

HANDY HINTS AND TRICKS OF THE TRADE

BUILDING EVs AT HOME.

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Introduction.

This paper has been prepared to help home converters to meet and overcome the many challenges that they are bound to meet along the way. It has been compiled from personal experience and advice from others who have “been there”.

Some of the tips are tricks of the trade, while others have resulted from trial and error (and barked knuckles).

Unfortunately, the list is not exhaustive, but we will try to add new tips as they become known to us.

As is usual in these cases, we do not guarantee success. We only claim that they worked for us. Builders should make themselves aware of all hazards, and ensure that they work within their level of competence.

The tips fall into broad headings, but there are overlaps. None of it is rocket science!

Planning where things will go.

It is advisable to plan your build in some detail. There will be bits and pieces, which you will make up as you go along, but the “big stuff” should be thought through before even buying parts.

Find out the weight (approximately) of the bits you are removing, and write them down. Weigh the car, plus front and rear distribution before starting work. You will need these numbers later.

When removing the petrol engine, tag all the electrical cables as you disconnect them. If you don't know what the connection does, try to work out what the general role of the component is (eg pollution control, choke, aircon sensor). Once the engine is gone, and these wires are flapping, it will be much harder to work out what can go, and what should stay.

When the engine bay and fuel tank void are empty, measure them to determine the best rectangular volume available for batteries etc. Work out where the motor will go, and check that it will fit. Remember that it not only must fit, but it must be able to be put in and taken out, Eg. It must be able to be slid onto the gearbox spigot shaft. You should remember that you might need to take it apart again in the future, and you won't want to have to destroy half the car to do so!

Battery boxes are probably the hardest items to fit. The fuel tank space is an obvious starting point, although it is unlikely that you will get more than half of your batteries into it. Contrary to what you might be told, Lithium batteries should not be laid down flat unless the manufacturer says so in writing. Check that the cells will fit, and how many will fit in various configurations, i.e. you might be able to get more in by turning them sideways. This is the time to see which cells will best fit your spaces as they come in many shapes and sizes.

The process should be repeated for the engine bay, or wherever else you plan to put batteries. Remember that the cells will need to be mounted in boxes, and that these boxes will need to meet strict criteria. This means that you must allow space for the box as well as “rattle room” for the individual cells, plus any fastenings required. As a rule of thumb, allow **at least** 10mm extra length in each box above the theoretical length of the number of cells times the nominal width of each cell. For very long boxes, allow more, particularly if the cells are more than 200mm long. This is because they can have a bow of up to 3mm each. So two cells mounted + to – can measure up to 6mm more in width than you would expect from the data sheet. ***Be warned!***

When all of the sums have been done, it pays to make up a dummy battery pack out of old cardboard cartons. Gaffer tape and old disposable nappy boxes work reasonably well. Pay attention to the vertical fit. A rectangular shape that fits low down, might foul on something above. Check that the dummy can be put in and out without hitting any fixed objects, like steering columns. Check, also, that any mounting brackets will clear. You can sometimes mount one bank of cells above another with the top bank staggered by 50 or so mm, but you should consider how the cells might be changed from time to time without pulling the whole car to bits.

Check that the weight of batteries plus boxes is not excessive (compare with the mass of bits removed). You have some scope to increase weight, but you must not exceed the GVM of the vehicle or you won't get through rego.

Fabrication.

The rules dictate the G-forces that the battery boxes must withstand, and these forces must be anchored back to the vehicle. This means bolts and welding, usually to structural members in the body. If you plan to bolt through box sections, you will need to provide crush tubes to prevent distortion of the member, and these will require access for drilling etc. Box sections often have intermediate walls, which make drilling more difficult, and filing almost impossible. Think this through before making the box/es. Hopefully, you will have been talking to an accredited engineer by now.

Templates are useful for all sorts of jobs. There are many irregular shapes in a car, and it is often easier to make a template with trimming, by trial and error, than going straight to metal. Once the template fits, it can be traced onto metal and cut accurately.

This technique is particularly useful for motor mounts, and a cardboard template can easily be converted to CAD for laser cutting.

When making the battery boxes, it is a good idea to cut out a piece of MDF the size of the base of the batteries (plus the extra allowances above), making sure that it is

square. Cut similar patterns for the ends and sides, and place these inside the box as you make it. This will prevent the frames (usually angle iron) from creeping inwards or distorting. Always weld so that shrinkage bowing occurs outwards rather than inwards. This is just a matter of tacking and welding in the right order, but if it is not done, the resultant “waisting” of the box can mean real headaches when you try to fit the batteries.

Once the motor and battery boxes are in, you will be able to assess the room available for other components. Hopefully, you will have a broad idea of how things are going to fit, but now you can make mounts for contactors, fuses, controller, vacuum pump, etc. The key is to keep HT cables short and logical. It is also a good idea to keep everything accessible, and not “build your way out”. Ideally, you should be able to get at, and replace, as many components as possible, without removing anything else. The least accessible component will be the one that fails first!

Electrical.

Ducts from front to rear of the vehicle will usually be necessary. Most authorities prefer high tension (HT) cables to be outside the cabin, although this is usually not mandatory. When fixing ducts to the underside of the vehicle, rivets are more secure than tech screws, and don't have points intruding into the vehicle. Use steel, not aluminium, rivets, and use a diameter greater than 3mm (1/8”).

Keep low tension cables in separate ducts from HT, and feed all cables through the duct before installing. Trailer cable (7 core) is very useful as it is usually good quality, already double insulated, and the wires are different colours.

It is worth leaving a strand of builders line in the conduit with the ends coiled and taped neatly, so that extra wires can be pulled through later if needs be. Remember to pull another line through with the new cables, so that it is there for next time. Alternatively, you can place one or two spare cables in the conduit, and loop the ends tidily for future use.

The 240volt line from the “filler cap” should go to a junction box, to which all chargers are connected. This box can be mounted in a well behind the rear wheel where it is dry and reasonably accessible. Similarly, a connector between the HT charger and HT charging cables to the batteries should be placed near the above. This will greatly facilitate assembly and servicing.

When wiring an EV, it is usual to need a number of wires hooked up to constant 12 volt auxiliary power, and others to the ignition circuit, and it is tempting to add these either to the battery +ve terminal or the contactor terminal. This is fine until you want to change the battery or isolate /trace a circuit. Then wires can drop down and get lost, causing headaches and anguish.

Try mounting two junction boxes (terminal blocks) on the firewall with a feed wire to each (one for ignition and one for +ve power). The various circuits can then be added to the screws in the blocks as required, and can be readily traced and isolated.

A note can be kept of which circuit connects to which screw on the block to make things even easier.

Similar boxes can be extended to the rear (if there is a 12volt charger there, the constant 12 volt will be there already; it only needs a box).

When wiring the many circuits, there is a temptation to make it all neat as you go. Heat shrink is great for covering joins, but is unforgiving when you need to trace and rearrange wiring. Think the wiring through as you go, but just bundle wires using twist ties, which allows you to add and subtract wires at will.

When the wiring is finished, you can use small cable ties and split “concertina” tubing to cover them all up neatly. You can always get at them again if need be. The finished loom can be fixed at intervals with half-saddles and tech screws. Always know what is behind anything you drill!

It is a good idea to have a general colour system, Eg. brown for +ve ignition, red for constant +ve, black for earth and so on. Striped cables can be hard to get, but motor wreckers will sometimes let you strip old looms. The more colours you have, the easier to trace later. Always check used cables for continuity before using!

When wiring the car, it is a very good idea to record the loom. This means the wire colours, where they go from and too, and via what bundle. A series of wiring diagrams for individual circuits can be more easily followed and drawn up, rather than everything on one page. Label all relays as you go. It is surprising how quickly one can forget.

Don't forget to install fuses.

When connecting up any batteries, it is important that the terminals are clean. With Lithium cells, it is even more important. The terminals can be cleaned (sanded), but will develop a new oxide film in as little as 20 minutes.

A good trick for getting a really good contact, is to sand each terminal in turn, and immediately fit the connecting strap/cable using conductive grease. Unfortunately, sanding is slow and messy, but a Black and Decker rotary sanding file or similar will make light work of it. Just a quick touch is all it takes.

Body preparation.

The general appearance of the car will influence the Inspector when the car goes in for its rego inspection. Obviously, a really daggy car is not a suitable candidate for conversion, but even good cars can need attention.

The steering and suspension components will get attention along with brake hoses and the like. Boots and hoses with cracks will attract adverse comment and probable failure of the inspection.

All damaged rubber should be replaced, and the oily mess left behind should be thoroughly cleaned up. This is best done after the petrol engine has been removed and before the car goes into the shed for the start of work. If necessary, it can be done before the engine is removed. The parts should be sprayed/brushed with degreaser and hosed off. Repeat as necessary.

This will avoid making a mess of your new installation later, and will make building cleaner and more pleasant.

All the faulty suspension parts, brake hoses, boots and ball joints should be done before starting your conversion. It is tempting to leave them until later, or when there is a delay in supply of electrical parts, but they will be easiest when everything is out and access is greatest.

Where possible, it is handy to use stainless steel fastenings (but not if high tensile is required!). These fittings are now quite inexpensive, allow easy removal at a later date, and look very good.

You will make many brackets, plates and other bits. Many of these will be cut, welded or ground, and it is tempting to use them as fast as you can make them. Unfortunately, newly worked steel rusts quickly, and needs protection. A can of matt black epoxy spray paint can sort this, and a spray booth can be made from an old carton with one side removed. Wire hooks from the top can be used to hang small bits, and they will dry over night. Simple work planning can minimise delays. Finish the day with a painting job.

Much of the time seems to be spent looking for something that one had in one's hand and just put down! This is exasperating and time-wasting. With a little practice, one can establish a clear corner of a bench for putting things down. This might be while one makes another part to fit, or to answer the 'phone, but once the habit is established, it can save lots of frustration. A good spot is near the vise.

Similarly, one can use plastic ice-cream containers as holding boxes for parts. Use a new container for parts from another component, and label them with Texta if holding over night (or put a paper note in it).

If you are lucky enough to have a pit, keep a basic set of tools in it. This will save a lot of climbing in and out (unless you need the exercise!). There are plenty of cheap tools available in discount shops, and while these tools might not be your first choice for quality, they will do the job on occasion and save you time and the temptation to take shortcuts with inappropriate tools.

Safety.

Even at low voltages (3 Volts), electricity can be dangerous. It is not just electric shock, but bright flashes and molten metal from accidental shorts can cause injury to eyes and skin. Delicate and expensive components can also be damaged.

Disconnect all circuits when working on them, unless they need to be alive. This is obvious, but not usually done.

Use proper tools designed for electricians whenever possible. If you do not have such tools, you can often modify what you do have by insulating shafts and handles with heat shrink tubing. If in doubt, use a double thickness to be sure that there is enough thickness.

Wear safety glasses (or, at least, ordinary spectacles) to shield your eyes from flying metal. You can always get new specs. But you only get the one set of eyes!

When drilling, grinding, soldering or filing, particularly in the engine bay, make sure that parts nearby are protected. Cover motor brush houses and anywhere else where metal might cause harm. Remove the covers with care so as not to tip rubbish in afterwards.

If you don't know what you are doing, stop doing it until you do!

Read the instructions. This includes the bits about what not to do! Reading them only when all else has failed, can be very expensive.