why and wherefore

To have a system that produces energy without any external influences seems like a Victorian dream of perpetual motion, and takes us back to an age where energy expectations were far less demanding. A wind or solar system is half way to that utopian dream, in that the energy is derived from natural and sustainable products of our environment. If you want electricity the choice as I see it is, you either buy it through the National Grid, which is the main network for distributing electricity throughout the UK, or you generate it yourself.

There are properties where no grid electricity is available and so for people living in them the question 'why?' does not exist, as modern life would be severely compromised without electricity. So the main choice for these 'off-grid' households is between hydrocarbon fuel-powered generators or wind and solar unless there is access to hydro-electric power or enough enthusiasm to use pedal power. But for those of us who have an electrical mains connection the 'why?' question' is complex and involves thinking about the future, which then brings into focus such considerations as whether you want to depend on a system based on huge profits for and run by corporate entities.

The world, however, is changing fast and as I write international politicians are all talking about carbon reduction and rapid climate change. The most widely accepted view now is that atmospheric carbon (CO_2) is making a significant contribution to global warming, which could escalate to catastrophic proportions for most life forms. Most electricity is still generated by burning carbon in some form, like oil, gas, or coal, and so to reduce your own contribution to CO_2 production it is helpful to reduce not only your electricity consumption, but also your reliance on National Grid supply.

Let's talk a bit more about the National Grid electricity supply. It's a huge system based on economies of scale where enormous power stations produce the electricity. Demand and supply within the grid must be carefully balanced otherwise the voltage and cycles of the electricity supplied will vary and create problems within the distribution system and for the performance of the appliances that are being powered. For this reason some of the power stations are kept running at low output to provide rapid reaction to variations in demand. It is very inefficient for these power stations to be used in this fashion, but it is in the nature of the system that it should be so.

Added to this the distribution system, or National Grid, is inefficient by its very nature as moving power over long distances automatically 'leaks' power within the wires and transformers. A more in-depth explanation of the theory behind this is given in the *electricity* chapter (page 109). So from all of that you can see that it's desirable to have your own little local, home-generating system rather than relying completely on an inefficient and polluting national one.

cost-effectiveness

Once your system is up and running you will immediately see a reduction in your day-to-day expenditure on mains electricity, the level of which will depend on the installed capacity (size) of the system and the site. What is harder to predict is how long it will take you to recoup the cost of building and maintaining your system. This is commonly thought of as 'payback time'.

There are several ways of thinking about this and Paul Gipe goes into some detail in his book *Wind Power for Home and Business*, see *resources* (page 177). His study looks at two options: to either spend money on building a renewable energy system or put the money in the bank and use it, and the interest earned from it, to pay the electricity bills. The results were, of course, determined by the economic situation during the course of the study: namely the interest rate, inflation levels, and the inflation in energy prices. These are all linked in a constantly-changing way. The study was based on spending or saving $20,000 and at the end of twenty years the results showed that the renewable system was $30,000 in credit after paying for the system, and the savings were completely depleted and showed a deficit of $29,000.

Another consideration is: do you want to be involved in a saving system that encourages growth and enriches bankers and shareholders? There is also the issue of possibly indirectly investing in dubious companies and ecologically-damaging projects as a product of your bank investments.

The bottom line question, as I see it, is: are you prepared to take responsibility and reduce your energy demands and impact on the environment despite the greed and ambivalence of most of the population, or do you follow them like a sheep in the excesses of modern energy consumption?

Inspired by Paul Gipe's assertions about the cost-effectiveness of systems producing home-generated energy, I decided to use the data gathered and used in the *research* chapter (see page 151) to produce a cost-benefit analysis of the systems monitored there. The analysis assumes the system is grid-connect and 100 percent efficient – mine is neither so you will see differences when I come to talk about my actual figures.

The study is projected over twenty years and compares the cost of installing and using each system during that time, to putting the money into a bank account and paying for the portion of the electricity bill that is equal to the solar or wind output from it.

Interest is added to the total remaining in the bank account on a yearly basis and the electricity cost is increased each year by the assumed level of inflation. ROC payments received are set at 20 pence, and this payment is assumed to remain the same throughout the period. A detailed breakdown of the analysis for each system can be found on pages 172-174.

The problem with this type of analysis is the long-term nature of the predictions and the unpredictability of changes in economic conditions. At the time of writing interest rates are about 1 per cent and inflation about 3 per cent. However, I can remember when, in the early nineties, inflation was up to 15 per cent and interest rates were at a similar level. Last year (2008) saw huge increases in the price of fuel and energy with electricity reaching 24 pence per kWh, which has now reduced to around 17 pence.

All this shows that the factors that can influence economic circumstances are complex. They can also affect the value of a currency on the world market and hence the cost of goods in any one country. So my study has used relatively benign interest and inflation rates to make sure it does not show a 'best-case' scenario only. I have used 3 per cent inflation and 2 per cent interest after tax, as these two factors are generally closely linked. It does not take into account events like the recent hike in fuel prices, although I am assuming that fuel prices will show a general trend upwards as fuel is a limited resource.

The analysis projects payback times for three systems, namely 800W fixed solar panels, a FuturEnergy 1kW wind turbine, and a Proven 2.5kW wind turbine used on a grid connect system. The costs of these systems are variable and costs are currently increasing as the value of the pound is decreasing in relation to other currencies. As a result my analysis is only really a guesstimate based on benign figures, so it should not lead anyone to false hopes, although the other side of that coin is that things only have to change slightly and the payback times could come down dramatically.

The sort of changes that would affect an existing system could be: higher energy costs or greater ROC payments. A high-value pound would make the components cheaper, but a low-value pound would put gas and oil prices up and make the price of electricity more expensive. The output figures used are taken directly from the research data I've recorded and were compiled by me, so represent **real** data as opposed to manufacturers' estimated figures.

So the study shows that:
Using 800W solar (photovoltaic) grid connect panels, yielding 850kWh/year, with an initial outlay of £3500, would cover the initial cost of the panels in 11 years and leave you £3783 in credit after 20 years. Putting the £3500 into a bank account and using the money to pay for the portion of the electricity bill that is equal to the solar output each year, leaves £558 after 20 years.

Using a FuturEnergy 1kW grid connect wind turbine, yielding 445kWh/year, with an initial outlay of £2500, would cover the initial cost of the turbine in 14 years and leave you £2002 in credit after 20 years. Putting the £2500 into a bank account and using the money to pay for the portion of the electricity bill that is equal to the FuturEnergy turbine's output each year, leaves £941 after 20 years.

Using a Proven 2.5kW grid connect wind turbine, giving 2038kWh/year, with an initial outlay of £14,000, would cover the initial cost of the turbine in 17 years and leave you £6618 in credit after 20 years.

Putting the £14,000 into a bank account and using the money to pay for the portion of the electricity bill that is equal to the Proven turbine's output each year, leaves £8333 after 20 years.

Well, if you are of an independent mind then it is now much easier to fit a wind or solar system than it ever has been in the past. The improved availability of parts and price reductions in recent years has made fitting a relatively complex system much easier. I have been building wind turbines and the associated systems for the last twenty years, and it seems that technology and commercial production has effectively 'cut me off at the pass'. By this I mean that all the low-tech solutions I have discovered and developed in the past are now redundant because more reliable systems are available almost over the counter. This does mean that we have to rely on commercial production of components and all that entails, but it certainly takes much of the struggle and heartache out of building and using a wind and solar home-generation system. For that I am heartily grateful.

The UK government announced in July 09 the detail of their proposed feed-in tariffs for the renewable electrical microgeneration scheme. This is a replacement for the ROCs system and will be effective from April 2010. It provides a pricing structure for payments irrespective of whether the electricity is used on the property or sold into the grid. The preliminaries are: as follows, but there may well be changes as the scheme is developed and you will have to work with your energy supplier.

The prices given per kilowatt hour and installed capacity, i.e. theoretical maximum output of the generator, are:

Solar	36.5 pence for up to 4 kilowatt installed capacity
Solar	28p for up to 10 kilowatt installed capacity
Wind	23p for between 1.5 and 15 kilowatt installed capacity

As I have said these are early days and things may well change, but there are indications that there will be an annual taper of 7% reduction in these prices. The effect of this taper means that the price paid will depend on the year of installation. For instance if the solar and/or wind generators are installed in 2010 the top rate will be paid for a predetermined and extended period (in Germany it is 20 years). If installation is in 2011 then the 7% reduction will be imposed and will apply for the duration of the payment period.

This reduction in payment level will apply to each consecutive year, and so gives an incentive to make the investment in year one rather than (say) year 5 when the payments will be 4 x 7% less (28%).

So, in this book I am going to try to give you the confidence that you can, given the will, reduce your grid-sourced electrical demands without returning to nineteenth-century living. It does, however, help if waste-reducing practices are included in everyday life, like switching off unused appliances and lights, not leaving the computer on all the time, and perhaps forgetting to switch the television on ever again. In this way you can attain a level of energy supply that is far less wasteful and polluting than the alternative and, as I have experienced, is far more secure. If something happens to interrupt nationwide or global energy supplies then at least your own system will continue working.

Let's just look at the reductionist question again. You can reduce your electrical and energy requirements considerably by changing your living arrangements and lifestyle. This, of course, is not something that can happen overnight, but many people are coming to realise that life is short and then you die. It's the bit in between birth and dying that is important, so why waste it all by doing things that you don't want to do? I know there has to be a balance between ambition, identity, satisfaction and living, but many people just get dragged along by a consumption-led society and look where that has taken us. I'm writing this at a time when the final throw of the dice has shown how poorly thought out the Thatcherite 'greed is good' principle was and it has now, in 2009, come to its inevitable conclusion with the impending total collapse of the world banking system.

The point I suppose I'm trying to make is that we can reduce our consumption and gradually wean ourselves away from consumerism and that gadgets and convenience articles are the results of a busy life in which you are too busy to actually live. Saying no to this leads indirectly to a place where you are no longer under the thumb of the finance industry, do not wish to buy stuff as compensation for an over-busy life, and do have time to actually enjoy life.

So, where do you start? Well it's just a matter of not using things and finding practical alternatives. The main thing to understand is that mains electricity is environmentally very expensive, in that it is wasteful and in some cases its use is totally unjustified. Space and water heating use large amounts of energy that can be provided more efficiently by a wood stove or, if this is impracticable, by using a gas condensing boiler. The use of gas as a direct form of heating is ultimately much less polluting than the equivalent heat from electricity. The use of gadgets and tumble dryers can be cut out eventually because, hopefully, you will have regained bits of your life in which everyday tasks can be carried out in a relaxed fashion. Low-energy products can also be helpful.

This is, of course, the view of someone in the affluent West where, at the moment, starvation is not an immediate threat. This non-consumerist way of life already exists in many other cultures throughout the world, so it can be seen as a credible alternative view.

system choice

This is just a brief guide to systems before we move on to the more detailed sections and is intended to give a bit of background so that further chapters are easier to understand.

The cost of a system will be determined by individual circumstances and I won't try to guide you about that. You need to consider whether you want to start off with a small system and build up the capacity over time, or pay out more and go large. Each person has their own value system and financial constraints so with the information in this book you can work out what you want to spend and install.

The main deciding factors beyond cost are:

- what is required from the system
- the nature of the site and its local environs

system requirements

Let's assume that electrical power is required to provide all or part of the power for home use and so reduce grid-supplied power consumption. There are two electrical systems that can be adopted: either grid-tie or battery. It is important to understand that it is always necessary to have some form of backup power when dealing with batteries.

For systems that are totally 'off-grid' a carbon fuel-based generator is a must to make sure that those flat batteries don't stay flat, and that the power necessary for fridges, freezers, and lights is available.

For battery systems on sites where mains electricity is available, then the mains can be used as a backup. This can either be by the manual operation of a battery charger or through the use of an uninterruptable power supply (UPS) inverter. The UPS inverter switches over automatically under a variety of situations (see inverter section, page 143).

For grid-tied systems the grid is used as a theoretical store of energy and there are no batteries. When the grid goes down then all power is lost. The grid-tie inverter automatically switches off when it does not receive a mains signal, to protect the linesmen working on line faults. Practically this is not a good thing for some wind turbines, but it is not difficult to set up an automatic dump of electricity from the turbine for these grid-down situations, see the *wind turbines* chapter for more information (page 143).

system size

One of the first questions you will ask yourself is 'how big does the system need to be to run what I want it to?' Unfortunately the answer is not as easy to come by as you might expect. The question and answer can be divided into two halves, namely: 'what are reasonable expectations for power output from specific technology on your site?' and 'what equipment do you want to run using energy from the system?' And this is further complicated depending on whether the system is stand-alone or grid connected.

There are two ways of finding out how much electricity the equipment you want to run will need. To try either way, you will need to understand the following electrical terms.

Watts is a measure of power and each piece of equipment should have an indication of its wattage on it. Watt hours is a measure of power used over time. A kilowatt is 1000 watts so a kilowatt hour is 1000 watts used over 1 hour (kWh).

Let's just look at the last point in more detail. A 20 watt low-energy light bulb running for 6 hours a day will consume 120 watt hours per day (watts x hours) and so will use 840 watt hours each week (0.84 kWh a week). To put this in the context of producing your own electricity, my research for our site and during a particular year (2008), see *research* chapter page 000, shows the recorded output of a 400 watt solar panel array varies between 2 and 12 kWh per week.

So, going back to calculating your electrical needs, the options seem to be:

Work out the consumption in watts of all your electrical goods, and then convert that to kilowatt hours by estimating weekly use. From this kilowatt hour per week figure you could then estimate the size of the system you need.

Or, if you are grid connected, calculate your weekly use by taking readings from your electricity meter. Allowance should be made for large loads like space and water heating, welding equipment (if, like me, you have some), large machine tools etc. as for general use it is not practical to power these types of load from a home-generation system. You are then back to trying to match two variable things, namely consumption and generation.

The problem with these approaches is that you can do all the maths you want, but in the end you are dealing with variable loads and unpredictable electrical generation due to site variations, yearly variations, and the difference between manufacturers' output figures and reality. Once you have read the rest of this book you will realise that this way leads to madness unless you overestimate to a huge degree and install a very large system.

My experience has shown me that the best approach is to be pragmatic and develop a system over time. This way of thinking allows you to assess how things actually work best in your situation. So you install either a turbine- or a solar-array-powered system depending on the constraints of your site. This can be used initially to (say) power your lighting system and see how reliable it is. The use of modern inverters and charge controllers for battery systems can help to prevent serious damage to batteries from either overcharging or over-discharging. If you manage to keep your batteries constantly well charged then you could maybe then add the fridge to the load on the system.

Once a reasonable equilibrium has been attained in the system over something like six months, then you know that to power more of the system, further generation is needed and you will be better able to assess what seems to be best for your site, as well as spreading the cost of installation over time. The main initial considerations are making sure the inverter, see page 143, is big enough to allow for expansion, and whether you go for a battery or grid connect system. I have tried to guide you through the decision-making process in the various and item-specific chapters that follow.

site

You may have set your heart on a wind turbine to show your green credentials and have always wanted one, but if your site doesn't suit using one then it isn't worth trying – you will be wasting your time and cash.

But if the site is wrong for a turbine it may be good for solar panels (photovoltaics), which can be mounted on low roofs or frames in the garden. The most important factor is that they have a good window to the sky facing south: by 'window' I mean uninterrupted view of the sky. If you have big skies, like we have here in Lincolnshire, then the system can benefit from the panels tracking the sun. If, however, there are buildings, trees and any such tall things that cause shade then fixed panels facing the window to the sky, facing about south-ish, is better, and the money saved by not buying the tracking can go towards another panel.

grants

At the time of writing there are grants available in the United Kingdom for installing renewable energy systems. There are some local initiatives run through county councils and the Energy Saving Trust manages grants provided by BERR (Department for Business, Enterprise and Regulatory Reform) under their Low-Carbon Buildings Programme, see *resources* (page 177). The criteria for getting these grants are determined by various factors like income or the energy efficiency of the building. There are local grants for home insulation so it can be improved to the national standard and qualify for a grant.

For the Energy Saving Trust grants the building has to be fitted with the correct insulation, low-energy lights and thermostatic heat controls in each room, i.e. radiator thermostats.

To qualify for a grant the systems must be comprised of certified products installed by a certified installer, and so you are over a barrel. Either you pay large installation fees, which is fine if you are not able to do it yourself, or you do it yourself and forget the grant. Installers can, however, help you with grant applications and applying for planning permission.

There are many things to consider as you investigate whether to build your own home-generation supply system and I have tried to touch on the most important ones here. In the next chapter I will explain the components that will be in that system and some of the ways they can be used.