NegaWatts before Mega-Watts – the importance of demand reduction

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In the current energy debate, most of the noise is between the various factions who wish to supply our energy, but very little is said about how we can reduce our demand in the first place. ***Chris Morgan*** *suggests that saving energy is the proper place to start the debate, and that once demand has been reduced, there is much less to argue about.*

Living off fossil fuels in so profligate a manner as we do today has always been something of an affront to those who survive without them, and to those future generations who will also have to do without. Even if new oil reserves are found beneath the shrinking Arctic, we still have to understand the folly of placing ourselves almost wholly at the mercy of one finite fuel source. With the world situation likely to get more, rather than less, volatile and with 'Peak Oil' fast becoming a reality (not to mention climate change), awareness of the need to find alternatives is picking up, with both renewables and nuclear lobbies finding more of a voice.

But in the ensuing clamour, the principal mechanism by which we could reduce global warming and wean ourselves off of coal, oil and gas has been overlooked. Our best chance, and perhaps our only real chance, is to use less, to conserve, to save energy. We should be investing in negawatts (energy saved), rather than megawatts (energy generated) – however these are supplied.

Reducing Consumption

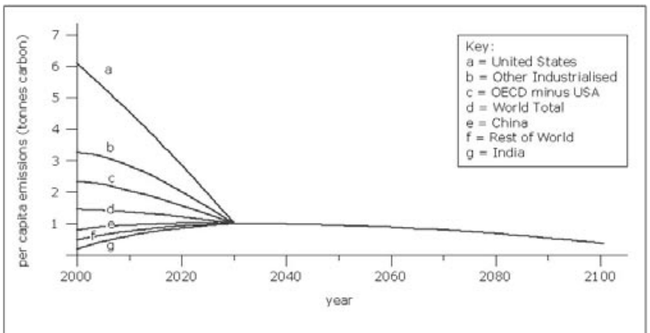
Demand reduction is our best chance, and perhaps our only chance, because the potential to save energy is so much greater than anything which can be conjured up by either the renewables or nuclear brigades. In addition, one watt saved is almost always cheaper than one watt generated, so there is plenty of financial incentive, not to mention the extra jobs associated with conservation. But no-one seems very interested...

Why has the need to conserve energy played such a small part in the energy debate? Perhaps it is because using less is just not something we like to do these days. As a society, we seem bound inextricably to consume ever more, in order to feed the apparent need for unlimited economic growth, and thus politicians who appear above all to need the support of business will tend not to promote such awkward notions. Perhaps it is also because we don't like change. In the construction industry, for example, the recent enthusiasm for renewables has probably got most to do with the fact that meeting carbon targets this way avoids the need to fundamentally address inefficient construction practice. We are not addressing the root of the problem, and until we do, the numbers will never stack up.

Contract & Converge

If we accept the need to reduce our energy consumption in the first instance, the next question has to be, by how much? Perhaps the most authoritative overview on this comes from the Royal Commission for Environmental Pollution, who's CO2 emission reduction targets, adopted by the UK Government, are based on the "contraction and convergence principle" proposed by the Global Commons Institute [1].

This principle states that every human is entitled to release into the atmosphere the same quantity of greenhouse gases. The current distribution of global carbon emissions is skewed between the developed and developing countries, so the principle ensures that, over time, each nation's emissions would shift towards a uniform per capita basis (convergence) and then reduce (contraction) to a truly sustainable level.



Global Commons Institute: Contraction and Convergence

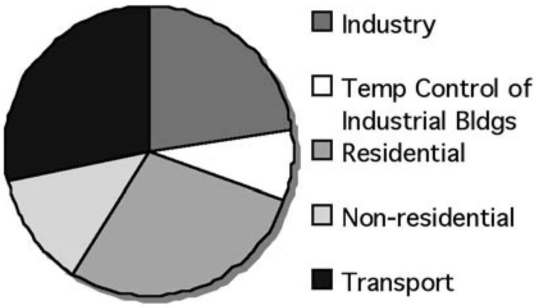
To achieve this, an intermediate global target of 1 tonne of carbon per person is set for 2030 to aid convergence, and thereafter the amount is reduced to the final target of 0.2 tonnes per person by 2100 (see above). This represents more than a ten-fold reduction in carbon use for the UK. In other words, we are aiming for a 90 per cent saving on current consumption levels.

In many cases this is not that difficult to do. Certainly it is possible with new buildings, whereas in many older buildings it is essentially impractical to aim for more than a 50 per cent reduction in emissions. On this basis, some argue for a widespread re-building programme of the most inefficient, or hard-to-alter properties, but a more welcome alternative might be to invest in more renewable devices in the existing stock to offset their increased energy use, rather than knocking them down and starting again.

In any event the scene is set: we need ultimately to reduce energy use by about 90 per cent.

Start at Home

About half of all UK energy is consumed by buildings (below), so buildings seem to be the best place to start and are the main focus of this article. But, of course, much work will also have to be done on transportation and industry – the other main culprits.



Buildings Use 50% of UK Energy

At a more domestic scale, an assessment of the ecological footprint of an average housing development will often reveal that the largest overall environmental damage is not being done by the energy used in the buildings, but by the transportation of people to and from work and school, and by the transportation of food consumed. So, at a personal level, your own travel and eating habits can place a heavier burden on the environment than your domestic energy use. Rather than put a wind turbine on your roof, how about aiming to eat only food grown in the UK, or growing some of your own food in your garden or allotment?

Saving Energy in Buildings

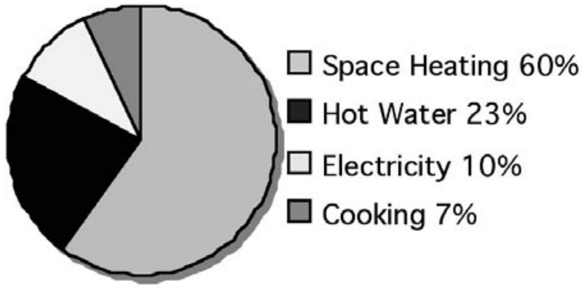
The main thrust of the article is, however, about what can be done to save energy in the home and office. It is necessarily brief, and for more information the very best sources are the Centre for Alternative Technology [2] and the Energy Saving Trust [3].

Embodied energy is the energy used to extract, manufacture and transport the various materials needed to make a building. Estimates vary, as do circumstances, but generally the amount of energy embedded in a house is between 5 and 10 per cent of that which will be used in its lifetime. Using natural materials, such as wood from local suppliers, will obviously reduce the embodied energy of a building and this can only be a good thing but, if you are serious about energy conservation, the focus has to be on the operational energy, that is the energy used in the lifetime of the building to keep the occupants warm, clean and fed.

Energy typically used in housing is shown below. For commercial buildings, space heating typically uses 50 per cent, ventilation and cooling uses 30 per cent and lighting uses 20 per cent. To save energy, we need to tackle the biggest culprit first and in a house that's space heating.

Space Heating

The space heating requirements of a typical 1970s dwelling (i.e. built according to the 1970 Building regulations), will be approximately 160 kWh/m2. By contrast, a 1990s building should consume only 104 kWh/m2 for space heating, while a house built to the 2000 regulations should only



Breakdown of Energy Use in a Typical Dwelling

require 50 kWh/m2 – that's less than a third of the older housing stock.

This sounds pretty good, but whilst energy standards for new buildings have improved over the last years, they represent only a small fraction of the overall building stock and overall energy use has continued to increase, so we still have a long way to go.

It is relatively simple to design a house now which will use no more than 10 kWh/m2, and even less, such that there is no longer any need for a heating system at all, in theory at least. Such buildings have been built in Scotland; it is not technically very difficult, nor is it necessarily any more expensive than building a normal house.

But even at the target figure of 10 kWh/m2, we are well under a tenth of the 160 kWh/m2 average for the UK. Such buildings have perhaps 200mm of insulation, highly efficient double glazing, low air-leakage rates and heat exchange on their air extract systems, but note: no mention of renewable energy supply!

Design for Purpose

People often forget that they are perhaps the main determinant in any system (and the main reason many systems don't work as anticipated!) Occupancy is perhaps the first question to be asked of any heating system. If you spend most of your time at home, for example, then a system which keeps the building warm constantly is like-

Checklist for reducing space heating

- Keep spaces smaller or double up on how a space is used
- Turn the thermostat down - just one degree can save 10 per cent on heating
- Use surrounding landscape to provide shelter from cold winds
- Keep the building relatively compact (low volume to surface area ratio) with few protrusions
- Orientate main 'day' rooms of building to face south
- Use passive solar design to optimise solar gain (larger southerly windows, simple shading, thermal mass to balance gains)
- Use zones of higher and lower temperatures
- Use (unheated) buffer spaces to the north, and as lobbies to entrance doors
- Use high levels of thermal insulation, at least 200mm to walls and 300mm or more to roofs
- Avoid thermal bridging (where components 'bridge' the insulation, metal components are particularly bad)
- Use secondary glazing where existing windows can't be upgraded, or double or triple glazing with low 'e' glass, wooden frames and insulated spacer bars as appropriate
- Reduce air leakage to absolute minimum (see www.seda2.org/guides [4])
- Fit heat exchangers to air extract systems to recover heat lost by ventilation
- Use most efficient boilers, fans and so on
- Keep electronic controls simple and effective
- Use shutters and/or curtains to reduce heat loss though windows at night
- Aim for radiant heat not convective heat as less heat is lost through ventilation and its healthier
- Leaving bath and shower water in the bath until it cools is the simplest form of heat recovery (but increases cleaning!)

Checklist for reducing water heating

- Use solar water heating (should reduce energy input by 50% minimum, even in Scotland)
- Keep bathrooms and kitchens close together, with a central tank, to reduce heat loss from hot water standing in pipes
- Carefully lag the hot water cylinder and all pipes
- Use showers in preference to baths, and use aerated shower heads.
- Get a kettle with a level indicator and only boil what you need

Checklist for reducing electricity use

- Use low-energy Compact Fluorescent Lamps (CFLs) rather than incandescent light bulbs
- Use most efficient appliances (and hot supply to washing machines and dishwashers)
- Avoid using sleep/standby mode for any appliances, e.g. TVs, computers etc. If there's no 'off' button, just pull the plug out
- Consider 'task lighting' (e.g. desk lamps or reading lamps) rather than lighting the whole room
- Lighter finishes in a room will make it brighter and reduce the need for artificial lighting

ly to be most effectively coupled with thermal mass – a heavyweight building. Conversely, a young couple who are both at work all day, often out in the evenings and away at weekends would be more effectively served by a fast response system and a lightweight envelope. Follow the checklist for a brief overview of most of the other potential issues to be addressed.

Conscientiously addressing all of the relevant points above, should easily reduce your energy bills to at least a quarter or less of what they would otherwise be. Payback times will vary considerably but the main point is that with the reduced demand, the scene is set for renewables to play a role...

Renewables Mop Up the Rest

To the typical amount of 160 kWh/m2 for space heating, we have to add about 50 kWh/m2 for hot water heating and 40 kWh/m2 for electricity. Thus we have an overall energy use of 250 kWh/m2 for the average house. There is greater scope to reduce space heating, but hot water and electricity usage can also be easily halved or more, allowing us to aim for an overall energy use of just 25-50 kWh/m2, all of which can be then met easily by non-fossil fuel means.

With a very much smaller overall demand, renewable supplies make sense; they can contribute all, or significant amounts, of the energy needed in most cases, leaving little need for oil and gas, and no need for discussions about nuclear. The existing electricity grid infrastructure, amended to suit the mix of supply, can still operate to support those without a direct renewable supply.

Scale is very important when considering renewable supply technologies. Some technologies are only really suitable for single houses or small clusters, such as photovoltaics and solar water heating. Whereas in many cases, the more households you can get involved, the more efficient the process is. District heating and combined heat and power (CHP) are two examples of this latter scenario.

In terms of heating, if the heating demand is only one-tenth of the current demand, it is quite feasible to imagine Scotland's buildings heated entirely by biofuels, in most cases via centralised systems using district heating networks. The additional benefit of this, which should be immediately apparent to Reforesting Scotland readers, is that the basic resource is in the rural areas, and that this could potentially bring a good deal more currency into the rural and forest economies.

Heating for hot water could be provided by solar water installations, halving the demand, and coupled with the reduction measures outlined above, the rest could be simply delivered by biofuel and electricity derived from small-scale renewables. Hot water storage could become a very useful 'battery' mechanism for renewable electricity supply, thus going some way to balancing the inevitable peaks and troughs of nature-derived power.

Other renewable supply technologies would have their place. Wind in particular could provide large chunks of the overall electricity needed. Small-scale hydro power is often considered the most benign renewable supply, and is very useful where you have a significant head (height difference) to exploit. Both hydro- and wind power have the benefit of tending to provide more energy in the colder months, when it is most needed.

Photovoltaics, on the other hand, may prove to be less useful overall, but particularly valuable in providing energy when it is most sunny, for example on pumps for solar water systems, cooling fans or air conditioning during warm weather. As with all renewable supplies, the key is to 'go with the flow'; wanting the energy when it is most likely to be available, rather than trying to make the supply curve fit the pre-determined demand curve – it rarely will!

Ground, water or air-sourced heat pumps improve upon existing electric heating installations but should not be seen as the panacea they appear to be at present, unless

A windmill and solar water panels provide electricity and heat for a house on Fair Isle, near Shetland

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the electricity to power them is provided locally and renewably. CHP, whether renewably fuelled or not, only works effectively when there is a significant base load which does not change. Hospitals and swimming pools provide the sort of base load required, whereas CHP for a small group of houses is unlikely to be worthwhile.

When compared to other European countries, and with respect to the many practitioners out there, renewable energy supply is still in its infancy in the UK and we have a lot to learn. It is imperative that we invest more time and energy into the necessary complexities of integration and controls, but it is also imperative that we step back and attempt a strategic overview rather than latching onto one technology or other and allowing that to drive the agenda.

Postscript

My prompt for writing this article was the increasing frequency of having to argue that a normal house, with a heat pump and wind turbine attached – with no mention of energy saving – is not, in fact, a 'sustainable house'. We have to get it into our heads that the only way we will crack this particular nut is to start using much, much less energy.

Far from being a swipe at the renewables industry, this is really the basis upon which renewables make most sense. With reduced demand, renewables can wipe the board and we can do without oil, gas, nuclear and the rest. However, without this basis in reduced demand, renewables will probably struggle to entirely shake the tag of being a bit player in the energy market, and will thus continue to face the spectre of competing against the powerful nuclear lobby.

I hope with this article to have substantiated the claim that reduction in energy demand – negawatts - must come before discussion about supply - megawatts – of whatever type, and thus to have set the scene a little for the following articles about renewable energy supply.

Further Information:

[1] Global Commons Institute: www.gci.org.uk
[2] Centre for Alternative Technology: www.cat.org.uk
[3] Energy Saving Trust: www.est.org.uk
[4] Scottish Ecological Design Association: www.seda2.org

Chris Morgan is Chair of the Scottish Ecological Design Association and one of only two Architects accredited to B level by the RIAS in Sustainable Design. He set up his practice, Locate Architects, after seven years as an Architect with Gaia Architects. He has been a member of Reforesting Scotland since first coming to Scotland in 1997.*