Add-on equipment you might be offered alongside your PV system **- Guidance for Consumers**

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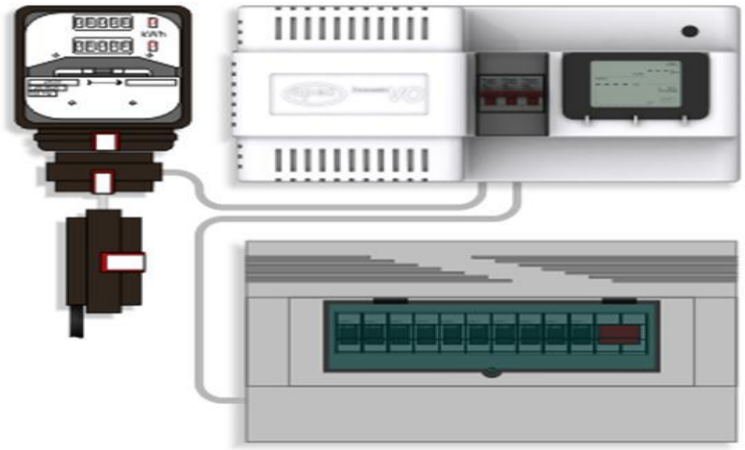
Some companies selling solar photovoltaic (PV) systems now offer a PV system with additional items that, it is usually claimed, will save consumers money. This document provides some basic information about what they do, and what savings you might make with them. You may have other reasons for wanting to have these items that are not included here, for example, reducing your carbon emissions.

1. Voltage optimisers



Voltage optimisers (VOs) reduce the electricity voltage coming into your home and so, it is claimed, will save you money on your electricity bills. But how much they save will vary from home to home and RECC has found no publicly-available robust evidence to support claims of 10-15% 'typical' savings.[1]

Outside of the UK, the majority of Europe and the rest of the world receive electricity at around 220V. The electrical and electronic product manufacturers design their products to work within a wide voltage supply range but generally they can operate well around the 220V level. Appliances that are supplied with a voltage that is higher than they require to function effectively may wear out more quickly.

The UK National Grid typically supplies electricity to homes at voltages higher than this – around 240V, but in some places over 250 volts.[2]

VOs are designed to reduce your incoming electricity voltage,[3] usually to around 220V, feeding the lower voltage to circuits in the home that power lighting, appliances etc. It is claimed that the voltage reduction leads to a reduced energy consumption and lower electricity bills and to a longer life for appliances.[4] Manufacturers generally claim 'typical' savings in the region of 10-15 per cent. RECC has found no objective robust evidence, for

[1] We understand that there are some studies in the pipeline; we'll be keeping an eye out for the results.
[2] As a result of european harmonisation, the electricity supply in the UK is now within the range 230V +10% to - 6% i.e. between 253V and 216.2V. The figure of 242V is cited as 'typical' in various sources but not all properties or businesses are supplied at this level.
[3] While 'optimising' does not necessarily mean 'reducing' the voltage, in the UK it does normally involve reduction since supply voltage here tends towards the top-end of the range laid down in standards.
[4] To date, we haven't found any claim as to how much of an effect a VO has on appliance life nor any robust actual measurement of it, so these claims are not further considered at this time.

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example tests over time across a range of homes and incoming voltages, that suggest a 'typical' home can achieve this.

One UK study that technical experts BRE judged to be 'robust', found that the VO tested led to an average reduction in electricity demand of more like 5 per cent. That study showed how much the impact can vary from home to home: in one case, demand actually increased with the VO, in another the reduction was 19 per cent.[5]

Not all VO systems are the same and newer ones may perform better (or worse) than this. But, in the absence of clear evidence of what they can achieve in the home setting, you could bear the following in mind if you are trying to decide if they are worth it for you:

A. the voltage optimiser may reduce the voltage, but this doesn't mean it will reduce the electricity by the same proportion; and
B. savings will vary significantly from home to home.

A. Reducing the voltage

A 10% reduction in voltage does not automatically mean a 10% reduction in your electricity usage (or your bill). Not everything will use less electricity at a lower voltage. In general, most appliances with a heating element (such as kettles and electric ovens) will, other things being equal, consume less power with a VO but also produce less heat. So if you lower the voltage, your kettle will simply take longer to boil or your Sunday roast longer to cook and you'll end up using the same amount of kWhs.

LED lights use the same amount of power, whatever the supply voltage is,[6] so there will be no savings by reducing the voltage for LEDs.

Modern TVs and laptops consume the same energy over a wide range of input voltages. A power supply unit such as those for laptops, for example, is designed to provide the laptop with a fixed voltage, whatever the incoming supply voltage to the unit itself is. The total energy demand of the computer and power supply will not change if the supply voltage varies. Which? has also noted '*most new TVs and hi-fis are designed to consume minimal energy when they're on standby, so a voltage optimiser is unlikely to make any substantial saving*.'

Some electricity savings have been shown with:

- **appliances with motors, such as fridges and freezers.** These have been shown to consume less power at a reduced voltage. But the more energy-efficient appliances benefit less. In one study, a B-rated model did consume less energy with a VO but an A+ model of the same appliance showed no saving at all.[7]

- **certain types of lighting.** Incandescent (filament) lighting will use less electricity at a lower voltage (and last longer) so there will be some saving, but the lights will be less bright.

[5] Energy Saving Trial Report for the VPhase VX1 Domestic Voltage Optimisation Device, EA Technology, June 2011. Tests on one VO (the VX1 VPhase) in 50 homes over an extended period.
[6] Carbon Trust, Voltage Management, undated.
[7] Energy Saving Trial Report for the VPhase VX1 Domestic Voltage Optimisation Device, EA Technology, June 2011. Tests on one VO (the VX1 VPhase) in 50 homes over an extended period.

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B. Savings will vary

Anecdotal evidence suggests that some companies selling VOs as part of a PV package take manufacturer claims as likely savings and then build that into a quote. But these figures may be based on small-scale tests in one or two homes or on savings on individual appliances. These tell us little about what the VO might or might not achieve in other homes.

Claims of 'typical' savings may be way off for an individual home. One reasonably robust test of the effect of a VO in lots of houses over an extended period, for example, found a huge range of performance from an increase in electricity consumption of 4% to a reduction of 19%.[8]

The savings you are likely to achieve depends on:

- **how high your incoming voltage is** (the higher the incoming voltage, the more the reduction to c.220V represents). Incoming voltage varies across the UK. Has your supplier tested your incoming voltage over a period of perhaps 7 days before estimating what you will save?

- **what appliances you have**. Savings in tests on individual products such as refrigerators do not really help assess the effect of VOs on the entire load of a dwelling which is a mixture of different types of load. Has your supplier looked at how many energy-efficient appliances and LEDs you have, if you have an electric shower, a cold-fill washing machine etc.?

- **how much electricity you currently use**. The greater the overall consumption, the greater the money savings from a given percentage reduction in demand that the VO delivers.

- **how long the VO lasts**. A couple of the models we have seen claim a 25-year life expectancy; none offer a warranty of more than five years.

What's the most I might save?

Because the savings, if any, depend so much on the individual circumstances, it's hard for us to put a figure on how much you might save. It might be useful, though, to consider:

- the average electricity bill for a medium-use household, according to Department of Energy and Climate Change figures, is around £600.[9] If a VO could save 10 per cent of this, that would be worth around £60 in Year 1. If it saved 5 per cent, that's worth £30.

- Any savings from a VO will reduce over time if you replace old appliances with new more energy-efficient models.

[8] Energy Saving Trial Report for the VPhase VX1 Domestic Voltage Optimisation Device, EA Technology, June 2011. Tests on one VO (the VX1 VPhase) in 50 homes over an extended period.

[9] Based on 3,800kWh of electricity. A household using 5,000 kWh would pay more like £800, so a 10% saving would be worth £80, a 5% saving around £40.

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Are they worth it?

If you are interested in whether the VO will save you more than it costs you, you need to know the price you pay for it against the savings you may make.

The price of these items is not easily ascertained on the various manufacturers' websites. We have seen estimates of £300 to £500.

You may not find the price spelled out in your PV quote if the company selling the PV system is 'throwing in the VO for free' as part of a package of items alongside the PV panels. So you might want to compare any such package deal with what you would pay for the PV system alone. It is best to get at least three quotes for your particular situation and it is worth remembering:

- the Energy Saving Trust suggests a 4kWp system costs between £5,000 and £8,000 and prices are generally continuing to fall;
- if you are buying on finance, you will be paying interest too;
- you could save in the region of £30 a year on your electric bill simply by not leaving appliances on standby;
- you could invest in low-energy lighting options. Which? estimates that these save you £7 to £7.50 a year for every filament bulb replaced (see page 9 of this document on LEDs, below).

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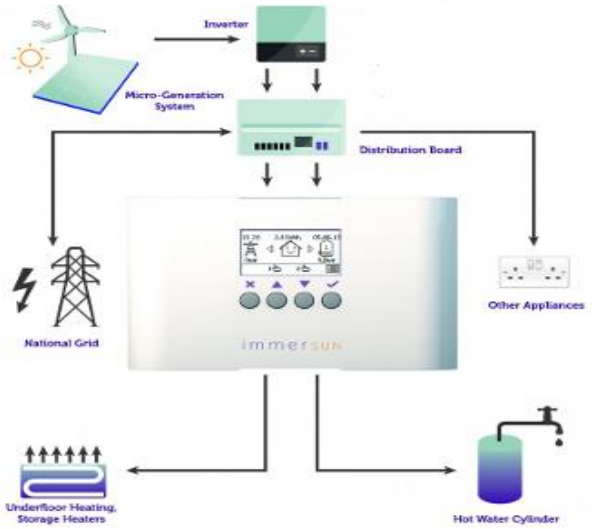
2. Diversion devices (eg Solar IBoost, Immersun, Solic 200)



These devices divert surplus energy from your PV system to heat water in your hot water tank (if you have one), instead of exporting it to the grid. You save the money that you would have spent heating the water.

Savings will vary, depending on how much 'surplus' you have to divert, what fuel you are currently using to heat your water and when you use hot water and how much. Those savings might be reduced when/if you get a smart meter which will measure the electricity that you export (see page 7, below, for more on this).

Your PV system will generate only in daylight hours. If it generates more than you are able to use during the day, the 'surplus' energy will normally be 'exported' - sent to the grid. Diversion devices essentially divert some of this 'surplus' energy to heat your water instead, sending it to the immersion element in your hot water cylinder.[10]

You save some of what you would have spent on gas or electricity to heat your water. And even though you will export less than you would have without the diverter, you will still currently get the same 'export tariff income' from your electricity supplier. This is because the export tariff is paid on a 'deemed' 50 per cent of your PV system's output, regardless of how much is actually exported.[11]

But they are not for everyone:

- if you have a combi boiler you do not have a tank or an immersion rod to which they can divert the surplus.

[10] One device – the Immersun – is claimed to also divert to a storage heater or electric underfloor heating also.
[11] If the device means you are able to use your boiler less, or not at all, in the summer months, then another benefit might be extending the life of the boiler. Again, we have not to date found any quantification of this potential benefit, so it is not considered here at this time.

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- If you use very little stored hot water, you will not really benefit from a diverter. For example, if you have an electric shower, do not take baths and have cold-fill appliances you are mainly heating water as you use it, rather than drawing on a tank of hot water.

- The system best suits those who use hot water mainly in the evening (for washing up or evening baths).

For those for whom they are suitable, manufacturers claim the devices will save you varying amounts : 'up to 80 per cent of hot water costs'; '50p a day' or £180 a year; 'up to £250'.

As with Voltage Optimisers, it is tricky to give an idea of how much a diverter might save you because it depends on a number of factors. You should bear in mind:

- **how much of your system's output you manage to use.** The more of your system's output you use to power your lights and appliances, the less will be available to divert to hot water heating. For gas-heated homes, hot water heating is, on average, around 21% of the heating bill or 3,500 kWh. The diverter device cannot replace all of this, it is close to the total output of many PV systems. And it is worth remembering that PV systems generate much less in winter, so there will be less output and thus less surplus available in the winter months. On the other hand…

- **there is a limit to how much can be diverted to the tank.** Once the tank is hot, the thermostat in the immersion turns off the heating element. Thereafter any remaining surplus electricity will be exported.

- **what fuel you currently use to heat your water**. If you heat it with electricity currently, then you will save whatever you pay for electricity for every kWh you divert to heat the water. That could be around 16p per kWh (based on DECC average tariff figures). But if you are currently using heating oil or mains gas, then the saving per kWh of gas or oil you do not use[12] is around 5p.[13] This makes a big difference to payback periods.

- **when you get a smart meter.** If you install PV currently, you receive a payment ('export tariff') on the basis of you exporting (rather than using) a 'deemed' 50 per cent of your system's output, regardless of how much you actually export. In future, smart meters, which are being rolled out over the next few years, will be able to measure how much you actually export. At the time of writing DECC has said it intends to '*end 'deemed' exports for all FITs installations and see the entire scheme moved to export tariff payments based on actual meter reads on the completion of the smart meter roll-out'.* If that becomes policy and it applies to you, every kWh that heats hot water is one less kWh on which you will get paid the export tariff.

- **how long the devices last without needing a repair or replacement**. IBoost has a 2 year warranty, Immersun a 3-year one and the Solic 200 has 10 years, though life expectancy may be longer.

[12] There may be significant differences in efficiency in heating water with electricity vs gas/oil in an old boiler.
[13] Based on per kWh estimates from DECC (gas 5p, electricity 16p) and from the Energy Saving Trust (oil, 5.36p).

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How much could I save?

It is difficult to say, as it depends on the above. To give an idea, if you could divert all of a surplus to heating hot water, then bigger would be better. For example, if you are someone in a 'best-case' scenario for PV, living in the sunniest part of the UK, with:

- 4kWp of PV installed
- a perfect roof (south-facing, a roof-slope at 35-40 degrees) AND
- 50 per cent of the PV output is available to divert.

then you will have a high output and plenty to divert. Based on you being able to divert and use all the surplus, you might save:

- around £300 annually if you currently heat your water with electricity OR
- around £90 annually if you are replacing gas

Say, you have the same roof and panels but instead, you are living in the north-west. Then you might save:

- around £240 annually if you are replacing electricity OR
- around £70 annually if you are replacing gas.

In either case, the tank might not need all that surplus to get hot so that would limit your savings.

Over however many years the diverter's in place, energy prices may go up in real terms, increasing what you save. But smart meters may be installed, which could offset some of this.

Are they worth it?

Whether these devices pay for themselves depends on how much they save and for how long but also how much they cost.

You may not find the price spelled out in your PV quote if the company is 'throwing in the diverter for free' as part of a package of items alongside the PV panels. So you might want to compare any such package deal with what you would pay for the PV system alone (see Voltage Optimisers, above, for average PV prices).

RECC has seen prices for diverters that range from around £300 to £500, including fitting. If you are replacing gas, that will take longer to pay back than if you are currently heating your water with electricity.

Bear in mind that you could also increase your use of the PV output, and save on your electricity bill, by investing in a few timers to maximise your use of appliances during the day when the panels are generating.

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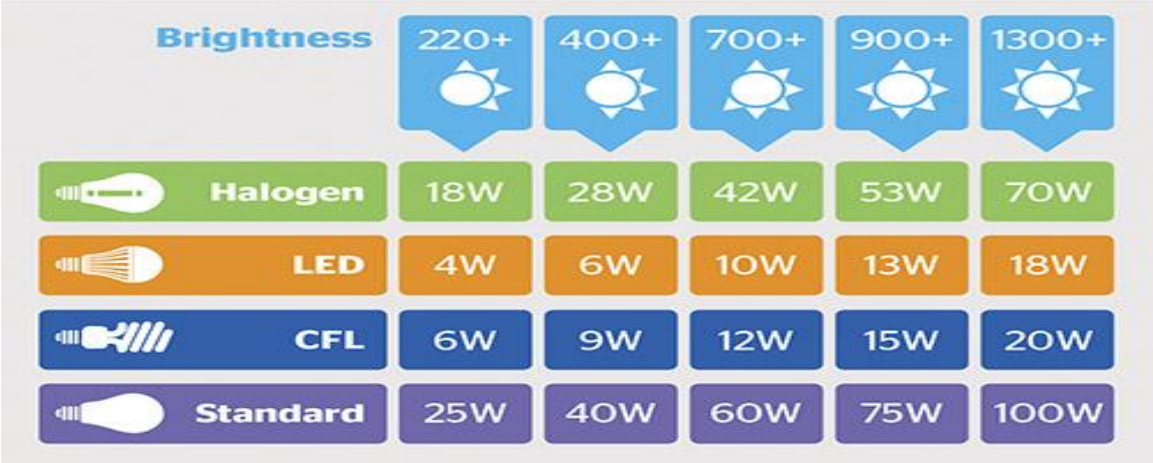
3. LEDs

LEDs, or light-emitting diodes, use very little energy, claim to last a very long time and, unlike regular energy-saving bulbs, they are instantly bright when switched on. They do vary in performance, though, and some won't work with dimmer switches. The better-performing ones will pay for themselves quickly, saving you around £7.50 per LED per year compared to standard filament bulbs (much much less if they are replacing energy-saving bulbs though).

LED bulbs differ from traditional incandescent filament bulbs in the way they produce light. While old-fashioned light bulbs passed electricity through a filament, LEDs produce light through the use of a semi-conductor that emits light energy when an electrical current is passed through it.

They are now available in a bigger range of wattages than previously so you can use them to replace up to 100W bulbs. The table below, from Which?, shows the wattage-equivalents of the various types of light. (As a guide, a bedside lamp might have a 40W bulb/400 lumens, the equivalent LED would be a 6W.)



Source: Which?

LEDs are the most expensive type of regular light bulbs but have a number of advantages:

- They are the most energy-efficient bulbs. They use 90% less energy than traditional incandescents. (Energy-saving CFLs use 60%-80% less).
- They claim to be ultra long lasting, working for maybe 25,000 hours or 25 years (1000 hours is about a year's use when the bulb is on for around 3 hours per day). Energy-saving CFLs claim to last up up to 10 years.[14]
- They give out their light almost instantly when you flick the light switch, so you don't have to put up with dim light while they warm up.

[14] Generally LEDs don't fail, their lumen (or brightness) output just reduces over the years. eg 25,000 hours to L70 would indicate that after 25,000 hours the lamp will have an output 30% less than when it was brand new.

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But the are not all the same:

- **Performance varies**. In Which? tests, based on 5000 hours of use, some bulbs were more than 20 per cent dimmer than advertised, while the most efficient LEDs emitted many times more lumens (or brightness) per watt as the least efficient.[15] The more efficient the bulb, the lower your energy bills.

- **Value for money varies**. The cheapest are not necessarily the poorest performers. One of the Which? five Best Buys cost under £5 for a 60W-equivalent LED that claims to last 25,000 hours.[16]

- **The 'warmth' of the light LEDs emit varies.** Some can be 'colder' than you are used to. Light temperature is measured in Kelvin (K) and the K number should be shown on the packaging. The higher the number the colder (more blue-y white) the light. Candlelight is around 1500K, standard bulbs 2700K (sometimes called 'warm white') and 'cool' white over 6000K.

- **They do not all work with dimmer switches**. The lower wattage LEDs do not work with regular dimmer switches. To be able to dim these LED lights you might need to upgrade to a dimmer that recognises low electrical loads. The packaging should say whether LEDs are dimmable.

How much will I save?
Which? estimates that each 10W LED saves:

- almost £7.50 a year in electricity per 60W incandescent bulb replaced
- around £7 for each halogen bulb replaced and
- around 50 pence for each energy-saving bulb replaced.

For an LED that lasts 25 years, replacing a 60W bulb would save more than £180 in energy use (at current tariffs) over its lifetime.

Are they worth it?
Yes, provided you are getting good quality LEDs, particularly if you will be using them to replace filament or halogen bulbs:

- the cheapest of the Which? Best Buys, replacing a standard 60W bulb, would pay for itself in less than a year, the most expensive in two years.

- replacing an energy-saving CFL bulb, the cheapest Best Buy LED would take longer to pay for itself in energy savings – around 10 years if you paid the £4.99 price Which? paid. (If electricity prices rise in real terms over those years, then the payback time would be less).

[15] The most efficient emitted 102 lumens, the least efficient only 13 lumens per watt
[16] The full Which? results are available to Which? subscribers at www.which.co.uk

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If you are offered the LEDs as part of a package with PV, ask:

1. What make of LEDs
2. The wattage of each LED
3. The K number or temperature of the light.
4. The claimed lifespan
5. If you have dimmer switches, whether the LEDs will work with them.

If they are not separately priced in your quote, check the price of the overall package with LEDs against the cost of PV-only quotes to get a feel for what you are in effect paying.

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4. Batteries/storage systems for Solar PV

Batteries to capture the output of solar PV systems could potentially allow you to store output generated during the day for use after the sun goes down, saving you money on your electricity bill. But you need to have some 'surplus' electricity to store (there may be little or none in the winter), smaller ones do not store very much at all and various models may be of little, or even no, use in a power-cut. At present, they are also relatively expensive, though expected to become cheaper. At today's prices, though, they may have worn out before they could pay for themselves in savings.

When the PV system is generating during the day, the battery system is set to check whether the current being generated is being consumed in the household, running lights and appliances. If it is, all devices are supplied first. If it is not and you are not using all that the PV system is generating then the surplus goes to charge the battery. Once the battery is full, if there is still more electricity being produced, this will be exported to the grid. (Without the battery, or a diverter as described above, all the surplus electricity would be exported).

In the evening, when the panels are no longer generating, the battery can discharge its load, giving you renewably-generated power to use.

The text below answers some questions you might ask about battery systems in general. NB – At the time of writing the Microgeneration Certification Scheme (MCS) is planning a Consumer Guide to help you ask more detailed questions if you are considering a particular battery system.[17]

Are they suitable for everyone with PV?

You need to be generating enough surplus electricity to charge a battery. You may not, for example:

- if you have or will have a small system (under 3kW); or
- if you use, or will use, a high percentage of your PV system's output, for example by running energy-hungry appliances during the day on timers in the winter. PV panels generate far less in winter, around 4 times less in December than in June.

[17] As well as questions on the type of battery, its capacity, efficiency and life expectancy, this will include questions such as whether you can add to it at a later date, whether there are special storage location considerations (such as the need for ventilation) and whether you will need to change your PV inverter).

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An installer should be able to tell you when throughout the year you are likely to be generating enough surplus to charge the battery fully.[18]

What are they like?

There are different types of batteries but the ones you are most likely to come across for PV storage in the home are either lithium-ion or lead-acid.

Lithium batteries are currently the more expensive but are more efficient.

Lithium batteries last longer than lead-acid, but even those are likely to need replacing at least once during the lifetime of the PV panels. At the time of writing, various manufacturers give a life expectancy of 10 years.

The batteries can be quite large and heavy. A typical domestic one might be the size of a washing machine; the one in the picture above weighs 95kg.

There is at present no MCS standard for solar-storage batteries, so you will not be able to find an MCS-certified system - but technical and installation standards are in the pipeline.

How much power can they supply?

The bigger the battery, the more they can store. The more they can store, the more they can output (though it will only be a proportion of how much they can store).

Batteries have a 'nominal capacity' (how much they can store) and 'useable capacity'(how much they discharge or output).

Lithium batteries discharge to 70 -75% of their nominal capacity, the cheaper lead-acid batteries to 50%. So a 6kW lead-acid battery will deliver up to 3kW, but the same nominal capacity lithium battery will discharge up to 4.5kW.

All battery systems also lose some energy in the charge-discharge cycle but some technologies lose less than others.

A company selling you a system should be able to tell you when throughout the year you are likely to be generating enough surplus to charge the battery and, when it is charged, what type of appliances could be operated and for how long: for how many hours it will power low-powered items like your lights, TV and fridge-freezer for example, but also heavier energy users like your dishwasher or tumble dryer.

Will they help in a power-cut?

Some batteries linked to PV systems will not operate at all during a power-cut. Those that do may not last as long as the power cut before they run out. And if the power cut is late at night or early in the morning, the battery may already have discharged by the time the power-cut starts.

[18] A battery left sat partially discharged for long periods, as could happen with a PV-connected system in the UK's winter, can result in a reduced lifetime. To prevent this, systems may have a 'winter mode' setting that either puts the system to sleep or reduces the discharge from it in the winter (or even charges it from the mains) to maintain battery health.

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Some manufacturers make claims around how long the battery will provide you with power to run your whole house or at least your low/medium wattage appliances for a period. The claims vary from a few hours to a whole evening or even 8 hours. In practice, a fully-charged medium-sized battery might well keep the fridge-freezer running and the lights and the telly on for the whole evening, because they do not use much energy per hour. But it is likely that if you were to put the washing-machine on you would burn through the battery's power in no time.

Can I go off-grid if I have a battery?

It is unlikely. You would need to be generating enough electricity across the whole year to store sufficient to run the house even in winter, when output (and so what's available to charge the battery) is much lower. Most households will not have enough room to put up that many solar panels.

So claims that 'you will never have another electricity bill' or that you will 'become independent from ever-increasing energy prices' or that you can 'go off-grid' with these batteries are unlikely to be true for the majority of domestic households.

How much will I save?

Some manufacturers make savings claims in terms of how much the batteries can increase 'self-use' or 'self-consumption' – in other words, how much of the PV output you use in your home, rather than export to the grid. But how much you might increase this depends on your circumstances.

To work out likely savings, you (or your supplier) need to know:

- the output of your PV system
- how much of that output you are likely to use during the day (which may increase if you invest in some timers once you have got PV)
- how much power the battery needs to charge
- if you have enough spare generation to charge the battery and over how much of the year
- how much the battery can store
- how much the battery will discharge

Assuming you have enough surplus to charge the battery, you would expect to save whatever your electricity tariff is (average is 16p per kWh) X the number of kWh you manage to use from the battery rather than use from your electricity supplier.

But in certain circumstances, there are other factors you might need to take into account in working out potential savings. Your Feed-in tariff (FiT) payment could be affected, depending on the battery. The FiT is paid on the amount of energy the generation meter shows your PV system to have generated. With 'AC-coupled' batteries, the output of the PV system is registered by the generation meter before any battery is charged from it. But 'DC-coupled' batteries sit on the other side of the generation meter. In effect, they charge from the PV system **before** that output has registered on the meter. When the batteries discharge, that output is registered on the generation meter. Since all batteries lose energy in the charge-discharge cycle, some of the original PV output, and the FiT that would have been paid on it, is lost in the process. How much of a loss that represents in money terms depends on the per kWh FiT rate you are getting.

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Your export tariff income could be affected, if/when you have a smart meter fitted. If you install PV currently, you receive a payment ('export tariff') on the basis of you exporting (rather than using) a 'deemed' 50 per cent of your system's output, regardless of how much you actually export. In future, smart meters, which are being rolled out over the next few years, will be able to measure how much you actually export. At the time of writing DECC has said it intends to '*end 'deemed' exports for all FITs installations and see the entire scheme moved to export tariff payments based on actual meter reads on the completion of the smart meter roll-out'.* If that becomes policy, other things being equal, the more you use at home (e.g. by installing a battery), the less there will be to export and the lower your export tariff income will be.

Are they worth it?

In purely financial terms, for the typical domestic user and at today's prices, it is ulikley that they will they pay for themselves in their expected lifespan. However, prices are coming down and so this may change in the future.

At present battery systems cost as much as around £5,000, fitted. With a life expectancy of 10 years, a £5,000 battery would have to save you an average of £500 a year at today's prices to pay for itself before it wears out, a £3,000 one £300 a year and so on.

A typical lithium 6 or 7kW battery, assuming you have enough surplus from your PV system to charge it, might output 4.5 to 5kWh. If you could achieve this all year round, then you would be getting around 1700 kWh out of the battery. At today's average 16p per kWh,[19] that would save you around £270 a year. (Smaller systems would obviously save less).

Realistically, the savings will be (possibly considerably) less than this: they will be reduced for every day that you can't fully charge the battery (such as on short winter days). And if you have a DC-coupled battery, the savings will be offset to an extent by the loss in FiT.

Of course, electricity prices may rise over the lifetime of the battery so each kWh you save would be worth more and the payback would be reduced. But that would be offset somewhat if smart meters also come in during that lifetime and the Government goes ahead with its intentions on export tariffs.

[19] DECC figure, including standing charges and taxes.

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