

ecolonomics

Paul Mobbs' newsletter of thoughts, ideas and observations on energy, economics and human ecology

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Mandelbrot's systems within systems, the layers of the universe experiencing itself subjectively

It's been a long time since I've written an *ecolonomics* – *it's been one of those years*. Last time I had time to take a pause from work was February. From the Spring onwards I've had the busiest period of work for quite a while. Trouble is, when you're writing creatively for your work it's not something you want to do when you're taking time-off. I've also suffered a serious lack of 'wind-down walks' this year, which also hasn't helped my compositional mood. Realising that Autumn was nearly over I went for a walk before an approaching storm stripped the trees of their leaves. As I reflect on the walk, and the related activities in the few days since, I find myself returning to one theme – *why can't people accept the reality of the world we live in, and, to deflect from this unwelcome reality, why do they spin incredible stories to create a delusional sense of well-being?*

Banburyshire, Sunday 7th November 2010.

Sunday morning; out of curiosity, I issue a console command to illicit some data from my computer; uptime. The response was rather curious; 09:46:51 up 62 days, 20:09. My computer had been running continuously for nearly 63 days (ever since I redesigned the office at the end of August and shut it down during the reorganisation – ending what was probably an equally long period of operation). It hadn't been idling either, often averaging 72% on both processors. This is not a server, it's my main work machine. As well as running file sharing and my automated web searching/indexing scripts I use it for downloading files, email, web, word processing, editing video files and making DVDs.

What this data tells me something very important; if I start work now I'll work all day, as I've been doing for the past few months. I queue some commands to execute sequentially, start some programmes running that will take a few hours to complete running in parallel, and then lock the screen. I pack my day bag, tie on my boots, pick up my walking poles, and leave the house heading West. My thoughts, constrained to the narrow confines of the jobs at hand, begin to re-route, taking in new conscious landscapes of ideas and thoughts. It's a liberating experience, and all of a sudden I find that I'm feeling a lot more "connected" than before – when I was wired into my digital universe.

Just over eighty years ago [Edward Bernays](#)¹ published his pamphlet, [Propaganda](#)². It marked the beginning of the process we know know as "spin" and "public relations". What Bernays (the nephew of Sigmund Freud) noted was that as part of our simplification on the pressures within our everyday lives we allow many decisions to be taken by others, and in that process there is the potential for our choices to be guided by those who are able to intercede within the various chains of social communication that inform our lives. By managing the message, the "invisible governors" of our lives can direct us towards certain ends over others:

"In theory, everybody buys the best and cheapest commodities offered him on the market. In practice, if everyone went around pricing, and chemically testing before purchasing, the dozens of soaps or fabrics or brands of bread which are for sale, economic life would become hopelessly jammed. To avoid such confusion, society consents to have its choice narrowed to ideas and objects brought to its attention through propaganda of all kinds. There is consequently a vast and continuous effort going on to capture our minds in the interest of some policy or commodity or idea."

We assume that the options society offers us to

choose from will be rational; *but what if they are not?* That's an interesting question to pose within our daily lives because, within the specialisations created by advanced economic organisation and the various bodies of "experts" that it throws up to handle our demands, who's looking at how the system as a whole is functioning? Looking beyond that initial query, it raises questions about the information we use ourselves in order to weave the narrative of our own lives, and how that affects our ability to envision what our future may be.

As I leave the edge of Banbury, [heading West](#)³ towards Broughton, I ponder Bernays' ideas (and the whole body of work on this issue since) and the "causality" of certain interests and ideologies in national policy. I don't have a particular destination; like Bernays' "invisible governors" I let my feet decide which path to take. From Banbury Cross I climbed to the top of Crouch Hill, then headed down *Salt Way* (an ancient trackway) before meeting Brought Road at *The Bretch* (known locally as *Giant's Caves*, an ancient quarry site). There I find a wonderful crop of [Shaggy Inkcap mushrooms](#)⁴, but as I have nothing to cook or carry them in, and a long day ahead, I leave them for another forager to find.

To understand Bernays, and those that followed his lead – such as [Victor Lebow](#)⁵ in the 1950s/1960s, and latterly those promoting the latest trendy fad of "[behavioural economics](#)"⁶ (a view of economics that, 70 years later, fully internalises Bernays' "invisible governors" approach) – in the years that followed *Propaganda*, you have to view "the public" as an almost passive consuming entity. It's interests are to seek their optimum self-interests as cheaply and easily as possible. The process of public relations that he outlined has today developed at the most simple level into advertising and marketing, but at its most sophisticated it can be seen in the complex image/perception management, social profiling and media spin practised by political parties and large corporations.

As "consumers" we have no responsibility to any external framework; the objective of this mode of organisation is to serve only our own fantastical desires for satisfaction. In terms of the developed consumer society, personal consumption has no guiding ideology, no defined code of conduct, and certainly no long-term purpose; it is guided by a mass of inward desires to sate the emptiness of not having that which others around us possess. For a society that is able to constrain itself to its "[better angels](#)"⁷ the scope of these fantastical desires should not throw up many difficulties. However the reality is somewhat different; in consuming we satisfy not the stolid needs of our moderating conscience but the boundless desires of our "inner toddler" – not understanding why or what it is that we're searching for, because we don't have the experience to explore

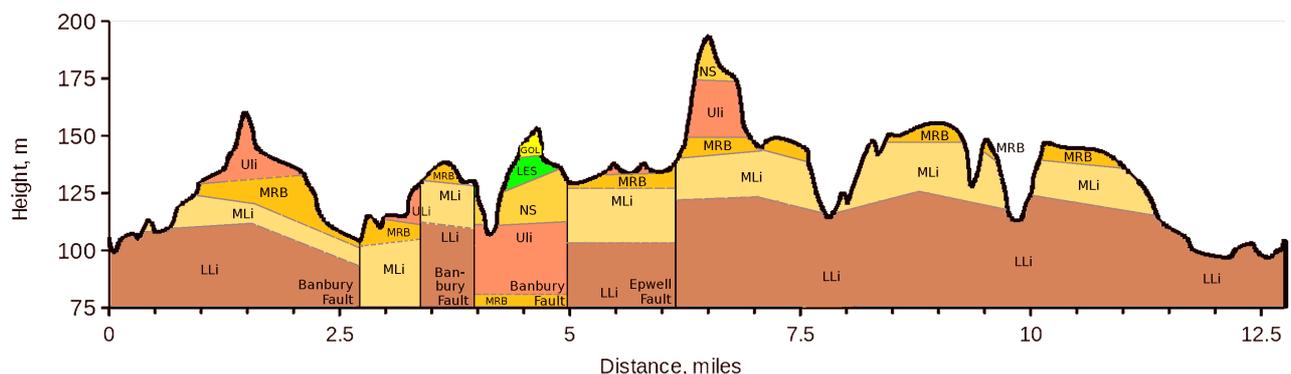
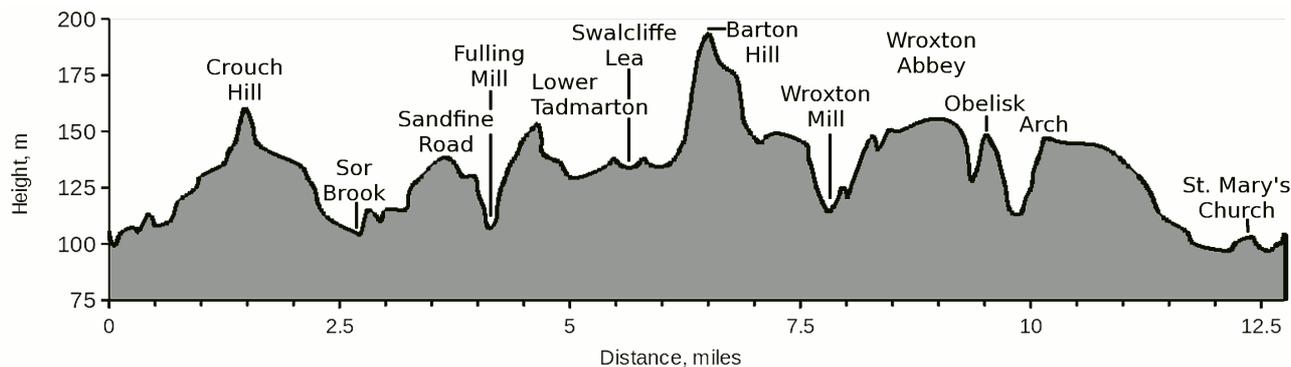
that reality within our own existence – and resorting instead to, collectively at least, seemingly unbridled impulses to guide our actions.

Walking can be a meditative process: It is rhythmic, as both your feet and heart syncopate with the pace of travel; with persistence you develop a relationship between breath, step and your physical exertion that, rather than expending effort, allows relaxation⁸; and as walking outdoors becomes an autonomic rather than deliberative process your mind is left free to take in the world around you, and simultaneously to wander amongst your own thoughts.

After negotiating the speeding vehicles on the North Newington road and crossing Sor Brook, I followed the back road to Broughton. At the junction before the castle grounds I turn right along Sandfine Road, following it around the edge of the park grounds. Pausing briefly for a drink, and to sample a few of the last remaining blackberries in the hedgerow for a little energising sugar, I follow the lane to the fork in the road at the top of the hill that, taking a left, will bring me down to Fulling Mill and the bridge over Shutford Stream.

What makes my progress far more interesting than merely the physical progression through the landscape is that I have a long-standing relationship with this area. I've been walking here for about 30 years; I know the hills and valleys, and the footpaths that connect them, and the plants and wildlife that are common all around. What makes this even more interesting is that I also understand how this landscape came to be. The geological processes scream at you; from the visible [faults](#)⁹ that traverse the fields around this location, to the break-of-slope in the hillside that bears witness to a boundary in the underlying [stratigraphy](#)¹⁰, to the post-glacial erosion scars that have been accentuated and extended by both agriculture and centuries of people moving across the landscape. I'm not simply crossing this land, my relationship to its physical existence immerses me within it, and the knowledge of when and how it came to be enlarges my enjoyment of it.

Such an attitude is of course the antithesis of consumerism. What Bernays, Lebow, and the newly fashionable high priests of behavioural economics (e.g. Thaler and Sunstein, and their "[nudge](#)"¹¹ that has so [captivated the current government](#)¹²) promote is that consumption should be an act that follows from our innate desires. Conscious thought – an understanding of precisely what, or the context within which, you are consuming a certain product, service or attitude – might get in the way of serving that inner desire, ultimately detracting from the level of enjoyment that we receive from it. However, the objective reality of the process of consumption – especially the state of cognitive dissonance often labelled [post purchase realisation](#)¹³ – is probably the most telling aspect of the psycho-economic relation-



Abbreviations (from top/highest to bottom/lowest): **GOL**, Great Oolitic Limestone formation; **NS**, Northampton Sand formation (sandy limestone); **ULi**, Upper Lias mudstones; **MRB**, Marlstone Rock Bed (ferruginous sandy limestone/ironstone); **ES**, Estuarine/Horsehay sandstone; **MLi**, Middle Lias formation (mudstone interbedded with siltstone and limestone); **LLi**, Lower Lias formation (mudstones).

Looking 'through' the ground beneath your feet

Above is a profile of my route (total ascension is around 350m-400m/1,150ft-1,300ft – vertical exaggeration about 15:1), and below that a geological impression of the land I was walking over. This is not a formal [geological 'section'](#)²⁰, but is instead is an illustrative approximation of the rock strata beneath the surface – both the varying thickness of the strata in this area, the changing height and the complex nature of the local fractured geology make a truly accurate section rather difficult to produce from the available survey data. This group of rocks is often called the *Liassic*, and covers the [early Jurassic epoch](#)²¹. It is these same rocks that outcrop on the lower parts of the Jurassic Coast in Dorset and on the coast of the North Yorkshire Moors – and similar fossils are found in all these areas (the best place to see fossils of the MRB is in the walls of St. Mary's church in Banbury). The ironstone beds were worked in this area during the 1950s/1960s to supply Corby steelworks, but were then abandoned due to the availability of higher quality and cheaper imported sources of iron ore.

ship between our existence in modern society and consumerism; *consumption is only transitory, and as any single act can only provide momentary relief to the reality of our modern existence, it's a process that must be repeated at regular intervals to maintain the desired state of mind!*

Let's take a recent, if extreme example to provide a little more insight – the threatened burning of the Koran by an American Christian group. The perceived threat in this case isn't the conflagration of a set of bound printed pages, creating heat and light through the [gasification](#)¹⁴ of carbohydrate bonds and the subsequent thermal oxidation of the carbon residue (in short, *the burning of a book*). Instead it is the symbolic act of [libricide](#)¹⁵ – *the destruction of the thing that the book represents* – that is the cause of the offence. In the same way differentiating *why* we consume from the physical act of consumption can have a similarly deleterious effect on the values that we might attach to this past-time. If we were to understand the psychological processes involved in

our idolisation of consumer goods, and the inane symbolism of the values we attach to the goods themselves (aka. [branding](#)¹⁶), perhaps we could better deal with the emptiness and dissonance that results from our inevitable short-term enjoyment of any purchase – and as a result move on to find a more rewarding way of demarcating our existence.

This landscape provides an interesting example in this respect. If you read some of the ["outdoors interests"](#)¹⁷ magazines in circulation today (*and especially their associated advertising!*) you can see how the objectification of the natural landscape serves the cultural desire to consume. It doesn't matter that the subject of these activities is the natural environment; the focus is on "bigger", "longer", "higher" and being more "remote", rather than focussing on the potential of what's outside your back door.

That stands in stark contrast to what I see before me. This landscape *"IS"*; it does not exist in its current form because of my viewing it, but because of the millennia of geological, natural and latterly

anthropogenic changes that have created what is around me. In refusing to idealise and commodify the landscape, and instead accepting the reality of its existence for “what it is” (see the box on the previous page), it is still possible to create equally as much enjoyment as any process of objectification – and, in my personal view, *more*. The great difference is that, in accepting the outside world “for what it is”, it can raise some uncomfortable (in terms of how we might view ourselves in the modern world) questions about our place within it.

As I cogitate on this idea I'm sitting on a horse jump at the top of the hill [beyond Fulling Mill](#)¹⁸. I'd quite like to take out my [storm kettle](#)¹⁹ and make a brew, but the hedgerows in this area have been flailed to a pulp, and so there are no good sticks to fuel it. I might pass some better sites later, and so instead I satisfy myself with a drink and a hunk of my *own-made* nutty-seedy bread; i.e., *I'm contented with what I have right now because it suits my needs at this point in time*.

From this vantage point – which in geological terms, with its [isolated outlier](#)²² of [oolitic limestone](#)²³, is the very last throw of the [Cotswold Hills](#)²⁴ to the north and east of England – I can look north-west across the [marlstone/ironstone plateau](#)²⁵ between Edge Hill to the north (scene of the first major engagement of the Civil War) and Sibford Heath to the west. Looking down the broad valley, past the imposing (albeit ploughed-out) remains of [Madmarston Hill](#)²⁶, rather than turning north to Shutford, or south to return home via Bloxham, I'm tempted to continue west into 'the wilds'; I pack up, and move off along the Roman road past Swacliffe Lea. Once known as '[Salt Street](#)'²⁷, it's part of a trackway that extended from the salt producing area at Droitwich, forty miles to the north-west. Much of the route I've followed since Crouch Hill is part of this ancient transport corridor, crossing the Cherwell at Twyford heading eastward into Buckinghamshire.

The sky has clouded over and there's a light shower – the early signs of the approaching storm. With the wind blowing across the open expanse of this broad valley it's quite cold here. There's nothing to do about that fact; like the landscape, it just “is”. In many ways the popularised “myth” of consumerism is like that [ancient story of the King](#)²⁸ who punished honest reality and rewarded vain reassurance, only to later be driven mad by his poor choices in the midst of a raging storm – well, almost, except for the fact that the recent credit crunch is merely the light shower preceding the oncoming storm of the [Limits to Growth](#)²⁹.

The human creative consciousness will never be limited by physical reality; and, in fact, from ancient philosophical myths to more modern superhero comics or Tolkein's *The Lord of the Rings*, we are able to conjure incredible feats of *storytelling* from our minds. The difficulty we face today is that the

narrative of the “human story” has, as part of our marketed and hyper-real modern reality, supplanted the reality of our true biological nature. The problem that this creates today is that as the ecological limits of our “real” existence are beginning – from climate change to peak oil – to reassert themselves it invalidates large parts of that abstract narrative. Credit shortages today don't mean much, but oil and phosphate shortage in the years to come certainly will. The abstracted nature of human reality will always fail against the physical nature of the real world, whether we like it or not.

The difficulty is, being the person (like the boy in the [Emperor's New Clothes](#)³⁰) who states this obvious truth is likely to land you in some rather difficult situations; even if they don't want to acknowledge it I think many people can perceive that there's something “wrong” with the way we are required to live out our lives today. Perhaps to relieve these tensions society [seeks to deride](#)³¹ any viewpoint that promotes a more naturalistic/less technological lifestyle; this is not a new trend, as over history those with wealth and power have sought to ridicule or [forcibly oppose anyone](#)³² (and let's not forget the significance of my [home town of Banbury](#)³³ in this process) who has, against the grain of the economic process of the time, tried to return to a [more simple](#)³⁴, [primitivist](#)³⁵ form of existence.

My thoughts on this weighty concept are a little disjointed as I'm currently labouring to the top of Barton Hill, the high point of today's outing. I'm trying to understand the “meaning” I get from this activity. It's not 'permanence' (in contrast to human time-scales at least) that this landscape exhibits, but rather a continuity of change that creates meaning – both to its evolution and my interaction with it. I think we can all learn something valuable from this process, and how it can be applied to our own consumption values, in order to tackle the ecological difficulties the human species is experiencing today.

I pause by the small pond on the south side of the hill and catch my breath. An enticing bunch of hawthorn berries dangles in front of me; I take a few moments to pick and suck the pith from each one before unceremoniously spitting the skin and pip into the undergrowth. I've seen no one (outside of a car that is) for at least the last hour or so. With the sky clearing, the rain shower now departed off to the east, I continue to the top.

I take a proper rest near the top of [Barton Hill](#)³⁶ (about 190 metres [AOD](#)³⁷, just before the horse paddocks that straddle the summit). From here you not only get a good view of the surrounding area, you can also, being a fairly clear day, see to Muswell and Brill Hill near Bicester (20 miles), Beckley near Oxford (25 miles), and beyond them both the thin grey line of the Chilterns (40 miles) – and to the east and north-east you can see the ground rising in

Northamptonshire towards Daventry (20 miles). From the far side of the hill, before the descent into Shutford, to the north-west you can see the Lickey Hills (40 miles), the ridge at Abberley (50 miles) and Clee Hill (60 miles). Unfortunately this hilltop doesn't give a view to the west or south-west, and so you can't see the Cotswold or the Malvern Hills.

What you also see, wherever you look, from the fields and farms, to the small settlements connected by power lines and of many con-trails in the sky above, is the vast panoply of the human system – even more so at night when the lights stretch to the horizon, fed by the arteries of the floodlit road network. A mass system of energised activity, developed to serve the needs of the human population but, within the positive feedback loop of advanced economic development, which is now consuming beyond the capacity of our environment to support it.

We are not short of resources – quite the opposite in fact; *we are surrounded by them*. For example, three-quarters of the copper ever mined in human history is *still in use*³⁸. The difficulty is that these various resources are already employed for other purposes. From my vantage point I can see tonnes of copper – in the form of power lines stretching across the landscape – but if you were to utilise that material for another purpose then the people in the villages would be none to happy about their power supply being cut off! This might seem a rather pointless argument, but it demonstrates the flaw in the present debate about eco-efficiency. Recycling more material is a good thing, but it doesn't escape from the fact that the economy requires a growing mass of energy and resources in order to keep economic growth functioning. In fact, far from reducing consumption, every revolutionary change in technology towards more efficient systems has driven the economy to *consume more*³⁹ – meaning that the net effect is not to save the material/energy anticipated, or even to *accelerate demand*⁴⁰.

After about fifteen minutes the cold starts to penetrate again, and so I get up and start walking north. Here, at the top of this magnificent hilltop, someone has used a lot of resources to create an extensive stables complex. For a difficult to access, hilltop location someone's been to a lot of effort to create this... *and for what purpose other than personal self-satisfaction*. Then, as I look down from the top of the northern flank of the hill, I see on the rooftops of Shutford (one of the villages that was quickly gentrified in this area during the 1980s), various solar thermal and solar photovoltaic arrays. Again, lots of invested resources, albeit in technologies which do produce energy in return, but compared to the consuming lifestyles of those who typically live in the villages north-west of Banbury these technologies produce an insignificant quantity of energy⁴¹. If they *really wanted* to really make a difference they'd seek a less affluent, less transport intensive and lower

consumption mode of existence – but of course that doesn't fit within the present social and cultural pressures to consume.

I descend the slope from the crest of the hill. As I cross the boundary between the sandstone of the hilltop and the Upper Lias clays below, the exuding groundwater coats the surface of the field in a layer of sludgy mud and I go skating for about 10 metres down the slope. Getting up my leg is smeared in mud; I scrape it cleanly off using my knife and then, more cautiously, continue on my way. I quickly pass through the village of Shutford – the lengthening shadows telling me that it will soon be sunset and I'm proceeding far too slowly to return to Banbury before dusk. I get to 'Sibford Fiveways' (as my Granddad often said, "you can go anywhere from Sibford Fiveways"), and take the second left to take me on to Wroxton Mill. It's obviously "pub Sunday lunch" going home time as a procession of Audi's, BMW's and 4x4's speed past me on the narrow road.

Returning to the eco-efficiency problem, it's clear that any process which seeks to deal with the problems of the present economic system in isolation from the purposes of that system is doomed to failure – the rebound/take-back of energy and resources as a result of increasing the efficiency of technology being the ideal example. What we must create, to summarise my thoughts rather clumsily, is *economically inefficient thermodynamic efficiency*; actions that use less resources but don't create a boost to the economy in order to enlarge consumption in general. The difficulty for the promoters of greater efficiency is that the traditional sweeteners for change (such as jobs and wealth) would not materialise with this approach – like traditional efficiency measures it would not stimulate growth.

There is however a more important "economic self-interest" driver to encourage such a change in approach. The economic inefficiencies created by climate change and resource depletion will inevitably achieve the same economic inefficiencies within the economy as a whole, but far more chaotically for our society. In the face of resource shortages merely shifting towards renewable energy, leaving aside the practical limitations on its use, is not a solution. The idea of simply shifting energy supply to other sources does not address the purposes of why we use energy, and therefore the issue of the energy equilibrium and the role of entropy (or rather, overcoming entropy) within the *high-tech systems*⁴² which we are told will "save the planet". Consequently "planned economic inefficiency" is really the only way of re-balancing demand and supply in ways that we have a far greater chance of managing the outcomes. The only problem is getting "the powers that be" to realise that this is the case whilst we still have the ability to do something about the problem.

At Wroxton Mill I dither as to which direction to go; my feet are getting tired and so take a minute

or so to make up their mind which path to take. In the end I continue north-west towards Wroxton rather than taking the more direct route home through North Newington. I make my way along the long slender valley of Padsdon Bottom, stopping for a couple of handfuls of hawthorn berries on the way to keep up the blood sugar, and, near the [enclosure](#)⁴³, stop to watch the setting sun skirt the hilltops on the western edge of the ironstone plateau. Resisting the urge to move on, I pause for a little longer to collect my thoughts on the last leg of the walk home.

Today there are a plethora of schemes and plans for how we will either reduce carbon, increase renewable energy sources, reduce fossil fuel use, or shift to a low carbon economy. In contrast – and returning to the simplicity-based lifestyle point from earlier – there are no UK-based, mainstream plans that deal directly with the [de-materialisation](#)⁴⁴ of the consumer lifestyle against a background of a diminishing resource base. If our present consumer lifestyle is unsustainable because of its demand for natural resources, then no amount of bolt-on eco-efficiency and renewable energy will make it sustainable; making systems more eco-efficient might make “the party” last a little longer, but it doesn’t avoid the eventual outcome of depletion. In the short term we have the [economic rebound problems](#)⁴⁵ to deal with too, although this will reduce as depletion takes hold in the middle of this century; and adding renewable energy doesn’t make a difference either because, even if we could get all the low carbon energy we wanted from natural sources, we’re still going to run out of other essential “stuff” at some point in the future.

To solve the lifestyle problem we have to shift from *linear* to *cyclical* forms of consumption – not just recycling, but rather systems which are designed to maximise the lifetime of each component using the least energy and resources possible. We must also shift from a system of parallel, linear consumption systems towards integrating different systems in order to get, in the language of economics, economies of scale in the way we do things. For example, why have a TV, games console, video player and stereo system when a programmable multi-function device (such as a computer) can perform all these functions in one machine, often using less energy and resources as a result.

More importantly, we have to improve the [resilience](#)⁴⁶ and [reliability](#)⁴⁷ of our consumption systems, especially the most important ones such as food production, winter heating and hot water. For example, large energy grids represent a [single point of failure](#)⁴⁸, and, as the supply of dense energy sources (especially gas) diminishes, the operation of these bulk consumption systems will become less reliable; in contrast smaller independent, distributed

or personal supply systems based upon localised sources are able to operate irrespective of the conditions around them, creating greater resilience. This is all sounds very complex, and it is, but there is a very simple way of approaching these difficulties – *design*, or rather, *a design philosophy that internalises [biophysical](#)⁴⁹ and [ecological principles](#)⁵⁰.*

Natural ecological systems are stable because they require few external inputs – *usually just sunshine* – in order to function. [Entropy](#)⁵¹ – the tendency for matter to be dispersed and energy degraded – is minimised in these systems because all that the life processes need in order to keep the equilibrium stable against entropy is the input of environmental energy flowing through the system; with the renewable flow of energy to counteract entropy, everything is reclaimed and reused through an interlocking series of life-based systems, from birds and bees through to fungi and bacteria – and with often more than one species performing the same function interchangeably to cycle energy and nutrients through the system. As a result of these factors, over time evolution tends to *work within* rather than *detracting from* the ecological equilibrium of the environment. Providing that there are not external factors to destabilise this ecological balance – such as climate change, volcanic eruptions or blinkered economists – the evolution of species within a balanced ecosystem will be constrained by the [available energy and nutrients flowing through the system](#)⁵².

Nature often provides the best design template for us to [emulate](#)⁵³, but also the starkest critique of why, as we have moved away from our close associations with natural systems, human-designed systems are nowhere near as efficient as biological ones⁵⁴. A characteristic of many natural systems is that they are [metastable](#)⁵⁵. Ecosystems use the environmental energy sources (heat, sunlight, water, etc.) that flow through them to maintain an equilibrium which favours the diversity of species that it contains – and this self-reinforcing equilibrium is maintained by the diversity of species unless the principles on which it is based radically change.

The difficulty is that such an approach, given the need to operate without centralisation and with minimal turnover of resources, wouldn’t be conducive to the continuance of the centralising tendencies of economic efficiency. Thinking more broadly about the potential conflicts with present-day sensibilities, not only is this approach contrary to the wasteful, planned/perceived obsolescence-led systems of our throwaway society, but, unlike most natural systems which exhibit a limiting balance on populations, the human system today operates on the principle of exponential material growth. Ultimately this is the fundamental difference between metastable, natural ecosystems and the human ecological system: Natural ecosystems tend to be stable because they are

Permaneering Design Principles

It's possible to write a whole book on this issue so I'll just summarise the main points from my initial deliberations. Note also that the use of the word "system" is abstract – it could mean a simple mechanical linkage or the entire human system. These points are in no specific order, and rather than a hierarchy should be viewed as a holistic approach to how we construct human technological or cultural systems:

Simplicity – not so much as the opposite principle to complexity, but rather the characteristic of a simplicity of operation and design so that the system's performance and interaction with other related system elements can be easily understood;

Transparency – not just in terms of the operation of the system being readily understood, but also ensuring that the elements of the system are not encumbered by restrictions over copyright, patent, or other [black box](#)⁵⁶ design features that might hinder our understanding and maintenance/modification of the system;

Integration – through its design a system should function transparently with the other systems that it must interact with to support their operation;

Modularity – rather than relying on a single, monolithic structure, a system should be composed of a collection of small modules that perform a simple task very efficiently;

Redundancy – the system, or parts of it, should be designed so that it can be backed-up by other redundant parts, or have its parts/modules easily replaced by cannibalising less important parts of the same or other systems to keep it functioning;

Diversity – related to modularity and redundancy, if all the functions of a system were designed the same a single design fault would affect the whole system, so instead we should seek a variety of approaches to the same problem/function to avoid the likelihood of systemic design flaws creating more widespread problems (which is why open standards

are such an important element in system design, ensuring that diverse designs can reproduce the same, compatible functions);

Durability – the complementary principle to redundancy, each individual part should be made to last for its maximum possible operational lifetime so that, if necessary, it can be reused again and again in different applications;

Serviceability/adaptability – as far as possible all systems and their components should be serviceable and replaceable to avoid the entire system having to be discarded, and this potential should include the ability for users to adapt or extend the functions of a system;

Autonomy – we should, as far as possible make, systems operate in a stand-alone way as creating interlinked chains of control and interoperability creates a greater likelihood of a cascade of failures causing disruption to the whole system;

Scalability – by extending the principles of modularity and redundancy we create systems that are scalable, being able to increase their capacity by adding additional components rather than engineering whole new systems to replace them; and

Iteration – these principles could be applied to a single component, but by enlarging the scope of the components/sub-systems that they encompass they should be applied from "top to bottom" within the system in order to apply the philosophy of this approach across the entire system, so creating a systemic level of compatibility from "end to end".

fixed by the energy flowing through them, and so changes are limited by the succession of species within the same domain rather than the physical growth of resource flow through the ecosystem; for the human ecosystem, and clearly so in the model followed for the last few centuries, growth is the characteristic that dominates change and so rather than ecological succession we see the wholesale take-over of other ecosystems/resources, through human adaptation of the environment, in order to [fuel human growth](#)⁵⁷.

Even so, we see viable examples of the development of diverse, decentralised systems already under development – from creation of [free and open source software](#) (FOSS)⁵⁸ and computer operating systems, to the use of [permaculture design](#)⁵⁹ to plan ecologically balanced food production systems. Of these two examples it is permaculture that perhaps best represents the approach we will need to take in the future. In many ways the [principles of permaculture](#)⁶⁰ (see the box on the next page) emu-

late aspects of the metastable nature of natural ecosystems. However, in designing "hard engineering" systems – such as those for energy supply or utilising non-renewable resources (such as the production of metal goods) – the principles that mirror largely biological systems are not directly applicable to the abiotic, mechanistic assemblage of parts that make up human-created systems.

Despite this, modern engineering still has much to learn from natural structures in order to radically improve both design and efficiency, and I think that permaculture principles, with a tweak, do apply to engineering. We could design engineered systems which, in their structure and the way they operate, replicate elements of the stability, diversity and resilience that we see in nature. If we're looking for a label, then what about *Persistent Materials and Engineering?* – or just "permaneering" for short! (see the "permaneering design principles" box above). So, anyone up for a little permaneering, perhaps?

I'm pounding through the grounds of Wroxton

Permaculture and Permaculture Principles

Permaculture⁵⁹ is probably the nearest thing we have to an adaptable design system based upon biophysical concepts. Developed in Australia in the 1970s, permaculture is an approach that seeks to design human systems (often food production, but also wider lifestyle solutions) that fit harmoniously within a functioning ecosystem, and which thus require far lower inputs of both time and energy/natural resources to produce a high-yielding and self-sustaining system. The themes of permaculture were stated as 12 principles by its co-creator, David Holmgren, in *Permaculture: Principles and Pathways Beyond Sustainability*⁶⁰:

- 1. Observe and interact** – By taking the time to engage with nature we can design solutions that suit our particular situation.
- 2. Catch and store energy** – By developing systems that collect resources when they are abundant, we can use them in times of need.
- 3. Obtain a yield** – Ensure that you are getting truly useful rewards as part of the work that you are doing.
- 4. Apply self-regulation and accept feedback** – We need to discourage inappropriate activity to ensure systems can continue to function well.
- 5. Use and value renewable resources and services** – Make the best use of nature's abundance to reduce our consumptive behaviour and dependence on non-renewable resources.
- 6. Produce no waste** – By valuing and making use of all the resources that are available to us, nothing goes to waste.
- 7. Design from patterns to details** – By stepping back, we can observe patterns in nature and society. These can form the backbone of our designs, with the details filled in as we go.
- 8. Integrate rather than segregate** – By putting the right things in the right place, relationships develop between those things and they work together to support each other.
- 9. Use small and slow solutions** – Small and slow systems are easier to maintain than big ones, making better use of local resources and producing more sustainable outcomes.
- 10. Use and value diversity** – Diversity reduces vulnerability to a variety of threats and takes advantage of the unique nature of the environment in which it resides.
- 11. Use edges and value the marginal** – The interface between things is where interesting events take place. These are often the most valuable, diverse and productive elements in the system.
- 12. Creatively use and respond to change** – We can have a positive impact on inevitable change by carefully observing, and then intervening at the right time.

Abbey – I've been here before, as noted in my last *ecolonomics* post written almost eleven months ago⁶¹. Behind me there is a huge wall of cloud stretching for 120° or so around the western horizon – a weather front (given it's height and structure, an occluded front?⁶²) that's heralding the approaching storm.

As I past through the old park I think about how culture relates to technology. In the past old buildings, like Wroxton Abbey, were developed gradually; very little was thrown away, what worked well was kept, and new developments were often extensions to or layers applied over the old (in that sense, the old human “culture of technology” operated as an extensible⁶³ system). Rather like natural organisms, human technology evolved from what went before. What's happened in the Twentieth Century is that we've made culture, and hence the built environment, disposable – they can no longer “learn”⁶⁴ through a more organic form of evolutionary development because they are continually being “junked”. Given that buildings and our large infrastructure systems represent our largest investment of resources, is it any wonder that we've got problems with resource depletion?

In the consumer society “design” is something that is a surface feature, usually associated with fashion or as a means to distinguish similar products. What I mean by “design” is the deliberate engineering of whole systems, in depth, and according to principles that create, as far as possible, a *metastable system*; that is, a system that is able to function independently and perform its functions reliably, as far as is practicable, with renewable of energy and resource inputs. We have certain identifiable problems that we must contend with in the future – such energy depletion, climate change, food shortages, etc. By designing metastable systems that internalise such restrictions we can develop solutions that not only are able to meet certain criteria, such as reducing carbon emissions, but which are in a sense “future proof” because they should keep operating within the boundaries that we define in the design – for example, the temperature, weather conditions or resource availability that we expect will be common in 100 years time.

If we look at old buildings or other ancient human artefacts we can see metastability principles at work – they are very simply designed, with a minimum number of standardised components, and with very simple criteria for how they should perform (e.g., a door, chimney, wall, etc.). For example, what we call vernacular architecture⁶⁵ is really a design solution that is specific to the ecological conditions that exist in a given locality. It favours the types of wood, stone and other materials that are common to that area, the design and use of which has evolved culturally through many centuries of practical human innova-

tion as people selected those ideas that worked well and discarded those that didn't.

If we consider other human artefacts we can see this same idea at work. Just think about the average cup; for thousands of years people have made round, hand-sized cups for every day use. Recently we might see funny shapes and sizes, but for most people a "cup" is a simple receptacle, the curve of its opening matching the profile of our lower mandible to allow a clean transfer of liquid into our mouth. In terms of human society, the cup represents a culturally-originated metastable design – try as we might we just can't improve upon its basic function, shape and proportions.

Today we don't see this approach in the mainstream of manufacturing and technological development. Rather than learning as we go by trial and error and embedding those solutions in culture, just as evolution accomplishes within the natural environment in order to find the best solutions, today our needs are "designed" to meet new and abstract criteria. The short service life, as a result of the need to differentiate alternating fashions, means that we junk entire systems/products and start again on a regular basis. Even more bizarrely, as noted in the 'Transparency' section of the *Permaneering Principles*, modern intellectual property law, especially patent and design rights, effectively prevent incremental development by legally barring the re-design of existing systems in order to protect the economic power of one group of creative people over another. The imperative for growth and consumption also means that the market usually adopts the option that creates the greatest level of material turnover because, in the global market, making small margins on a large turnover creates the greatest returns.

For example, today it is common practice to demolish entire buildings and clear a site for reconstruction, but 200 years ago the pre-existing structures would have been largely retained and adapted to perform new purposes; and whereas only thirty years ago machines such as cars would have gone to a breakers yard to allow the recovery of spare parts, today the whole car is thrown into a crusher or fragmentiser before being taken to the metals reclamation furnace. This trend evolved because today's cars not designed to be serviced by their owners, which as a result has enabled manufacturers to sell more new, rather than recycling used, car parts, so increasing the car producer's turnover.

On reaching the [stone arch](#)⁶⁶ I take a pause and finish the last of my water and bread. It's just about dark now, any traces of the sunset having been obliterated by the advancing wall of cloud behind me. It's getting cold, and there's a mist rising from the fields around. After a fairly long walk I'm feeling quite relaxed, but my head is still buzzing with ideas. Now I have to go back through

the town, making the abrupt transition from the care-free environment of open fields to the comparatively high-speed world of busy streets and frantic road junctions... *back to manufactured rather than experiential reality!*

It might represent a seemingly large leap, from the operation of self-interest within free market toward a more ecological planning of human systems, but there is an example of this happening in the past. One of the great engineering innovations within the Industrial Revolution wasn't technical, it was cultural – rather like the general adoption of [permaneering](#) would ultimately be. Up until the middle of the Nineteenth Century engineering systems were designed in a piecemeal way, each company producing it's own proprietary and largely incompatible designs, parts and tools. Then in the 1840s, Joseph Whitworth created the revolutionary concept of [engineering standardisation](#)⁶⁷. By making the most basic parts of engineering systems – the screws, bolts and rods used to build the machine – a standard size, the process of both building and maintaining machines became far simpler.

From this beginning was developed the concept of [open standards](#)⁶⁸, and this approach has been one of the reasons why, in the latter half of the Industrial Revolution, technology was able to develop so rapidly and cheaply. Even in recent times we see the same process taking place – for example, the adoption of open standards was the most critical aspect of the success of the [IBM-compatible personal computer](#)⁶⁹, and the modern microcomputer industry that it spawned.

More recently though, with the post-War emphasis on the maximisation of intellectual capital within businesses through the use of various types of [intellectual property rights](#)⁷⁰, we've seen a return back to the old, pre-Whitworth systems of proprietary controls over manufactured goods – and as a result, a growing level of incompatibility. Machines, especially consumer electronics and household goods, are becoming less compatible and as a result they are often junked rather than repaired or reused. We also see incompatible standards arising for similar functions in order to create market advantages for their producers, for example the rise of incompatible standards for normal and high definition DVDs and copy-protected CDs. In fact, under certain types of intellectual property, the adaptation of reuse of technological devices can be ruled illegal and result in civil or criminal penalties. Whilst this might be excellent in terms of the economic efficiencies it creates, it is a dire state of affairs in terms of thermodynamic efficiency.

This brings us back to energy...

The manner in which we conceive, design, produce and then maintain the energy and resource systems that support our future society is as impor-

tant as where the raw energy or materials they convey are sourced. This is because, as global energy production diminishes, it will become harder to produce and maintain engineered systems at a high level of reliability and serviceability. For example, if we develop renewable energy systems based upon the expectations of today's energy market what residual value will that equipment have in twenty or fifty years time, after the peak of oil and gas production? Too many schemes for our future well-being assume that existing concepts and standards will still apply in the future. In a sense this just represents the systematic enactment of J.K. Galbraith's observations on the nature of [conventional wisdom](#)⁷¹, and as Galbraith states, such hubris is easily and inevitably overcome by changing circumstances. The difficulty is that, when looking at energy systems, invalidating the principles upon which the system was conceived could also waste the energy, materials and money that was put into their original construction.

Today, in the fully globalised world economy, the most affluent nations require a complex array of trading links to supply their needs. More significantly, states such as Britain import a large proportion of their food because their agricultural systems have specialised in producing large quantities of a few food commodities in order to extract a higher economic return from agriculture. Underpinning these trends has been the development of telecommunications, information technology, and the use of electronics and machine tool systems to produce and maintain these systems. In turn these systems are reliant upon a range of elements that have only become significant in their application since the Second World War – and all are comparatively rarer than those we relied upon before. Each increase in technological sophistication in turn generates the [emergence](#)⁷² of new and increasingly complex patterns of activity in society. The difficulty is that each increase in complexity also brings with it the potential for increasing instability due to the over-dependence upon disparate resources, and the need to coordinate the production and transport of these resources over longer distances.

Over the last two decades a new field of research has sprung up within human anthropology that examines the physical basis of how societies operate, and how technology and new forms of organisation can contribute to the success or failure of more advanced societies. Research studies by [Joseph Tainter](#)⁷³, [Jared Diamond](#)⁷⁴ and [Thomas Homer-Dixon](#)⁷⁵ have highlighted the importance of [complexity](#)⁷⁶ in determining the sustainability of a society. By putting increasing reliance upon scarce and rare resources and a dependency upon continuous growth – the opposite trend taken by nature over the course of evolution – our technological society is creating an increasingly [precarious system](#)⁷⁷ that is

prone to unpredictable and potentially [catastrophic failure](#)⁷⁸.

To avoid making the same mistakes as past societies we need to do what the human species are uniquely able to do – *think abstractly*. That doesn't just mean creating strategies to decide where our energy comes from in the future. Implicit in this process must be the consideration of the design principles we apply in their creation to ensure that, come what may, the value (both financial, energy and material) that we invest in them today creates the greatest benefit to future generations – who will have to use, maintain, but ultimately reconfigure and adapt those technologies to suit their needs with perhaps far less energy and resources than are available to us today.

I'm thinking about this when, five minutes away from home, I pass through St. Mary's churchyard. In the walls of the *two hundred* year old structure are frozen, in the rock of which it is constructed, the fossils of animals preserved when the marlstone was formed nearly *two hundred million* years ago. Walking a little further I see a complex assemblage (the creation of the water currents that deposited these sediments) of [bivalves](#)⁷⁹, [belemnites](#)⁸⁰ and possibly the tail end of an [ammonite](#)⁸¹, cut in cross section – looking like one of Mandelbrot's [geometric labyrinths](#)⁸². Mandelbrot died a few weeks ago, and looking at the remains of these creatures I'm reminded of the words of another, unfortunately now dead, honest observer of the world, [Bill Hicks](#)⁸³; “we are all one consciousness experiencing itself subjectively”. If that's the case, then a lot of people are obviously, with the distractions of the modern world, not making the right connections to appreciate the reality of the world around them. Then again, perhaps the world around them doesn't give them the answers that, like King Lear, flatter their existence sufficiently.

Irrespective of what we do today, odds are that in another couple of hundred million years time all that will be left of our present-day world will be the fractured and mineral-stained oxide residue of the substances constituting human society today. The human species will, certainly, end at some point and the natural world will evolve towards another global equilibrium, perhaps with a new and unexpected dominant species. *That's not the issue*. What matters is, in our quest to understand ourselves, we are able to differentiate the messages that we can receive from the real world around us from the fantastical stories we create within our own minds; so ensuring that this end date isn't somewhere in the immediate future! To that end we can consciously design our future existence, learning from how the world around us operates, or we can continue to ignore the world around us until we too join the ranks of previous experiments in evolutionary consciousness.

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