Sustainable Living Programme
2008 Edition

Energy – seeing the bigger picture

We use energy to heat our homes, to power a train or a bus... Listening to a recording on a CD player uses energy. Without controllable energy there would be no TV, no computers and no cars. A lot of the comfort we experience in our 21st Century lives and most of the production of essential items is related to our easy access to energy in its different forms, and to *cheap oil* energy, too. Electricity prices have risen 50% since 1999, too, so maybe not cheap!

In Maori tradition, energy is an even broader concept. Energy flows include the living vibrations of the land and its people present and past, so that the greatest challenge is the channeling rather than diffusion or dispersal, of available energy.

In Western science, we can describe several basic forms of energy movement as we experience it. Light and heat shining from the sun or a lamp, is known as **radiant energy**. **Chemical energy** refers to the stored energy in, for example, carbohydrates and proteins in food or the propane and butane in bottled gas, and the energy in oil. **Conducted energy** includes geothermal energy transferred through water from hot rocks below the Earth's surface. **Kinetic energy** is seen in moving parts while **electrical energy** is described by the product of voltage potential and the current that flows once a circuit is made. Energy is neither lost nor created, it is just converted from one described form into another.
This is what is known as:

Conservation of energy:
You can't create or destroy energy but it can be converted from one form to another. The total energy of a closed system is constant.

Apart from solar input and radiation of energy back into space, the Earth is closed system.

You can change energy from one form to another, for example, stored chemical energy into heat, by oxidation (burning fuel and rusting are both e.g.'s of oxidation), for heat that will boil water and make steam, expanding steam to push (with kinetic energy) a piston or turn a turbine, that generates electrical energy. This can be transmitted long distances by cable and turned into light, in a light bulb, or sound in an audio speaker system, or heat in a range or hot-water cylinder. There are 'losses' at each transfer which have the effect of warming the air, of dispersing energy.

Energy-flows are essential to human life. Muscles use chemical energy to do the work of living, such as our heartbeat, breathing, walking and digesting the food. Even when resting, we need energy from food plus a background temperature of 16 to 20°C to be healthy. When we're active our chemical energy

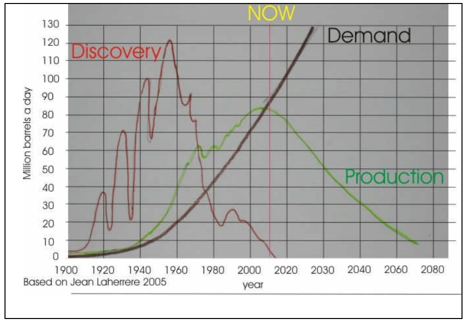
requirement from food rises. The muscle movement warms us, so that we can cope better with cold air.

Our personal energy supply is from food, especially carbohydrates (such as potato and grain starches, sugar in fruit), in fats (butter, oils, meats, some seeds) and in proteins (beans, meat, fish, nuts and grains). There is more than enough energy in a few slices of buttered bread to power a bicycle ride across town, for example.

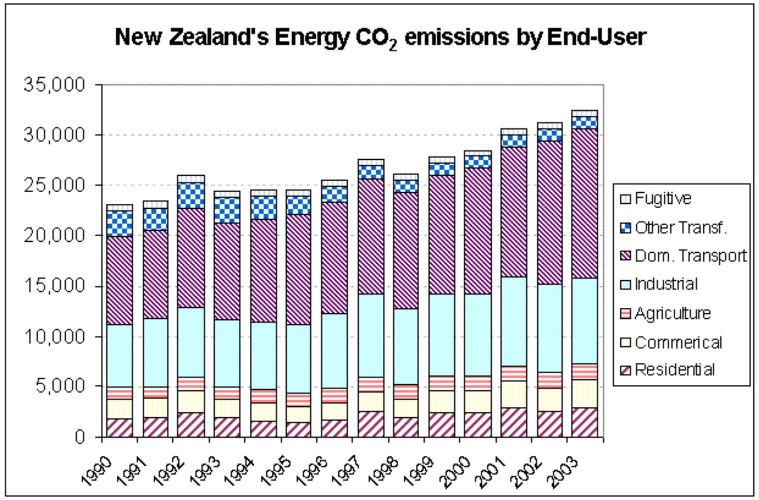
Energy from food
Domesticated animals convert the plant-stored energy quite inefficiently. It takes over four times as much grain to feed chickens or cattle raised for human consumption as the quantity of grain required to feed the same number of humans directly (but grain feeding typically applies to intensive agriculture in Germany or USA, not pastoral farming New Zealand style). Eating meat from animals is less energy-efficient than eating plants directly.

Photosynthesis is where the energy in food originally comes from
The carbohydrates mentioned earlier, along with other chemicals, are made in nature by green plants, and acquired by animals when they eat plants. The green plants capture their energy from sunlight and make the chemicals in their cells from soil minerals, carbon dioxide (CO_2) and water using photosynthesis - meaning 'put together by light'. Photosynthesis captures the sun's energy. Plants store energy chemically.

Geological accidents have preserved some of this historic energy.
Over hundreds of millions of years, forests and peat swamps filled with dead plants became covered by clay silts, which trapped the carbon and hydrogen compounds where they could not react with oxygen from the atmosphere and break down. Compressed by the weight of material accumulating above, they formed into **fossil fuels** – solid coal, liquid oil and pockets of gas, which very recently (in geological time), humans have begun to extract and burn. Fossil fuels are called non-renewable because once burnt, or used, they are gone for good. Nature does not make more anywhere near as fast as we are burning them. We may have already reached the point where annual world oil and gas production has levelled and begins to drop although demand continues to rise See website: www.peakoil.net



Our rate of fossil fuel use in transport, electricity generation and industrial processes has grown rapidly, and with it our CO_2 emissions. In a decade, NZ saw a 22% rise in CO_2 emissions, from 25.5 million tons emitted in 1991 (1990 the 'benchmark year' for Kyoto Protocol) to 31.1 million in 2001.

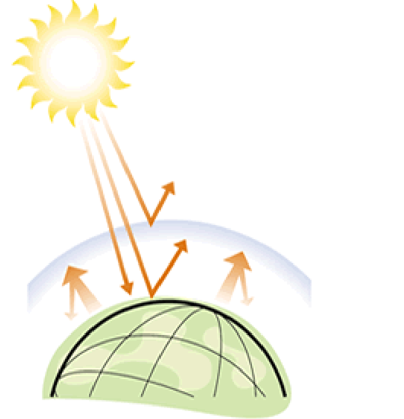


Global warming in simple terms

Sunshine (radiant solar energy) warms the Earth's land and oceans and is re-radiated outward to space, with a balance surface temperature reached somewhere between the freezing point and boiling point of water. Some of the re-radiated heat is retained in the atmosphere by naturally occurring 'greenhouse gases' such as CO2, nitrogen dioxide (NO_2), methane (CH_4) and especially water vapour. This is known as the **natural greenhouse effect.**

Without any natural greenhouse gases, earth would be roughly 30 degrees cooler (-16 degrees C) and life as we know it would not exist. However, Earth's heat is being retained more effectively today than a century ago by the greater concentration of greenhouse gases in the atmosphere, which is causing the atmosphere to become warmer and warmer. This temperature rise is known as the **enhanced greenhouse effect.**
(see diagram on next page)

Most scientists believe that extra greenhouse gas emissions from human activity are large contributors to global climate change. Global concern in the 1990s led to the Kyoto Protocol that committed developed countries such as NZ, Japan and the EU to reduce their greenhouse gas output.



Natural greenhouse effect
Sun's energy trapped by water vapour and gases in the atmosphere. It is a natural process but recently (100+ years) there's an
Enhanced greenhouse effect
Earth is being heated up by the thickening 'blanket' of greenhouse gases including carbon compounds from burning forests and fossil fuel sources, plus livestock gut methane gas emissions and agricultural nitrous oxide, plus extra water vapour in highest- altitude clouds (in part from jet aircraft).

The Kyoto Protocol will come into force for those signatory nations in 2008. There had been resistance to ratifying the Protocol by the USA and Australia, but Australia is now supporting it (2008).

As a signatory, New Zealand's target is a reduction in greenhouse gas emissions back to 1990 levels, over the period 2008 to 2012. Currently our emissions are more than 5% above 1990 levels. The New Zealand Government has released a policy package that will assist us to achieve our target. This can be found on www.climatechange.govt.nz. New Zealand can meet its target by reducing its gross emissions of greenhouse gases, growing forests (which absorb carbon dioxide from the atmosphere) to offset emissions, and/or by helping other countries to reduce their emissions.

Kyoto does not rely on the reduction of just one gas in order to achieve our target. This is especially relevant to the NZ case, as the main source of emissions here is methane, which is 21 times as strong as CO_2 in its warming effect. Methane gas (CH_4) is largely produced in the gut of ruminant farm animals (such as cows and sheep) and in other countries also from rice cultivation within flooded fields. Other methane sources include landfills, burning plant matter, leaking coal mines and landfill venting. Each molecule of methane is much more potent as a greenhouse warming gas than CO_2 although total quantities released into the global atmosphere are smaller. NZ has very large numbers of sheep and cattle, making methane emissions and agricultural nitrous oxides significant for us. Agriculture produces over half of NZ's total greenhouse gas emissions (NZ emissions comprise about 43% CH_4, about 16% NO_2, and about 40% CO_2).

Burning the fossil carbon store
Fossil fuels release CO_2 gas when they burn (oxidise), which in itself is not a harmful substance. But fossil fuels are a limited 'resource' of carbon that is being burnt millions of times faster than the rate at which they were originally stored (taken out of the atmosphere) by nature.

The proportions of oxygen and carbon dioxide in the Earth's atmosphere are changing. Increasing CO_2 in the atmosphere today is directly related to fossil fuel burning, and also influenced by loss of carbon-storing soils and forests, from fires and forest clearance. Measurements show that **the concentration of CO_2 in the atmosphere is now higher than at any time during at least the past 420,000 years,** if not several million years.

Electricity generation releases CO_2 when fossil fuels such as coal or gas are burned to power the generators. In contrast, electricity generated from hydro lake storage, from wind generators or geothermal steam, does not release CO_2 (only after the construction stage, which itself involves energy-intensive production of concrete or metal, and vehicle use). Burning wood also releases CO_2 but because trees absorb CO_2 from the atmosphere to grow, the net impact of burning wood is neutral. The more trees we plant, the more CO_2 is absorbed.

Living on a greenhouse planet

There is increasing evidence that the Earth is warming up, and that it is already leading to shrinking glaciers and sea ice, and is affecting the flowering times of plants and the migration patterns of birds. The climate is changing, bringing greater variability in weather, which may have major agricultural impacts such as floods and droughts. A rise in sea levels can threaten coasts (where many cities have been built). Some Pacific Islands, such as Tuvalu, may have to be evacuated in the long run due to sea-level rise, tropical cyclones and dying coral reefs. For NZ, global warming could see

- a rise in average sea level by perhaps 10cm by 2030 and 40cm by 2100;
- up to twice the frequency of heavy rain and associated floods (especially on the West);
- more droughts on East coasts of NZ and a degree rise in average temperatures by 2030
- Snow lines and glaciers will retreat. Some ski fields close.
- The temperature change, and especially less frequent frosts, will be sufficient to begin altering the growing regions of crops and living places of pest insects.
- We would have more uncomfortably-hot summer days in cities, too, especially in Auckland and Christchurch.

(Source of these 2004 projections: NZ Government, Climate Change office. Since then, sea level rise projections are higher)

One of the problems associated with climate change is that once started, it is very hard to stop. Our past and present emissions of greenhouse gases have already committed the Earth to a substantial warming that will continue for the rest of the 21st century, and sea-level rise will continue for several more centuries, fed by flow of ice from land to sea (Greenland, Antarctica, Himalayas, etc.) Melting of permafrost in Siberia would also release methane gas from beneath the surface, itself a more potent greenhouse gas than carbon dioxide, which would contribute to a run-away warming effect.

Energy use in New Zealand

Although New Zealand's small population contributes under 1% of the world's total greenhouse gases, when calculated per person our greenhouse gas emissions are amongst the highest in the developed world. This is because

of both our high emissions for agriculture (methane and nitrogen oxides), and also because we are relatively big users of fossil fuels per person, especially in vehicle and freight transport. Our per-person CO2 emissions have been growing steadily.

As demand for electricity has grown in New Zealand, so has our use of gas-burning power stations. According to Ministry of Commerce back in1997 the majority of New Zealand's electricity was generated through hydro-power (about 79%) but its fallen since then. Geothermal steam accounts for about 6% and fossil fuels the remainder: gas 12% and coal 1%. However, a growing share of our electricity today is being generated by burning fossil fuels. From this mixture of energy sources it can be calculated that the statistically average NZ household's electricity use of 7,240 kilowatt hours (from the Year 10 HEEP report) creates 1,086 kg from the currently used average emission factor of .15 kg CO_2/kwh of carbon dioxide in its generation (data from NIWA, 2002). *In Australia the same level of electricity use creates a much higher carbon emission, because its generation is mostly by coal-fired power stations.* New Zealand has large coal reserves, but the carbon emission impact and toxic air pollutants created by coal burning have deterred greater use. Successive governments have had popular policies of being nuclear-free, so nuclear electricity generation is not used, in contrast to the UK, France and USA. Radio-active waste re-processing and indefinite safe storage is a very expensive and uncertain area.

Reducing peak demand by electricity conservation is an alternative to electricity generation and saves on the construction costs for power stations and transmission lines. Each kilowatt of power saved by a consumer is worth several made at the generator, because of inefficiencies in transmission over long distances. In the longer term there may be increased NZ commitment to distributed generation, with a premium tariff paid to local generators who feed in to the grid (from solar power, or wind), saving on central generation capacity. (http://refit.org.nz/about-fits)

The largest contributor to carbon dioxide emissions from NZ households is the oil & petrol use in vehicles. See the *Travel* notes in this series to find out more.

For further information see the National Energy Efficiency and Conservation Strategy, at www.eeca.govt.nz and EECA's site for households at www.energywise.org.nz

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Rediscovering alternatives

The NZ Government's commitment to the development of renewable energy sources such as wind and sunshine, also bio-fuels (crops grown for energy content) along with a large base of hydro-electricity generation, provides a good start for shifting away from fossil fuel dependence when demand for power grows, without using nuclear.

A world-wide search for alternatives to fossil fuels in renewable energy sources is under way, including active solar water-heating on house roofs, making solar-electricity from sunlight (photo-voltaics), passive-solar house heating design and electricity from tides, waves and wind-turbines. NZ's own wind-turbine construction began in Christchurch, (www.windflow.co.nz) supplying at least one 'wind farm' and several electricity generation companies now manage hill-top 'wind farms' of imported turbines, e.g. in the Manawatu Gorge and Tararuas.

A wind-farm of three-bladed turbines in the Tararuas. These are now generating for the NZ grid.

Wind turbine blades for the *Windflow* two-bladed turbine, constructed in Christchurch and operating since 2004.

The role of wood.
Wood is 'carbon neutral' because, when burned, it releases only as much CO_2 as the tree had absorbed during growth. This only applies though if the wood harvested for burning is replaced by growth in new plantings - so that on average we continue to grow as much tree timber as we burn.

Meanwhile, all burners of fossil fuel need to be much more efficient to get more useful energy out of any carbon fuels that are burnt, to control costs on a dwindling (and increasingly expensive) resource, and to reduce the extra greenhouse warming effect.

Should we switch from burning fuels directly for heat, to electric heating?

Heating rooms and hot water by electricity does not avoid CO_2 production on the 35% proportion of the power that comes from coal and gas-fuelled power stations. You cause the release of at least two times more CO_2 by using electric heating from a fossil-fuelled power station than you would by burning the same amount of fuel directly where you need the heat. This is because a coal or gas-fired power station is an inefficient energy-converter from the chemical energy in the fuel and a further significant loss occurs in power transmission before the electricity reaches your house. However, if you burn fuel directly it must be clean burning, or you create a new problem locally (air particulate pollution) to replace the carbon inefficiency. Look up the Clean Heat Programme of Environment Canterbury to read about this. http://www.cleanheat.org.nz/why-clean-heat.html

Space for your notes