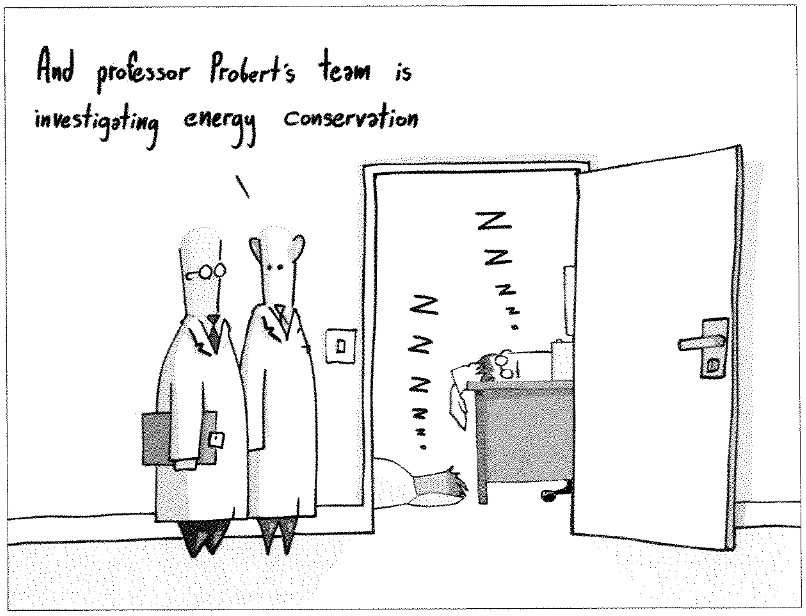
Alternative views of energy



Each person uses about 30 MJ of energy per day

For the last few years I have been looking at alternative sources of energy and trying to sell the benefits of them to the public. It is a bit like trying to get school kids to do physics. It seems that we like to live for the moment and rarely consider the future. Things are just fine as they stand, so why bother? Power is available 24 hours a day and only costs about 7 pence for a whole kilowatt-hour. That's dirt-cheap.

So how can we supply all the energy we need in a sustainable manner? If you were paid a salary for producing physical energy, then cycling a bike connected to a generator would probably be the best method of earning money. However, a fit cyclist would only earn about 2 to 3 pence an hour, and I don't think that many of us would "grid-link" our bikes together to bring in an income.

Even though energy efficiency has increased in many areas, the demand for energy continues to grow, outweighing the efficiency advantage. Televisions, for example, now use a fraction of the power that they needed 30 years ago. Yet in that time a plethora of gadgets has been added to the typical household inventory, including DVD players, surround-sound satellite set-top boxes and the like. These tend to be on 24 hour stand-by, drawing about 3–5 W continuously. They use as much energy in one day as a typical 1970s television did if left fully on for an hour.

As for cars, their engines are more efficient and they use lighter components than 30 years ago. Yet CD players, GPS, air-conditioning and antilock braking systems are now pretty much standard, offsetting the design advantages of the car itself.

So how much energy do we actually need? From a biological basis, each person uses about 3 kW – roughly 450 kJ per day – which essentially comes from food that we eat, which we convert into energy to move around and keep us warm. This is, if you like, the "base level" that every human being needs. But if you look at the additional energy we need to heat and light our houses, wash and dry our clothes, drive around by car and so on, we use something like 200 kW, which is about 30 MJ per day. This figure is even higher if we take into account the energy spent in manufacturing our possessions and food.

Most of this energy comes from the Sun, in one way or another. Fossil fuels are a great store of solar energy, banked over millions of years, but they are a finite energy source. So to keep the environment in its status quo, we can only really use the solar energy that falls on the planet, which provides a maximum of 1 kWh m^{-2}. Given that commercially available solar photovoltaic panels currently have a top efficiency of about 17%, every person on the planet would need about 100 m^2 of solar panels and 12 hours of sunshine a day to a maintain their current lifestyles – assuming no losses from storing or converting the energy. To run the world entirely on renewable energy would require a lot of space per person. Of course, some of the energy is available through wind power, biofuels, hydroelectricity and other sources, but the amount is still finite.

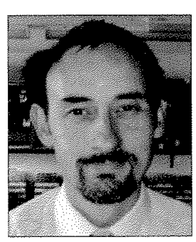
One hope for the future is to use hydrogen-powered fuel-cell systems, which convert chemical energy directly into electricity with heat and water as by-products. They are about twice as efficient as internal-combustion engines, which means that fuel cells could let us travel twice as far using the same amount of energy. However, hydrogen is not readily available in a pure and usable form, and energy has to be expended producing it. What is shocking is that a fuel cell only gives us back 40% of the energy needed to make the hydrogen in the first place. The losses in energy are the penalty for being able to store the hydrogen in a useful form.

If we use electrolysis to turn fossil fuels into hydrogen, we make the carbon-dioxide issue even worse since we get less energy back than it took to produce the hydrogen. If we use solar photovoltaics to do the conversion, we effectively reduce our useful output to about 7% of the potential energy. Developing fuel cells that can use fossil fuels or methanol might help, but would not completely solve the problem.

What other energy sources do we have? We can use geothermal and tidal sources, but they are currently limited and significant expansion may be difficult. The obvious energy source – and one that has been generating useful amounts of power for years – is nuclear power. It generates almost no carbon dioxide and seems to meet all the requirements for a good form of energy; but at what price?

Nuclear power stations use heat engines that are poor at extracting useful energy and that dump a lot of heat. Then there is the demon of nuclear waste; dealing with the waste makes the cost of this form of energy prohibitively high. There has been talk of using beams of neutrons or light to convert the waste into harmless products, but a working "transmutation" device is years away. Burying the waste seems the best solution, but this faces stiff public opposition as we cannot guarantee that the spent fuel will never come back to haunt us.

We could always consider reducing our energy demands and ration power to a limited number of watts per person, although this would affect our lifestyles and the economy. The only other option left is extremely controversial: to limit the total human population. Indeed, this dreadful scenario could occur anyway if we carry on using energy as we do; in a sense it is nature's way of controlling the planet. Is this really our future?



Mark Klimek is technical director at Solar and Wind Applications, Ayr, UK, e-mail mark.kilmek@solarwindapplications.com