Renewable Energy

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IZWA

Institute for Zero Waste - Africa

Designing Pollution Out,
Designing Jobs In !

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What is Energy?

Energy is the fire within every living thing. Among humans, it is energy that warms our blood, that breaks down our food, and keeps our hearts pumping.

Every living thing on this planet needs energy to survive. Everyday we use energy to meet our most basic of needs. We need energy to cook food and to keep warm. In the home we also use energy to heat water and the insides of our homes, to keep our food fresh in a fridge, to listen to music and watch TV, and to light up our rooms at night.

Energy also helps to keep our economy going. The electricity industry employs thousands of people just to supply our homes, factories, hospitals and farms with electricity. The oil industry employs just as many people to keep our cars, trucks, taxis and buses running with petrol and diesel (and also paraffin for cooking and heating in the home). All agriculture, business and industry use energy in some form or the other at all times. Together, these three use up to 85% of all energy.

To sum up, energy is the ability to do work of some sort: to move something, to change something from one form to another (cold to hot), or to stop something happening (a brake).

So, what's the problem?

The way we use energy throughout the world is causing a lot of harm. We are poisoning our children with the petrol, diesel and paraffin that we use. In countries like Lesotho, Namibia and Mozambique, we are moving thousands of people to build big dams so that we can create electricity from the flow of water over the dam wall. When we burn dirty coal in our electricity plants, factories and homes, we warm up our planet and cause floods and drought somewhere else. Burning coal also causes many health problems for people using coal at home, or living near coal fired power stations, especially problems with their lungs and throats. Their houses are also difficult to keep clean, and even their washing gets made dirty again.

Our coal fired power stations are amongst the dirtiest in the world.

The way we are currently using energy means that we will pay more and more for that energy, as the fixed resources (coal, oil and wood) run out, or simply get more expensive to access. If we continue in this way, this will mean no fossil energy for our grandchildren and those that follow after them. This also impacts badly on our health, our studies, our enjoyment of life. It also makes it more difficult for us to afford safe and clean energy.

What can we do?

We have to ask ourselves:

"What are the social, environmental and financial costs of our use of energy?"

"What can we do with energy supply, and use sources that are better?"

"What are the challenges facing the government and the people in finding a better energy mix?"

At the same time, we must improve living conditions in informal settlements and townships. We must find solutions that also allow current and future generations to live a better life, with increased sustainability. The quality of life, a healthy environment and sound development are all closely linked, and energy is an integral part of this. Bringing energy and environmental concerns into all stages of housing delivery and the upgrading of our homes process, as well as improved public transport, will save money and improve the quality of life, not only for us today, but for the generations that are yet to come.

Today's world:

Coal and Oil energy

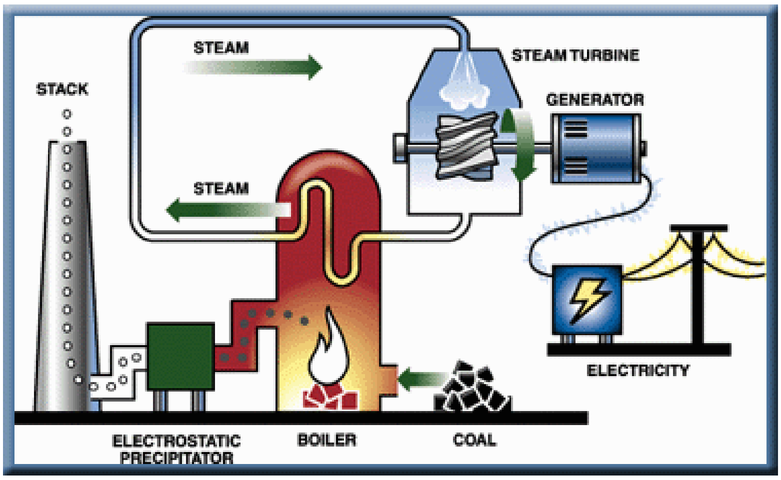
Coal is used in mainly two ways in our country – the largest portion by far to make electricity, and the smaller portion to burn either at homes or in industry. As you know, burning of coal generates harmful emissions, and to replace coal with renewable energy would be good to do – the main reason why we do not do this, is that the public, not the coal mine, or Eskom, or industries that use most of the electricity, pay for the impacts of burning coal – you and I pay the price, by falling ill, and damaging our environment, with impacts such as global climate chaos (mistakenly called 'climate change').

The impacts of oil, the basis of all our liquid fuels today, is equally harmful to all life. The illegal invasion of Iraq, the pipeline struggles of the Ogoni people in Nigeria, tanker accidents on oceans, the harm in places like South Durban and Sasolburg, and those living near busy roads and rubbish dumps (incorrectly called landfills), are a quick review of the harm that fossil fuels cause.

So, the two main types of energy we use are electricity and liquid fuels like petrol and paraffin.

How do we make electricity?

Usually, coal is burnt, and used to heat water to change it into steam. This steam is then used to turn a turbine, which then generates electricity. Other ways we are using currently is to use the heat of nuclear radiation. Unlike the diagram on the right, most of our power plants do not have adequate pollution control equipment.



What is Nuclear Energy?

Nuclear energy is the energy stored in the smallest piece of matter: the nucleus, or centre, of an atom. When the nucleus of one atom, Uranium, is broken (called "fission"), it forms two new atoms and lets out a large amount of energy in the form of heat. This heat is used to drive a turbine, which then generates electricity. We have one nuclear power station in South Africa at Koeberg, 28 km from the Cape Town city centre.

What is the problem with Nuclear Power??

Nuclear power is not safe. When the nucleus of the Uranium atom splits it also creates new atoms (such as Strontium and Cesium), which are very dangerous because they are radio-active. This means that these new atoms are always giving off little amounts of radiation. When they go in through the mouth and nose and find their way into the bones and organs of people, they can break down cells in those organs and bones. This causes cancer and birth defects. The National Union of Mineworkers says that many people have died from working in nuclear power plants and Uranium mines. many doctors around the world say that communities living near nuclear power stations also die more from cancer and give birth to damaged children. Nuclear power stations can also have major accidents, such as the Chernobyl accident in the former Soviet Union, where it has been confirmed that millions were impacted by the accident, and that farms far away from Russia, in the UK are still not able to sell their produce, as they are contaminated by radiation for a long time to come.

Certain types of radiation can also travel through a person, just like X rays do, which also cause much harm. It must be remembered that radiation cannot be seen, heard, touched, smelt, tasted or destroyed.

Nuclear power also produces dangerous radio-active waste at every stage of the nuclear fuel cycle: from uranium mining, to reactors, to the re-processing of irradiated nuclear fuel. No-one in the world has found a proper solution to the long-term storage of this used fuel and other high radioactivity waste. There is also a strong link to the international nuclear weapons programme, including depleted uranium ammunition. When Koeberg comes to the end of its life, it will also be contaminated and the whole building will have to be treated as radioactive waste, which will remain dangerous for hundreds of thousands of years.

There is no debate whether radiation kills; maims; causes mutations; is cumulative; causes leukemia (mainly in children), cancers, respiratory illnesses and attacks the immune system (with children, pregnant women and the elderly the most vulnerable). The only disagreement is about what is considered an allowable dose.

There is no such thing as a "safe" dose of radiation, and radiation remains dangerous for many thousands of years.

The only people who say that radiation is safe are those who make money from radioactive processes, and cannot be trusted, as they have proven so far, here and overseas.

Why other forms of energy?

Firstly, because the sources used for energy today are all non-renewable – they will all end some day, and also because of issues like global warming, and pollution at the local level, we need to use less oil for transport, and less coal and nuclear power for electricity and industry. There are a number of ways we can better use energy, and make energy safely and cleanly.

Tomorrow's World

Saving Energy

Saving energy is the cheapest, quickest and best intervention we can make right now. Using better ways in which we manage ourselves (changing our behaviour), as well as using existing technology to reduce the amount of electricity we use. It is relatively easy to reduce demand by 20% or 30% by making very small changes. The main reason why this is not happening, is that the government believes that by selling electricity cheaply to the end-user (and this is only cheap because all the costs are not included), we will attract lots of investment. Not only are we unsure of what real benefits foreign investment provides for us, we also should not be asking companies, like those than run aluminium smelters, to come into our country. One smelter that may come to Coega will use more electricity than the whole of Nelson Mandela Metro, and yet only create a few hundred jobs at best, probably far fewer.

Energy Efficiency

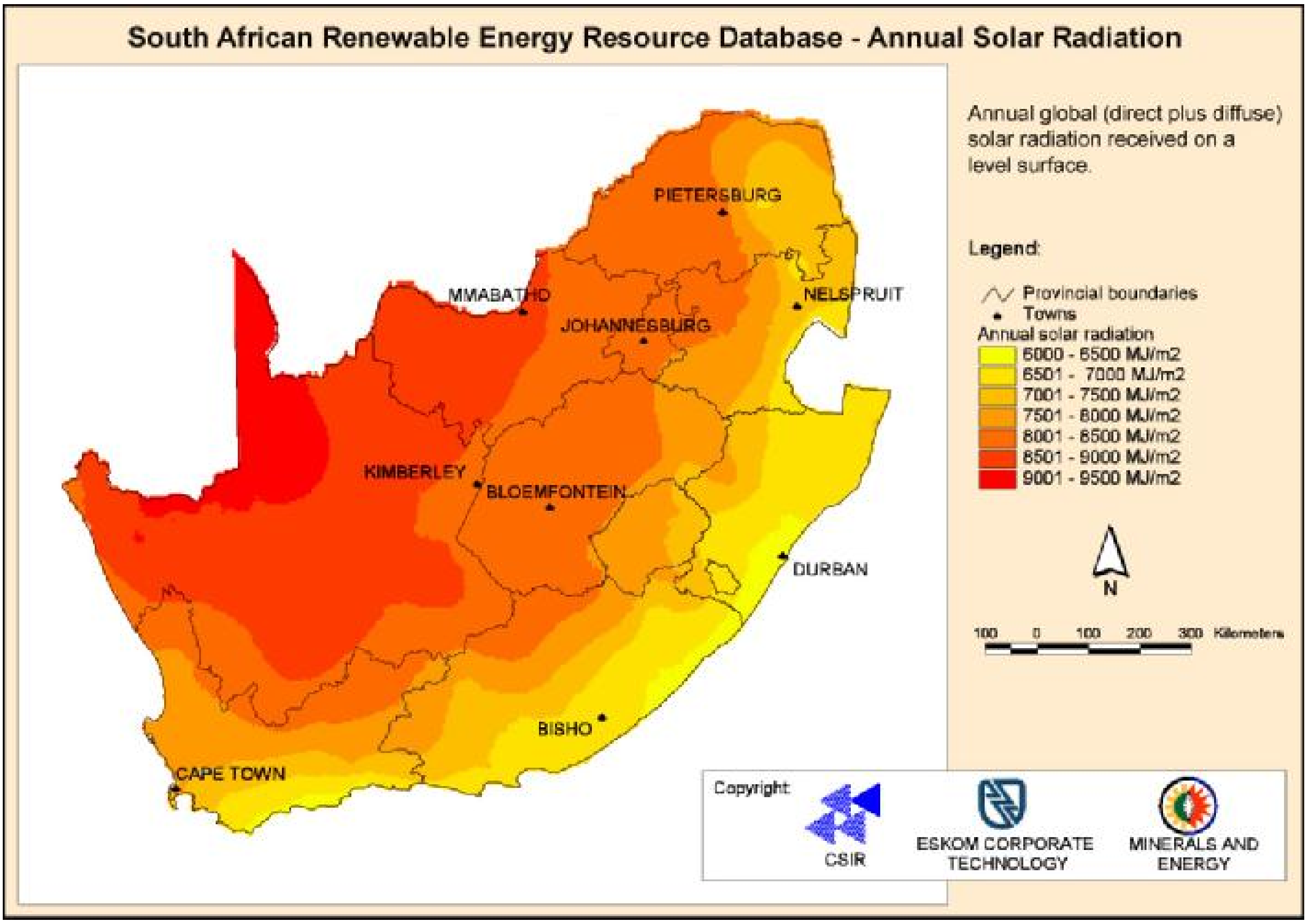
If we use less electricity to do the same jobs we are being energy efficient. At home, some fridges and stoves, for example, use less electricity than those that we used in the past. Compact Flourescent Lights (CFLs), which use less electricity for the same amount of light are now widely available, and actualyl work out cheaper in the long run. If we put in ceilings and insulation, and make sure that our buildings and windows face North with suitable overhangs, we can also reduce the energy we use for heating or cooling our homes and factories. Eskom was able to reduce their electricity consumption at the head office by 34%, by implementing energy efficiency.

In factories, the largest users of electricity, companies should be made to use energy efficient equipment at all stages, and also to re-design their products and processes so that they use less energy.

We can also design buildings so that they use much less energy – it is possible, using today's technology, to reduce energy use in buildings by up to 80%.

Solar energy

All our energy comes from the sun, as it heats and cools the world, making wind, helps us grow food, and so on. If we used 2 percent of the world's deserts for electricity generation, we could supply the



whole world.The annual global solar radiation average received by South Africa is approximately 5.5 kWh/m2/day, one of the highest national levels in the world.

The annual 24-hour global solar radiation average is about 220 watts per square meter in South Africa, only 150 watts per square meter in parts of the United States, about 110 watts in the EU. As you can see from the chart, South Africa is blessed with some of the best solar energy in the world.

Solar Water Heating

If we were to use energy directly from the sun to heat water in our homes and factories, we would save roughly half of the electricity that we normally use from the national grid. In some countries, governments pass laws that compel people to use solar heating. If everyone were to use Solar Water Heaters (SWH) in South Africa, we could do away with one 2000 Megawatt coal-fired power station, or 12 pebble-bed nuclear reactors. Solar cooling can also be used instead of normal airconditioners.

Cape Town is passing a law that will promote SWH. These products cost from between R5000 to R12000 for homes, but pay for themselves within a few years, by saving roughly 40% of your electricity account. In many countries, governments subsidise the initial cost of the SWH, and you can repay that through savings.

A typical solar water heater on the right– although there are many designs, this is what many of them look like, but often with glass covering the pipes.

Solar Thermal

Left - Large mirrors reflect the heat of the sun to one spot on the tower, making that spot very hot – this heats water to make steam, which then turns a turbine to make electricity.

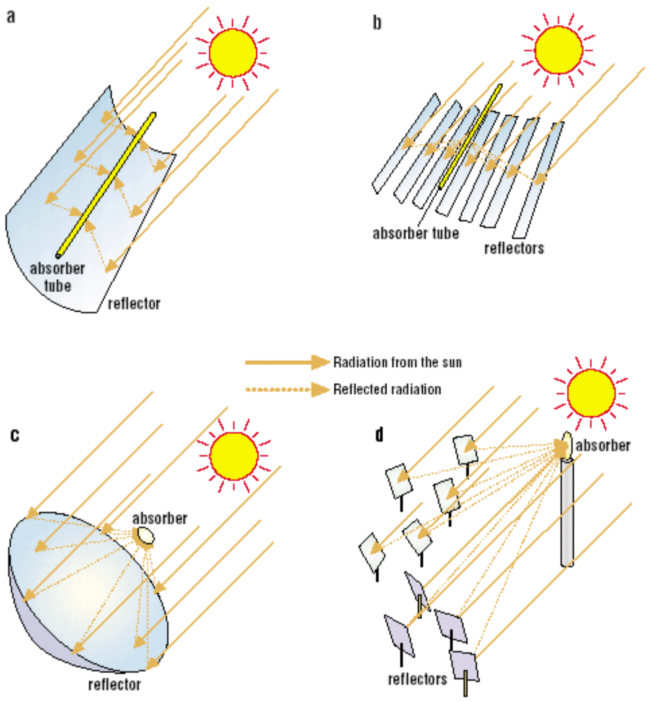
There are different kinds of mirrors that can be used – those that are quite flat, like those on the left, or they can be curved (like half a pipe) and a pipe for water can run through the middle (see below).

Solar power can also be used to generate large amounts of electricity, by concentrating the power of the sun with mirrors or lenses, like a giant magnifying glass. This very hot process easily and quickly turns water into steam, which can then drive a turbine – it is exactly the same generating process as coal fired power stations, except that the source of heat is the sun.

Some people are concerned that this particular (unlike some others) can only generate power during the day, but it must be remembered that the best energy solutions include a mix of many different technologies, so that we do not end up (like now) relying only on one technology.

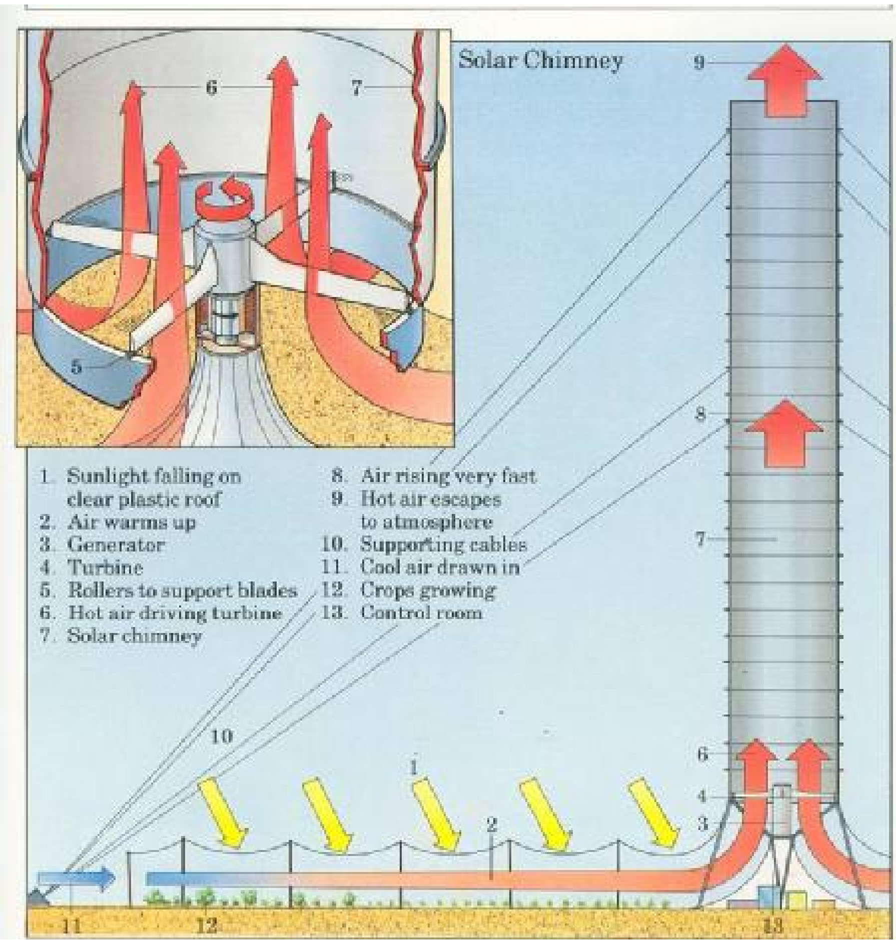
We can also use low temperature Solar Thermal for the drying of food, for example, which can have an alternate source of heat for the few days when there is not enough sun.

Right – some different types of solar reflector designs



Solar Thermal Chimneys

Solar chimney power stations can function effectively due to the fact that warm air rises. Solar radiation heats air underneath a glass ceiling so that it rises through a chimney. To replace the air, which has risen, air from the edge of the glass ceiling flows inward, and then itself begins to heat up. In this way the sun's heat radiation is converted into kinetic energy, or a 'motor' of constantly rising air. A turbine built into the chimney then converts the wind power by means of a generator into electrical energy.



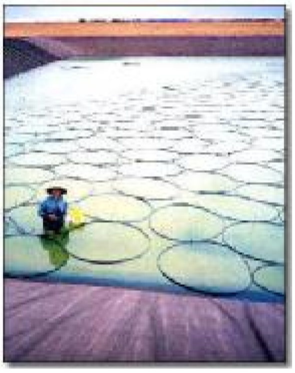
A prototype in Manzanares, south of Madrid, (above left) delivered power practically uninterrupted between 1986 and 1989 with a Peak Output of 50 kW. Its collector had a diameter of 240 meters while the chimney had a diameter of ten meters and was 195 meters tall. Australia is busy building one that will generate 200 MW, much more than the proposed Pebble Bed Nuclear Reactor, with no fuel costs and minimal pollution.

Solar Panels (PV – Photovoltaic – Sunlight into electricity)

Sunlight can also be changed into electricity through solar panels, called photovoltaic panels, which are normally linked to batteries. Because your lights, radios and TV sets do not use a lot of electricity, they make the best uses for solar panels. Solar panels are also great for people who live far away from grid electricity, but many large panels together can also generate great amounts of electricity useful for grids. Since the demand for solar energy is growing all the time, the cost of manufacturing solar panels is coming down every year.

Solar ponds

There are different solar pond concepts, but the most widely used was developed in Israel and it works this way. An excavation is constructed that is about 8 to 10 feet deep and is lined with a material to prevent water leakage. The pond area can be of almost any size, but the area is dependent on the power expected to be realized from it. It is then filled with brine (salt solution = water and common salt) that is almost saturated with salt at the bottom and nearly pure water near the surface. Wih this salt-gradient pond, the solar energy falling on it largely passes through the water to the bottom where it is absorbed. If this were done with pure water, the warmed water at the bottom, being less dense, would mix with the water above it thus losing energy to the surroundings. However, with the denser fluid near the bottom, even if heated, is denser than the water above it and little or no mixing takes place. Therefore the water at the bottom gets quite hot and the only heat losses are to the ground (small) and by conduction up through the pond to the surface. But since the pond is rather deep (6 to 10 feet) this loss is also not great. Hot water is extracted from the bottom of the pond and circulated to a heat exchanger where the heat is extracted by another fluid and used as needed. This could be for producing hot water for washing purposes, or it could be used as the heat source for an engine to produce mechanical/electrical power.



The annual average daily solar radiation falling on a horizontal surface in Durban is about 18,000 kJ/day per square meter. This is about 0.20 kW/square meter, and if the pond is about 20% efficient in collecting energy, this means that about 25 square meters of area is needed to produce an average ANNUAL kilowatt of power. In places like the Karoo, this would probably be twice as efficient.

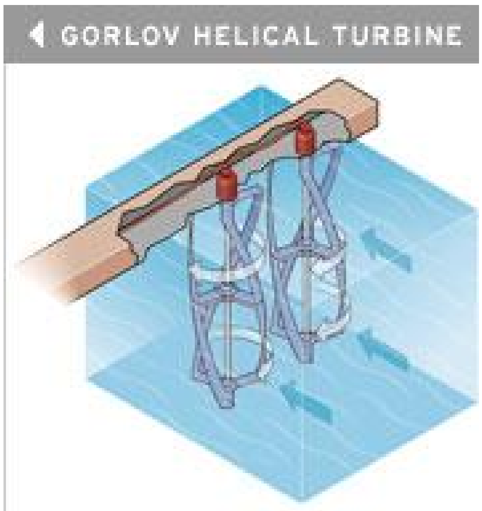
OCEAN ENERGY

Ocean Current

Another good answer to those who say that "all renewable energy is intermittent" (comes and goes) is to suggest that Ocean Currents are a good source of non-stop energy. Water in the oceans is constantly moving, at different levels underwater, and never stops These currents are very strong, and are responsible for some of our plastic bags being found in Australia! Similar technology for micro-hydro and wave energy can be used here, and is already being tested commercially.

It must be remembered that water is about 10 times more dense than ir, so the turbine needed to generate electricity can be 10 times smaller than that used for wind energy, making it even more attractive.

The Gorlov turbine (right) is also a very clever design, as the turbine does not have to face the direction in which the water is moving from – it has also been proven to be harmless to aquatic life, making it an elegant solution. Off the Durban / KZN coats, we could generate at least 2000 MW easily.



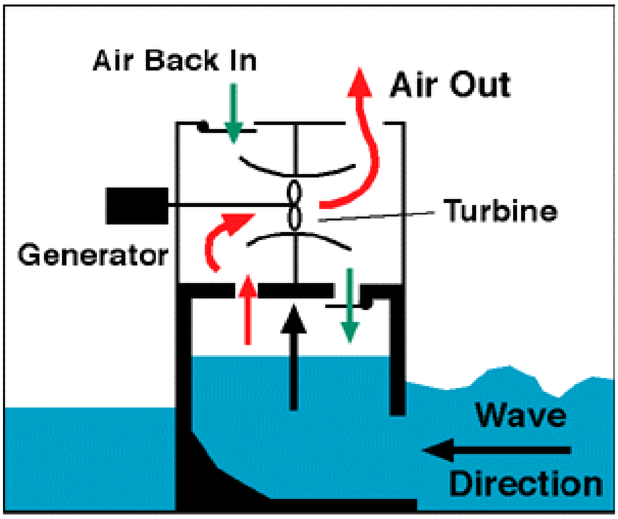
The design of Gorlov's helical turbine means that it will continue to rotate regardless of the direction of the current.

Tidal energy

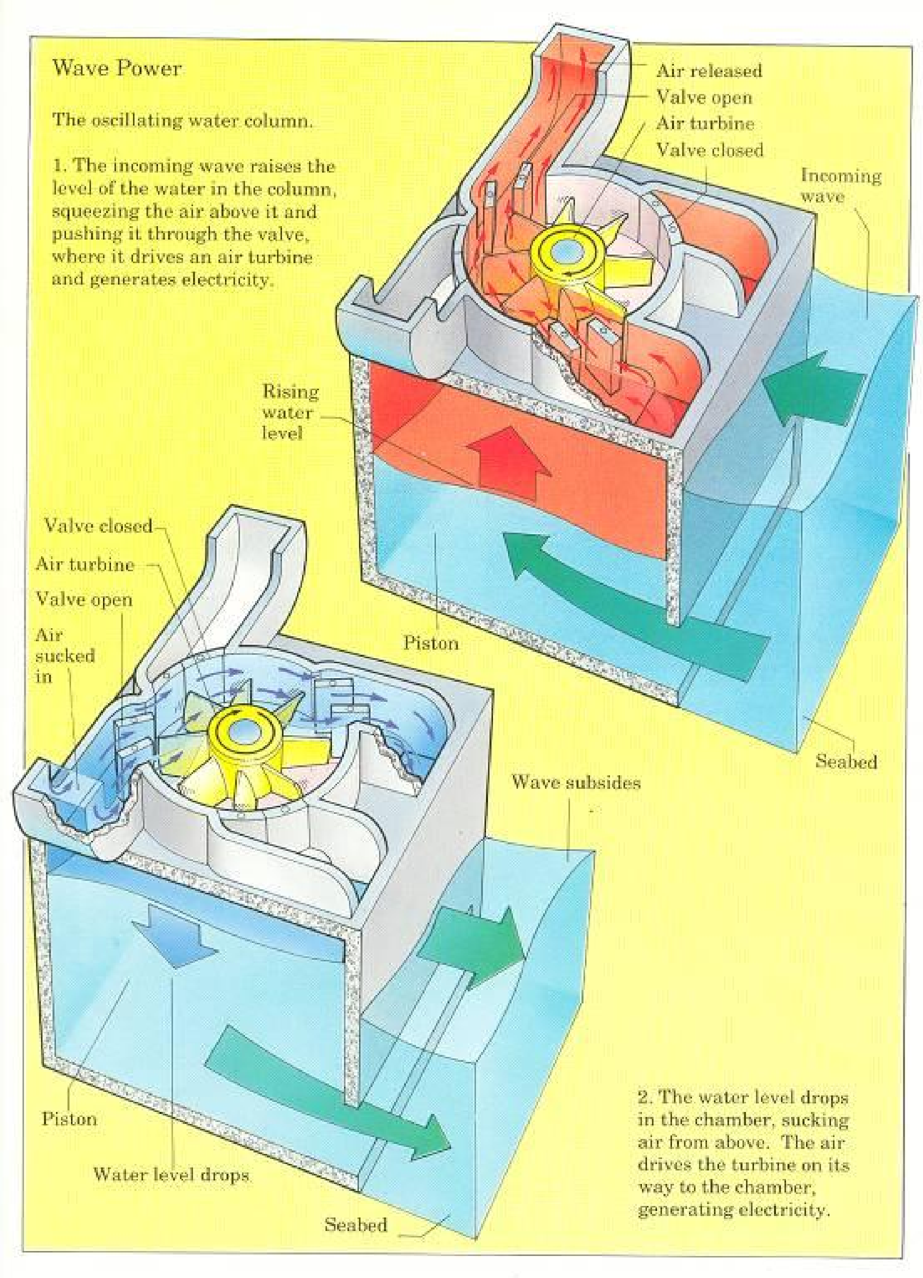
Tidal energy relies on the movement of water when the tide comes in and goes out – the technology used is much like that used for ocean current. However, as the tides only rise and fall a few metres in South Africa, this will not be a great source of our energy.

Wave Energy

The waves at the edge of the ocean can also generate electricity, as can the swells on the surface of the ocean. This is the energy held in rising and falling waves at sea, which makes a wave generator go up and down, and so make electricity. This is already happening commercially, as throughout the world, governments and businesses are conducting more research on wave energy, and beginning to implement exciting solutions. South

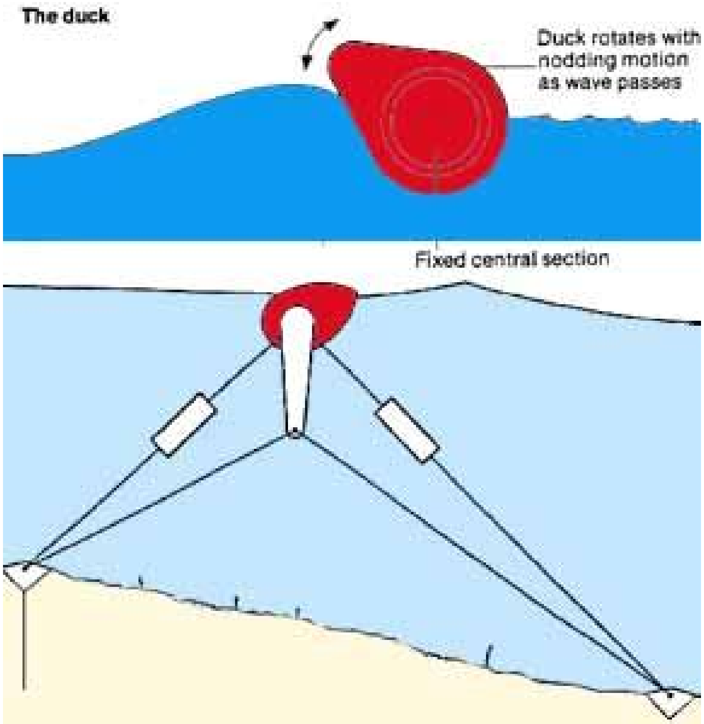


Wave energy is captured in a very easy way – the waves (which never stop) go into the pipe at the bottom – this pushes the air in the tube out – while it is doing this, it can turn a fan (turbine) which generates electricity. When the wave drops, air comes rushing back in, which can turn the turbine again, to make more electricity.



Africa's coastline has excellent potential for wave power generation, and Stellenbosch University has already produced working models. For example, it is estimated that 2% of the ocean's wave energy could supply the current worldwide demand for electricity. Every metre of coastline in Northern California provides enough energy to power 20 average American households, who use a lot more electricity than South Africans. Rough calculations show that 40m of wavefront could produce enough power to run the Point Hotel in Cape Town (200 kw per 40m of wave), and with only 1 km of wave, we could generate enough power for Cape Town. We are sure they are sorry for not doing this sooner, given their current energy stress.

Wave Duck



The wave duck is another simple machine to make electricity. Although there are some concerns about using them in very rough seas, as they may pull out of the ground if not safely and securely tethered, they are simple and reliable.

The diagram on the left is very clear, and self-explanatory.

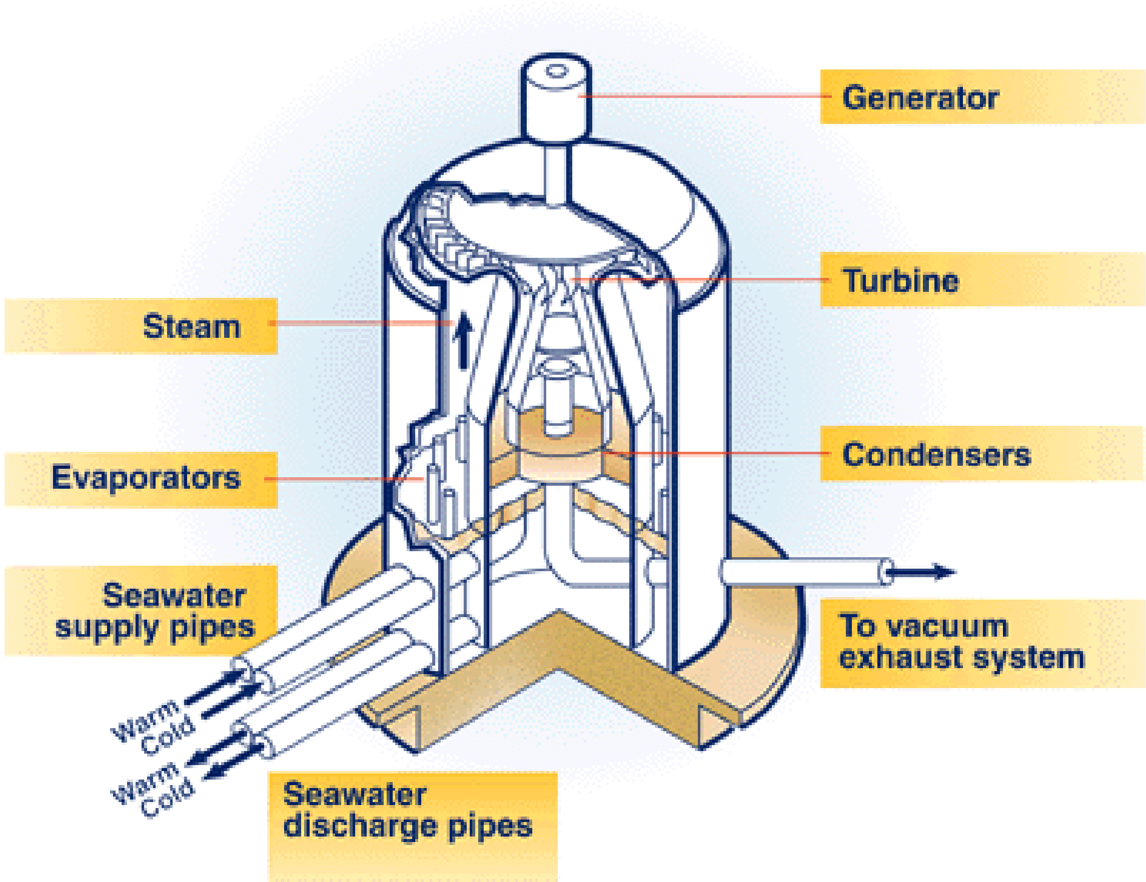
The simplicity of the design makes it perfect for relatively small scale use off our coastline.

Otec

OTEC stands for Ocean Thermal Energy Conversion, which is the greatest untapped environmental energy source on the planet. This technology uses the natural temperature differences between warm tropical water at the surface of the oceans and the cold deep waters below. The greatest advantage to using this energy source is the fact that it requires NO FUEL. No fuel is required to generate megawatts of power. It also does not contribute to global warming, like most other power generated today. No cooling towers, no exhaust gasses, no fuel deliveries and no radiation. Not only does this energy source not pollute, it actually enhances fisheries by bringing up nutrient rich water from the bottom of the ocean which greatly promotes the growth of microorganisms that feed larger sea creatures.

Ocean Thermal Energy Conversion is the power of the future. Looking at the earth as a system, the only significant input of energy to the planet is the radiant energy from the sun. Two thirds of the energy collecting surface of this planet are covered with sea water. This water absorbs this energy, and stores it at the surface. The colder water of the oceans is denser, so it stays deep under the surface. The energy collected at the surface is sometimes more than the surface can contain. This is evident in tropical storms and hurricanes, the physical manifestation of this energy overload. So how do we tap this vast energy stored in the oceans? The answer is ocean thermal energy conversion.

OTEC uses the same technology as conventional steam turbine generator systems, only without burning fossil fuels. This is done by using the heat of the surface of tropical seas to fuel the boilers. Steam turbines work by using a temperature difference to produce a phase change in a liquid medium, causing pressure which is used to turn the impellers of the turbine. This phase change usually starts at normal temperature and pressure, but the process can be performed at a negative pressure, bringing the temperature necessary to produce the phase change right down. If a closed loop boiler/condenser system is started at a lower internal pressure, the whole system can be supported at temperatures as low as 10 degrees Celsius. The surface of the ocean in tropical waters is far above this, usually around 26 degrees C, which means the water in the boiler will quickly turn to steam. Once the water goes through the turbine, the steam must be cooled enough to once again become water, which also causes a greater pressure on the turbines, producing more energy. This cooling can be provided by water found deeper in the ocean. Water found at depths of 1000 metres is very cold, usually around 5 degrees C. This is easily cold enough to condense the steam that passes through the turbines back into water. So if you can economically get water from deep in the ocean to the surface, you can generate electricity without fuel. A bonus is that the waste product from OTEC is potable water!



Wind Energy



Wind energy is one of the fastest growing industries in the world, and the cost of wind power has been coming down every year. It is also competitive with coal and gas. If you take into account the health costs of coal, wind has already been found to be cheaper than coal and gas fired power stations in the USA. In some countries wind already produces over 10% of people's energy needs and by 2010, wind energy will supply over 10% of Europe's power needs. Some analysts predict that wind could supply up to half of all global energy needs by 2100. Wind is better than coal and nuclear power because it can often create electricity close to where it is used; there are very few impacts on the environment; it creates local jobs; and South Africa has great wind resources along our coastline and the escarpment. We need to use this energy source more in the future. Wind energy is captured simply by letting the wind turn the blades of the rotor, like a fan, which then makes electricity.

In 1998, the International Energy Association predicted 45 GW (more than our whole country uses at present) installed wind by 2020– this was achieved in 2004, 16 years before target. It is said that this will grow to 5 times that by 2014

The market is growing at 34% per annum on average. It must be remembered, that the potential for wind in SA has been dramatically underestimated, without even taking into account potential for export. All studies, including those by the Department of Minerals and Energy are based on the flawed calculations of Diab and Eskom, and also exclude offshore wind potential, which is not included in their report to any significant degree. Further calculations confirm that the practical application of wind power in SA is in the order of 50GW, not forgetting that only 1% to 2% of the land is actually used – the balance is still productive land.


Micro wind

Micro wind is simply small wind turbines – many places around the world have been using micro-wind power for years, with local communities making their own wind turbines. One of the best applications for these is for charging batteries, which usually have to be carried long distances to receive charging.

The wind turbines on the right have been made by local communities. (ITDG projects)

Hydro-energy

For centuries, people have been using the energy from small amounts of moving water ("hydro-energy") to grind grain - like the Josephine Mill, next to the Newlands sports ground in Cape Town. In the last hundred years, however, engineers have built massive dams to hold back large amounts of water, and then let it out to run through big turbines, to generate hydro-electricity. But these big dams have equally huge environmental problems (like the Narmada Dam in India and the Three Gorges in China, as well as our own Lesotho Water Highlands project) and some wise governments are moving back to small hydro-electric generation (or "micro-hydro"), as this has little impact on the environment. We can build micro-hydro schemes on small rivers and equally small dams. If we use local technology and skills, we can also create local jobs. In some countries such as Sri Lanka, micro-hydro can supply up to 90 percent of people's energy needs.

Micro-hydro is the most appropriate onshore water based technology for local use, given the distribution of water resources. Much more local benefit will flow from micro-hydro than large scale environmentally and socially disruptive hydro dams.

Micro hydro in genuine run-of-river schemes means that the flow of the water is not blocked or dammed, and is usually less than 10 MW in size.

Bio-energy

"Bio" means "life", so "Bio-mass" is the raw material of living things. "Bio-fuels" are the kind of fuels we can get from "bio-mass", and the outcome is "bio-energy". So we can burn bio-fuels directly, such as wood, but we can also change bio-mass, such as sugar-cane or beet, into gas. We can also change bio-mass chemically into liquid fuels, such as ethanol, which we can then use to generate electricity, or burn as transport fuel. The left-over mush (or "slurry") can then be used as compost. We can call wood and other bio-fuels sustainable and renewable, if we harvest them in a way that does not destroy the environment. In many countries, bio-gas "digesters" are used to produce gas for homes or communities, and in Denmark 20 large bio-gas plants currently digest wastes from animal and food-processing wastes. We can also capture usable gas from sewage.

National security is an issue with imported fossil fuel. A reduced need for imported oil will make us less dependent on outside sources, and will also insulate us from increasing oil prices, foretold by varied sources such as Mathew Simmons (American oil advisor) and Al Qaeda. The last two years alone, from 2004 to 2006, has resulted in oil prices leaping from about US$25 per barrel, to about US$75 per barrel, resulting in much higher petrol, diesel and paraffin prices, and many increases in food prices. A large, distributed network of biofuels plants is also much more secure from terrorism than a few large refineries greatly reducing transport costs, thereby enhancing the energy efficiency of the economy. A competitive alternative to oil will provide more consumer choice and price competition at the pump, as well as generating many more sustainable livelihoods / jobs. Biofuels can be more environmentally friendly, resulting in cleaner air, soil and water.

Biofuels have the potential to dramatically reduce Green House Gases, helping prevent global climate change. A key issue with crop based biofuels is the use of food crops for fuel for the rich – it would be both morally and ethically unacceptable to increase food production for fuel, while people are starving. The use of increased land for this is also unacceptable.

Types of biofuels

Methane – usually in gas form, although this can be liquified and transported.

Ethanol – produced in liquid form, as a petrol additive / subsititute, and some engines can run directly on ethanol such as racing cars.

Bio-diesel – produced in liquid form, manufactured from vegetable / algae oils

Butanol can be produced by fermentation of biomass with the bacterium Clostridium acetobutylicum,

Methane

Methane is produced when organic matter decomposes in the absence of air (anaerobic decomposition / composting). Sources of methane include human and animal sewage, and collected organic material. This is a far better option than both flush toilets (which add to the pollution, while not recovering either water or nutrients for food and other agricultural uses) or dumping organic matter in "landfills " – another name for a rubbish dump.

Anaerobic biogas digestion is a 3000 year old technology that can be used to co-digest food and sewage waste to produce energy in the form of methane rich biogas which can be used for heating, cooking and electricity production – basically, as we would use LP gas today.. Biogas digesters can be used to generate copious amounts of gas from farm wastes and residues, sewage, municipal biodegradable wastes and food industry wastes. Another advantage of this process is that the "waste" is actually a high quality compost, which can be used to grow mushrooms or fish food, and then after even a second use, still be good quality compost.

The digestion of animal waste has the greatest energy potential, for example the faeces of a single dairy cow can produce 9kg of LPG equivalent gas in 20 days. Energy from Biogas Digesters can be part of closed loop resource systems and therefore as close to 'zero carbon' as possible using biomass for energy. Combustion of biogas produces lower levels of green house gases (GHG's) and other pollutants than liquid biofuels and wood. Biogas Digesters have many other environmental benefits, namely:

- Emissions of the powerful GHG's methane and nitrous oxide from decomposing wastes are avoided.
- BD effluent can be used to substitute nitrogen fertilizer inputs and avoid associated damage to soils and ecosystems.

- Fibrous residues and sludge waste can provide organic matter for improving soil organism diversity and activity, improving water retention capacity in drought and helping to reduce erosion rates
- Chemical free waste water recycling
- Waste to Landfill collection and disposal costs

Over 20 years of operation, the Rural Energy Offices in China have installed 180 million energy saving cook stoves and nearly 7 million household biogas systems in rural areas. China has one of the most successful biogas programmes in the world. Since 1985 there has been a dedicated and comprehensive development plan for biogas dissemination, which has been incorporated into the national five year economic development plans and fed through to each level of national administration (state, province, prefecture, county, district and township).

There are hardly any biogas systems in South Africa, both because electricity is perceived as being cheap, and the cultural issues around the use of sewage – people have been taught that sewage is dirty, and that therefore the gas must be dirty too – nothing could be further from the truth, as burning bio-gas is much, much cleaner than burning paraffin, for example.

The current trend of collecting methane from rubbish dumps ("landfills") is a good one, but burning that gas near people is not a good idea, as the volumes being burnt are high, and this increases local air pollution.

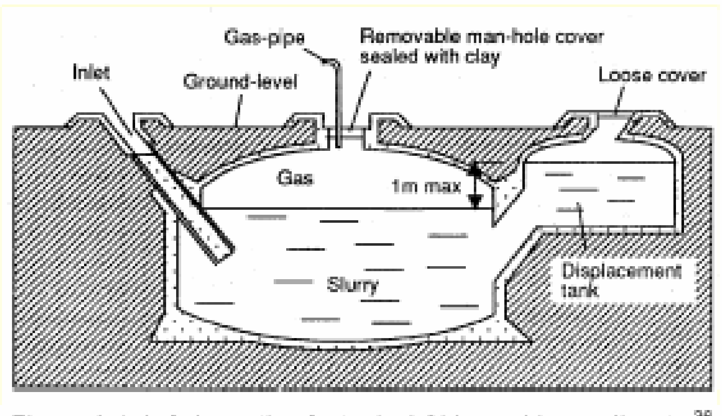


Figure A 1.4: Schematic of a typical Chinese biogas digester[38]

Ethanol

Ethanol is made by fermenting and then distilling starch and sugar crops -- maize, sorghum, potatoes, wheat, sugar-cane, even cornstalks, fruit and vegetable waste. Potential sources would include sugar cane bagasse; restaurant (putrescible) waste and other organic resources. Depending on the raw materials (wastes) available, it may be necessary to apply the cellulose based method for ethanol production.

Ethanol (ethyl alcohol, grain alcohol), according to the US Department of Energy's National Renewable Energy Laboratory, is a "clear, colorless liquid with a characteristic, agreeable odour" and is made from the sugars, starch or cellulose in plants and blended with petrol.

Ethanol is also a high-performance motor fuel that cuts poisonous exhaust emissions and is better for the environment. Henry Ford designed the famed Model T Ford to run on alcohol -- he said it was "the fuel of the future". The US now uses more than 60 billion litres of cleaner, ethanol-blended petrol a year, totalling 12% of fuel sales in the US. Most of it is a 10% blend, but 85% and even 95% blends are now being tested. Ethanol blends are increasingly used in South Africa, while Brazil, the world leader, produces four billion gallons of ethanol a year: all Brazilian fuel contains at least 24% ethanol, and much of it is 100% ethanol (engines can be designed to run on 100% ethanol).

Chrysler, Ford, and General Motors all recommend ethanol fuels, and nearly every car manufacturer in the world approves ethanol blends in their warranty coverage. Over two trillion miles have been driven on ethanol-blended fuels in the US since 1980.

The benefits of ethanol:

- Much cleaner fuel than petrol, and leads to a significant reduction in harmful emissons.
- Is a renewable fuel, which does not increase GHG’s, and is biodegradeable.
- Provides high octane at low cost as an alternative to harmful fuel additives
- Blends can be used in all petrol engines without modifications

Reductions in harmful emissions:

§ carbon monoxide levels more than any other oxygenate: by 25-30%
§ nitrogen oxide emissions by up to 20%
§ Volatile Organic Compounds (VOCs) by 30% or more
§ net carbon dioxide emissions by up to 100% on a full life-cycle basis
§ dramatically reduce emissions of hydrocarbons, a major contributor to the depletion of the ozone layer,
§ significant decrease in Sulphur dioxide and Particulate Matter (PM),
§ reduced emissions of cancer-causing benzene and butadiene by more than 50%.

A good way in which to manufacture ethanol is to use food waste – especially fruit, as anything with a high sugar level can be made into ethanol – so, markets, fruit processing and juicing factories, etc. are all potential sources of raw materials for ethanol production.

It is estimated that a minimum of 1500 South Africans die annually[1] from unsafe paraffin stoves. Ethanol can be turned into a gel, and used in stoves similar to those we use for paraffin. Ethanol gel is a far superior fuel, especially as children are less likely to drink the gel (as it is quite thick); and there are even stoves that go out when knocked out, instead of turning into a fast spreading fire, as happens regularly in our townships, and especially in informal settlements. Ethanol manufacture, distribution and use creates far more local employment than paraffin.

Butanol

Butanol can be produced by fermentation of biomass with the bacterium Clostridium acetobutylicum, also known as the Weizmann organism, as it was Chaim Weizmann who first used this bacteria for the production of acetone from starch (with the main use of acetone being the making of Cordite) in 1916. The butanol was a side effect of this fermentation (twice as much butanol was produced). The process also creates a recoverable amount of H2 (Hydrogen, which can also be used as an energy source)[2]

Butanol sees use as a solvent for a wide variety of chemical and textile processes, as a paint thinner, as well as a component of hydraulic and brake fluids. It is also used as a base for perfumes, but on its own has a highly alcoholic aroma.

Butanol may also be used as a direct biofuel in any standard internal combustion engine engineered for gasoline usage (such as a modern car). Butanol is reported to yield 36,000 kJ/kg (15,500 BTU/lb) when burned. This can be expressed volumetrically as 29,200 kJ/l (104,800 BTU/US gal). This means that switching a petrol engine over to butanol results in a fuel consumption penalty of only 10% without engine modification. But as butanol's octane rating is 25% higher than petrol's, increasing the compression accordingly could make 25% more power and >10% more mileage than petrol.
Note: EEI's David Ramey claims that butanol's mpg is considerably better than gasoline's, even with no engine modifications. This may make sense as higher octane ratings constitute slower burning, so better energy transfer and efficiency result, leading to better mileage (if the lower energy content is naturally overcome) without modification

[1] Paraffin Safety Association
[2] Wikipedia

Bio-diesel

Most people do not know that the original diesel engine was designed to run on peanut oil! The diesel we have become used to is a new product, made by fossil fuel companies as a replacement for the original natural product.

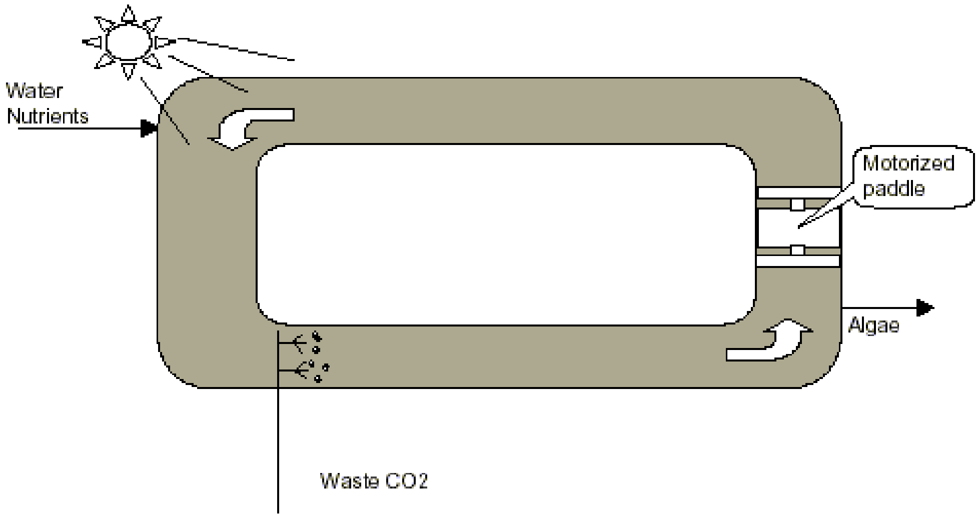
Normal non-injected diesel engines can run on vegetable oil as they are, the only two concerns being that there should be no rubber between the fuel tank and the pistons (oil destroys rubber) and that on cold days in cold areas, the oil sometimes gets too thick to flow. However, some advances have been made in this regard, with the production of bio-diesel, which is vegetable oil converted to a diesel-like product, that can be directly substituted for fossil diesel. This is made by following a process called trans-esterification, which requires the addition of methanol, and the separating of the oil into glycerine and biodiesel – the glycerine "waste" makes nice soap!

The most obvious raw material for biodiesel production is waste vegetable oil from food outlets, restaurants, factories and hotels. This will require either a partnership with organisations currently collecting oil (such as the Rose Foundation), or a separate collection system, with small scale producers at the local and localised levels, to keep transport overhead low.

A very exciting alternative to using food crops as a renewable oil source, is that of oil produced from algae, that green scum normally seen on stagnant ponds. Simply put, algae is grown on media such as sewage, and then harvested (depending on the type, up to 80% of the algae can be oil) and then converted, as any vegetable oil, into biodiesel. South Africa covers 122,3 million hectares – the current estimate is that about 0.01% of the country will produce all our liquid fuel needs if we use the biodiesel from algae process, based on sewage as the feedstock .(90 000 hectares – the size of a few game farms) A single acre of algae ponds can produce 60 000 litres of biodiesel in comparison, Soybeans produces up to 240 litres of biodiesel per acre, Jatropha produces up to 800 litres per acre (while also poisoning the land) and Coconuts produce just under 1200 litres per acre. Palm oil -- currently the best non-algal source -- produces up to 2600 litres per acre. That is to say, algae is up to 25 times better a source for biodiesel than palm oil, and 300 times better than soybeans.

Some benefits of algae based biodiesel:

- No chemicals
- Improved compostable sewage waste
- Low costs
- Low input costs and low energy input
- Crushed algae is a valuable animal feed



As can be seen above, waste carbon dioxide can also be fed into algae production, helping algae grow faster.

Hydrogen

Hydrogen is touted as the “fuel of the future”, particularly for vehicles. This thinking appears limited in practicality and pragmatism. There is no infrastructure for hydrogen delivery to point of sale, nor indeed, at point of sale; therefore, very few hydrogen based vehicles being designed or manufactured, but the infrastructure is not in place because there are so few hydrogen driven vehicles in the marketplace!

The energy used to “make” hydrogen must be from a renewable source, or else the energy balance is in the negative i.e. it takes more energy to make hydrogen than we get out. If hydrogen manufacture is RE based, then the energy balance can be good. Using existing potable water is problematic – it is a lot more logical to investigate the use of seawater as the raw material for hydrogen – the potential for OTEC here is significant, as potable water is a by product of this ocean energy technology.

The most practical and pragmatic use for hydrogen at the moment is for fuel cells – which, while expensive, are appropriate as part of the energy mix. Fuel cells are devices that combine the basic elements of hydrogen and oxygen to produce energy and water. Many people see them as a good way to store energy from natural sources, such as solar and wind. This is because fuel cells need some energy first to produce hydrogen, which can then be made into electricity. Fuel cell technology is growing fast: some of the big motor companies want to have products on the market by 2003. Many cities around the world are already testing fuel cell engines and these engines could soon replace the noisy, polluting car engine we know so well. Fuel cells produce energy “on tap” and can also be used as small, portable power plants (much better than pebble-bed reactors). Another advantage of hydrogen fuel cells, is that we can use intermittent (as well as other) renewable technologies to produce the hydrogen.

The simplest technology to make hydrogen appears to be the use of simple and well-known electrolysis, with the waste products being oxygen and salts. It would be of use to direct the 'waste' oxygen to commercial applications such as a bleaching alternative to chlorine in the paper industry, or similar.

Geo-thermal energy

When the heat from the centre of the earth ("geo-thermal" energy) is close enough to the surface, we can use it to heat water, and so generate electricity. Global usage is growing very fast and now stands above 8000 MW. Geo-thermal energy is not dependent on the weather and can be utilised 24 hours a day.

While this document does not claim to be inclusive of all technologies and options, it is considered a useful basic document on energy.

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What is the Institute for Zero Waste in Africa?

Our Mission Statement

Working towards a world without waste through public education and practical application of Zero Waste principles.

Charter Principles

1. Redesign products and methods of production to eliminate waste by mimicking natural processes and developing closed-loops
2. Convert waste to resources for the benefits of local production and the creation of a healthy and sustainable society.
3. Resist incineration and land filling in order to promote innovation in resource conservation and methods of production
4. Collaborate with others with common interests worldwide

Objectives

1. To advance the education of the public by all appropriate communication means and through supporting the elimination of waste and the associated health impacts.
2. To promote and fund appropriate research for the public benefit, including education
3. To promote the effectiveness of other Zero Waste initiatives
4. To promote the principles of waste avoidance and minimisation, re-use, repair, recycling and composting, through sustainable resource management in accordance with best environmental options.

Institute for Zero Waste in Africa

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