jet planes, with appropriate silencing, coupled to a high efficiency electric generator. A turbine the size of a loaf of bread can produce enough output to easily power a car.

Even a steam turbine could be used. Turbines are simple, efficient, long lasting and will run on many different unrefined fuels including oils from fuel crops, completely renewable.

Hybrid petrol/electric cars like the Toyota Prius are coming onto the market which are a step in the right direction. It is interesting to note that the demand for hybrid cars in the USA is currently exceeding supply, even though they are significantly more expensive.

The way I see it is this: petrol cars are dinosaurs; highly evolved dinosaurs but dinosaurs nevertheless. Electric cars are furry mammals that currently coexist in very small numbers. My guess is that the coming oil shortage will see the eventual extinction of dinosaurs, except as museum pieces, and the evolution of a more effective and efficient mammalian mode of transport. This is a time of great change, something akin to the dawn of the motor car era when innovation and opportunity abounded, and it's happening right now. I personally can't wait for the car manufacturers so I'm doing it myself.

My conversion

After several years of dreaming and several months of research and collecting parts, I purchased a 1987 Suzuki Mighty

Boy with a view to converting it to run on electricity. This car was chosen because it was cheap, it is a ute, so batteries could be mounted in the tray, and it is very small and therefore relatively inexpensive to convert. The old petrol engine came out on 21 June, 2004.

The new motor is an Advanced DC 8" series wound DC model. It's 100-year-old technology, but simple and reliable for the first-timer. These motors are made in the USA especially for electric conversions. It is a fairly powerful engine for such a small car.

There is 45kW of power available at the wheels. The original petrol engine was rated at just 18kW peak! The motor needs a speed controller which connects to the accelerator pedal. A Curtis 1231C8601 500A model was chosen. These have a reliable reputation and run at 144 Volt nominal. No regeneration is available currently, but I will work on that later.

I did a lot of research on batteries with a view to using Lithium Ion or Nickel Metal Hydride (NiMH) batteries. Unfortunately, NiMH had recently doubled in price. At five times the cost of Lead Acid I would have considered it a worthwhile investment, but not at ten.

Lithium Ion batteries are very interesting but I would have needed to go to 200Ah capacity because they don't like to be drawn at high amperages and have voltage draw-down trouble when cold. They also need a complex battery management system, and are even more expensive than NiMH.

When they come down in price in the future, Lithium Ion will be the battery of choice, because they give relatively long range in a light and small battery pack. (Look for 'Thundersky' from China.) So that pretty much left only one choice: good ol' Lead Acid!

Again, 150-year-old technology, but relatively inexpensive and reliable. Trojans seem to be the popular contender and they made a smallish one to suit my

The batteries are mounted under the tray, so the cargo area is still fully useable.

Inside the engine bay. Note how small the electric motor is compared to a petrol engine.

Vital statistics

Battery voltage: 144V nominal (12 x Trojan 27TMH flooded lead acid)
Max current draw: 400A (detuned from 500A)
Max power: 400A @144V = 57kW (theoretical, 45 to 50kW more likely)
Top speed: >110kmh
Acceleration: Not yet measured but significantly faster than the petrol model.
Kerb weight: 900kg
Gears: Normal gearbox is still in place but without a clutch. For normal driving only fourth gear and reverse are required. It is like driving a very smooth automatic.

FAQS

Q. What, it doesn't use petrol?

A. Nope

Q. How fast will it go?

A. A lot faster than the speed limit, but I usually drive 70 to 90kmh. Faster than 90kmh is really scary in such a small car. Acceleration is much quicker than when it was on petrol and as quick as most modern cars.

Q. How far will it go on a charge?

A. About 40km of regular driving, more if you take it easy. Its a commuter not a grand tourer.

Q. The short range is a problem isn't it?

A. That depends how far you commute in a day. This car satisfies 90% of my driving requirements. New technology lithium ion batteries will soon all but eliminate the range issue. And for long trips an onboard generator can be added to turn it into a hybrid.

Q. How do you refuel it?

A. From the 240 Volt electricity supply. It has an inbuilt charger and a plug behind the cab. I charge it at night using off-peak electricity with a power cord hanging from the garage roof. It takes about 10 seconds to plug it in and two to three hours to recharge.

Q. How much does it cost to run?

A. About two cents per kilometre using off-peak electricity. Compare that to 10 cents per kilometre for your average petrol car.

Q. How much did it cost?

A. About the same as a new small car.

Q. Its not environmentally friendly because the energy still comes from a power station burning fossil fuel.

A. This car makes more efficient use of fossil fuel than the most efficient petrol/diesel engine car. Emissions from power stations are carefully monitored. Not so for emissions from petrol engine cars. Also electric cars can be fuelled directly from renewable resources such as solar and wind power. The batteries are completely recyclable when discarded.

Q. How long do the batteries last?

A. Ask me in a year or two.

Q. Does it have gears?

A. Yes and no. The gears are still there but really only fourth and reverse are needed. Second and third can be used for fast acceleration. There is no clutch.

Q. Can you run a generator from the wheels to recharge the batteries as you are driving?

A. Can you stand in a bucket and lift yourself up?

Q. Could it be done cheaper?

A. This conversion was done in my shed using small volume specialist components imported and purchased at retail prices from expensive countries. I am sure car manufacturers could build electric cars for less than of the cost of petrol cars. Batteries are the biggest (most expensive) hurdle but less so with modern developments.

Q. Can you charge the batteries from solar power?

A. Yes I do this already. The three solar panels give enough power for one or two kilometres per day.

requirements. At just 105Ah, the 27RV (27TMH in the USA) wouldn't give me much range, but I had serious weight constraints. The Mighty Boy only has 350kg payload capacity including two occupants. I decided to go with 12 of these batteries to give a 144 Volt (nominal) battery pack. However, the pack would weigh 312kg by itself, leaving just 38kg for the driver to keep it within the GVM for licensing. I am not quite that skinny, so I had to have the GVM (gross vehicle mass—(the total licenceable mass including occupants) legally changed to allow for the extra weight.

With all these American bits in the car, I wanted to look elsewhere for a charger. The Italian Zivan NG3 got rave reviews any time I mentioned it to other converters. All the gauges and small EV specific components I sourced from EV Parts in Washington, USA.

Other electrical bits like the kilowatt-hour meter I got from my local electrical distributor. The guy was a tad suspicious of a DIY nut buying all these high voltage bits. I think he thought I'd fry myself. Fortunately I'm still here and pretty well underdone. My local sparky did check it over though.

I had the adapter plate and coupling from the electric motor to the existing gearbox specially manufactured. I had some teething problems which took a bit of sorting. My local mechanic at Margaret River Motors did the installing.

The battery box I farmed out to my local welding expert. He makes farm gates and the like for a living. I think this was one of the strangest projects he has ever worked on. We cut bits off the little ute and welded more bits on until I had a lovely box that started just behind the front seats and went to the back of the tray. Pure art!

Wiring it all together looks pretty simple on paper, but that's where the simplicity ends. I did this myself on many late winter nights in an open carport. An

Future enhancements

- Regenerative braking.
- A small petrol generator in the tray for extending the range when required.
- Supercapacitor boosting for breathtaking acceleration whilst protecting the batteries.
- Lithium Ion batteries and battery management system for 150km+ range.
- Investigate steam or gas turbine hybrid configuration.
- A dual motor 3 phase AC drivetrain with 300kW+ output. May need a new car for this.

electric heater also had to be added to get it licensed.

The first test drive was on 21 September, 2004. It ran well, but made a godawful noise when decelerating. We pulled the engine out and made some slight modifications to the coupling, adding three grub screws to hold it tight on the motor shaft. Back in with the donk and it ran really beautifully for a week or so, until it started making a noise again. Out with the donk and some more modifications. This time it ran well.

I took it up to Perth to get licensed on 24 November, 2004. The head inspector took it for a drive and gave it a caning. The little car performed admirably and he stepped out impressed. After a whole day of consultations with licensing inspectors, an engineer and a suspension specialist, they finally signed it off just before closing time.

Since that time I have put three solar panels on the roof, and constructed a step-up (12 to 144 Volt) charger. The panels give about one 'free' kilometre for every two hours in the sun. This may not seem like much but it represents a 10% reduction in my daily energy usage. A more efficient engine and drivetrain would add significantly to this. As far as I know this is the first road-registered solar/electric hybrid car in Western Australia, if not Australia.

The car is now running very well. It is not exactly a chick-magnet, but I still prefer driving it to anything else! It's reasonably fast, reliable, quiet, non-polluting and economical. It may not go very far yet, but I have plans...

But in the meantime, back to my day job!

Thanks to Jim Lissiman for initial advice on getting started, Michael Symons, who was a trove of information on engines, controllers and batteries, Bob Fox from Witchcliffe for body modifications, Gary Madson from Margaret River Motors, Simon Dodd for the adapter plate and coupling. And finally, my partner Tova and kids, for putting up with me!