grid-connected systems

Grid-tied, or grid-connected systems are home-generation systems that are connected via a 'synchronous inverter' to a utility-provided electricity supply. In the UK we refer to electricity utilities as the National Grid and we refer to the energy we use as being supplied by the grid or 'mains electricity'. The synchronous inverter provides the interface between the generation system and the mains-power grid. It takes the variable voltage from the wind turbine or solar panel system and changes it into mains, alternating current (AC) power, which in the UK is 240 volts. The inverter takes its signal from the mains so that power added to the grid is in phase, see the *system components* chapter (page 23). This means that the peaks and troughs of the AC sine wave are exactly the same for the mains and the added inverter electricity. The AC output has to be in phase with the grid power otherwise the power will be lost.

The general idea is that the home-generated power is fed into the grid inverter. This then goes through an electricity meter which is connected into the house wiring system near the fuse box. This meter is used to record total generation for ROCs or feed-in tariff payment claims. If you are using more power than your home-generation system is producing then the extra you need is drawn from the grid. If, however, you are using less, then the surplus goes into the grid.

I have always wondered why the home-generated power takes preference over the mains power within a grid-connect system, as it seems that the power is effectively mixing together. Having recently spoken to Ken Hobbs of Power Store, see *resources* (page 177), he explained how the grid-connect inverter keeps the home-generated power about half a volt above mains voltage and so makes sure the home-produced electricity is used first.

advantages and disadvantages

There are two types of grid-connect systems: those with battery backup and those without. Grid-connected systems without a battery backup have one particular drawback in that if the utility grid supply fails then the inverter will automatically disconnect itself from the utility grid. This is to protect linesmen working on the grid system, but means that you suffer the same power cuts as everyone else.

Grid-connect systems with a battery backup include the addition of a battery bank and charge controller and can provide power in the event of grid supply failure. The size of the battery bank depends on how much of your system you wish to run during power cuts. It could be that you choose just to run the essentials, like fridge, freezer, lights and central heating pump. These batteries will not be constantly cycled, as with a system that relies completely on batteries, and so gel batteries are ideal as they are maintenance-free and sealed.

There are many advantages of using a grid-connected system as they are:

- simple to install: there is less hardware and no need for batteries, a battery shed and the associated costs. The inverter is just a box about the size of a small suitcase that is fitted on the wall.
- highly efficient: all the power generated goes into the grid and so no power is lost in the batteries (usually about 20 per cent) or in charge controllers or dump loads. As all the power produced is going through the inverter and meter, then the meter shows total generation rather than with a battery system which just shows power consumed and takes no account of the power lost in the batteries. This is pertinent as this meter will, without a shadow of a doubt, be used as a ROC meter.
- reliable: well, as reliable as the grid power supply but you have no battery maintenance to worry about.
- flexible: you either use the power or it goes into the grid.
- durable: there's no need to think about when you need to replace batteries.
- stable: the system is entirely based on the stability of the grid, which has huge resources to keep the voltage and cycles within close limits.

There are several disadvantages to grid tie that I can think of, which are:

- you are not autonomous as far as power is concerned
- at the moment electricity companies regard buying the electricity from systems producing below 6 kilowatt hours as uneconomic. This means that any surplus power you do not use is given to the grid free of charge if you have a small system. You can, however, claim ROCs from some companies, see the *building a system* chapter (page 127)

grid-connect inverter standards

There are various international standards that apply to grid-connect inverters and all inverters used for grid-connect purposes must comply with UK law and standards:

- safety: inverters must be G83 compatible and in the event of failure of the grid they must automatically disconnect themselves to aid shut down
- power quality: the conversion of direct current to alternating current electricity must be within the limits for harmonic frequency variation of 5 per cent for current and 2 per cent for voltage, to protect the loads and utility equipment
- compatibility with the solar array: the array's maximum power voltage at the standard operating conditions must be compatible with the inverter's nominal direct current input voltage. The maximum open circuit voltage for the array should also be well within the inverter's tolerable voltage range

inverter and generation-system compatibility

It goes without saying that the inverter and the home generation system must be compatible with each other and certain considerations must be taken into account when choosing the appropriate components:

- the size of the inverter must never be less that 90 per cent of the peak wattage of the system. It is, however, a good idea to install a larger unit to allow for system expansion. Some inverters can be slaved together, which means that their control systems are connected together and so two inverters will act as one unit.
- the inverter must be able to handle the maximum current and voltage of the system.

grid-connect solar panels

A solar grid-connect system automatically senses the voltage and current produced and adjusts its setting to achieve maximum output for the conditions at the time. This can be achieved because, unlike turbines, solar arrays have a maximum voltage and current. There is no problem with overvoltage or with simply disconnecting the panels from the load.

The associated technology is called Maximum Power Point. There is a difference between the actual output of the panel and the manufacturers' figures due to the difference between battery voltage and peak power panel voltage. The Maximum Power Point software in the grid connect system allows the maximum power to be collected from the panels because it is not tied to a battery voltage and the voltage can rise as long as current does not fall. Once again we return to volts x amps = watts.

grid-connect wind turbines

Things are slightly different with grid-connected turbines in that the three-phase alternating current output of the turbine is fed through a rectifier before feeding direct current into the grid-connect inverter. A meter is installed between the inverter and the mains connection to measure the total output. It is important to remember that turbines should not be disconnected from their loads, so if there is a mains power cut and the inverter automatically switches off, then a dump load should automatically be switched into the circuit to provide the necessary loading and prevent that nasty, damaging turbine 'over-speed'.

fig 51: 6 kilowatt grid-tie inverter (right) and turbine controller (left)

Wind turbine grid inverters are different to solar panel grid inverters in that the inverter needs to be tuned to the turbine. There are three settings – low, mid and high – for voltage and current that need to be matched to the turbine. If this is not done then the turbine will either have too much load and never start correctly, or there will be insufficient load that will allow the turbine to speed up, producing excess volts.

If this happens the inverter will switch off to prevent it being damaged and as a result the turbine load dump will start working. This means that the turbine output will be diverted to the dump and so no electrical power will be available to your system from the turbine and you go back to using mains electricity. It also means that none of the electricity produced by the turbine during this process will be recorded by the ROCs meter. This is why it is important to match the grid-tie inverter and the turbine to get trouble-free and productive operation.