Innovation is Key

to a Resilient and Prosperous Future

By Moth Lubcke

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Introduction

Anyone who has been following my blog would have noticed that I've spent a bit of time on fuels recently. It began with a debate initiated by an elderly economist who, unlike myself, is simply unconvinced by the scientific evidence at hand (to be discussed throughout this report). What might surprise people such as this self-titled AGW "sceptic" is that there are elements on which we would both agree.

He has the standard rambles through the usual denial points (his favourite is the, "it's been warmer before!" statements). Anyway, once you get past this debunked stuff, you get to the meat of something interesting. He starts to sound a bit like me, however our instigating pressures are different. In short, he makes the point that, as we're so reliant on fossil fuels, any taxes placed on it to curb emissions will cause the collapse of the western world. He gets a little paranoid, mentioning de-industrialization and demonstrated scare tactics akin to Monckton (and he calls me the alarmist).

He is correct however, when he makes the point that limiting fossil fuels will put massive pressures on current practices - which would probably lead to them becoming obsolete... But of course, this cannot be the whole story or else why would we be such polar opposites? He, like many others saying the same type of statements, is of course "cherry picking" what suits his argument. It falls desperately short of the bigger picture. Sure, in his case, dusk will set on a life of abundance of fossil fuels - so why would he be concerned? Climate change, ocean acidification, fossil fuel scarcity, agro-chemical limitations, etc; these are all problems of future generations as far as an aging economist is concerned.

The point is this; placing pressure on fossil fuel usage *is part of the idea*, with the other being the *encouragement of innovative ways to greet a new and certainly different world*. Prof. Vaclav Smil and many others have long been doing an excellent job on opening discussion on this topic (who I consider to have shaped my reasoning and the opinions largely from chapter 10 on). We need to face our future *creatively* and *openly* or else, if we put our heads in the sand like the mentioned economist would have us do, we will face a future which we are ill prepared for.

It really comes down to a simple argument, as far as I'm concerned; the age of fossil fuels is limited and we are needlessly reliant on the energy source. It matters not what angle your coming from (expect if your industry is the fossil fuel provider) – all sensible roads lead to a new age without this increasingly old, dirty technology.

Here's what I think...

The Peak

As pointed out above, an elderly gent that made himself known to me has made the point (quite rightly) that by restricting our use of fossil fuels we will hinder the function of most of our current practices. I've said as much many times in previous posts and elaborated in some detail regarding food production (1). Although I found a site (2) that stated that in the US, it took 10 calories of fossil fuels to produce 1 calorie of food energy, this should be treated lightly. It is without a doubt an industry heavily reliant on fossil fuels, but it is difficult to place a line as to where the energy requirements are no longer on the farm; between there and the plate (indeed there are many related industries with overlap). What is easy to state is that all our actions in industrialized communities are held up on pillars of fossil fuels.

I made the point in the introduction that as much as this aspect of our elderly friend is correct, it is cherry picked to illustrate his point and fails to take full respect for the situation. In this part of my continuing discussion, I wish to explore the idea of "peak oil".

Peak Oil

Firstly, Wikipedia covers the subject well enough (3), so I'll only offer a basic rundown in this post.

'Peak oil' first appeared as an idea when, in 1956 Marion King Hubbard used a model to more or less accurately predict oil production trends in the US through to the 1970's. It turns out to be a bell shaped graph - with production growing exponentially before slowing to an apex point (the peak point) and then fall away. Our friend on his alarmist campaign makes the point that in the 1970's people were screaming out about peak oil - and rightfully so; for the US hit peak oil at this point, which caused a noticeable decline in the world production which did not reach the same values again until the 1990's (4).

Image (1)

It's a concern because following this apex, production can't keep up demands, which puts pressure on all dependant industries.

At other times, we've simply moved to other places and dug wells there (one could put a strong case that much aggression has been in the name of this black gold under other guises - but that is the topic for others). However, there will be a point where the existing wells are slowing down and what remaining reserves exist are just too difficult to dig up. Looking at the reserves of fossil fuels, I already question our efforts to obtain material at the expense of mountains (5) and our ability to safely pipe deep sea reserves (6).

It is obviously difficult to say when we'll hit the world apex point - we are definitely willing to go to great effort to obtain the material; which adds to complicate these predictions. However, if you looked

at it solely from price, sure the barrel price is lower than the massive peak in 2008, but if we take into account the typically overlooked environmental costs (especially mountaintop removal, tar sands and now in the gulf of Mexico) and all the costs of aggression related to gaining control of reserves, the slow increase in barrel prices would surely becomes a sharper slope. Unfortunately such work would be open to debate, so I'll only speculate on it here.

Regardless of all this, prices are always on the rise and will never drop significantly again. To say where world peak oil really occurs/occurred will be left to retrospect, but what is certain is that I will see my children get their license in a time where petrol will either be too expensive or cars will be powered by other means - and this is a trivial fact when you look at all the many industries which are currently heavily reliant on fossil fuels. Within a generation, we can expect that massive changes in energy sources (as well as the required infrastructural modifications to support such changes) will be required if we are to maintain the current standard of living at a reasonable price. The sooner we do so, the longer we have to invest thus the less the impact to societies.

Like our elderly friend, I too worry about our reliance on energy supply, but I am not worried about regulations and taxes dooming us; I am worried about the inevitable retraction of this fuel and being ill-prepared to meet this challenge. It is difficult to say just when we hit the peak, but all forecasts suggest that I will ride the roller-coaster down the other side (one interesting commentary about securing the next major power supply, nuclear, can be found at (7)).

Wheat and Flower Power

If no-one has picked up on it, I'll make the point now; I conveniently shifted between peak oil, peak natural gas and peak coal in the previous post. As far as I'm concerned, it is more or less irrelevant; oil may fade away first followed by gas then coal - or it all might happen in a different order (in *No option*, I will discuss the problem of coal further). Bio-fuels might come along to assist oil, there-by buying some time, but let's hope not.

"Why not?" I hear you ask. Surely bio-fuels are the way of the future? No, I disagree. They will be, unless, of course, we're able to change the way in which we see the world and how we fuel things. However, it is naive and as short sighted as visions of a fossil fuelled future. That is to say, we cannot see the future through the smog. In this instalment, I wish to explore bio-fuels (rather lightly, I will admit) and their limitations.

Bio-fuels

I've already discussed bio-fuels on a number of occasions (see (1) and (2) for recent examples), so I'll try to be as quick possible. Basically bio-fuels are fuels that we are able grow ourselves, ethanol and bio-diesel (methyl esters derived from vegetable oils). Ethanol comes from the fermenting of sugars (I noted CSR on the pump the other day) and the methyl esters are left once you have removed the glycerine from the oil (usually from canola). Bio-fuels work well and are already available for public use. They have also attracted an amount of Greenwashing that claim that they burn clean and the process of producing them also recaptures CO_2 from the atmosphere. While there is some truth to this, it ignores some of the uglier sides to bio-fuels.

The most obvious (and exaggerated by Christopher Monckton) problem with bio-fuels is that the production is at the cost of displacing primary food production.

A while ago my father sent me an email regarding an article which explored bio-fuel production via algae which eliminated or at the least reduces this competition between food and fuel production. Spending a little time surfing the net, I came across Oilgae.com that are promoting as much and suggest that fuel production via algae is also more efficient that by other crops (see (3)). As I've only read a handful about algae derived bio-fuels, I won't comment greatly but to say that if these claims are correct, I strongly believe that the greater amount of our future bio-fuels should be developed from algae or other more innovative ideas (ie. irrigating the Sahara) where food production and remnant vegetation is not placed at jeopardy.

Back on the farm however, producing grain for food calories or fuel calories, producing vegetable matter for human consumption or diesel combustion; it seems logical that the energy content that ends up as a product and the CO_2 collected and emitted in the produce would be

more or less the same. What does change is the amount of food and the amount of fuel produced. I'm not sure about the reader, but personally I'd prefer my son's tummy to be full rather than my car's tank. In a meeting on Monday, I learnt that some associates had done some work on this and I will certainly include them as a reference once their work is published (if suitable and more importantly, if I remember).

Image (2)

Looking at Wikipedia, on the page about World energy resources and consumption (4), the opening sentence states that in 2008, 80 to 90% of the 474 exajoules consumed across the world was derived from fossil fuel energy. Following my previous post, although the apex point of the various fossil fuels will be left to retrospect analysis, what is clear is that some point over the next decade (or possibly two - unlikely though) we will become aware of a slowing down of production of fossil fuels. As we've seen on a number of occasions - even just over the past few decades - when the market catches wind of change, it panics. As most of our current activities are shoulder-deep in this wonderfully easy source of energy, it will hit us hard.

Without foresight and in the state of near panic, states will be quick to secure as much of the stuff remaining as they can and jump on the bio-fuel bandwagon to maintain as much of a business-as-usual approach as they can. What a quick flip over the entire history of our species will produce is a comprehensive list of conflicts relating to limited resources – the same would clear ensue from the apex as we slide towards fossil fuel depletion. The ever energy hungry we become (and terribly inefficient we remain), the greater the shock when we're stuck with two options - food or fuel.

No, bio-fuels cannot fully replace our thirst of fossil fuels. It will play a role in coming generations, but only after food security.

Detour into troubled water

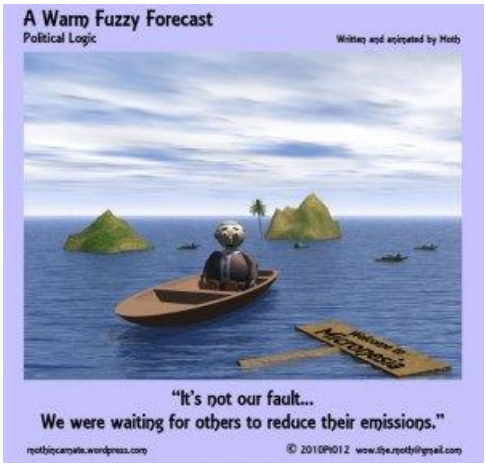
Originally, I was going to motor on through with land use and species loss, but hit a wall as I wish to rely on other points that would require a bit of explaining (I'm keeping these chapters under ~800 words each). Hence, I've decided to make a detour in this part so that it can be used to refer to in later sections, thereby reducing the necessary weight later on. One of my pet-peeves is the debate over anthropogenic global warming (AGW). As far as I can tell, such a debate is trivial (something that I hope to explain through *Innovation is Key*) and focused more on promoting paralysis – while the public decide if the evidence is good enough – which of course assists well-established industries that are growing beyond their natural lifespan.

Short on Climate Change

Anyone who has been following discussions online regarding climate change should be well aware of the data (if not see NASA (1), or NOAA Climate (2) for valid and up-to-date data). The cause of this is irrelevant to the fact that we are experiencing an age of changing climate regardless. It is true also that we have experienced changes in climate over the past few millennia, including a couple of warmer and cooler periods, however the best minds have been working on this problem for over a century and it looks very likely that these previous events do not relate to our current situation and thus they offer no reassurance for the future.

There is ever mounting evidence of our changing climate and a general consensus that this should be addressed as a matter of urgency both within the academic community and various governing bodies. When we couple this with the of the previous few chapters, it becomes even more important that we develop other sources of energy.

Short on Sea Levels



This is the area where I'm most out of my element (living in South Australia it's a surprise that I don't think snow and ice are just a myth! Luckily I grew up in the south east of Victoria and went on many trips to the snow topped mountains). For that reason, I feel that John Cook at Skeptical Science puts together a great post regarding Greenland's Ice loss (3). Observations by NASA (4), and NOAA (5) (again) demonstrate a general increase of sea levels over time. Some of this is be due to thermal expansion, but the bulk will be from ice loss (Grinsted, et al. 2010). This threatens have a detrimental effect on biodiversity that rely on wetlands (Traill et al. 2010), but more on that later.

Short on Ocean Acidification

I get annoyed when I hear people state that CO_2 is a harmless gas. If you again go to NASA (6) or NOAA (7), you'll find that the concentration of CO_2 in the atmosphere has increased by more than 100ppm since the industrial revolution (Raupach et al. 2007) and is at the time of writing this 392.94ppm at the Mauna Loa Observatory, Hawaii (8). Of the anthropogenic CO_2 emissions over the past 200 years, around a third has been taken up by the oceans, which has already caused the ocean pH to drop by 0.1 (Fabry et al. 2008). As pH reduces, carbonate ions become less available for the many phyla of ocean dwelling animals that produce calcium carbonate exoskeleton and for coral production (Fabry et al. 2008). I'll develop in this relationship between pH and fitness in a later post.

I know that I've been quite light on these points (but I do provide the references and I suggest anyone with any interest to look them up for further insight). However, reviewing a wide range of the discussions among different blogs, I fear that denial manages to induce inaction through a number of useful tools; over complication and confusion (ie. an inability to see the forest through the trees), an avoidance of scientific rigour (look at the time it took Prof Abraham to dissect the mess that was Monckton's presentation; where science papers go through an appropriate review process and are open among peers to be debated and retested, work like Chris Monckton's presentation is assumed to be taken at face value without such review), and an overwhelming obsession with uncertainty (I often hear, "we need to be absolutely sure if we're going to make changes"), to name a few.

What I offer here are some basic points which are based on observation. What I will do next is develop on the various effects of these known points. There are always uncertainties and unknowns (if there were none left, we wouldn't need science any longer), however previous model predictions are increasingly looking like they are underestimations (Grinsted, et al. 2010). If you want to be any more certain, it'll only be in retrospect. The above points are irrefutable and dangerous if inaction continues (of which I plan to discuss). I will hopefully add some clarity to what I've long felt is a pointless and distracting debate and from there I hope to begin to develop optimism in our potential to change.

Where will the wild things move?

As pointed out above, my plan was to jump straight into land use and species loss, but I felt the need to first set out some basics. At first, there might be some confusing as to why I needed to talk about climate change, sea levels and the decreasing pH of our oceans - indeed when one talks about land use and species loss, it's usually discussing deforestation, degradation of environmental systems and other over-exploitation causes. These problems have made headlines for longer than I've been around (with no headway made to reduce our impact as I see it) and are not directly the focus here. Inaction has, without a doubt, been the result of avoidance and profit. Indeed, most people are within driving distance of a reserve of some sort and so feel that there's a place for the our fauna and flora, however this is even less likely to do over the coming century (many of the relating issues and human dependencies on ecosystems are discussed in *The Human Island*).

When local is no longer local

According to the numbers found at the DEH (1), the Adelaide and Mt Lofty ranges cover 780,000 ha, of which 98,000 ha is remnant native vegetation. Of course this is highly patchy and much of it is land that was of low agricultural or social value. Any local would have also noticed the abundance of exotics - especially olive - in this "remnant" vegetation. My passion as a ecology student was this very issue of islandisation and invasive species management, so I'll have to watch myself here for detouring on tangents. There has been a lot of work regarding biodiversity and species fitness within increasingly isolated patches of remnant vegetation, which suggests that patch size (Ferraz et al. 2007, and, Helzer and Jelinski, 1999), risk related to migration across inhospitable terrain (Bickford et al. 2010), and a need to address the overall diversity supported by the patch (Franklin, J. F., 1993) are among a number of important factors for species persistence.

As was made clear in the previous chapter, regardless of the forces (which are hotly debated among the general community), there has been a general and ongoing trend of global warming since the nineteenth century. This trend has noticeably effected and will continue to shift ecosystem function with climate shifts (Traill et al. 2010). Range of many species has tended poleward and upslope as climate shifts to a warmer state (Anderson et al. 2009). Giam at al. (2010) also demonstrated that equatorial regions were at greatest extinction risks due to both climate change and socio-economic factors.

Returning to the Mt Lofty and Adelaide region, as outlined on the DEH website, there are various biodiversity conservation plans and policies aimed to preserve the remnant flora and fauna of the state. This may not do under changing climate factors, with distribution regions no longer suitable for the locals. In previous times of climate change, migration towards or away from poles would encounter only geographical barriers (such as mountain ranges, rivers and of course continent borders). Over the pass three centuries, land-use modifications and invasive species introduction relating to human activity has added to these geographical barriers. Plant

distribution, for instance, is unlikely to be able to pass agricultural land - let alone suburban sprawl. Feder (2010) and Ferraz et al. (2007) suggest that an individual's ability to survive would rely on being able to move great distances or be highly tolerant to climate change.

Predictions of the changing climate across South Australia (2) (continuing the example) would strongly suggest that a poleward movement would mean that the majority of South Australia's population (mostly along the southern regions of the state) and agricultural regions become major barriers for such migration. As various species of flora and fauna have different potential for migration rate and tolerances to overcoming barriers, it would make sense that such migrations would also upset ecological interactions between species which would logically further increase extinction rates, due to the loss of various services with ecosystems.

With the wild things looking for a more suitable home, it's pretty evident that soil erosion (such as dry land salinity and acidity), altered water usage and sprawl have far larger effects than have been generally appreciated.

In the previous chapter, I quickly looked at climate change migration response of species and barriers to that movement which will have an adverse effect on biodiversity. I'm going to carry on from this and comment on the future of coastal wetlands and associated lowlands. In respects to the previous section, these environments are probably less likely to be able to migrate being often heavily reliant on the local water / land balance which means that the land and ocean barriers are too large to overcome. Another issue will obviously complicate the situation; this is of course raising sea levels.

Wet.Lands.

Image (3)

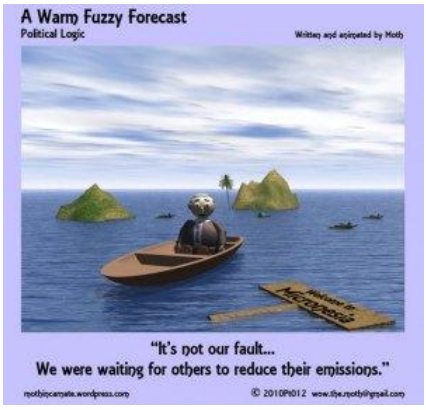
Right off that bat, I'll admit that inspiration for this section came from a very recent paper by Traill et al. (2010). With projections of sea level rise ranging from centimetres to many metres over the next century, Traill el al. (2010) modelled what effect this would have on the habitat of a keystone waterbird species, the magpie goose (*Anseranas semipalmata*) which rely on subcoastal floodplains in northern Australia and New Guinea. Using relatively coarse (90m) digital elevation models (DEM), they suggested a sudden tipping point in population numbers after 100-150 years (Traill et al. 2010). They note a number of weaknesses to their study - the most important being the coarseness of their DEM, which does not give true indication of intrusion through finer channels (Traill et al. 2010).

The major transferable elements that I took away from this paper where that; 1) inundation and habitat lost is likely to occur more rapidly than species adaptation, 2) nutrient value of the current floodplains are the result of millennia and will both be lost through inundation and be unavailable in remaining areas, 3) although storm surges were not included in this study, they are likely to exacerbate this intrusion of sea water, and 4) the removal of one keystone species will have a detrimental effect on other species as well socio-economic factors (Traill et al. 2010).

Any near coastal land within the different projection sea level heights and most islands are very likely to face nutrient loss, habitat loss and ultimately an increase in local (if not global) extinction of various species as a result of sea water inundation. With very little flow reaching the Murray mouth and Coorong region a persistent problem and dredging a continuous management strategy (MDBC, 2008), here is a local example of a Ramsar listed (1) area, already under considerable stress which will be at further risk of habitat and nutrient loss as

sea levels rise. Unless flows are restored, it is also likely that sea water would be able to change the water chemistry further upstream, impacting on both agricultural land and wetlands.

Grinstead et al. (2010) have recently suggested that IPCC projections for sea level rise by 2090-2099 might be an underestimate by close to a factor of 3 and that the rate of sea level change over the coming century is greater than that of the last 2000 years.



As temperatures are noticeably on the rise, sea levels are following as is the potential for an increase in storm surges (Woth et al. 2006) there is little question that this will have a detrimental effect on not only island ecosystems, but indeed all coastal wetlands, many of which are already subject to other anthropogenic impact stresses (Michener et al. 1997). Many of the wetlands at risk are Ramsar listed and home to migratory birds (which would suggest the ramifications are far reaching in nutrient distribution) and other keystone species that provide various ecological survives that include socio-economic benefits (Traill et al. 2010). Without proper recognition of wetlands and the above impacts, we won't risk being short of wetlands (there will be plenty of inundation), but risk losing economically and ecologically important wetland environments and sudden disappearance of once abundant species.

Immersed in trouble

Image (4)

Following the trend from lands in trouble, to the wetlands divide, now I'll let go of the lands completely and take an ever too brief look at the state of our ocean. I feel that I will unable to give this environment enough justice in this format. However for the sake of consistency, I'll try my best. Looking at the impacts we've had on our oceans, it's like saying, "pick a card; any card!" Our attitude towards this alien environment has been at best, appalling. Over the previous two centuries we have proven ourselves to be increasingly efficient at pulling every living thing out of the oceans - from anchovies to whales and while big boats are bringing ever bigger catches in, other big boats are taking our effluent and refuse out and dumping it out of sight. As soon as the catch starts to fall off in a region, the boats move somewhere else (leaving a barren ocean in their wake – increasingly at the expense of developing countries).

In that respect it's similar to poor farming techniques in Australia that continues to move stock across the land, leaving a simplified and chemically poisoned landscape in its wake. The old time stereotypical dirty sailor, going from port to port should at least continue to apply to their ships and the biological matter that is transferred in their ballast water (1).

And while all this plundering and polluting of the oceans occurred, a silent foe - the child of our emissions - has slipped onto the scene to make the atmosphere of this underwater world even less pleasant for the remaining locals.

Taking the base out of a limestone home

Unlike the uncertainties related to climate change predictions, the result of CO_2 concentration changes in water is predictable (Doney et al. 2009). As previously stated, around a third of the CO_2 emissions since the industrial revolution has be absorbed by the ocean where it interacts with water molecules to produce carbonic acid, H2CO3 (Doney et al. 2009). Pre-industrial ocean pH was 8.21, which has since dropped to currently 8.10 (Doney et al. 2009). As the pH decreases, the amount of carbonate ion available within surface waters (the most active region) also decreases, which is important component for species that excrete calcium carbonate shells (Fabry et al. 2008). Thus far, carbonate depletion has been roughly 30 μmol kg−1 seawater (Hoegh-Guldberg et al. 2007).

Although it has been demonstrated that coral polyps may be able to persist in lower pH oceans, where they are unable to construct coral, fitness is decreased due to the absence of this

protective cover (Fine and Tchernov, 2007) and/or the extra energy invested in calcification (Hoegh-Guldberg et al. 2007), and with the bed of calcium carbonate on which new coral is formed close to the surface at increased risk of erosion, it is unlikely that polyps will be able to migrate to higher latitude under a changing climate (Doney et al. 2009) (see *Where will the wild things move?* on distribution) or be able to build structures higher as sea levels increase.

Calcification is prolific among many phyla. Many of these species are important food sources (ie. plankton, coral and algae), provide nursery environments for other species (ie. algae and coral), are important for nitrogen fixation in oceans (ie. cyanobacteria) and protection for storm surges (ie. coral), (see Doney et al. 2009 and Hoegh-Guldberg et al. 2007). As fitness of these groups diminishes with decreasing pH of oceans, there is a wide range of biodiversity and socio-economic ramifications that can occur from increasingly acidic oceans (Hoegh-Guldberg et al. 2007).

To put it another way; as carbonate ions become less available, these species will have to work harder to product protective shells - either spending more energy to do so or on other methods to protect themselves. Less will be successful, thus providing less homes and food for other species - including economically valuable fish species. These in turn provide less food for predatory species (including us). With the likelihood of increased storm events, corals will be less able to provide coast protection from surges. Many coastal molluscs are keystone species (2) which too will have reduced fitness, with detrimental ramifications on the local ecology. In every way, ocean acidification will affect the ecology of our oceans.

The current concentration of CO_2 in the atmosphere is higher than that seen in over 740,000 years, if not much longer (Hoegh-Guldberg et al. 2007), with the rate of change accelerating (Raupach et al. 2007). Although the ability to adapt to these changes are not well known (see Doney et al. 2009 and Hoegh-Guldberg et al. 2007), certainly the rate of change over the coming centuries, coupled with many anthropogenic impacts discussed at the beginning of this piece would suggest that without better management, we are likely to witness degradation of the ecology and ever increasing extinction rates in all oceans.

A clock with loose spring keeps poor time

This will be the last point of this section, before shifting to more of an opinion based look into the future human practices. Thus far, I've ventured from land, to wetland and then out to sea, but now I want to look at change as a whole. As most people would be aware, many species rely on environmental cues as part of their yearly cycle. This is everything from first bloom or chrysalis to a migration that spans many thousands of kilometres. In all ecosystems, there are many services that are provided by a species to other species which is paramount for the receiving species fitness if not local persistence, which includes nutrient, mineral and energy transfer (Traill et al. 2010 and discussed in greater detail in *The Human Island*). In extreme examples this is called symbiosis; where the relationship can be complex, resulting from a long co-evolutionary relationship (Hill, 2009). There are interactions that involve these environmental cues (eg. pollination, migration) that human activity is benefited by (Traill et at; 2010).

Image (5)

As was highlighted in chapter 4 there is a noticeable global warming trend, which should be evident in a change in species response to a change in timing of these cues.

Response to change

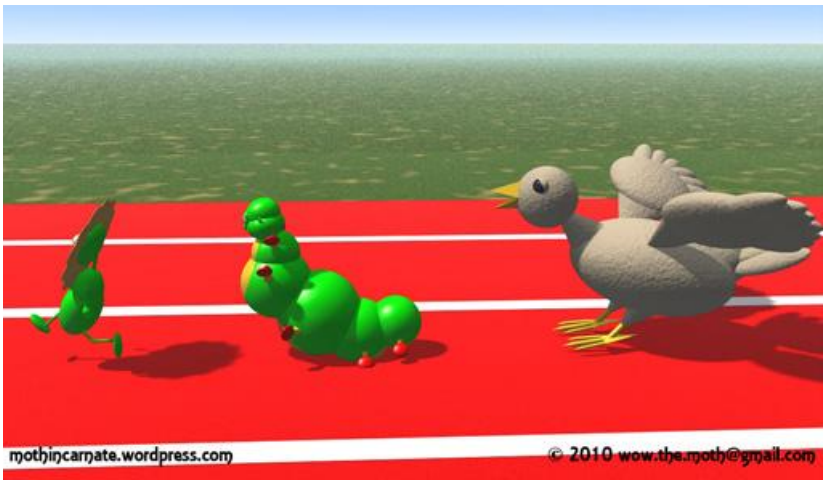
Rosenzweig et al. (2009) looked at data sets from more than 28,800 biological and 829 physical systems with collections from 1970 to 2004 and found that around 90% of changes observed in the former group and 95% of changes in the latter group were, at a global scale, the expected result due to global warming. Of the ~80 studies (>29,500 data sets), only 3 studies (9 data sets in 4 cells) showed that the results are due to other anthropogenic drivers (ie. land use changes, harvest and pollution) (Rosenzweig et al. 2009). Rosenzweig et al. (2009) also state that it is highly likely (>90% probability) that the observed warming is the result of anthropogenic modified greenhouse gas concentrations.

A similar study was carried out in the UK by Amano et al. (2010), where data of first bloom from 405 plant species, spanning 250 years was analysed. This study showed an average 5 days earlier of flowering for every 1 degree C increase (Amano et al. 2010).

As different species will react to different cues, such as climate cues (eg. ice melt, rainfall changes and temperature) or non-climate cue (day length), it can be argued that as climate changes increase, inter-species relationships will be stressed due to shifts in timing (Brook, 2009). The greater a species is reliant on another at a lower trophic level, the more that species would need to respond as peaks of that food supply shift due to climate change (Brook, 2009).

Failure to meet this change, as with all those previously discussed, would reduce fitness and lead to a reduction of biodiversity. It is generally believed that ecosystems are more resilient to shock when biodiversity, or at least key species are maintained (Fischer et al. 2006). Adding this to all that has been discussed in previous chapters demonstrates potential impact of

species loss from the various impacts above, which thus exacerbate degradation of those ecosystems and certainly causes detrimental impacts on other systems that rely on those services - including our own species (Traill, et al. 2010). Life of all species is intertwined.



Indeed, already what I notice when out on the road driving through agricultural landscape as part of my fieldwork is more opportunistic farming (many farmers following the recent big rains) and a change in crops (mostly a removal of vineyards and orchards). As much as 60% of crops rely on natural pollination, not to mention the vast amount of soil conditioning and pest control and other services provided by the local ecosystem (Traill et al. 2010), it seems naïve to me to assume such opportunistic farming can remain viable under both a continuous loss of biodiversity and changing climate.

This brief example of farming is in essence my reason for writing this collection. In far too many ways, our species has developed quicker and more efficient ways to achieve the results of work. This has lead to a society unimaginable several generations ago. It has lead to an average standard of living greater than that ever known before and without a doubt has increased our potential for ever greater heights. This has, however, caused a nasty side-effect of an entirely new form of ignorance and certainly elements of gluttony.

I don't wish to harp on, like some Tolkien nightmare of the machine, for I am happy with what we have created and that it will give my son opportunities that his ancestors, who landed in South Australia in the 1870's, could never have dreamed of in their comparably harsh venture to establish this place as a state. On the other hand, they saw species on their plot that my son will never see. As much as we have come a long way, especially over the past two centuries, we've also forgotten our roots and humility for a much wider world than just the cities that we have built.

On a much more modern note; the more that we understand ecology and biological properties, the more we will be able to exploit such services at a reduction of economic outlay and energy. It is likely that the answers to many diseases and food source issues will be resolved through such understanding, but this will be remain a decreasing likelihood as species loss and climate change continue to be ignored.

Intermission: Save Ourselves!

The next parts of this piece will be far more open to debate than the previous part, as it will be more opinion based, rather than evidence based. I believe that I more or less think like an ecologist, rather than an economist and so will argue about innovation from this perspective and from similar views. The road forward is far from clear, however, I feel that the previous parts to this piece has made a strong enough case that a energy supplied through fossil fuels is largely a figment of the 20th century and will be replaced almost entirely by the 22nd century and without properly addressing these issues sooner, rather than later, we run the risk of ever increasing cost in development and innovation, continuing extinction rates, being unable to meet the energy, water and food needs of our species, increasing the risk of illness due to pollution, environmental degradation and a reduction in ecological services and an inability to adapt to climate related changes.

Before I begin on this opinion based part, I wish to make clearer to the reader who I am and what I stand for. This is in part due to some of the criticism I've faced recently and also to give an indication of my motivations in the coming sections.

About me

It's difficult for me to find the root to my views. The best that I can suggest is that I have always been fascinated by everything. Even as a young child, if something broke in the house, instead of it being thrown out, I tended to steal it and pull it to bits, just to try to work it out. In that respect, as a teenager, I showed more ability in physics, chemistry, maths and electronics. Although I was always interested in bugs and collected hundreds to my parents continuous horror, I never had more than a casual interest in biology (I even remember the resentment I felt when a biology teacher started referring to organs, all these strange enzymes and Latin derived scientific names for species – I hated how difficult it all way to remember).

I turned my back on high school at the beginning of the final year. I thought I could do better in a traineeship. That didn't pan out and when 20, I returned to complete high school. I figured at this point that I would aim for astrophysics or electronics; I was still absolutely amazed by technology.

However, something had changed in the few years. I had become a bit of a fitness junky. Hiking and exploring had given me a new sense of connection with my local landscape. It had also been picked up by one of the best teachers I had come by at this point, that I had a form of dyslexia.

So by the time I actually finished high school, new worlds of literature and ecology had opened up to me, which shifted me towards biodiversity and conservation at university. Much that I remembered from my youth; the text books I had (my parents often gave me non-fiction books

as presents because I was more likely to read them than fiction), the fascinating look into the world on *Beyond 2000*, and even the few whims into environmental concern inspired by Greenpeace and WWF campaigns mainly around the late 80's and early 90's; all seemed to concrete this wonderful interest in the world. It was also throughout my teens that I spent time in Far North Queensland and fell in love with the Daintree and Great Barrier Reef.

My interest in technology (especially the history on invention) had not waned, however. As I saw it, we had developed dramatically over the previous two centuries, but being beyond a human life span, most people seemed to feel that what we had created was “the real world” and not the product of amazing minds and abundant energy. We seemed to be unable to appreciate the amount of change that we had created to landscapes. Such ventures away from suburbia and into remnant vegetation seemed to instil this deeply into my being.

What irritated me most was the effects of invasive species (for they were invaders on the few areas that we had assumed to be "protecting").

I figured that I’d like to work with invasive species management and environmental corridor establishment, so that we could better live in balance with our local environment. Such work is in short supply, however.

I ended up working in air quality monitoring for the government. It was within this position that I became aware of the real world data of impacts within my home state, such as; dry land salinity / acidity, the poor health of the Murray Darling Basin, sea grass loss and over fishing, species loss and landscape use changes (mainly through sprawl), eco-efficiency, human health-related concerns related to air quality, and climate change (relating very much, at this point, to the ongoing drought, weather pattern changes, BOM climate predictions and concerns relating to agriculture and future water security) to name a few off the top of my head.

In this way, I became concerned about future food supply and learnt more about local agriculture. I also learnt in this period what it meant to collect and explore data and report on it within the political arena. Without elaborating, this lesson also left a strong impression on me.

The points made in the first section are based on some of the available literature. I’ve seen a lot more and have liaised with a wide number of stakeholders and industry leaders who have a strong opinions and relevant experiences with a number of these issues. I’m the first to admit that until late 2009, I was fairly ignorant to the AGW public debate and was more or less in the thick of discussions regarding the future of biodiversity, agriculture and our species in response to a changing climate.

It was when I listened to a presentation by Christopher Monckton in 2009, and the support that he seemed to have, that I decided that had to write on the subject. It was also about this time that some failed farmer went on a hunger strike because he wasn’t allowed to continue poor quality agricultural practices.

The Bullet

It is propaganda that fuels the idea the climate change is a myth. It is propaganda that suggests that the IPCC and UN are trying to de-industrialize the west and reap massive profits at the expense of the common folk. It is ignorant to all that I have written and will write to suggest that I condone a collapse of our society; quite the opposite in fact.

I argue that;

1. the world is changing,
2. although fossil fuels cannot continue to assist us for more than another generation or two and even then, oil will forever increase in price, gas is far too valuable to be burnt and coal has inspired the horrible ecologically damaging of mountain top removal, powers the dirtiest power stations and also is incredibly important in steel production (something I'll discuss later),
3. species loss is poorly addressed at the detriment to both biodiversity and human health,
4. agricultural practices are largely inadequate and short sighted,
5. there is an unjust stigma surrounding environmental concern (ie. "damn tree-huggers"), and,
6. there is an unmerited and totally trivial debate over one aspect (ie. AGW) of a range of related issues that are doing a world of damage and ensuring that we will not provide the best possible land to future generations.

I hate the greeny “save the planet” jargon. It means nothing. No matter how much damage we do to the Earth, short of the unlikely all out nuclear war, we are unlikely to ‘destroy’ the Earth. We would, without a doubt make this planet uninhabitable for human life before we destroy it. In our wake, give it a few million years, life would prosper again. What “save the planet” fails to do is address the cause and effect. What we’re really talking about is ensuring our own survival; save ourselves (indeed *from* ourselves). A statement like this brings home the reality of the situation and removes the stigma. This argument is the true argument and is largely lost under a sea of political and ideological nonsense.

What I plan by writing this is not to follow the hopeless dreamers, but correctly address the situation. We will not de-carbonate our energy supply in the next decade and I doubt we will manage to keep CO_2 concentrations below 450ppm. However, bickering over trivial uncertainties associated with AGW could mean the difference of peak CO_2 concentrations of 500ppm or 800ppm, the relative expense of innovation and massive differences in potential species loss.

It is only through being a realist that we can take appropriate steps to address a changing world and not through idealism. What I've written to this point is the reality. The uncertainties can be ignored in the noise surrounding the certainties. If we are going to live up to this image that we egotistically hold of our species; that of the custodians and dominant species on this planet, then we need to pull our socks up and face the facts! Otherwise we are nothing more than a plague and like all plagues, we will hit a population collapse sooner or later.

Hungry, Hungry Human

Image (6)

I hope that the previous sections have provided some clarity of a range of impacts related to our use of fossil fuels. I know that in general, I brushed over various subjects, rather than explain the cause and effect to any great degree. This is because a number of other resources have already done this work. I also included all the references, so that it's easy to venture back for further detail. In this way, although I developed an argument of a world in trouble, I didn't want to dwell too much on the bad, for there are many opportunities for a prosperous and bright future. The following section is the heart of *Innovation is Key*.

Gaskins et al. (2007) found that people who were already ill were more likely to have a better diet than those who were not. I guess in the same way, I hope the previous sections were able to demonstrate that we are sick, ecological systems that we rely on are sick and ignorance in the face of a changing world is likely to exacerbate the illness.

The first issue I'd like to address is very much like an overweight patient sitting before the GP, who has just been told that their high energy, heavily processed diet is leading them straight to type two diabetes and chronic illness. Does the patient refute the GP's qualification on the advice of the questionable Lord Monckton (for instance) and continue an unhealthy diet (ie. "you can't prove beyond a doubt that I'll get sick") or does he/she take the message on board?

New heavy consumers

Recently I asked a question on a blog (which will remain nameless) I've been following for some time now which alone caused an unexpected backlash. I totally agree with many points made, however, the point was made that environmentalists believe that the best low-carbon solution was to simplify to a less consumer orientated society; that this was unrealistic. I certainly don't disagree - the way forward is not to head backwards (nor is to continue business as usual on a different power source in my opinion). However, (this being the point that caused the explosion of attacks) why shouldn't efficiency remain part of our future, even if the power supply is abundant without the environmental impacts of fossil fuels?

The anger that I faced largely came in the form of, "don't force you're ideology on me and force me to use less energy... Why should I? There's an amazing amount of energy to exploit?"

Sure, we have the history of using as much resources as efficiency improves, preferring to increase output, however that overly simplifies human activity and resource interactions and devalues the potential for human ingenuity; are we so mindless that we will act as we have always acted before, or can we challenge the paradigms?

Around the point I was "ousted" as a "hairshirt green", I figured that I was unlikely to get a reasonable response and moved on. Later on, I'll look more into my reasoning my initial question, however, at this point, I want to focus on the reaction I received and a look at the consumer.

The weight of the situation

Image (7)

The World Health Organization (WHO), projected that, in 2005, over 1.6 billion people over the age of 15 were overweight. This, WHO suggests, could double within a decade [1]. The reasons WHO associate this with are both poor diet (heavy in sugars and fats while low in vitamins and minerals) and increasingly sedentary lifestyles [1]. While this used to be a concern of more affluent societies, it is a rising problem among all socio-economic groups [1], which would suggest that poor diet is the cheap and readily available. In other words; *fast food*.

It is natural to assume that the energy consumption per capita would relate to the general standards of living of people within that society. However, in the US, the consumption of energy per capita is roughly twice as the average of a country within the European Union (EU) and yet this does not equate to greater standard of living - using a number of socio-economic indicators, the US actually falls behind the EU nations average standards of living (Smil, 2009).

Smil (2009) argued, that this is the result of how different the transport system is in both regions and modifying them would be improbable. Many people in cities of the US spend more than 30-40% of their yearly income on transportation alone [2], however, this is certainly causes by a combination of urban-city travel (cheaper housing further away, but increased travel costs), unnecessarily large vehicles and frequent solo travel.

Water too has been treated as an all too abundant commodity, where copious amounts of energy are used to pump it from location to location, treated to drinking standard from where it is as likely to be drunk as it is to be flushed away [2].

The criticism thrown at me, as discussed above, largely regarded such things as trivial when the nuclear age takes true hold; as cheap and abundant energy drives many generations without the pesky issue of CO_2 emissions. We can expend the extra energy to make nitrogen fertilizers by other means, water security will no longer be an issue, high product turnover rates seem more viable, etc.

I argue, how far does this go? Will processing food and liposuction be so cheap an easy that we won't need to worry about sustainable agriculture and fitness? Will the ecological services we obtain from nature become relics of a simple past; so much so that concern over

biodiversity loss becomes at best a hobby? Will our ability to condition the atmosphere be so great that forests in general can finally be cleared to make way for more human habitation and entertainment, with nothing by parks as distant reminders of a green world? Will we be become so complacent that when the day finally comes, however centuries hence, that this wonderful material is finally spent, that we are unable to use the grey matter in any imaginative fashion to find a solution to a world so fundamentally changed and deplete of useful services?

If efficiency can only be marginal at a personal difference, that still a bonus. The real goal of efficiency should be to keep us on our toes and keep wondering how we could both improve and do things differently. Constant improvement could mean the difference of a millennium of nuclear power or much much more. It should also lead to the development of technologies unimaginable at this point in time. It would almost certainly address a need to relate with our local flora and fauna for the sake of mental and physical health.

When you have a man in his 30's using a personal scooters as transport, solely because his lifestyle has led to him being unable to walk further than to his letter box and the sheer bulk is enough to cause stress to his heart, or technology with an average lifespan of a few years you cannot help but wonder what the real costs are with the cheap and easy energy supply and how we tend to use it without thinking.

The, "just 'cos it's there and easy," is without a doubt the root of unsustainable lifestyles and reflects the more abhorrent human tendencies.

Dim Food

Fast food may be cheap off the shelf, and there is certainly no doubt it tastes great - that's how it was designed to be. However excess is not good for anyone. Just because liposuction or a valve replacement becomes cheap and easy, does not excuse gluttony when health risks could be avoided (and thus tax-payer expense through medical costs).

Image (8)

Likewise, just because energy is cheap and easy doesn't mean I need a flimsy and useless shelter that looks good but almost always needs climate control. Just because it can be made for next to nothing doesn't mean I need a car as big as 'all out doors'. You cannot justify over consumption alone on the relative availability of energy.

This seems to be the mentality of our history with fossil fuels and seems equally prevalent within the circles of advocates of, arguably, the next phase of high grade reliable energy; nuclear. What is obvious with this attitude is the quick turnover of produce, the divide between the "have"s and "have not"s (ie. disparity) and therefore represents a definitive failure in promising to improve the lives of all of our species.

As like with fast food, it seems that we're engineered to want not only to keep up, but ultimately out do "the Jones's"; where the brave work by *Doctors without Boarders* (1) and others are extreme and isolated cases of altruism.

Indeed, if all this abundant cheap energy really led to the improvement of the standards of living of our species, it would be hard to condone poorer people turning to highly processes fast food because it's the cheap option. Working close to a decade in retail, I saw firsthand on a daily basis heavily overweight parents, their obese children and a mountain of junk food for the weekly consumption – generally coming to a similar price to a healthier shopping cart (amounting to more food / energy however), but the bonus of little preparation time.

As discussed in the chapter section, I had what turned into a pointless rant with some Hungry Nuclear Consumers (from here on HNCs), one of which argued that industry long ago cut the fat and was working more or less efficiently enough. I couldn't disagree more.

Image (9)

Eating with the lights out - don't cut yourself

Early 2010, I wrote a piece titled, *The distance in consumption* (2), in which I explored our relationship with food. In short, we harvest two things; energy and material. Almost all the energy we ingest was originally collected from the sun via photosynthesis and a diet in legume and grains, with complimentary additions provide all the essential material ([2] and Smil, 2008). The higher the

trophic level (food web) the species product (ie. meat) is and the more the product has been modified from its natural state, the more inefficient the product is for its nutrient content (which in most cases is designed for its flavour and is compatibly lower in nutritional value than more natural produce [1]).

We've all heard someone chuckle how in temperate regions, the price of tropical imports are compatible to produce that should be locally grown. If your weekly shop is entirely from a large supermarket chain, you would also be inclined to purchase more packaged good rather than fresh produce that are noticeably more expensive and definitely require more time in preparation.

For instance; why buy a couple kilograms of potatoes and bother with the peeling and cutting when frozen potato portions are cheaper and ready to be cooked?

How on earth is this even possible? The more you look into what you eat and where it comes from, the more you understand what some of the HNCs label as *efficient* - it solely rests on the back of cheap and abundant energy.

This is to say, when travel, storage and processing are not an issue, a company is more cost effective when it finds an area where labour is cheap, taxes are low and environmental regulation is a low priority. Thus the company can reduce its expense on wages and taxes as well as reap the benefits of cheap material exploitation and poor waste management policies.

By reducing these costs, while being supported by cheap and abundant energy, it becomes more cost effective to transport produce great distances and store them for indefinite time spans than to deliver fresh local produce. In fact, the chain from farm to supermarket is saturated with so many middle men that it is far from profitable for the local farmer. When you venture to a place like the Central Markets in Adelaide and begin to learn a thing or two about the store owners, you find a different culture. Many of these stalls have a close relationship with local farmers. The food is cheaper and much much fresher.

Efficiency, as it was understood by the HNC's I debated with was little more than having the energy to devalue goods, services, the environment and communities. Regardless of the energy requirements, we could find ourselves replacing scores of ecological services, for little more than entertainment purposes; why farm when we can synthesise food? Efficiency in this light is nothing but a guise for energy dependent unethical practices that undermine sustainability. The future as desired by certain HNCs is one of unimaginably cheap energy – imagine what that would mean for such "efficient practices".

The HNCs promoters of an abundant nuclear future may have their orders ready for the ever bigger SUV, but I cannot help but worry. Our track record with cheap energy is one of affluence *beyond* excess and a devaluation of the most fundamental resources and services. It should not be a case of limiting the use of energy, but the ever invigorating question of how to use it better and protect the value of the natural world and communities.

Chariots of Smoke

Initially, the plan was to continue the last piece with a look into consumables that are not eaten.

However, this would be self-evidently redundant. As food production becomes more designed for taste rather than nutrition, it becomes more for entertainment than survival. As technology continues to update, with cheap, short-lived components, we see the same trend as with food; buy buy buy!!!

Instead, I'll continue with a thought made near the end of the last chapter; the mentality of the ever bigger personal chariot. It's without a doubt a status symbol within all societies of our species. On a cheap pump, who cared how many miles it gets to the gallon; as long as it's big, loud and fast!

I guess no other technology stands as a more appropriate example of how we currently approach cheap and abundant energy. However, even if we can produce new vehicles that do not have emissions of any sort and are cheaper than today, this will be impractical for tomorrow's communities.

Of all necessary behavioural changes, how we view our reliance on these wheeled beasts of burden will be paramount and will have the greatest impact on improving the general standard of living.

"Fully sick wheels bro!"

How we move ourselves across the earth has changed dramatically over the past two centuries. However, most modern transport is little more than improved technology from the last 19th and early twentieth century (Smil,2009).

Indeed, looking at more than 80 years (from 1923 - 2006) in the US, the average miles to the gallon (mpg) only underwent one major period of improvement; this followed the oil scare in the 1970's, with vehicles improving from 11.9mpg in 1973 to 16.6mpg at 1991 (42%), after which improvements slowed to the ongoing rate of 1.8%, (Sivak and Tsimhoni, 2009, and Fig 1. below).

Much of the results of improved efficiency have been offset by increasing demands on transport (Åhman, 2001). An example would be demonstrated by a 1.5% annual increase of CO_2 emissions in the US from 1990 to 2007 (Boies et al., 2009) while the efficiency improvement rate was 1.8%. that is to say, that even with improvements, we still use more and more personal vehicles each year. This is an example of the “problem with efficiency” that was inappropriately argued against me as discussed in the previous chapter.

With internal combustion engines, it remains that you lose more energy than use productively. Sivak and Tsimhoni (2009) correctly suggest that as you improve the mpg, each subsequent

improvement saves less fossil fuel (ie. 1mpg improvement on 15mpg compared to 40mpg will have more of an effect on the average yearly consumption.

If you look into the above references and their following references, there are many papers that discuss internal combustion engine improvements and alternative energy engines.

With increasing vehicles per household and an increase in single person travel (in what appears to be ever increasing typical car size), there seems to be a number of short comings and certainly a loss of potential when we predominately focus on alternative personal vehicles. As our population grows, and single person trips grow, obviously congestion will increase. As I've previously mentioned, even if generation III and IV reactors can provide a radically increased energy resource, it seems mindless to assume that we can continue business as usual under a nuclear guise. Personal vehicles are increasingly flamboyant and inefficient (in use and in design). Continuation on this path will just mean more hours creeping slowly along the highway and increasing personal and environmental impacts.

From here, then?

Image (10)

Although I have serious doubts regarding the typical "population growth = economic growth" attitude, with a finite space and resource base, I believe that it is still possible to increase our population size to as much as the predicted 9 billion and not only conserve biodiversity, but also improve many natural systems. The reason I mention this at this point is that I also believe that the biggest cause of change will not be through heavy political regulation or through a new age of environmental enlightenment, but more realistically through a significant shift in transport and infrastructure. If we want more people, we will need greater density lifestyles – including increased public transport networks.

Arguably, our greatest impacts on environments are the result of transport and our physical footprint on the surface of the earth. It is here that the greatest change in perspective will have the greatest results on the larger environment and the next wave of cheap and abundant energy will be core to this, but I strongly believe that without a significant shift in our perspective, we will only repeat past mistakes to environments that are already stressed due to landscape use changes and climate change as discussed in the first 9 chapters. In chapter 14, I will begin to discuss how we can approach a changing world with innovation.

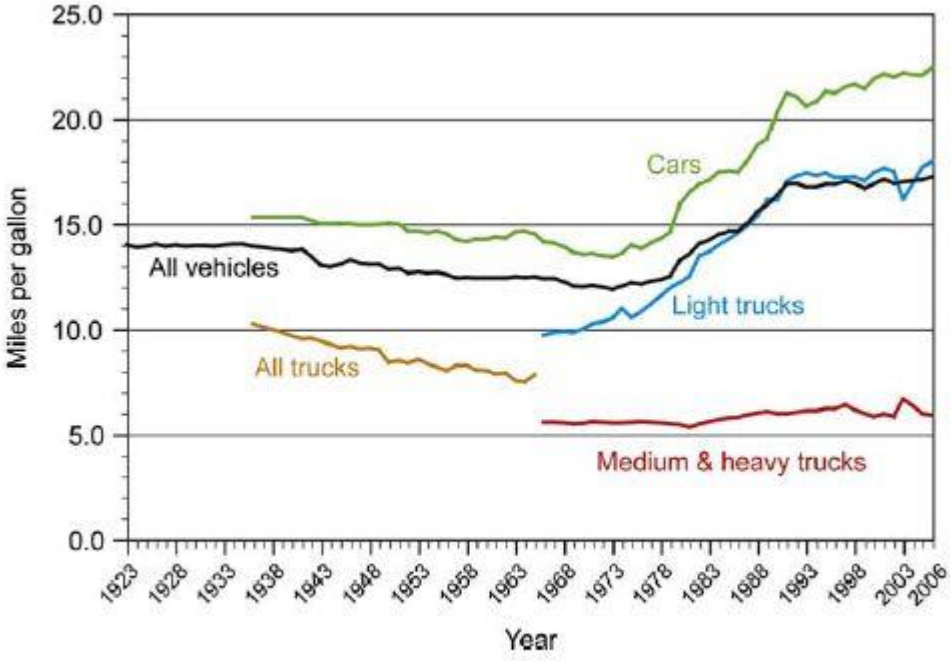


Fig. 1. Fuel efficiency of vehicles from 1923 to 2006.

Chronic Sprawl

Probably to most counter intuitive, counterproductive, inefficient and unhealthy ramifications of the social developments of the previous two centuries is the increasing tendency of urban sprawl. Each and every one of us in developed western communities have seen at least one advertisement regarding some new suburban development; where you can own a nice patch of land with sweeping views, fresh air – all within a short drive from business districts! Sounds great doesn't it?

Image (11)

Give it a decade and your view is replaced with the neighbour's second floor and the short drive to work becomes a long painful creeping journey, nose to tail and immersed in the fumes of idle engines. Give it another decade and you'll soon be watching the next new development with the desire to move there for the sweeping views and easy commute into work...

This is arguably the life of urban sprawl.

We want the personal patch like we want that burger...

And it's potentially just as unhealthy. Overman et al. (2008) demonstrates that the relationship is, however, a difficult one to truly assess. They concluded that it is likely that people who are prone to obesity are inclined to favour sprawling neighbourhoods rather than the opposite – that urban sprawl tends to cause an increase in body mass index (BMI), which has been the conclusion of a number of other papers.

Image (12)

Of course, when looking at human motivators, results are hard to conclude, due to the various nature and nurture influences on the individual level, however, the majority of work (including the previously mentioned paper) do find a general increase in BMI in sprawling neighbourhoods compared to none sprawling areas. Urban sprawl is typified by suburbs of low-density, relatively homogeneous residential living (Frumkin, 2002, and, Ewing et

al. 2003). In these sprawl areas, walking to the services is less likely than in older mixed use neighbourhoods, more or less due to this separation from services (Ewing, 2003).

A review of much of the literature demonstrates a fair amount of debate regarding the physical and mental health aspects associated with urban sprawl (see Brueckner and Largey, 2008), however, I agree that the detrimental impacts out weight the benefits of such low-density homogeneous suburbs (see Frumkin, 2002).

Locally, such sprawling suburbs areas were, until recent decades, rural agricultural land. The reduction in profitability of agricultural land is arguably the result of cheap imports discussed in previous sections, while the profitability of landscape for residential use is quite likely the result of cheap fuel and the continuing desire for open space living. In both cases, cheap energy supplies the motivator.

This is based on the observed population growth throughout the Mt Lofty region although public transport has not significantly improved (in fact train services are currently not in use). As a result, much of the most fertile land on the Adelaide plains and into the Mt Lofty region are now under concrete slabs or polluted by new industrial and private transport use. Although Brueckner (2000) states similar, while ending on the note that it is unlikely that there will be a significant loss of agricultural land, I would agree, but only on a global scale and one that only superficially reflects quality of ecological services and production of remaining primary production within the region.

Although, like BMI results, there is general consensus that there are many benefits to open spaces and that of personal fitness, sprawl obviously reflects a lifestyle that leads to a reduction of diverse open space and encourages personal vehicle use rather than personal fitness benefits of public transport, bicycle use and walking (Brueckner, 2000, Frumkin, 2002, Smil 2009, [2]). When one includes the loss of fertile agricultural land, ecological loss and fragmentation, water quantity and quality security concerns, continuous population growth, peak oil and commuter congestion (and related pollution regarding both exhaust and tyre wear), it's not difficult to come to a conclusion that sprawl is unsustainable and impractical.

In a number of the referenced papers, there is also mention that typically related infrastructural costs and driving related health cost are ignored in the development of new suburbs. That is to say, the true cost is often greater than the advertised sales cost of new property and one that is somewhat dispersed among the great population.

Such costs might dull the vivid sunset glow on the posters.

For as much as we all seem to appreciate the tranquillity of open spaces, *we lose this when we're all there together*! For as much as we yearn for an escape, the further we move, the more time we find ourselves stuck in traffic, wishing ever more loudly for a holiday. As much as we long for that patch, we all too often find ourselves looking up at our neighbour staring down at us and our kids from their second story window.

We want space and we want easy transport options to work, services and for leisure purposes. Most people would happily agree that preservation of natural environments should be on the cards. I personally feel that this is all possible, while we begin to address the problems associated with the use of fossil fuels and continued population growth, without *major* political regulation. We just need to change our attitude.

Keeping in mind the previous chapters to this work, I feel that there is certainly room to improve. I also feel that the best likely way to secure future high grade energy will require at least some assistance through generation III and IV reactors. What I disagree with, however, is that we have a good track record with cheap and abundant energy. Regardless of how much potential energy we have in the palm of our hand, consideration *must* be maintained for *genuine* efficiency or else we will run the risk of complacency and the continuation of devalued resources, services and communities.

Image (13)

A hypothetical situation would be if we developed a method of replacing the atmospheric conditioning done by photosynthetic species (ie CO_2 sink); that, let's say, a unit the size of a typical 10 storey office building can replace 20 hectares of forest atmospheric conditioning, but at an exuberant energy cost. It's easy to see how we could be so foolish to make such a transition for the simple reason to have more room for entertainment.

Do enough of this (and also replace a number of other ecological services with "cheap" alternatives) and we've dramatically increased our energy consumption. If we can build more reactors to keep up, it'll be fine... how far does it go until we're on the downward slope of peak radioactive material? As with all resources it should not be so much a question of how much we use, rather how well we use it. If we used landscape more efficiently, for instance, we would not need as much land (of course, to overcome the superficial efficiencies discussed previously, natural landscape preservation must be part of the planning).

If we exploit ecological services to their fullest; if we endeavour to ever increase our efficient use of energy and resources; if we maintain innovative thinking, we'll certainly extend the lifespan of whatever non-renewable energy source, reduce waste and no doubt have a compatibly lower energy budget (for services used) once that finite resource is also exploited as well as having developed an increase understanding and integration with natural systems and the promotion of a culture of innovation.

Go hard or go smart

What often is thrown in my face (recently from a HNC as well) is that for major change, governments would need an impractical iron fist. I certainly disagree, as like I disagree with many schemes to limit emissions. People resist when you try to tell them what not to do. What works better is incentive to change. I can almost hear the reader roll their eyes, however, hear me out. I'm not talking about some form of gold star sticker; I'm talking about a shift to more practical infrastructural spending.

There's an obvious hive of activity associated with sprawl; whether it's in building, providing new service points, increased spending on fuel etc. On the outset, it obviously makes sense to

invest in providing new patches for ever increasing sprawling populations as it, apparently, fuels economies (even many of the negative associations, such as health, feed GDP, such as increased medical costs and more cars lead to more accidents). However there is another way to invest that could potentially increase spending, population size and value both of natural environments and urban areas.

Image (14)

Rather than focusing investments on new infrastructure, why not improve public transport, water and energy to key suburbs and cities? Capital cities in Australia are wonderful places to walk around. I personally enjoy Adelaide, Sydney and Melbourne as wonderful places to explore on foot.

Increasing such infrastructure will give greater incentive to live closer to work areas and reduce reliance on personal transport. As populations increase over the coming decades (as well as the potential for abundant nuclear energy) it seems unlikely that open space appreciation can exist with ever increasing sprawl.

Incentives in; quick and cheap rail among (and loop services within) these key suburbs and city centres; a reduction in low density living in these areas (ie. infrastructural and financial support to encourage people to be inclined to move into town houses or apartments); a reduction of personal traffic in these key areas (ie. close roads to all but commercial traffic, pedestrians and bicycles); a correction of council rates in low density areas to suit congestion, environmental impacts and maintenance cost...etc...

I know I've only covered it briefly and there are certainly many issues not addressed. However, clean, efficient and quick public transports as well as comfortable higher density options, cleaner streets, a reduction in vehicle related noise and chemical pollution would increase the comfort and practicality of such areas. Providing cheaper hire use of vehicles also provides communal car use for part time users living in mixed use, higher density areas.

Provided that a reduction in sprawl is properly encouraged, this newly freed land will also provide useful land for local farming (cheap local fresh produce), rehabilitation of local fauna and flora (local access to open spaces and natural environments and an increase in ecological services, such as water treatments, storm protection soil improvement and sustainable harvest) and of course stylised parks and entertainment areas (local access to open spaces aesthetically appealing and various physical and mental health applications related to entertainment).

Image (15)

The only governance changes that I would suggest would be a correction in council rates and altered infrastructural investments, as previously mentioned, and possibly an obligation to provide native corridors for species movement and a return to productive gardens (which can be partially funded by governmental incentives See (1)). Otherwise, it's investing in making CBD's and key suburbs more liveable and worth a reduction of personal outdoor space when compared to ease of access to services, public open spaces, reliable and efficient public transport and comfortable higher-density living.

Locally, there is a lot of reshuffling at the moment and certainly potential to make such investments. As population increases and oil price increases, sprawl will become increasingly inefficient and costly. Investing ahead of time in practical and enjoyable upward living will provide room to dramatically alter and improve standard of living, provided that it is done innovatively.

Social Upgrade

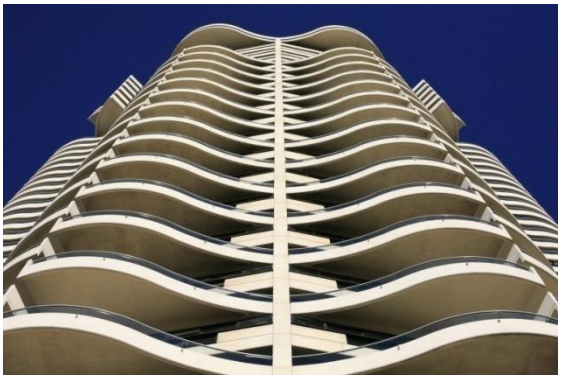


Image (16)

To begin this section, I wanted to make a personal remark. After close to a decade of relying on Adelaide's bus service which appears to consider timetables as a mere suggestion, where the drivers will chose to pull over for a smoke whenever the moment takes them and the observably apathetic customer concern phone line, I am the *least* likely to advocate public transport lightly. Over the past few years of driving, I have resisted opportunities to catch a bus and have witnessed my fiancée being turned down for jobs simply because she doesn't drive (it was never a problem in Melbourne with their public transport system). The stigma with public transport in SA certainly speaks for itself.

However, as Prof. Peter Newman discusses in [2], in Perth, the Southern Railway has demonstrated how efficient public transport can alter commuting habits and such techniques, as part of Transit-Orientated Developments (TODs), can change the needs and distribution of people. As rail can be electrified and light rail is practical within nodal regions, it is an easy and practical way to remove one aspect of fossil fuel use - thus relying on *source energy* to provide the next step in a shift away from fossil fuels (that is to say, if electrified, the retrofit would be required once and not progressively with innovation).

By investing in TOD infrastructure, governments are only providing the foundation on which business and citizens can build upon for their own benefit, rather than governments capping and condemning progress.

I know that I will upset some readers by not covering much in the way of renewables. Like biofuels, I feel that they have limited benefit and potential at this point. Sprawling suburbs should, in my opinion, be encouraged to collect water, capture wind and/or solar energy and have on-site grey water processing. Similar, yet at a larger scale, should be taken on in nodal higher density developments – for instance toilet water that is recycled grey water - and a number of passive and renewable energy sourced climate controls are used within building design.

As vehicles are pushed outside of these regions, it is possible to reduce other wastes (both in water and thermal energy) within these regions which are practical and will help decrease our impact on neighbouring environments. The removal of vehicles also opens much more pedestrian space and floor space by the removal of congested roads and parking spaces. Roof spaces should also be used as valuable floor space or at the very least retrofitted for wind/solar energy capture or passive thermal control.

Obviously there will be those who will prefer *their space* at the expense of the work in yard maintenance. Through a combination of policies and incentives, this can also provide a number of benefits both socially and environmentally. As the concrete slab is laid, there is little question that this covers useful land. That would be fine, were it not for landscape design that covers the

rest of the yard in concrete, stone or worse - fake grass. Why have a yard if there's no visible yard? If it's for entertaining, a property of higher density can provide adequate yard (town house) or balcony space (apartments) or the newly opened spaces in the reduction of sprawl will provide open places to lay a picnic rug and kick a footie with the kids or greater mixed use open space entertainment and services.

Image (17)

That's not to say that land use such as this should be stopped - if someone wants a yard of concrete, *that should be their choice*. However, it should be reflected by their rates/taxes as an understanding of their dependence on other services and environmental footprint.

It has been only been since the end WWII that there has been a reduction of personal vegetable gardens and a retraction of fruit trees. Proper water collection and on-site treatment can provide the required water (and many of the minerals). Even with low energy units, it's foreseeable that every house can have a cheap watering computer that does much of the yard irrigation work - you just need to prepared the land and collect the yield.

This will also open the opportunity to interact with neighbours to trade and share produce, providing an increased sense of community (see link 1). Yards should also be encouraged to re-introduce local flora species (and other suitable substitutes) that provide a number of services to local fauna. This, coupled with open space and roadside re-introduction will help to re-establish local biodiversity and assist in species movement across a landscape (both in response to climate changes and for general dispersal). Favouring species that provide different local services (such as for pollinators, storm protection, thermal control, water management etc) also will assist with biodiversity resilience and infrastructural protection as climate continues to change. Also something that is often overlooked; there would certainly be an increase in a sense of not only community, but also *place* with increasing local biodiversity richness.

Whether you live in bustling new higher density areas, or fringing open spaces, if properly encouraged, there is room not only to reduce congestion, but a cities impact on the local environment, personal fitness and interaction (both very likely to improve mood), cleaner area / local air quality, reduce energy consumption, increase population *and* biodiversity *and* other open space entertainment; all while assisting to improve species resilience to current climate change and urban resilience.

Pretty cool, huh?

No Option

Almost all transport is currently the result of oil. Nitrate fertilisers derived by natural gas play a major role in feeding the world [2]. As these two fossil fuels peak (oil is peaking and natural gas will in the coming decades) food production is the most obviously threatened industry, subject to expenses relating to both. Without significant changes to practices, this will lead ever increasing costs and unavailability over the coming decades - something even more troubling when we include population growth and distance food travels to reach major populations.

Image (18)

The HNCs have argued that on the back of abundant nuclear energy, we can make changes to transport and derive fixed nitrogen through other means. Business-as-usual advocates (BAUs) have argued that fuel and fertiliser can be derived from coal - of which we are a long way from peak supply. I have concerns about both arguments, but mostly relying on coal.

Iron Age with plastic surgery

In an article by Prof. Vaclav Smil (2009), he accurately highlights just how iron-age we remain. In 2008, primary iron smelting produced 930 million tonnes, almost all of which is used to produce steel. Coke, derived by pyrolysis of coal, is important part of steel production. Even with improvements, 420 million tonnes of coke, plus equivalent to another 100 million tonnes of coke was required for the 2008 iron production. Without coal, we would need to revert back to charcoal that is produced by woody biomass. Just to maintain current iron production, the *yearly* requirement of wood - even if high-yield species were used - would require a land area around half the size of Bazil's Amazon tropical rain forest (Smil, 2009). Obviously production of that magnitude is absurd.

Image (19)

What strikes me as equally insane is that in any city I've visited, there are numerous steel graveyards left to rust rather than be recycled.

There remains to date, no meaningful alternatives to fossil fuels for steel production, just as with jets and large cargo ships. Just as it remains with first generation bio-fuels, non-food related agriculture (here for charcoal) would be impractical to maintain business as usual as fossil fuels creep beyond peak (regardless of how long we have for coal). To maintain practices as they currently are is nothing short of greed at the expense of future generations.

By reducing our dependence on fossil fuels (whether it's nuclear, renewables or a combination), electrification of efficient TODs, and encouragement of increased density cities (through humanistic design), surrounded by multi-land use practices (including nearby primary food production, open space entertainment and reclaiming natural vegetation) we can make meaningful steps to reduce our emissions.

Recycling of steel will also help preserve coal supplies for longer term availability. In this way, we can protect flight, cargo shipping and steel production for a longer period (and help keep costs down), where emissions are less of a concern (based on reductions discussed above) and increase development time for substitutes in these activities.

Modifications as argued by BAUs are not required if we can think innovatively and approach city development with fresh eyes. It would also insure that we use this finite supply with increased *genuine* efficiency rather than mindlessly burning it up. The HNCs also risk complacency when they say that they can just make nitrogen fertilisers. If we explore other methods, we may not need nitrogen fertilisers at all (would be good to avoid related pollution which is increasingly becoming a major problem from such fertiliser use).

Image (20)

Our dependence on oil, coal and gas goes beyond the tank. Like coal based coke, many of the materials we use around us came from these hydrocarbons (especially plastics). About the only substance around me that isn't directly created from these fossils is the wood of the desk (which still holds a large CO_2 footprint from its production). Even the concrete is reinforced by steel.

As we burn it all up, we'll find ourselves increasingly requiring new methods of our practices. *We cannot avoid this fact*. What we can avoid is the sharp price increases and radical last-minute changes typical of knee-jerk realisation. If we begin adaptations *sooner* rather than later, we can insure heavily-dependant industries have more time to adapt and improve while the current energy supplies remain relatively cheap.

Food from a Changing World

Seeing as I've covered a look into urban restructure and production of goods, I guess I should return to the farm. This has been a reoccurring thought throughout this work. There is little doubt that the world is changing - regardless of what *a small group of people* will have you believe. I've discussed the biophysical indicators previously and it has been demonstrated that the climate or hardiness zones are shifting poleward (1). Without properly addressing this change, *farming will not cope*. It will be even worse in poorer countries that have less resources and support. Post-peak oil will make all aspects of farming and transport more expensive.

Simply ignoring the problems until there are no other options is mindless.

I've tried to explain throughout this work just how real the change is and how close it is at hand. To wait until it's irrefutable – until abundant energy is no longer so abundant or until agenda based media makes up its mind of just how strong the scientific consensus is and what that truly means – is to wait to see if the doctor was right in stating the mole is cancerous (ie. when it's too late).

The fight is harder when the evidence is *beyond* overwhelming (for it's already overwhelming). I've also tried to demonstrate some amazing room for innovation, entrepreneurialship and to invest in increasingly balanced, humanistic and sustainable societies. There is money in change and there is hope! There is a prosperous new world that can be achieved, *but only with a changed social structure*.

Back on the farm

Since late 2009, when I began blogging, I've discussed farming continuously. It's probably strange that I'm so interested, as the last farmer in my family was my Dad's dad. My father once took me to one patch from his childhood, with a crumbling stone building (once his home) resting at the foot of a rolling landscape.

I grew up in cattle country down in the Gippsland and spent a little bit of time on the farms down there. I'm not sure where the true root of it sits (for I have a thousand memories at hand), but I've always held a strong respect and interest in agriculture and farmers.

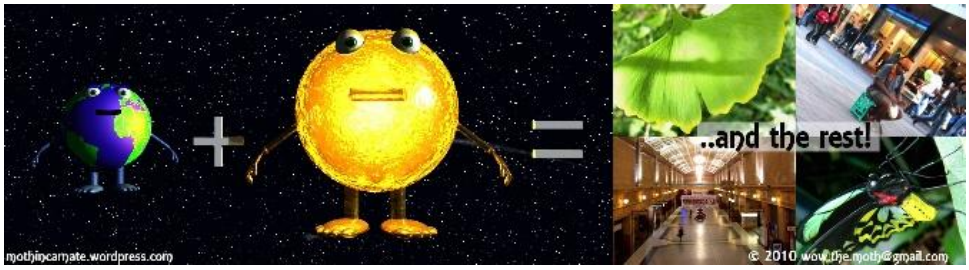
Another thing I might note is that in comments on other blogs, I've often had others retort that they are multi-generational farmers. This is something on the cards to be discussed outside of this series, however, I would like to say that this is an obvious lie in many cases. It's easy to make wild claims on the faceless internet, however real life isn't like that and no farmer I've met has ever shot down discussion regarding innovation and potential impacts of climat, nor have I met many farmers that have the time or interest to waste indulging in the often trivial debates prolific on the blogosphere.

Sure, most feel that they understand their land unlike any city boy with a degree ever could (and they're right), but I've generally found that they like ideas they can use to improve and they understand the language of the land. They know things are changing and most also recognise that traditional European-style farming will not continue on Australia's back. I get wary with posers telling me in comment streams a fake personal history so blatantly untrue.

I think that there are a number of social dysfunctions in the younger generations and like the bulk of this series, there have been many social changes that have had dramatic implications to potential, profit, food and water security and standard of living, whilst sacrificing certain forms of resilience. Again, this is something that I'll look into more outside this series.

What I believe needs to occur is a reintroduction of the local farms (in land opened up from sprawl, as previously discussed). As oil prices increase, cheap foreign goods will no-longer be so cheap. There is also a valid point that nothing is fresher than local fresh produce. Sure, transport temperate and tropical produce between latitudes (where feasible), however what can be grown locally will help to maintain lower prices across the board. On an electrified train system, there will be a greater connectivity without the need of fuel dependant vehicles.

There is a growing buzz about bio-fuels made from agricultural waste (ie. second generation bio-fuels). This, plus much of the vegetable oil waste and gas produced via anaerobic digestion, I feel will provide the bulk of sustainable bio-fuels which can be best applied in agriculture (where most electrification techniques couldn't meet the industry's needs). Processing of this material in less fertile areas of agricultural regions could also be predominately on renewables - thus reducing the need to build the grid (or select a region closer to an existing grid) while also reducing the processing costs - again lowering food prices.



Potassium and nitrogen are two limited materials in agriculture. Personally, I have limited working knowledge of potassium, however, I do know that it is often a concern in grey water. As I've argued earlier in the series, on-site processing (using on-site renewable energy supply) of grey water should be adopted, from which the cleaner grey water can be returned for environmental flows and agricultural irrigation (providing some minerals - including potassium). Certain anaerobic digesters will also supply more high quality organic fertilisers which are still under utilised to this day.

Nitrogen has a few options. Obviously at present, natural gas provides much of our usable nitrogen. There are a number of other options that could be used as an alternative, but in all, there is the risk of pollution (especially in run-off water ways). Naturally, it is left up to bacteria in root nodules of legume species, to fix nitrogen into a useful form, however, this process could not provide enough nitrogen fixation to feed our growing population.

It certainly is the most sensible way to provide nitrogen without as many problems as using nitrogen fertilisers derived from natural gas (again, anaerobic digesters should play a larger

role as well). I would suggest genetic modification (GM) aimed at overly redundant nodule growth on legume species and / or nodule development on other crop species may help solve this problem. Another option might be to produce a land cover hybrid species that produce excessive nodules and also provides continuous ground cover, but is not a consumable itself. The water retention, top soil protection and continuous injection of fixed nitrogen may overcome costs in maintaining this secondary species (it may also provide a good stock feed). GM may provide the answer or at least assist in a changing landscape.

Rounding Up

I opened this work on the note that an individual who once wasted a fair amount of my time actually had something interesting to say; we both shared concerns regarding how reliant our species is on fossil oil, coal and gas. His concern was that taxing carbon will take us back to pre-industrial societies and famine (if Stern is correct, at worst this represents about 2% of the global GDP [3] – hardly doom and gloom if you ask me). My concern was that doing nothing about our addiction will take us back to pre-industrial societies and famine, through short-sighted, knee-jerk planning. His argument was that climate change science doesn't merit concern. Mine, that it is too troubling to ignore and that the many related issues mean that focusing on this one aspect was nothing but a futile act of distraction.

To explain my concerns, I chose to avoid the IPCC and hockey stick graphs as there is *small* yet noisy group that obsess over these, climate models and Al Gore. I'm not sure when these obsessive individuals decided that they were climate experts, let alone even scientists of any sort - largely it seems that they read a few books on some "swindle" and figured that paraphrasing such work would earn them some form of respect (more a question of their character and personal needs rather than adding anything beneficial to science).

As I'm *not* a climate scientist and have seen many excellent blogs and web sources out there that explain much of the climate science which are run and written by actual climate scientist, I chose to avoid much of the depth others have provided, simply to provide concise snippets with a number of references included to give an introduction to a much *larger* associated problem (than just anthropogenic global warming). From experience, I've come to realise that even such excellent scientific communication falls on the deaf ears of this small obsessive group, so I didn't wish to be yet another one heading down that same path.

In that way, I provided some physical responses of a changing world; temperature trends, ocean acidification and sea levels. The world *is* warming, oceans pH *is* decreasing and sea levels *are* rising. We may be discussing small changes so far (as some try to use to wave off such concerns), however, I then went on to show some evidence in biological indicators of change; species distribution, timing of biological events, de-calcification, and a look into this continuous change into the future. Small changes will remain small over a human lifetime but at a multigenerational scale, change is more evident (1).

With all this in mind, I talked about peak oil, gas and coal and how over the coming century, regardless of all else, oil *will* become ever more expensive, with gas to follow and coal left, not only to provide an important role in steel production but also to pick up the pieces of business-as-usual mentality. This outlook, I hoped to make clear, is not a sustainable future and will only increasingly become difficult to maintain.

Looking at the "consumer", I've tried to explain what has happened, largely since WWII, on the back of cheap and abundant energy; developed nations have become fatter, used energy

inefficiently, population has exploded, the need for "stuff" has ever increased, sprawl has taken ever larger areas of land, congestion has meant copious amounts of emissions are wasted crawling along freeways, and, food increasingly comes from poorer nations at the expense of the local environment and exploitation of cheap labour (and at the cost of farmers closer to home); waste of useful material is a prevalent part of a complacent lifestyle. Whatever the new source of energy is (even if it is as abundant as nuclear advocates assure us) we need to be wary of how we manage such energy - especially in relation to landscape and natural resources.

As I've expressed throughout; efficiency should be an integral part of inspiring innovation, but only where it is genuine efficiency, based on sound policies that discourage unethical increases to production rather than environmental protection and societal resilience.

However, I truly believe that an answer can be found that allows for; species resilience to changing climate; open space management and increasing population; agriculture on low oil and gas; better waste management (eventually no landfill requirements, as radical as it sounds); increased fitness and social health; and an ever increasing standard of living for all of our species while protecting the local biodiversity.

It all starts with thinking differently. A changing world needs changing ideas. For governments to first invest in nodal TODs infrastructure, industrial and citizen investments can follow to make the most of a bustling multi-use metropolitan. To encourage an upward growth can allow for a disintegration of sprawling areas, which can then be redeveloped into working farms, rehabilitated native vegetation, stylised parks and other open space entertainment. It should be achievable to have all the wealth of inner-city lifestyle, minus the chemical and noise pollution, with cheap food and a quick and an easy ride to a number of open space activities. You should be able to walk to work and have a short bike ride (or light rail commute) to somewhere open to kick a ball with the kids.

It's not about regulation and condemnation, but encouragement and investment. It's not about killing industry and a reduction of money flow, but *changing* the profitable pathways for industry and developing *new* cash flows never before seen. It's not about tapping off all fossil fuel use tomorrow, but using it where we need to and preserving supplies for industries that don't have an immediate choice (ie. flight, shipping and steel). It's not about telling people what they can't have, but showing them how they can have more by doing things differently.

We have the chance for a much more prosperous society; but only through innovation.

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Links

The Peak

(1) http://newanthropocene.wordpress.com/2010/06/03/jelly-bean-junkies-monckton-screams-biofuel-propaganda/
(2) http://www.lifeaftertheoilcrash.net/
(3) http://en.wikipedia.org/wiki/Peak_oil
(4) http://en.wikipedia.org/wiki/File:PU200611_Fig1.png
(5) http://en.wikipedia.org/wiki/Mountaintop_removal_mining
(6) http://en.wikipedia.org/wiki/Deepwater_Horizon
(7) http://bravenewclimate.com/2010/04/15/dv82xl/

Wheat and Flower Power

(1) http://newanthropocene.wordpress.com/2010/06/03/jelly-bean-junkies-monckton-screams-biofuel-propaganda/
(2) http://newanthropocene.wordpress.com/2010/04/28/is-monkton-working-for-an-amish-conspiracy-how-the-future-is-more-than-debate-over-climate-change/
(3) http://www.oilgae.com/algae/oil/oil.html
(4) http://en.wikipedia.org/wiki/World_energy_resources_and_consumption#cite_note-EIA-0

Detour into Troubled Water

(1) http://climate.nasa.gov/keyIndicators/index.cfm#GlobalTemperature
(2) http://www.climate.gov/#climateWatch
(3) http://www.skepticalscience.com/news.php?n=183
(4) http://climate.nasa.gov/keyIndicators/index.cfm#SeaLevel
(5) http://tidesandcurrents.noaa.gov/sltrends/sltrends.html
(6) http://climate.nasa.gov/keyIndicators/index.cfm#CarbonDioxide
(7) http://www.esrl.noaa.gov/gmd/ccgg/trends/
(8) http://www.esrl.noaa.gov/gmd/ccgg/trends/#mlo

Where will the Wild Things move?

(1) http://www.environment.sa.gov.au/biodiversity/threatened-species/regional-recovery-pilot.html
(2) http://www.climatechangeinaustralia.gov.au/satemp1.php

Between Earth and Sea

(1) http://www.ramsar.org/cda/en/ramsar-home/main/ramsar/1%5E7715_4000_0__

Immersed in Trouble

(1) http://en.wikipedia.org/wiki/Ship_pollution
(2) http://en.wikipedia.org/wiki/Keystone_species

Dim Food

(1) http://www.doctorswithoutborders.org/
(2) http://newanthropocene.wordpress.com/2010/04/20/the-distance-in-consumption-where-we-should-put-our-plate/

Food from a Changing World

(1) http://www.arborday.org/media/mapchanges.cfm

Rewired Thinking

(1) http://www.energybulletin.net/node/5104

Rounding up

(1) http://newanthropocene.wordpress.com/2011/04/18/you-haven%E2%80%99t-felt-climate-change/

Image sources

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