housewarming

Guides

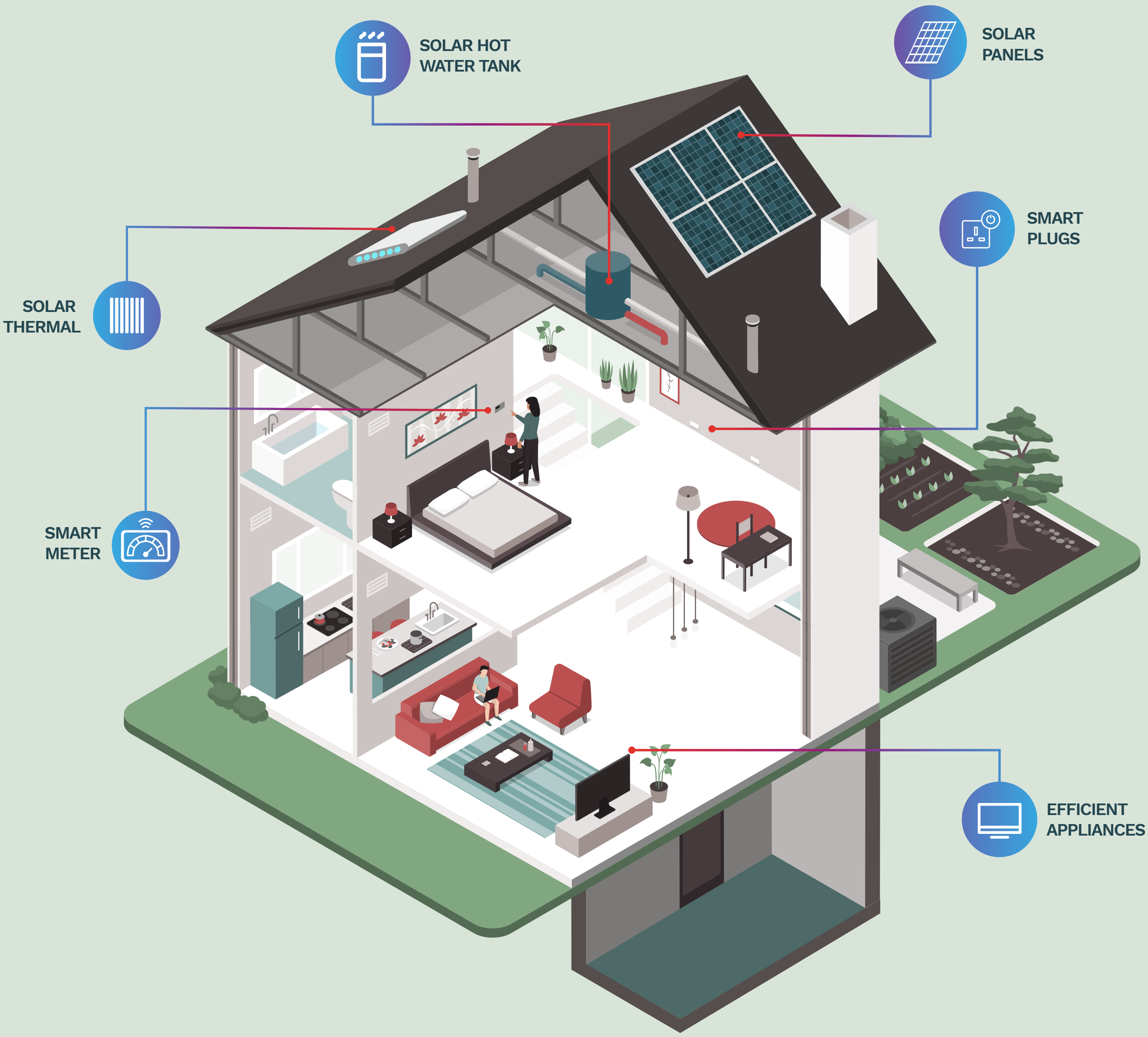
h7

Electricity, Appliances and Home Renewables

Low Carbon Oxford North

housewarming

Electricity, Appliances and Home Renewables



Low Carbon Oxford North

CONTENTS

WELCOME TO OUR SEVENTH HOUSEWARMING GUIDE

The first six Housewarming Guides focused on how to reduce heat loss and how best to heat your home to achieve the lowest carbon emissions and costs. This seventh guide focuses on electricity – how you might use it more efficiently in your electrical appliances and how you might generate it at home through renewable sources to save money and further reduce carbon emissions.

According to the World Electricity Council UK households have the 6th highest electricity consumption globally and this contributes to our high carbon emissions. This level of consumption can largely be attributed to the wide range of household appliances common in our homes. The average UK household electricity consumption is about 3300 kWh per year, according to Ofgem.

As this includes a proportion of homes with electric heating, the average general electrical consumption is closer to 2900 kWh per year. Your own household consumption may be very different as it is dominated by lifestyle choices such as how many people work from home and how often you use the tumble dryer.

To make the best decisions about cutting electricity use it is important to understand how different devices contribute to your total household consumption. Improve the way you use energy before starting to look at generating electricity at home. The next section of this guide will help you do this.

The subsequent section covers home renewables. For most homes in most urban areas, renewable electricity generation from solar PV is likely to be the only electricity option. Renewable heat is a different category, with solar hot water and heating from air source heat pumps likely to be the most common and appropriate choices. We cover renewable heating in Housewarming Guide H5: Heating and Controls.

This guide focuses on electricity and how we consume it.

Even if you cannot generate renewable electricity at home, the UK is increasingly using its own abundant renewable resources. In the UK in 2022 about 15% of all energy used was from renewables. Of this, the proportion of electricity from renewables reached 40%. Gas and other fossil-fuelled electricity generation is reducing and therefore so is the total carbon content of electricity at our meters.

As of 2023 carbon emissions from electricity are still equal per kWh of energy delivered to the meter to those from gas heating, although falling. It continues to be worth reducing our electricity use for carbon reasons, as well as to cut our costs. There may be changes we can make in how and when we use electricity at home that help accelerate the use of more renewable generation to reduce costs and carbon. In future, we can expect smart tariffs to help make these changes more easily.

In this guide we discuss:

- What you can do to keep a check on how much electricity you use.
- How you can generate some renewable energy at home.
- The bigger picture of renewable energy on the national grid.
- Energy storage and changing your patterns of use.
- Controls and apps which help you minimise your bills.
- Whole house planning.

Electricity

Electricity has only been a significant energy source for about 100 years. By 1935 only two thirds of homes had electric light. The 1957 Electricity Act created the Central Electricity Generating Board which nationalised the whole of the UK's electricity infrastructure so that a national strategic plan could be implemented to provide electricity to everyone. However, 6% of farms and 3% of other rural premises in England and Wales still had no electricity in 1965 – and it was not until 2008 that the last Welsh village, Abergeirw, was finally connected!

The first electric lights appeared in Oxford in the 1880s powered by private generators in individual buildings. In 1892 the Oxford Electric Light Company began generating on Cannon Wharf, Osney, initially feeding a few streetlights and by 1895 supplying most colleges and some university buildings. It was originally coal-fired, converting to oil in 1963, and was closed in 1969 as the National Grid and CEGB took on the role of supplying to the whole country.

HOUSEHOLD ELECTRICAL APPLIANCES

Understanding which household appliances use electricity, how much they use and how that consumption can be reduced is an essential starting point in cutting electricity bills. Buying the most efficient appliance and using it badly will not save energy. The most appropriate appliance used well will be the cheapest to run.

At present in most of our homes, electricity is used almost exclusively in lights and appliances. In some households, electricity is the energy source for the heating system, for instance in night storage heaters or a heat pump, so electricity consumption will be much higher. This section focuses on the 2900 kWh used in lights and appliances, about 20% of the total energy (electricity and gas) used in the average home.

In a low-carbon future, where we use more electric cars and have heat pumps, electricity use will rise significantly, though gas use will almost disappear, and we won't be buying petrol. For example, an electric car covering 8000 miles per year at 4 miles/kWh will use 2000 kWh. An air source heat pump might use 3000 kWh per year (see more in our other **Guides H1: Taking Stock** and **H5: Heating and Controls**).

A typical UK electricity bill will be made up from all the large and small bits of consumption from all the electrical devices in our home. The charts show sample split and totals so you can see where you fit in.

In May 2023 the price for electricity was 34p/kWh and for gas 10.5p/kWh.

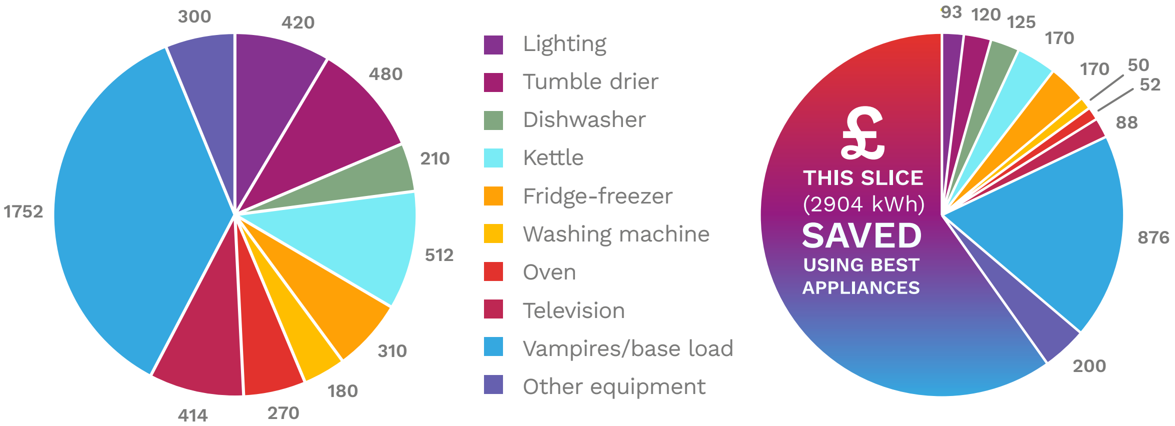
What are kW and kWh?

The rated power of an electrical device is given in kW (kilo-Watts) and you should find this rating on a plate on any electrical equipment. One kW is the same as 1000 W (Watts) so a 1200 W vacuum cleaner could also be described as 1.2 kW.

A kWh is the 'unit' of energy we pay for in our bills. For electricity it is the number recorded by the meter. A kWh is also what you use if 1 kW of power operates for 1 hour. Ten kWh would be used by a 5 kW device running for 2 hours. So, if your vacuum cleaner is rated at 1.2 kW and ran for about 1 hour a week at full output, you would use 1.2 kWh per week - about 60 kWh in a year. Similarly, a broadband router drawing 8 W in use for 24 hours a day uses about 70 kWh per year – more than your vacuum cleaner! A 100 W light bulb running for 10 hours uses 1 kWh.

OLDER APPLIANCES: HOUSEHOLD ELECTRICITY BILL SPLIT BY END USE

MOST EFFICIENT APPLIANCES: HOUSEHOLD ELECTRICITY BILL SPLIT BY END USE



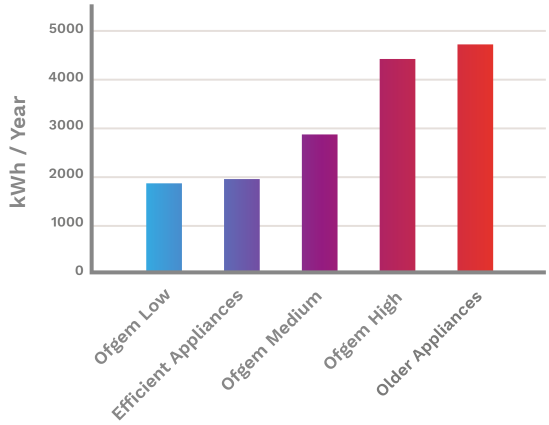
All figures quoted are kWh/year

NOTES

The figures we have shown for ‘most efficient’ and ‘older’ appliance electricity consumption do not represent average households in the way that the Ofgem 2900 kWh figure does. This is because:

- The average ‘Ofgem’ household does not own the full range of appliances shown here, (e.g. fewer than half of UK households have a dishwasher: 2019 Trendmonitor report);
- Every household has to use some additional electricity to provide their space and hot water use (even a gas central heating system could use 100 kWh per year on pumping the water through the radiators);
- Virtually no household will have bought the full set of brand new, super-efficient appliances we have identified, so the ‘most efficient’ is an aim. Even in brand new homes it is unlikely every appliance is top of the range.
- How your own bill is split depends on the type of house you live in, the age and type of appliances you use and what your family does day to day.
- All figures quoted are kWh/year.
- There are a number of websites that could help you calculate your own energy consumption, for example www.saveonenergy.com/resources/energy-consumption/

EXAMPLE FIGURES FOR ANNUAL ELECTRICITY CONSUMPTION (2022)



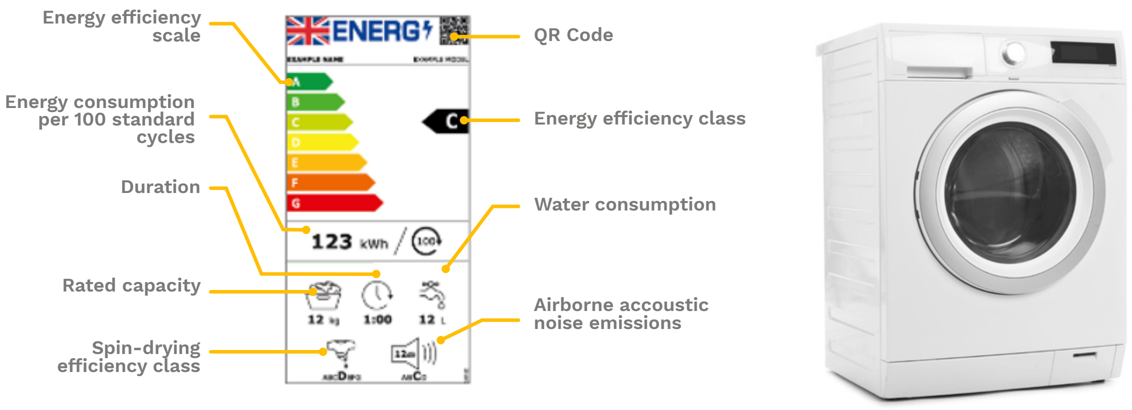
THE RELATIVE RUNNING COSTS OF DIFFERENT APPLIANCES

Though lights and appliances make up 20% of average energy consumption, the high unit cost of electricity means that this fifth of our energy use could represent half of our total energy bill.

Each household uses a different mixture of appliances and a varying number of lights. These, in turn, are of different ages and, therefore, different efficiencies. The technology behind each appliance or light bulb has been changing and becoming more energy efficient – the newest will use less electricity for the same task than the product they replace. This energy efficiency is normally expressed as the amount of electricity (kWh) required to deliver a unit of service, for instance, per litre of space inside a fridge or freezer, per kg of clothes that can be put into the drum of a washing machine or per unit of area of a television screen. This is useful because it allows different sizes of appliances to be compared, but it has the disadvantage of encouraging the manufacturers to produce larger appliances which, in total, could use more electricity. Thus, it is possible to buy a very efficient new appliance which uses more electricity, just because it is so large. The American-style, two-door, upright fridge-freezers are an example of this trend, especially if they have a chilled water dispenser. With appliances, every 'new use' probably carries an energy penalty.

Most of us have seen the colour-coded chart showing the energy efficiency of lights and appliances. What many people do not know is that the system changed in March 2021 as so many devices had reached the old A rating. The new system means that for some appliances an old A rating would now be an F! This is because new devices have been made more energy efficient so the rating system had to catch-up with that change. This is all explained at www.energylabel.org.uk

NEW LABEL FOR WASHING MACHINES



Note: the new charts have a Union Jack at the top left.

The Energy Saving Trust has a range of guides on all the different types of appliances: www.energysavingtrust.org.uk/advice/home-appliances/. The efficiency of devices continues to improve and so we find it may be economic (and environmentally beneficial) to replace older appliances before they fail as the embodied energy will be paid back really quickly and the materials in the old machine recycled.

Our behaviour affects our electricity use. Do you turn off lights when you leave the room? Do you cook a lot, using the oven most days? Do you wash and iron your clothes frequently, or wait until they are clearly dirty? Do you have three children who are always gaming? This means that all our numbers are best guesses so you must judge their accuracy for your lifestyle and increase or decrease them as seems sensible. The total you reach should be around the same as on your annual electricity bill.

If you have a display monitor (that came with your smart meter) this will show you the amount of electricity your house is using at that precise moment. It can help you identify your biggest loads (which appliance uses the most energy) and, importantly, help you track down demand when you think everything is off!

DIFFERENT APPLIANCE CATEGORIES AND HOW THEY USE POWER

There are two main categories of appliances, which are defined by patterns of power demand:

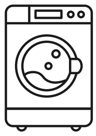
- Those which use a constant amount of electricity when they are switched on. The power rating times the duration of use give the total electricity used (e.g., a 3 kW kettle x 10 minutes = 0.5 kWh).
- Those where the energy demand varies, because the machine includes a thermostat or operates on a cycle. With these appliances, the power rating only indicates the maximum demanded per cycle and gives no information about the total energy used. For example, a washing machine might use 300 W to turn the drum and pump water for 2 hours thus using 0.6 kWh but if it also used its 2.4 kW electric heater to heat the water for 20 minutes that adds 0.8 kWh – which is why cooler washes use much less energy.

We have indicated below how much electricity is used, on average, in each category and what that might mean in terms of your existing appliance compared to a new model. It is up to you to adjust for your own home and usage patterns – published 'average' numbers are guesswork in relation to your home, so treat them as such. In all cases, an individual appliance has a power rating (in W or kW somewhere on the product) that indicates the maximum power it will require.

Appliances that have cycles and energy use that varies

Energy use in many of these appliances – washing machines, dishwashers, tumble dryers, ovens – is strongly dependent on user behaviour. Changing your habits could save as much energy as moving to a more modern product. This can be done by changing the programme or temperature or using an eco-cycle and, obviously, by reducing how often the appliance is used.

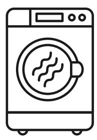
- **Washing machines**



Wash temperature is important because it affects the energy used to heat the incoming water. In the last few years there has been a switch to lower wash temperatures, e.g., 30ºC or 40ºC, supported by detergents that work well with this cooler water, which can halve electricity use. The most recent models have bigger drums, typically 8-9 kg instead of 4-5 kg. Manufacturers have compensated for this by developing cycles that sense the quantity of the load and adjust the inputs, to avoid waste. The energy label is based on 100 washes per year, which is an average: too few for a family with active children but too many for others. Fast spin speeds are good at reducing the water content in the clothes and are essential if a tumble dryer is going to be used afterwards. The energy used in spinning is a lot less than that required to tumble dry.

A modern, super-efficient washing machine will use 0.5 kWh per cycle x 100 washes = 50 kWh per year. An older appliance in a larger family will use 0.9 kWh x 200 washes = 180 kWh per year.

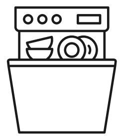
- **Tumble dryers**



Between half and two-thirds of households have a tumble dryer, depending on the family composition and type of dwelling. (Tumble dryers are more often found in flats.) These should be vented outside to avoid condensation. Usage normally varies with the seasons, as some clothes can be dried outside in the summer, so the average is probably less than the total number of washes. Tumble dryers are energy-intensive appliances because the whole process involves heating a lot of air. The most modern appliances incorporate a much more efficient heat pump. Tumble-drying is one of the most expensive things we can do so, where possible, dry clothes on a washing line or clothes airer, subject to not making the house too damp. If you need to use a tumble dryer, make sure you have used the maximum spin speed on the washing machine to extract as much water as possible before you tumble.

The best tumble dryer will use about 1.5 kWh per load x 80 uses = 120 kWh per year. An average dryer in a larger family will use 3 kWh per load x 160 uses = 480 kWh per year. In both cases, the dryer uses considerably more energy than the washing machine.

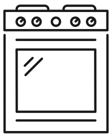
- **Dishwashers**



About half of households have a dishwasher. These are meant to be more energy and water efficient than washing by hand, but this assumes you pre-rinsed dishes when doing them yourself. A machine takes in cold water and heats it which might be more efficient than from a tank or combi-boiler as there is usually a long pipe run where heat is wasted. The choice and number of weekly cycles determines the total energy use. Aim to fill the dishwasher completely and run it on fewer days. Use an eco-setting if possible and plan ahead for cheap night rate or your own ‘free’ solar electricity.

A modern dishwasher used 208 times a year (four times a week) is 0.6 kWh x 208 = 125 kWh per year. A larger family with an older appliance uses it 280 times a year which is 0.75 kWh x 280 = 210 kWh per year.

- **Ovens**

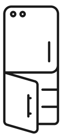


Most households have switched to electric ovens. How often the oven is used makes the biggest difference to electricity usage. Rather than cooking dishes separately, putting several things in at the same time is most efficient. One tip is not to put the oven on to 'pre-heat' too soon, most warm up quite quickly. The fan cycle shortens cooking time but is not necessarily more energy intensive. Consider using a microwave to heat a complete meal as this is the most efficient way of getting heat right into the food.

When cooking, try to prepare meals that maximise the use of the oven or one ring. For example, use a pot which can boil potatoes and has a vegetable steamer above to steam carrots at the same time. If you are using the oven to cook, do as many things together as possible and perhaps cook your pudding in the same oven while it still hot.

A modern oven used twice a week uses 0.5 kWh x 104 = 52 kWh per year. An average model used four times a week uses 1.3 kWh x 208 = 270 kWh per year.

- **Fridges and fridge-freezers**



Together with fridges, freezers and fridge-freezers form the category of 'cold appliances'. Efficiency is important with these products as they are switched on all the time: there is little influence from our usage patterns. There have been mandatory, minimum standards of energy efficiency since 1999 and these have reduced electricity consumption considerably. An old (perhaps a spare in the garage or shed?) appliance is probably very energy hungry and worth changing. As mentioned earlier, be wary of pressure to buy a bigger appliance than you really need. For example, a C rated 635 litre 'American' fridge freezer uses around 225 kWh per year whereas a 422 litre free-standing 'European' unit uses only 163 kWh per year.

Another tip is to defrost food overnight in the fridge as this helps to reduce the fridge's electricity demand and is better for the food.

A modern 350-litre fridge-freezer uses about 170 kWh per year. An older 350-litre fridge-freezer uses about 310 kWh per year.

Appliances that use the same amount of energy constantly when on

- **Lighting**

Electricity use in lighting is highly seasonal and occurs mainly at the end of the day. Most of us have around 37 light fittings in the house and garden, and the average bulb is on for about 700 hours a year (just under 2 hours a day). Rigorous attention to switching lights off could probably reduce this to 500 hours a year. It is a myth that turning lights on and off is wasteful of power.

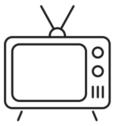
Light emitting diodes (LEDs) use the least energy for the same amount of light, typically 5 W per bulb. Compact fluorescent lights and halogens are more power hungry (25-50 W per bulb) and the original incandescent bulb has the highest demand (usually 100 W). If every light bulb is an LED, in a careful household this would be 37 x 5 W x 500 hours = 93 kWh of electricity per year. In reality, the average household has a mix of bulbs and could be using as much as 420 kWh, so this is an opportunity to save energy.

- **Kettles**

Electric kettles, like ovens, have a high-power demand, close to 3 kW. Don't over-fill your kettle. Just heat enough water for what you need. Heating more water simply means you pay to make it all boil then it cools down again before you next need hot water.

The average kettle uses 2.8 kW x 1 minute x 10 times daily = 170 kWh per year. An over-filled kettle uses 2.8 kW x 3 minutes x 10 times daily = 512 kWh per year.

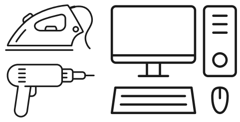
- **Televisions**



The biggest influences on energy use are the size of the screen, hours of use, and whether the set is left on standby when it is 'off'. In many households, there is more than one television. The use of other screens (phones, tablets, laptops) means that televisions are on slightly less.

A television with a 43" (1.1m) screen on 4 hours a day (1460 hours pa) at 60 W = 88 kWh per year. A television with a 70" (1.8m) screen on 6 hours a day at 189 W = 414 kWh per year.

- **Other appliances**



We also use electricity in computers, monitors, printers, games machines, microwaves, vacuum cleaners, sewing machines, extract fans, central heating pumps and other small appliances. A minority of households use electricity for heating hot water or for space heating. These uses can be substantial and are in addition to the data provided here. Each device, individually, rarely accounts for more than 3% of electricity demand, but together could use over 20% in some homes.

Lights and appliances make up 20% of average energy consumption but half our bills.

- **Vampires and base load**

Around the house there are, inevitably, appliances that are never turned off. Often, they are of marginal or no use - hence they are called vampires or wall thieves, sucking power at all times. These include clocks on ovens, lights on freezers, front doorbells, charging points for mobile phones, routers for the computer, the television on standby ready to record. (The cold appliances – fridges and freezers – are also on 24/7, as described above, but are providing a useful service. Their average baseload is about 35 W).

Many of these other pieces of equipment are using tiny amounts of electricity, for instance 1-5W each, but because there are so many (often more than 20), the total consumption is considerable and often the largest user of electricity in the home. Switch things off at the wall if they are not being used so as to reduce 'standby' or 'vampire' loads.

This demand rarely varies over the year, so it is known as base load and can be really difficult to reduce significantly. When all the major appliances are turned off, for instance just before you go to bed, check the figure on your in-house display, if you have one. If it shows 0.1 kW, this is 100 W. While this may be on the low side for the national average (no-one knows what it should be), it is what is being used in your home.

If the base load is 100 W, the annual total is 100 W x 8760 hours = 876 kWh. At 34 pence per kWh (February 2023) that is nearly £300.

MAKING THE MOST OF ELECTRICITY TARIFFS

If you have an energy tariff that charges different day and night rates, then think about whether you can run appliances at different times to take advantage of the cheaper electricity. If you are on an Economy 7 tariff, for example, then this might help you. You may not be able to switch off fridges and freezers, which need to run all the time, but you might be able to use your washing machine or dishwasher when electricity costs are lower.

Fire Risk Hazard

The Centre for Sustainable Energy www.cse.org.uk suggests using lower cost energy at night for appliances *"but ONLY if you're up and about. Don't run these appliances when you're asleep as they are a potential fire hazard."*

Examples of tariffs now available include:

- **Economy 7:**

This was set up in the late 1970s alongside nuclear power. Economy 7 has cheaper rates of electricity typically for 7 of the hours between 23:00 and 08:00 (depending on your supplier and changing between winter and summer), so from around midnight until first thing in the morning. This period is when electricity demand is generally at its lowest and it makes sense for the grid to shift some demand from daytime peaks into the night. This smoothing-out of demand helps power stations run at optimum efficiency and also helps use any wind energy at night.

- **Economy 10 (by SSE and OVO energy):**

This has 10 hours of lower rate electricity made up from 3 time bands: from midnight to 05:00, 13:00 to 16:00, and 20:00 to 22:00 in the winter (GMT, so it changes by an hour in summer).

- **Agile Octopus:**

This is a fully active tariff where the price of electricity changes according to wholesale market changes. (At the time of writing this was not operating due to extreme energy prices in 2022/23.) This means you cannot predict when prices will be low, though generally this will be at night. You will be sent a signal or message which alerts you to when prices are falling and you can programme some devices to respond automatically. Prices can even be below zero so you get paid to use electricity.

Depending on the electricity tariff and whether you have the right meters, changing your tariff might be a simple way to save money. This will not, in itself, reduce your overall electricity use or how much carbon your household is emitting unless your tariff reduces price when renewables are generating most.

TOP TIP: If you read your electricity meter over several days at the start and end of time bands for an 'agile' tariff (or use smart meter data) you can see how much electricity you use during those bands and work out if the tariff is good for you.

SUMMARY

In monetary terms half of home energy bills are typically made up from electricity used in lights and appliances. As your home becomes more energy-efficient and the cost of heating reduces, the running cost of lights and appliances will increase in importance. Every product purchased affects your total energy use for many years so choose an efficient one! Better still, a decision not to purchase a tumble dryer, 'American' style fridge or second television will help keep bills lower. Limiting carbon emissions and climate change will depend upon changing lifestyle choices and behaviour.

HOME RENEWABLES: SOLAR PV

Solar Photovoltaics (PV) is the only electricity generating technology that makes sense for most UK homes. This section does not cover renewables for heating your home - other than the brief summary in the box below - as these are described in detail in Housewarming Guide H5: Heating and Controls. The exception is solar thermal hot water systems which we cover in a later section in this guide.

Home renewable heating technologies

- Air source heat pumps: these use the heat available in the air all around us and it should be possible to install them in most houses, particularly once homes have improved their insulation.
- Ground source heat pumps: these use geothermal energy coming up from the earth's core, supplemented to some degree by the sun heating the surface during the summer months. The amount of ground needed is significant, so you need a very large garden or piece of land free of trees. For example, for just a 6 kW heat pump (small, well-insulated house) you would need at least 170m² of clear land (nearly a whole tennis court) if you lay pipes horizontally. You would use less land for vertical boreholes, but these cost considerably more.
- Biomass: wood stoves can be used to heat individual rooms. Using a biomass boiler may well be appropriate outside an urban area, with consideration given to the wood source and local pollution laws.
- Water source heat pumps: these can be used in a few specific locations with the right flow rate, temperature and access rights. However, this is rare and complex, and we do not cover it within the Housewarming Guide series.

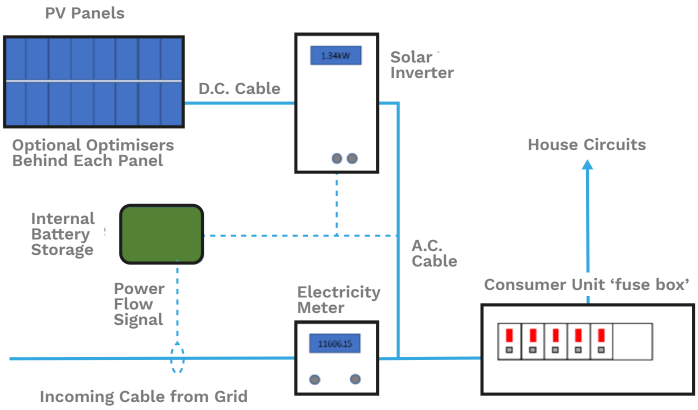
Solar PV is becoming increasingly common in the UK both in field arrays and on the roofs of buildings. The panels generate electricity when light falls on solar cells which are larger versions of those that power watches and calculators. Multiple cells are combined together to manufacture a panel and panels connected together to form an array. The electrical output of the array is direct current (DC) electricity like in a battery. This is converted to mains alternating current (AC) electricity by an inverter which is then connected into the electrical grid and can be used in your home.
In your home, your solar panels will connect to the grid through your electricity meter, in parallel with any supply from the grid. You may also connect a battery storage system and there might also be optimisers connected to your solar panels.

The embodied carbon from their manufacture will typically be repaid in a few years. With an expected lifespan of over 25 years this means they will avoid a significant quantity of carbon emissions.

What is an optimiser?

A solar PV array is made up of many panels connected together. When a shadow falls on just one panel it can reduce the output of the whole array. However, if optimisers are fitted to each panel, this effect is much reduced.

For many arrays there will not be shadows and so they are not worth fitting, but if your roof does have small shadows falling across it for much of the day then they probably should be used.



HOW MUCH ELECTRICITY WILL A SOLAR PV ARRAY GENERATE?

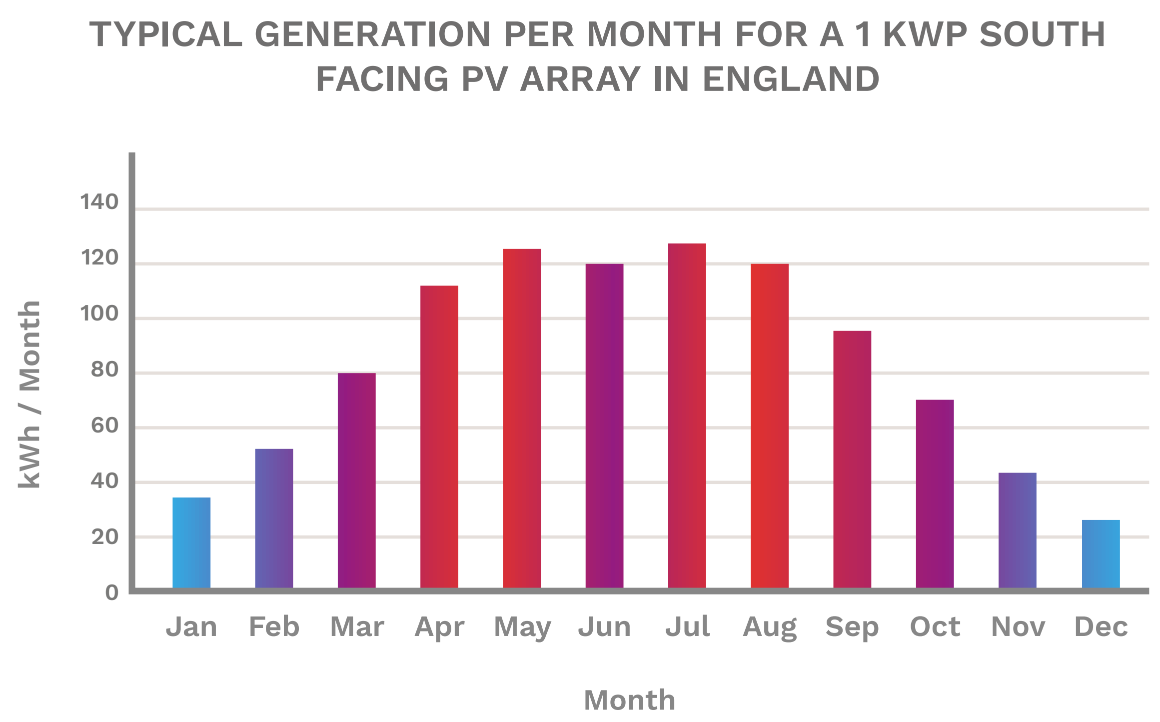
A number of different elements affect how much electricity a solar PV array will generate, and these are covered below.

The output of the solar panels

The output of each individual solar panel is described by its kWp (see box), which is its maximum output of electricity under full sunshine in moderate temperatures. The size of a solar PV array is usually described by its peak electrical output or kWp, which is the total kWp of all the panels connected in that array. Roof mounted solar panels might be rated at about 0.35 kWp each, with those for field arrays over 0.5 kWp.

What is kWp?

The output of a solar PV panel depends on the strength of sunlight falling on it and the temperature of the panels. This means that under a thundercloud in June your roof array might only be generating 400 W, whereas under clear blue skies in May it might be 2.5 kW. Because of this, international standards have been developed to allow all manufacturers' panels to be compared side by side so panels are tested under the same conditions. The output is measured and reported using a rating known as kWp (kilo-Watts peak).



The time, size of array and weather conditions

- **Time of year:** there will be less in the winter. Solar generation is determined by the hours of daylight, so it peaks in summer and is at the lowest in winter. (See graph on previous page).
- **Variations in output:** there will be less in the morning and evening, and electricity will only be generated during daylight hours.
- **Size of array:** The chart on the previous page shows how the electricity generation from solar PV varies through the year (for an average 1 kWp array in England, which might be 2 to 4 panels). Multiply kWh/ month, from this chart, by the kWp for any size of array to assess how much electricity you could expect to generate e.g., for a 2.5 kWp array, multiply the kWh generation figure x 2.5.
- **Weather conditions:** there will be less under cloud.

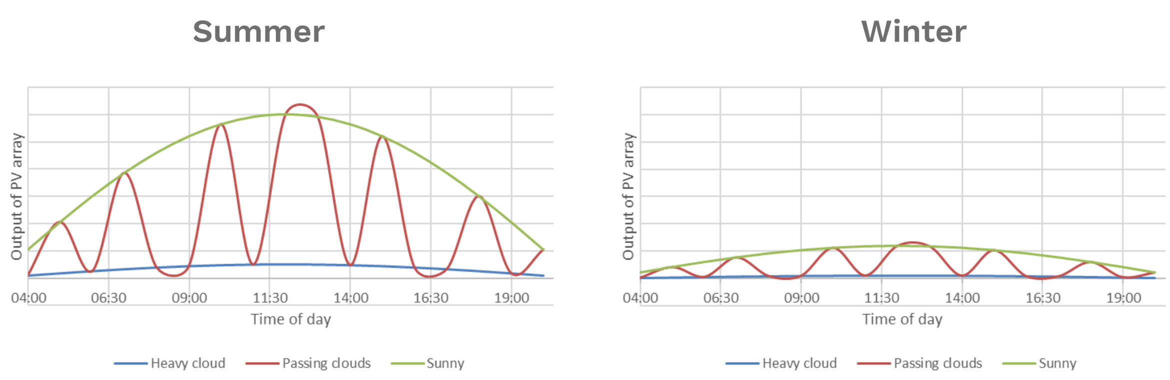
The angle and orientation of the panels

When you are thinking about PV you need to know that the amount of solar energy you get at any given moment depends on how strongly the sun is shining and how directly it shines on the panels. You get the most output annually from an array facing between +/-30 degrees of due south and at a pitch of about 30 to 50 degrees to the horizontal which is coincidentally about the same pitch as most UK house roofs.

Any shading will reduce the output. Even the shadow of a chimney on one panel will reduce the generation significantly unless optimisers are fitted (see earlier box). Shading from a large tree will make a very big difference.

This all means that the best place for solar PV is likely to be a large, pitched roof facing south on a 2-storey building and with no shading nearby. This is also likely to have lowest cost per kWp to install. Conversely, a series of small roofs with some facing east and west will have lower generation and cost more to install so may not be quite

OUTPUT UNDER DIFFERENT WEATHER CONDITIONS:



HOW ANNUAL SOLAR PV GENERATION REDUCES AWAY FROM THE BEST ALIGNED ROOF:

		Orientation from south in degrees			
	Tilt Angle (degrees)	0 (South)	30	60	90 (East/West)
Horizontal	0-10	90.10%	89.70%	88.40%	86.60%
	11-20	96.50%	95%	90.70%	84.80%
	21-30	99.20%	97.10%	91%	82.50%
	31-40	100%	97.40%	90%	79.40%
	41-50	99%	96.10%	88.20%	76.80%
	51-60	94.20%	91.40%	82.80%	70.70%
	61-70	88.50%	86%	77.50%	65.70%
	71-80	81.10%	78.80%	71.20%	60.10%
vertical	81-90	72.30%	70.50%	64.10%	54.30%

as good – but they might match your demand better (see later).

DESIGNING THE SOLAR PV ARRAY FOR YOUR HOME

All of the above elements need to be taken into account in the design of a solar PV array for your own home, as well as a few other questions:

Is your rooftop suitable for a solar PV installation?

Once you have checked your own roof orientation and shading, you also need to make sure it is robust enough to carry the weight of the solar panels. Most roofs will be strong enough for solar panels without reinforcement: any reputable installer (see later) will do a brief survey to check this before quoting.

What size of solar array can you fit on your roof?

The maximum size of your solar array will be defined by the number of panels you can fit on your roof that face the right direction and that are not overly shaded. A competent installer will make an assessment for you.

A ~2.5 kWp array will be about 16m² in total and roughly 7 panels, though the exact numbers depend on the precise choice of panel and their kWp. You can expect to see about 1000 kWh of electricity per kWp installed for a south-facing roof at typical tilt with no shading. This is a rough figure for Oxford: it increases a little as you go south and decreases as you go north. So, a ~2.5 kWp array will generate about 2500 kWh per year, a little less than annual consumption of a typical home.

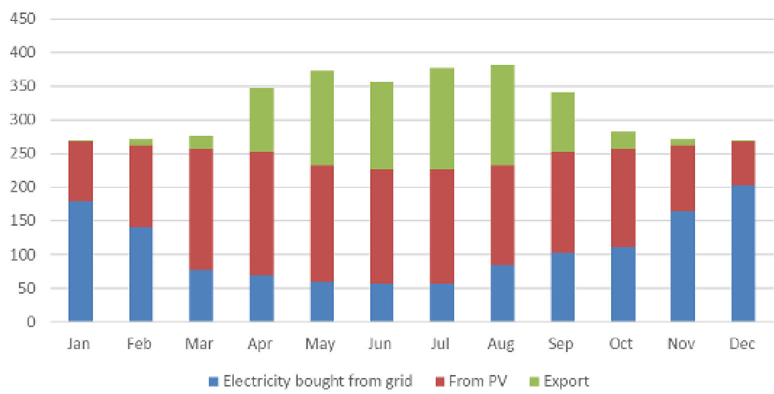
A ~4 kWp array will generate about 4000 kWh per year in an average year which is more than an average house uses in the UK. Of course, the panels do not generate at night, nor do they produce much under heavy cloud especially in winter so even with a 4 kWp array you will still buy some electricity and quite a lot will be exported (unless you have a battery or divert to a hot water tank – see below). A larger array, say 4 kWp, will save more carbon but because it is more likely to export may not be so economic unless you can change how you use electricity and/or add storage.

How much electricity do you use now and are you likely to use in the next few years?

The largest size of array you can fit on your roof and the most you can generate may not be right for you if you do not use a good proportion of the electricity you will be generating. The size of the array needs to be balanced against your likely consumption to make the most sense financially. Take into account how your consumption may change over the next few years when you are considering this.

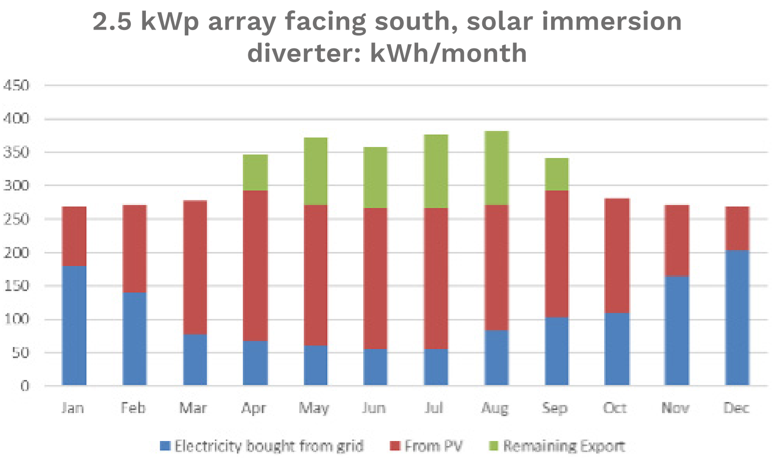
SIMPLE SCENARIO – SOLAR PLUS WHITE GOODS

Example split of electricity in a home with 2.5 kWp array facing south: kWh/month



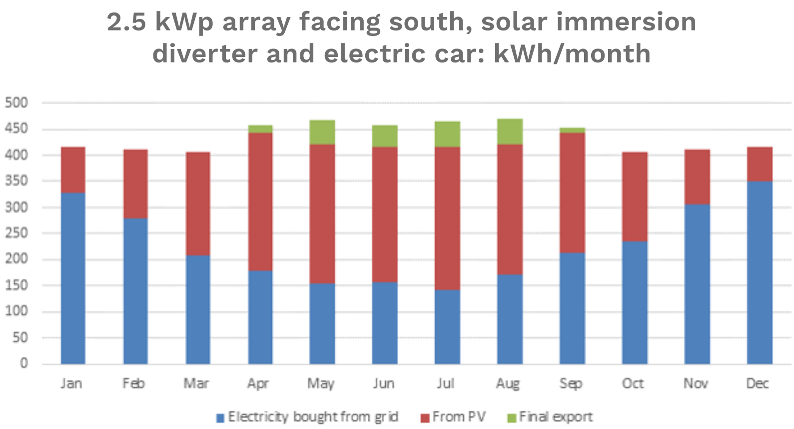
A battery here might store up to ~800 kWh per year for use at night.

SOLAR PLUS WHITE GOODS AND SOLAR IMMERSION HEATER



As the immersion heater now uses some electricity otherwise exported, a battery here might only store ~400 kWh per year for use at night.

SOLAR PLUS WHITE GOODS AND SOLAR IMMERSION DIVERTER PLUS EV CHARGING



Unless the household is very diligently focused on using all the solar power, there will inevitably be many times when there is export. Here we show ~ 200 kWh of export per year.

Note that your winter consumption of electricity is normally higher than in summer as you are likely to use more lights and electricity for heating (even a gas boiler uses some electricity) and spend more time indoors.

What time of day do you use electricity?

Bear in mind that you will generate most from south-facing panels. However, the highest annual output might not be the most economic for you. If you are never at home during the middle of the day in summer but use a lot of electricity in the morning or evening, then a more easterly or westerly facing array (or one facing each way) may better match your use and so be more economic – or you may find investing in a battery store is worthwhile (see right).

When you have rooftop solar PV your home will draw energy first from the solar before importing top-up electricity from the grid. Your background base load will be covered first. However, if the weather is good, you can choose to use other appliances while the sun is shining and you are generating most. Remember, any kWh of 'free' solar electricity you use will be a straight saving from the cost of importing grid electricity.

What time of day do you use electricity?

An efficient order of use might be:

- 1st Any background loads in the house such as wifi, fridge, freezer,
- 2nd Loads you can choose to run in the daytime and, ideally, when the sun is shining such as the dishwasher, washing machine or charging an electric car,
- 3rd Heating the hot water in the hot water tank,
- 4th Charging a battery electricity storage system.

Would battery and/or thermal (hot water) storage be right for you?

If you are not consuming all your solar energy during the day, there are options to make sure you are making the most of it:

- **Thermal (hot water) storage**

You can use solar PV diverters (see page 26 below) to direct excess solar energy that you are not consuming during normal use to your hot water tank. This will help to ensure you are making the most of your generation and that you do not export unnecessarily. However, it will not take long on a sunny day to completely heat your hot water tank and so there may still be some export.

Solar PV does not naturally match a heat pump at all well as solar generates most from March to October and you are most likely to be using your heat pump to heat your home from October to March. However, your heat pump is also likely to be heating your hot water through the summer. If so, make sure you set the time control on the heat pump so the solar PV heats the tank across the sunniest, middle part of the day.

- **Battery electricity storage system**

A battery electricity storage system will be a set of high capacity batteries, a control system and a charger/inverter. The control system can be set up to respond how you want, for example, to charge from otherwise exported solar PV generation or from cheap rate electricity. These battery electricity storage systems are expected to have a life of at least 10 years and cost ~£2000 to ~£10,000.

Most of these systems work in one of two ways:

- **A direct connection from solar PV**

This type charges the batteries during sunny days solely from solar PV generation when electricity would otherwise be exported. When demand in your home increases and you would pay for power from the grid then the inverter converts the energy in the batteries back into mains electricity. This type of system is best installed at the same time as solar PV as it then needs only one inverter.

A battery electricity storage system.

- **A stand-alone battery storage system**

As well as storing excess solar generation this kind of battery storage can also check the price of electricity if you are on a time-of-day tariff. If electricity is cheap or you have a solar PV system that would otherwise export, then the batteries charge. If electricity is costly and you are importing, then an inverter converts the energy in the batteries back into mains electricity. This type of system can be installed separately from solar PV as it is a complete system with a separate inverter.

Regardless of which type you have, if you use a lot of electricity during the daytime and have only a small solar PV array (say less than 2 kWp) then battery storage probably doesn't make sense. Conversely, if you are away from the house during the day and have a large solar PV array (say 4 kWp) then it probably does make sense.

The battery will store the otherwise exported solar generation to use in the evenings and overnight. However, if your house uses a lot of electricity when you are not there, for example, you have a swimming pool, then battery storage is unlikely to be relevant.

If you have a smart meter your supplier should be able to let you see data showing how much electricity you use during the day across the year which will help you make the calculations.

Some larger battery storage systems can be installed so they can operate during a power cut. The most expensive will be able to run the whole house for several hours whilst some can be configured to power lower loads such as the central heating boiler's electrical supply and some lights.

- **EV charging in sunlight (with solar) or cheaper night rates**

Another example of energy storage is a battery electric car or bike, even a laptop battery to a small degree! These can be used to store cheap and/or low-carbon renewable during times of high output and thus displace fossil fuels later on.

If you have fitted, or plan to fit, solar PV then investigate car chargers that can use daytime solar generation that would otherwise have been exported or cheaper night rate electricity. At the simplest level, a plug-in mains-powered car charger could be connected via a 3 kW rated plug-in time switch.

If you have an electric car that you charge frequently it is unlikely that you will benefit from further battery storage system in your home.

Vehicle to Grid Mode

In future, the battery of an electric car could be used as a short-term store to support the grid at times of peak demand in what is called 'Vehicle to Grid' or V2G mode. This is extensively used in Japan where many EVs are plugged into special bi-directional chargers. Many countries are testing this.

The idea is that when your car is parked and plugged in it can earn money for you by acting as part of a grid-wide battery. The grid sends signals to the charger controlling whether it charges or discharges. You would still be able to decide when and how much electricity goes in or out so you know your car will be sufficiently charged when you need to use it. Some trials have been done in the UK which suggests using V2G is beneficial but, as yet, no established rules nor tariffs are in place.

This may come in 5 to 10 years' time. If energy prices and global supply remain as they are now this may be accelerated to help with energy security.

MORE ON FINANCES

The biggest financial benefit a householder gets from solar PV is through not buying electricity. Each kWh you generate from your solar PV and then use is one you will not buy from the grid. This means that to make the panels pay back most quickly you need to use the solar power when it is being generated and avoid exporting to the grid. You will still import some electricity from the grid, especially on winter days and at night.

MCS-registered installers must provide you with details of costs, generation and payback in their quotes and should be happy to quote for different sizes of installation to help you decide. A 4 kWp array might cost £9,000. These costs are indications at the time of writing as local site conditions vary widely and prices of equipment are changing all the time. The installation for most houses will need to include scaffolding so, if you are having any other work which needs scaffolding, try to coincide the work to save overall costs.

Generally speaking, if you have average or lower electricity consumption and expect that to remain the same it is likely that a ~2.5 kWp solar array will give the best payback. Conversely, if you have higher than average consumption, are planning or already have an electric car and/or a heat pump, then a larger array is likely to be better for you. The analysis of the true situation is complex and requires a comparison of half-hourly electricity use against time of day and time of year. In any case we cannot predict the future!

Example financial calculation: 4 kWp solar array

Capital cost	£9000	
Annual output	4000 kWh	Average in typical year, bias towards summer generation
CO_2 saved per year	~0.8 tonnes	Based on standard UK electricity emissions
Savings in electricity **Export income**	£700 – 70% of generation £48 – export – 30% of generation	Based on assumed 25p/kWh long-term cost of electricity and 4p/kWh for export under the Smart Export Guarantee (SEG) which is given to every accredited installation.
Payback	12 years	Base case, no inflation
Effective simple rate of interest	8.3%	

Notes:

1. A solar diverter will improve the payback a little.
2. You can expect to replace the inverter at least once during the 25-year life of the panels. This might cost a few hundred to a thousand pounds.

Some solar electricity may inevitably be exported from your house. If you have a smart meter or export meter this is recorded and you can get paid for this through an 'export guarantee scheme payment' from one of the electricity companies. You will get paid much less per unit for export than you pay for imports and it must be installed by an MCS installer to qualify. Hence it makes financial sense to use all the solar power you can in your home.

The installation should include a generation meter (costed as part of the installation) but this could be part of the inverter unless you have an older installation and benefit from the Feed-in Tariff subsidy. If you already have a smart meter this should allow measurement of export. If you sell the export you will need to provide the export reading to the supplier that is paying for the electricity. Energy Saving Trust and Which? both provide guides on this topic.

- www.energysavingtrust.org.uk/advice/smart-export-guarantee/
- www.which.co.uk/news/article/smart-export-guarantee-rates-the-best-and-worst-seg-tariffs-for-solar-panel-owners-azICP0i78MD8

WHAT PERMISSION IS NEEDED TO INSTALL SOLAR PV?

Most homes will not need any permission to install solar PV on their roof. Homes have deemed consent or permitted development rights if the panels are within 100mm of the original roof surface. You may fit them in the garden if you meet certain criteria: check with your local planning department. Your installer should apply on your behalf for a Buildings Regulation Compliance Certificate and provide this to you at the end of the works.

There are two circumstances when you need to check if you need permission:

- The first is if you own a listed home or live in a conservation area. You will need to check requirements with your local council.
- For large arrays you need permission from the local grid operator - the District Network Operator (DNO). In Oxford this is SSE. You only require permission from the DNO to connect more than ~4 kWp of panels if connected to a normal household supply. If you do want to connect more than the 4 kWp limit ask your installer to request permission before work starts.

MAINTENANCE REQUIRED FOR THE SOLAR PV

Solar PV requires no regular maintenance and should be self-cleaning unless panels are fitted to a shallow slope – or are flat – in which case occasional cleaning makes sense.

It is wise to check the inverter or meter at least every month and record the generation and export at the same time, ideally in a spreadsheet with your other meter readings. This is to ensure that a fault does not go unnoticed. Regular reading of the generation meter is recommended, as with all meters, so you get a picture of how your system performs and can spot any unexpected reduction in output. In this way you can build up a picture of how much is generated and if you see a sudden drop then there may be a fault. Noting the export will also allow you to judge how much you could change your behaviour to use more of the electricity from your panels.

Solar panels should come with a 20- to 25-year warranty on performance. It is standard for inverters to have warranties for 10 years. Meters usually have warranties for a minimum of 1 year and the installer's workmanship should have a guarantee for 2 years. An MCS installer will use MCS certified panels and inverters.

CHOOSING AN INSTALLER

Installers of solar PV should be Microgeneration Certification Scheme (MCS) registered. If you want to get paid for export, you must have an MCS certificate. MCS details and a directory of certified contractors can be found at www.mcscertified.com/. Ideally the installer should also be a member of the RECC (the Renewable Energy Consumer Code, see more at www.recc.org.uk).

The installer should provide a quote which includes an estimate of the annual generation and the assumptions behind that. This should include some indication of how much will be used in the house and how much will be exported.

Make sure the quotation covers all aspects of the work, including any scaffolding and site clearance after the works. It is wise to obtain three quotations for the works.

Always ask for the installer's insurance details up front. Make sure you check what warranties are associated with the solar panels, inverter, optimisers, batteries and any of the equipment and how long the work is guaranteed for. Check before you make the final payment that the warranties for the kit are signed over to the homeowner.

Types of electricity supply

UK mains electricity in a house we all call 240 V. Technically this is actually 230 V -6% to +10%, which is 216.6 V to 253 V. All new electrical appliances are required to work within this voltage range. Usually, you have one cable coming into your house bringing a 'single phase' 240 V supply.

The local electrical network in the road outside your house will be a 'three-phase' system as for the whole of the UK's electricity system. In the road it is normally 415 V and is likely to be in underground cables leading to a substation somewhere along the road. A very few houses and most commercial and other buildings have a 'three-phase' connection which is split into 230 V wiring inside the building near the electricity meter. If you do have a 'three- phase' supply you can connect three ~4 kWp arrays. Your bill will say if you have a three-phase supply, or you can ask an electrician.

(Continued overleaf)

Types of electricity supply
(Continued)

For complex reasons due to the history of how the UK electricity system was built and developed, connecting any electrical generation to buildings comes with some complexity. The system was designed and built to allow huge central generators to connect to the National Grid, send power at very high voltages along transmission lines to 'grid supply points', such as the National Grid's Cowley site south of Blackbird Leys, and then distribute it in smaller and smaller cables and at lower and lower voltages to our homes and businesses. Trying to push power back up the system can cause problems and so we are limited to ~4 kWp of PV per phase unless we get special permission.

CONTROLS AND APPS THAT MIGHT HELP YOU

There are increasing numbers of apps being developed to help you make the most of cheaper rate electricity and/or solar generated electricity.

- **Whole house electricity use monitoring**

The data from a home electricity monitoring device you fit yourself such as an OWL, a My Energi Harvi or an Energenie Whole House Monitor (there are others) can help you better understand your own patterns of usage and shift these if there are benefits. These allow you to set up and monitor the system so you can optimise the generation and use of electricity.
If you already have a battery storage device this may also hold the data. If you have a smart meter your supplier may allow you to see half-hourly data and download it from your account online.

Several independent organisations have web sites that give general guides including:

- www.cse.org.uk/
- www.moneysavingexpert.com/utilities/economy-7/
- www.energysavingtrust.org.uk/

Several companies that started by manufacturing solar PV inverters have moved into battery storage and solar diverters and, in some cases, even whole-system integration including electric vehicle chargers. They often also have a metering system and a controller and/or app so you need to consider the whole house solution as you start to plan.

- **Solar diverters**

There are many solar diverters that allow your otherwise exported solar electricity to heat your hot water tank. Some work independently of other equipment (eg inverters) such as Marlec's iboost, the Immersun or Solic 200. Others are part of an integrated system that might include inverters and your EV charger like MyEnergi Eddi or SolarEdge. This is good way of keeping the energy 'at home' if you normally have a hot water tank. It won't work if have a combi-boiler because you won't normally have a hot water tank: combis are hardly ever fitted with a hot water tank.

- **Timer controls for your appliances**

Some home appliances now come with integrated timer controls and many even with wifi and email connections. These allow you to control when the appliance operates so you can fill your dishwasher in the morning ahead of a sunny day and use solar generated electricity to run it.

There are several systems of remote-controlled plug sockets ('smart plugs') you can use to add automation to a 'dumb' appliance and so control it in a way that reduces your bill, for example by running during the middle of the day when solar PV is generating. Some are essentially timers but some have more complex control over wifi or internet.

Smart plugs

A review of 10 can be found here:

- www.goodhousekeeping.com/uk/product-reviews/tech/g28393904/best-smart-plugs/

More information about them in general here:

- www.thewiredshopper.com/how-much-energy-do-smart-plugs-use/

Note that because they use some energy themselves they are only worth using as an energy-saving device if you are controlling larger appliances.

Cyber-security and hacking

We hear and read a lot about the risk of hackers getting into our computers and stealing data and, in a few cases, money. The risk needs to be taken seriously when it comes to automatic systems controlling our energy, but a few simple measures will protect you.

Most unauthorised access to computers and systems is because someone either left the password as an easy target (for example, see Which? guide to video doorbells) or it was accidentally handed over in a 'phishing' scam. There are numerous guides online about how to avoid being taken in by phishing scams, such as:

- www.phishing.org/10-ways-to-avoid-phishing-scams - a general guide
- www.ncsc.gov.uk/collection/small-business-guide/avoiding-phishing-attacks - for small businesses but with lots of good advice for everyone
- www.uk.pcmag.com/antivirus/118573/how-to-avoid-phishing-scams - for the more technically minded.

The key advice on how to avoid getting caught by phishing scams is never to click the link in the message. If you think it might be genuine always go to the named company via their main website, preferably using another device. For example, if the message comes in on your phone, use a tablet or computer.

HOME RENEWABLES: SOLAR THERMAL

Collecting the sun's heat to warm water was probably the first renewable energy technology to find practical use in the UK after the 1970s oil crises. As solar PV technology has advanced, solar thermal has become less interesting because, if you have space on your roof for any solar panels, solar PV will generally be easier to install and maintain. However, if you have space for both, solar thermal well matched to your hot water load and properly maintained can collect more energy per year.

Panels or tubes that collect heat are fitted to the roof of a building and pipes connect these via a pump to the heat exchanger in the hot water storage tank. This circuit is sealed from the water system in your house as it has anti-corrosion and antifreeze chemicals in it, much like your central heating system. The storage tank is like an immersion tank but may have two coils: one for the solar heating at the bottom of the tank and one for the conventional heating which may be gas, oil or heat pump.

If the house has solely electric heating then a single coil tank designed for solar heating is all that is required. In a few installations a second tank is fitted as a 'pre-heat' tank and the existing immersion tank remains in place. The pre-heated water from the first tank is fed into the main immersion tank where the cold water used to go. In all cases an immersion heater is fitted too as back up and, in some installations, for legionella control. Check this with a Gas Safe registered plumber, MCS installer or other suitably qualified surveyor.

How solar hot water systems work

Infra-red radiation from the sun is converted to heat in the fluid within the panels during daylight hours under direct sun or thin cloud. A control system has sensors on the panels and the tank and decides whether the liquid in the panels is hotter than the water in the tank. If so, the pump runs to move the hot fluid through the heat exchanger in the tank. (The pump and control system do use some electricity.) As the day goes on, the water in the tank gets hotter and hotter until there is a point in the afternoon when the panels may no longer produce a high enough temperature to further heat the tank.

Some systems in soft water areas can be 'direct' systems which heat the water within your tank. These will not be suitable in Oxford as the water is hard. In some cases, it is also possible to fit a 'thermosyphon' system which does not have a pump. This requires the panels to be around 3m lower than the hot water tank. If you have a single storey extension facing south and a hot water tank in the main roof this might work. Such a system will require less maintenance than a pumped system and doesn't use electricity to run a pump and controller.

THE KEY DIFFERENCE BETWEEN SOLAR PV AND SOLAR THERMAL

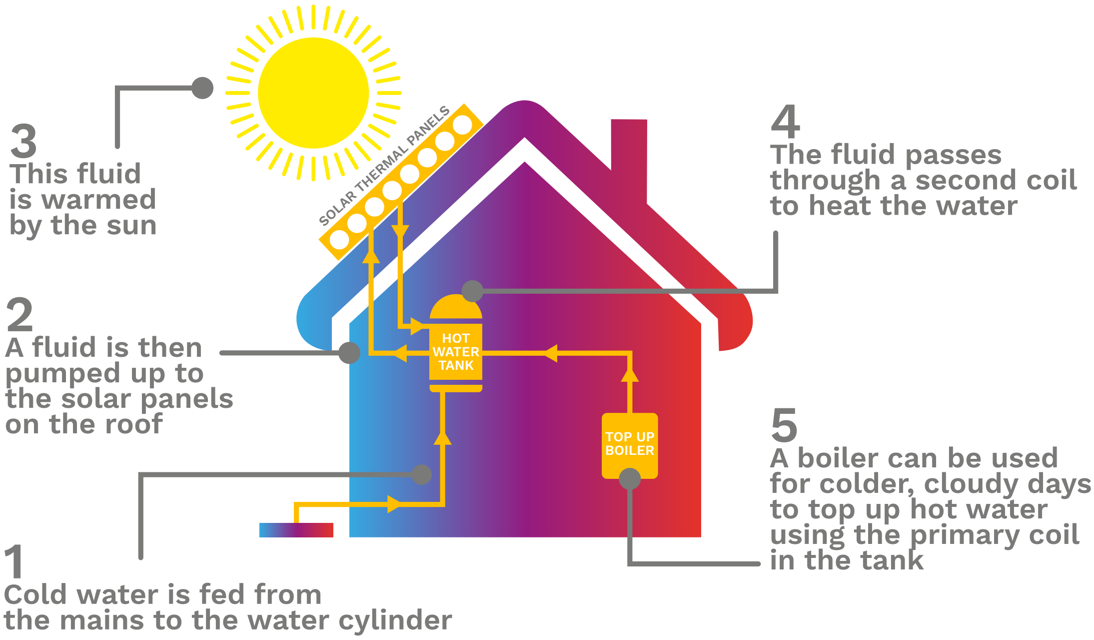
If you don't use the electricity from the solar PV it gets exported to the grid and is still beneficial as it contributes to our national electricity supply. However, if you don't use any hot water then, once the storage tank is fully hot, the solar hot water panels cannot collect any more heat. If you are frequently away or the household doesn't use much hot water then a solar hot water system probably does not make sense. Conversely, a household with many active people who are normally at home and take frequent showers or baths will be a good match. Because of this, great care is required in matching the panels on your roof to the storage tank size and water use in the home.

FITTING SOLAR THERMAL TO A HOME

Solar hot water can work well with any heating system. The key requirement is that the solar hot water system will need either a separate 'pre-heat' tank or a tank with a second coil inside specifically for the solar heating. If you are considering a new heating system and/or solar hot water, think about how they will be integrated. This is regardless of whether you are going to use gas, a heat pump or electricity to provide hot water. Which? has a guide to solar hot water which includes the diagram below. See

- www.which.co.uk/reviews/solar-panels/article/solar-water-heating-with-solar-thermal-panels-aFNiM0I472jL

SOLAR THERMAL PANELS




Flat solar hot water panels.


Evacuated tube collectors.

Flat panels are cheaper and look a bit like solar PV panels. Evacuated (or vacuum) tube collectors are more efficient so the system should collect more heat. However, they are more costly and, if the vacuum fails, the efficiency drops and this can be difficult to detect, though they sometimes can be seen to go cloudy if the vacuum has failed.

MAINTENANCE

Solar hot water systems require annual maintenance to check the pressure of the system, the fluid condition and the pump and control system operation. If these are not checked and maintained the system at best will not work and at worst can be damaged beyond repair. In summer it is important to check weekly that the system is working as a fault such as loss of fluid pressure can cause damage in the strong sun if not quickly repaired. You may need to replace the pump and control system during the 25-year life of the system.

FINANCIALS

The economics are strongly dependent on how much hot water you use in summer, and you must have a hot water tank. You should be able to estimate your annual hot water bill by looking at your monthly summer bills if they are based on meter readings not estimates. If you use gas for providing hot water make sure your central heating is turned off in summer as it might be burning gas to heat the house on cool mornings which is wasteful and will exaggerate your summer bills. Unless you do a lot of cooking using gas, your June, July and August bills will largely be for hot water. This is one of the many reasons you should read your meter every month.

The cost of installation is much more site-specific than for PV due to the amount of plumbing that is required. Pipework is much more difficult to thread through the house than an electrical cable and you will need a new hot water tank.

The reality is that as we move to air source heat pumps which will deliver low-carbon heat to your tank it is likely to be much more cost effective to use any roof space for solar PV.

Solar thermal costs

The total installed cost of solar hot water might be between £4000 and £8000. Building Research Establishment says a typical UK home uses 4 kWh of energy per day to heat water, which is ~1500 kWh per year. Data from the government's Department for Energy Security and Net Zero (DESNZ) suggests a higher figure of 2700 kWh/year, but some households may use less. USwitch suggests it is about 10% of your annual heating bill so that might be between 1000 and 3000 kWh per year.

Before the 2023 energy prices rises 10% of an average bill would be around £60. Estimates of long-term energy costs are difficult to make but if we said in future they would be three times what they were in 2020 that would mean an average of £180 per year for hot water. If solar hot water were to save 60% of this, that would be £108. There would be some annual maintenance cost of perhaps an average of £50 per year, so that saves about £50 per year for an average user.

RENEWABLE ENERGY AND THE NATIONAL GRID

OVERVIEW

Most renewable electricity will be fed into the grid from large-scale wind, solar and hydro-electric plants so we will all being using more low-carbon renewables in future. The UK Government has committed to fully decarbonising electricity generation by 2035 but as yet there are no details about how this will be achieved. Here we briefly present the renewable energy technologies that are not normally relevant to individual houses in most urban settings but are generating an increasing proportion of the electricity we use.

TECHNOLOGIES

- **Solar PV**

Field arrays of solar PV are essentially just very large versions of what you would have on your roof. When at peak output, the largest can generate as much as a small power station. As they are generally much closer to where we use electricity, they also reduce losses in the grid.

- **Wave power**

This is still at the pre-commercial, research and demonstration stage. Should it be possible to make this commercially viable then the UK has a huge resource from the long ‘fetch’ of waves coming in from the Atlantic.

- **Tidal energy**

There are a few examples of historic tide mills around our coast, for example, at Eling near Southampton which still operates. Large-scale research and development are still underway to extract tidal energy more efficiently and it may well be possible to make this technology commercially viable in the next 5 to 10 years.

- **Wind energy**

Wind energy is one of the UK’s most abundant renewable energy sources with the potential to provide all our electricity when combined with storage. Onshore wind power is now the cheapest form of electricity available to the UK, with offshore wind power close behind. The structure of the wind means it blows fastest high above our heads and away from trees, hedges and buildings. Consequently, wind turbines are most effective when they are tall and installed where the ground is flat and open, on high hills or at sea. This means that it is rarely worth considering wind energy in an urban setting and it is certainly not viable at individual household level in Oxford.

Wind energy is one of the UK's most abundant renewable energy sources.

- **Hydroelectricity**

This is a very effective means of generating electricity and has the advantage over many others that it is often possible to store the water supply and so turn the power output up and down according to need. The main disadvantages are that the UK has exploited almost all the available hydroelectric sites and this energy runs out in drought conditions.

Oxford's Osney weir has two small hydroelectric schemes, one of 49 kW and the other of ~55 kW (The average load of a typical house is about 0.5 kW.) Sandford and Sutton Courtney weirs further along the Thames have also been developed with ~450 kW and ~390 kW respectively.

- **Pump-storage**

Though not technically renewable, some hydroelectricity can be run 'backwards' as pump-storage. Dinorwig in Wales is the largest of the UK's pump-storage schemes allowing rapid generation or demand from storage to cover many different grid circumstances. It was built in the 1970s to store cheap night-time electricity for use at peak times during the following day. It operates every day and invisibly smooths out our demand and generation.

VARIABLE OUTPUT AND HOW TO MANAGE IT

As with PV on your house roof, the output of renewables varies according to the weather or the tides. This means we may need to alter our electricity consumption habits to make best use of these clean, green resources.

We need to use this energy when it is there! It may also mean increased use of 'agile' tariffs which are cheaper when there is a lot of renewable generation to encourage us to use the power when it is readily available.

As we move to a lower carbon energy supply we will find more storage helpful. Demand management can definitely help our transition to a net-zero energy system by matching generation and demand, but since society has grown accustomed to using anything electrical whenever we want, we have developed energy storage. At national level, the UK's pump-storage schemes allow rapid generation or demand from storage to cover many different grid circumstances.

In addition, there are technologies which are increasingly being used at national grid scale to store electricity for use at times when high demand is not matched by high generation. There are already 'grid-scale' batteries in use alongside wind farms and solar panels and at some pinch points in the grid. There is also a lot of research and development work looking into other forms of storage.

WHOLE HOUSE PLANNING

When you are improving your home, you may not do everything all at once but could progress in stages over time. If so, consider which steps could be easier and cheaper by being done together.

BUILDING A WHOLE HOUSE PLAN

If you will be fitting roof-mounted solar, the following may help:

- If you have a choice at the design stage of a loft conversion, extension or roof replacement, ask your architect / draughtsman to design for solar.
- If you are having work done on a roof or a new roof on an extension, make sure it will be strong enough to take the weight of solar panels and try to arrange a large south-facing slope if possible.
- Don't have south-facing roof lights if at all possible as these overheat the room below and reduce the space for solar PV or solar hot water. Put the rooflights on the north face.
- If work is being done on the roof, then consider running the right power cable/s at the same time for solar PV and/or pipes for solar hot water. At the very least, make sure there is an access route for cables or pipes and ideally fit a duct through which they can be run.
- If you are having electrical work done and your consumer unit (fuse box or fuse board) is being modified, take time to consider what you might need later for solar PV and/or an EV charger and heat pump.
- If your hot water tank needs replacing, then make sure you install one appropriate for the next stages. For example, include a second coil for solar hot water if that is what you plan to do later and/or a coil that suits a heat pump, or check whether these could be retrofitted later.
- When finalising your design make sure any control system you fit is appropriate to properly control and optimise all the parts. Then make sure it is set up properly. For example, if you have solar hot water, make sure the main heating (heat pump or gas boiler) does not heat the tank in the morning in spring, summer and autumn. This is because the solar heating will be most effective when heating a cold tank. If your household is used to lots of hot showers in the morning, then you may need to fit a bigger tank to benefit properly from solar heating. An MCS solar heating installer should be able to advise you.

SUMMARY

According to the World Electricity Council UK households have the 6th highest electricity consumption globally and this contributes to our high carbon emissions. Average UK household electricity consumption is about 3300 kWh per year, according to Ofgem, though the average general electrical consumption, without electric heating, is closer to 2900 kWh per year. This varies greatly between homes for several reasons including the number of occupants and the type and age of the appliances. We have given many examples of how much different appliances consume so you can investigate how to reduce your electricity consumption and perhaps set a target.

Once you have taken steps to shrink your electricity bill you can look at generating some electricity yourself. For most homes in most urban areas, renewable electricity generation from solar PV is likely to be the only electricity option. A south-facing roof on a typical house could provide a third to a half of the annual consumption with an array of up to 16 panels and 4 kWp maximum output, some being exported. East- and west-facing arrays may generate less but might match your consumption better and could be more economic.

Battery electricity storage has come of age and, alongside solar or perhaps a cheap night-rate tariff, can help balance cost, carbon and use of renewable energy. Home systems installed at the same time as solar PV make the most sense but they can be added later. A solar diverter which heats your hot water tank from otherwise exported solar generation adds to the benefits.

There are many apps and control hardware appearing on the market to help optimise your electricity use if you have solar PV. Integrated systems can let you choose which end use to prioritise - charge an electric car, heat the water tank, or store in the battery for use later.

Renewable heat is a very different category with solar hot water the main option. (We cover renewable heating in **Housewarming Guide H5: Heating and Controls**). Solar hot water systems are a good additional technology if you have the roof space, they are well matched to your hot water use, and are well maintained.

As with all our guides, we suggest you think about the whole house and complete system and then plan everything you want to do. This will ensure, for example, that you have your electrical consumer unit (fuse box) made ready for future additions of a heat pump and electric car charger when you install solar PV so you can save time and money later.

DISCLAIMER

This guidance document is written with the intention of providing a better basis for home owners to decide how to reduce the energy consumption and carbon emissions of their homes.

We have not surveyed your home and so the suggestions and discussions in this document can only be a general guide and so LCON and its consultants cannot be held responsible for or accept any liability for damage, failures or disputes which result from the use of this document.

We recommend that specific decisions are made only after a suitable survey by an appropriately qualified specialist. We recommend gaining several quotes for work from a number of suppliers and suitably qualified and experienced companies with appropriate insurance.

It is essential to follow material manufacturer's instructions and specification sheets to avoid risks of damage to structure and property and to ensure the intended performance is achieved. We recommend the use of only those products with appropriate independent certification for the intended use e.g a BBA (British Board of Agreement) certificate.

We recommend appropriate contracts are used and signed by all parties before work is undertaken and suitable legal advice should be sought.

LCON does not endorse any brands mentioned in the guides, and any mentioned are examples only. The Housewarming Guides have been written as a series and it is recommended that they are all read for a full understanding.

CREDITS

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