ENERGY EFFICIENCY IN BUILDING – AN INTRODUCTION

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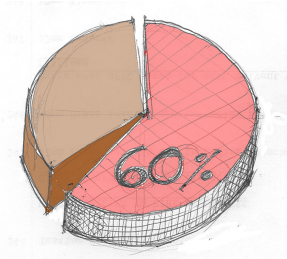
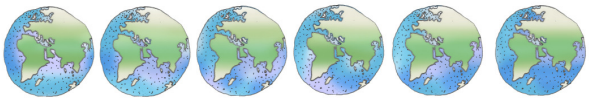
Buildings and their activities consume about **60% of all energy used on earth**, from the construction process, through the use of the building, to its eventual demolition. Below we will explain how that happens and what steps we can take to reduce the amount of energy consumed – i.e. how to be more energy efficient in buildings.



So why be concerned about this? Energy generation from coal and oil-based sources emits greenhouse gases that are direct causes of global warming. The future of our planet is thus at stake.

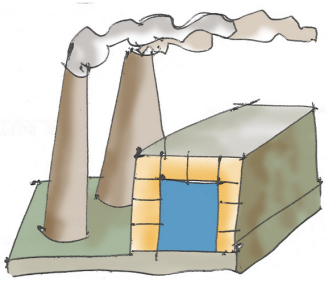


TYPES OF ENERGY IN BUILDING

We usually think of energy in buildings as limited to electrical lights, power points and a few appliances, but a building consumes energy in many different ways. There are five such categories:

1. Embodied energy is consumed in the manufacture of construction materials, components and systems.
2. Grey energy is consumed in the distribution and transport of materials to the construction site.
3. Induced energy is consumed during the construction of the building.
4. Operating energy is consumed in running the building and its equipment and appliances.
5. Energy is also consumed in the maintenance, alteration and final disposal (demolition) of the building.

As the operating energy can be the biggest component and the one closest to building users, most of us usually disregard the impacts of the other four types. However, as building users, decision-makers, home-owners and economic consumers, we can all influence the extent of the embodied, grey, induced and disposal energy of buildings.



HOW DO WE REDUCE CONSUMPTION OF THESE TYPES OF ENERGY?

The embodied energy of manufacture of construction materials:

Select materials that use little energy in their manufacture. How do we know which materials are better? The basic rules of thumb are:

- *Nature knows best* - the closer to the raw state a material is, the better. Stone, whole timber, compacted earth, etc. uses very little energy.

- *Re-use first, then recycle, before using new*. For example, re-used steel window frames are more energy efficient than melting down steel for making new windows. This, in its turn, is more efficient than making new window-frames from fresh iron-ore. This applies to using crushed rubble and waste from other processes directly without transforming it first.

- *Less is more* – simple designs use less material. The larger and more elaborate, the more material a building uses.

- *Use lower–embodied energy alternatives*: For example, aluminium uses a lot more energy to manufacture than steel. Steel window frames, even new, are thus more energy efficient than aluminium. Cement is very energy inefficient and also pollutes directly with greenhouse gases. Minimising cement (by using alternatives like clay bricks instead of cement) in buildings reduces energy use.

The implication is thus that rudimentary (basic) and traditional technology is more energy efficient.

The grey energy of distribution and transport to site:

Select materials from close by.
Here the basic rules of thumb are:

- *Local is lekker* – the closer to site the material is sourced, the less grey energy it consumes. Getting materials from an immediate radius of 50 km around the site is better than from 500 km away.

- *Regional is next best* for anything that cannot be obtained locally (importing from Zimbabwe, Botswana or South-Africa is better than from Brazil). We should also have a "Team Africa", not just a Team Namibia!

- *Avoid importing materials from overseas*. For example, steel fittings made in Europe often are made from iron mined in Africa, refined elsewhere, and cast in Europe. This may require three or more journeys across the globe, whether by oil-fuelled ship, train or aeroplane.

- The implication is thus that we must develop and support local production of construction materials and components. Thus - "Viva Namibia" (especially Team Namibia) "Yebo Southern Africa", and "Uh-Oh, rest of the world".

The induced energy of building construction:

Choose more energy efficient construction technologies, with basic rules of thumb as follows:

- *Avoid unnecessary waste on site*. For example, using whole sheets of corrugated iron instead of having to cut off bits that must be thrown away. Also, brick walls don't need the disposable shuttering that concrete walls need.

- *Use water sparingly (*pumping water uses energy too). When you open a tap, in order to get the pressure for the water to flow from that tap, it had to be pumped from a storage dam to a high reservoir.

- *Recycle building waste*, preferably in the building itself. All waste equals energy. (You can even say that all waste is food – whether for people, earthworms or industry.)

- The most important - *use people power rather than machine power*. Labour-intensive technologies not only use less energy, but also have social benefits. For example, digging pipelines by hand rather than using an excavator might take longer, but puts more money in local people's pockets and less in the pocket of the petroleum companies!

The operating energy of running a building, equipment and appliances:

This contains two aspects – reducing energy consumption through the good design of a building (passive design), and reducing energy consumption by using appropriate technology (active design). More about this later.

Energy consumed in maintenance, alteration and final disposal (demolition):

Keeping the building fabric in a good state is crucial to making buildings last longer.

- *Long-lasting buildings* give more use per amount of energy invested in them. Buildings are currently designed for 20 years lifetime. If they can last for 40 years, you can halve the energy invested.

- *Buildings must be adaptable*. If they are not needed for one use anymore, it should be possible to easily convert them to another use without large-scale demolition.

- *Buildings must be easy to maintain* (not maintenance-free!), so that they do not degrade earlier than the time for which they are needed. There is no such thing as a maintenance-free building or machine.

- *Labour-intensive processes* rather than machine-dependent for maintenance and repair are essential. It means repairs and maintenance can be made on site, and components need not be sent far away to be repaired.

- *Low-embodied energy materials* must be planned in from the start. Don't lock the building and its occupants into expensive systems at the beginning.

- *Re-usable components* that can be reutilised as they are for new buildings or expansion, rather than unusable waste, will save energy. For example, bricks can be re-used, but it's difficult to re-use broken concrete rubble.

The implication – don't make disposable/ throw-away buildings.

OPERATING ENERGY EFFICIENCY

Running a building, its equipment and appliances with less energy:

The need for energy in a building is two-fold:

Firstly to allow for human comfort in terms of aspects like coolness in summer, warmth in winter, light to work by, quiet for sleep or work, etc.

Secondly to power the appliances and equipment indispensable to modern work and life. This includes office and household machines like a computer, copier, fax, alarm system, switchboard, light, fridge, television, stove, hot water, etc. Also the machines that factories use to produce their products with, those needed in hospitals for operations, etc.

Strategies, both passive and active:

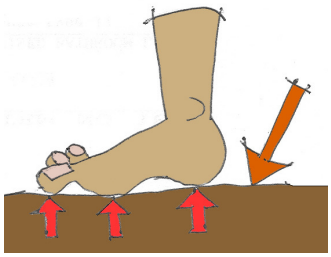
The needs of human comfort such as coolness in summer are conventionally dealt with by machines. However, the most effective way of conserving energy is to exploit natural forces – sunlight, wind and daylight. This is called **Passive Solar Design**, and relies on sensible design decisions made (both for new and renovated buildings) and does not use additional mechanical systems:

Coolness & warmth: is it all hot air?

Yes, of course. Cold is just the absence of heat. Conventionally we plug in a heater when it's cold, or switch on a fan or air-conditioning when it's hot, but there are other **passive** ways.

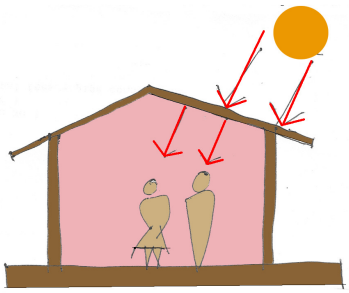
We need to understand that heat gets transferred in three ways to either make us hot or cold:

1. Conduction is the transfer of heat from one solid material to another. For instance, if you walk barefoot on a hot stone pavement, the heat is conducted from the stone to your skin and burns you through conduction.



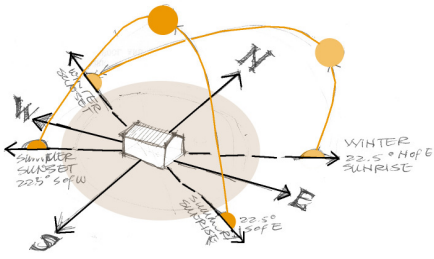
2. Convection is the transfer of heat by means of heated air. For instance, a hot stone pavement heats the air above it and the moving hot air heats up your stoep and you while sitting there.

3. Radiation is the transfer of heat through open space by means of infrared heat rays. This can be short- or long-wave radiation. Examples are sunrays that warm up skin or materials, or a corrugated iron roof that radiates its heat downwards onto your head.



We also need to understand that all our natural heat (even our body heat!) comes from the sun. The sun radiates heat with long-wave radiation to the earth through clear skies. This heats up surfaces like the ground and building walls and roofs. This affects how we can utilise sunlight, wind and daylight to keep us cool in summer and warm in winter.

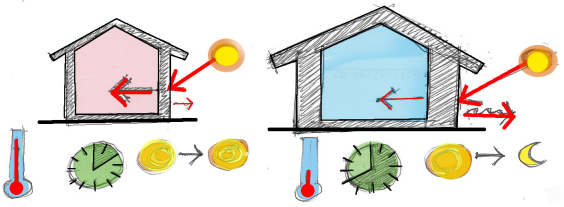
- *East or west, north is best.* Orientation is crucial. The sun is low in the east in the morning and low in the west in the evening. It then shines directly on these sides of a building and heats the surface up by radiation. The absorbed heat is conducted through the inside surface and re-radiates to the inside space.



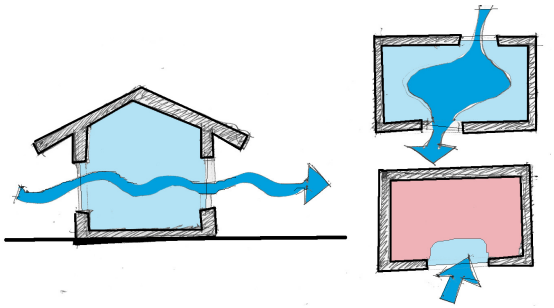
Buildings that have their largest sides facing east or west will thus absorb too much heat from the sun. By making the narrow sides of the building face east and west, we reduce the amount of heat absorbed. As a bonus, at midday the summer sun sits high in the sky and winter sun sits low. With the right overhang, we can keep the summer sun out

and let the winter sun in to warm our rooms in winter.

- *Through thick or thin?* When a material absorbs heat, it needs to travel through the thickness of the material before it can be radiated out on the surface. Firstly, the thicker the material it is, the longer it takes for the heat to travel through. In a very thick wall, this means that the heat is only released on the other side much later (sometimes up to 12 hours). This is called the flywheel effect. Secondly, some materials take more energy to heat up than others, called their thermal mass. For example, metal heats up very quickly and bricks take very long. The less energy is needed, the hotter the material gets and the more heat is transferred to the inside. These two issues explain why corrugated iron shacks get so unbearably hot. And why a house with thin brick walls is hotter than one with thick walls.



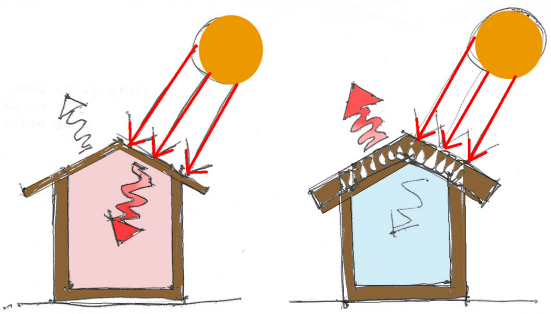
- *Let the outside in.* Once heat is trapped within a building, the inside air is hot and the only way to cool it is to get rid of the hot air. For that we need air movement, both horizontally and vertically. Although air does move around corners, it slows down when it does so. More efficient air-movement needs cross-ventilation. Rooms thus need openings on opposite, or at least two sides, to prevent 'dead' corners where the heat can collect.



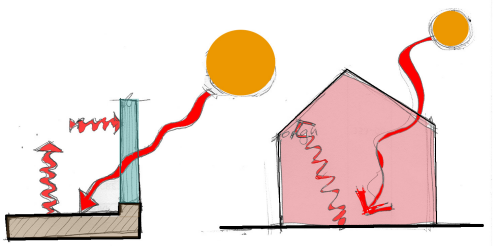
A good habit is to open the windows at night when the air is cool. Let the hot inside air out and the cool outside air in. Close the windows later when the outside air has heated up to keep the cool air inside. Air moving over the skin also promotes perspiration and cooling of the body – we talk about clothes later. We have to open windows! In some buildings, windows can't open – change them.

- *Up, up and away….*The fact that hot air rises, creates what we call the stack effect. We can use the stack effect in buildings by firstly making high ceilings, sloping them to one side or the middle, and putting openings at the top to let the hot air out. We thus utilise convection to get rid of excess heat.

- *Wrap it up, baby!* Just as we use oven gloves to keep our hands from burning when we take a hot pot from the stove, we should wrap up our roofs to protect the inside from the sun's heat. This means putting in insulation, which can be a radiant barrier like silver foil (that reflects the heat rays), or a conduction barrier like fibreglass, polystyrene, polyester wool or sustainable alternatives like sheep-wool, cardboard, reeds, etc.



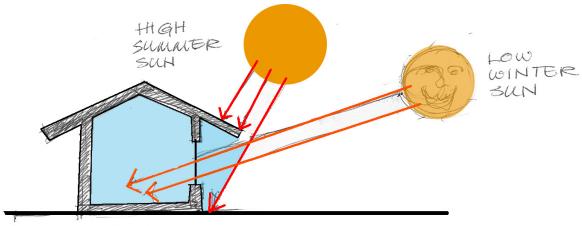
- *People who live in glass houses….* will get very hot! Glass is transparent for the sun's long-wave radiation. Once inside, after absorption by surfaces, the heat is re-radiated as short-wave radiation that cannot get out through glass. This is the famous "greenhouse" effect.



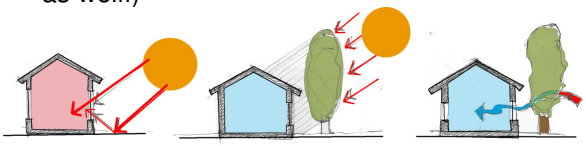
Large surfaces of glass thus increase the heat load of a building disproportionately. In conjunction with this, glass radiates heat not to inanimate surfaces only, but also to body surface, i.e. skin. Even though the thermostat says 21 degrees (cool by most standards) you can feel overheated as your skin absorbs the radiation from the glass

directly, without it heating up the air in between. This is called the radiation effect.

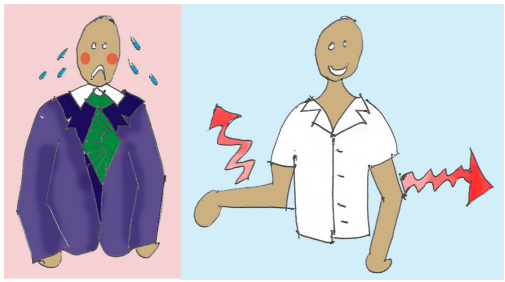
- *Sam said: wear a hat*. We've already shown how buildings can heat up from sun on their surfaces. By shading outer surfaces, especially glass, we can radically reduce the amount of heat absorbed. Ways to do this are to have roof overhangs, sunshades over windows, screens over east and west walls, and trees and planting that screen surfaces.



- *How green was my valley?* Plants have a major role to play in cooling buildings. They shade walls and surrounding surfaces, reducing the absorption and reflection of heat into the building. In addition, they transpirate, in other words, 'exhale water'. This adds water vapour to the air and cools it. Air moving into the building through a screen of plants is much cooler than air moving over a bare surface (that emits heat as well!)



- *Instead of your heart, wear the season on your sleeve*. Human bodies are little heat generators. We can choose to keep heat in or cold out through the clothing that we wear. Namibians often wear the most inappropriate clothes for the climate!



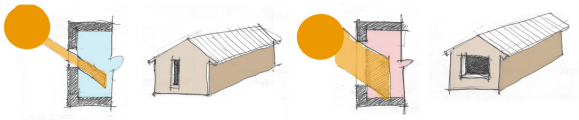
By capitalising on the fact that we radiate heat from skin, we can cool ourselves by taking off our jackets or jerseys, by wearing short sleeves, and by wearing natural fabrics like cotton and linen, instead of synthetics, that breathe. Just a tip – to radiate heat, you need a surface that can absorb it on the other side. A concrete or tiled floor works well, but a carpeted one not at all. We can also clothe our buildings according to the season – put loose carpets down in winter, take them away and store them in summer.

Light up your life:

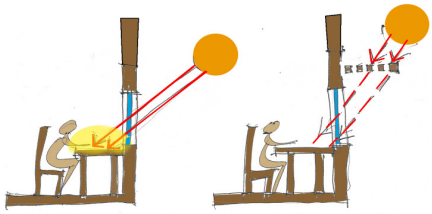
Daylight rules OK! How often do you switch on lights in the daytime? Is it really necessary with that huge light bulb out in the sky – the sun? By designing and adapting your windows in the right way, you can avoid the need for artificial light in the daytime.

- *Number and size of openings* of course influence the amount of light that you get. Too small and too few windows, and light will be insufficient. Too many large openings, and the space will overheat.

- *Position and shape of openings* are important. Windows should be tall and thin on the west and east sides, and wide on the north and south sides. The low morning and evening sun can heat interiors too much through wide east and west windows.



- *External shade* is crucial, as light must be bright but not cause glare (especially for computer tasks) to avoid reflections on screens and people thus closing blinds and switching on lights.

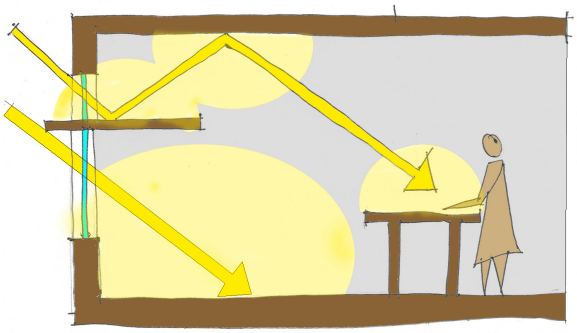


- *The type of glazing* can affect the quality of daylight. There are now several high-tech solutions on the market for glare-free, heat-controlling glass that allows us to have bigger windows for more daylight, but less heat gain in summer.

- *Colour and reflectivity of surfaces* play a big role as light reflects off floors, walls and ceilings. Dark surfaces makes light seem full of glare in contrast, whereas light colours reflect and diffuse the interior light. Textured

surfaces (such as lime wash paint) are better than smooth, as they scatter the light rays and diffuse them, spreading the light further and softening it.

- Architects have *special tricks like light-shelves* – a white shelf one-third from the top of a window. The light reflects from the shelf onto a white ceiling and deeper into a space, illuminating deeper interiors. These can also be inserted into an existing building.



How active is passive?

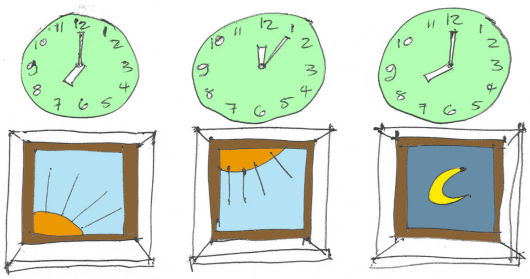
People tend to get confused between the terms, as a passive building needs a lot of activity from its occupants! They must open and close windows, draw or open curtains or blinds, put on or take off jackets and sweaters. In an active building, this activity would be confined to switching on fans, air-conditioners or heaters.

However, “passive” refers to the lack of artificial energy required, and active means high energy input from all the mechanical and electrical appliances.

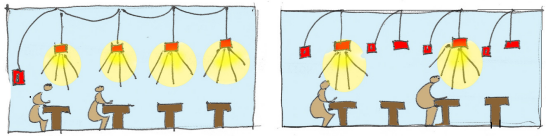
Active design looks at the types of mechanical and electrical appliances and how they function. Active design often uses technological interventions to increase efficiency:

A good active design goes through a series of questions:

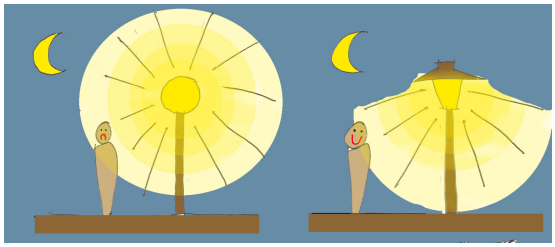
1. *Can the technology be replaced or augmented by a passive method?* For example, cooling a space by opening windows opposite each other (cross-ventilation), rather than putting in air-conditioning.



2. *Is the technology required that often and when is it required?* In an open-plan office where staff are often out on assignments, it is better to have individual light switches for desks rather than a single one for a whole room, so that only the required lights are switched on, and not the whole rooms. This is referred to as ‘task lighting’. A switch that turns off all the lights when the last person locks up the office is also a good idea.

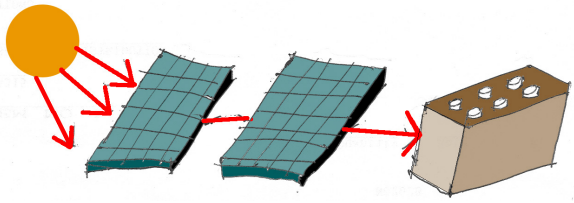


3. *How do we reduce the amount of energy we need (energy efficiency)?* For instance, night-time lighting requirements must be assessed in terms of the spread of light on surfaces and in spaces needed, the reflection capacity of those surfaces, unnecessary spill of light, unnecessary heat emission of bulbs, the colour of light, and spillage into the sky (light pollution). We don’t need to waste light.

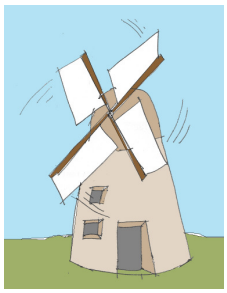


4. *Can the technology be a type that uses less energy?* For example: if passive cooling is not enough, active systems can be installed. Instead of a conventional split unit or central system, Passive Downdraft Evaporative Cooling (PDEC) and evaporative coolers (swamp coolers) are now much more sophisticated and use a fraction of the energy. New air conditioning systems like VRF also uses less energy than older types.

5. *What kind of energy does it use – renewable or non-renewable?* Solar (photovoltaic and water heating) and wind power are only two of the many options of renewable energy available for specific uses.



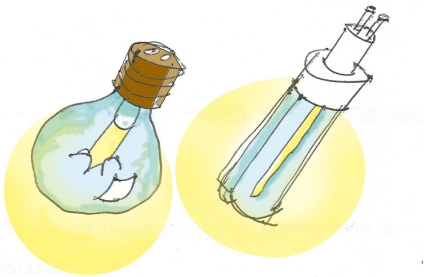
6. *What is the best type of renewable energy for the application?* Using solar power (photovoltaic) to heat water makes no sense, as a solar thermal system is cheaper and much more efficient. Solar PV doesn't make sense for cooking, but gas does. Putting in a wind generator where there is no wind doesn't make sense either.



EXERCISE

Imagine a scenario that your building (house or office, whatever) is cut off from grid power for a week at least. You have no batteries and no candles.

1. What will happen? What will you do – can you cope?



2. Can you make calls if the switchboard has no power and your cell battery is flat?

3. Can you work on a computer without grid power? If there is a backup power supply with batteries, why not load it with solar.

4. Can you get to your office/ lecture-room if the lift doesn't work? Then why use the lift normally if you can take the stairs (and get some exercise!).

5. Can you open windows to cool your work/living space if fans don't work, and air-conditioning shuts down?

6. Will your taps have water?

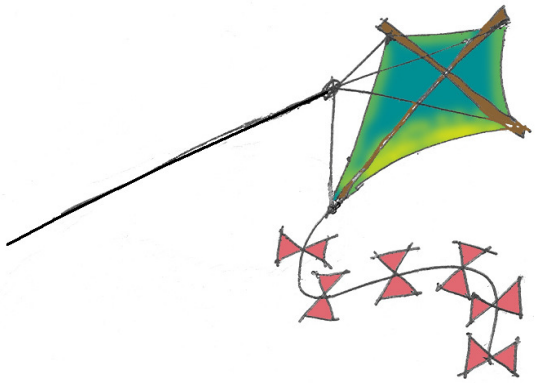
7. Can you heat water for drinking and washing people and clothes?

8. Can you cook food?

9. Will you have lights to study, read, work, and eat at night?

You will be able to do all of these things with renewable energy and passive solar design. And you can do it this way even if there is grid power.

Why bother? To save energy, save money and benefit the environment as a result.



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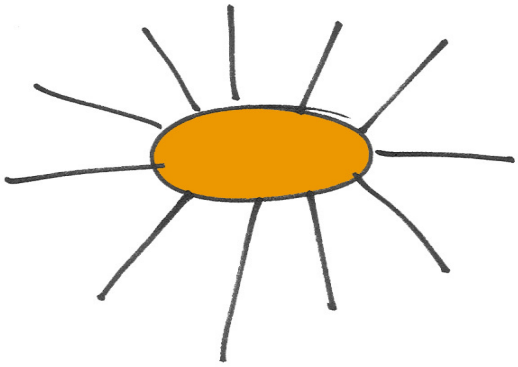
Large hydro-electric and nuclear power are not considered "green" or sustainable energy sources by most authorities on renewable energy and should thus not be promoted. In a country like Namibia, with the best solar reserves in the world and of the best wind capacity in Africa on the coast, who needs hydro and nuclear anyway?