Generating Electricity Off Grid

If a stand-alone electricity generating system is being considered (not connected to the national electricity grid), a fundamental point needs to be addressed i.e. how big a system to install. This will be based entirely upon your anticipated energy demand (peak and average).

How much electricity do I need?

If you are frugal with your electricity consumption you may be able to employ renewable technologies only e.g. a combined wind/solar system with battery storage. But if you use electricity for: clothes irons, kettles, toasters, cookers, water heaters (inc showers), tumble dryers, automatic washers, storage heaters and electric heaters you would need a fairly large and expensive renewable-energy system (up to 50kWh output per day). Even when not using the above equipment, typical households might use 5KW/h per day just on lighting, TVs, computers, refrigerators and freezers. Employing low energy-consuming equipment/practices such as compact fluorescent (energy-saving) lighting, 'A'-rated appliances, gas-fired irons etc can reduce that daily demand to around 1kWh or less. The smaller you can make your energy demand, the smaller and cheaper the generating system required. This is crucial if you wish to employ renewable technologies i.e. photovoltaics and wind but less of a problem if using micro hydro-turbines.

What sort of system do I need?

Most small systems usually (but not always) produce a 12v or 24v DC output which is used to charge a set of batteries. If you wish to use 240V AC equipment, the DC has to be converted to AC by an inverter. Basically the battery set is connected to the inverter input (via heavy duty cable) and 240v AC output is available on demand from a socket built into the inverter. Modern inverters are around 95% efficient and consume very little power when not in operation. Inverters up to 2.5 KW (peak) output will cost around £600 but above 2.5KW they usually cost £1000 +.

The main problem with pure renewable systems is that even if you have a big battery system you have to be able to put back into the batteries whatever you take out.

Examples

Small Wind Turbine

If this is sited in a reasonably open windy location, it could typically produce around 1000-2000 times the rated output over a year, i.e. A wind turbine rated at 0.4kW would cost around £800 and might produce 400-800kWh per year. At 12 volts DC output this can equate to a charging current of around 30amps and perhaps 1kWh per day. But ¾ of this might be produced in winter and for several days at a time and then followed be no significant wind at all.

See information sheet 7 - Wind Power for further details.

Photovoltaic Panels

PV panels generate about 850 times their output per year if properly sited (i.e. south-facing and at a angle of around 40º). 3 x 50w PV panels might cost around £800 to buy and should generate around 135kWh per year. At 12 volts DC

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output and on a clear summer day they may put 70Ampere/hours into the batteries whereas in midwinter it would be no more than 18A/h. Over the year perhaps ¾ of the electricity would be produced between April and September and for several days at a time, there may be no significant sunshine at all.

See information sheet 3 – Solar Electricity for further details.

Points to Consider

Wind turbines are totally dependent on local wind conditions (effects of localised turbulence, degree of shelter etc). Similarly, solar arrays are dependent upon the angle of inclination (although sun-tracking systems can be used to increase the array's effectiveness) and degree of shading (especially in winter when the sun is low in the sky). Therefore, the only way to (relatively) accurately assess a potential sun/wind resource (or water resource in the case of hydro turbines) is to take measurements at the site over at least a 12 month period.

Battery storage needed is dependent on the amount of energy required by the household over a 24-hour period. A daily draw from the batteries of say 200 amp/hours would require a battery bank of at least 300 amp/hours capacity to ensure one day power supply. This is because batteries cannot realistically be fully charged up and then fully drained many times without damaging them. A typical 12v DC leisure/deep cycle battery holds either 120A/h or 240A/h and so the minimum battery size for 200A/h consumption would be either 2 x 240A/h or 4 x 120A/h batteries. If 200A/h per day is being consumed, then at least 200 A/h must be put back in by the solar/wind system otherwise you end up with no power or you use a diesel/petrol generator to make up the difference.

It is best only to run smaller equipment i.e. lights, television, computer, pumps and low energy refrigerator from the batteries and for a short a time as possible so as to reduce the charging time needed. If any piece of electrical equipment is used continuously it may seriously deplete your battery system e.g. a conventional PC or TV will consume around 70 amp/hours (at 12v) if used for 8 hours.

Any regularly used equipment rated over 2Kw or any that draws over 1Kw for more than a few minutes is not really suitable for use in a battery system unless you have a particularly large battery set/inverter with a big charging system. High consumption equipment is best supplied directly from a diesel/petrol-fired generator. This is because putting the electricity back will require a very long battery-charging period.

As most household applications use 240 volts AC, it is important that the DC power is converted to AC by an Inverter. This is a key component and comes in two forms:

Inverter only, this converts DC – AC and is rated according to the average and maximum peak load taken out e.g. 1800w, 2500w peak.

Interface inverter. In addition to converting DC to AC, an interface inverter allows mains 240v AC (or from a generator) to be used to recharge the batteries if they fall below a certain level due to demand exceeding supply of DC. They also automatically change the supply over from the inverter whenever mains electricity or generator output becomes available.

In order to know how much battery power is required for equipment you

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need to add up the consumption of each item and multiply by the number of hours in use per day. E.g. 3 x 10w lights for 4 hours, 1 x 100w TV for 3 hours etc. This can then be converted via the formula:

$$\text{Current (Amps)} = \frac{\text{Power (watts)}}{\text{Voltage}}$$

An example of the typical equipment costs for a hybrid PV/Wind system for a small low-energy consumption house

10 x 50 watt monocrystalline PV panels @ £250 = £2500

2 x 400w Wind turbines + towers = £2000

Charge controller = £100

Inverter (modified sine-wave) 2000 watt continuous rating= £600

6 x 120 amp deep cycle Batteries = £900 (or 6 x leisure batteries = £240)

Associated wiring & meters = £100
+ Miscellaneous

TOTAL = c. £5,500 - £6,500

The most practical and flexible system to install is one that incorporates renewables and a diesel-powered generator. Electricity supply is then more reliable (especially in winter). The generator can then be used to directly supply 240V AC and also provide additional battery charging (it is worth noting that battery chargers are fairly inefficient i.e.50% - 75%). The supply to the house can then be switched from the inverter to the generator either manually or automatically. If the generator has an output of 5 – 10 KW, larger appliances i.e. washing machines, tumble dryers etc, can be used when the generator is running. Costs will vary widely. You could belt-drive a 240v AC alternator from any static engine – a 5KVA (around 4KW) alternator would cost around £500. A new, purpose made generator set of around 5KVA would cost around £6,000.

Diesel oil can potentially provide 10.5Kw of heat per litre but when burnt in an engine around 8.5Kw of that potential energy is lost in friction, unburned fuel and heat. If the generator is only used to supply, e.g. a TV (100w), over 99% of the energy potential of the diesel oil is being wasted. Therefore, wherever possible, try to use the full output of the generator in order to get the most out of the fuel and to keep the environmental impact to a minimum.

Combined heat and power

To get the very most from the fuel you use when running a generator, it is preferable that a water-cooled engine is used. This allows the generator cooling system to be used to indirectly heat water for domestic hot water/central heating. If the cooling system output is also passed through a water jacket on the exhaust manifold (commonly used in boat engines), it will significantly increase the available heat as well as cooling and muffling the exhaust. Up to 60% of lost heat can be recovered in this way. This increases the efficiency of fuel use from around 20% (electricity only) to around 65% (electricity and heat).

Use of generator cooling system for domestic water heating

When a water-cooled internal combustion engine is used, for example to drive a generator or pump, it is possible to re-use hot water from the engine's cooling system.

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Basically it is a matter of tapping into the radiator's top and bottom hoses. You can do this by replacing the engines existing straight hoses with hoses that have tees in them (most engines also have a water take-off point on the top of the cylinder head that can be used instead of a teed top hose). The top hose brings the hot water (flow pipe) from the engine and the bottom hose (return pipe) supplies cooled water to the engine. When the tees from the flow and return pipes are connected by flexible pipes to the coil of an indirect water cylinder, the hot water from the engine cooling system heats the water in the tank. (I find plastic domestic water pipe such as HEP2O ideally suited as it can stand the temperatures and is cheap and easy to install).

Unless you have an open unpressurised system, you cannot use a domestic indirect hot water cylinder as they are not designed for the engine's pressurised water system. The appropriate pressure-tested hot water cylinders are commonly referred to as Calorifiers and can be obtained from larger plumbing suppliers or most chandlers. They come in various sizes, are made specifically for horizontal or vertical installation and are commonly supplied with one or two internal coils. You would expect to pay around £200 for a 100 litre calorifier. For a pressurised system you have to remember to use the expansion bottle normally fitted in a vehicle for water topping-up.

For further energy efficiency advice contact Community Energy Plus – www.cep.org.uk or call 0800 512012

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