RURAL ENERGY GUIDE

Understanding electricity and rural electrification in South Africa

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CHAPTER 1

Where does electricity come from?

This chapter describes various ways that electricity is produced in South Africa.

It is divided into two main sections:

- The production of grid electricity (i.e. the electricity carried over power-lines
- Options for producing non-grid electricity

The vast majority of the electricity produced in South Africa is generated in power stations which use coal as a fuel. This chapter helps to explain why this electricity from coal is fairly cheap to *produce* – but the next chapter will explain why it can be expensive to carry the electricity from power stations into rural villages.

When power lines do not yet reach deep rural areas, the government also encourages other non-grid electricity options, such as solar PV systems, for local electricity supplies. This chapter helps to explain such options, and discusses some of their advantages and disadvantages.

Introduction

At present, about 50% of rural households in South Africa are connected with grid electricity. In some areas where grid electricity will not be available in the near future, there are government-supported programmes to help people obtain other non-grid electricity supplies.

When it comes to energy matters, rural communities are intensely interested in obtaining electricity. They are also often very concerned about whether they can obtain grid electricity, or non-grid electricity.

It helps to have an understanding of the different ways that electricity can be produced and supplied. This chapter focuses on the various ways that electricity can be *generated*, while the next chapter will take up the story of how it is supplied to rural communities. Chapter 3 discusses ways of paying for electricity, including different kinds of electricity tariffs and different levels of electricity supply. Chapter 4 looks at the costs of using electricity for different tasks, and Chapter 5 discusses how rural electrification planning is carried out.

Electricity generation

The production of electricity is also called "electricity generation". Before going on to discuss large power stations, we begin with an example of a small electricity generator.

Many rural people will be familiar with small electricity generators, which run off petrol or diesel. In places where grid electricity is not available, these small electricity generators are used by some wealthier households, schools, churches, shops, etc., to produce their own electricity supply. (They are quite expensive to run. The fuel costs quite a lot, and they also need regular maintenance.) However, the purpose here is to illustrate how these generators work.



A small petrol generator

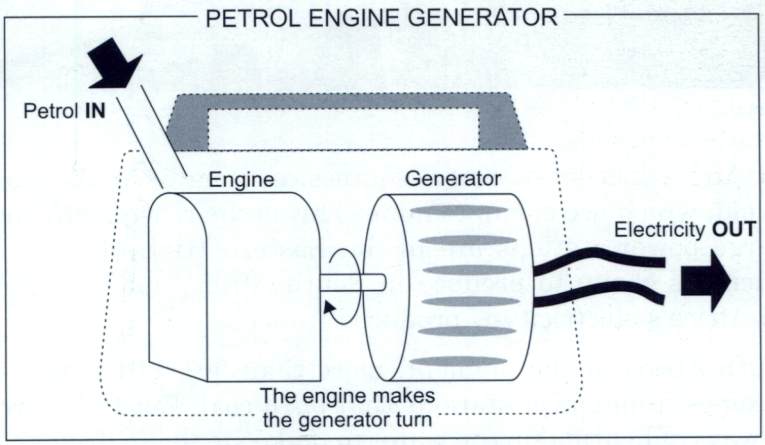
These small generators have two main parts.

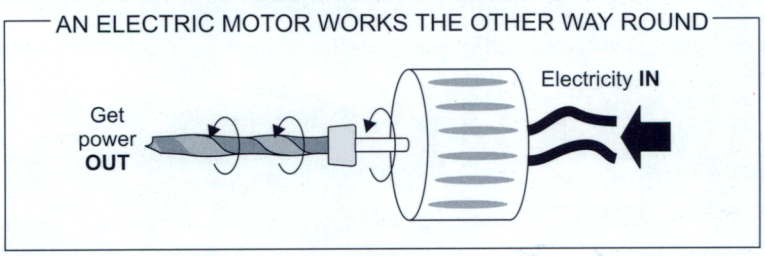
First there is an engine, which is similar to a car engine (but smaller). The smallest generators normally use petrol engines, while larger ones normally use diesel engines.

Secondly, there is the electric generator. This is what actually produces the electricity. The electric generator is quite similar to an electric motor. An electric motor turns round when electricity is *supplied*. However, an electric generator operates the other way: by making the generator turn round, it *produces* electricity.

In these small generator sets, the petrol or diesel engine makes the electric generator turn round, to produce electricity.

The large electricity generators in power stations work in much the same way.





Generating grid electricity

When people get electricity from the national electricity grid (in other words, from across the power lines), the electricity is also produced by electric generators. These generators are in power stations, and they are much larger. What makes them turn?

Coal-fired power stations

There are various ways. In South Africa, most of the power stations use coal, because coal is cheap and abundant in South Africa. The coal is burnt (as efficiently as possible) to heat water and produce high-pressure steam. This steam is forced through a *turbine*. The turbine spins round, and this is what makes the huge electric generators turn round to produce electricity.

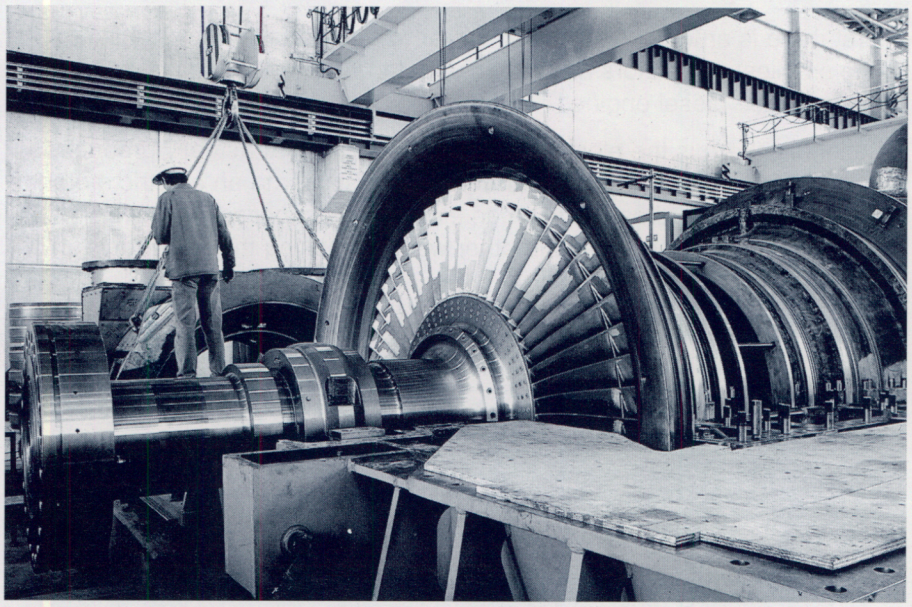


Photo: Eskom

South Africa has large coal resources, especially in the Eastern Highveld, which are cheap to mine. This is the reason why most of the large power stations are in the Eastern Highveld area, why electricity is cheap to produce in South Africa, and why most of South Africa's electricity is produced from coal.

In South Africa at the moment, more than 90% of the electricity used comes from power stations that burn coal. But there are also other ways of heating up the water to make steam, to drive the turbines.

Left: Turbines in a power station. A large South African power station uses about 30 thousand tons of coal and 9 million litres of water each day, to operate 'at full steam'.

★ The large turbines in a power station are shaped like complicated fans.

You can easily understand how they work, by thinking about a normal fan. If you make a fan turn round, it makes a wind. On the other hand, if you place this fan in a strong wind, the wind will make the fan turn round by itself.

In a similar way, when steam is forced through a turbine, it is like a very powerful "wind" that makes the turbine turn round.

★ There is growing concern in the world about the environmental damage caused by burning large amounts of "fossil fuels" like coal. On a global scale, this will cause a build-up of greenhouse gases like carbon dioxide in the atmosphere, and increase the dangers of climate change and global warming.

Other ways of generating grid electricity

There are also other ways of forcing turbines to turn round. For example, water itself can be very powerful. The force of water flowing through a large dam, or falling down a mountain, can be used to drive a turbine to generate electricity ("hydro-power"). South Africa has only a few large hydro power stations. In general the country is short of water, so there is not very much hydro power inside the country.

However, in some nearby countries there are stronger rivers, drawing water from tropical rainfall areas, as in Mozambique, Zimbabwe, Zambia and Zaire. There could be a great use of this hydro-power in southern and central parts of Africa.

In areas where there are strong winds, the power of the wind can be used to generate electricity, using windmills (also called "wind-turbines"). In some parts of the world, the production of electricity from wind turbines is growing faster than any other type of electricity production. But this is not the case in South Africa. This is partly because most parts of the country do not experience strong, regular winds, but mainly it is because South Africa has cheaper electricity produced by burning cheap coal. This electricity from burning coal is about three times cheaper to produce than electricity from wind energy.

South Africa has a nuclear power station near Cape Town (at Koeberg). Nuclear power stations use radio-active materials to create heat – and then the heat is used to make steam, which drives the turbines. Very strict safety controls are required for nuclear power stations. Many countries are now choosing to avoid using nuclear energy for generating electricity. This is mainly because the people in these countries feel that nuclear energy can be dangerous, and because they think it will be dangerous or expensive to take care of the radio-active nuclear waste that is left behind. However, some countries continue to use a lot of nuclear energy. At present, South Africa is continuing to investigate new ways of generating electricity from nuclear energy.

What other fuels can be used to make heat, in order to produce electricity in power stations? Almost anything that burns! Some countries have power stations that burn straw from the fields in the countryside, or other waste materials which are collected in cities. You can also use wood. Compared with coal, these materials do not have such a high energy content, and they are more difficult to collect. This means that countries like South Africa are less likely to use them, because coal is cheaper to use.

So in South Africa, most of the country's electricity at present comes from power stations that burn coal. A smaller amount comes from a nuclear power station and from some hydro-power stations.

The nuclear power station at Koeberg is protected by thick concrete domes.



Photo: Eskom

★ Radio-active materials occur in nature. An example is Uranium, which is mined in South Africa. Materials like Uranium give out small quantities of energy all the time, until eventually they decay and stop being radio-active. In nature, this radio-activity is usually not dangerous, because it is very spread-out and weak. However, it has to be made more concentrated to operate a power station. Then it becomes potentially dangerous to living creatures, and that is why strict safety controls are required.

And in areas which do not yet have grid electricity?

Options for non-grid electricity

Although rural electrification has been expanding quite fast in South Africa – faster than anywhere else in Africa – there are still many rural communities that are not yet connected to the national grid. How do people use electricity in these areas?

There are various options for obtaining non-grid electricity.

Dry-cell batteries

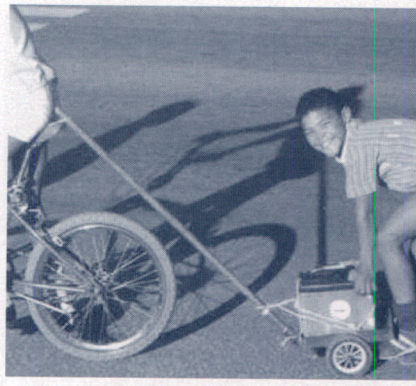
A simple but expensive option is to use small "dry-cell" batteries. These can provide enough electricity to operate small appliances like radios and torches. But since they need to be replaced regularly, they become an expensive item in the household budget for poorer families. Sometimes people are spending something like 40% of their total energy expenditure on dry-cell batteries. They are willing to spend this much mainly because they want to listen to a radio.



A radio "dry-cell" battery.

Rechargeable batteries

There are various kinds of "re-chargeable" batteries. The commonest, in rural areas, is a car-type rechargeable battery. These are often used for operating a TV when grid electricity is not available. They are quite expensive to buy, and then there is the regular cost of having the battery re-charged, usually by taking it to a place which *does* have grid electricity (although these batteries can also be re-charged using generators, solar systems, etc.). The cost of transporting the battery to be re-charged adds onto the charging cost. There is also the cost of replacing these batteries from time to time, as they do not last for ever. All in all, electricity from re-chargeable batteries is also expensive!



A rechargeable battery in transit.

Other kinds of re-chargeable batteries include the small (and expensive!) batteries used in cell phones. Fortunately, these can last quite a long time before they need to be replaced, and they only need small amounts of electricity to be re-charged. It is quite possible to charge them using small solar systems, in areas which are not connected to the electricity grid.

Re-chargeable "car batteries"

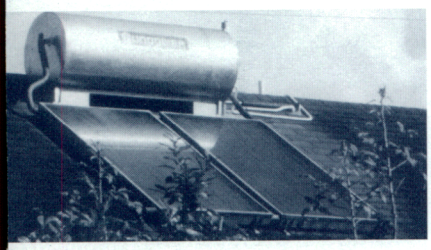
In fact, a normal car battery is not very good for providing electricity in the home. Normal car batteries are designed to provide quite a lot of power *for a short time*, when they are used to start the car's engine. They are not meant to be run down until they go flat. That damages them, and they will soon wear out. It is better to use another kind of battery, which has heavier lead plates inside. These batteries cost a bit more to buy, but they should last longer and will save money in the end. They can often be identified by the fact that they are supplied with handles for carrying them more easily. They are sometimes called "portable batteries" or "modified SLI batteries".

Charging cell-phone batteries at school?

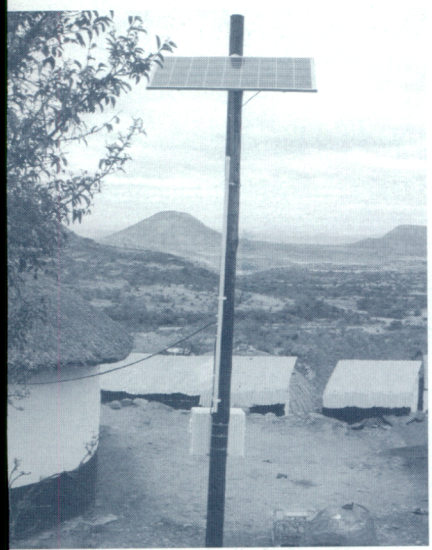
Many rural schools have been getting electrified, even in areas where there is not yet grid electricity. A couple of thousand rural schools have been provided with solar electricity systems. The largest numbers of these are in Eastern Cape and Limpopo Province. Some of these schools will charge cell-phone batteries for members of the community, at a lower cost than if a person had to travel to town to get the battery re-charged.



PV panels on a clinic roof



A solar water heater is quite different from a PV system. It collects heat and does not produce electricity.



A solar home system

Solar PV systems

In the past, re-chargeable batteries and petrol or diesel generators were the main options for providing electricity in areas that do not have the grid. In places where there is quite a lot of wind, some farmers have also used small wind-generators to produce electricity. However, for producing small amounts of electricity (like electricity for lights, for TV and radio, etc.) all of these are more expensive to operate than a solar PV system.

"PV" stands for "photovoltaic". This term is a way of saying that solar PV panels can change the energy of *light* ("photons") into electricity – volts and amps.

When bright light strikes a solar PV panel, the energy in the light in converted directly into electrical energy. The electricity can either be used straight away, or stored in a battery. Of course, by storing the electricity in a battery, it is possible to use the electricity at another time, for example at night when the sun is not shining, or on cloudy days, when the solar panels do not produce so much electricity.

Notice that there is a big difference between *solar PV panels*, which produce electricity, and *solar water heater* panels, which collect heat.

Solar water heaters are quite simple – more or less like black boxes which contain water. The *heat* of the sun warms up the water.

Solar PV panels on the other hand are a modern technology, which has taken many years to develop. The *light* of the sun provides the power for PV panels, not the heat. In fact, PV panels operate best when they are not hot, but when the light is bright. If PV panels heat up too much, they cannot provide so much electricity.

One good thing about PV systems is that they can last a very long time. A good quality PV panel can keep on producing electricity for fifteen or twenty years, maybe more. (However, the batteries will need to be replaced from time to time.)

Another advantage is that PV systems do not require as much maintenance as a petrol or diesel generator, and do not require fuel to operate.

However, there are also disadvantages.

Firstly, small PV systems can only provide a limited amount of electricity. For example, an average solar home system has one PV panel (usually producing about 50 Watts of electricity in bright light) and this can provide enough electricity to operate a few lights and a black-and-white TV. To use a colour TV, you would probably need two PV panels. And there is not enough electricity for cooking. (Cooking and heating require much larger amounts of energy than lights, TVs, radios, etc.)

Secondly, although PV systems are fairly cheap to operate, they are quite expensive to purchase in the first place. A small solar home system could cost around four thousand rand to buy. The

larger systems installed at schools, for example, can cost around R70 000 to install.

To help rural people obtain solar home systems in a more affordable way, the government in South Africa is encouraging solar companies to offer solar home systems in a different way. Instead of purchasing these systems, households can "hire" them, by paying a regular monthly fee. At the same time, the government is providing a subsidy, to bring down the cost of these monthly payments. (For more information about this, see Chapter 5.)

Apart from solar home systems for households, solar PV systems are widely used for powering rural telephones, the cell-phone network, and are also used for water pumping.

They are very good for water pumping, because in this case no batteries are needed, and that makes the systems more efficient. Very little maintenance is required, compared with diesel water pumps or water-pumping windmills. However, PV pumping systems are expensive to purchase. They are most suitable for smaller water-pumping requirements, like drinking water for a small community, or a supply of drinking water for animals. For large water-pumping requirements, like irrigating a large area of land, diesel pumps would be cheaper than PV pumping. And whenever grid electricity is available, this will provide the cheapest option, cheaper than PV, and cheaper and more reliable than diesel engines.

Many schools and clinics in the country have been provided with PV systems. For clinics, they provide electricity mainly for vaccine refrigerators, lighting and sometimes radio-telephones. In schools, the systems are intended to provide electricity mainly for lights and for TVs and video. The electricity could also be used for computers. However, many of these schools have experienced problems with obtaining equipment (like the TV and video), problems with poor maintenance of the PV systems, and problems of security, theft and vandalism.

AC and DC electricity

The electricity which you get from a battery **flows in one direction**. This is called DC or "direct current" electricity. The electricity in a small PV system is usually DC electricity. In this case, you need to use lights, TVs, etc. which work on DC electricity.

Some very high voltage power lines are also DC.

The normal electricity obtained from the grid, however, is AC or "alternating current" electricity. This electricity **flows in two directions**, backwards and forwards. Because AC electricity is more common, most common appliances in shops are designed to use AC electricity.

Solar systems can also provide AC electricity, if this is required. However, this requires another piece of equipment, called an **inverter**. An inverter changes DC electricity to AC electricity. The solar systems in schools, for example, have inverters and provide AC electricity.

Electricity from water – hydro-electric power

Water is heavy, and when a large quantity of water comes down a mountain slope, or pours out of a dam, it contains a lot of energy which can be converted to electricity. Even smaller rivers can provide useful hydro-power, if there is a regular supply of water and there is a steep enough slope.

These are the two main requirements for hydro-power: enough water, and enough slope. These two factors work together.

Small hydro-power systems are a very good supply of electricity in remote areas, if you are lucky enough to have a suitable river nearby. Unfortunately, water is scarce in many parts of South Africa. The best opportunities for small hydro-power are found mainly on the eastern side of the Drakensberg mountains.



The large windmills used to generate electricity usually have three blades. The common windmills in rural areas of South Africa, with many blades, are for pumping water – not for producing electricity.

Electricity from the wind

Windmills that produce electricity are also called "wind turbine generators". They come in many different sizes. Very small ones only generate about 50 Watts in a strong breeze, while very large ones can generate more than a million Watts (more than a Megawatt) each.

Many countries are using large wind turbines to feed electricity into their national grids. The windmills need to be located in windy areas, and can either be on land or in the sea. A big advantage is that this electricity is coming from a renewable energy source (the wind) and does not cause pollution. This is the main reason why some countries provide subsidies to assist the growth of wind energy.

Recently, the use of wind energy has been growing faster than any other form of energy in the world. There are "wind farms" (with large numbers of large wind turbines) in many countries. Even so, wind energy only contributes a small fraction of the world's electricity at present.

In South Africa, there are no large-scale wind farms in operation yet. As mentioned before, this is partly because the cost of electricity in South Africa is so low, compared with most other countries. The cost of electricity from wind turbines would be about three times the present cost of generating electricity from coal in South Africa (ignoring the costs of pollution from coal).

When electric wind turbines are used in places that are *not* connected to the grid, they usually require some way of storing the electricity, for example in batteries. This is because the wind is not a very regular source of energy. Batteries can store electricity so that it can be used when the wind is not blowing. But using batteries pushes up the cost of using electricity from wind turbines, by a large amount. In most areas of the country, solar PV systems can provide cheaper electricity than windmill-battery systems.

In fact, most inland parts of South Africa do not receive enough wind to make wind turbine generators an attractive source of elec-

tricity, on their own. However, the picture can change if wind turbines are combined with other electricity sources, such as diesel generators and solar PV systems. When several different sources of energy are combined together in this way, it is called a "hybrid energy system".

Hybrid systems for electricity, and mini-grids

As mentioned above, a hybrid energy system makes use of two or more sources of power, for example:

- wind and diesel
- wind, solar, diesel generator, batteries

These electricity systems are more complex, but they can end up being more economical in some conditions. Savings can occur, for example, because

- the diesel generator can act as a back-up, so less battery storage is required (battery storage is expensive!)
- the sun may be shining at one time, and the wind may be blowing hard at another time, so the solar and wind energy can help to balance each other – again, this reduces the need for large amounts of battery storage

Such hybrid systems are best for providing medium amounts of electricity, rather than small amounts for a single household. They could be suitable for providing power for a small village, far from the national grid. However, the costs of producing the electricity with a hybrid system will still be quite high, usually more than a rand per kilowatt-hour. (A kilowatt-hour is one "unit" of electrical energy. See Chapter 4 for more information about kilowatt-hours and the costs of electricity.)

Mini-grids:

If a hybrid system provides electricity for many households, and possibly shops, schools, a clinic, a business centre, etc., all these electricity users will need to be connected to the hybrid system. In other words, there will be a "local grid" of electric cables to distribute the electricity. This is often called a mini-grid.

Installing a mini-grid costs additional money, to get the electricity to each of the electricity users, especially if they are far apart. Hybrid mini-grid systems are most likely to be viable and valuable when

- the electricity users are quite close together
- the place is far from the national grid (eg. 50 km away) – otherwise, it may be more economical to extend the national grid, rather than install a hybrid system
- the users will consume a medium amount of electricity, not a very small amount
- the electricity can be used for income-generating purposes and valuable social services, not just domestic purposes
- people are able to pay for the cost of the electricity – or subsidies are available to make the cost more affordable to the users.

Price comparison

Electricity produced by a hybrid energy system will usually cost more than a rand per kilowatt-hour.

By comparison, Eskom produces electricity from its large coal power stations at a cost of around 7 to 10 cents per kilowatt-hour. This is just the cost of *producing* the electricity. There are further costs in getting the electricity around the country. A common price which households paid in 2002 was about 35 to 40 cents per kilowatt-hour for grid electricity.

There could also be situations where it would be useful to have a mini-grid in the central part of a village, while more scattered households could use separate solar home systems for their electricity.

However, in many parts of South Africa, people are hopeful about getting full grid electricity in such circumstances (even if they have already waited many years for this).

CHAPTER 2

How does electricity get to you?

Grid electricity is generated in power stations, often far away from the places where the electricity is used. This chapter describes how electricity is carried over various kinds of power lines into rural areas. It explains why the electricity is pushed up to very high voltages to travel across the country, and then brought down to the lower voltages which people use in their homes.

The costs of carrying electricity over long distances can affect the costs of rural electrification, and hence the speed at which the electricity grid is extended into rural areas.

Introduction

People using a generator or a solar system can produce electricity in their own homes. But for people who are connected to the national grid, the electricity has to travel a long way – probably all the way from Eskom's main power stations in the Eastern Highveld.

This chapter describes how electricity is carried across the country, and into people's homes (and the other places where electricity is used). For rural electrification, this takes place in various stages, including the main power lines which spread across the country, smaller power lines in rural areas, and local connections to homesteads and other electricity consumers. In the next chapter we will go one step further along the electricity path and look at electricity meters inside the home. These measure the amount of electricity used, and affect the way that people pay for their electricity.

It can be useful for people such as rural energy activists and development workers to understand the path which electricity takes, from the power stations to the electricity users. This is mainly because the *costs* of rural grid electrification depend quite a lot on the equipment needed to carry electricity into rural areas. These costs, in turn, affect electrification planning, and therefore questions like:

- When will electricity arrive?
- Who will get it?

"Transmission" and "distribution"

Electricity travels from the power stations to a rural village in various stages:

The power lines which carry the electricity long distances across the country make up the electricity **transmission** network. For example, these transmission lines are used to carry electricity from a power station in Mpumalanga down to the Eastern Cape.

The electricity supply then gets divided up and sent to various local areas. This is called electricity **distribution**.

Both transmission and distribution networks require electricity lines or cables. But because the power lines carry different amounts of electricity in each case, they involve different types of cables, and different types of poles or pylons. The transmission and distribution networks also operate at different voltages.

Before discussing these in more detail, it may be useful to say a few words about volts and voltages, since many people find such electrical terms confusing.

Volts and voltages

It is difficult to explain to someone what "voltage" means, partly because electricity is invisible. Here are some different ways you could help to explain it.

- You could say that voltage is like the "force" which pushes the electricity.
- You could give an example of water flowing through a pipe, and say that voltage is like the "pressure" which pushes the water.
- Carrying on with this example, imagine you are squirting water out of a hosepipe. If you want the spray of water to go a longer way, you need more water pressure. Similarly, if you want electricity to travel a long way, it helps to have a higher voltage.
- Electricity usually travels over wires, but a *very* high voltage can travel through the air, without wires. An example of electricity travelling a long way, without wires, is a lightning strike. Lightning happens when a very high voltage builds up, either between clouds and the earth, or between different clouds.

You could also relate voltages to matters of **danger** and **safety**. Higher voltages can be more dangerous, because the higher-pressure electricity can travel through the air – like lightning – or more easily give someone a shock. For example, electricity out of a normal plug in South Africa is about 220 to 230 volts. This is enough to give a nasty and dangerous shock, if someone touches a bare wire, but as long as the wires are properly insulated it is safe. By comparison, the electricity from a 9 volt radio battery, or from a 12 volt car battery, is unlikely to cause any noticeable electrical shock.

★ Wires conduct electricity because the metal inside is a good **conductor**. Water can also be a good conductor, so never mix electricity with water! Some substances have a high resistance to conducting electricity. These are **insulators**. The plastic insulation around household wires is an example.



Something which people usually find hard to understand is that the electricity voltage is not the same as the "power" of the electricity. You could give an example to help explain this:

- In a house with grid electricity, you can plug in a TV or an electric heater to the same plug socket. In each case the voltage is the same (about 220 to 230 volts), but the electric heater uses much more power than the TV. The heater uses up electricity faster.

Electric power is measured in Watts. The voltage is measured in Volts.

> For more detailed information about electrical terms like Volts, Watts and Amps you can refer to the Appendix "Technical Notes" at the end of this book.

Transmission – Carrying electricity across the country at very high voltages

Every time electricity flows through a wire or cable, some of it gets lost. Maybe only very small amounts get lost, but if the cables cover long distances, these losses add up every kilometre. So to carry large amounts of electricity over long distances, it is important to cut down on those electricity losses.

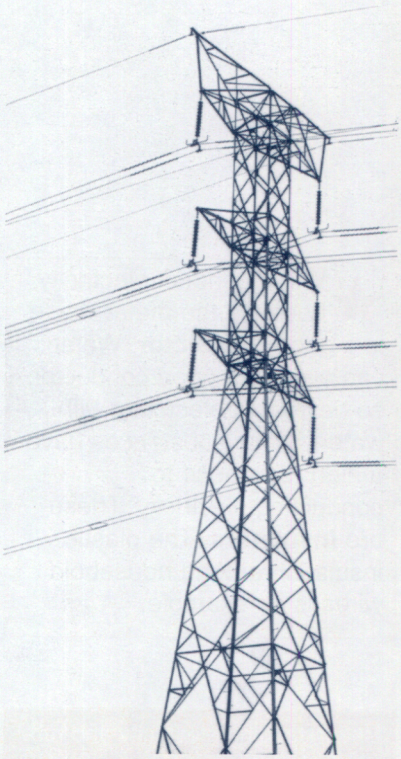
> Even good conductors like electricity cables have some **resistance** to carrying electricity. This resistance causes some of the electrical energy to get wasted along the way. Thicker cables have less resistance than thin cables.

This can be done by sending the electricity at very high voltages. High voltage electricity can travel with less resistance – and it is this resistance in the cables which leads to electricity losses.

The resistance can also be cut down by using thick cables. Therefore the main Eskom transmission grid, which carries bulk supplies of electricity over long distances, uses thick cables and is at very high voltages (such as 400 000 volts).

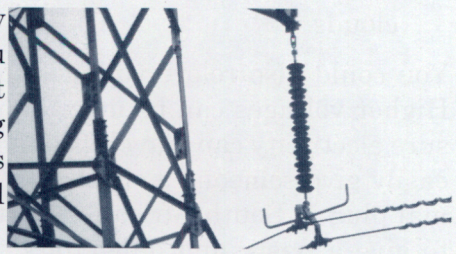
These very high voltages make the electricity potentially more dangerous. Such high-voltage electricity can even spark through the air, particularly if the air is moist, or smoky. So these cables are kept high off the ground, using high pylons (as shown in the picture).

Have a look at where the cables are connected to the pylons. You will see that there is a long string of "insulators" between the electricity cables and the pylons. These insulators stop the electricity from leaking into the metal pylons (which would of course be dangerous for people who might touch the pylons).



High voltage power lines

Very high voltage electricity requires more insulators, and you can tell whether a power line is at a very high voltage by counting the number of insulators. In this case, there are 11 insulators and the voltage is 132 000 volts.



These main power lines are very expensive to construct. They can cost around R1 million per kilometre. They are used to carry huge amounts of electricity across the country.

Transformers

Transformers come in different sizes – from as small as a matchbox to the size of the large equipment found at power stations and sub-stations. In each case, though, they have the same purpose: to change the voltage of electricity (up or down). More information about transformers can be found in the Appendix, "Technical notes".

Electricity distribution

Once you get closer to where the electricity will be used, it is possible to switch down to lower voltages, and use cheaper power lines. This is because, now, the amounts of electricity which are being carried are not so large.

The voltage of the electricity is changed by going through **transformers** at sub-stations. Here is a picture of a sub-station where the electricity comes in at 132 000 volts and goes out at 33 000 volts.





A medium-voltage power line, operating at 22 000 volts. This is the same as 22 kilovolts. Engineers refer to it as a 22 kV line.

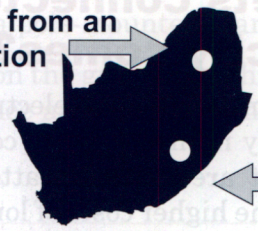
In rural areas of South Africa, the electricity is normally carried to village areas and small towns on "medium voltage" lines. Common voltages for this are 33 000 volts, 22 000 volts and 11 000 volts. This still sounds high! But compared with the high-voltage transmission lines, these rural lines can be regarded as "medium voltage".

Notice the number of insulators on the medium-voltage 22 000 volts line in the photograph on the left.

These lines do not have to be so high off the ground, so the poles can be less expensive. However, medium-voltage lines still cost quite a lot. It depends on how easy it is to install the lines. In normal circumstances, they can cost about R60 000 per kilometre to install. In mountainous countryside, or other difficult circumstances, they could cost more.

Voltages like 22 kV (or 22 000 volts) are still too high for people to use the electricity directly. So, before the electricity can be connected to homes and to other electricity users, the voltage has to be brought down once again. This requires another transformer. The electricity that comes into homes is usually at 230 volts.

Getting electricity from an Eskom power station in Mpumalanga ...

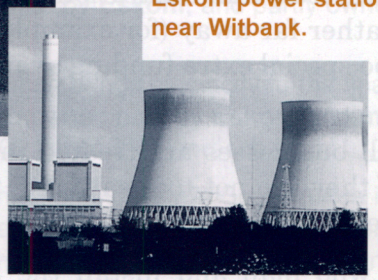


... and making a cup of tea in a village in the Eastern Cape

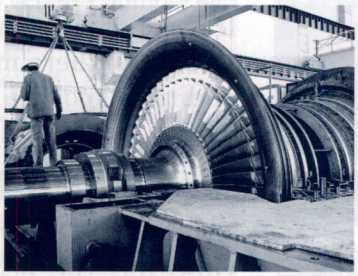


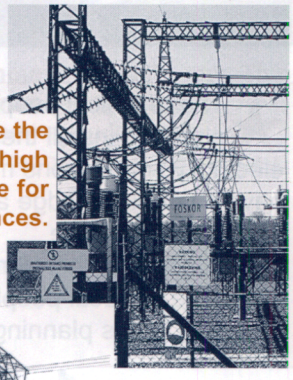
The story starts in Mpumalanga. Miners are mining the coal used to produce electricity.

Close to the coal mine, the coal is burnt at an Eskom power station near Witbank.



The heat is used to make steam. The pressure of the steam drives turbine machines. These turbines are connected to huge electricity generators.





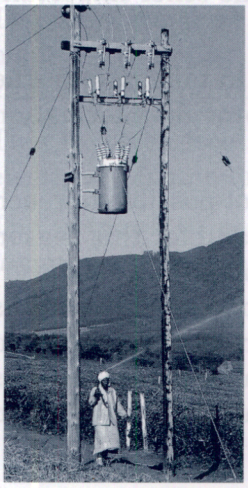
Transformers change the electricity to very high voltages, suitable for crossing long distances.



High-voltage power lines carry the electricity to areas of the Eastern Cape.



Getting closer to the villages, medium-voltage power lines carry the electricity to Matatiele and beyond.



Another transformer is needed to bring down the electricity voltage to the low voltage which people use.

SOME ENERGY-USERS IN THE VILLAGES



This home, in Dengwane village, has electricity. But the family does not have enough money to use much electricity. They only use it for lights. To heat water, they usually use an mbawula, burning cow-dung.

This lady lives in a village that does not have a connection to the electricity grid. She usually uses a gas stove to make tea. She also has a solar system which provides some electricity – but she uses this only for lights.



Does electricity solve everybody's energy problems?

Some people believe that electricity will solve all their energy problems, when it arrives. However, this is not true.

It is true that there are some things you cannot do without electricity. And electricity can improve people's quality of life. But experience shows that poorer households carry on using other forms of energy (like paraffin, wood, or gas) even after getting electricity.

Wealthy people are able to use electricity for almost all their energy needs in the home. They use it for cooking, heating water, lighting and a wide range of appliances. It is convenient, and it is clean to use.

But poorer households find it difficult to pay for the large amounts of electricity needed for cooking or heating water. They also find it difficult to buy the more expensive electric appliances like stoves. As a result, they carry on using cheaper fuels like wood (if this is readily available), or cheaper appliances like paraffin stoves.

For this reason, it is important for communities to think about *all* their energy needs, and not focus only on electricity.

This is also the way that the government is now thinking about rural energy needs. The government wants to get electricity to as many people as possible, but at the same time wants to improve the supplies of other fuels like paraffin and gas.

Another common belief is that getting electricity will create jobs. Electricity can help, but it is not enough by itself to create jobs. You can think of many other requirements, such as business skills, money to buy equipment, good transport, and being able to sell products.



CHAPTER 3

Ways of paying for electricity

These Rural Energy Guides are written mainly for people who are not electricity specialists or engineers. However, this chapter needs to cover a number of quite technical (and sometimes complex) issues.

First we look at different types of electricity meters. These affect the physical way that people pay for electricity. Pre-payment meters are common in South Africa, and are usually preferred by people who want to keep a watchful eye on their electricity payments.

The type of electricity meter will affect how you pay for electricity, for example by purchasing electricity cards or coupons, or paying a bill at the end of each month. But a more complex question is how much you pay for the electricity used. This is worked out according to various "electricity tariffs".

A simple and common form of electricity tariff involves (i) an initial connection fee, and (ii) a charge for the amounts of electricity you use. But both of these can be affected by the "level of electricity supply" which you have. Some households and other customers need to use larger electricity supplies, which cost more. Others choose a lower "level of supply", which costs less. An important point here is that electricity users need to decide what suits them best. This is not such an easy choice, and we have found that many people do not have enough information to choose their best option. Therefore we try to explain

- what is meant by different "levels of supply"
- how to choose between different levels of supply, to fit a customer's energy needs and available budget

There are also other types of electricity tariffs which need to be considered. They will be of interest to two groups of people, mainly:

- People who consume large amounts of electricity. They can benefit from moving to more complicated tariffs which have higher fixed charges each month, but lower charges for the amounts of electricity used.
- People who consume small amounts of electricity. They may get extra benefits from moving to a proposed "Basic electricity support tariff" which provides for a certain amount of electricity free (or at very low cost) each month.

Unfortunately, most rural electricity customers find it hard to obtain information that helps them decide about such options. This is the reason why this chapter needs to provide some technical details.

Introduction

There are various ways of paying for electricity in South Africa. In the simple and common ways of paying for electricity, the amount you pay each month depends on the quantity of electricity you use.

In addition to the amount you pay for the electricity you use, there is usually also an initial connection fee. The amount paid for the initial connection can depend on the "strength" of the electricity supply you want, or more exactly, how many Amps of current you can use. People can choose between these different levels of supply, according to their needs and their budget.

Because these different levels of supply can be an important choice which householders and other electricity users need to make, this chapter includes an explanation of different supply levels and what you can do with them.

First, though, a word about different types of electricity meters.

Types of electricity meters

Electricity meters measure the amount of electricity used. Each electricity customer usually gets an electricity meter installed at their house or building.

There are two main types of electricity meters in South Africa: credit meters and pre-payment meters. Pre-payment meters are normally installed inside the house or building. Credit meters may be inside, or sometimes outside (to make it easier to read the meter).



Credit meters just measure the amount of electricity used. The bill arrives later, after someone has come to read the meter.

Credit meters

A "credit meter" keeps a record of how much electricity has been used. It turns round like a clock, adding up the electricity units – it turns fast when a lot of electricity is being consumed, and it turns slowly when the electricity consumption is low. Then a person comes to read the meter (normally every month) to work out the electricity bill which is owed. This is called credit-metering, because the electricity customer is using electricity "on credit" and only pays later for what he or she has used.

There are two main disadvantages of credit meters:

- It is expensive to send a person every month to read these meters (especially in spread-out rural areas, but also in towns), and this can push up the price of providing electricity.
- If you have a credit meter, it can be difficult to keep track of how much electricity you are using. If you have a pre-payment meter, it is easier to keep track of electricity expenses.

On the other hand, this traditional style of electricy metering and payment may be more convenient for some users. With credit-metering, there is no need to purchase electricity coupons or cards (as you have to do with pre-payment meters).

Pre-payment meters

"Pre-payment meters" have become more common in South Africa, and the good results are being shared with other countries.

In one type of pre-payment meter, the customer buys an electricity card in advance. The card is inserted into the pre-payment meter. This tells the meter how much electricity has been bought. The customer can then use this amount of electricity, until it runs out (or another card is inserted).

There is another kind of pre-payment meter which does away with these cards. Instead, when you go to buy some more electricity from an electricity sales-point, you are given a number, which you have to type in when you get home. The number is worked out by the company's computer system, and when you type this number into your meter, the meter will record how much electricity you have bought.

Many electricity users prefer pre-payment meters, because it is easier to know how much electricity you are using, and therefore easier to budget. The pre-payment system is also more efficient for the electricity supplier, since it takes away the need for meter-readers to go around checking meters every month. However, some people experience difficulties with electricity cards. One of the difficulties is that, in some places, people have to travel quite far to buy the cards.

Or no meter at all?

In some parts of the country, Eskom has tried out another experimental payment system, for households that do not use large amounts of electricity. Here, a household pays a fixed amount each month (for example R15 a month). They are then able to turn on their electricity at any time. However, they are limited in how much current they can use at any time. This is an example of a "current-limited supply". In this case, the participating households could only use a small current such as two-and-a-half Amps. This is enough for lights, radio, a TV or other small appliances that do not draw much current, but not enough for heating or cooking.

Electricity suppliers like Eskom often experiment at new ways of providing services, but this method of payment (a fixed monthly charge, irrespective of the amount of electricity used) got a mixed reception in the communities where it has been tried. Some people welcomed it, but others did not like paying a fixed amount every month – they preferred to budget themselves for what they could afford. One of the main disadvantages, of course, was the small amount of electric current that they could use.

One of Eskom's principles is to offer customers a choice, wherever possible. In the pilot areas where this payment system was tried out, customers could choose a normal pre-payment metering system, if they preferred. The pre-payment systems allowed them to use larger electrical currents (e.g. for cooking) but cost more for the



Pre-payment meters have helped the South African electrification programme by cutting costs and making electricity more affordable.

For schools: credit meters or pre-payment meters?

In some places, rural schools have pre-payment meters, but in other areas credit meters are used for schools.

A few years ago, the Eastern Cape Department of Education had difficulties paying for school electricity bills. Some schools had their electricity supplies cut off, as a result. These schools had credit meters, and they were building up high electricity bills.

A number of school teachers said they would prefer to have pre-payment meters. In this case, they said that the school communities would be able to pay for some electricity themselves, to avoid losing their electricity supply completely.

connection fee. Several households chose to move to the normal pre-payment metering systems, rather than pay a fixed monthly charge for the low-current supply.

Current-limited electricity supplies

In fact, *all* safe electricity supplies need to have a current limit. If too much electrical current flows through the cables, they will heat up. This could cause them to melt, and cause fires, electric shocks, etc. It is therefore necessary to have a current limit for **safety purposes**.

Secondly, it costs more to install an electricity system which can supply high currents. If people do not need to use such high currents, it is possible to economise by designing the system for lower currents. In this way the **costs of connection** can be brought down.

Fuses and circuit breakers

To guard against safety dangers, an electricity supply normally has a fuse or a circuit breaker, which will cut off the electricity if too much current is flowing through the wires. A fuse is a thin or soft wire, normally inside a protective casing. If too much current flows, the fuse will "blow" (i.e. burn up). This makes a break in the electrical circuit, so that no more current can flow.

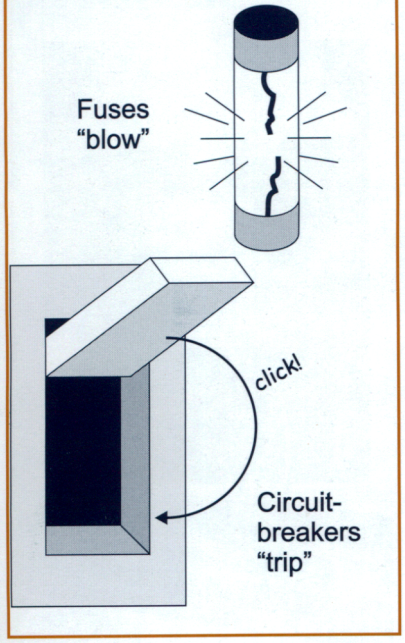
Many individual electrical appliances (e.g. TVs) also have fuses inside them, to guard against too much current flowing. The fuse protects the appliance from damage. It is cheap to replace a fuse if it burns out. But if instead a very strong current flowed *into* the TV this could cause expensive damage.

Circuit breakers are switches which cut off the current. A circuit breaker can be designed to switch off the electricity automatically if too much current flows, just like a fuse. This function is also called "overload protection".

An "overload" occurs when too much current is flowing. For example, this could be caused by an accidental short circuit (two wires touching), or it could be a result of using too many appliances at the same time (overloading the electricity supply).

As mentioned before, any safe electricity supply should have some form of overload protection, either in the form of wire fuses or in the form of an automatic circuit-breaker switch. The advantage of automatic circuit-breaker switches is that when they "trip" (i.e. switch off, because there is too much current) it is easy to switch them back on again – easier than replacing the wire of a fuse.

OVERLOAD PROTECTION
Fuses and circuit-breakers can cut off the electricity if too much current flows.



Electrical current (Amps)

As with other electrical terms like Volts, Watts, kilowatt-hours, etc., many people do not have an exact understanding of "Amps" – which is the way of measuring electrical current.

One way of helping to explain electrical current and "Amps" to people is by giving some examples.

For instance, take the example of an electric hotplate, with two rings. Stoves and hotplates use quite a lot of electricity. If you turn on one hotplate to "high", it will use a certain amount of electric current, normally about 5 Amps. Now, if you turn on the second hotplate to "high" as well, it will need another 5 Amps, making 10 Amps of current altogether.

Appliances like lights, TVs and radios do not use as much current. In general, appliances which are used for *heating* and *cooking* usually need higher currents (larger amounts of electricity) to operate. By comparison, a TV usually uses less than 1 Amp, and an ordinary light bulb only uses about a quarter of an Amp.

Electric current, cables, equipment and costs

If you want to use larger amounts of electric current, the cables must be thick enough to handle this current safely. There are also other items of electric equipment that need to properly sized to handle the current required. For example, transformers are designed to handle a certain amount of electricity, and if more than this is required, it may be necessary to install larger transformers.

These are concerns for the electricity supplier, who must make sure that the cables coming into a house are the right size, and that the transformers can handle the electricity demand. In general, it costs more to provide an electricity system which can supply high currents. Thicker cables are more expensive, and so are larger transformers. On the other hand, it is possible to supply electricity connections at a lower cost if they are designed for smaller electric currents.

Different "levels of supply"

In South Africa, householders can usually choose between different "levels of supply" when they obtain an electricity connection. Basically, this refers to the maximum amount of current which the household will be able to use at any time. For example, if a household chooses a 20-Amp electricity supply, this means they will be able to use up to 20 Amps of electric current, but if they use more than this, their electricity supply will cut out. (It can be switched back on again, after the electric load is reduced.)

20-Amp supplies

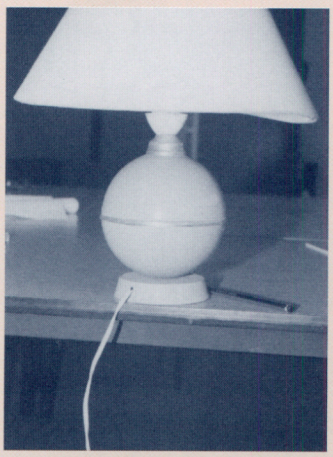
A 20-Amp electricity supply is sufficient for many households. It provides enough electric current to be able to use common household appliances like stoves, refrigerators, lights, TVs, heaters, kettles, irons, etc. Remember, however, that some appliances consume more electricity than others. With a 20-Amp supply, there may be problems if you want to use a number of "power hungry" appliances at the same time. The total amount of current might then come to more than 20 Amps, and the electricity would switch off.

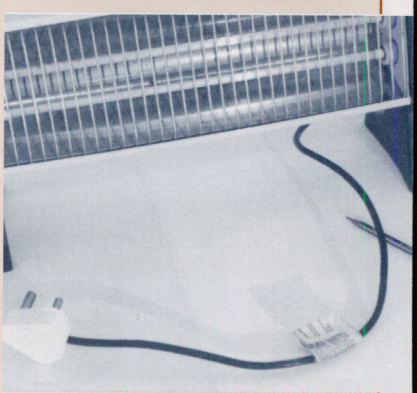
Electric current (Amps): an illustration

Electric voltage is measured in Volts, and electric current is measured in Amps. Earlier, we gave an example to help explain voltage, by comparing it to the pressure that pushes water in a water pipe. Using the same example, electric current would be like the size of the pipe: how wide it is.

A wide water pipe can carry a larger amount of water than a narrow pipe, at the same water pressure. In a somewhat similar way, thicker electrical cables can carry larger electrical currents.

You will notice that the electrical cable for a heater is thicker than the cables used for an electric light. This is because the electric heater draws more current than an electric light. Thicker cables are used for higher currents.





Here is an example. An electric hotplate usually uses a bit less than 5 Amps when it is switched onto its highest setting. If you had two hotplate rings switched onto high (at the same time) this would add up to almost 10 Amps. Now, what if you want to operate a kettle at the same time? Kettles vary, but they often use about 10 Amps. So in total, this would add up to almost 20 Amps – which is still within the limits of a 20-Amp supply. But now, suppose you also had an electric heater switched on (another 4 or 5 Amps for the heater). The total would then come to about 24 Amps, and this would be too much. The overload circuit breaker would switch off the electricity.

60-Amp supplies (and higher)

People who want to use more electricity than 20 Amps can choose a higher level of supply, such as 60 Amps, but for this you generally need to pay a higher connection fee. A household with an electric geyser (a hot water cylinder) may need a higher level of supply than 20 Amps. An electric geyser can use something like 17 Amps just by itself, so if you want to be able to use other appliances at the same time as the electric geyser is heating up, the total load will probably come to more than 20 Amps.

20-Amp supplies are probably the commonest for households in newly electrified urban and rural areas. People who choose 60-Amp supplies are more likely to be

- in large or wealthy households where there are many electrical appliances, including ones that consume a lot of electricity (like electric heaters, air conditioners, large stoves, hot water cylinders, etc.)
- people who also use the electricity for business activities, like welding (which needs high electric currents)
- people who are supplying their household electricity to several families (e.g. to "backyard shacks" on the property)

Really big consumers of electricity can choose to go higher than 60 Amps. When households fit into this category, they can apply for one of Eskom's high power domestic tariffs, called "Homepower". Electricity tariffs will be discussed in another section below.

Lower levels of supply

We have already mentioned a much lower level of supply which is available in some places, namely two-and-a-half Amps. At present there is no connection fee for obtaining a two-and-a-half Amp supply from Eskom. This makes it a more affordable option for poor households. However, this electricity supply can only be used for limited purposes, like lights, radio, TV, fans, etc. – generally not for heating or cooking.

It is interesting, however, to compare the electricity you get from this two-and-a-half Amp supply with the electricity you get from a solar home system. A two-and-a-half Amp *grid electricity* supply can provide much more electricity than a solar home system. Nonetheless, a solar home system can perform almost the same



functions: it provides enough electricity for a few lights and for a TV and radio. This is achieved by using very efficient appliances, which do not consume much electricity. For more details, have a look at the box below.

Some comparisons between a solar home system and a two-and-a-half Amp grid electricity supply

	Solar home system (with one PV panel)	2.5 Amp grid supply
Type of electricity	12 Volts, Direct Current (same as a car battery)	230 Volts, Alternating Current (same as normal grid electricity)
Types of appliances you can use	High-efficiency lights, radio, TV (black and white), some hi-fi's	Lights, radio, TV (black and white or colour TV), hi-fi, electric drill, fans, some fridges, small vacuum cleaner
Types of appliances you cannot use	Stoves, hotplates, kettles, heaters, irons, fridge, vacuum cleaner, etc.	Stoves, hotplates, kettles, heaters, irons
Maximum amount of electrical energy per month	About 9 electricity units (9 kilowatt-hours) per month	About 350 electricity units (350 kilowatt-hours) per month – if you used it 24 hours a day
Typical electricity consumption per month	About 6 units per month	About 50 units per month

Because a two-and-a-half Amp supply is quite limiting, it is sometimes possible to obtain other levels, such as 8 Amps or 10 Amps. 8 Amps is enough to operate an electric hotplate, with some power to spare for other appliances like lights and TV. But it is only enough for a single-plate hotplate, whereas 10 Amps would allow you to use two rings of a hotplate at the same time.

Comparing different levels of supply

Some guidelines are provided on the next page to show the current required for different types of appliances, and the kinds of appliances you could operate with different levels of electricity supply.

If you need to work out for yourself what appliance combinations are possible, you can refer to the Appendix at the back of this book. It explains a simple method for doing this more accurately.

Different levels of supply

Guidelines for what appliances can be used

Common household appliances and the current they require	*Typical current requirement (in Amps, at 230 Volts)*
Light bulb (60 Watts)	0.25 A
Energy-efficient light (11 Watts)	0.04 A
Radio	0.04 A
TV (black-and-white)	0.1 A
Colour TV	0.4 A
Hi-Fi	0.25 A
Electric hotplate, one ring on High	4.5 A
Electric hotplate, one ring on Low	2 A
Electric hotplate, two rings on High	9 A
Kettle	10 A
Iron	5 A
Small microwave oven	3.5 A
Large stove and oven	15–40 A
Electric heater, one bar	4–5 A
Electric heater, two bars	8–10 A
Washing machine, with own water heating	12 A
Electric water geyser	9–17 A
Fridge	1.1 A
Ceiling fan	0.2 A
Vacuum cleaner	3.5 A

Any of these appliances can be used by itself, as long as it does not use more current than the current-limit of the electricity supply. For using several appliances at the same time, you need to add together the currents of each appliance, then check that this total is less than the current-limit.

Examples of appliances that could be operated together at the same time

	Total current (approximate)
2.5 Amps level of supply	
a. 4 lights + colour TV	1.5 A
b. 6 lights + colour TV + radio + hi-fi	2.3 A
10 Amps level of supply	
a. 4 lights + one ring hotplate + TV + fridge	7 A
b. 4 lights + two hotplate rings on High	10 A
c. 4 lights + two hotplate rings on Medium + TV + fridge	9.5 A
d. Vacuum cleaner + fridge + one-bar heater	9.5 A
20 Amps level of supply	
a. 8 lights + 2 hotplate rings + oven	20 A
b. 8 lights + 2 hotplate rings + fridge + TV	14 A
c. Kettle + iron + vacuum cleaner + fridge	19.5 A
d. 4 lights + two-bar heater + TV + fridge + 2 hotplate rings	20 A
60 Amps level of supply	
a. 8 lights + electric geyser + large stove and oven + TV + 2-bar heater + fridge	40–60 A
b. 8 lights + stove (medium) + electric geyser + fridge + washing machine + kettle + iron	40–60 A

Note: Some appliances like ovens, geysers, fridges and irons turn off and on – they do not use electricity all the time. It is also unusual to use all the "power hungry" appliances at the same time, so in practice a 60 Amps supply will cover all normal household appliance use.

Connection costs for different levels of supply

The connection costs which a household pays for different levels of supply can be expected to vary from year to year. This may be because it is necessary to adjust for inflation, or also because of changes in electrification policies. There are also differences between different electricity suppliers. For example, the connection costs charged by Eskom may be different from those charged by a municipality that supplies electricity. But in principle, a customer will need to pay a higher connection cost for a higher level of supply. Here are some examples from Eskom's "Homelight 1" tariffs, for 2003:

Level of supply	*Standard connection fee*
2.5 Amps	No charge
20 Amps	R150
60 Amps	R1000

Up-to-date information on Eskom tariffs can be obtained from Eskom offices or the Eskom website, www.eskom.co.za.

Connection fees and other charges will be discussed further in the section below on Electricity Tariffs.

The principle of customer choice

Large electricity suppliers like Eskom prefer to offer their customers a choice, where possible. Therefore, a household (or other customer) can usually choose what level of supply they want – as long as they are willing to pay the difference in price. This choice can be made when the electricity supply is first connected, but it can also be made at a later stage. It is usually possible to upgrade to a higher level of supply, if a customer finds that this is necessary, and is willing to pay the upgrade fee.

It is also possible to move to a lower level of supply. A special example here is the proposed Basic Electricity Support Tariff. This tariff is still under discussion and has not yet been finalised at the time of writing. The idea is to provide a certain amount of electricity free, or at a very low cost, for needy households. One proposal is that any household can apply, but in order to qualify for this special tariff the household will need to move to a fairly low current-limited supply, such as 10 Amps. (The aim is to help the poor, so it is proposed that people wanting to move to this form of electricity supply could do so free of charge.) Further information about the planned Basic Electricity Support Tariff is provided in the next section.

The "weak grid" approach

Eskom is always trying to bring down the costs of rural electrification. This is so that they can reach more people, within the available funds for rural electrification.

One way of bringing down the costs is by designing electricity systems that carry less current. Engineers sometimes call this a "weak grid" approach.

After studying the amounts of electricity used in electrified rural communities, it seems that the average amounts of electricity used are quite low, and these needs could be met using thinner cables, smaller transformers and other techniques for bringing down the costs of supply.

An electricity company like Eskom will normally lose money in a large rural electrification programme. Because many rural customers cannot afford to use much electricity, their payments are low, and these payments are not enough to cover the cost of providing the electricity.

There was a time when Eskom and other electricity suppliers wanted to encourage rural households to use more electricity. In this way, they thought the payments could be higher, and the financial losses would not be so serious. For example, some electricity suppliers provided their new customers with electric hotplates, to encourage them to cook with electricity.

However, a new approach is being discussed in Eskom. This focuses more on reducing the costs of supplying the electricity. That is where the "weak grid" approach comes in. It will work best if customers do not use electricity for cooking or heating. The idea is that these customers will probably carry on using other fuels for cooking and heating, including paraffin and gas, and wood. It is expected that many rural households will use electricity mainly for lower-power appliances, like lights and TVs.

Electricity tariffs

How much do you pay for the electricity you use? This depends on the electricity tariff. Electricity tariffs are the way that electricity suppliers work out how much to charge for electricity use.

Sometimes, electricity tariffs are very simple and straightforward. But they can also be more complicated. At the moment, there are hundreds of different electricity tariffs operating in South Africa. Eskom has a range of different tariffs, suitable for different kinds of electricity users (large and small customers, homes, farms, businesses, etc.). In addition, many municipalities have their own sets of tariffs. However most rural households and other rural electricity customers use straightforward Eskom tariffs.

A "unit" of electricity

The following chapter will explain how an electricity "unit" is equal to one kilowatt-hour of electrical energy. It also provides examples of what you can do with one unit of electricity, using different appliances.

Example of a simple flat-rate tariff

This is probably the easiest type of tariff to understand. It is also the basic tariff most commonly used by the majority of households in South Africa.

It is called a flat-rate tariff because each unit of electricity costs the same amount. In other words, you are being charged at the same ("flat") rate for each unit of electricity you consume.

Paying for units of electricity

A unit of electricity is a certain fixed amount of electrical energy. It is equal to one kilowatt-hour. As a rough guide, this is the amount of electrical energy needed to operate a one-bar electric heater for one hour. It is enough to operate an electric light bulb for something like 10 to 15 hours.



It is standard practice around the world to measure people's electricity consumption in electricity units of one kilowatt-hour. And just as one might say that the price of petrol or paraffin is "so much per litre", it is common to say that the price of electricity is "so much per unit" or "so much per kilowatt-hour".

With a flat-rate tariff, the cost per unit stays the same, whether you use a small amount or a larger amount of electricity each month. So if you use 100 units per month, you will pay twice as much as someone who uses 50 units per month.

Of course this is a common way of paying for things. In a similar way, if you buy 100 litres of petrol this will cost twice as much as buying 50 litres. However, not all electricity tariffs are like this. With some tariffs, you pay more for some units than for others. The box below gives some examples of other types of tariffs.

Some different types of electricity tariffs

Flat-rate tariff
Each unit costs the same.

Declining block tariff
Each month, the first set of units you use costs more. When you use more units than this, the price per unit falls. This type of tariff becomes more economical for people who use a lot of electricity.

Inclining block tariff
Each month, the first set of units you use costs less. But when you use more units than this, the price per unit rises. This kind of tariff can be used to discourage people from using too much electricity, or as a means of making it more affordable for people who only use small amounts each month.

Time-of-use tariff
The cost per unit depends on the time of day. The electricity units may be cheaper at night (when there is spare electricity available), and more expensive during the times when the demand for electricity is highest (early morning and evening). This encourages efficient use of resources.

Circuit-breaker tariff
People are not charged per unit consumed. Instead they pay a set amount for the electricity supply. If they use too much electrical current (more than the maximum allowed) a circuit-breaker switches off the electricity.

Eskom's Homelight tariffs

The commonest example of a flat-rate tariff, used by large numbers of rural households in South Africa, is Eskom's "Homelight 1" tariff. Here is how it works. We will use prices from 2003 to illustrate this example. Of course, the actual prices are likely to change at least once a year, to keep pace with inflation, etc.:

Eskom Homelight 1 Tariff (2003 example)

Level of supply	*Initial connection charge*	*Energy charge: cost per electricity unit*
2.5 Amps	No charge	43.5 cents per unit
20 Amps	R150	43.5 cents per unit
60 Amps	R1000	48.9 cents per unit

One unit = 1 kilowatt-hour. Prices include VAT

20 Amp supply

The majority of these households use a 20-Amp supply (as was discussed in the previous section of this chapter). This means they would pay R150 at the beginning, when they get the electricity connection installed. After that, how much they pay depends on how many electricity units they use each month. Someone using 100 units a month would pay 100 × 43.5 cents, or R43.50 per month.

2.5 Amp supply

Notice that if somebody chooses to use the lower 2.5 Amps level of supply, they do not have to pay any connection fee under this tariff – but they will pay the same amount as somebody on the 20 Amps supply for each unit of electricity they use. This is different from the experiment we mentioned earlier, where people were offered a 2.5 Amp connection for a fixed monthly payment (a "circuit-breaker tariff").

60 Amp supply

People who choose a higher 60 Amps level of supply have to pay a higher connection fee (R1000), and also pay slightly more for each unit of electricity (48.9 cents per unit) under this tariff. This is because it costs the electricity supplier more to provide the larger amounts of electric current.

This flat-rate tariff subsidises low-use customers

With a flat-rate tariff like this, the people who are consuming small amounts of electricity are actually receiving a subsidy. They are paying less for the electricity than it costs to supply. This is not a mistake. It was planned as part of the National Electrification Programme, in order to make electricity more affordable for low-income households.



To get an idea why this type of tariff provides a subsidy to low-income households, have a look at the following approximate figures. They compare

- the costs of supplying the electricity (e.g. the cost for Eskom)
- the costs of consuming the electricity (the cost for the electricity user)

Example: 20-Amp supply, Eskom Homelight 1 tariff
Comparing the costs of electricity supply and electricity use

Per customer	*Cost for electricity supplier*	*Cost for electricity user*
Providing the electricity connection	Usually R2000-R4000	Connection fee R150
Providing service and maintenance	About R30 per month	No separate charge
Cost per unit of electricity consumed	Maybe 20 cents	43.5 cents

The last row of this table shows that the customer is paying more for each unit of electricity than it costs to produce a unit of electricity. This could provide a profit for the electricity supplier. However, the electricity supplier needs to cover other costs as well. These include the capital cost of the electricity connection (which is much more than the connection fee which a customer pays), and also the costs of providing service and maintenance. There can be other supply costs as well, not shown in the simplified table above. The main point is that the "profit" from selling electricity units would have to cover all these other costs as well, if the electricity supplier is going to break even.

A low-income electrified rural household may use electricity very sparingly. It is quite common for poorer families to spend only about R20 a month to buy electricity (less than 50 units a month), and the majority of rural households do not use more than 100 units a month. This does not provide enough income for the electricity supplier to cover the monthly service and maintenance costs, let alone the capital cost of the electricity connection. For example, leaving aside the capital costs for the moment:

At 50 units per month electricity consumption

	For 50 units (energy cost)	*Service and maintenance*	*Total (excluding capital costs)*
Customer pays:	R21-75		R21-75
Supply costs:	R10 approx.	R30	R40
		Supplier loses: R18-25 a month, apart from capital costs	

At 100 units per month electricity consumption

	For 100 units (energy cost)	*Service and maintenance*	*Total (excluding capital costs)*
Customer pays:	R43-50		R43-50
Supply costs:	R20 approx.	R30	R50

Supplier loses: R6-50 a month, apart from capital costs

In principle, a flat-rate tariff should be able to cover all the costs, including capital costs, if that is the aim of the tariff. But in the example given here, people consuming relatively small quantities of electricity are not paying enough to cover these costs. Only people consuming larger amounts, like 400 units a month, pay enough to cover these costs:

At 400 units per month electricity consumption

	For 400 units (energy cost)	*Service and maintenance*	*Total (excluding capital costs)*
Customer pays:	R174		R174
Supply costs:	R80 approx.	R30	R110

Supplier gains: R64 a month, enough to cover capital costs

This means that richer households, consuming more than 400 units a month, could be helping to subsidise the households who use less than that amount. However, in practice, few households using this tariff consume 400 units or more per month. So the subsidy has to come from somewhere else, e.g. from other groups of electricity customers.

In summary, the flat-rate Homelight tariff (and other similar tariffs in South Africa) provides a subsidy for people who use smaller amounts of electricity. It does not recover the full costs of supplying the electricity. It is the cheapest standard option for low-usage households, and it provides for easy access to electricity because the connection fees are kept low.

For households using large amounts of electricity it is not the most economical option to choose. The following example will show another type of tariff, suited to medium and high-usage residential customers, Eskom's "Homepower" tariff.

After that, we will give an illustration of another form of subsidised tariff, targeted especially at very low-income households.



Example of a tariff with different parts: Eskom "Homepower"

The simple flat-rate tariff described above only had one charge each month, the amount paid for the units of electricity consumed. (This is also called an "energy charge", since the units of electricity measure the energy that is used.) The next example illustrates a tariff that has different parts:

- an energy charge – for the units consumed
- other fixed monthly charges, to cover service costs and some capital costs

As with the previous example, there is also an initial connection fee.

This is another common form of tariff. We can use Eskom's "Homepower Standard" tariff as an illustration. Many municipalities also operate similar tariffs to this. The figures that follow are based on 2003 information. Prices will change from year to year.

A multi-part tariff, with some fixed monthly charges as well as an energy charge, can reflect the costs of providing an electricity service more accurately. It can be cheaper for large users, but more expensive for people using small amounts of electricity.

The Eskom Homepower tariff is designed for residential customers who use larger amounts of electricity. As mentioned, it contains some fixed monthly charges, but to compensate for this the energy charge (the price per kilowatt-hour, or per unit) can be lower. This means that the tariff would be more expensive for someone using small amounts of electricity, because of the fixed monthly charges, but would work out cheaper for someone using larger quantities of electricity, because of the lower energy charges.

Fixed monthly charges (in 2003):

Each month, there is

- a "basic charge" of about R56, which is a contribution to Eskom's costs for services like meter reading and managing electricity bills
- a "network charge" of about R49, which is a contribution to the capital costs of the electricity network

Energy charge:

- the cost per unit of electricity is approximately 26 cents per kilowatt-hour

You can see that the energy charge here (26 cents per unit) is much less than the energy charge for the flat-rate Homelight tariff described in the previous section (43 cents per unit). This is because the Homelight tariff only has the one charge, and the 43 cents per unit is supposed to cover other costs like capital and service costs as well. In the case of the Homepower tariff, these other costs are billed separately, so the energy charge can be lower.

What does this add up to per month? It depends on how much electricity is consumed.

A typical middle-income urban household often uses about 15 units of electricity per day, or 450 units (kilowatt-hours) per month. Of course this can vary a great deal, but using 450 units per month as

an example, the Homepower Tariff payment for a month would be

(R56 basic + R49 network charge) + (26c per unit × 450 units)
= (R105) + (R117)
= R222

By comparison, if you used the Homelight Tariff at a flat rate of 43 cents per unit, the monthly payment would be

43 cents per unit × 450 units
= R193-50

So in this case, the Homelight tariff would still be slightly cheaper. But for a family using a larger amount of electricity, the situation changes. Say the monthly electricity consumption is 1000 units. In this case, the comparison is

Homepower tariff: R365 per month
Homelight tariff: R450 per month

This is why the Homepower tariff is more suitable for households consuming large amounts of electricity.

It also allows for the installation of higher capacity electricity supplies. These can be more than 80 Amps, for single phase supplies, and even higher capacities for three-phase supplies. Three phase electricity is useful for operating larger electric loads. The connection fee you pay depends on the capacity of the supply, and whether it is one-phase or three-phase. For example, for 60 Amps (single phase) it is R1000. For a very large three-phase supply it could be R4800 or more.

Example of a subsidised social tariff

Earlier, we saw that the Eskom Homelight Tariff (which most rural families use) is already a subsidised tariff, for people who consume fairly small amounts of electricity. Yet even so, many low-income families in South Africa find it difficult to afford to use electricity. This had led to a situation where the country has invested thousands of millions of rands to provide new electricity connections, yet many needy households are unable to get much benefit from their electricity supply, because they cannot afford to use much electricity at all.

Some free electricity?

For several years, the National Electricity Regulator, and later the Government, have considered introducing some form of "poverty tariff", to help the poor gain greater benefits from electricity. Various names have been used – e.g. a "lifeline tariff", "Electricity Basic Service Support Tariff" (EBSST), or lately a "Basic Electricity Support Tariff" (BEST). Such a tariff could offer a certain amount of very cheap or free electricity each month.

Several municipalities have already started doing this, in various ways. There have been some arguments, and even threats of court cases, about whether municipalities have the right to do this. On



the one hand, electricity prices should be approved by the National Electricity Regulator. On the other hand, the South African constitution makes it the right and duty of local government (e.g. municipalities) to ensure the provision of services, including electricity.

In line with government policy development, Eskom has piloted such a tariff in various parts of the country and it is expected that a national scheme will now go ahead.

The final version of this tariff may only be known in the near future, but to give an example of how it could work, we will use a version where

- each month, a household using this tariff gets the first 50 units of electricity at no charge per unit (there may be a small administrative fee)
- if they use more than 50 units per month, these further units would be charged at the normal rate (e.g. the same as the Homelight tariff, which is roughly 43 cents per unit, in 2003)

The potential benefits

What would this mean for poor households? The impact could be huge, if such a tariff is introduced nationwide.

Firstly, 50 units of electricity is more than enough for home lighting, and operating a radio, TV, etc., so this free electricity allowance should already contribute to people's quality of life and security. Secondly, however, the big and burdensome energy need for low-income households is energy for cooking. Poor families generally use fuels like wood, dung and paraffin for cooking, rather than electricity (also coal, where cheaply available). There are serious health and safety problems associated with all these other fuels, and to make a really big impact on people's well-being, better solutions for their cooking energy are urgently needed.

50 units of electricity per month is not enough to complete normal cooking tasks. You would probably need about 120 units (120 kilowatt-hours) per month for basic cooking – assuming that these cooking tasks are carried out carefully and efficiently.

The biggest impact of the proposed Basic Electricity Support Tariff could be: to make electric cooking more affordable than using any other commercial fuel – for example, cheaper than using paraffin or gas.

Suppose a household does use 120 units of electricity each month. If the first 50 units are free, they only have to pay for the next 70 units. At 43 cents per unit, this would cost about R30.

R30 for 120 kilowatt-hours means that the average price per unit is now down to about 25 cents per kilowatt-hour (R30 ÷ 120 units). This is cheap energy!

Who could afford to cook, using this tariff?

First, remember that the Basic Electricity Support Tariff outlined above (50 units free per month, followed by normal rates per unit) has not yet been confirmed, so it should be treated as an illustration for the moment. Some municipalities already have slightly different schemes in operation, e.g. 20 units free per month, for all customers. But if we take the example of 50 free units, who could afford to cook with electricity, under this tariff?

We need to consider two groups of low-income households:

- *People who already use commercial fuels for most of their cooking*

  Many low-income households in this category use paraffin, and a minority use gas. However, the low-cost electricity would be cheaper to use than either paraffin or gas, so these households could save money by cooking with electricity instead, if a tariff like this is available to them.

  This group of households includes rural households in parts of the country where firewood is not readily available as well as many low-income urban households.

  In areas where coal is widely used, the picture is more complicated. Coal is a cheap energy source in areas near the coal fields (although very dirty and polluting) and it is often used for cooking and heating at the same time. For combined cooking and heating, coal could still be a cheaper option than this low-cost electricity, so it is likely that some families would continue to use coal in winter.

- *People who do not use much commercial energy, and rely to a great extent on collecting wood, cow dung, etc*

  This group of households (mainly rural) might have easier access to natural non-commercial fuels like wood and dung, and might not have enough money to choose to use higher-quality commercial fuels, as long as they can collect their own fuel "free".

  In this case, some of these households are likely to carry on using collected firewood, etc. If they do have access to the subsidised electricity tariff, they might still only use the electricity for lights, mainly, not for cooking. (The cost of an electric hotplate could also be an obstacle for them.)

  However, collecting and using fuels like wood and dung can be burdensome, time-consuming, dirty, inconvenient and can bring serious health risks (especially from exposure to the smoke) – so it can hardly be considered "free of cost". Many households in this group would therefore love to cook with cleaner, more convenient fuels, and for some, the proposed subsidised electricity tariff could make this possible.



Who would qualify for such a tariff?

There are different opinions about this. A "poverty tariff" is mainly intended to help people who are experiencing poverty. It could be a waste to provide the same subsidy to everyone, including richer people who can afford to pay for their services. On the other hand, it is difficult (and expensive!) to identify every "poor" household in the country, in order to establish who should qualify for the subsidy, and who should not.

Different approaches are being tried:

1. Some municipalities, like Cape Town, offer a small amount of free electricity to all their customers. This does not make much difference to the electricity bills of larger customers, but it makes more of a difference to people consuming smaller amounts of electricity.
2. Other municipalities, like Polokwane, identify poorer households one by one. These customers can get the special subsidy, while others pay the normal rates.
3. Another proposed solution is that anyone can apply for the subsidy, if they want to, but in order to qualify for the subsidy they would need to use a lower-current electricity supply (e.g. 10 Amps).

The last of these (*Option 3*) is probably the best solution. It is open to everyone, but there are some limits. A high-income household would probably choose to keep the convenience of having a larger electricity supply, while a poor household could save money by using a lower-current electricity supply and by enjoying the benefits of the free electricity allowance. A 10 Amps supply is enough for basic cooking.

The disadvantages of the other options are:

Option 1: It would be very expensive for the country to provide some free electricity to every household, rich or poor.

Option 2: It is expensive to identify poorest households, one by one, around the country. This expense could be higher than the subsidy itself.

Comparing costs: different tariffs, different fuels

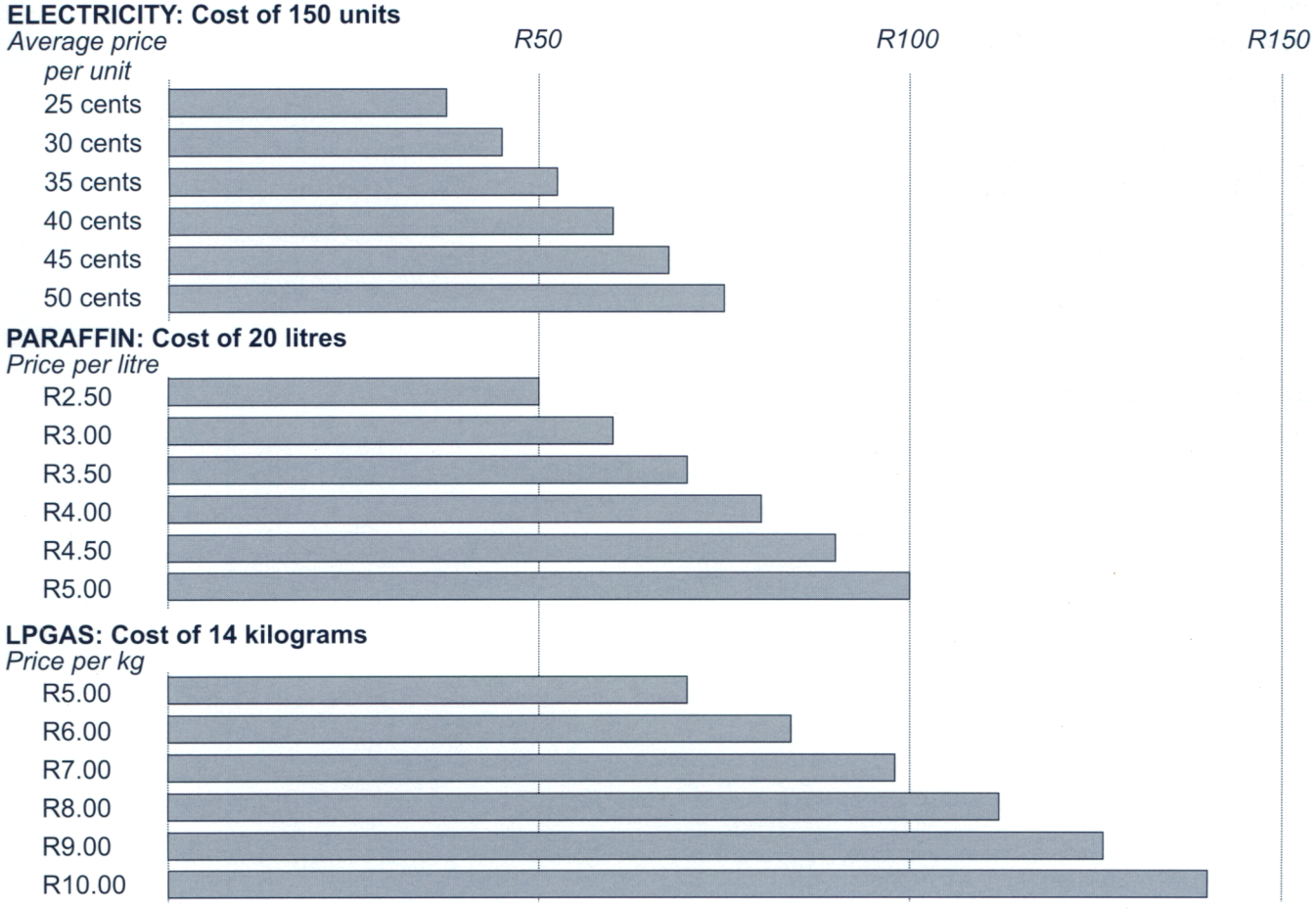
Let's suppose that a household can carry out its basic cooking tasks using roughly

	Electricity:	150 units of electricity per month
or	Paraffin:	20 litres of paraffin per month
or	LPGas:	14 kg of gas per month

(These quantities of electricity, paraffin or gas each provide roughly the same amount of useful cooking energy.)

What would be the cheapest option? Obviously, this depends on the local prices that you have to pay for electricity, paraffin or gas. The figures below could help you to make a comparison between the costs of using these different fuels. Find out the local prices for electricity (per unit), paraffin (per litre) and gas (per kg). And then choose the same prices, or the closest ones, in the tables below. After choosing the local prices for electricity, paraffin and gas, you can use the graphs to see how much these fuels would cost each month for basic cooking.

Comparing the price of 150 units of electricity, 20 litres of paraffin or 14 kg of LPGas



Information needs

It is not easy for a rural householder to find out vital information about things like the costs of using electricity. Unfortunately, it is quite complicated to provide accurate information about what electricity costs, and the comparative costs of using other fuels like paraffin and gas. Householders who are short of money are also not in a position to make experiments, trying out the various options for themselves. As a result of these difficulties, there are many people in the country who are short of money but are paying more, because they do not know how to find the cheapest and best solutions for their energy needs.

For households with little income, the costs of energy use are a major problem. It is really important to try to take away this burden. Poor households can spend up to 30% of their income on energy. Weathier families may only spend 5%. This is why energy policies have to take special account of the majority of poorer households in South Africa. Policy measures like a subsidised electricity tariff for the poor are an example of this.

But in order to be effective and successful, these government policies need to be combined with ways of informing rural communities (and other low-income communities). They need to be informed about government plans and they need to understand how to choose their best options. Well-informed community leaders, youth activists and local government representatives can pass on such information, to help achieve this aim.



CHAPTER 4

The costs of using grid electricity for different tasks

Different electrical appliances use different quantities of electricity. This chapter provides a guide to the amounts of electricity that are used by common appliances, and how much it costs to run them.

This is useful information for people using grid electricity, because it can help them to

- budget their electricity use economically
- decide what appliances to use
- make better choices about when to use electricity or when to use other fuels instead

Introduction

People are often not certain about how much it costs to use electricity for different tasks, like for cooking, heating, lights, running a TV, etc. However, it is easy to give some general guidelines. In this chapter we will take examples of common electrical appliances, and indicate

- how much electricity they consume, and
- how much this is likely to cost, for each type of appliance

If you want to work out the cost of running an electrical appliance, there are three questions you need to answer:

1. **How much electrical power does it consume?** (for example, an electric heater can consume ten times as much power as an electric light bulb). The power consumption is measured in Watts, as explained below.
2. **How long is the appliance switched on?** (e.g. how many hours per day). This can vary, of course. But you can often make a fairly good estimate for each type of appliance.
3. **What price do you pay for electricity?** (how much do you pay for each unit of electricity used). Electricity tariffs were discussed in the previous chapter. For the guidelines, we will use typical 2003 electricity prices – but to be more accurate you need to check the exact electricity price you are paying.

This is a valuable exercise for school pupils. It helps them learn more about electricity, and helps their family understand the costs of using electricity for different tasks.

Once you have an answer for these questions, it is quite simple for you to work out for yourself the electricity cost for using each appliance. We will show the steps for doing that. It is a useful way to get more accurate information, for a particular situation. But for people who just want general guidelines on the costs of using different appliances, and who do not want to get involved in making calculations, we have worked out some "typical" figures. These will show you that

- electrical appliances for **cooking and heating** usually consume more electricity than other kinds of appliances
- appliances like **lights** do not require much electrical power, but if there are many of them and they are switched on for a long time, this can increase the monthly electricity bills
- **low-power appliances like radios** use very little electricity, and cost almost nothing to run if you have grid electricity

To start with, we need to look at the power consumption of different electrical appliances.

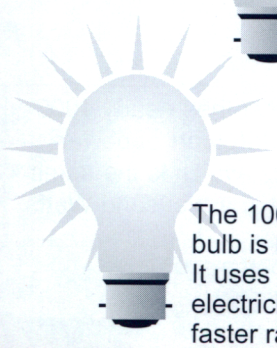
The power consumption of common electrical appliances

Different appliances have different power consumptions. This means that that they use up energy (such as electricity) at a faster or slower rate.

Power is measured in Watts



The 60 Watt bulb is not so bright. It uses less electricity.



The 100 Watt bulb is brighter. It uses electricity at a faster rate.

If you look at the back of most electrical appliances, you will find there is some information written about the amount of electricity it requires.

For example, at the back of an iron, you may find something like this:

1150 W

This stands for 1150 Watts, and shows the power consumption of the iron when it is switched on.

Appliances can vary a great deal in how much electrical power they consume. For example, a cell phone may only consume 3 Watts, while an electric hotplate (with one ring on high) can consume 1000 Watts. A kettle, which is used to boil water faster than a hotplate, can have a power consumption of 2000 Watts or more.

When you purchase an electric light bulb, you can choose between different "Wattages". For ordinary light bulbs, common sizes are 60 Watts and 100 Watts. The 100 Watt bulb is brighter, and it uses electricity at a faster rate than a 60 Watt bulb.

You can also get lights which are called "energy-efficient lights". The light in the picture alongside only consumes 15 Watts. However, it produces the same amount of light as a normal 60-Watt light bulb. This is why it is called "energy efficient". If you run this light for an hour, it will use only a quarter as much electricity as a 60-Watt bulb. And of course, the cost of the electricity it uses will also be a quarter as much.





"Watts" are not just used to measure *electrical* power. They can also be used to measure the power of other forms of energy – for example, the power of a paraffin stove, a motor car engine, or the power of solar energy.

How much **power** does this minibus produce? According to the manufacturer, its engine has a maximum power of 70 000 Watts. But of course, if the engine is just going softly, waiting at a stop street, it uses much less power.

The power comes from the petrol. If the bus is driven hard, with a full load, it needs more power. It will then consume petrol faster.



In a similar way, an electric hotplate consumes more power when it is switched onto "high". If it is switched down to low, for slow cooking, it will then use less power.

For an engineer, "power" is defined as the ***rate*** *at which energy is used (or produced).* How much energy is used every second? In the case of the minibus, this is like how much petrol is used every second.

A hotplate switched up high uses electricity at a higher rate than when it is switched down to low.

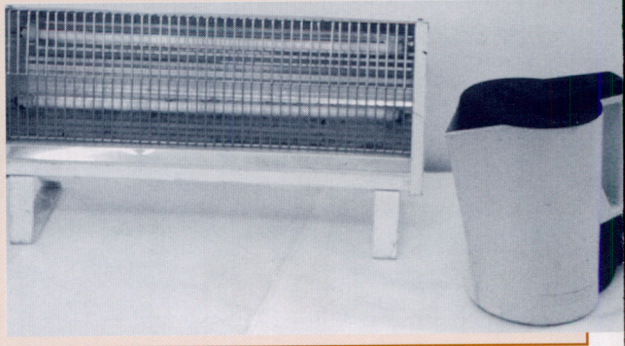
Thousands and millions of Watts: kilowatts and Megawatts

The "Watt" is a small amount of power. Often we need to talk about **thousands** of Watts at a time (for example, the power consumption of a kettle is a couple of thousand Watts).

In the same way, short distances can be measured in metres, while longer distances are measured in kilometres. A **kilo**metre is one **thousand** metres.

In measurements like this, "kilo" stands for one thousand. Just as a kilometre is a thousand metres, a **kilowatt** is a **thousand Watts**.

Each bar of this heater consumes nearly 1000 Watts of electricity, or one **kilowatt** of power. The kettle uses 2300 Watts, which is the same as 2.3 kilowatts. A kilowatt is a thousand Watts.



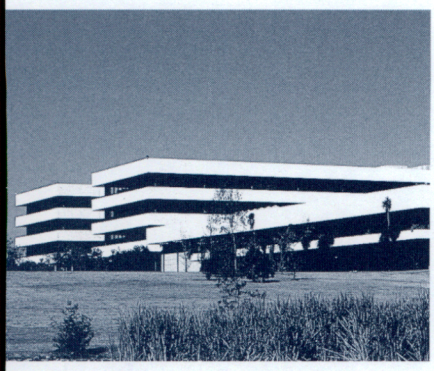
Abbreviations

The common abbreviations for Watts, kilowatts and Megawatts are

W	**Watts**
kW	**kilowatts**
MW	**Megawatts**

When you talk about even larger amounts of power – like the power produced at a big power station – then you are talking about **millions** of watts. For example, Eskom's nuclear power station near Cape Town has three units which generate electricity. Each one can produce approximately 800 million Watts of electricity. And the main Eskom power stations, which use coal to produce the electricity, provide even larger amounts of electrical power.

A **million Watts** (1000 000 Watts) is called a **Megawatt**. "Mega" stands for one million.



Eskom's central headquarters are at a place called "Megawatt Park", near Johannesburg. This humorous name reminds us that Eskom produces millions of Watts of electrical power – very large amounts. In fact, all of Eskom's power stations together can produce about 39 000 000 000 Watts, or 39 000 Megawatts of electricity. This is about half of all the electricity produced in Africa.

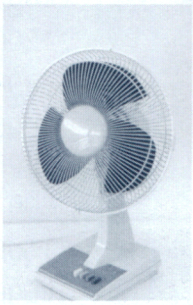
Examples of power consumption



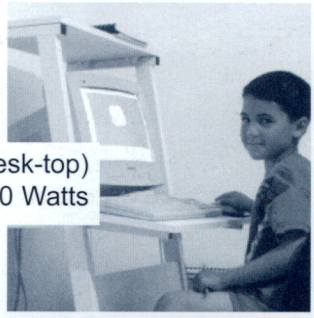
Cell phone
Consumption: 3 Watts



Table lamp
Consumption: 60 Watts



Fan
Consumption: 40 Watts



Computer (desk-top)
Consumption: 150 Watts



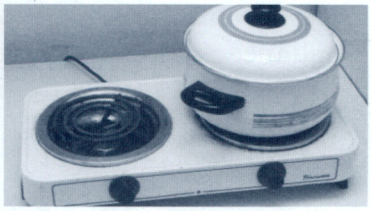
Iron
Consumption: 1200 Watts



Cooking fire
Consumption about 8000 Watts
However, not all of this power is "useful", because a lot of the heat gets lost.



Paraffin stove
Consumption about 2000 Watts
However, some of the heating energy gets lost.



Electric hotplate
Consumption about 1000 Watts, with one hotplate on "high".

Typical power consumption figures for household appliances

Different *models* of appliances can have different power consumptions, so to be more accurate it is best to check the information provided on a particular appliance. (It is usually printed on a plate or label.) Some typical values are as follows:

Common household electric appliances	*Typical power consumption (in Watts)*
Ordinary light bulbs	60 W, 100 W, or sometimes 40 W
Energy-efficient lights	11 to 18 W
Radio	5 to 10 W
TV (black-and-white)	20 to 30 W
Colour TV	70 to 150 W
Hi-Fi	25 to 100 W
Electric hotplate, one ring on High	1000 W
Electric hotplate, one ring on Low	400 W (this varies with the model)
Electric hotplate, two rings on High	2000 W
Kettle	1500 to 2500 W
Iron	1200 W
Microwave oven	600 to 1000 W
Large stove and oven	8000 to 12000 W (but much less when only some parts are used)
Electric heater, one bar	800 to 1000 W
Electric heater, two bars	1600 to 2000 W
Washing machine, with own water heating	2500 W (but less if there is no water heating – e.g. 500 W)
Electric water geyser	2000 to 4000 W
Fridge	300 W
Sewing machine	100 W
Ceiling fan	40 W
Vacuum cleaner	600 to 1200 W
Electric drill	300 to 400 W

You will notice that

- appliances for heating and cooking have larger power consumptions
- appliances with strong electric motors (like a large vacuum cleaner) have quite high power consumptions
- appliances with smaller electric motors (like an electric drill, a fridge, a sewing machine or a fan) have medium power consumptions
- electric lights (especially energy-efficient lights) have a low power consumption
- electronic equipment, like TVs and radio, usually have quite a low power consumption.

The amount of energy used for running different appliances

The difference between "energy" and "power"

In everyday language, people talk about "energy" and "power" as if they are the same. This makes it difficult to understand that they are slightly different. As mentioned earlier, power is the *rate* at which energy is used (or produced) – for example, how much energy per second, or how much energy per hour.

If you switch on a light bulb for a short time, it will use up electricity at a certain rate. This is the "power consumption" of the light bulb, for example 60 Watts of electrical power. If you use the bulb for one minute, for an hour, or even for a whole day, it still uses electricity at the same rate of 60 Watts. The power consumption is the same at any time, because the bulb requires enough electrical power to operate steadily. If you compare this with water flowing through a pipe: the power is like how fast the water goes through the pipe.

"Energy" on the other hand is the total amount: the power multiplied by the time that the power is used. So if a 60 Watt bulb is used for one hour, the power stays the same at 60 Watts, but the energy used is 60 Watts × 1 hour (or 60 Watt-hours). If you use it for two hours, the energy consumed is 60 Watts × 2 hours (120 Watt-hours).

If we go back to the illustration of water flowing through a pipe, energy could be compared to the total amount of water that has flowed. For example, you could collect the water in a tank. The total amount collected will depend on how fast the water is flowing through the pipe as well as how long the water runs for. In a similar way, energy is "how much electricity is flowing" (the power, Watts) multiplied by how long it is flowing for.

So the connection between energy and power is very simple:

energy = power × time

or

power = energy ÷ time

Electric energy is usually measured in kilowatt-hours

A "kilowatt-hour" is the common unit for measuring amounts of electrical energy.

A kilowatt is a thousand Watts, so a kilowatt-hour is 1000 Watts multiplied by one hour. (This is roughly the amount of energy used if you have a one-bar electric heater and run it for one hour.)

When people talk about "a unit of electricity" this is the same as a kilowatt-hour. The common abbreviation for a kilowatt-hour is **kWh**.

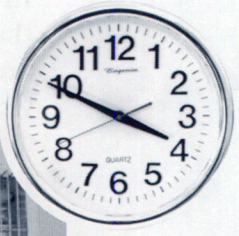


1 "electricity unit" = 1 kWh

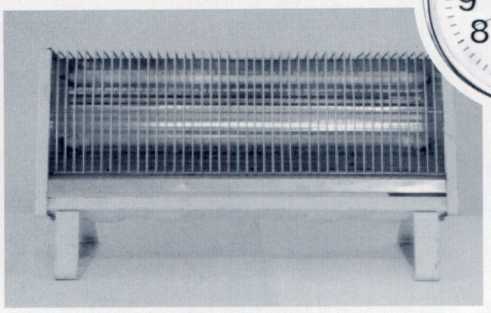
and

1 kWh = 1 kilowatt × 1 hour, or 1000 Watts × 1 hour

An example (to explain "kilowatt-hours")



This heater has two bars.

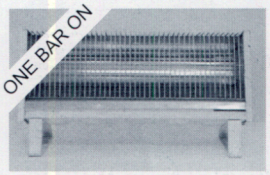


Each bar uses 1000 watts of electricity, or **1 kilowatt**. (That is the power consumption.)

If you use only one bar of the heater for **one hour**, you will use one unit of electricity, or **1 kilowatt-hour**. (This is the energy consumption.)

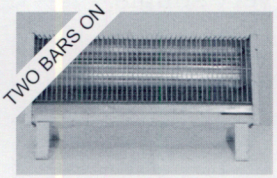
If you use both bars of the heater for one hour, the energy consumption will be two units of electricity, or 2 kilowatt-hours.

The amount of electrical energy used is found by multiplying the power consumption of the appliance by the amount of time it is used.





Power consumption: × Time used: = Electrical energy consumption:
1 kilowatt **1 hour** **1 kilowatt-hour**





Power consumption: × Time used = Electrical energy consumption:
2 kilowatts **1 hour** **2 kilowatt-hours**

and in general:

power consumption × time used = energy consumption

You can look at it another way:

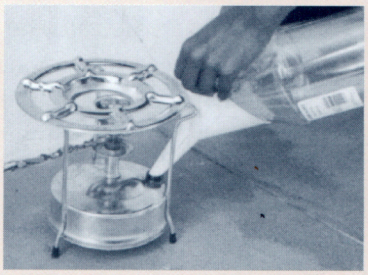
- "Energy" is like **the amount of fuel in your tank**. This could be petrol, diesel, paraffin, the amount of electricity you have paid for using a pre-payment card, or the amount of electricity stored in a battery.
- "Power consumption" is **how fast** you use up the fuel, or the electricity.

Comparing electrical energy with other fuels

There is energy in these pieces of wood. How much energy? That depends mainly on the weight of the pieces of wood. These pieces weigh about 1 kg. They have roughly the same heating energy as six units of electricity. However, it is difficult to use this energy efficiently – because when you burn the wood, some of the energy goes to waste.



There is energy in paraffin. How much? In one litre of paraffin there is roughly the same amount of heating energy as ten units of electricity.



The energy in....	is roughly the same as....
One kilogram of dry wood	six units of electricity
One litre of paraffin	ten units of electricity
One kilogram of gas	thirteen units of electricity

How long are appliances used?

So far, we have discussed the power consumption of different appliances, and we have clarified that the *energy* they use is equal to their *power consumption* multiplied by the *amount of time* they are used.

The electricity cost for each appliance depends on how long it is used.

This brings up the **next question**, when you are working out the costs of running different electrical appliances. How long are they used for? For example, how many hours per day, or how many hours per month?

This is always a difficult question to answer accurately. Different households use appliances for different lengths of time. Also, some appliances (like lights and heaters) may be used more in winter than summer. There are others (like TVs and stoves) which may be used more on week-ends than during the week.

If you are working out electricity costs for a particular household, it is best to find out how long that household uses their different appliances on average, per month. (Ask the members of the household.) Do this for

- summer months
- winter months

because people usually use more energy for lights and heating in winter.

Here are some general guidelines about how long appliances are used.

Guidelines

Electric lights. Main lights are often used 4 to 6 hours per day. Outside "security" lights may be on all night (e.g. 12 hours). For lights which are used for long hours, it is best to use energy-efficient lights (low Watts).

Electric hotplates. The amount of use will depend a lot on the way a family cooks, the size of the household, etc. Also, appliances like this may be used more on week-ends. A common estimate is that two hotplates may be used for around two hours a day. But they will not be on full power all this time. At full power, a single hotplate may use 1000 Watts of power, but while cooking a stew, for example, the *average* power may only be something like 600 or 700 Watts, because the stove is switched down to medium or low for most of the cooking time.

Kettle. Because kettles boil water fast, they are normally used for quite a short period each day – maybe 30 minutes in total.

TV and radio. A common estimate is about 4 hours per day. Radios may be used more than this (but this does not make much difference for estimating electricity bills, because radios use so little electricity).

Iron. Say a household does ironing three times a week, for an hour each time. This comes to an average of about 30 minutes per day (roughly the same as 3 hours per week). However, the iron switches itself on and off, during use, so the actual "on" time is going to be less than this.

Some points about the time use and energy consumption of common household appliances

Some appliances are not used every day. For example, ironing may not be done every day. In this case, you can rather estimate how many hours per week or per month. Or else, work out a daily average, "as if" used every day.

Some appliances switch themselves on and off while they are being used. Again, an iron is an example. When it reaches the right temperature, the heating element switches off, and only comes back on when the temperature has dropped below the desired temperature. Other common appliances that switch on and off, while in use, are fridges, ovens and water heaters. So when we estimate the energy consumption of appliances like these, we have to estimate how long they are actually using the full power. A fridge is usually "switched on" all day and night, but the motor only runs for some of this time – maybe three or four hours a day, altogether.

Many appliances have different power settings. For example, an electric hotplate has different power settings, and is not normally used at full power all the time. Here, we can estimate an *average* power consumption (e.g. somewhere between the highest and lowest settings).

Some appliances, like washing machines, use different amounts of power at different times while they are operating. Many washing machines only use full power when they are heating up water. When only the motor is running, they use less power. Again, it is easiest to estimate an *average* power consumption, in a case like this.

Fridge. A fridge is normally switched on all the time, but the motor only runs now and then. How long the motor runs will vary in summer and winter, and also depends on what is in the fridge, how often it is opened, etc. An average estimate is about 3 to 4 hours per day, for when the motor is running.

Washing machine. Maybe ½ hour per day, on average (but not on full power all this time).

Electric heaters. This varies a great deal – partly because it is quite expensive to use electric heaters. A common guideline used is about 4 hours a day, for a heater in winter months.

Electric geyser. This can also vary a lot, depending mainly on how much hot water is used, and how hot the water is. For example, if you use 200 litres of hot water each day, at a temperature of around 55 degrees, this may require about 10 kilowatt-hours of electrical energy. Using 100 litres a day may require about 5 kWh of electricity. Using these estimates would give you figures like:

Amount of hot water	*Electrical energy*	*Size of geyser*	*Power of geyser*	*Hours "on" per day*
100 litres per day	5 kWh per day	100 litres	2 kW	2 ½ hours
200 litres per day	10 kWh per day	200 litres	4 kW	2 ½ hours

Examples of energy consumption

Using the guidelines above, here are examples of typical energy consumption for some common household appliances. We will work out how many kilowatt-hours (units of electricity) are used *per month*. To do this, we estimate the amount of time they are used each day, and multiply this by thirty days.

In some cases you will see two figures for the power consumption of the appliances: the maximum power consumption (full power) and the "average" power consumption – which is an estimate of average power for appliances which can operate at different power levels while they are being used.



Steps in estimating the energy consumption of appliances, and what they cost to operate *(useful for students)*

Step 1: Find out the power consumption of the appliance, in Watts. Look on the appliance for a label that tells you what its power consumption is, or else use the guidelines given earlier.

Step 2: If the appliance does not use full power all the time, you can estimate the average power it uses (see guidelines).

Step 3: Estimate how many hours, on average, the appliance is used per day. If it is an appliance which switches on and off during use (e.g. an iron, oven, fridge or water heater) you need to estimate how long it is actually "on", per day. (See guidelines for examples.)

Step 4: Multiply the hours-per-day, in Step 3, by 30 days if you are working out the energy consumption per month. This gives average hours of use per month, for each appliance.

Step 5: Multiply the hours of use per month by the power consumption of the appliance. (If appropriate, use "average power consumption" if that is different from the full power consumption.) This gives the energy consumption in Watt-hours per month:

> *Power consumption (Watts) × Time used (hours per month) = Energy consumption (Watt-hours per month)*

Step 6: An electricity unit is one kilowatt-hour, or 1000 Watt-hours. Therefore, divide the energy consumption from Step 5 by 1000. This converts the energy consumption in Watt-hours to "electricity units" (kilowatt-hours).

Step 7: Find out the cost of an electricity unit (how many cents per kilowatt-hour). Then for each appliance, multiply the energy consumption by the cost of electricity per unit:

> *Energy consumption per month (Electricity units or kilowatt-hours)*
> *× Cost per electricity unit (cents per kilowatt-hour)*
> *= Cost per month (in cents)*

Divide by 100 to convert this to Rands per month.

Result: This gives you the estimated cost of electricity (Rands per month) for operating each appliance.

If you have several appliances of the same type (e.g. four 60 Watt light bulbs), and they are all used the same length of time per day, you can multiply the cost for one appliance by the number of these appliances, to get a total.

If you have several appliances of the same type (e.g. light bulbs) but they are used for different times each day and/or have different power consumptions, you should work out their electricity costs separately from one another.

Examples of energy consumption for common household appliances

The main purpose of this table is to give examples of energy consumption for some different appliances – how many units of electricity they use per month. We have also added an illustration of how much this electricity could cost, per month, if an electricity unit costs 40 cents. In the next section we will give a table that contains more appliances, and more cost estimates (for different electricity prices).

Appliance	*Typical power consumption (in Watts)*		*Example of how long the appliance is used*		*Energy consumption in electricity units per month*	*Example of cost per month, if an electricity unit costs 40c*
	Full power	*Average power during use*	*Hours used per day*	*Hours used per month*	*(kilowatt-hours per month)*	*Rands per month*
One light bulb (60 W)	60 W		5 hours/day	150 hrs/month	9 units/month	R3.60
One energy-efficient light (15 W)	15 W		5 hours/day	150 hrs/month	2 units/month	R0.80
Electric hotplate	2000 Watts (2 plates on)	1400 W (2 plates on)	2 hours/day (2 plates on)	60 hrs/month	84 units/month	R33.60
Oven	2500 W		½ hour/day (when oven is heating)	15 hrs/month	38 units/month	R15.20
Kettle	2000 W		½ hour/day	15 hrs/month	30 units/month	R12
TV	70 W		4 hours/day	120 hrs/month	8 units/month	R3.20
Radio	8 W		4 hours/day	120 hrs/month	1 unit/month	R0.40
Iron	1200 W	400 W	½ hour/day	15 hrs/month	6 units/month	R2.40
Fridge	300 W		4 hours/day (when motor is on)	120 hrs/month	36 units/month	R14.40
Washing machine	2500 W	1500 W	½ hour/day	15 hrs/month	23 units/month	R9.20
Heater (one bar)	800 W		4 hours/day (winter)	120 hrs/month	96 units/month	R38.40
Heater (two bars)	1600 W		4 hours/day (winter)	120 hrs/month	192 units/month	R76.80
Heater (two bars all day)	1600 W		24 hours/day	720 hrs/month	1152 units/month	R460.80
Geyser, 200 litres	4000 W		2½ hours/day	75 hrs/month	300 units/month	R120
Geyser, 100 litres	2000 W		2½ hours/day	75 hrs/month	150 units/month	R60



Anyone who leaves an electric heater running all day can expect very high electricity bills. Also, a family with an electric geyser should be careful about not using large quantities of hot water. A common problem is that these are slightly "invisible" uses of electricity. A geyser is usually out of sight, and electric heaters run

quietly in the background, so many families do not pay so much attention to using these appliances. In fact, they might pay more attention to saving energy on more visible appliances, like lights and TVs – being careful to switch them off when they are not needed. However, lights and TVs use much less electricity than appliances like heaters and geysers.

For a family with little income, it is unlikely they would afford to use electric heaters or electric water heating. They should judge what electricity appliances they need most, and which give best "value for money". Cooking with electricity is probably a good choice in South Africa, for families who can afford to pay around R50 – R100 per month on their energy bills. It is cleaner, safer and convenient, compared with alternatives like wood fires and paraffin stoves.

The cost of a kilowatt-hour of electricity

As explained in Chapter 3, the cost of one unit of electricity (one kilowatt-hour) can depend on the electricity tariff you are using. The prices vary from year to year.

Most rural households are on Eskom "Homelight" tariffs, which are the same across the country. These are simple tariffs, because each unit used costs a fixed amount.

In 2002 a common cost per unit of electricity was 35 to 40 cents per kilowatt-hour. Eskom "Homelight 1" tariffs in early 2003 had the following charges per unit:

2.5 Amp supply: 43.5 cents per kilowatt-hour

20 Amp supply: 43.5 cents per kilowatt-hour

60 Amp supply: 48.9 cents per kilowatt-hour

Municipalities also supply electricity (mainly in urban areas) and can have different tariffs.

To find out the price you are paying, check the pre-payment electricity coupons or your electricity bills. These should show (a) the total cost, and (b) the number of units paid for. Divide the total cost by the number of units, to get the cost per unit.

Chapter 3 also described more complicated tariffs, such as

- tariffs that have a fixed charge each month as well as a charge for the amount of electricity used
- tariffs that provide a certain number of units free each month

In both these cases, the best way to find out the *average* cost per unit is the same as above: find out the total cost paid each month, and then divide by the total number of units used in that month.

What can you do with a kilowatt-hour of electricity?

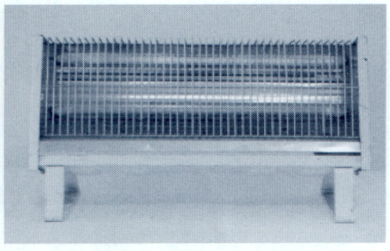
Here are some examples of what you can do with one kilowatt-hour of electricity.



Lights

With one kilowatt-hour you can use

	One 100-Watt bulb	for 10 hours
or	One 60-Watt bulb	for 17 hours
or	A fluorescent light (30 Watts)	for 33 hours
or	An energy-efficient light (15 Watts)	for 66 hours



Heaters

With one kilowatt-hour you can use

	A heater, one bar (1000 Watts)	for 1 hour
or	A heater, two bars (2000 Watts)	for 30 minutes



Cooking

With one kilowatt-hour you can use

	A kettle (2000 Watts)	for 30 minutes
or	A one-plate cooker, on high (1000 Watts)	for 1 hour
or	A one-plate cooker, on low (400 Watts)	for 2½ hours
or	A two-plate cooker, with both plates on high (2000 Watts)	for 30 minutes
or	A two-plate cooker, with both plates on low (800 Watts)	for 1¼ hours
or	A four-plate stove and oven, with everything on high (12 000 Watts)	for 5 minutes!
or	A four-plate stove and oven, normal cooking (maybe 3000 Watts)	for 20 minutes
or	A microwave oven (700 Watts)	for 1 hour 25 mins
or	An electric frying pan, on high (1200 Watts)	for 50 minutes
or	An electric frying pan, on low (400 Watts)	for 2½ hours

TV, radio and hi-fi

With one kilowatt-hour you can use

	A small colour TV (70 Watts)	for 14 hours
or	A larger colour TV (120 Watts)	for 8 hours
or	A small black-and-white TV (20 Watts)	for 50 hours
or	A radio (8 Watts)	for 125 hours
or	A small hi-fi (30 Watts)	for 33 hours
or	A very loud hi-fi (100 Watts)	for 10 hours



Some other household appliances

With one kilowatt-hour you can use

	A cooling fan (40 Watts)	for 25 hours
or	A fridge (300 Watts, when motor is running)	for nearly a day
or	A vacuum cleaner (1200 Watts)	for 50 minutes
or	An iron (1200 Watts – but it does not stay on all the time)	for 50 minutes to maybe 2 hours
or	A hair drier (1200 Watts)	for 50 minutes



Examples of the cost of running different appliances

Here are some examples of the costs of running different appliances. They are worked out for three different electricity prices (30 cents, 40 cents and 50 cents per unit). Choose the electricity price which is closest to the price you pay for a unit of electricity.

		Cost of a unit of electricity (choose)		
		***30** cents per unit*	***40** cents per unit*	***50** cents per unit*
	Units used per month	*Cost per month*	*Cost per month*	*Cost per month*
Lights				
An energy-efficient light (15 W), used 5 hours/day	2	R0.68	R0.90	R1.13
A 60 W light bulb, used 5 hours/day	9	R2.70	R3.60	R4.50
Four 60 W bulbs, used 5 hours/day	36	R10.80	R14.40	R18.00
Heaters				
One-bar heater (800 W) used 4 hours/day	96	R28.80	R38.40	R48.00
Two-bar heater (1600 W) used 4 hours/day	192	R57.60	R76.80	R96.00
Two-bar heater used 12 hours/day	576	R172.80	R230.40	R288.00
Cooking				
One-plate hotplate on high (1000 W), 1 hour/day	30	R9.00	R12.00	R15.00
Two hotplates, on high (2000 W), 2 hours/day	120	R36.00	R48.00	R60.00
Two hotplates on medium (1400 W), 2 hours/day	84	R25.20	R33.60	R42.00
Oven (2500 W), 30 minutes/day	38	R11.25	R15.00	R18.75
Stove and oven (average 3000 Watts), 2 hours/day	180	R54.00	R72.00	R90.00
Microwave oven (average 700 Watts), 1 hour/day	21	R6.30	R8.40	R10.50
Electric frypan on high (1200 Watts), 1 hour/day	36	R10.80	R14.40	R18.00
Kettle (2000 Watts) 30 minutes/day	30	R9.00	R12.00	R15.00
TV, radio and hi-fi				
Colour TV (70 W), 4 hours/day	8	R2.52	R3.36	R4.20
Colour TV (120 W), 4 hours/day	14	R4.32	R5.76	R7.20
Radio (8 W), 4 hours/day	1	R0.29	R0.38	R0.48
Hi-Fi (50 W), 4 hours/day	6	R1.80	R2.40	R3.00
Hot water geysers				
100 litre geyser (2000 W), 2.5 hours/day	150	R45.00	R60.00	R75.00
200 litre geyser (4000 W), 2.5 hours/day	300	R90.00	R120.00	R150.00
200 litre geyser (4000 W), 4 hours/day	480	R144.00	R192.00	R240.00
Other household appliances				
Fridge (300 W), running 4 hours/day	36	R10.80	R14.40	R18.00
Iron (1200 W), 30 minutes/day	18	R5.40	R7.20	R9.00
Washing machine (average 1500 W), 30 mins/day	23	R6.75	R9.00	R11.25
Vacuum cleaner (1000 W), 30 minutes/day	15	R4.50	R6.00	R7.50
Cooling fan (40 W), 6 hours/day	7	R2.16	R2.88	R3.60

Remember that these are just approximate costs. Appliances can vary in their power consumption, and the amount of time that they are used per day.

CHAPTER 5

Electrification planning in South Africa

The aim of providing universal access to electricity

South Africa has an ambitious electrification target: to provide access to electricity for everyone in the country – in other words, "universal access".

Of course, this may not be possible to achieve, right up to a 100% level. There may always be some people without access to electricity, such as homeless people. However, if almost everyone in the country has access to some form of electricity supply, the target will have been effectively achieved.

What are the reasons for this ambitious target?

The government believes that:

- Access to electricity is important for raising people's quality of life, and improving their development opportunities.
- In keeping with South Africa's level of economic development, the benefits of an affordable basic electricity service should be made available for all citizens, as soon as possible.
- People have suffered from unequal and unfair access to services in the past, and it is desirable to correct these inequities.

Secondly, energy planners and policy-makers believe that South Africa has sufficient resources and capability to make this target possible to achieve. It will be expensive and difficult, and will take several more years to get there, but it is still considered to be a feasible and worthwhile objective for the country.

This target doesn't mean that electricity (by itself) is expected to solve everyone's complete energy needs. Energy policy-makers recognise that electricity has a special value, but other forms of energy are also important. Since the majority of lower-income urban and rural households do not use electricity to cover all of their energy needs, there are further government policies to improve other energy supplies at the same time.

For households that use electricity plus other fuels, the emphasis is on

- electricity for particular purposes, where it is either necessary or strongly desirable (like TVs, lights)
- other fuels for cooking and heating, if these are viewed to be more affordable than electricity, and suitable for the purpose

In this light, electricity is not seen as an answer for the "basic energy needs" of poor households. The basic household energy needs are for cooking and sometimes heating. Instead, the idea of trying to achieve universal access to electricity is targeted at higher developmental needs, like the greater convenience, security and safety of using electric lights; and the social benefits of modern telecommunications (TV, radios, phones, etc.).

It is worth noting that South African electrification is unusual, compared with other countries in Africa. Most other African countries are not in a position to provide electricity access to the majority of the population.

Progress with electrification since 1994

The proportion of the population with access to electricity has risen from about one-third to more than two-thirds. In urban areas, the proportion is now between 80 and 90%. In rural areas it has reached around 50%.

This remarkable progress has required an investment of around R1 000 000 000 (one billion rand) each year.

Until recently, most of this social investment money has come from Eskom. As a very large and successful electricity utility, Eskom has been able to cross-subsidise the national electrification programme, by using "surpluses" obtained from sales to its other existing customers. This phase of the electrification programme therefore relied on the strength of the Electricity Supply Industry (ESI) in South Africa plus the social commitment of the main players in the ESI, namely Eskom and local authorities. In this regard, Eskom has acted in the public interest rather than simply as a profit-making company.

The ESI is now being re-structured. Among other things, Eskom is now paying tax to the government. In this new situation, the funds for carrying on with the electrification programme will now come from the government.

Another aspect of the restructuring is on the side of "electricity distribution". At the moment, electricity is distributed by a mixture of many municipalities and by Eskom as well. The restructuring aims at setting up a number of separate "Regional Electricity Distributors" or REDs. Each of these will be responsible for an area roughly the size of a province, and within each RED there will be

? Would poor rural and urban households prefer to cook with electricity, if they could afford to do so?

Probably they would prefer to use electricity, although not always. Some people prefer other ways of cooking, even when they can afford to use electricity. However, for most poorer families that have grid electricity, the choice of whether to use it for cooking is based on costs. They may not be able to afford an electric stove or hotplate, and they may not be able to afford to pay for enough electricity for cooking.

The government is investigating ways of providing cheaper electricity for poor households. For example, a "basic electricity support tariff" is being piloted, which could allow households to obtain a certain amount of electricity free each month, or at a very low cost. This would help to make sure that households in need are able to afford to use electricity for lights, etc., at a low cost. It could also allow more households to be able to cook with electricity, by bringing down their monthly electricity bill to a point where electricity might be cheaper to use than, say, paraffin.



a rationalisation of the resources of the municipalities and Eskom distributors.

These REDS will be responsible for carrying out the next stages of the electrification programme. However, in order to reach some remoter rural areas which are difficult to reach with grid electrification, the government provides subsidy schemes for non-grid electrification as well. In this case, a number of private companies and other utilities are involved in carrying out the non-grid side of the electrification programme.

Costs of electrification

In order to understand electrification planning, it is useful to have a sense of the costs involved, at various stages of bringing electricity to households and other customers.

More detailed explanation of these stages, and the costs involved, can be found in Chapter 2. Here is a brief summary:

- High-voltage lines are needed to carry electricity from power stations to other parts of the country. This is the electricity "backbone" or electricity transmission system. High voltage lines are expensive infrastructure. They can cost hundreds of thousands of rand per kilometre, or more.
- Medium-voltage lines are used to carry electricity through rural areas. Their cost varies, but usually it is around R60,000 per kilometre.
- Once this electricity reaches a particular area, transformers are required and further local cables, in order to reach each electricity customer. The cables cost more if customers are spread far apart.
- There are additional costs for providing connections and meters.

From this, it is understandable that rural electrification can cost more than electrifying urban areas. There are extra costs because longer lengths of cables are required. In general, the costs of reaching households in a particular area depend on

- how far this area is from the existing grid
- how far apart the houses are
- the nature of the countryside (e.g. hilly areas are more difficult to cover)

The costs also depend on how much electricity needs to be supplied to a particular area. Larger quantities require the use of thicker, more expensive cables, larger transformers, etc. In order to reach larger numbers of people at an affordable cost, Eskom offers lower-current options, which are more economical to supply. (More information on limited-current electricity supplies was provided in Chapter 3.)

? Think of a rural village which is ten kilometres away from the existing electricity grid. Why could it cost less to electrify the village next year, instead of this year?

The rural electricity network expands from year to year. This year, the village may be ten km from the nearest power lines, and that could make it very expensive to bring grid electricity at the present time. However, next year, maybe the grid has expanded to reach another village five kilometres away, and the power lines are now closer to the first village, making the next stage of expansion affordable.

One important thing to note is: the cost of bringing electricity to a particular area that is presently unelectrified will vary from year to year. Next year it may be cheaper than this year.

The main aim of grid electrification planning so far has been to reach as many people as possible, within the budgets available for this. It is understandable, then, that a higher percentage of people in urban areas have obtained access to electricity. Urban electrification can reach more people at a lower cost per connection. The average "cost per connection" has been the main rule used by Eskom when planning electrification projects.

In practice, the average cost per connection varies somewhat from year to year. It is usually about R3000 per household, on average, or slightly less. As mentioned earlier, the money to pay for these grid connection costs came mainly from Eskom and now comes from the government.

Some places are still far away from the grid, or the households are very scattered. In these circumstances, the grid connection costs could be much higher, e.g. R5000 or more per household. A significant number of households in deeper rural areas fall under this category. Some of these may get grid electricity, but only quite some time ahead. In other cases, grid electrification may never be an economical option. Because of this, the electrification programme also includes the option of non-grid electrification.

Non-grid electrification for households relies mainly on the use of solar home systems. The cost of a solar home system can vary, depending on its size, the exchange rate, and other factors. A common cost would be in the region of R4000. There are also some running and maintenance costs, particularly the cost of replacing a battery every few years.

Most rural households would find it difficult to purchase such a solar home system, because of the initial price. It would also seem unfair if households in grid areas are receiving a subsidy of R3000 or more for grid electricity, while people living in areas not reached by the grid do not receive any similar support. The government is therefore implementing a subsidy scheme for solar home systems as well.

Subsidies for rural electrification

The main form of subsidy for rural **grid electrification** is the initial cost of providing the grid connections. As mentioned above, this is around R3000 per household, on average. In some countries, the electricity customers are required to pay for the cost of connection, but in the South African national electrification programme, people pay for only a small proportion of this cost themselves.

For people using very small amounts of electricity, there is another hidden subsidy. This is because their low electricity payments each month may not cover the monthly costs of supplying the electricity, and of maintaining the electricity system.



When the electrification programme was first planned, it was guessed that households would consume something like 350 units of electricity a month. If this were true, the electrification programme would eventually cover its costs. However, in practice, the average household electricity consumption is usually less than 100 units per month in low-income rural areas. In effect, other people who are consuming more electricity are cross-subsidising people who use very small amounts. This seems to be a fair way of spreading the benefits of electricity to more people.

The main form of subsidy for **non-grid electrification** is an amount which is paid to companies supplying solar home systems, in order to bring the cost down to a more affordable level. This amount is paid by the government. In 2001 it was set at R3500 per system. Under this scheme, customers do not buy the solar systems. Instead, they pay a monthly fee for the electricity service. The companies are responsible for making sure the systems operate well, and for maintenance (including battery replacements, from time to time).

In addition to these subsidies, the government, Eskom, and a number of local authorities are piloting a Basic Electricity Support Tariff. The aim is to provide assistance to low-income electricity users (both in urban and rural areas). The final form of this tariff may be decided soon, but the principle is that low-income households should be able to get a certain amount of electricity each month at a very low cost. A similar monthly subsidy is being considered for non-grid electricity customers as well.

Planning rural grid electrification

Most rural electrification has been carried out and planned by Eskom, whereas in urban areas it has been mainly the responsibility of municipalities, but sometimes also Eskom.

The way rural electrification is planned seems to vary somewhat, in different areas of the country. For example, in some regions there is more consultation between Eskom and local authorities or representative groups such as "Electrification Forums". In other parts of the country there may be less consultation of this nature. However, the main principles behind rural electrification planning have been applied across the country.

The approximate costs of electrifying a certain area are worked out by Eskom, or electrification planning consultants. If these costs indicate that the average cost per connection will be within the budget limit, this area can then qualify for future electrification. However, the exact timing cannot be easily predicted, because this electrification may depend on the progress achieved in other electrification projects "along the way". Overall, the electrification plans are "rolling" plans, which need to be refined and revised year by year, as the grid expands.

One reason why it is not possible to predict the exact rate of progress is that the overall annual budget available for electrifica-

tion can vary from year to year, and it may not be known accurately for the years ahead. This means that electrification plans may need to be speeded up or delayed, according to actual budgets available. Secondly, the accurate costs for a given electrification project are only worked out closer to the time of implementation. In fact, actual costs will only be accurately known when the electrification is carried out. If the actual costs vary from the initial estimate, this could affect the budget available for other projects.

In the past, the main yardstick for deciding whether a certain area could be electrified was the question "Does the average cost of connection in that area fall within the limit set by the electrification planners?" This limit varies slightly from year to year, depending on budgets and the progress made by the electricity suppliers in bringing down the costs of providing grid electricity.

This yardstick still remains very important. However, there are other factors to be considered, when prioritising and scheduling electrification projects. For example,

- Certain rural areas of the country have been identified as high-priority development nodes, which are especially in need of improved services and economic development. These areas are intended to receive special attention (although this does not imply that other areas will receive reduced attention).
- Secondly, electrification plans are now expected to be built into the Integrated Development Planning (IDP) process, for which the district municipalities are mainly responsible. So there should be closer consultation between electrification planners (e.g. in Eskom) and the local authorities involved in IDP.

The IDP process is meant to look at local development needs and opportunities in an integrated way. Within the IDP framework, it would make sense to prioritise those electrification projects which can lead to maximum economic and social development benefits. For example, electrifying one area might reach a larger number of households, while electrifying another area might have better potential for assisting job-creation and income generation. Difficult choices like these may need to be made in the combined IDP/electrification planning process.

Planning non-grid electrification

Of course, anyone is free to buy a solar system from a private company or shop. However, planned non-grid electrification is another matter. The government wants to make non-grid electricity more widely available and more affordable for people living in areas that are unlikely to get grid electricity in the next few years. This is part of the goal of providing "universal access" to electricity.

In order to bring down the costs of non-grid electrification, particularly for poorer households, the government has two main strategies:



- To provide *subsidies* (as described earlier) to reduce the amount households need to pay for solar home systems
- To encourage a number of companies or utilities to get involved in non-grid electrification *on a large scale*, so that they can operate more efficiently and bring the costs down

The subsidies should also allow the companies to make a profit, even though they are selling their services to rural households with little income, so that the companies can be financially viable.

A number of areas in South Africa have been identified where large numbers of people are unlikely to get grid electricity in the next few years. This can be because they are living far away from the electricity grid, or because the houses are far apart, so that grid electrification would be very expensive. This indicates a need for non-grid electricity. For each of these areas, the government has selected a non-grid service provider. These companies (or groups of companies) will be able to get the government subsidy for the solar home systems they supply. In return, they must provide a reliable non-grid electricity service for rural households in the area where they are appointed.

Sometimes these areas are referred to as "non-grid concession areas". What this means is that one supplier of solar home systems has been given the exclusive right to government subsidy for supplying solar home systems in that area.

The purpose of this is to encourage these companies to build up the quality and scale of their operations, so that they are efficient, reliable and financially viable. They are protected from competition in the area where they operate, but they are required to deliver a service at a price which is decided by the government. In this way, the government wants to make non-grid electrification affordable for more rural households, at the same time as encouraging the private sector to contribute to this goal.

The non-grid service providers are also expected to see that people have better access to other fuels, to meet their cooking needs, such as paraffin and gas.

The geographic area covered by each of the non-grid "concession areas" will include localities that are grid-electrified as well as other localities not reached by the grid. This is one reason why the term "non-grid concession area" could be misleading. It does not mean that only non-grid electrification is planned in that geographic area. Instead, a mixture of grid electrification (where possible) and non-grid electrification would usually occur side by side. The particular localities where grid electrification is not foreseen are called "permission areas". In these areas, the non-grid companies have permission to supply subsidised solar home systems.

How is the planning done? Based mainly on cost estimates, Eskom* can identify places where grid electrification is unlikely to be affordable in the near to medium future. These are identified as permission areas for non-grid electrification. The main consulta-

* Or other licensed electricity suppliers. Some municipalities include rural communities in their area of electricity supply.

tions with local communities and local authorities are then usually carried out by the companies appointed as non-grid service providers for that region. Some communities welcome the option of non-grid electrification, while others are not so keen, because they would prefer to get grid electricity, and they fear that their chance of getting the grid will be reduced if they go for the "solar" option.

The policy, however, is that solar electrification would not stand in the way of grid electrification. If grid electricity becomes possible in an area which has already received subsidised solar home systems, the solar systems are expected to be removed and replaced with the grid electricity. (The solar equipment is not owned by the householders, but rather "rented". The companies that own the equipment can remove the solar systems and use them elsewhere, if grid electricity becomes available.)

Both grid and non-grid electrification planning are now meant to be linked to the broader Integrated Development Planning process. The IDP process is intended to be participatory, allowing for full local stakeholder consultations. This should enable local groups to be better informed about the options available, and assist the formulation of plans which respond to local needs and opportunities.

Changes ahead?

Firstly, it is likely that experience with Integrated Development Plans will grow over time. It may still be a few years before most municipalities (including rural district municipalities) are up to speed with effective Integrated Development Planning. This could mean that electrification planning may not be firmly anchored in Plans, in all areas of the country within a short time. Gradually, the IDP process is expected to become more thorough.

Secondly, the restructuring of the electricity industry in South Africa is likely to bring some changes. This restructuring has been planned for years, although in practice it is taking place slowly. In some ways, the restructuring of electricity distribution seems to make sense. Instead of having numerous municipalities as well as Eskom involved in electricity distribution, it should lead to a more efficient "rationalisation" and sharing of assets. However, many people are concerned that this restructuring could also bring some negative effects, such as higher electricity prices, and less commitment to unprofitable activities such as rural electrification.

Thirdly, some of the initiatives we have mentioned should probably be regarded as "pilots". This includes the proposed Basic Electricity Support Tariff (extra subsidies for needy households), a similar monthly subsidy for users of solar home systems, and possibly the entire non-grid electrification programme. Any new venture, like these, needs to be tested out in practice. Plans may be revised if the results do not turn out as expected, or if people come up with better ideas about how to solve the problems and achieve the goals.



APPENDIX

Technical notes

This appendix provides

- three useful electricity equations, which can help people understand how electricity is measured
- steps for working out what appliances can be used, with a limited-current electricity supply
- a short explanation of equipment to change voltages and currents (transformers and inverters)

Three useful equations

There are three simple electricity equations which make it easier to understand electrical terms like current, voltage, power and energy.

1. Current, voltage and resistance

First,

Voltage = Current × Resistance

This is known as Ohm's Law, and it applies when an electric current flows through a "resistance".

Resistance is a physical property. Any wire has a certain amount of resistance, meaning that the electricity does not flow completely freely through it. The amount of resistance in a wire depends mainly on

- what it is made of (e.g. copper is a good conductor, and has low resistance)
- how long it is (longer wires have more resistance)
- how thick the wire is (thicker wires have less resistance)

Resistance is measured in units called Ohms.

Because of the resistance in a wire, some of the electricity gets "wasted" as heat. Instead of flowing freely through the wire, the electrons heat up the molecules in the wire. This is a waste if the purpose is just to carry electricity from one place to another - from a power station to homes, or inside a home. For this reason, wires are chosen carefully so that they are suitable for the purpose, and the resistance losses are kept down to a small amount.

There are other times, however, when the heat caused by the resistance is exactly what you want. The heating elements of an electric heater, or a kettle or stove, are resistances. The heating bar of a common electric heater is a long coil of "resistance wire".

Going back to the equation, we can find out how the current, voltage and resistance are connected to one another. Current here is measured in Amps, the voltage is measured in Volts, and the resistance is measured in Ohms. I stands for current, V stands for voltage, and R stands for resistance:

V (Volts) = I (Amps) × R (Ohms)

Using a kettle as an example, we can find out how much current flows through a kettle. The resistance of the heating element of this kettle is 23 Ohms.

The voltage from a normal plug is about 230 Volts. Now we can find out the current as follows.

V = I × R

230 Volts = I Amps × 23 Ohms

Re-arranging the equation,

I Amps = 230 Volts / 23 Ohms

So **I = 10 Amps** (the current used by the kettle)

Ohm's Law can be written in different ways, depending on what you want to find out:

V = I × R
I = V / R
or **R = V / I**

2. Current, voltage and power

Secondly, the equation which connects electrical current, voltage and power is also simple.

Power = Current × Voltage

If the current is measured in Amps and the Voltage is in Volts, then the Power will be in Watts:

Power (Watts) = Current (Amps) × Voltage (Volts)

Going back to the kettle example, what power does it consume? The voltage was 230 Volts and we found the current was 10 Amps. So the power is

Power (Watts) = 10 Amps × 230 Volts = 2300 Watts

A kilowatt is 1000 Watts, so 2300 Watts is the same as 2.3 kilowatts.

3. Energy, power and time

Thirdly, electrical energy is power multiplied by time. Electrical energy is usually measured in Watt-hours or kilowatt-hours. The equations are

Energy (Watt-hours) = Power (Watts) × Time (hours)

or **Energy (kilowatt-hours) = Power (kilowatts) × Time (hours)**



The abbreviations for Watts and kilowatts are W and kW. The abbreviations for energy are Wh (Watt-hours) and kWh (kilowatt-hours). One kWh is one "electricity unit".

Going back to the kettle example, how much energy does it use, if it is used for 30 minutes a day? 30 minutes is 0.5 hours, and we found the power consumption is 2300 Watts, or 2.3 kilowatts. So the energy used, in this example, is

Energy (in kilowatt-hours) = 2.3 kilowatts × 0.5 hours = 1.15 kilowatt-hours

(This is just slightly more than one unit of electricity.)

Steps for working out what appliances can be used with a limited-current electricity supply

Suppose you have a 20 Amp electricity supply, and you want to work out what combination of appliances can be used at the same time. In other words, the total current of all these appliances must not come to more than 20 Amps.

There are two ways you could do this:

a) Find out the current used by each appliance and add these currents together, *or*

b) Find out how much power you have available, and add up the powers of all the appliances

The second way is usually easier.

a) Adding up currents

You could find out the "typical" current of different appliances by using tables given in Chapter 3. Or you can find out the actual currents by looking at the labels on the appliances. Sometimes these labels will give the current, in Amps. But usually they will show the power consumption in Watts or kilowatts.

Use the power equation to convert Watts (power) to Amps (current). Take the plug voltage as 230 Volts, and divide the power consumption by this voltage:

Power = Current × Voltage

so **Current = Power / Voltage**

This gives you the current (Amps), when you know the power consumption (Watts) of the appliance.

Current (in Amps) = Power consumption (in Watts) / 230 Volts

b) Adding up Watts

This method is usually quicker. First, find the total power (Watts) that can be used with this electricity supply. In our example, we are using a current-limited supply of 20 Amps maximum. Multiply this by the voltage to get the maximum power.

Maximum power (Watts) = 20 Amps × 230 Volts = 4600 Watts (or 4.6 kilowatts)

Now, add up the power (Watts) of each appliance. You can find this on the labels of the appliances. As long as the Watts add up to 4600 or less, you should be able to use this combination of appliances together.

If you were trying to find out the same thing for a 10 Amp current-limited supply, then the maximum wattage would be

Maximum power (Watts) = 10 Amps × 230 Volts = 2300 Watts (or 2.3 kilowatts)

Note: Some appliances use more current for a short time when they switch on. Appliances with electric motors can have a higher "surge" current at the beginning.

To change voltages and currents: transformers and inverters

Here is a short explanation about transformers and inverters.

Transformers are commonly used to change the voltage of an electricity supply (as described in Chapter 2). They normally work with *alternating current* (or "AC") electricity. They can work in two ways:

- Step-up transformers push up the voltage and at the same time reduce the current
- Step-down transformers bring down the voltage and at the same time push up the current

The voltage times the current remains the same.

The *capacity* of a transformer refers to how much "voltage × current" it can handle. The capacity is measured in units of Volt-Amperes (VA) or more often kVA, which is 1000 VA. One kVA is similar to a kilowatt (kW) of power. If the voltage and current are "in phase" with each other, 1 kVA = 1 kW.

Inverters are used to convert *direct current* ("DC") electricity to alternating current AC electricity. They usually change the voltage as well. For example, a solar system may produce 12 Volts DC electricity, similar to the electricity from a car battery. An inverter can convert this to AC electricity, at 220 - 230 Volts, similar to grid electricity.



RURAL ENERGY GUIDE

Understanding electricity and rural electrification in South Africa



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