The super low energy house

Tom Chalko's household uses about 0.8 kWh of electricity per day. If he had to buy electricity from the grid, it would cost less than $50 per year. He tells us how he achieves this extraordinarily low power use.

Our so-called civilisation is based on waste. Most people on Earth assume that all resources (including energy) are unlimited and the only limit is what they can afford. Energy demand grows steadily and our leaders consider only one solution: build more power stations. It doesn't even cross their minds that the more energy people are given, the more they will waste.

I wonder why no leader in the world considers another approach: increasing energy efficiency in an effort to reduce the demand for energy.

Energy production from fossil fuels in Australia is only about 20% efficient. This means that for every 1kWh of electrical energy produced, 4 kWh is wasted, mainly via various chimneys (see Fig 1). Power transmission lines waste another 7% of the energy they transmit. So, when we waste electricity produced from fossil fuels, our waste is amplified about five times. Electricity is great, but wasting it is an environmental crime.

It is a well-known trait of human nature that we only think when we have to. My own road to energy efficiency started when I had to live with a limited energy supply.

In 2002 I could only afford a combined wind and solar power system with the capacity of about 2.5kWh per day. Having paid no attention to energy efficiency for the previous 50 years of my life, I initially struggled with chronic lack of energy. Today, after numerous improvements to my household appliances (and my lifestyle) my wind and solar power station can power three households like mine, if they existed nearby. I have spare energy for welding, soldering, machining, power tools and a multitude of projects that I enjoy undertaking.

Right: Tom Chalko's solar hot water system with solar collectors inclined for winter sun. Note the well-insulated pipes and the electronically controlled instantaneous gas booster.

Only after minimising energy waste and achieving energy efficiency does transition to renewable energy sources begin to make sense. Those who do not aim for energy efficiency cannot even begin to imagine relying on renewable energy.

Since my energy efficiency ideas apply to almost any household, I decided to share them in this article.

Measuring energy consumption

My first step was to identify 'energy thieves' in my household. This was necessary to develop a strategy that could give me the maximum possible improvement in energy efficiency and the maximum comfort for the limited budget I had available. Initially I purchased a portable energy meter, but eventually installed a permanent one, so that I could monitor my total energy consumption at a glance. My permanent energy meter is a modified Altronics energy meter (kit K4600), depicted in the picture overleaf. I changed the transformer in the meter to improve its own energy efficiency, improved the built-in battery charger and installed a NiMH battery with 900mAh capacity so that the meter could reliably remember its measurements after my inverter went dormant for many hours.

Reducing electricity consumption

Being able to measure the power consumption for each and every appliance in my household, I took the following steps to reduce my demand for energy.

Lights: I have changed all globes to compact fluorescent lights, because they consume about one fiftht less energy than standard globes that produce a similar amount of light. Initially I wasted some money on cheap/under-

developed lights that were noisy, unreliable or had unpleasant light. I downgraded these lamps to garage and workshop use and replaced them with lights that I tested to be silent and pleasant to use.

Fridge: I have turned a chest freezer into a fridge by adding an external thermostat. The thermostat cuts the power when the temperature of my choice (+5ºC) is reached. This solution takes advantage of the fact that cold air is heavy and reduces the energy required for home refrigeration to one tenth, depending on the quality/size of the freezer and climatic conditions. A chest fridge becomes quite insignificant in the household energy budget, because its daily energy consumption is somewhere between 0.1 and 0.2kWh. Details of my chest fridge solution were published in *Renew* 90 and 92, and the summary is available at mtbest.net, in case you cannot find the above issues in a hurry.

Standby power: Many household appliances (TVs, VCRs, microwaves, ovens, washing machines, power plug-packs, transformers, chargers, lamps, clocks etc) consume power even when no one uses them, even when no one is home. The energy waste from standby power is responsible for 10% of the total energy consumption in buildings around the world.

Minimising the standby power consumption turned out to be my greatest challenge. For inverter-powered households like mine, elimination of the standby power waste is actually very important. The reason for this is that a typical 2.5kW power inverter needs about 20watts to be fully powered up. Most good inverters have a sleep mode that consumes much less energy. However, in order to enter sleep mode there has to be no power demand from household appliances. The problem is serious: 20watts for 20 hours is about 0.4kWh. As you can see, an inverter alone can consume 50% of my current daily consumption of energy.

I began with my chest fridge and demonstrated to myself and everyone else that zero standby power consumption of house appliances is achievable. My chest fridge consumes zero power when its compressor does not work, and my power inverter can enter an energy saving mode for as long and as frequently as possible.

With other appliances I adopted the following strategies:

- I used power boards to power groups of devices that work together. For example my computer, printer, modem, router etc. are powered from one power board, so that I can power down the entire group by flicking just one switch. This strategy ensures the printer cannot be left on when I turn my computer off, for example.
- For appliances that are used solo, such as a microwave, I try to discipline myself to turn them off at the power point as soon as I finish using them.
- Before I go to bed and before I leave the house for more than an hour, I check my energy meter to see if something is still powered up. Then I make sure that I achieve zero power consumption by turning off devices that someone forgot to turn off.

Computer: Since I use the computer and internet for at least five hours each day, I decided to use a laptop instead of a desktop. My Dell laptop and two-way satellite internet system (transmitter and receiver) consume together about 52watts. This is a fraction of the power used by even the best desktop. When I use my laptop I make sure that I power it from the mains so that its battery is always full. Laptop batteries typically have efficiency of only 50% so that from the energy efficiency point of view, it makes sense not to discharge them if possible. Powering the laptop from the mains has one more advantage: the laptop battery serves as a reliable UPS (uninterrupted power supply).

Above: Warming up a stew and water on the Morsø stove.

Other appliances: I have discarded my electric kettle and my toaster, because I concluded that life on Earth was better without these two energy thieves. For cooking I use a gas cook top and my wood stove, when it is on. I use the microwave, but only for reheating food. My electric rice cooker and bread maker both have well-insulated double-skin bodies and lids and are thermostatically controlled for automatic operation. Each of these devices is only used a few minutes per day (on average) and hence they do not ruin my energy budget. My Asko washing machine uses 0.2kWh per wash, which is quite negligible when I schedule my washes once or twice a week.

Reducing gas consumption

One of the greatest energy savers in a household is a well-installed solar hot water system. Please let me stress, 'well-installed'. I hear many complaints that solar hot water systems only work in summer. Solar hot water systems installed in a hurry usually miss the necessary insulation around pipes. In summer, the air is warm and the associated heat loss can be small. In winter, however, 10 metres of poorly insulated copper pipe can cool 50ºC solar-heated hot water from a roof tank to 30ºC at the tap, making it too cool

for a shower. If you want to enjoy your solar hot water all year round, you need to:

• Insulate all copper pipes very well, especially those carrying hot water. Just because solar energy is free it does not mean that it should be wasted. Our comfort depends on energy efficiency. My approach is illustrated in the photo of the solar hot water system. I use 90mm PVC rainwater tube around copper pipes that are covered with the best available foam insulation. PVC tube prevents UV deterioration of the foam, keeps the foam dry (for best insulation) and creates an air cavity, which in itself is a good thermal insulator. To protect the foam around curved tubes of the solar collector I used black polyethylene irrigation pipes, cut along their lengths for easier installation.

• Mount your solar collector at an angle that is optimal for winter sun.

• Install a solar collector and tank as large as you can afford. Mine has a 4m^2 solar heat collector and a 300 litre tank.

• Install a hot water booster for situations when you need more hot water than the sun can provide. I use an instantaneous, electronically controlled Bosch gas unit that I can power up whenever I run out of solar hot water. When it is off it does not consume any energy. In winter the solar-heated water passes through this unit, whether it is powered up or not. In summer I can by-pass the gas heater. The amount of gas that is used in the gas heater is proportional to the temperature difference between the outlet and inlet water. If I did not have a solar hot water system, the gas would need to heat the water from 10ºC (average ambient temperature in winter) to about 40ºC that I need for shower. On a cloudy winter day, the sun can heat the water to about 30ºC. This means, that water needs to be heated up by only 10ºC rather than by 30ºC. With solar preheating, my Bosch water heater can use 67% less gas! The practical energy saving is such that a 40kg bottle of gas used for hot water and cooking lasts my family and visitors for two years and two months (26 months). This rate of gas consumption prompts me to think about my own methane-generating plant to gain 100% energy self-sufficiency.

Tom's energy meter (modified Altronics kit) installed indoors next to the switch box, enables him to monitor power and energy use

Heating and cooling

Winter heating and summer cooling can waste a lot of energy if a house is not well insulated. For this reason I insulated walls, ceiling, floor (from underneath) and equipped all windows with either double-glazing or bubble-glazing (see *ReNew* 97 for bubble-glazing details).

My main source of heat in winter is a Morsø wood stove (pictured) that I equipped with a non-vertical flue to retain more heat and increase its heat efficiency to about 70%. This means that my wood stove is 3.5 times more efficient than fossil fuel power stations, simply because I do not attempt to change heat to electricity. My stove does not require a fan and its hot-top can be used to cook food.

In winter I take advantage of every moment of sunshine using reflective solar heating (see *ReNew 88* for details). Reflective solar heating works at the speed of light and reduces my solid fuel needs by about 60%. Not only does this save energy and reduce pollution, but it saves me time too, because I only need to source and prepare one third of the fuel I used to source.

In summer I use reflective blinds to reduce the amount of solar energy that enters my house (details are in *ReNew 94*). They work very well, providing that I do not forget to use them on the sunny side. For cooling I have installed four windows in the highest part of my house so that I can always let the warmest air out.

Water and waste

My household, garden and the native tree nursery are 100% water self-sufficient. I collect and store rainwater at higher elevation than my house, which enables me to use gravity to deliver pressurised water to my house, garden and the native tree nursery.

All waste from my household is biologically processed in a worm farm. Worms and the associated eco-system turn all solids into a liquid (a bio-processed grey water) that fertilises and waters my lawn. The worm farm uses gravity at all inlets as well as the outlet and does not use any power.

What next?

Conscious awareness of energy efficiency inevitably brings some logical changes to lifestyle, but this is a topic for another article. One aspect of this change I describe in my cookbook (mtbest.net/cookbook). ✻

For updates on Tom Chalko's house go to www.mtbest.net.