Low-Tech Living as a 'Demand-Side' Response to Climate Change and Peak Oil

Simplicity is the Ultimate Sophistication

Samuel Alexander and Paul Yacoumis

Simplicity Institute Report 15d, 2015

Simplicity Institute

LOW-TECH LIVING AS A 'DEMAND-SIDE' RESPONSE TO CLIMATE CHANGE AND PEAK OIL

Simplicity is the ultimate sophistication

Samuel Alexander and Paul Yacoumis

Abstract: *Energy is often called the 'lifeblood' of civilisation, yet the overconsumption of fossil energy lies at the heart of two of the greatest challenges facing humanity today: climate change and peak oil. While transitioning to renewable energy systems is an essential 'supply side' strategy in response to climate change and peak oil, the extent of the problems and the speed at which decarbonisation must occur means that there must also be a 'demand side' response. This means consuming much less energy not just 'greening' supply, at least in the most developed regions of the world. In that context, this paper provides an energy analysis of various 'low tech' options – such as solar shower bags, solar ovens, washing lines, and cycling – and considers the extent to which these types of 'simple living' practices could reduce energy consumption if widely embraced. We demonstrate that low-tech options provide a very promising means of significantly reducing energy (and water) consumption.*[1]

1. TECHNOLOGY FETISHISM

All problems have hi-tech solutions. This is one of the defining assumptions of our technocratic, industrial civilisation, and yet it is an assumption that seems to be failing on its own terms. As the world continues to celebrate the most 'advanced' and 'profitable' technologies, we find our ecosystems being degraded and our communities fragmented more so now than ever before. Unfortunately, it seems that technology often just helps us get better at doing the wrong things, or the right things in unnecessarily harmful, energy-intensive ways.

Without denying the obvious *benefits* of many advanced technologies – such as the Internet, medical procedures, labour-saving machinery, etc. – humanity must nevertheless develop a more critical understanding of the *costs* of our technologies, costs that are often hidden or indirect, escaping our notice as we marvel at the latest invention. It is naïve to think that advanced technologies can solve all societal problems, and yet this naivety permeates contemporary understandings of what 'progress' and 'sustainable development' mean (Huesemann and Huesemann, 2011). The most pernicious consequence of this blind faith in technology is that it deflects attention away from the need to rethink our lifestyles, our economic structures, or our systems of governance, because it is assumed that technology will solve our problems without the perceived inconvenience of having to change the way we live. In this light, technology becomes an ethical void, one in which our societies are expected to become just and sustainable, without us having to live justly or sustainably ourselves. Even ethical problems are assumed to have hi-tech rather than behavioural solutions. This is techno-fetishism.

But what is technology? Technology can be defined simply as any tool, invention, technique, or design that assists in achieving certain goals. It follows that even the most primitive human societies were, in a sense, technological. The prehistoric tribes that used fragments of stone to create axes were developing technology, just as the engineers

---

[1] While our focus herein is on the direct energy and water savings of low-tech living, it is our view that prefiguring a simpler way to live has deeper significance too, in that it helps create the cultural conditions needed for a post-capitalist politics and economics to emerge, which we maintain is a necessary part of the decarbonisation project. In this paper, however, space does not permit any sustained engagement with those underlying political or macroeconomic issues.

that design spacecraft today are. Technology is a broad term, therefore, and so it makes no sense to be either for or against technology without stating what types of technology are being considered. Moreover, technology can only be judged according to some goal or end that the technology is supposed to help us achieve. A technology may be very good at achieving a certain goal, but if the goal is dubious or comes at too great a cost, then the technology's appropriateness is questionable, no matter how effectively or efficiently it achieves that goal. In fact, when the goal is misconceived, the effectiveness or efficiency of a technology is more of a flaw than a feature.

Technology, in short, is a means to an end. This calls on us to assess the ends that our technologies are serving, and not merely get lost admiring the often dazzling means. As Henry Thoreau said: 'Our inventions are wont to be pretty toys, which distract our attention from serious things. They are but improved means to an unimproved end' (Thoreau, 1982: 306). Granted, we have become very good at cutting down rainforests and emptying the oceans in the pursuit of economic growth and more affluent lifestyles, using machinery and techniques that would have amazed earlier generations. It is not clear, however, whether all such inventions have been a positive advance. Just because we *can* do something does not mean that we *should*.

Have our communities, for example, been enriched by Facebook? Or is there more alienation today than ever before? Should the development and refinement of 'fracking' techniques be considered progress? Or are they merely feeding an addiction to fossil fuels and hastening climate disruption? Instead of saying that all problems have hi-tech solutions, perhaps it would be closer to the truth to say that many of our greatest problems have hi-tech *causes*. At least, advanced technology has allowed our misguided ethics to devastate the biosphere in unprecedented ways. As we continue to degrade our planet ever more efficiently, and live in the shadow of nuclear weapons that still threaten to turn on us, homo sapiens may come to be described as the species that was more clever than wise; the species that chose to destroy the foundations of its own existence, spellbound by its own technological power but lacking the maturity to wield it responsibly.

Despite the ominous dark side of many of our inventions, many people still think that the problems we face are not because of too much advanced technology, but too little (see, e.g., Nordaus and Schellenberger, 2011). Entranced by the many wonderful inventions that have genuinely advanced the human situation, techno-optimists think that all our problems therefore must have hi-tech solutions (for a critique, see Alexander, 2014a). Geo-engineering is perhaps the most perverse example of this techno-fetish – a so-called 'solution' to climate change that risks causing greater problems without necessarily stabilising the climate (see generally, Hamilton, 2013). But geo-engineering is merely an extreme example of a more insidious and generalised *zeitgeist*. The underlying assumption, once more, is that we do not need to change our ways of living or capitalist structures to solve our environmental and social ills. Instead, it is assumed that we must simply get better at forcing nature to do what she is told through the application of technology within a market-based society.

In an age so enamoured with hi-tech thinking, any consideration of low-tech solutions – which are the focus of this essay – will immediately be dismissed by some as being 'Luddite'. By 'low-tech' we refer to things such as cooking with solar ovens, showering under solar shower bags, drying clothes on a washing line, keeping warm with a woollen jumper rather than a heater, even using a bike instead of driving. Regrettably, it is often considered an affront to human ingenuity to think that we cannot solve all problems with technological innovation and application. Low-tech is reproached as being primitive or 'just for hippies'. But could it be that various low-tech options are actually more civilised, all things considered, than some of their hi-tech replacements? Could 'advancement' or 'progress' today actually involve a move toward, rather than away from, some low-tech alternative technologies? These are some of the questions we explore in this essay by attempting to assess the potential energy savings of various low-tech options. By doing so we hope to understand the extent to which a society could reduce its energy consumption if various low-tech options were broadly embraced.

It is important to point out at once that the following review of low-tech options must not be interpreted to be a blanket rejection of appropriate hi-tech options. The key word there, of course, is 'appropriate' (see Schumacher, 1973). There is surely a place for hi-tech innovations like solar PV and wind turbines, and arguably computers should or could be a part of the good, sustainable, interconnected society (although let us not forget that life went on well enough without computers not so long ago). Without doubt, many medical treatments are genuine 'goods' also, and the list could go on. We must not throw out the baby with the bathwater. But this essay attempts to examine with some analytical rigour the question of whether, or to what extent, various low-tech options provide an effective and available means of reducing energy demand. In an age when the overconsumption of energy underlies some of our most pressing problems – climate change and peak oil, in particular (as outlined below) – it should be clear that this analysis is about looking forwards, not backwards.

2. Living in an Age of Limits

Before beginning the substantive analysis we wish to outline the broad context in which this analysis takes place. First and foremost, this means acknowledging that we are living at the 'limits to growth' (Meadow *et al*, 2004; Turner, 2012). If once we lived on a relatively 'empty' planet, that planet is now 'full'. There are now more than seven billion people trying to live on a planet that has declining biocapacity (Global Footprint Network, 2013). Indeed, we are living in an age frequently described by scientists as the Anthropocene, signifying the first geological epoch that has been induced by human impacts on the planet. Geological timeframes are normally measured in millions or tens of millions of years, but the Anthropocene refers merely to the last three hundred years of industrialisation. During this geological blink-of-an-eye, humanity has degraded Earth's ecosystems in unprecedented ways and at unprecedented speed. Among a host of other ecological aberrations, this has induced what has been called 'the sixth great extinction' (Kolbert, 2014). Over the last 40 years we have destroyed over 50% of Earth's vertebrae wildlife (mammals, birds, reptilians, amphibians, and fish) (WWF, 2014). As George Monbiot (2014) asks: 'Who believes that a social and economic system which has this effect is a healthy one? Who, contemplating this loss, could call it progress?' Strangely, the last few decades are in fact widely considered a time of great progress, despite this continuing holocaust of biodiversity. It seems the dominant conception of progress is deeply flawed.

Humanity's impact has been so devastating because fossil fuels have given us extraordinary powers, at a time when our ethical vision has been narrow and short-sighted. With this one-off inheritance of dense, stored, non-renewable energy, we have been able to use machines and other technologies and techniques to do things we simply could never have done without a cheap and abundant supply of energy. But this power has come at a devastating ecological cost. Not only is global capitalism destroying the ecological foundations of the planet's declining biodiversity, but the vast amount of carbon being emitted into the atmosphere is destabilising the climate in ways that is threatening the viability of the planet for human civilisation. Current trends suggest we are facing a future 4°C hotter or more by 2100 (Potsdam, 2012; Christoff, 2013), which climate scientist Joachim Shellnhuber argues could reduce the carrying capacity of the planet to below one billion people (Kanter, 2009). This presents us with a foreseeable moral tragedy almost unfathomable in its enormity. We may try to understand this scenario intellectually, but it is doubtful whether there are any among us with the emotional capacity to truly absorb the meaning of it (Gardiner, 2011).

In international climate negotiations, it has been agreed that humanity must avoid a temperature rise of more than 2°C above pre-industrial levels (UNFCCC, 2011). For this goal to be achieved, however, it has been shown that the wealthy 'Annex 1' nations need to decarbonise their economies by 8-10% p.a. over coming decades, starting immediately (see Anderson, 2013). The problem is that historically, long term emissions reductions of more than 1% p.a. have been associated with recession (Stern, 2006), and while surely greater reductions could be achieved if we seriously *planned* for decarbonisation, it nevertheless seems clear enough that reductions of 8-10% year on year are incompatible with continued economic growth (for the details of this argument, see Alexander, 2014b). The basic reasoning here is that decarbonising by 8-10% p.a. will mean a significant reduction in overall energy consumption, and given the close connection between energy and the economy (Ayres and Warr, 2009), an economy cannot continue growing in terms of GDP while also reducing energy consumption so significantly.

Therefore, effectively responding to climate change means transcending the growth paradigm that has defined industrial civilisation and embracing 'degrowth' strategies of planned economic contraction. Not only does this mean transitioning to renewable energy systems and producing goods and services more efficiently, which can be understood as 'supply side' responses. It also requires that the most developed regions of the world simply consume less energy and resources, which is a 'demand side' response that must supplement 'supply side' strategies.

As well as climate change, there is also the looming problem of peak oil (and other peak resources). Peak oil refers to the point at which the rate of oil production cannot be increased (whether for geological, economic, or political reasons, or some mixture of such reasons). When this happens, and while oil demand continues to grow, the price of oil will inevitably increase. In fact, this is the dynamic we have seen unfolding since the mid-2000s, when the growth of conventional crude oil began to plateau (Alexander, 2015), forcing producers to extract unconventional oils that are far more expensive due to their lower energy returns on investment (Murphy, 2014).

Oil, however, is often called the 'lifeblood' of industrial economies, and when it gets expensive, everything dependent on oil (which is pretty much everything) gets more expensive too. This begins to suffocate oil-addicted economies, as there is less and less discretionary income to spend paying back our debts, or to consume in ways that help grow our economies. And when debts do not get paid back, and when growth-based economies do not grow, life begins to fray in undesirable ways (see, e.g., Tverberg, 2012).

Many analysts think that this process of civilisational deterioration is already underway (see Heinberg, 2011; Gilding, 2011; Greer, 2008), a process that is likely to intensify in coming years as oil becomes scarcer; as climate change worsens; and as the broader limits to growth tighten their grips on the global economy (Turner, 2012). In this broad context, the notion of 'deindustrial' civilisation can be better understood. It refers to an industrial civilisation in the process of deteriorating or collapsing as the supply of cheap and abundant fossil energy comes to an end, fundamentally changing the conditions of development. Deindustrialisation can also refer to the voluntary process of building a new, low-carbon civilisation as a means of dealing with energy descent and turning crisis into opportunity. That latter definition can sit within the former, and this paper is based on the view that low-tech living will become increasingly necessary as industrial civilisation continues its inevitable decline.

There is one point deserving of further emphasis. In response to the problems of climate change and peak oil, many people naturally hold up renewable energy as the salvation of civilisation, arguing that all we need to do is transition to renewable energy and the problems of peak oil and climate change will be resolved. The problem is that it is highly doubtful that renewable energy will ever be able to sustain a growth-orientated, industrial civilisation. Although it may be technically feasible from an engineering perspective, the problems of intermittency and storage make renewable energy supply much more expensive and problematic than most analysts think (see Moriarty and Honnery, 2012; Trainer, 2013a; Trainer, 2013b). Even if electricity could be affordably supplied by renewables, electricity only constitutes about 18% of final energy consumption (IEA, 2012), meaning that there is still around 82% of energy to replace, including oil used for transport, pesticides, and plastics, etc. If we try to produce that remaining segment of energy with biofuels, the production of biofuels would compete with land for food production, a conflict that also seems to be already underway, despite the relatively low levels of biofuels production today (Timilsina, 2014). Biofuels also have a very low energy return on investment – between 1 and 3 (Murphy, 2014: 12), suggesting that they will never be able to sustain an industrial civilisation, as we know it today.

What all this means is that responding to today's energy, economic, and ecological crises is not simply a matter of transitioning to renewable energy systems, necessary though that is. It also requires that we (in the developed world) simply consume *far less energy*. Given the close relationship between energy and economics, a radical reduction in energy consumption implies embracing a post-growth macroeconomic framework and materially sufficient but non-affluent ways of living (see Alexander, 2013a; Trainer, 2010). Again, this radically new way of life should be understood in a context of deindustrialisation, which involves trying to retain the best parts of the existing civilisation, and creatively using its existing products and waste streams, while eliminating (or letting wither away) those parts that simply cannot be sustained in an energy and resource constrained world (see Holmgren, 2012; Greer, 2009). While this will involve using the most appropriate forms of advanced technologies to help us decarbonise our economies, the equally important but neglected part of the equation involves a deep behavioural shift away from high-consumption, energy-intensive ways of living.

We do not, however, assume that mere 'lifestyle' responses to climate change and peak oil are enough to address those problems. The subtext of our analysis is that the revolution that is needed must begin with individuals and communities prefiguring a 'simpler way' to live and beginning to build the structures that support that way of life (Trainer, 2010). The relevance of low-tech living therefore goes beyond its immediate energy and water savings, significant though they are. Low-tech living can also play a part in creating the cultural conditions needed for the fundamental structural transformation of our economies to take place (Alexander, 2013b).

For present purposes, the essential point can be summarised as follows. Addressing the world's problems cannot simply be solved from the 'supply side'. That is, we cannot just transition to renewable energy and more efficient productive processes and expect the growth model of global capitalism to persist more or less as usual. Rather, we also need to consume far less energy and resources – that is, we must confront our problems from the 'demand side' too. This is the essential framework within which the following analysis takes place. Low-tech options are being considered in this paper as a means of reducing energy consumption from the 'demand side'. It will also be seen that low-tech options can lead to significant water savings, which, along with energy savings, is a necessary part of a sustainable way of life (for a justification for water conversation, see Brown, 2011). We show that low-tech options are full of potential and should be receiving far more attention than they do. They also provide paths to increased resilience – the ability to withstand shocks – in ways that will be explained.

3. A Review of Low-Tech Living

Having outlined why energy consumption must be reduced, the analysis will now explore various low-tech options that have the potential to assist in that critically important societal goal. This is particularly relevant to the energy-intensive lifestyles prevalent in the most highly developed regions of the world, but they are also relevant to the poorer parts of the world. With respect to the latter, the argument is not so much that they need to reduce energy consumption so much as they should embrace low-tech as one means of escaping the conventional development path that is in the process of 'locking' them into high-carbon, industrial modes of existence.

The following review will consider such low-tech options as solar shower bags, hand-washing clothes, washing lines, simple warming and cooling techniques, cycling, solar ovens, non-electric fridges, composting toilets etc., in the attempt to understand the extent to which these options could help achieve the goal of minimising energy consumption, if they were broadly embraced across a culture. Low-tech can also refer simply to behaviour change, as opposed to relying on technological solutions of any variety. While much has been written on low-tech or alt-tech options, the following analysis represents the first attempt to quantify with some analytical rigour the potential energy savings of a range of such options. We hope that over time these tentative figures and analyses can be refined, updated, and expanded upon.

A few words on methodological issues are required. As will be seen, some of the low-tech options below are more or less effective depending on weather conditions. For example, a solar shower bag will be more effective (and much more pleasant!) in warmer months or regions, and non-electric fridges may be more effective over a longer period in cooler months or regions. What this means is that an analysis of low-tech options is ultimately context-dependent, and this means universal statements cannot always be made with much confidence. Nevertheless, by clearly stating the assumptions of the analysis, we provide the methodological framework for this type of analysis to be applied in various contexts.

Furthermore, although this type of analysis is ultimately context-dependent, there will obviously be much overlap between contexts, insofar as most regions of the world, to varying degrees, have something resembling the four seasons. Indeed, we have chosen Melbourne, Australia, as the case study for the following analysis precisely because it is a good example of a region that has four seasons (and also because it is our home region, which means we have been able to personally test and apply the following low-tech options).

Finally, the fact that different regions of the world have different weather patterns does not mean that the final energy conclusions from the analysis are only relevant to Melbourne. This is because there is something of a balancing effect that flows from different weather patterns. For example, a region that has more hot days each year than Melbourne might allow solar shower bags to be used more often, while this warmer region might not be able to use a non-electric fridge so effectively; similarly, a region much cooler than Melbourne may be able to use a non-electric fridge for more months of the year (or all year), but find it more difficult to use solar shower bags. Not only that, several of the low-tech options (e.g. composting toilets) are not usually linked to weather patterns at all, meaning that the analysis is more or less universally applicable. For these reasons, we would argue that the analysis below, while often shaped by a particular context, is of more general significance. As will be seen below, each of the low-tech options considered also requires more specific methodological assumptions, which will be stated as the analysis proceeds.[2]

[2] One final general point is that we've chosen to ignore the embedded energy in the alternative technologies we discuss, on the assumption that the embedded energy is likely to be negligible in comparison to the potential energy savings they provide. Most of the low-tech options we discuss can be made from recycled or salvaged materials, and others, such as a solar shower bag, have low embedded energy. In any case, low-tech options have vastly lower embedded energy than their hi-tech alternatives (e.g. washing machine compared to a washing line). This means that ignoring the embedded energy does not distort the following analysis in any significant way.

We begin our investigation by calculating a baseline 'reference' scenario for each of the technologies discussed; that is, what might be considered the 'typical' use of the conventional technology in the Melbourne area today. Our reference household is a unit or semi-detached dwelling situated in the inner-northern suburbs and has two occupants, the most common occupancy rate in greater Melbourne.[3] We conduct our calculations using publicly available data on appropriate usage metrics related to each technology under consideration (discussed on a per-technology basis below). We then develop multiple scenarios representing varying levels of adoption of the low-impact technologies discussed, and calculate the energy and water consumption under each scenario. These 'alternative' scenarios range from moderate to radical levels of low-tech adoption, which are also described on a per-technology basis. Finally, we compare the reference and alternative scenarios to calculate the potential water and energy savings afforded by adoption of the various low-tech options.

The following analysis is intended to be illustrative of potential solutions in a general sense. We will, however, present our assumptions and the sources used to inform them.

3.1 *Showering*

The conventional method of showering is to heat water with electricity or gas. But using electricity or gas is unnecessary on warm days when water can be heated directly from the sun. Most readers will be familiar with 'solar shower bags', often used when camping, which are black plastic or canvas bags that are filled with water and heated in the sun (see Figure 1). After a few hours in the sun the water is warm enough to use for a comfortable shower, without requiring energy inputs other than free, zero-carbon sunlight. But why should solar shower bags only be used when camping?

Figure 1 – A solar shower bag heating water using sunlight

In the reference scenario, based on conventional methods of showering, we assume an average shower duration of 5.6 minutes[4] and an average flow rate of 6.5 litres per minute[5] (L/min), giving us an average of 36 litres of water use per shower. In line with actual observations, we assume occupants shower 5.6 times per week on average.[6]

[3] http://profile.id.com.au/australia/household-size?WebID=260

[4] Average between winter and summer median duration: Redhead, M (2013), Melbourne Residential Water End Uses Winter 2010 / Summer 2012, Final Report June 2013, p24.

[5] Average between winter and summer median flow rates, ibid. p25.

[6] Average between winter and summer average frequency: Redhead, M (2013), Melbourne Residential Water End Uses Winter 2010 / Summer 2012, Final Report June 2013, p26.

A reasonable estimate is that half (18L) of the water used for showering is heated.[7] Assuming the household hot water system must heat water by 45 degrees Celsius to reach the set thermostat temperature of 60 degrees,[8] and that the water is heated with a 'task efficiency' of 73% (using an electric storage system),[9] we estimate that the end-use energy consumption for a single shower is 1.3 kilowatt-hours (kWh).

In terms of the alternative scenarios, we also make several assumptions. We suppose, firstly, that 20L is a sufficient volume of water when using the solar shower – a reasonable estimate based on personal experience.[10] We recognise that weather conditions can render a solar shower either uncomfortable or impossible on some days, so we consider only days between October and April (the warmer months in Australia), with a maximum temperature over 22 degrees Celsius, and with more than 4 hours of sunlight, as suitable for the purposes of solar showering. According to the Australian Bureau of Meteorology, these criteria yielded 108 suitable days for solar showering in Melbourne over the 2013-2014 period.[11] For simplicity, we assume that whenever a solar shower is possible (108 days), it will be taken.

The reference scenario yielded a result of 21,199 litres of water and 851 kWh of energy consumed by our two-person household annually. Five alternative scenarios are described as follows:

- Moderate 1: Reducing shower time to 3 minutes with no use of a solar shower.
- Moderate 2: Using a solar shower, when possible, but showering regularly otherwise.
- Strong 1: Using a solar shower, when possible, and reducing shower time to 3 minutes otherwise.
- Strong 2: Using a solar shower, when possible, otherwise reducing shower time to 3 minutes, and reducing shower frequency by one-third (equivalent of showering around 4 times per week).
- Radical: Using a solar shower, when possible, otherwise reducing shower time to 3 minutes, and reducing shower frequency by two-thirds (equivalent of showering around 2 times per week).

The results, based on a two-person household, are summarised below in Table 1:

	Annual water saving (L)	**Annual water saving (%)**	Annual energy saving (kWh)	**Annual energy saving (%)**
Moderate 1	9842.6	***46%***	352.8	***46%***
Moderate 2	3542.4	***17%***	281.8	***37%***
Strong 1	9734.6	***46%***	503.8	***66%***
Strong 2	13556.2	***64%***	589.2	***78%***
Radical	17377.8	***82%***	674.5	***89%***

Table 1: Potential water and energy savings from low-tech showering practices

[7] S.J. Kenway, A. Priestley, S. Cook, S. Seo, M. Inman, A. Gregory and M. Hall, Energy use in the provision and consumption of urban water in Australia and New Zealand, 10 December 2008, p19.

[8] Ibid. p19

[9] George Wilkenfeld & Associates Pty Ltd (2008), Victoria's Greenhouse Gas Emissions 1990, 1995, 2000 and 2005: END-USE ALLOCATION OF EMISSIONS, report to the Department of Sustainability and Environment, February 2008, p84.

[10] See also, Redhead, M (2013), Melbourne Residential Water End Uses Winter 2010 / Summer 2012, Final Report June 2013.

[11] http://www.bom.gov.au

It is clear that changing our showering behaviour, in terms of shower duration and frequency, has an enormous impact on our water and energy consumption. Under the 'radical' scenario our two-person household is saving over 17,000 litres of water per year, and reducing shower-related energy consumption by nearly 90%. An interesting point to note is that reducing shower time to 3 minutes, without using a solar shower, actually saves more water and energy than simply replacing conventional showers with a solar shower, when possible. Nevertheless, the low-tech solar shower bag clearly provides a way to save significantly more energy and water when combined with taking shorter and less frequent showers.

3.2 *Heating*

Conventional heating methods involve using gas or electricity to heat living areas. Low-tech alternatives can reduce the need for such energy-intensive heating methods by wearing woollen clothing, insulating one's home well, and, when heating is deemed necessary, heating fewer spaces.

Our reference household is equipped with a wall-mounted gas space heater. A commonly accepted value for average household heating demand is 0.1 kW per square metre,[12] which we adopt in this paper. We assume heating is required in an area of the house with a floor area totalling 60 square metres. According to the Australian Bureau of Statistics most Victorian households use heating for more than 3 months, but less than 6 months, of the year.[13] We take a baseline of 150 days (approximately 5 months) as our reference scenario and assume that the heater is in operation for an average of 8 hours on each of these days. In addition, based on SA government figures, we assume a heater efficiency of 75%. We acknowledge that insulation varies greatly in housing across Melbourne, as does the health status of individuals, so we leave scope for the necessity of artificial heating in times of temperature extremes.

This reference scenario sees our household consuming 9,600 kWh of energy annually for heating, a figure that aligns closely with CSIRO estimates.[14] Three alternative scenarios are described as follows, all of which assume appropriate clothing:

- Moderate: Insulating house well, and halving the amount of time each day heating is used (i.e. 3 hours instead of 6).
- Strong: Insulating house well, heating only on days between May and September (Australian winter) with a maximum temperature below 15 degrees Celsius (41 days in total for 2014, according to the Bureau of Meteorology), and halving the amount of time heating is used on these days.
- Radical: Insulating house well, heating only on the 10 coldest days, and halving the amount of time heating is used on these days.

The results are summarised in the following table:

[12] SA government, 'Energy efficient heating, https://www.sa.gov.au/topics/water-energy-and-environment/energy/saving-energy-at-home/household-appliances-and-other-energy-users/heating-and-cooling/energy-efficient-heating

[13] ABS, 'Heating and cooling', http://www.abs.gov.au/ausstats/abs@.nsf/0/85424ADCCF6E5AE9CA257A670013AF89?opendocument

[14] CSIRO, 'Zero Emission House', available at: http://joshshouse.com.au/wp-content/uploads/2014/10/Zero_emission_house_ETF_factsheet-Standard-1.pdf

	Annual energy saving (kWh)	**Annual energy saving (%)**
Moderate	4800	***50%***
Strong	8288	***86%***
Radical	9280	***97%***

Table 2: Potential energy savings from low-tech heating practices

From this analysis we see that we can save upwards of 90% of our energy consumption for heating space by simply adopting the humble sweater as our *modus operandi* in order to keep warm, rather than relying on energy-intensive heating appliances. This would obviously require a 'reframing' of our attitudes to keeping warm, but if that inner work was done (see generally, Burch, 2013) then staying warm in a low-carbon world would be achievable in many climates without hardship. Well-designed, passive solar houses with good insulation would also assist greatly. Other low-tech heating options include highly efficient rocket stove thermal mass heaters, which could be especially useful in colder regions of the world. But the best place to start is with appropriate clothing (Havenith, 1999).

3.3 *Cooling*

The conventional means of cooling houses on hot days is to use air-conditioners, which are energy-intensive to operate. Low-tech and low-energy alternatives exist, such as closing curtains or blinds to keep the sun out, or using simple fans rather than air-conditioners.

Data made available by the South Australian government suggests that ducted evaporative air conditioners consume approximately 1.5 kW of energy and 24 L of water every hour on average,[15] which we take as representative of the Victorian context also. According to the Australian Bureau of Statistics almost half of all Victorian households use their air conditioners between 1 and 3 months of the year.[16] We take a point of 60 days as our reference scenario and, in addition, assume that the air conditioner is in operation for an average of 6 hours on each of these days.

For the low-tech scenarios, we assume a mid-range value of energy consumption for ceiling and portable fans based on SA governments data (0.0667 kW per hour). In calculating the use of fans, we assume our occupants require 3 rooms to be artificially cooled. We acknowledge that insulation varies greatly in housing across Melbourne, as does the health status of individuals, so we leave scope for the necessity of artificial cooling in times of temperature extremes.

The reference scenario sees our household consuming 540 kWh of energy and 8,640 litres of water annually to cool the house in hot temperatures. Three alternative scenarios are described as follows:

- <u>Moderate</u>: Using blinds as insulation from sunlight/external heat, and halving the amount of time each day air conditioning is used (i.e. 3 hours instead of 6).
- <u>Strong</u>: Using blinds as insulation and air conditioning only on days with a maximum temperature above 35 degrees Celsius (10 days in total for 2014, according to the Bureau of Meteorology).

---

[15] SA government, 'Energy efficient cooling', https://www.sa.gov.au/topics/water-energy-and-environment/energy/saving-energy-at-home/household-appliances-and-other-energy-users/heating-and-cooling/energy-efficient-cooling

[16] ABS, 'Heating and cooling', available at: http://www.abs.gov.au/ausstats/abs@.nsf/0/85424ADCCF6E5AE9CA257A670013AF89?opendocument

- Radical: Using blinds as insulation, and fans instead of air conditioning on days above 35 degrees Celsius.

The results are summarised in the following table:

	Annual water saving (L)	**Annual water saving (%)**	Annual energy saving (kWh)	**Annual energy saving (%)**
Moderate	4320	***50%***	270	***50%***
Strong	7200	***83%***	450	***83%***
Radical	8640	***100%***	528	***98%***

Table 3: Potential water and energy savings from low-tech cooling practices

We can see that, by significantly increasing our reliance on blinds to keep out heat and restricting our reliance on air conditioning to days when temperatures soar, we can reduce our cooling-related energy and water usage by well over three-quarters. Moreover, if we choose fan cooling instead of air conditioning on such days, we eradicate nearly all cooling-related energy and water consumption.

3.4 *Drying clothes*

The conventional way to dry clothes is to use an electric clothes dryer, which is very energy-intensive. A low-tech alternative is to use a simple washing line to dry clothes outside.

According to Sustainability Victoria, the average dryer use by Victorian households is 78 cycles per year, or 1.5 cycles per week.[17] Taking a mid-range approach to their energy data, we calculate an average per-cycle energy consumption of 4.6 kWh, and an annual energy consumption of 359 kWh, which represents our reference scenario.

Three alternative scenarios are described as follows:

- Moderate: Reducing electric drying to the four coldest and wettest months of the year, and using a clothesline otherwise.
- Strong: Running the dryer for only five cycles per year (say, on the wettest and coldest days), and using a clothesline otherwise.
- Radical: Using a clothesline only throughout the year (some days may necessitate indoor clothes drying racks).

The results are summarised in the following table:

	Annual energy saving (kWh)	**Annual energy saving (%)**
Moderate	239.2	***67%***
Strong	335.8	***94%***
Radical	358.8	***100%***

Table 4: Potential energy savings from low-tech clothes drying practices

[17] Sustainability Victoria, 'Washers and Dryers', http://www.sustainability.vic.gov.au/~/media/resources/documents/services%20and%20advice/households/smarter%20choice/fact%20sheets%20june%202014/rse017_sc_fact%20sheet_a5_washers%20and%20dryers_lr.pdf

The decision to dry clothes by clothesline rather than electric dryer can save a significant amount of energy, up to 100% if adopted as a complete replacement. From experience we know this can be achieved without hardship in Melbourne. At most it requires some planning in winter to ensure that washing is done on sunny days.

3.5 *Television*

The conventional way to spend leisure is to watch many hours of television each day, often on large, energy-intensive plasma screens. The low-tech alternative is to turn off the TV and spend leisure in ways that do not depend on energy-intensive technologies (e.g. reading a book, playing the guitar, talking with friends, doing craft, etc.).

Our reference scenario assumes two televisions in the household, reflecting the national average[18], both of which are 32 inch LCD screens (the most popular TV in terms of sales in 2009).[19] The average number of hours of TV each occupant watches in the house also reflects the national average: approximately 3 hours per day.[17] Energy consumption for a TV in use is estimated at 0.15 kW,[17] and standby energy consumption is 0.001 kW.[16]

We have assumed the occupants watch 2 hours of TV together, plus one hour separately each day. This equals a daily total of 4 hours of TV operation. The reference scenario energy consumption therefore totals 235 kWh per year.

Three alternative scenarios are as follows:

- Moderate: Halving TV watching time, but keeping TVs in standby mode when not in use.
- Strong: Watching only 5 hours per week, and switching TVs off at wall when not in use.
- Radical: Removing TVs altogether (or watching negligible amounts).

The results are summarised in the following table:

	Annual energy saving (kWh)	**Annual energy saving (%)**
Moderate	108.77	***46%***
Strong	196.06	***83%***
Radical	235.06	***100%***

Table 5: Potential energy savings from low-tech (non-television) leisure activities

It's clear that reducing TV watching time is a much more effective energy-saving behaviour than simply ensuring the TV is switched off at the wall when not in use. Not only would this transition reduce energy consumption directly, it would also mean less exposure to consumerist messages from advertising that promotes energy-intensive lifestyles. This means there would likely be indirect energy savings too.

---

18 Energy Use in the Australian Residential Sector 1986-2020, http://industry.gov.au/Energy/EnergyEfficiency/Documents/04_2013/energy-use-australian-residential-sector-1986-2020-part1.pdf

19 Baseline TV Power Consumption 2009, http://www.energyrating.gov.au/wp-content/uploads/Energy_Rating_Documents/Library/Home_Entertainment/Televisions/200919-tv-power-consump.pdf

3.6 *Driving*

The conventional means of transporting ourselves to and from work and leisure activities is to drive in a private motor vehicle. In many parts of the world, however, there are public transport options available, as well as the option of cycling. Shorter trips could be walked.

Perhaps the most involved analysis, the following calculations largely draw on 'average usage' statistics for private vehicles and public transport (PT) published by the Victorian Government Department of Transport and the Public Transport Users Association. Many of these details, while crucial to our calculations, are not vital for describing the various scenarios, and so will be included only in the Appendix.

There are several assumptions that we should note at this stage, however, to set the context for our reference scenario. We are first assuming that both our occupants are of working age, own a car each, and drive to work separately. We assume that each work trip is a 16km round trip, half of all trips made are shorter than 5km (corresponding closely with data for Melbourne published by Deakin University),[20] and of those shorter trips the average is 3km. The total distance each occupant travels per day is 33 kilometres, 83% of which is by car and a further 12.5% by a mix of PT modes – bus, train and tram. Some trips are shared. We also assume that a greater shift to cycling and PT is feasible for the occupants of our household, which is not unreasonable for most inner-suburban residents in fair health.

The reference scenario for our household yields an annual energy consumption of 18773 kWh for transport, which is one of the largest contributors to household energy consumption.

Three alternative scenarios are described as follows:

- Moderate: Switching to public transport for all work trips.
- Strong: All trips under 5km are walked or cycled, a car is used for one trip per week (an average of 5km per week) by each occupant, public transport is used for all other trips.
- Radical: Shared car usage totalling 100km over the course of a year, all other trips are walked or cycled.

The results are summarised as follows:

	Annual energy saving (kWh)	**Annual energy saving (%)**
Moderate	8361.6	***45%***
Strong	15504.0	***83%***
Radical	18659.2	***99%***

Table 6: Potential energy savings from low-tech transport practices

We can see that even with a modest change to our travel decisions – for example, shifting from private vehicle to public transport for work trips only – we can potentially save a significant amount of fossil fuel energy. By choosing the bicycle as our preferred mode of transport we are able to realise an even greater energy benefit.

[20] Deakin University, Environmental benefits of cycling: https://www.deakin.edu.au/travelsmart/docs/theenvironmentabenefitsofcycling_fact%20sheet.pdf

3.7 Five Other Low-Tech Options (in brief)

The above analysis has demonstrated that low-tech options can lead to huge energy and water savings, depending on the degree to which they are adopted. We conclude this part of the analysis with a more conceptual discussion of several more low-tech options, which in the future could also receive the same type of analysis we have undertaken above. For present purposes, we simply highlight some of the more interesting and promising options:

- <u>Solar ovens / parabolic solar dishes</u>: The conventional means of cooking food is with gas or electric ovens and stoves. Solar ovens and parabolic solar dishes provide a hugely promising means of replacing those methods, on suitable days, using free energy from the sun and without hi-tech PV solar panels.

- <u>Fridge / Freezer</u>: The conventional means of keeping food sufficiently cold or frozen is to use a fridge and freezer, both of which are energy intensive. However, in many parts of the world, including Melbourne, the winter months are sufficiently cold to keep food from spoiling too quickly without a fridge, and there are other low-tech options that can help keep food for longer even in warmer months and warmer regions of the world (e.g. evaporative coolers). Behavioural and dietary changes (e.g. eat less meat and dairy or purchase meat on the day it is to be consumed) can also make it easier to turn off your fridge/freezer. While this low-tech option may indeed find fewer supporters than the others, we nevertheless feel this deserves to be included because the fridge-freezer is a significant category of energy consumption in the household. This also challenges us to think through whether we could cope well enough even if something as seemingly indispensable as a fridge-freezer were not available. It can be helpful to remember that the fridge/freezer is a relatively new innovation, and many of our ancestors survived without one.

- <u>Hand washing clothes and dishes</u>: The conventional means of washing clothes and dishes is to use an electric washing machine. Dishes can be washed by hand, and clothes can be washed in a tub with a manual agitator, especially in the warmer months when a spin-dryer is not necessary.

- <u>Organic food</u>: Industrial methods of food production and global distribution are incredibly complex and energy-intensive. Local, organic food production – a low-tech option which was used throughout history – is far less-energy intensive, but does require more human labour. Any transition to a low-carbon world is going to require industrial and globalised methods to be replaced by local and organic methods (Jeavons, 2012).

- <u>Composting toilets:</u> Following on from the last point, in order to replace the fossil-fuel dependent fertilisers used widely in industrial food production today, we are going to need a huge increase in organic fertilisers. One promising low-tech option is to compost human waste for 'humanure' via composting toilets (see Jenkins, 2005). Currently most people conceive of human waste as a problem, but it could be part of the solution if we compost it responsibly. This would significantly reduce or eliminate the need for fossil-fuel dependent fertilisers as well as hugely reduce or eliminate the amount of water required in flushing toilets. As these systems become universally adopted, we would also lessen the need for complex and centralised sewage infrastructure that currently depend on fossil fuels.

4. Conclusion

Although the analysis above has much room for refinement and development in context and household specific ways, it has been demonstrated that what we have called low-tech options have the potential to significantly reduce the energy intensity (and water intensity) of our ways of living. Our personal experience practising all of these low-tech options at times, many of them often, and some of them always, also gives us confidence that the results above are broadly correct. Indeed, when low-tech 'demand side' strategies are applied in conjunction with hi-tech 'supply side' strategies (e.g. solar PV), our personal experience confirms that people can be net-producers of renewable electricity, provided ordinary consumption of electricity is significantly reduced. Moreover, we know that this can be done without diminishing quality of life, although low-tech practices do often demand a greater time investment than their conventional alternatives, which can call for broader lifestyle changes to accommodate this increased time commitment.

Adopting low-tech options certainly requires a rethinking of conventional practices and attitudes, but if we are serious about a 'demand side' response to climate change and peak oil – which is a *necessary* part of any effective response – then these low-tech options are likely to be a critical part of any future adaptation to an energy descent context. Many people will resist this conclusion, no doubt, and insist that we can universalise the conventional 'affluent' ways of living as well as create a post-carbon world. But this is an unjustifiable assumption, which may arise in part from a blind faith in technological solutions or perhaps from a natural human aversion to change. A post-carbon world, however, means a world far less energy-intensive than developed regions of the world, and transitioning to such a world probably implies, whether we like it or not, the embrace of some low-tech options.

Importantly, these low-tech options deserve consideration not just as a means of *voluntaril*y responding to climate change and peak oil. They can also be seen as ways of becoming more resilient in circumstances of economic shock, recession, disruption or collapse, where it may be that the conventional ways of living simply aren't available or affordable (see De Young and Princen, 2012). In other words, the low-tech options demonstrate ways to adapt to challenging circumstances, even if they are not freely chosen in advance. Of course, it would be far better to begin working toward these low-tech options now, because prevention of energy crises would be more desirable than dealing with them when they arrive. Accordingly, we ought to be giving these low-tech options more consideration now, because energy and economic crises are already unfolding, and deeper crises seem to be on the horizon (Friedrichs, 2013; Turner, 2012; Gilding, 2011).

This analysis sits in the broader context of a world facing social and environmental crises that cannot be solved within consumer capitalism. Low-tech options are part of an alternative vision of progress that involves rejecting affluent lifestyles for environmental and social justice reasons, and moving toward a 'simpler way' of life based on material sufficiency, highly-localised economies, and self-governing communities (see Trainer, 2010; Alexander, 2012; Alexander, 2013a). Our argument must not, however, be interpreted as a blanket rejection of advanced technology, which certainly has its place. Nor have we argued that the energy crises we face have mere 'lifestyle' solutions. There are a great many structural issues that must be addressed too. But we hope this analysis helps provoke a broader conversation about which technologies are 'appropriate' for our times. When the humble washing line is compared with the electric clothes dryer, one can certainly sympathise with Leonardo Da Vinci's famous decree: 'Simplicity is the ultimate sophistication.'

REFERENCES

Alexander, S. 2012. 'The sufficiency economy: Envisioning a prosperous way down' *Simplicity Institute Report* 12s, 1-31.

Alexander, S. 2013a. *Entropia: Life beyond industrial civilisation*. Simplicity Institute, Melbourne.

Alexander, S. 2013b. ''Voluntary simplicity and the social reconstruction of law: Degrowth from the grassroots up'. *Environmental Values* 22(2): 287-308.

Alexander, S. 2014a. 'A critique of techno-optimism: Efficiency without sufficiency is lost' *Post-Carbon Pathways* (Working Paper Series, 1/14) 1-21.

Alexander, S. 2014b, 'Degrowth and the carbon budget: Powerdown strategies for climate stability' *Simplicity Institute Report 14h*. 1-24.

Alexander, S. 2015. 'The paradox of oil: The cheaper it is, the more it costs' *Simplicity Institute Report*, 15a, 1-17.

Anderson, K. 2013. 'Avoiding dangerous climate change demands de-growth strategies from wealthier nations' available at www.kevinanderson.info [accessed 15 July 2014].

Ayres, R. and Warr, B. 2009. *The economic growth engine: How energy and work drive material prosperity*. Edward Elgar, Cheltenham.

Brown, L. 2011. *World on the edge: How to prevent environmental and economic collapse.* New York: W. W. Norton and Company.

Burch, M. 2013. *The hidden door: Mindful sufficiency as an alternative to extinction*. Melbourne: Simplicity Institute Publishing.

Christoff, P. ed. 2013. *Four degrees of global warming*. London, Taylor and Francis.

De Young, R. and Princen, T. (eds) 2012. *The Localization Reader: Adapting to the Coming Downshift*. MIT Press, Cambridge.

Friedrichs, J. 2013. *The future is not what it used to be: Climate change and energy scarcity*. Cambridge, MA: MIT Press.

Gardiner, S. 2011. *The perfect moral storm: The ethical tragedy of climate change*. Oxford University Press, Oxford.

Greer, J.M., 2008. *The long descent*, New Society Publishers, Gabriola Island.

Greer, J.M. 2009. *The ecotechnic future: Envisioning a post-peak world.* Gabriola Island: New Society Publishers.

Hamilton, C. 2013. *Earthmasters: Playing God with the climate*. Crows Nest, NSW: Allen and Unwin.

Havenith, G. 1999. 'Heat balance when wearing protective clothing' *Annals of Occupational Hygiene* 43(5): 289-296.

Heinberg, R. 2011. *The end of growth: Adapting to our new economic reality*, New Society Publishers, Gabriola Island.

Holmgren, D. 2012. 'Retrofitting the suburbs for the energy descent future.' *Simplicity Institute Report* 12i: 1-8.

International Energy Agency (IEA) 2012b. *Key World Energy Statistics 2012*. Available at: http://www.iea.org/publications/freepublications/publication/kwes.pdf (accessed 1 July 2014).

Gilding, P. 2011. *The great disruption: How the climate crisis will transform the global economy*. London: Bloomsbury.

Global Footprint Network. 2013. Reports available at: http://www.footprintnetwork.org/en/index.php/GFN/ (accessed 3 September 2013).

Huesemann, M., and Huesemann, J. 2011. *Techno-fix: Why technology won't save us or the environment.* Gabriola Island: New Society Publishers.

Jeavons, J. 2012 (8th ed.). *How to grow more vegetables*. Berkeley: Ten Speed Press.

Jenkins, J. 2005 (3rd ed.). *The humanure handbook: A guide to composting human manure*. White River Junction, VT: Chelsea Green Publishing.

Kanter, J. 'Scientist: Warming could cut population to 1 billion' *New York Times* (13 March 2009).

Kolbert, E. 2014. *The sixth great extinction: An unnatural history*. Henry Holt, New York.

Meadows, D., Randers, J. and Meadows, D., 2004. *Limits to growth: The 30-year update,* Chelsea Green Pub., White River Junction, Vt.

Monbiot, G. 2014. 'It's time to shout stop on this war on the living world' *The Guardian* (2 October, 2014).

Moriarty, P. and Honnery, D. 2012. What is the global potential for renewable energy? *Renewable and Sustainable Energy Reviews* 16 (1): 244-252.

Murphy, D. 2014. 'The implications of the declining energy return on investment of oil production', *Philosophical Transactions of the Royal Society A*, 372, 20130126: 1-19.

Nordaus, T. and Schellenberger, M. 2011. Evolve: A case for modernization as the road to salvation. *Orion Magazine* (September/October 2011). Available at: http://www.orionmagazine.org/index.php/articles/article/6402/ (accessed 10 September 2013).

Potsdam Institute, 2012. *Turn down the heat: Why a 4° warmer world must be avoided*. Published by the World Bank, available at: http://documents.worldbank.org/curated/en/2012/11/17097815/turn-down-heat-4%C2%B0c-warmer-world-must-avoided [accessed 15 July 2014].

Schumacher, E. 1973. *Small is beautiful: A study of economics as if people mattered*. Vintage, Sydney.

Stern, N. 2006. *Stern review on the economics of climate change*. Cambridge, UK. Her Majesty's Treasury, Cambridge: Cambridge University Press.

Thoreau, H. 1982. *The portable Thoreau,* edited by Bode, C. Penguin, New York.

Timilsina, G. 2014. 'Biofuels in the long-run global energy supply mix for transportation' *Philosophical Transactions of the Royal Society A*, 372, 20120323: 1-19.

Trainer, T. 2010. *The transition to a sustainable and just world*, Envirobook, Sydney.

Trainer, T. 2013a. Can Europe run on renewable energy? A negative case. *Energy Policy* 63: 845-850.

Trainer, T. 2013b. Can the world run on renewable energy. *Humanomics* 29 (2): 88-104.

Turner, G. 2012. Are we on the cusp of collapse? Updated comparison of *The Limits to Growth* with historical data. *Gaia* 21(2): 116-124.

Tverberg, G. 2012. 'Oil supply limits and the continuing financial crisis', *Energy* 37(1): 27-34.

UNFCCC, 2011. *The Cancun Agreements*. Available at: http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf#page=2 (accessed 1 July, 2014).

APPENDIX

Some key assumptions in calculating transport scenarios are provided below for transparency.

The public transport mix used by our household occupants is assumed to be: 10% distance travelled by bus, 40% by train and 50% by tram. This appears to be a reasonable estimation based on local usage of these transport modes. Moreover, different PT mixes yield similar results in terms of energy savings due to the vast difference between private vehicle and PT energy consumption per passenger.

We have assumed zero energy consumption for walking and cycling. Of course, this is not strictly true, as our bodies require energy to undertake these activities. However, such activities consume an essentially negligible amount of energy when compared with fossil fuelled transportation. Furthermore, we argue that as the body requires a certain level of physical activity to remain healthy, much of the energy consumption for these 'manual' forms of transport could be considered necessary and even beneficial for maintaining basic human health, and thus might best be excluded from such an analysis.

Some key figures drawn from the Department of Transport's 2009 VISTA survey:[21]

- Average number of trips per occupant per day = 3.2 trips
- Passenger kilometres per person per day = 33 pkm/day
- Percentage of total distance travelled for the purpose of work = 32%
- Distance travelled by car as a percentage of total distance = 83%
- Distance travelled by PT as a percentage of total distance = 12.5%

Key figures drawn from analysis by the Public Transport Users Association:[22]

- Average car occupancy = 1.5
- Energy per car vehicle-km (assuming are fuel efficiency of 12 L/km) = 4.1 Megajoule/kilometre (MJ/km)
- Energy per tram passenger-km (conservative estimate) = 0.6 MJ/km
- Energy per bus passenger-km (conservative estimate) = 1.1 MJ/km
- Energy per train passenger-km (conservative estimate) = 0.18 MJ/km

[21] Department of Transport 2007, Victorian Integrated Survey of Travel and Activity 2007, http://www.dtpli.vic.gov.au/__data/assets/pdf_file/0004/220693/VISTA-07-Summary-Brochure.pdf

[22] PTUA, 2015, http://www.ptua.org.au/myths/energy/