

Off-Grid Power: Principles



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Close Comfort conditioners are self-contained and have extremely low power consumption, only 300 Watts compared with four or eight times as much for room air conditioners.

Although they are made for standard 230 – 240 V alternating current power supplies (or 115 V in some countries), there are many other ways to provide power such as solar panels, batteries and small generators.

In this technical note, we explain some of the basic principles used in providing power from batteries and solar panels.

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Basic Principles

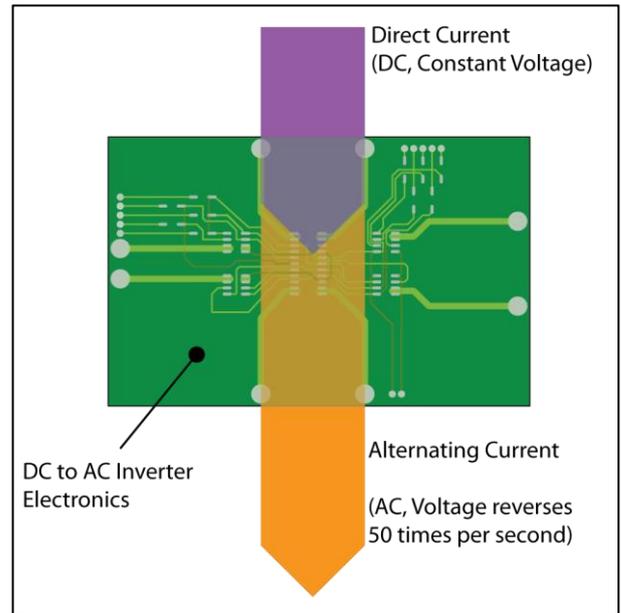
First we need to explain some basic principles used for providing backup power using batteries and solar power. By reading this technical note, you will learn many of the questions you should ask of your off-grid power supply provider.

Inverter

An inverter is an electronic device that converts direct current (DC, constant voltage) electric power, such as power from a battery, into alternating current (AC, varying voltage) electric power.

Direct current (DC) is the way that electric power is provided by batteries and solar panels. One wire or terminal is labelled **+** (positive, usually red wire) and the other one **-** (negative, usually black wire). Usually the battery voltage is 12 Volts or 24 Volts. Small batteries have lower voltage values, such as 1.5 Volts for common AA or AAA cells.

Alternating current (AC) is the way that electricity is normally provided for your home or office. One wire is labelled **A** (active, usually brown) and the second **N** (neutral, usually blue), and the third **E** (earth, usually green and yellow).

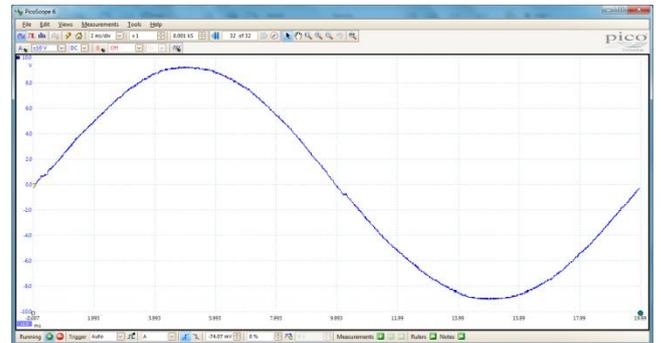


The standard AC power voltage in most countries is 230 Volts, and it alternates 50 times per second (50 Hz). However many countries have different standard voltages and frequencies. For example, in the USA, Canada, parts of Japan and most of South America the AC standard is 115 Volts, 60 Hz.

Waveform Pattern

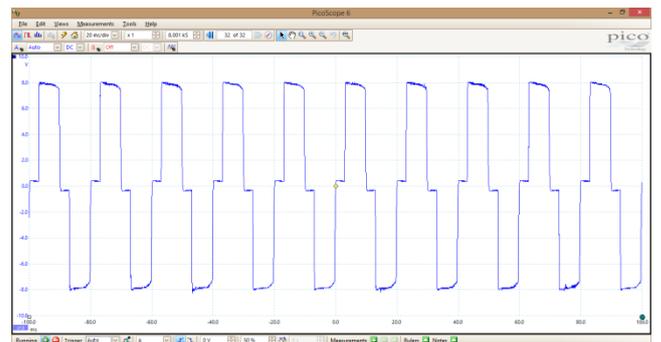
There are different patterns of AC voltage fluctuation produced by different inverters.

Here (to the right) is a 50 Hz sine wave pattern of voltage fluctuation – it looks like a smooth curve. The graph shows only one cycle which is 20 milliseconds from start to finish. This is the way the grid power is supplied.



The second graph (to the right) shows a square wave pattern of voltage fluctuation. The graph shows 10 cycles and is 200 milliseconds from start to finish.

Square wave inverters are cheaper and sometimes can be more energy efficient. However, some appliances make an additional buzzing noise when this kind of power supply is used.



UPS – Uninterruptible Power Supply

A UPS is used in places where there are frequent interruptions to the main power supply.

Also known as a “UPS inverter”, this device incorporates an inverter and battery management electronics.

The diagram shows how a UPS works when the main power supply is working.

The UPS connects the main AC power supply to the air conditioner (and other household appliances not shown in the diagram such as low power lights, LED or fluorescents, and maybe a fan).

Some of the power from the main power supply is converted to direct current (DC) and charges the battery connected to the UPS.

When the main power supply is interrupted, the UPS automatically starts drawing DC power from the battery and converts it to AC power for the air conditioner using its built-in inverter, as shown in the lower diagram.

The capacity of the UPS is usually given in Watts and VA (Volt-Amps). The VA rating is always higher than the Watts rating, usually by about 40-60%. We recommend a UPS with a capacity of at least 1200 Watts (2000 VA). However, many smaller UPS models can be used.

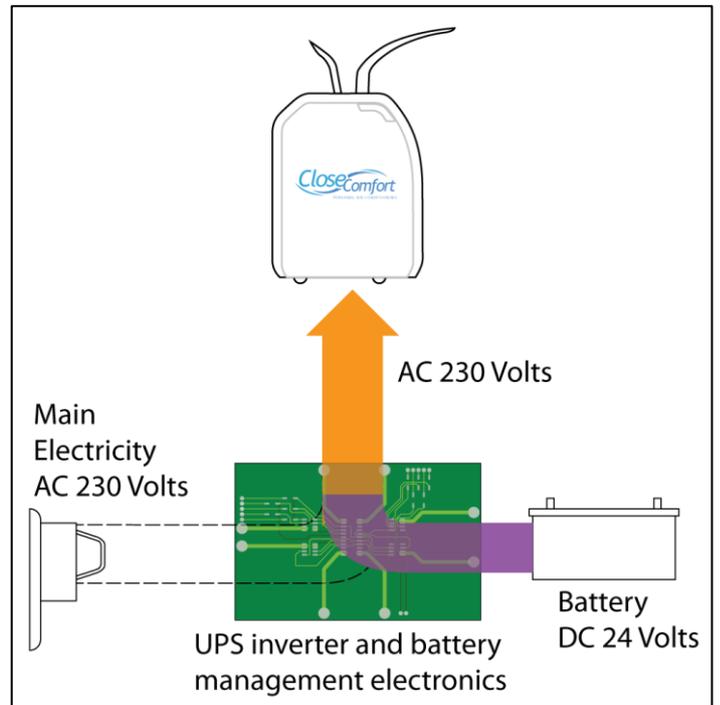
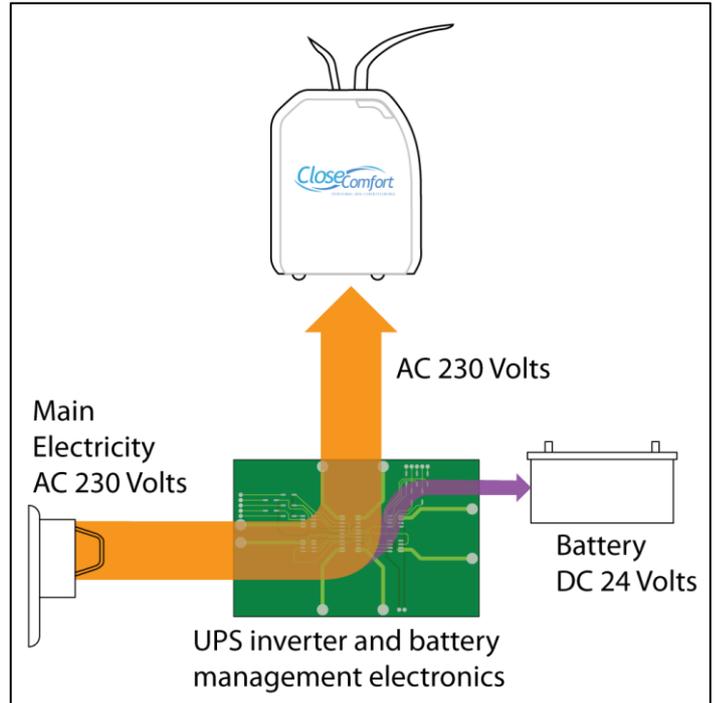
Why?

When the air conditioner compressor starts running about 90 seconds after opening the shorter cover flap, the instantaneous AC current needed to start the compressor is about 7 Amps, equivalent to an input power of 7×230 Volts or about 1600 Watts.

However, this input power is only needed for about 20-40 milliseconds.

Most UPS models will tolerate an overload for a short time. However, each model is different. We have found that some UPS models rated at 500 Watts (or 800 VA) allow the compressor to start, whereas other models rated at 1000 Watts (or 1500 VA) trip out when starting the compressor.

Therefore you need to test your UPS unit with an air conditioner and perhaps some lights as well to make sure it will start your air conditioner satisfactorily.



Solar Power Inverter

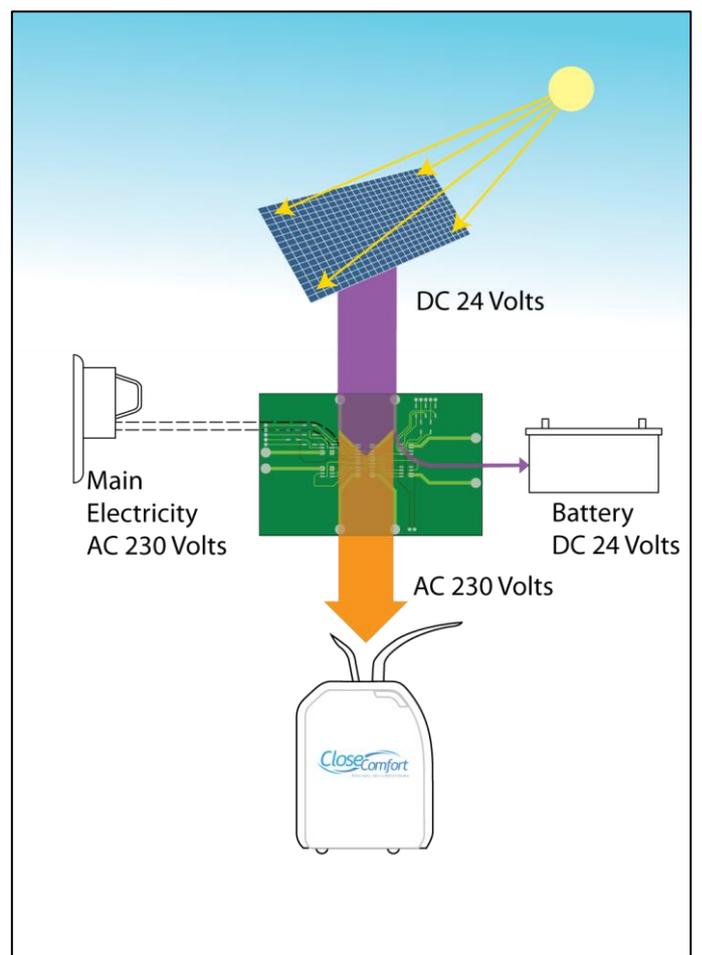
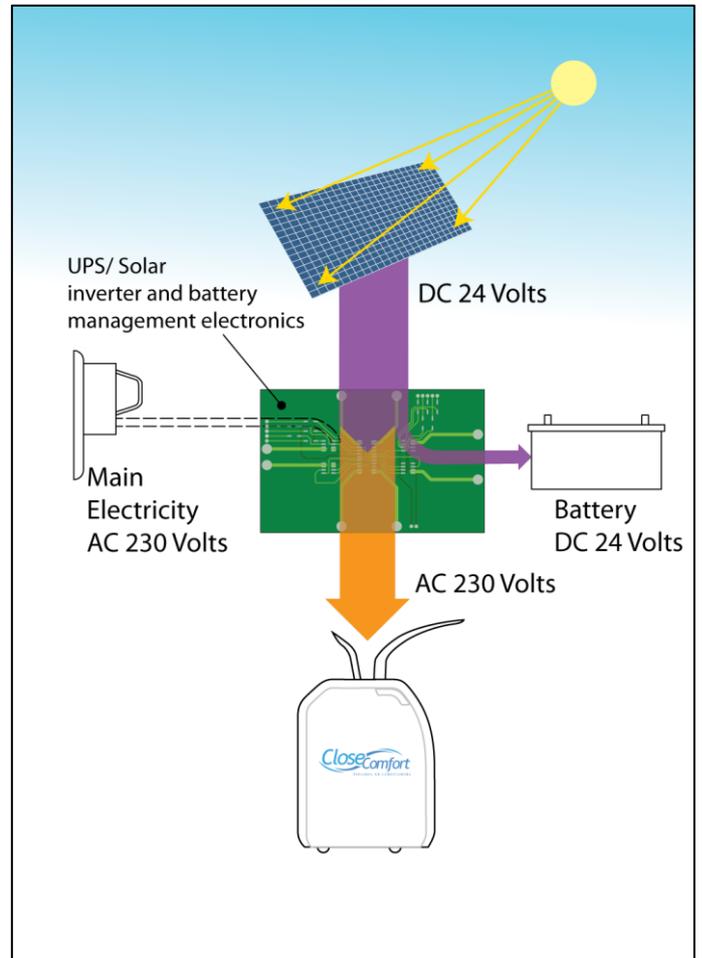
A solar power inverter enables the air conditioner to be run from a battery or solar panel. The inverter may also have a battery management system that monitors the battery charge automatically.

Not all solar power inverters can be used with batteries: you may need to check the specifications to find out.

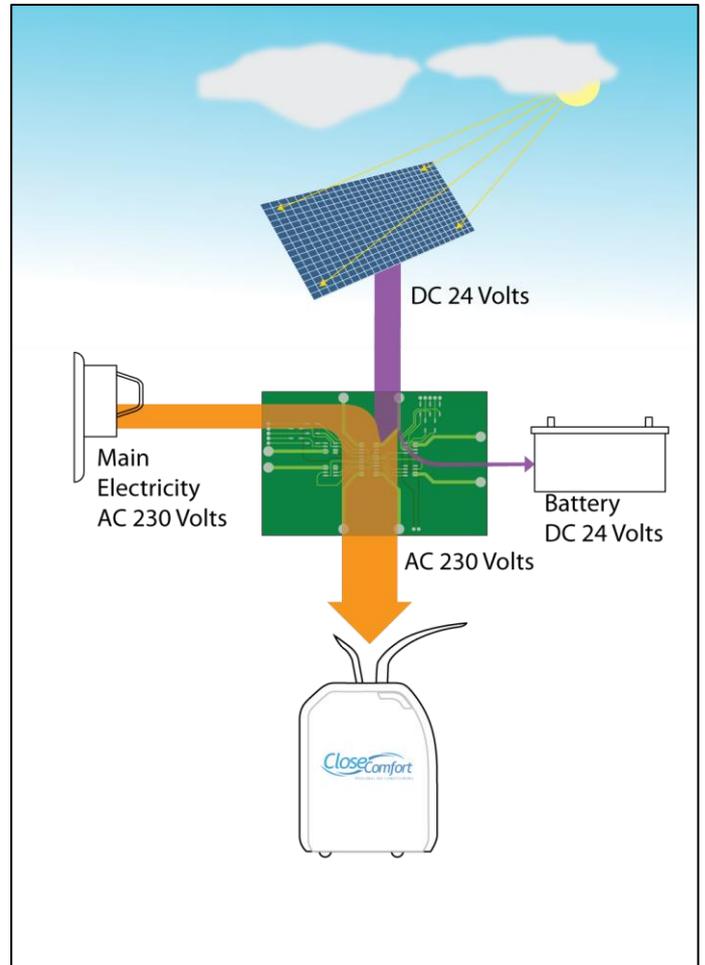
The first picture here shows how power from the solar panel operates the air conditioner and charges the battery during the day when the sun is shining.

When the battery is fully charged, the inverter reduces the current going to the battery as shown in the bottom diagram. This current is just sufficient to maintain the full charge in the battery. Most UPS models incorporate a similar feature.

Small solar systems provide 24 Volt power as shown. Medium and large scale solar systems provide much larger DC voltages, up to 600 Volts, depending on the size of the system.

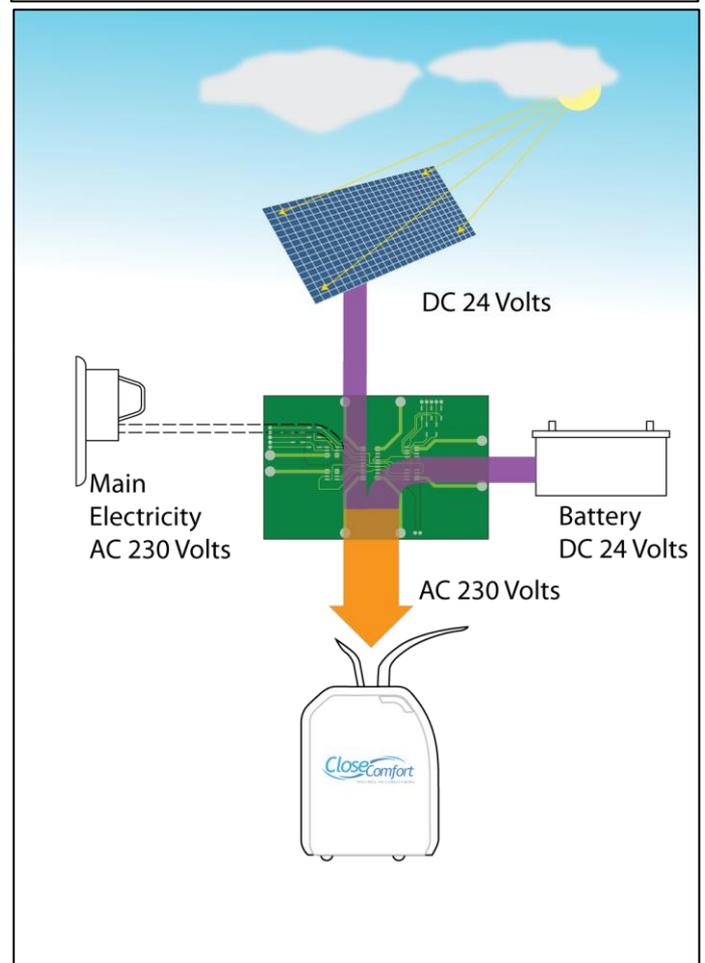


During cloudy weather or when the sun does not shine directly on the panel, less power is generated by the panel. The solar inverter automatically uses the main electricity supply to make up for the reduction in solar power.



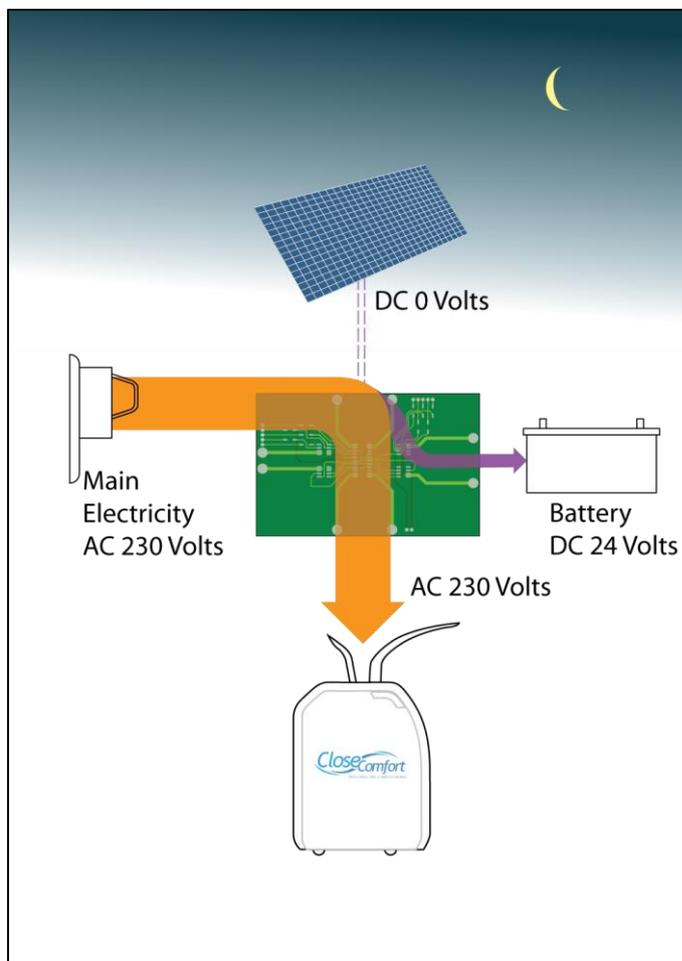
During mains power interruptions, the solar inverter automatically draws power from the battery to make up for the reduced solar power available.

Note that many solar inverters sold in Australia and other countries do not operate through mains power interruptions. However, specialist companies provide so-called "off grid" solar power supplies that do not require an active mains power connection.



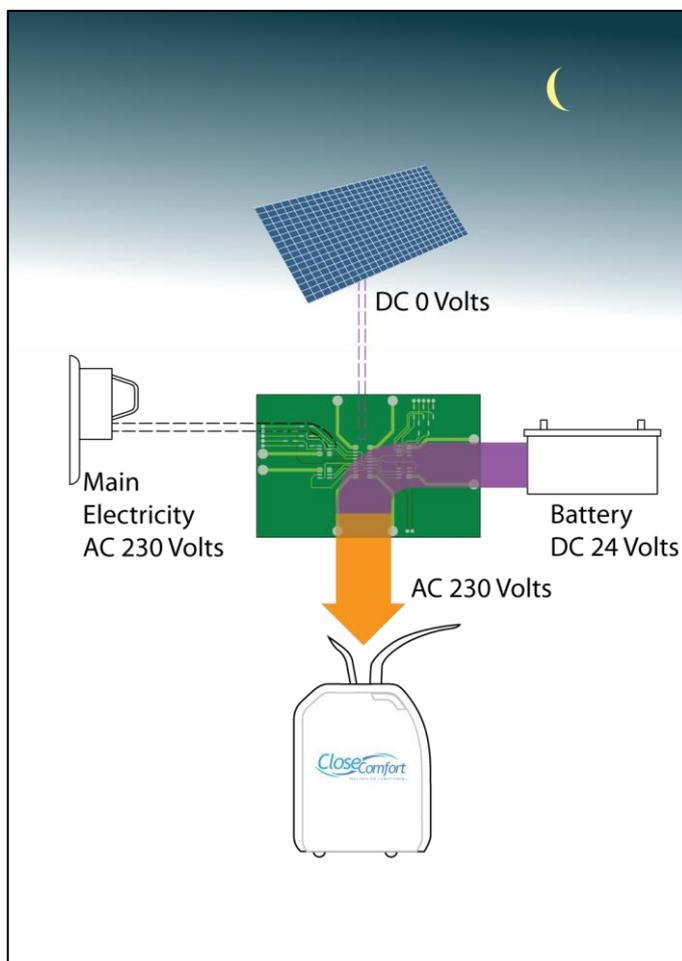
At night time when there is no solar power, the solar inverter uses mains power to run the air conditioner and also to top up the battery charge when needed, like a UPS.

Some inverters can be programmed to take advantage of cheaper off-peak electricity tariffs so they charge the batteries using as much off-peak power as possible.



During mains power interruptions, the solar inverter draws power from the battery like a UPS to keep the air conditioner running.

As above, please note that most inverters sold in Australia *do not* operate through mains power interruptions. However, specialist companies provide so-called "off grid" solar power supplies that do not require an active mains power connection.



Other Important Things to Know

Cost of off-grid power supplies

Off-grid power supplies are expensive. The total cost of an off-grid power supply system with good reliability will be several times the cost of your air conditioner. As a rough guide, currently, high performance lithium batteries cost about USD 500 (AUD 800) per kW hr of storage capacity. A battery with 1 kW hr storage will run a Close Comfort AC through an inverter for two, maybe nearly three hours.

Over time, however, in areas where electricity tariffs are high (say > 35 cents per kW hr), solar and battery storage systems can provide reliable power more cheaply than power utilities. However the cost of your system will depend on the maximum amount of power needed at any particular time.

Batteries

Lithium batteries can pose significant safety hazards, especially if they are not installed by experienced technicians. They can cause an intense fire, and under some circumstances can even explode. Therefore, most advanced countries are introducing safety standards to minimize the chance of a fire or explosion, and avoid injuries to people. For example, in most countries, large lithium batteries for off-grid power supplies cannot be installed where people normally congregate.

Even the older lead-acid batteries can pose significant risks from leakage of acid. Normally, an equivalent lead-acid battery system is less expensive than lithium batteries. However it is much heavier and therefore expensive to transport, and will last for a much shorter time, typically 3 years maximum. Lead-acid batteries which are fully discharged can last less than 12 months. If you plan to use lead-acid batteries, make sure you specify a “deep discharge” type of battery: do not use automotive batteries. While automotive batteries are cheaper, their useful storage capacity is much less than their rated capacity. Most lead-acid batteries also require regular maintenance to keep the acid level topped up and the battery terminals free from corrosion.

The capacity of the battery should be sufficient to run all the off-grid appliances that you would normally plan on using through the longest period when neither grid nor solar power is available. You will need to seek advice from local experts on this. Every location has different weather patterns and grid power availability.

The neither the battery nor inverter electronics can operate at 100% efficiency. Some electricity will be lost when transforming from AC to DC and vice versa. Count on 75% efficiency if no other information is available.

Most batteries will last a lot longer if you do not fully discharge them. Therefore the battery capacity needs to be sufficient to avoid being completely discharged, and also to overcome the charging and discharging energy loss.

Grid Power Voltage Variations

The stability of the grid voltage is another important factor. In most countries, the grid voltage is very stable and may only change by about 5 volts under the worst conditions.

In remote areas, or countries with fragile power supplies, the grid voltage can vary by 100 Volts or more. Not all inverters are designed for such large voltage variations.

Your Close Comfort air conditioner tolerates voltages as low as 185 Volts. Below this, there is a serious risk of damage to the compressor. Many other domestic appliances will be damaged under these conditions. If the main supply voltage will fall below 185 Volts, consider buying a voltage stabilizer.

Generators

Most small generators can also run Close Comfort, though the cost of fuel will be much higher than paying for grid power. A small generator may run as many as 5 or 10 Close Comfort ACs. However, make sure that they are not all switched on at exactly the same time or the surge current demanded by the compressors may stall the generator.

A suitable generator will cost less than an equivalent capacity solar and battery power supply.