Draft Discussion summary

Use of generators with electric vehicles:-

A. Mobile Recharge Station (ala David Sharpe)

The generator is an alternative recharge option to a fixed power point

Design Features

1. As light as possible
2. Fuel efficient as possible
3. Equate 240 volts at 10amps = 2.4 kW

Comment: not very elegant, possibly could double a days travel range

B. Range Extender

Run whilst driving through a battery charger - can extend range ~ 30%

Design Features

1. Light and fuel efficient
2. Match power to charger capacity
3. Battery overcharge protection may not be required with a good charger

Comment: There is uncertainty as to whether computerised chargers will be confused by large and rapid changes of current drawn from the pack. For this reason Rod Dilkes of EV Works prefers Option C

Zivan NG3 charger

Marco Sabatini <marco.sabatini@zivan.it>has been tested with diesel generator on a GEM Chrysler. Not all charger models will handle fluctuating current draw. Needs to be checked with

Chandima De Alwis <ChandimadeAlwis@mpower.com.au> *Technical Support* M+H Power Systems (Australian Zivan Distributor). Recommends:- The generator should supply at least 19 amps to satisfy a 15 amp charger, he suggests about doubling the genset size ie 144*30 =~4kW

Zivan chargers do not have input protection so the generator should have no high voltage spikes

The charge curve needs to be switched to a setting without auto shut off - he can advise

C. Parallel Power Source

Use as a supplementary or alternative high voltage power source

Design Features

1. Light and Fuel efficient
2. Output DC and match the main battery pack
3. Size to supply average power consumption for unlimited range extension or a bit lower in output than the car's cruising power could be fine. Eg 15 kW out put with a 20 kWh average consumption would keep you on the road for 4 hours, by which time you need food etc during which you would top up the batteries ready for your next stint. However it could be better subject to weight/cost to slightly overpower for unlimited range and generators are becoming available with 25kW. See Fischer Panda -Appendix 1

(The cruising power you need will depend very much on your speed and the wind resistance of the vehicle. For instance a Xantia at around 110 kph needs around 20 kW on the flat, the vast majority of this is wind resistance, rolling resistance is only dominant at much lower speeds.)

4. Battery overcharge protection is required
5. Ideally weight/cost can be balanced against some reduction in battery pack size perhaps in the order of 40kg/$4000.00

Battery Overcharge Protection

The EV power BMS (battery management system) sold by EV power can be easily modified to turn off a charger of whatever type if any cells are outside their happy voltage range (under charged or approaching over charge). The trouble with that is that the BMS will briefly trip on heavy acceleration due to low voltage across one or more cells even when the battery has plenty of charge and will not come on again till manually reset.

**Redesign to monitor just the upper voltage and turn off the charger if any cell is over.

Choosing the Generator

Power Required for Level Ground Driving - from Ken Koch, EV Consulting, Inc. Copyright 2008
http://www.evconsultinginc.com/articles/hybridizing_dc_system.html

Gen-set Kilowatt Rating Required		
30 mph	4.5 hp/3357 watts	3.5 kW
40 mph`	6.5 hp/4849 watts	5.0 kW
50 mph	10 hp/7460 watts	7.5 kW
60 mph	15 hp/11,190 watts	12 kW

Gen Head

110 volt AC generator (US standard) regulated to produce approx 155 volts DC
120 volt AC generator regulated to produce approx 169 volts DC
(NB AC voltage is usually measured in the RMS value. To convert from RMS to peak-to-peak value (for a sine wave only) you can multiply by sqrt(2)=1.41421)

Voltage Regulation:

1. Lead acid batteries, particularly open ones where you add distilled water are inherently immune to overcharging, they simply splits water to hydrogen and oxygen, wastes water but is harmless. Battery manufacturers recommend that battery banks be purposely overcharged periodically to ensure all cells are fully charged and to balance charge on the bank. Sealed lead acid batteries have chemical additives which "chew up" excessive charge once the cell has reached full capacity & prevent water losses. The chemical system adds complexity and can be overwhelmed by excessive charge so the overcharge method of balancing has to be used cautiously.

Almost all other battery systems, especially Li, will not tolerate overcharging, they are irrevocably damaged. They do still get charge imbalance however and need sophisticated electronic systems to deal with this.

2 The generator has a control system to ensure the output voltage is constant, some systems can be adjusted to alter the output voltage, this is the regulator system.

Comments:

High power voltage regulators are not cheap
Generator rewind or electronically modify alternator to required DC output
Modern alternators in cars run at higher frequencies than 50 Hz and the output is both filtered and regulated. They also deliver much smaller charging currents, so any damage to the battery is minimised.

Caution:

Batteries don't really like unfiltered rectified AC current. Lead-Acid Batteries die a lot quicker because the current surges cause local heating and swelling, and the paste flakes off the electrodes. The lifetime of NiMH batteries will also be shortened if unregulated unfiltered current is used. Li_Ion batteries will simply explode.

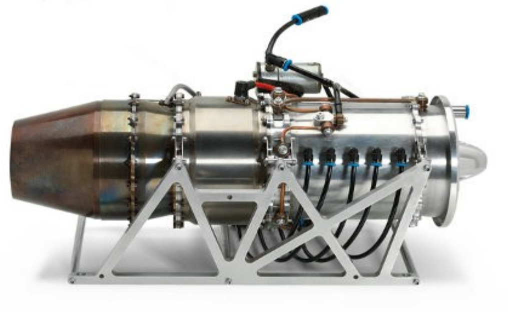
Don't do a whole bunch of caps in parallel or series. Particularly not supercaps, for all kinds of reasons. When you're dealing with that many of them, something will go wrong and bad things happen when capacitors die. The tolerances on each capacitor become intolerable (sorry, couldn't resist [ha, there's another one]) over anything more than a few capacitors.

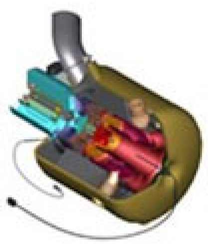
DIY sugestions for trailerable solution

120/208VAC 3ph 400Hz (40KVA @.75pf = 30Kw) Aircraft Generator producing 111A each phase @6000 rpm - Appears Brushless - Weight 80Lbs (meant for Boeing 737)   or

-120/208VAC 3ph 380-800Hz (35KVA @.85pf = 25Kw) Aircraft Generator (1950's era F-86 Fighter?) Has some Brushes - weight 82.5 lbs.
-800V/150A Full wave bridge rectifier
-24Hp Liquid cooled Kawasaki 4 stroke gas engine around 660cc
-A voltage regulator from an Aircraft Power Unit
generator head geared up 2 to 1

Motor
Most motors/generators will work at peak efficiency at one output, usually full power.
Diesel is more efficient than petrol
Natural gas with a high compression engine is a good but out of town fuel refilling is non existent.
Gas turbine
http://www.bladonjets.com/
5% size, weight & parts of equivalent piston engine
-High performance and efficiency
-Low emissions
- Low noise & no vibration
- Low manfacturing costs
- High reliability & low maintenance costs





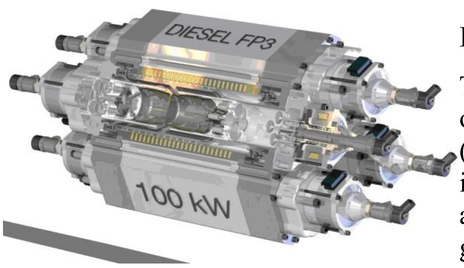
Capstone MicroTurbines
http://www.microturbine.com/prodsol/products/index.asp

Sterling cycle engines are ideal but where to get them?

KITS
Wilderness Electric Vehicles will soon have available hybrid conversion parts for Kit #1, Kit #2 and Kit #3. The heart of this hybrid conversion kit system is a Power Conversion Charger Unit (PCCU) designed and manufactured by us, Wildnerness EV. This unit is capable of converting 110 volts AC, 60 hz, electricity into DC power for charging batteries. It can convert house hold power to DC voltages including 48 to 96 volts at 5 to 30+ amp charging rates.
http://www.e-volks.com/hybridconversion.html

Some fancy lighter greener fuel efficient generators are being developed

Marine Generators Ossa Powerlite 25 kW weighs 248 Kg



Free Piston Power Pack

The FP3 is a most efficient, low cost, elegant electric generator module of exceptional power density. Operation is based on 'free pistons' (unrestrained by con-rods or crank shaft) being driven back and forth inside cylinders by controlled internal combustion. Permanent magnets are attached to these pistons and move through stator coils, thus generating electric power.

Compression ratio and stroke, as well as exhaust valve timing and lift, are software controlled rather than through conventional mechanical means. The result is mechanical simplicity, unequalled efficiency and extremely low harmful emissions.

http://www.freepistonpower.com/

Summary of free piston motor development:

http://www.technologyreview.com/printer_friendly_article.aspx?id=21442&channel=energy&section=

Designed specifically for the new breed of highly efficient series hybrid vehicles, **Lotus Engineering's Range Extender engine** was shown for the first time at the 63rd Frankfurt International Motor Show. In a series hybrid vehicle, the Range Extender engine is attached to an electricity generator and provides a highly efficient source of energy to power the electric motor directly or charge the vehicle's battery. The three-cylinder 1.2 liter Range Extender engine is optimized between two power generation points, giving 15 kW of electrical power at 1,500 rpm and 35 kW at 3,500 rpm via the integrated electrical generator. The battery can also power the electric motor which enables the design of a drive train with low emissions, optimized performance and acceptable range.

http://www.gizmag.com/lotus-hybrid-range-extender-engine/12840/?utm_source=Gizmag+Subscribers&utm_campaign=1527d4985a-UA-2235360-4&utm_medium=email

Ultra Lightweight Gas Turbine Range Extender for Electric Vehicles. Led by Bladon Jets, this consortium includes SR Drives and Jaguar Land Rover. Total project cost is £2,206,784, with the UK government-backed Technology Strategy Board providing £1,103,392.

The aim of this project is to develop an ultra-lightweight, gas turbine powered, electric vehicle range extender that will enable vehicle weight savings of 100 kg or more and a modest reduction in CO_2 emissions on the UNECE101 drive cycle. More substantial CO_2 savings can be achieved in real world use. The small size, multi-fuel capability and potential low cost of the ULRE could also help speed adoption of electric vehicles.

Regulatory Compliance

The biggest problem is compliance with emission control regulations. This is probably a much bigger problem than finding & fitting the generator. The cost of compliance testing would be high ($???). Put it on a trailer, backpack or other removable attachment rather than a fixed addition

Appendix 1

"Barry Fower" <BarryFower@fischerpanda.co.uk>

Thank you for the email, we have supplied quite a few of our DC generators into propulsion applications, all Dc voltages are available and we have made units with 144v DC output before.

Our systems are designed to be connected directly to the battery bank, you would then power the propulsion motor(s) from the batteries, our set has a auto function where it will monitor the battery bank and auto start when the battery level falls below a preset level, this is generally after a short time or when heavy load is applied, the system will also turn itself off when the battery level has reached the upper switch off level, all levels are adjustable.
The charge level given out by the generator is directly controlled by engine rpm, so as the batteries become better charged then the engine slows down to reduce the charge going into them. This makes the whole system more efficient and quieter.

Our system has a couple of draw backs regarding being used in vehicle applications, the first being that the system is designed to be as quiet as possible, to achieve this everything is water cooled so we can shut the generator up very tightly making it very quiet, the heat is then dissipated by a remote radiator system of which we have various options. Locating this radiator is sometimes difficult on a vehicle.
The other draw back is the system cost, I have shown below a budget cost for a 25kW - 144v DC system. The next system down is 16kW but very similar size.

AGT 25.000 PVMV-N system budget cost £21,000.00 + vat & delivery.

I have also attached a drawing of the generator so you can see its size and a drawing of the sort of radiator you would need, we do have other options. If you think the system is suitable for your application then please come back to me

Appendix 2

Ken Koch, EV Consulting, Inc. Copyright 2008

A battery pack must be employed which is no less than 96 volts, nor more than 108 volts. This requirement must be strictly adhered to for good compatibility and power balance. If a pack is less than 96 volts, the drive system will draw too much power from the generator, but not enough from the batteries. If the pack is more than 108 volts, the drive system will draw too much power from the batteries, but not enough from the gen-set. If no batteries are used, the voltage ripple of the power bridge rectifier output may be excessive and damage the motor controller.

1. The battery voltage must be monitored, and the gen-set power must be cut back if the battery voltage is more than 2.35 volts/cell. For a 96-volt pack, this voltage is 113 volts; for a 108-volt pack, this voltage is 127 volts. Exceeding this voltage while driving high current into the battery pack will cause excessive battery heat and excessive battery gassing.
2. The gen-set absolutely must put out all of its power at 120 VAC through one or more 120 VAC outlets. This gen-set configuration may take some extra research on the part of the user to find. If, for example, one chooses a widely available 5.5 kW gen-set, it might have two outlets: One for 120 VAC, and the other for 240 VAC. The 120 VAC outlet may be rated for only 15 amps, and the 240 outlet for 20 amps. But the 240 VAC output is incompatible and unusable. All power must be delivered through a single 120 VAC outlet…or more than one 120 VAC if each can deliver the amps and can be connected in parallel. A single 120 VAC outlet with a 5.5 kW gen-set could put out up to 45 amps. Three outlets with a 5.5 kW gen-set will put out the current at up to 15 amps each outlet.

Once the gen-set is identified and purchased, the 120 VAC outlet(s) may be driven into a high-powered bridge rectifier. This unit "converts" AC into pulsating DC, and consists of four power diodes that must be rated for at least 100 amps and 400 VDC. Batteries are necessary because they act not only as energy storage devices, but also as filter capacitors to smooth out the pulsating DC. Schematically the bridge rectifier assembly looks like the figure shown below. All diodes must be case-isolated from one another, and mounted to individual heat sinks.

POWER BRIDGE RECTIFIER PARTS LIST

* D1, D2, D3, D4 Rectifier Diode, #1N3292R, 100A, 500VDC
  NOTE: These diodes are high power-rated, and have 3/8" dia. studs at the base plus heavy-conductor leads at the top.
* HS1, HS2, HS3, HS4 #345-1049 Heat Sink, Undrilled, 4.75" L x 3.00 W X 2.62"H.
  NOTE: Machining required to fit diodes to heat sinks.
* B1, B2 AC Fan, 120 VAC, 60 Hz, 35 cfm
  NOTE: Each fan should be positioned so that it provides airflow for cooling of each pair of heat sink assemblies.
* P1, J1 Anderson #6326-G1 175A Double Pole Connector, Blue.
  NOTE: These two connectors make a mating pair.
* P2, J2 Anderson #6326-G1 175A Double Pole Connector, Red.
  NOTE: These two connectors make a mating pair.
* Miscellaneous #4 GA Welding Cable, Insulated, Black
* Miscellaneous #4 GA x 5/16" Hole Welding Cable Lugs
* Miscellaneous Hardware, small gauge hookup wire, lugs, etc.