

Economic Growth & Its Future

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**David Korowicz
4 Casimir Road,
Harolds Cross,
Dublin 6W**

Introduction

The last two hundred years have seen an extraordinary growth in human population, urbanization, societal complexity, and wealth. This has required, and been facilitated by, ever more resources for our primary needs: food, water, shelter, waste disposal, and energy; and for our secondary needs such as the resources for discretionary consumption and for the operation of the complex bureaucratic and infrastructural aspects of our civilisation. The conventional wisdom assumes that this growth will continue.

Climatic change, oil and gas depletion, biodiversity loss, water and top-soil loss are among an array of threats that can be situated as a singular consequence of a massively consuming and growing population in a finite global ecosystem. We are in effect trapped within economic and social systems that require the growth in throughput of finite resources to maintain those same social and economic systems. And because of growing resource constraints, our relationship with such systems may be about to rupture.

The UN has estimated that by 2050, 9 billion people may live on earth, and that continued economic growth will allow billions of people to have western level of consumption. This implies yet more resources, energy and food will be accessible in a relatively stable climate. Not only do our assumptions intuitively accept this, many of our personal and social systems depend upon it. The Irish government urges the public to get a pension, and while warned that 'past history is not a guide to future performance', or 'prices may rise as well as fall', the background acceptance of continuing economic growth, is never questioned. The governments' investments in infrastructure, education, and state pensions are also framed within the assumption of growth. It is seen to have in this sense a historical inevitability.

That conventional wisdom is rarely charged with analytically justifying this assumption, despite the levels of resources we bet upon it, should be a warning. When attempts are made to justify the continuance of economic growth, it is principally through the lens of conventional economic theory, with little reference to the actual quality of human eco-systems. It is not surprising that such theory can assure us that growth can in effect continue indefinitely.

Our economy is in essence a materials and energy processing system. The earth's material resources are transformed using high quality energy into goods and services, and in the process low quality energy is dispersed into the environment along with waste. This process is subject to the laws of thermodynamics. And because they are laws of nature, all human activities are subject to them.

Our economy grows exponentially, meaning each years' 3% growth is bigger than the previous years. This means that each years' demands upon energy, resources, and the earth's capacity to absorb waste, is growing bigger. At such a growth rate, the size of the global economy would double in only 24 years. We could try and run these processes more efficiently, that is doing more for less. However, efficiency gains will always be limited by the laws of thermodynamics, while we expect economic growth to continue *ad infinitum*. Others suggest science and technology will allow us to escape the bounds of resource limitations. But science and technology are themselves energy and resource intensive, and often end up just displacing problems in time and space.

Awareness has grown, particularly over the last thirty years that the path we were on is unsustainable. Indeed one is likely to find that many people would agree that 'we are fishing unsustainably', or 'our increasing greenhouse gas emissions are unsustainable'. Virtually every indicator measuring our ecosystems health has got progressively worse. In response governments and wider society have laid out targets, signed treaties, passed laws, invested in research & development, agitated, and cajoled to reverse human impact. Yet despite this, growing damage to our ecosystem has consistently far outweighed our limited successes. In order to explain our failure we might consider that we are attempting to solve these problems within a system which is itself causing the problem, and our efforts are therefore doomed to failure. And if our economic system makes such growing demands upon our ecosystem then that system must itself, be unsustainable. The economist Hermann Daly called this an impossibility theorem, the idea of infinite growth on a finite planet.

A growing number of experts are warning that we are indeed reaching the limits of how much growth can be sustained. It is argued that the energy that sustains our complex world and drives its growth is on the cusp of decline; that our food production cannot sustain the multiple risks to its productivity even as population rises; that increasing biodiversity loss is presenting serious risks on many fronts; and that our climate system may have passed tipping points that ensure that no matter what we do with our emissions, we will face severe consequences.

It might be argued that such warnings have been made before, and yet economic growth continues unabated. Paul Ehrlich's *The Population Bomb*¹ published in 1968 warned of immanent economic meltdown, chaos, and mass famine caused by over-population. The landmark publication of *The Limits to Growth*², a early computer model of human-ecosystem interactions by Donalla and Dennis Meadows in 1972 marked a period of widespread popular worries about sustainability, especially when combined with the peaking of oil production in the lower 48 US states and the first oil crisis two years later. Forty years later, the population has increased by 3 billion and is still growing. And *The Limits to Growth* is now often dismissed for getting their predictions wrong (in fact *The Limits* did not make predictions, it gave scenarios).

In the last ten years new publications, particularly on the future of energy supplies, have grown each year. Energy Security, Food Security, and the threats from Climate Change have risen rapidly up the political agenda. Yet it is rarely acknowledged that such risks could crash the global economy and indeed civilisation; or if such a risk is acknowledged it is placed safely in the abstract future.

The principle arguments about economic growth remain around the distribution of its rewards. During the 1980's for every \$100 added to the global economy only \$2.20 was added to those who were living below the World banks poverty line, by the 1990's it had shrunk to 60 cents³. Within developed countries, real wages for the lowest quartile of workers changed little while the highest quartile saw accelerating increases in wages and other compensation.

¹ Ehrlich, P. *The Population Bomb* (1968) Ballantine Books

² Meadows D, Meadows D, *The Limits To Growth* (1972) Universe Books

³ Simms, A. *Trickle-down Myth*. In New Scientist 18 Oct 2008

It might be assumed that such imminent risks would have prompted a large scale re-assessment of risks and vulnerabilities, an analysis of remedial and long-term policy options, and direct action on the part of the state, EU, and international organisations. This clearly has not happened. Bottom-up initiatives such as Transition Towns and Post-Carbon Cities are immensely important as prototypes. However it is governments who are in a position to really effect change and to whom people will turn. If government fails to show leadership in times of evolving crisis, the public confidence needed to engineer difficult transformational projects could be lost, with the additional potential for significant social unrest. If precious and declining resources are wasted on propping up fundamentally unsustainable but historically understood systems, rather than invested in resilient systems, a massive opportunity that may never arise again is lost.

On the contrary, if government broadly understands the risks, has considered policy options, and can articulate a realistic but hopeful vision, society may move more confidently through the inevitable difficulties. By having a well-prepared political and policy vision, good government will be able to use crises as a lever to institute longer-term policy that is ecologically sound and adaptive to the future realities.

It is not an either/or question of whether one believes that such a disjunction is imminent or not; it is the growing probability that such a high consequence failure exists, and that means that responsible risk management must account for it. Nor is it an overtly political message; it is a message about survival, and the absolute limits that the laws of thermodynamics sets for human civilisation. We cannot avoid a potentially very difficult long-term global economic and social transformation. It is a challenge many other civilisations failed to meet as Jared Diamond discusses in his study *Collapse*.¹ The question is how best to adapt to that transition, resolutely, wisely and with foresight.

This is the context of this report. It looks at economic growth not just as an indicator, but as a thermodynamic, and cultural phenomena. It asks why we are trapped within growth economics, even as the risks to its continuation increase. It argues that economic growth cannot continue much longer and that the consequences of its collapse will be profound and systemic. Finally it attempts to understand how a forced de-growth policy might be framed and what it might contain.

¹ Diamond J. *Collapse* 2006. Penguin

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Chapter 1

Perspectives on Economic Growth

The growth in Gross Domestic Product (GDP) is far more than society's pre-eminent indicator, what it measures is inextricably linked to the fabric of our lives. We have adapted so well to growth that its constraints are often obscured. This chapter outlines some of the constraints of our dominant economic system, its main conclusions being:

- If an economy cannot grow it collapses, steady-state zero growth is impossible. We are in this sense, trapped within growth economics.
- Individuals, institutions, and society as a whole have internalised the logics of economic growth and the assumption of its continuation.
- At its heart, growth measures demands on the earth's resources, concentrated energy stores, and absorption capacity of waste.
- The growth and viability of our complex civilisation is dependent upon increasing high quality energy, and resource inputs.

1.1 Growth as Economics

Economic growth is the increase in the value of goods and services produced by an economy in a year. We measure this as the percentage increase in the real gross domestic product. By real, we mean that the GDP is measured in inflation adjusted terms. It comprises the monetised part of the economy only, much that is of value to society is not included, for example much child-care and voluntary work. It also includes some self-evident negative things: for example after a car crash, the costs of car repair or medical treatment is included in the GDP. As a society we like growth, for its promise that the pie of riches will grow year on year, increasing the chance that anyone of us will be able to afford more of what we desire.

Economic growth theory as conventionally understood is largely the attempt by economists to understand the features of this, and in doing so discover ways to develop, maintain, or enhance its growth, without causing damaging inflation. The pre-analytic vision within the training of most economists is that growth in GDP is a good thing, natural in the sense of the proper order of things. Were you to glance at the introductory text, *Macroeconomics*¹ co-authored by the current Federal Reserve Chairman Ben Bernanke, you will find only two pages out of 561 are given over to a (woeful) critique of possible limits to growth.

In outline, it is understood that economic growth is supported by increasing productive capacity which is self-reinforcing. Productive capacity combines human capital (skills, training etc); physical capital (machines, buildings etc); land & other resources; technology; entrepreneurship & management; and the political & legal environment. Average productivity (output per worker) has

¹ Bernanke, B., Frank, R. 2007. *Principles of Macroeconomics*, 3rd Ed. McGraw-Hill.

increased by over 2% each year in most developed economies. Many economists in developed countries see technology deployment as the principle driver of rising productivity.

Our economic system is always in a state of change, new businesses are born as others die. Part of this change is driven by competitive pressure as companies find ways to make more of something for less. A manufacturer of computers, by replacing workers by new processing technology, or moving production abroad where labour costs are lower, may be able to make computers cheaper. This potentially expands the number of potential customers who can now afford one, and old customers will find the lower price means they have more to spend on other things, equivalent to an income increase.

However, the labour displaced by rising productivity, be it new technology, or business models must be re-employed if severe political and economic consequences are not to follow. So the governments interest is in supporting the productive environment to encourage further growth and new jobs for displaced workers. This is the growth cycle from which products, services, and industries are born.

Yet the growth cycle requires that demand is maintained: if people were to decide that their needs were being met and decided not to purchase the new goods and services being created, unemployment would rise, and government revenues would fall. A fall in government revenues would lead to less ability to invest in productive capacity, and so lead to further declines in GDP.

It is this dynamic, facilitated by the globalisation of capital and communications that has allowed businesses to search for the optimum mix of productive resources across continents and the resultant focus on national competitiveness. Because low-skilled labour has become more integrated into the global market, it has been tending to keep wage costs low everywhere relative to the most highly skilled workers. This has caused a shift in the resources required to maintain competitiveness in the top tier countries, as more and more state wealth must be consumed to maintain and increase the education, research, infrastructure, and complex bureaucracy which supports it. For poorer countries (and sometimes for certain citizens within wealthy countries) it means a race to the bottom as employment conditions are lowered, environmental constraints of operation reduced, all while governments must competitively invest more in the needs for future growth, whereby reducing investment in the wider needs of their populations.

The money that enables the exchange of goods and services is not merely an enabler, but a central shaper of how economies develop¹. Money, apart from the 2-3% of actual cash, is created by commercial banks when a person or business takes out a loan. That money does not come from depositors but is created out of nothing but the promise to repay. In our current system debt and money exist in relationship to each other; if all loans were paid back money would be extinguished from the economy.

Money is lent by banks at interest, so at a particular moment in time, the money required to pay back all loan principles and interest does not exist. For this to occur, the money supply must expand by the creation of further debt. Ideally one wants expansion to be driven by companies investing in increasing productivity of real wealth, this ensures that the increasing profits will be able to service the debts into the future. This of course does not always happen; consider an asset price bubble, for example, when more and more debt goes on raising prices of non-productive assets such as homes.

¹ Douthwaite, R The Ecology of Money (1999) Schumacher Briefings

Money supply is always in a dynamic relationship between those repaying and those creating loans. If money supply grows in relation to available goods, inflation may result. It is the primary job of central banks to control inflation through interest rates and other requirements on banks. The real danger however is if money supply contracts in a self-reinforcing feedback. This happened during the Great Depression, and is happening in Ireland now. In a deflationary spiral, people stop borrowing so much as they may fear for their jobs or their ability to service their current debts. Business may stop borrowing as they fear for the future, and debt may also become more expensive. In such a situation old debts may be serviced, but new loans reduce. Money supply starts to drop, as do prices as there is less money chasing the supply of goods. Jobs are lost, there are more bad debts, banks may have to constrict already limited lending, fear for the future increases, money supply decreases further and so on.

For governments faced with such a crisis, the 'standard model' is to reflate the economy by massive public spending in unemployment assistance and infrastructure development, which hopefully introduces both enough money and confidence into the economy to initiate spending and borrowing for consumption and investment. This was the idea behind Roosevelt's New Deal, and is being widely discussed as part of the solution to the current crisis. To reflate an economy, a government must borrow- this will require lenders with faith in the future growth of the country's economy.

The embodied assumption in this economic system is that debts outstanding must always rise. Because economic growth and interest payments on a principle are exponential functions, each year's additional debt, on average, must be greater than the year before.

The growth cycle, and the monetary system outlined require growth if they are not to collapse in upon themselves. There is always a danger that a significant policy change could shift the economy into an uncontrollable depression and derail the original policy goal in the ensuing widespread and unpredictable social consequences. This represents a serious constraint for policymakers who want to institute fundamental policy changes. In this sense we really are trapped within our growth system.

1.2 Growth as Behaviour

Economic growth requires that we keep consuming more and more (or the population expands in proportion). That most people would prefer an increase in income is not in doubt. It provides the chance for foreign holidays, a nicer home, organic food, and more (perceived) security in retirement. We also have become accustomed to, and so place demands upon our political representatives for more investment in health care, education, the arts, infrastructure, and a host of other services. It is unique in human history that a society could support half its population in full-time education and support their existence in a largely unproductive manner up until the age of twenty. Many of the things that growth provides, even allowing for personal differences in how they are delivered, are considered good in themselves.

Yet within this there are contradictions. The first is that our expectations are shaped by experience. At an institutional level, we did not miss advanced surgical intervention before we knew it existed, though the universal experience of loved ones suffering was and will be always acute. We are however more sharply discontented when we watch suffering knowing the cure may exist but our health service cannot or will not provide it. The demands upon health care provision, driven in part by evolving science, technology, its financial backers, and public demand seems always to be playing catch-up with society's ability to fund it. In such a way, economic growth is internalised within social institutions.

As individuals, we did not desire exotic holidays when such a possibility seemed remote and unattainable for almost all of us. We did not feel the lack of consumer electronics when such marvels had yet to be invented. We were no less content with local entertainment before we were enticed by the global entertainment industry. And yet we do feel a loss or disaffection when we know of such things, when others around us have access to them, and yet it is beyond our economic means to access them.

Secondly, we know that more wealth or money does not increase our contentment, as we can see clearly in figure: 1. In the language of economics, there is a declining marginal utility. Above a certain minimum, every extra Euro acquired adds marginally less to our happiness. Nobody expects a fortune (having got over the initial joy) will bring us to a state of permanent bliss as our experience attests. What we do know is that well-being is supported by a range of attributes including: genetics; depth and interconnectedness of social interactions; feeling of material, physical, and social security; being acknowledged and listened to; and a level of control over one's personal actions. Particularly worth noting for the discussion below is that one factor detrimental to well-being is the degree of inequality in income distribution. This is true for society as a whole, but also true within peer groups, even when all members of the group have more than they need for basic survival.^{1, 2}

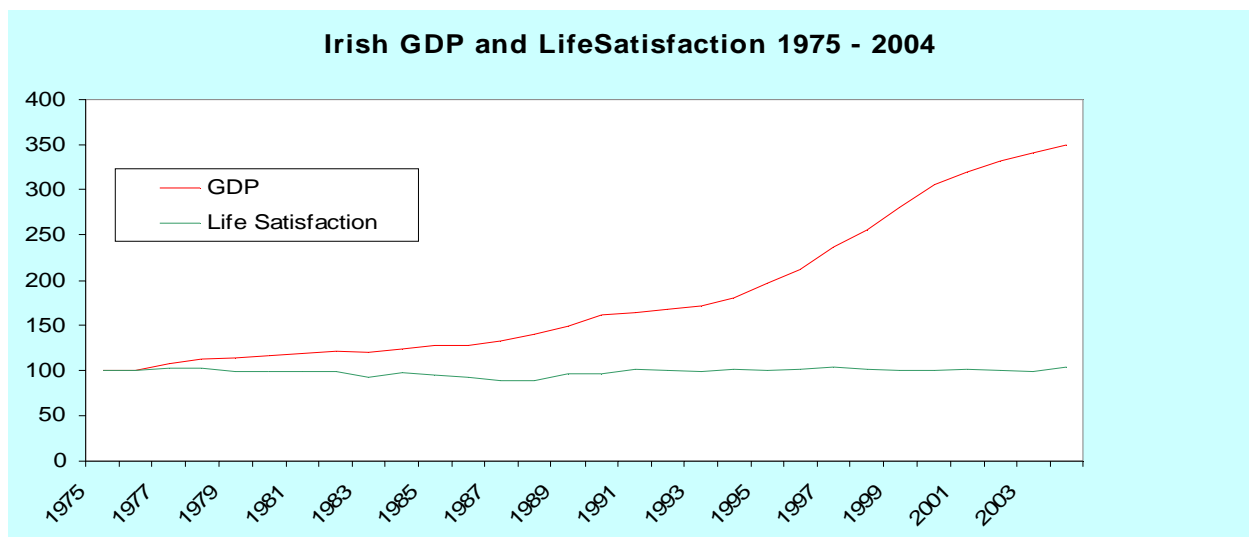


Figure: 1 Irish GDP verses life satisfaction from The New Economics Foundation 2006.

To understand consumption, and indeed why economic growth has been so successful (on its own terms), it is helpful to place it in the context of the wider human experience. For a vulnerable species that evolved in the relative scarcity of hunter-gatherer communities, it was an adaptive strategy to take food resources while the going was good. The future was more uncertain and the ability to store limited by what could be carried and kept before spoiling. Human traits favouring short-term acquisition would have been preferentially selected through evolution.

Human beings are acutely aware of status, and its psychological and physiological architecture is

¹ Hamilton, C. 2004. *Growth Fetish*. Pluto Press.

² Bruni, L.; Porta, P. 2005. *Economics and Happiness*. Oxford University Press.

embedded in our evolutionary history.^{1; 2} Status is a relative concept measuring the honour and prestige attached to one's position within a social group, in addition, its social markers help to define and construct our positions as group members. As a social species with both a need for belonging and a need to establish our relative positions (such as sexual fitness) within a group, status is one of the great unifying concepts between humans and other animals.

Before the modern age social and economic status was relatively fixed, and change in group identification changed slowly over time. Psychologically, our status was relatively secure. However economic growth gave rise to increasing economic differentiation, and the opportunity to display or sign it with new goods or social functions. The process of economic growth also led to greater populations, that were more urbanised and fluid; so disrupting many old group structures. The result was growing 'status anxiety'³ as people sought to find and establish their place within a more rapidly changing world.

Unwittingly, part of our 'growth culture' has been to create and maintain psychological anxiety in the service of continual consumption. In this way, we see while increasing consumption and wealth beyond a certain level may not make us more content, it promises to assuage (at least in the short-term) our fears of isolation and loss of status, a fear maintained by the modern world's rapidly changing social realities, and the vast resources deployed through advertising and the media.

Government is expected to act as hand-maiden of this growth. Our political system has evolved within the expectation of a growing economy, the central issue being how that growth in income is distributed. Our expectations for our institutions and as individuals are essentially short-term. Thus, elected politicians tend to preference short-termism or face the risk of defeat and job loss.

1.3 Growth as Culture

Our assumptions about the future are rooted in the past. We invest a large part of our current and future wealth, in the form of pensions, insurance, and debt to manage historically understood risks such as old age and demographic changes. Governments invest a large part of our current and future wealth, in the forms of infrastructure, and education to manage historically understood risks such as loss of future competitiveness. We invest in pensions and take on 30 year mortgages, while governments announce large-scale and long-term infrastructure projects such as roads and airport terminals. Behind this sits our faith in economic growth and progress. It is an acknowledgement that societies' evolution has a preferred direction, one that will reward our hopes. Our casual relationship with the future seems a gentle affirmation of the present.

For most people in Europe before 1700, village life and local economies changed little over many generations. Save for the vicissitudes of war or natural calamities, a person would have understood and lived a life much like that of their great-great-grandchildren. Social relations were relatively fixed, as was wealth though it fluctuated with the quality of harvests. Progress was seen largely in religious or spiritual terms, pertaining confidently to an afterlife. There was the time of the relatively unchanging day-to-day, the seasons, and the cycle of birth and death; and there was the theological time. Fate and the will of god were seen as the shaper of future events.

The ideas of risk and probability, in the sense of making a calculated assumption about the future likelihood of events, are recent in historical terms. The emergence of such concepts and there

¹ Cartwright, J. 2000. *Evolution and Human Behavior*. MIT Press.

² Dennett, D. 2003. *Freedom Evolves*. Allen Lane.

³ De Botton, A. 2004. *Status Anxiety*. Hamish Hamilton.

practical applications required not only innovations in mathematics, but a transformation in the way our ancestors saw themselves and their relationship with time.¹

When the foundations of probability and risk management were being established in the seventeenth century, Europeans had already begun the journey that had released man from the capriciousness of fate. The renaissance and reformation began the process that banished God from the future's minute and left it in the hands of Man, his experience and wits. An eighteenth century investor in merchant shipping to the colonies buying insurance from Lloyds, or parties to life or fire insurance would have to feel confident that the odds were free from piety or superstition.

The concept of progress also evolved at this time. Science could be understood as progressive because knowledge is a building upon and an adaptation to previous knowledge. The idea of progress began to take on ethical and philosophical characteristics, it was not only science and technology; but human society that would rise and rise to a more humane, civilized and wealthy state. For the philosopher John Gray² writing today, this was not a revolution, but rather a displacement of the religious impulse.

The growth of our economies and the world it built over two hundred years seem to affirm this framing narrative as myth. The sometimes heard refrain against those arguing for green measures is that they 'want to bring us back', as if we were fixed upon a line directed from a poor and fearful past to a rich and desirous future.

While we may narrativise our histories, lives, and politics in terms of ideas, actions and responses, in reality we are blind to much of our motivations, and have a far less predictable influence as both the actors and the acted upon, in the complex adaptive system of which we are part, and whose future evolution will always escape our best analysis.

1.4 Growth & Thermodynamics

Energy drives everything in the world, without it, nothing is created, nothing happens. For thousands of years before the industrial revolution, human societies were powered by the products of photosynthesis, in the form of food, fuel wood and charcoal. Widespread use of coal did not develop until the eighteenth century, and oil and gas not until the late nineteenth century. Today we see that energy use not just as the throughput of energy, but as embodied in all of the material products of our culture.

A simple definition of energy is the ability to do work. For most of human existence all work was the transformation of solar energy, via plants and animals, into human labour. Such efforts carried us step by step from our ancestral home in Africa to the furthest reaches of the earth. The control of fire and domestication of animals provided us with a source of energy outside ourselves, and helped to support the birth of what we call civilization. The ability to access fossilised solar energy (coal, oil, gas) has underpinned the growth of the last two hundred years. In its most direct terms, accessing this store allowed us to do more work per capita. As we moved from biomass, to coal, oil, and gas the energy quality (energy density, energy return after extracting costs of production; ease of use etc) on average increased.

¹ Bernstein, P. 1998. *Against the gods: The remarkable story of risk*. Wiley.

² Gray, J. 2004. *Heresies: Against Progress and Other Illusions*. Granta.

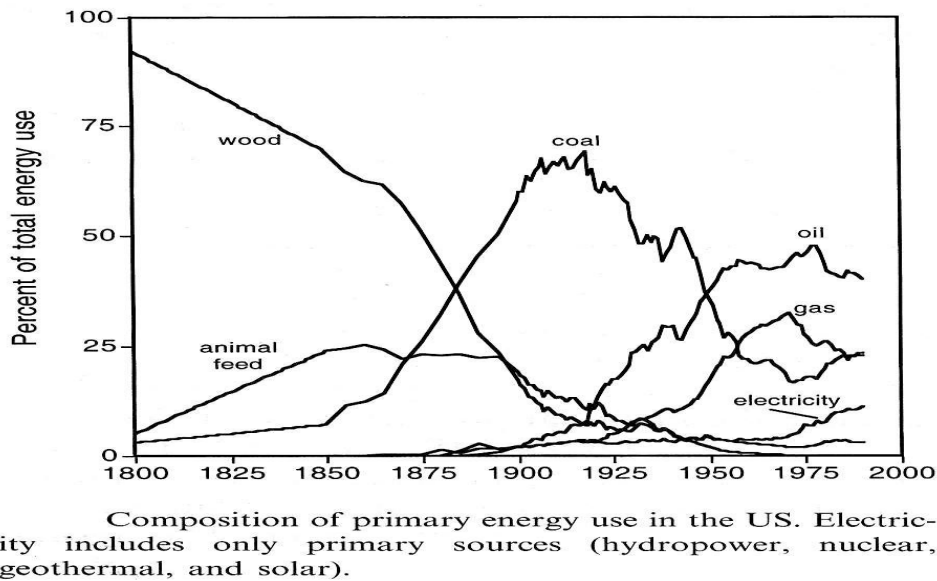
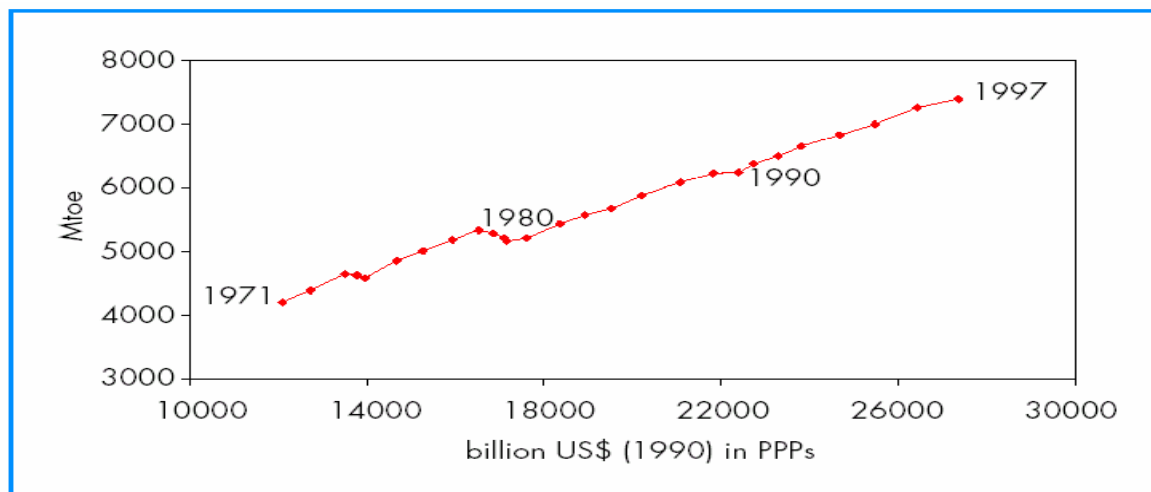


Figure 2: The changing sources of US primary energy¹

The global economy is a far from equilibrium system that converts high quality (low entropy) raw materials into goods and services, while disposing of high entropy materials and dissipating energy waste (heat). The extent of resource requirements, and the waste produced have increased as the global economy has grown. Growing complexity costs energy. The above formulation would be unusual in economics literature, but it does represent a fundamental truth about the economy, indeed of all systems, namely that the laws of thermodynamics confine and constrain all processes. The direct relationship between energy and GDP can be seen in figure 3.



Note: Transition economies are excluded.

Figure 3: World total primary supply in millions of tons of oil equivalent vs. GDP (1971-1997)²

Standard neoclassical theories of economic growth, the conventional wisdom, consider two

¹ Cleveland, C.; Kaufmann, R.; Stern, D.2000, eds. Aggregation and role of energy in the economy. *Ecological Economics* 32. Elsevier

² Source:IEA and Lambert, C. *Energy Demand and Prosperity*, Westminster Policy Forum

principle factors of production, capital and labour, which are substitutable with each other. Such a model did not explain the growth in the US economy; an unaccounted residual amounting to 80% of per capita growth in output was attributed to technological progress, now referred to indirectly as total factor productivity. It is argued that technological development is the principle growth driver, which is assumed to be exogenous and automatic. However, this explanation is unsatisfactory. Energy or material resources are not included directly as a factor of production, but as an intermediate product of capital and labour. In such a view, energy is not crucial to the functioning of the economy rather its economic importance is closely related to its share of GDP. Imagining a thought experiment in which all energy sources in the economy were cut such that electricity, transport fuels, and heating no longer provide their services, would the effect over a year on our economy amount to between 3-4% of GDP (the amount we spend on energy services), or more reasonably, would most economic activity grind to a halt?

It is not direct energy inputs that help create economic growth rather it is the amount of that energy converted into useful work. Robert Ayres and co-workers have shown that a growth model that includes useful work done (= energy x efficiency) shows a remarkable correlation between observed economic growth and energy.¹ This model explains the major contribution to growth as a combination of increasing energy inputs and higher efficiencies, and the changing quality. Centrally, the model shows that if economic growth is not just a consequence of energy use, but an inseparable cause, then decoupling and dematerialisation will be close to impossible. Other work by Cleveland² amongst others reaches similar conclusions.

1.5 Energy & Complexity

Before about 1750, localised food shortages and famines were reasonably common in Europe. It was in such cases often observed that abundant harvests could co-exist with nearby famine. The central problem of distribution was firstly that the money was a small part of the local economy, as most communities were largely self-sufficient. Secondly, there were very rudimentary transport links, and actual communication between towns may have been infrequent and haphazard. This meant that there was neither a proper signalling mechanism to indicate shortages, nor a trade and transport system to facilitate the resource redistribution. Local town-lands could find themselves vulnerable to harvest failure which was the bed-rock asset of community welfare, and therefore had to bear all the risk. The risk could be partially managed by storage and storage technology, but the ability to store for a rainy day also meant that there needed to be surplus production.

One of the great advantages of a growing interconnectedness between regions, and more trade with money was the localised risks could be shared over the whole network of regions. Surpluses could be sold to where prices were highest in the network, and the money received in return would hold its value better than the stored grain prone to rot or rodents. Distributing surpluses across the network was also the most efficient use of resources, in addition to freeing up more capital for investment. The growing size of the network, increased surpluses, and comparative advantage meant that more specialised roles could be performed in the network than in a similar number of isolated regions or towns. This meant new products and services could be developed.

The increase in connectedness, number of products produced, and size and diversity of social roles

¹ Ayres, Robert U., Leslie W. Ayres, Benjamin Warr. 2003. Energy, Power, and work in the US economy, 1990-1998. *Energy* 28.

² Cleveland, C.J. et al. 1984. Energy and the US Economy: a biophysical perspective. *Science* 255.

can be understood as growing complexity. Eric Beinhocker¹ compares the number of distinct culturally produced artefacts produced by the Yanomamo tribe on the Orinoco River, and New Yorkers. The Yanomamo have a few hundred, the New Yorkers have in the order of tens of billions, and this is a measure of complexity. Beinhocker says "To summarize 2.5 million years of economic history in brief: for a very, very long time not much happened; then all of a sudden all hell broke loose. It took 99.4% of economic history to reach the wealth levels of the Yanomamo, 0.59% to double that level by 1750, and then just 0.01% for global wealth to reach the level of the modern world". Such a network is also adaptive, meaning it self-regulates, nobody is needed to design and run it. Individual members of the network just play their part by farming or smithing say, and finding the best price for their surplus. The overall organisation observed is just the emergent effect of many individual parts playing their particular roles. And as in the example above, the growth in complexity can be seen to produce many advantages.

If we imagine that suddenly all our IT systems, introduced over the last 15 years, stopped working. The result would not be to return us to where we were just before their introduction. Many people would become uncontactable, records would disappear, much of business and commerce would be in crisis. Parts of our banking system, airline transport, stock markets would fail, and jobs would be lost. Over time some of our economy would be rebuilt, however many things would be permanently lost including records and the cost efficiencies that our IT system provided. There are two general conclusions that may be drawn. Firstly, as complex systems grow, they become, without an overall plan more and more deeply interconnected, as many parts of the system adapt to the changing environment. Secondly, as new technologies and business models emerge, their adoption and spread through wider networks will be dependent upon the efficiencies they provide in terms of lower costs and new market opportunities. One of the principle ways of gaining overall efficiency is by letting individual parts of the system share the costs of transactions by sharing common platforms (IT networks, supply chains), and integrating more. So the modern just-in-time delivery systems freed up the cost of holding stock, and allowed businesses to be highly responsive to changing demand.

Growing complexity also has costs, as roads must be built and maintained, and traders and their goods kept safe, a growing bureaucracy is needed to tax and manage larger or more complex investments. All of this requires energy, metals, wood etc, not just to increase the size of the network but also to maintain the networks basic functionality. The overall expectation is that the growing costs of complexity will be outweighed by the increasing benefits.

A less acknowledged cost is the risk of systemic failure. Integrated systems can reduce local risks as we discussed earlier; but by sharing a common platform, the risk of whole system failure becomes possible if the platform itself is undermined. This is particularly true if the platform relies on one key resource without easy substitution such as oil, or energy supply in general. In addition the tightly integration and high efficiencies of such networks means that a failure in one part of the system can cause cascading failure throughout the system. For example the shut-down of Ireland's pork industry was because a small number of pork production facilities used contaminated feed, and this was mixed with pork from many untainted sources. In the search for efficiency, pork processing has become more and more concentrated, resulting in the risks of local contamination now being shared by all Irish pork producers. Indeed our food industry is now so tightly coupled, and just-in-time delivery so well adapted that it has become extremely vulnerable to oil shocks or serious failures of international banking and finance. As our energy platform and financial systems are also tightly integrated, cascading failure can cause multi-system failure.

¹ Beinhocker E. 2007. *The Origin of Wealth*. Random House.

There is also a fundamental energy consideration at work. The second law of thermodynamics tells us that all processes are winding down from a more organised state to a more disorganised one, or from low to higher entropy. So how can we create a more and more complex society? The answer is by supplying more and more energy in to keep the system further and further away from the disorder to which it tends. Clearly if complexity costs energy, then energy supply is the master platform upon which all forms of complexity depend. It also demonstrates in general that the huge recent growth in complexity required the massive increases in energy inputs provided for by fossil fuels.

Joseph Tainter who studied the collapse of many civilisations argued that collapse was associated with declining marginal returns on complexity¹. His thesis runs as follows:

1. Societies are problem solving organisations that require energy and resources for growth and maintenance, in that process they also produce waste.
2. The easiest solutions to problems are found first. The resources and energy that is easiest to access and exploit are used first. As the easiest resources are used up, more effort has to go into accessing the same amount of resources. We will see this later when we discuss Energy-Return-On-Energy-Invested (EROEI), and declining marginal returns in science and technology.
3. Societies evolve into more and more complex organisations, become more interdependent as problems increase in difficulty. This requires greater resources, as resources become more difficult to exploit.
4. This leads to declining marginal returns on complexity.
5. As declining marginal returns continue, the ability to maintain complexity is compromised. This makes it more and more difficult for society to deal with new problems.
6. This leads to a collapse in complexity.

Such a formulation highlights many of the key issues of concern in this text.

¹ Tainter, J. 1988. *The Collapse of Complex Societies*. Cambridge.

Chapter 2

Growth & Its Limits

Humanity places demands upon the planet, both as a source of resources, and as a sink for its waste. This impact can be seen in the exponential growth in resource use, energy inputs, and the increase in greenhouse gas emissions, soil loss, deforestation, biodiversity loss, and aquifer depletion amongst others.

An extent of our human impact can be gleaned by considering the human appropriation of the earth's photosynthetic products^{1,2}. Such estimates have a wide margin of error, but are between a quarter and a half of the earth's land-based photosynthetic production.

The 4th Global Environmental Outlook³, published by the UNEP, catalogues the state of many of our critical resources. It notes that "humanity's [ecological] footprint is 21.9 hectares per person, while the earth's biological capacity is, on average, only 15.7 ha/person". At the launch, the UNEP's director Achim Steiner said:

"There have been enough wake-up calls since Brundtland. I sincerely hope GEO-4 is the final one. The systematic destruction of the Earth's natural and nature-based resources has reached the point where the economic viability of economies is being challenged-and where the bill we hand on to our children may prove impossible to pay".

The link between economic growth and carbon dioxide emissions is strong. Joseph Canadell and co-workers⁴ have shown that the emissions growth rate has risen from 1.3% per annum in the 1990's to 3.3% per annum between 2000-2006. They have estimated that approximately 65±16% of the increase has been attributable to economic growth, and 17±6% due to the increasing carbon intensity.

Steiner's frustration is in the context of a history of warnings issued over decades about growing general and specific ecological risks to human welfare. In that time governments have used a wide range of policy tools, international treaties, economic incentives, awareness campaigns, and no end of ambitious plans and pronouncements. This has resulted in some successes, but in aggregate, virtually all major ecological indicators are declining.

2.1 Consumption and Population

It is widely agreed that the principle driving forces behind the deterioration of human life-support systems are the combined impact of population size and growth, consumption, and the use of

¹ Vitousek, P. et al. 1986. Human Appropriation of the Products of Photosynthesis. *Bioscience* Vol 36 No 6.

² Haberl et al. 2002. Human Applications of Net Primary Production. *Science* 296.

³ www.unep.org/GEO/GEO4

⁴ Canadell et al. 2007. Contributions to accelerating atmospheric CO₂ growth from economic activity, carbon intensity, and the efficiency of natural sinks. PNAS www.pnas.org/doi/10.1073/pnas.0702737104

environmentally malign technologies. These have been combined in the identity $I \approx PAT$, where I is the impact of human activity on the planet, P is the population, A is expressed as income per person, and the technology (T) is a measure of the impact on the planet of each dollar we spend.¹

The human population has increased from approximately 1 billion in 1800, to 2 billion in 1927, 5 billion in 1987, to nearly 7 billion today. On current trends according to the UN, this will reach 9 billion by 2050. Every living person on the planet requires a minimal resource impact in order to survive, over 1 billion people living on the planet are close to this level, with many more not too far above.

It has been widely observed that in the poorest countries families tend to be larger. One major factor in reducing fertility (i.e. number of children per woman) is a rising GDP. Reductions in fertility are associated with greater access to family planning, provision of health-care and reduced child mortality, greater employment opportunities for women, and the education of women.² However, to provide the services above implies that the state in question is investing more wealth, either by redirecting wealth that was previously spent elsewhere, or by investing in the wealth derived from economic growth. The provision of these services is resource intensive, and a supporting economy must be robust enough to provide the investment.

This link between consumption and population creates a conundrum for those wishing to limit the human impact of population. If population is to be reduced in the poor and developing world, more direct (in terms of services), and indirect (supporting economy) utilisation of energy and material resources are required, with a corresponding increase in waste outputs. In a nutshell, reducing population can itself lead to increased environmental impact via rising consumption.

The impact of an average developed world family is still much greater than one in the poorest parts of the world. Thus a sub-Saharan family might have eight members with CO₂ emissions of 0.5 t/capita, 6.5 times less impact than a European three-person family using 10t/capita.

2.2 Exponential Growth

Producing goods or services in an economy will always require materials and energy, and will always result in waste. We can compare the energy intensity (energy use per euro of GDP created), resource intensity (resource used per euro of GDP created), waste intensity (ie CO₂ per euro of GDP) over time and between economies (ERW intensity). However, such comparisons are open to great uncertainties, and have been used as arguments to avoid taking political action to reduce greenhouse gas emissions.

The reduction of energy and carbon intensity across developed economies have led some to argue that their economies were 'dematerialising', rather than just undergoing a shift in the productive composition of the economy away from manufacturing and towards services. A dematerialised economy is of course meaningless. Fossil energy extraction and processing, heavy and medium manufacturing are ERW intensive; while services tend to be less so. As the most developed economies moved their economies towards high value financial, IT and creative services their ERW intensity reduced. However, the low intensity countries are bound to their high intensity trading partners for their support infrastructure (computers, steel for office building etc), for their consumption (cars, white goods), as prospective buyers of their services, and as visiting tourists.

¹ Ehrlich, P.; Ehrlich A. 2004. *At One with Nineveh*. Island Press.

² Thirlwall, A. 2006. *Growth and Development*. Palgrave.

National accounts of energy or carbon emissions do not measure our use of ERW, indeed much of China's emissions could be argued as being belonging to the actual importer-users of their manufacturing output.

Over the last few decades the Gross World Product (GWP) has increased at over 3% p.a. Most of this growth occurred in the developing and developed world, where until recently major economies such as China were able to maintain growth rates of over 10% pa over nearly a decade. The implications are dramatic. At a growth rate of 3%, the size of the global economy would have doubled in 24 years. With a growth rate of 10%, China's economy would have doubled in 7 years.

2.3 Arguments over the Limits to Growth

The arguments against there being a limit to growth generally have the following attributes:

- A rise in the market price of a good or service warns of its growing scarcity.
- The rise in price acts to reduce demand for that good and encourage efficiencies in its use.
- The price rise encourages investment in new technologies to substitute for it. Ideally the substitute is even better than the original.
- As demand for the substitute grows, economies of scale ensure falling prices.
- An environmental 'bad', that was previously unaccounted for by the economy, can be 'internalised' within the economy by creating a charge for its use.
- A growing economy allows us to manage better future risks of today's environmental damage.

We will look at each of these in turn, then draw some general conclusions:

Price Signals

In general market prices represent a signal about the current state of the market. Consumers, producing companies, financial markets, and governments are optimised to strongly favour short-term advantages. CEOs, and workers in the financial services are rewarded on their annual profits, and governments on their election cycle. People in general are disposed to valuing current gains over future gains or losses, this will be discussed in more detail when discounting is discussed.

In practice, we see for example that food prices have decreased over many decades while growing pressure on its key production resources (soil, water, fossil fuel inputs) have increased. The drive for lower prices, the competitive race amongst market players, and the globalisation of markets in search of efficiencies ensure short-term thinking. Should any particular market player or government attempt to internalise the costs of future shortages, the market will most likely move to source elsewhere, resulting in a failing company or a loss in GDP by the country.

Demand & Efficiencies

A rise in the price of a good tends to reduce demand for it. The relationship between the price increase and reduced demand is the good's elasticity. For non-essential discretionary consumption, a major price increase results in a large reduction in demand. Many essential goods and services are said to be inelastic, meaning rising prices have little effect on demand. Energy and food are considered inelastic goods because they are essential to our way of living. We may substitute cheaper food for expensive food, but we must eat. Likewise higher energy prices might encourage less leisure travel, but if public transport is not available, we may have to keep purchasing petrol to stay in employment.

The issue of efficiency in public discourse has become quite confused. Various studies have looked

at the scope for efficiency savings, these tend to include zero cost measures (such as turning off lights when not in use), and costed ones (energy efficient bulbs, insulation, new technologies). Sustainable Energy Ireland estimates an energy efficiency savings of 26%¹ is available to the Irish economy.

It has been known since the mid-nineteenth century that increasing the efficiency of a service may result in an increase in the use of that service. The general theory for this is known as the re-bound effect.² Let us say we use less energy and save money by insulating our house, what we do with the money we have saved will determine how much energy has been saved overall. Virtually anything we do with the money such as putting it towards a holiday, buying a book, or going to a restaurant will increase the energy used somewhere else in the economy. The re-bound effect links the local efficiency gains within a household or company with the macro use of the resource.

We could blunt this effect if energy prices were to rise, so that the efficiency gains were off-set by increasing costs. In this case, rising prices 'force' efficiencies, starting with the easiest measures (in terms of least effect on welfare for a family, or profits in the case of a company). For an economy we would expect rising prices have a minimal effect on economic growth initially as zero and low cost energy efficiency measures are forced first as they are essentially 'fat' on the economies energy intensity. However, the relationship between rising relative energy prices and efficiency measures in general is not so straight-forward. What is probable is a mixture of some real efficiency gains and demand reduction (lowering GDP, company profits, household welfare). Rising energy prices since 2005 have hit hardest those with least ability to cut energy use. The first group are the poor, where fuel poverty has increased, and this can be expected to increase if relative prices rise. Secondly, the most efficient businesses with high relative energy costs, such as commercial transport, aviation, and food inputs.

On the other side, the most inefficient energy users, with the most scope for improvements are likely to be businesses for whom energy input is small, relative to the costs of production, or wealthy individuals for whom the cost increases are immaterial.

We can see that because of the re-bound effect and the differential efficiency profile within an economy, estimates of efficiency gains over an economy are problematic.

New Technologies and Substitution

The first thing to note is how often science and technology is assumed to be responsive to any particular need we wish to fill. It seems to embody our faith in progress, its potentials asserted, and its faithful legion. The frequent references to the Manhattan Project, or the Apollo missions are presented as proof that if only the will were there, science and technology would do its part in freeing us from the limits imposed on our species by the ecosystem in which we live. Many of our expectations of future science and technology have not lived up to our hopes. The arrival of the intelligent robot, nuclear fusion and more recently, the imminent hydrogen age are being pushed further and further into the future.

Of course science and technology represent a pinnacle of human achievement. What it can deliver though is limited by physical laws, our abilities and imaginations, the resources required, and the context in which we expect it to work.

¹ Demand side management in Ireland-Evaluating the energy efficiency opportunity. Sustainable Energy Ireland. 2007.

² Polimeni, J. Mayumi, K. Giampietro, M. Alcott, B. 2008. *The Jevons Paradox and the Myth of Resource Efficiency Improvements*. Earthscan.

Science and technology are an exercise in problem solving. As generalised knowledge is established early on in the history of a discipline, the work that remains to be done becomes increasingly specialised. The problems become more difficult to solve, are more costly, and progress in smaller increments. Increasing investments in research yield declining marginal returns.¹

If the productivity of research is assessed by a measure such as patents issued, productivity seems to be declining in many areas. By way of illustration, the research leading to penicillin costing no more than \$20,000 had a major effect on human health. Whereas now the problems have become increasingly complex, resource intensive, and make marginal increments to human life expectancy, in spite of hundreds of millions of dollars being spent to develop a drug.

The conclusion is that further research and development is likely to be more resource intensive, yet on average give smaller returns to society. For a society trying to undergo an energy transformation, this means that more and more of possibly declining energy available to society must be devoted to research and development, but with less likelihood of significant breakthroughs.

There are also fundamental limits to substitution, and efficiency increases in particular industries and processes. Thermodynamic limits mean that there are declining marginal returns in attempting to increase efficiency. The synthesis of ammonia (for fertilisers say), the energy efficiency of power plants, and the productivity of grains are an example. This is also intuitive, we have raised the productivity of wheat using new seed varieties, pesticides, and fertilisers, but it would seem bizarre were this would continue ad infinitum, opening the possibility of infinite production per acre.

Because problems tend to be solved within a specific economic or environmental context, the externalised consequences arising from the solutions are often not accounted for. Government incentives, corporate and financial goals, and the political and social reality of 'the next big thing' tend to favour focussed solutions. The recent example of biofuel development is a case in point, which while (possibly) giving benefits as a substitute for oil, has major consequences for food and water security. As constraints on energy, resources, and waste grow, and the search for substitution pathways intensifies, coupling between resources will increase. This will increase the chance of more severe negative externalities.

Economies of Scale Ensure Falling Prices

It is almost a truth of economics that economies of scale will bring new technologies to market at lower prices. However, in the last few years the price of large-scale wind turbines has increased and time to delivery has increased beyond four years. This reflects firstly the growing desire for climate and energy security driving demand, and the limited ability of the industry to ramp up production to meet it.

A similar dynamic is evolving in the nuclear power industry. About half of the world's approximately 450 nuclear power plants are at the end of their lives. There have been few new ones built over the last two decades, resulting in few companies with the expertise in plant construction. As energy security becomes more urgent, there is likely to be a bidding war for the limited production capacity, with much of that being merely replacement.

We might expect more examples as a globalised world, anxious about its energy future, scrambles for solutions. In addition, as any new product, be it a nuclear power plant or home insulation are energy intensive, increasingly higher energy prices (as a function of GDP) and increased project

¹ Tainter J. 1996. Complexity, problem solving, and sustainable societies. *Getting Down to Earth: Practical Applications of Ecological Economics*. Island Press.

risks (to be discussed later) may make prices rise, even as productive capacity increases.

Internalising Ecological Risks into the Economy

If we were to pay for the costs of the externalities of our consumption by internalising the cost into the prices of goods and services, economics would force us to adjust down consumption in response. However we have built our economics on not charging for those services. If we put a price on carbon via a carbon tax on energy, and that tax had to reduce demand by say 3% per annum (Ireland's target), the price would have to be high enough to drive energy use down by this figure. There would be direct consequences for economic growth, and considerable public anger as the high energy prices of 2007/ early 2008 showed.

Research published by Robert Costanza and his colleagues estimated the total economic value of 17 ecosystem services needed to keep the earth's systems functioning.¹ The value was estimated at \$16-54 Trillion per annum, this was when total global gross national product was \$18 Trillion per annum. Of course without such services, human life and civilisation would cease to exist, so in theory, such services should have infinite value for us. But the figure does show that internalising such costs into our economies would be impossible as the value is greater than our global income.

A Growing Economy Allows Us to Manage Future Risks

This is not of course true if those future risks undermine the functioning of the economy.

It is also sometimes argued that rising incomes improve environmental quality. The hypothesis underlining the environmental Kuznets curve (EKC) is that resource depletion and pollution tend to rise as economies grow but then tend to fall once income reaches a certain level, producing an inverted-U shaped function. An example might be the improvement of water quality when a society can afford modern waste management. The initial research on which the EKC was based suggested some pollutants followed an inverted U curve as incomes rose.² This has been extrapolated by some to be a general feature of economic development. However this has been severely critiqued. Clearly such an argument does not hold for greenhouse gasses, or energy use. In addition, richer economies consume a lot more than poorer ones, but can afford to 'outsource' their dirtiest production.

General Point

The economic arguments against limits to growth that opened this section assume our economy is a perfectly functioning equilibrium system. It assumes price signals lead with perfect choreography to solutions. As we have seen above, the real world is more complex and unpredictable. What will turn out to be of immense importance when considering the process of energy decline are factors such as time, uncertainty, and complex behaviour. Classical economics cannot, nor rarely even acknowledges that such problems are beyond its competency.

¹ Costanza, R. et al. 1997. *The value of the world's ecosystem services and natural capital*. *Nature* 387.

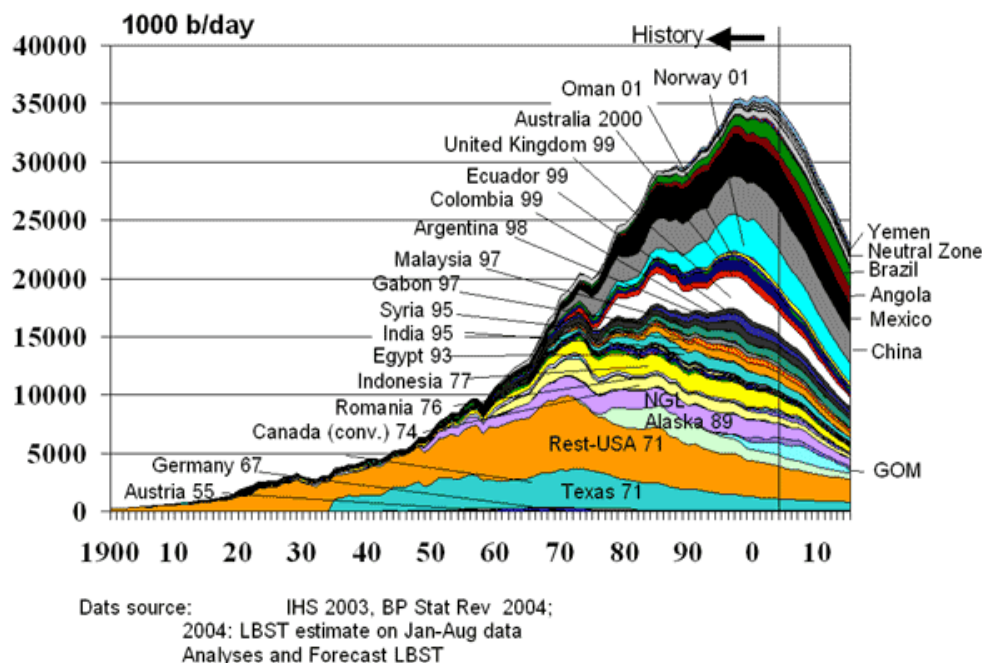
² Grossman G; Krueger, A. 1995. Economic growth and the environment. *Quarterly Journal of Economics*.

2.4 Energy

We have discussed the central role of energy for economic growth. The evolution of modern society is itself a creature of fossil fuels; our mode of habitation, work, culture and leisure reflect this. Our belief in continuing economic growth must also be a belief in continuing supplies of appropriate energy.

There are very good reasons for concluding that this assumption is about to break down due to the imminent onset of Peak Oil, severe natural gas supply issues, and Peak Gas. Recent research also questions the optimism surrounding coal supply. The attendant issue is what replacement energy sources are available, the quality of that energy, its cost, and to what extent it can be scaled up to replace the declining fossil fuel input and the increasing energy required by economic growth.

Peak Oil refers to the point at which the global production of oil can no longer increase. It does not mean oil has run out, but that after this point net production will go into decline. There are many factors that may hinder oil production, including geopolitical conflict and under-investment in production. However the fundamental point about peak oil is that it is based on geological constraints, not on temporary factors. A rise, peak and decline in oil production has been seen in many local contexts, oil production has been in decline in the lower 48 states of the US since 1971 as predicted by M King Hubbard; and in the UK's North Sea fields, since 1999, see Figure: 2. In both cases neither higher oil prices nor new technology arrested decline; decline is the inevitable consequence of production. It is most likely to be from another critical



resource, natural gas.

Figure: 4 Oil production in countries past peak with peak year noted. Even in advanced economies, production decline is terminal. The sum of smaller peaks is also a

It is almost universally agreed that peak oil will occur; the debate is about timing. Some believe that we are on the plateau of a peak today; at the other extreme, that it may not happen until after 2030. The majority suggests the peak will be prior to 2012. There are provisional grounds for assuming we are on a plateau at present, with little hope for further production increases, and growing risks of permanent decline. The International Energy Agency (IEA) recently reversed its over-optimistic production forecasts (really an assumption that production would follow demand) when it warned of a looming supply crunch.

Oil forms 40% of energy traded and over 90% of transport fuel globally.¹ Ireland has the third highest oil consumption per capita in the EU, arising from its use in transport and electricity generation, though in the latter case it is being phased out. This makes Ireland very sensitive to oil price shocks, and peak oil in general.

We have large complex infrastructures and capital invested in our current energy generation, distribution and modes of use. The transition from our current patterns of use to a new form would be time consuming and expensive. Robert Hirsch has emphasized the rate of turn-over of capital stock as 9 years for road transport stock, and 22 years for aircraft.² Because our economy and spatial development is so dependent on car use, adapting to a sudden change would be very difficult by reversal or adaptation. Hirsch suggests we would need 20 years prior to the onset of peak to prepare for the transition; thus 10 years would be very difficult and traumatic. Acknowledging that there is a medium to high chance that we will have peaked within 5 years should sound alarm bells.

Natural Gas

The International Energy Agency expects the global demand for natural gas to continue rising indefinitely. Sustainable Energy Ireland expects natural gas to rise from 40% of fuel inputs for electricity generation in 2005, to 51% by 2010, and 45% by 2020.³ Natural gas is also a finite resource, that will peak at some time, though estimates of when are more difficult to ascertain for a variety of reasons. In 2001 and 2002, for the first time, more gas was used globally than found, this is a repeat of the situation that occurred twenty years ago for oil.⁴ The former head of exploration technique at Total, Jean Laherrere has predicted a global gas peak in 2025.

Natural gas cannot be transported except at very high pressure, or very low temperatures, making delivery very expensive and technically complex. Coupled to this, most gas reserves are a long way from their markets. This means that gas must be delivered along fixed pipelines, planned long in advance, and that long-term contracts are the norm. Pricing in such contracts is generally linked to oil prices. Whatever about the infrastructure, the gas must be there in the first place. The onset

¹ Campbell, C. 2003. When will the World's Oil and Gas Production Peak? *Before the Wells Run Dry*, ed. Douthwaite R. Feasta and Lilliput Press.

² Hirsch, R. 2005. Peaking of World Oil Production: Impacts, Mitigation, and Risk Management. SIAC.

³ Ref: quoted in Delivering a Sustainable Energy Future for Ireland, Government White Paper, 2007.

⁴ Ref: Darley, J. 2004. *High Noon for Natural Gas*. Chelsea Green.

of peak gas is likely to be more sudden for gas fields, and the decline rate much greater than for oil. In addition, the IEA is already warning that Russian investment in infrastructure may prove inadequate to supply existing contracts.

Many gas producers are in decline (UK and US for example) and global demand is rising. This puts the energy security of more countries in the hands of fewer producers - and this dynamic will continue. While much comment has focused upon the geo-strategic aspects to this, particularly European-Russian relations, the underlying factor is that the pool of supplier countries will shrink because natural gas production is peaking in all supplier countries. Even with the best of relations between Russia and the EU there is scepticism that gas will keep flowing according to IEA projections.¹

Natural gas can be liquefied at atmospheric pressure when cooled to -260°F, which reduces the volume and allows for shipping and transport. The process from extracting natural gas through delivering it to a customer, via Liquefied Natural Gas (LNG), is known as the LNG Train. It is exceedingly expensive and very energy intensive. Just to ship LNG from Qatar to the eastern US would cost 15% of the energy contained within the shipment.² While massive investment is going into this area, there is a widespread fear of a large shortfall between the demand for LNG and the ability to supply it. Thus supply disruptions and high prices are an inevitable even before peak gas.

Coal

While the construction of new coal-fired electricity plants in China has received much attention, major coal-fired plants are being built and planned throughout the world, including in the wealthiest countries, in spite of publicly declared targets to reduce GHG emissions. In direct competition with natural gas, coal is seen to provide a cheaper and more secure electricity platform. At present, coal provides a quarter of global primary energy needs and 40% of electricity generation; again according to the IEA, coal use is expected to increase, including in the EU. Coincident with the increased use of coal is a rise in greenhouse gas emissions, with coal source emissions expected to pass oil in 2010. Indeed, if the IEA is correct, by 2030, coal-fired power plants could produce 3Gt of carbon a year compared to current total global emissions of 7GtC per year, in the absence of Carbon Capture and Storage (CCS). CCS is not yet commercial, and technical difficulties remain. It is expected to be 72-78% effective in reducing CO₂eq from power stations. All coal-fired electricity plants currently being built have no requirement that they are capable of being retro-filled with CCS should the technology and economics prove right in the future. With expected lifetimes of 40+ years, we are committing ourselves to long term emissions increases from coal-fired electricity production. The principle issue for CCS is the finance and energy costs. The average energy cost has been estimated by the Wuppertal Institute at 20-44%,³ which would imply an accelerated depletion of coal supplies and a massive increase in generation infrastructure. For the moment though, it will not make a serious dent in

¹ Stern, J. 2006. The New Security Environment for European Gas: Worsening Geopolitics and Increasing Global Competition. *LNG*. Oxford Institute for Energy Studies.

² Darley: 60.

³ www.wupperinst.org/uploads/tx_wibeitrag/II-Kap4-8-RECCS-Endbericht.pdf

coal emissions for at least 20 years, outside the crucial window in which emissions must be reduced substantially. Recently, a German research group, Energy Watch, has indicated that current coal reserve estimates are greatly exaggerated and that global coal production could peak in 15 years. A summation of the 'triple' peaks, coal, gas, and oil is shown in figure 3.

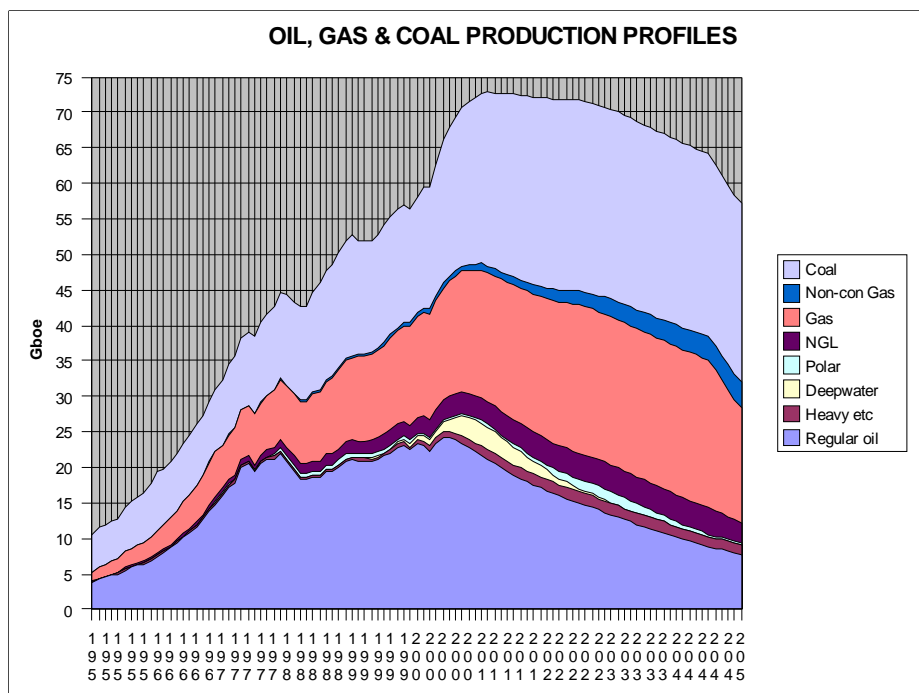


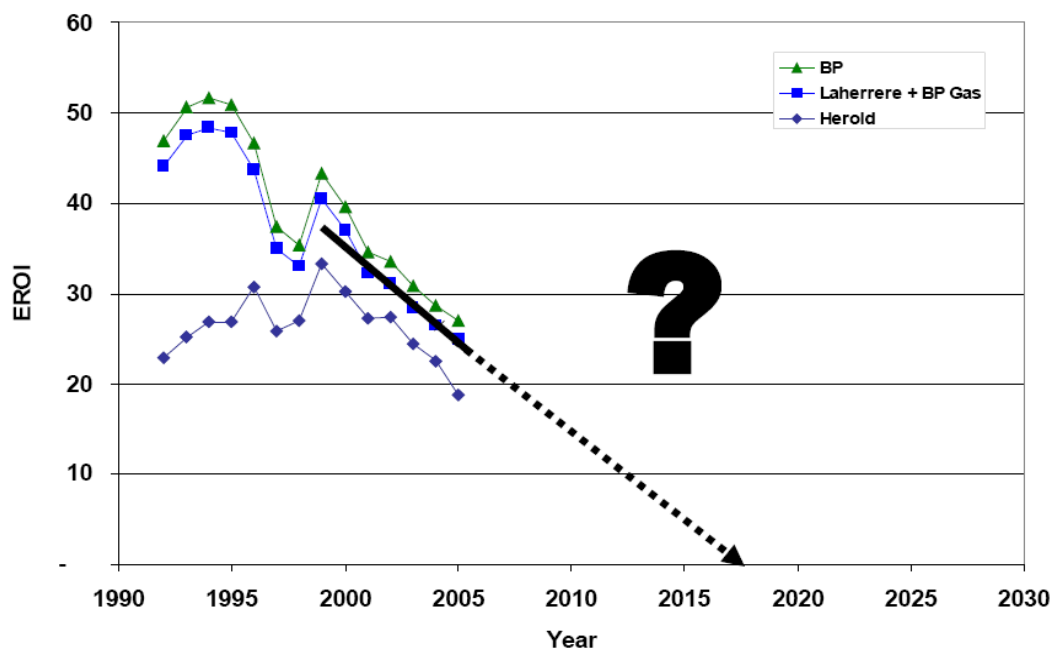
Figure 5: Estimated energy production from coal, gas, and oil, which is projected to peak in 2011. Based upon data from ASPO and the Energy Watch Group.

We should note a number of points about figure 5:

1. What is important for economic growth is not energy *per se*, but the

useful work that energy can provide. It takes energy to extract energy and convert it into useful work. As we move to more unconventional and deepwater oils, lower grade coals and smaller source fields, more energy must be invested to bring the fuel to market. In addition, tar sands and heavy oils require far more processing for them to be economically useful. All the above is captured in the energy-return-on-energy-invested (EROI). EROI has been declining for many years, reflecting the fact that the best, largest and easiest fields are exploited first. This means that as we pass peak energy, there are two energy reduction processes, the declining peak production combined with a growing reduction in the useful energy as a percentage of energy produced.

2. Different physical forms of energy have different economic usefulness even when they have the same net energy yield. Electricity is the most versatile energy carrier, so we are content to burn coal say, at low efficiency to generate it. Likewise, the fact that oil is both transportable at room temperature and pressure and has a very high energy density means it is suited to a wider range of activities (coal is unlikely to replace oil as aviation fuel). As we move along the depletion curve, the relative energy mix will determine the relative economic pressures. Relative economic usefulness is likely to decline.
3. Declining EROI means more energy must be spent to access and refine a fuel. This is likely to lead to increased greenhouse gas emissions per unit



energy production.

Figure 6: Declining energy return on energy invested. This is the thermodynamic expression of resource extraction and eventual depletion. Adaptation to oil and gas constraints

Various estimates of oil depletion rates exist, Chris Skrebowski¹ explained that Gabon's post-peak decline by 18%, North Sea production by 9%, and Indonesia by 8.5%. The International Energy Agency have noted that smaller fields and off-shore fields have higher decline rates, meaning as more marginal fields are developed and then pass peak, global decline rates could accelerate over time². Gas decline is likely to be on average greater than oil. If we wish to continue 'business as usual', we must replace the useful work done in our economy by the declining fuel sources and lower EORI plus the extra required by economic growth. So if oil declines at 5% per annum, and if the economy requires 1% growth, we need to replace the 6% of net energy with an energy source of similar quality per annum.

What can we gain by energy efficiency? No energy transformation process can ever be 100% efficient because of the second law of thermodynamics. One can make processes more energy efficient, but the marginal increase in energy efficiency will eventually require more energy to implement than is gained in the process (i.e. Around 2017 in figure: 4). Increasing economic growth will require more energy. Even if energy intensity (energy used to generate a unit of GDP) is reduced, energy is still required, and inevitably energy use driven by increased economic growth must exceed gains made in the economy because of efficiency.

2.5 Filling the Gap

To what extent can we substitute other energy sources to compensate for growing declines in fossil fuel and the need for the global economy to continue growing? An increase in energy efficiency could ease pressure for a while, subject to the constraints outlined earlier. However because efficiency improvements are limited, but growth is continually increasing exponentially, supplies of energy must ultimately keep increasing.

There are a number of important components of building infrastructure which we outline below:

a) *Energy Quality & Energy Return*

Fossil fuels are higher in quality than the renewables with which we might expect to replace them. That means they have higher energy densities, high energy returns, are easy to transport in the case of oil, and can run continuously. It is also worth noting that as our societies and economies have evolved, they have become adaptive to the fuel types they were dependent upon. Thus, biofuels were introduced relatively quickly because they were adaptive to cars currently in use and could rely upon existing agricultural systems. Replacing an oil based transport platform with an electric one would require new industrial transformation for car production, a transformation of our fleet, and an upgrading of our grid management.

The EROI for most biofuels is far lower than for oil. While the EROEI is difficult to estimate, it is an important indicator of how viable a fuel is within society:

Biodiesel-1-3:1
Coal-1:1-10:1
Ethanol-1.2:1

¹ Skrebowski, C. Over a million barrels lost per day due to depletion. *Petroleum Review*, Aug. 2003

² World Energy Outlook 2008, IEA.

NaturalGas-1:1to10:1
 Hydropower-10:1
 Hydrogen-0.5:1
 Nuclear-4:1
 Oil-1:1to100:1
 OilSands-2:1
 SolarPV-1:1to10:1
 Wind - 3:1 to 20:1

If an EROEI is less than 1, it is an energy sink, this is the case for hydrogen, which is not an energy source but an energy carrier. A source with an EROEI=5, means it takes 1 unit of energy invested in production to give a net surplus of 4 ($5 = (4+1)/1$). In understanding why an energy source with EROEI greater than 1 may not be a sufficient replacement for oil say with a high EROEI, we must make a distinction between what might be locally viable, but is not so for society as a whole (the same distinction we made with the re-bound effect).

Societies evolved and became more complex as increasing energy surpluses were available to society to do other things such as make more goods, invest in bureaucracy, and civilised culture. However the lower the EROEI, the smaller the surplus, and the less there is for society. This can be demonstrated in figure:7. It shows the total energy availability of energy in society and how this is split between energy used in extracting and processing the energy source, and how much is available to the rest of society. As can be seen, as the EROEI falls below about 8, the energy returns to society begin to plummet. What this means is that as EROEI drops, more and more of our total energy use would have to go on just obtaining the energy.

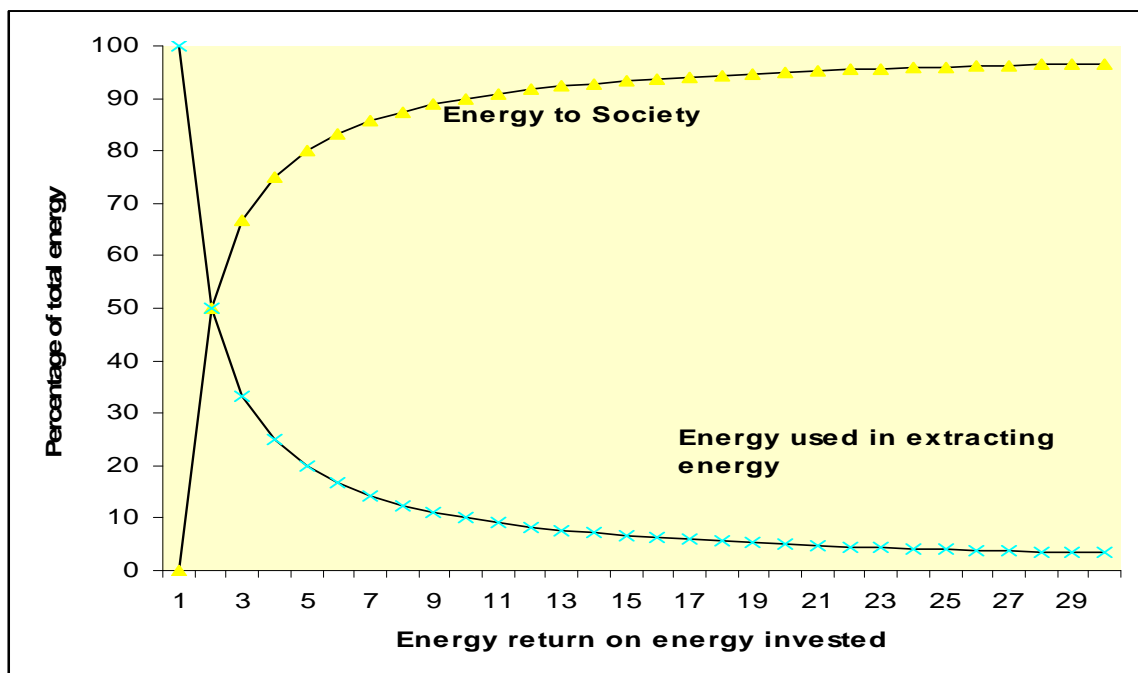


Figure: 7 The division between the energy available to society, and used to extract energy as a function of EROEI

From this graph, and using the figures quoted above, one can see why biodiesel, ethanol, and tar sands are not a replacement for oil with its high quality and EROEI. These criticisms are in addition

to the impact of biofuels on food production, water, and biodiversity.

b) Resources & Time

To bring a new technology to market and deploy it requires research and development, the building and scaling up of new factories. All of this requires energy and materials. Energy price rises will impact deployment cost on renewable energy. This also takes time. The four year lag in delivery of wind turbines is a case in point.

c) Economics & Finance

Large scale energy infrastructure investment requires the ability to raise capital over the long term. This generally means the debt financing has to be obtainable, and the future enterprise risks are understood and manageable. We shall see in the next chapter that these conditions will not be met in a declining economy driven by energy decline. Indeed the current financial crisis is already causing a retraction in project development.

2.5 Food

We will consider food because is a critical life support system in itself; but also to highlight how many seemingly distinct issues such as soil quality, water availability, biodiversity, human behaviour, deforestation, energy, and climate change, are deeply tied to each-others fate. Humanities myriad interactions with them, and they between each-other, are becoming increasingly strained as the stability of the networks ecological base is further undermined. Each year as our demands upon it increase, our economy and way of life struggle with increasing difficulty (declining marginal returns) to maintain stability. One frontline of that struggle is food.

To understand why food security is of such importance one needs to step back and explore some of the origins of the agricultural revolution, and its critical dependence on unsustainable systems.

Between 1900 and today, the gap in productivity between the least and most productive agriculture ranged from ten quintals per agricultural worker to a hundred, a ratio of 1 to 10. Today that ratio is about 1 to 1000.¹ This massive increase in productivity became known as the agricultural revolution. It enabled the global population to increase from 1.6 billion in 1900 to nearly 7 billion people today. It also meant that for the first time ever a large majority of Europeans have never

¹ Mazoyer, M, Roundart, L. 2006. *A History of World Agriculture*. Earthscan.

experienced food shortages. All this was achieved while food prices dropped in real terms, so even the poor in developed countries could afford regular meat.

The agricultural revolution has been credited to new plant and animal breeding technologies, but most was due to the marshalling of fossil fuel energy to satisfy our most basic need, food. Natural gas is the feedstock of fertilizer (accounting for a third of agricultural energy consumption and supporting 40% of world food protein production¹ and oil is the feedstock of herbicides and pesticides. Oil supports the use of farm machinery and irrigation pumps, the operation of animal facilities, food storage and transportation.

The secondary effects of this revolution were profound. Increased productivity meant that agricultural labourers, who once made up 40%-60% of the working population, left the land and moved to cities, driving urbanization and releasing the productive forces that drove industrialization. Land that formerly supported working horses and oxen was released for food production as farms became larger and mechanized. It has supported a globalization of food production and distribution that is highly efficient but utterly dependent upon liquid fuel.

Since the 1970s the marginal returns in agricultural productivity by investments in machinery, pesticides, and new crop varieties, etc. have been declining. This is due to reaching more rigid biological and photosynthetic limits; and the increasing investment required to militate against the damage and disturbance modern agriculture embodies. For example 10% of energy in US agriculture is used to off-set the effects of erosion, partially caused by mechanization; and increasing pesticide use is required to fight against pests developing resistance. Ultimately these are expressions of thermodynamic limits being reached.

The supply-demand balance, and food access and distribution are the kernel of human food security.

Demand-Side Drivers

Population: As population rises, demand for food grows. The current global population is 6.56 billion, by 2050 the UN expects it to rise to 9 billion (a 37% rise).

Diet: As societies grow richer, their diets tend to move up the food pyramid, to more energy, land, and water intensive food production. Lester Brown has calculated that if everybody on earth ate at a US level, the world would, with current harvests support 2.5 billion people (calculated using grain equivalents); an Italian level of consumption would support 5 billion people; at Indian levels of consumption, 10 billion people.²

Supply-Side Drivers

Soil: Globally the stock of food producing soil has been declining due to increasing salinity, desertification, loss of land to the built environment and nutrient loss.³ Carbon loss due to deep tilling has had the additional effect of contributing large

¹ Lucas, C, Jones, A, Hines, C. 2006. *Fueling a Food Crisis*. The Greens/ European Free Alliance.

² Ref: Brown, L. 2006. Plan B2.0. Norton.

³ Ref: Goudie, A. 2006. *The Human Impact on the Natural Environment*. Blackwell Publishing.

emissions of GHGs. The amount of reclaimed land has been a much smaller fraction of land loss. Deforestation, particularly in South America and South-East Asia has released land previously unavailable for food production, but at the cost of increasing GHG emissions and loss of biodiversity.

The expansion of crop yields has reached its natural limitations with declining marginal returns on investment (a directly comparable process to declining EROI in energy used earlier). As yet the effects of genetically modified crops are not established, and may in certain circumstances be helpful. However, side-effects of GM, such as loss of biodiversity, or increased need for water, or fertilisers will tend to displace these problems.

Water: It takes 1,000 litres of water to grow a kilo of wheat; between 2,000 and 5,000 litres of water to grow one kilo of rice; 5,000 litres for a kilo of cheddar cheese; and 11,000 litres to grow enough feed for enough cow to make a quarter-pound hamburger.¹ The human impact on water sources and courses has become more critical as demand rises, quality declines, and the unsustainable depletion of aquifers continues. Growing regional conflict over water resources is increasing, reflecting the current pressure on an increasingly scarce resource.

Fishing: More fish are now being commercially farmed, deflecting some of the pressure of increased fish consumption away from non-farmed stocks. The state of the world's fish stock remains unchanged for the last fifteen years: 52% of stocks fully exploited; 20% moderately exploited; 17% over exploited; 7% depleted; 3% underexploited; and 1% recovering from depletion.² However, climate change is expected to put considerable strain on fish stocks due to rising sea temperatures, and the loss of breeding sites such as coral reefs.³ The ability to significantly increase farmed stock will be limited by energy, water, and other environmental concerns. The conclusion therefore is that total food produced from fisheries and aquaculture is likely to decline over time, unless substantial action is taken on several fronts, especially climate change and fisheries management.

Climate Change: Climate change is expected to have a complex and non-linear relationship to food production, directly and indirectly via its effect on soil, biodiversity, and water. In addition, deforestation for food production or biofuels will provide a positive feedback to climate change. In some parts of the world, yields are expected to rise, in other parts, fall. The net effect according to the IPPC could be a modest rise in agricultural productivity below a 3C rise in average global temperature, and a fall thereafter. However, flooding and droughts would have a negative impact on this.⁴

In a recent report from the International Food Policy Research Institute analysis on the interaction of food security and climate change indicated that global food production could decline by 16% by 2020. This is a rapid production drop in a comparatively short period, in a context of increasing demand for food.

¹ Ref: Pearce, F. 2006. *When the Rivers Run Dry*. Eden Project Books.

² Ref: State of the Worlds Fisheries and Aquiculture. 2006. FAO.

³ Ref: IPCC 4th Assessment: Impacts, Adaptation and Vulnerability. 2007.

⁴ Ref: IPCC 4th Assessment: Impacts, Adaptation and Vulnerability. 2007.

In Ireland, climate change will certainly bring further risks as rainfall reduces in the East and South in the summer months while the West may suffer flooding along coast rivers and hillsides in the winter. New pests and diseases will inevitably follow warmer weather. Irrigation may become necessary to ensure reliable crops such as for the potato in the East. Extraction of water resources for urban use i.e. Lough Derg to serve Dublin's consumption, will not be tenable in these conditions. Storms may damage crops before harvesting on a more frequent basis. All of these factors coming together promise higher food prices for farmers and new pressure to bring good agricultural land into full productive use.

Biofuels: Biofuel production has recently become a direct competitor for agricultural land. Its development has been driven by climate change concerns and the rising oil prices. Increasing biofuel production has already affected food prices. Tyson, the world's largest protein producer has warned that higher grain prices were pushing up the cost of beef and chicken.¹ It has played a part (along with drought in Australia) in reducing wheat stocks to the lowest level in 25 years.² The growing displacement of grain for biofuels in the US doubled the cost of tortilla in Mexico in 2007, leading to riots. These concerns were amplified by the UN Energy report warning of possible major detrimental impacts on food security by bio-energy.³ Biofuel production, productivity, distribution, and economics are all dependent upon fossil fuel derived inputs and thus vulnerable to oil and gas price rises. The result is that post-peak, many of the targets for biofuel production in Europe may come under new pressures.

Oil has such a central role in the functioning of modern economies that scarcity causing very high oil prices could drive a major expansion of biofuels, effectively converting dwindling food production capacity in an attempt to prolong an increasingly strained but unsustainable way of life. Quite apart from the questionable morality of this course, the obvious tensions thus created between the wealthy and the rest could cause massive social unrest.

Plastics: Chemical plants consume about 10% of global oil supply, and about the same again in natural gas. The oil is used as feedstock that supports a vast array of products, including; plastics, detergents, computers, DVDs, paints, dyes, food-colouring, and perfume. Plant-derived carbohydrates could replace oil in this context, however it is estimated that it would take 27% of the combined US harvest of maize, soya and wheat to replace current US plastics production. Moreover, this assumes current production technologies, mechanization and fertilizer, all of which would be expected to be scarce and expensive in such a context.

Fossil fuels: It has been estimated that ten calories of fossil energy is required to give us one calorie of food energy. Energy investment in the whole food production process is so ubiquitous that only certain aspects will be highlighted.

Nitrogen fertilizer formed by the Haber-Bosch process uses hydrogen to capture atmospheric nitrogen and make ammonia. The hydrogen to make this comes from

¹ 'Tyson chief cautions on impact of rise in grain prices', Financial Times, 14 November 2006.

² 'World wheat stocks at lowest level for more than 25 years', Financial Times 13 October 2006.

³ UN Energy: Sustainable Bio-energy: A Framework for Decision-makers. May 2007.

natural gas. Hydrogen could of course be produced from coal, or electrolyzing water, but at a huge energy cost, and in the case of coal, massive GHG emissions. The utility of nitrogen fertilizer is clear, allowing crop yields to double and triple. It has been estimated that without nitrogen fertilizer no more than 48% of today's population could be fed at a generally inadequate per capita level of the year 1900.¹

Irrigation is used on only 17% of the world's cropland, but that land produces 40% of the world's food. Irrigation is very energy intensive, for example, it consumes 10-11 billion litres of diesel per year on the Indian subcontinent. "Energy costs are a life-and-death issue for small farmers in South Asia" according to Tushaar Shah, a scientist with the International Water Management Institute.²

Ireland cannot assume it is immune to food shocks. Globalised food production, distribution, and delivery have largely de-nationalised control of food. It is dependant upon energy and an intergated financial system. This was amply demonstrated during the fuel depot blockades in the UK in 2000, when supermarkets emptied and the Home Secretary Jack Straw accused the blockaders of "*threatening the lives of others and trying to put the whole of our economy and society at risk*".³ Thus it is important that we assess food reserves within the country at any one time or season.

¹ Ref: based on Simil, V. 1999. Long-Range Perspectives on Inorganic Fertilizers in Global Agriculture. International Fertilizer Development Centre.

² Ref: quoted in Strahan, D. 2007. The Last Oil Shock. John Murray Pub.

³ Source: BBC News. 4 November 2000.

Chapter 3

De-growth

We have discussed the links between the environment, particularly energy, and economic growth. In addition we highlighted some of the deep connections between our way of life and growth. If, as we expect, the global economy is about to experience a forced reduction in high quality, low cost fossil fuel inputs, the consequences for the economy and society will be severe. This chapter outlines some of what might be anticipated:

- The current financial crisis may be the context in which peak energy evolves.
- The main issue is not higher oil prices, but that reduced energy flows will cause a depression.
- The collapse of the global financial and monetary system could be rapid and cause profound problems for our way of life.

3.1 From the financial Crisis to the End of Growth

The current financial crisis was initiated by a bubble in the credit markets, supported by cheap money, financial innovation, and the perennial desire of people to make money while the going was good. Jeff Rubin, Chief Economist of CIBC World Markets notes that the Euro zone and Japan appeared already to be going into recession before the credit crisis hit the markets, and that had been prompted by the unprecedented rise in oil prices. He noted that four out of the last five recessions followed an oil price spike.

Past Recessions and Oil Spikes

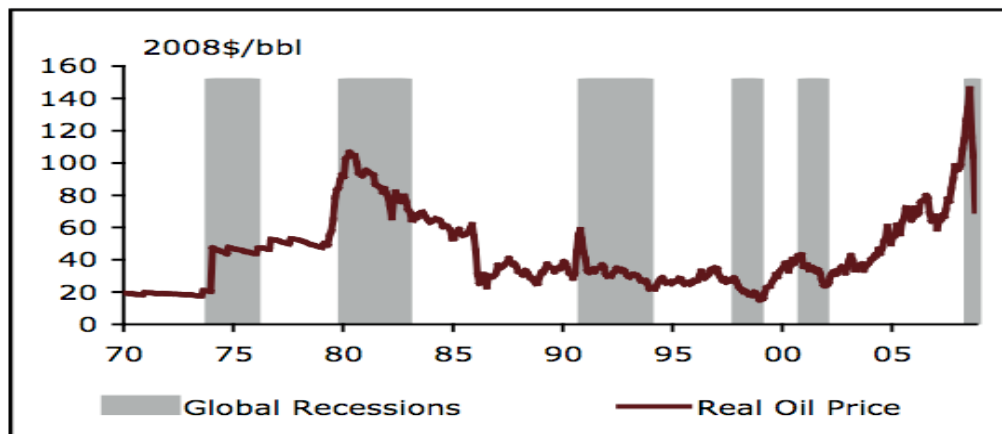


Figure 8: Four out of five last recessions followed oil price spikes. Source CIBC World Markets

When the price of oil was at \$135 per barrel, the US was spending the equivalent of 1\$ Trillion per annum for oil which is equivalent to 15% of the take-home pay for all taxpayers, nor does this percentage account for the indirect rises associated with food, and natural gas price rises. This hit discretionary consumption and put pressure on a person's ability to service loans, so pricking the credit bubble. The second element of the rise in oil prices was that money flowed out of the hands of people who spent everything they had on goods and services, and into the hands of savers in the oil rich countries. And even if the savings were recycled through Wall St, they leaked out of general consumption, so hitting GDP.

A similar argument can be made for Ireland, though the context is somewhat different. While government borrowing dropped considerably in the last decade, public borrowing soared. The result is that Ireland is now the most indebted country (along with Luxemburg) in the EU with a debt/GDP ratio of over 250%. We have entered a deflationary spiral like we discussed in the first chapter.

We can make a number of points regarding the current crisis, both as pointers to the future, and as a way of assessing our resilience at the onset of peak oil.

1. *Speed & Interconnectedness*

The rapid globalisation of the crisis demonstrated how intertwined our economies and financial systems were, and how quickly 'disturbances' in one part of the network propagated to other parts.

2. *Lack of preparation*

In spite of warnings of growing unsustainable debts, the risks of complex derivative instruments, and increasing warnings of a peak in global oil production, virtually no government had attempted to engage seriously with the risks beforehand.

3. *Freezing of the Banking System*

This is causing problems for many sectors. Local businesses cannot get temporary finance on which many rely. International shipping is in crisis as exporters are not sure importers will be able to pay them and banks are reluctant to issue Letters of Credit guaranteeing payment as they do not trust the counter-party bank.

4. *Credit & Debt*

Project financing through debt has become more and more difficult and expensive to obtain as banks hoard cash and rebuild their balance sheets. Governments are borrowing, with the expectation of future growth, though the costs and risks are rising (the cost of insuring Irish

government debt against default rose almost five times following the decision to guarantee the banks).

5. *Asset Volatility*

The large fluctuation in the values of currencies, the rapid fall in the price of energy, huge and rapid increases in the cost of debt, and dramatic falls in equity markets and property have made the investment climate very difficult and uncertain.

6. *Energy Investment (fossil fuels)*

The International Energy Agency has warned that the financial crisis was leading to a fall in investments, cancellations, and postponements in energy development projects. This has been driven by falling energy prices, and an inability to access debt at affordable prices.

7. *Energy Investment (renewables)*

The development of renewable infrastructure has come under serious pressure, both for the reasons mentioned in 6 above, but also because governments who were incentivising renewable energy are both pulling back on their climate commitments and their support budgets are coming under strain.

8. *Climate Change*

Climate change policy has moved down the agenda as people give precedence to current concerns. This is resulting in some governments pulling back on, or trying to water-down agreements.

9. *Energy Use*

Lower economic activity is causing lower growth, and maybe even a reduction in energy use according to the IEA.

10. *Political & Institutional Uncertainty*

The speed and complexity of the situation has become highly problematic for those expected to manage, this has become more and more publicly apparent, reducing governments capacity to instil confidence.

The declines in expected investment into oil exploration and production (bring peak forward), and the effect of the economic recession on energy consumption (pushing out peak) should not obscure the fact that we are on its cusp.

3.2 The Economy and Energy

The interlinkages between economic growth and energy prices is likely to mean that we will not notice when we have passed the physical peak of global oil production, but rather a point will come when the ability of our economy to continue to grow will be choked off by energy price rises, leading to a further depression, and so on. We may have a cycling between smaller spurts of growth and higher energy prices followed by deeper depressions and falling energy prices, until growth falls away to ongoing depression.

As the peak of global oil production is felt, quoting the price of oil may obscure the changed context of what such a price might mean. The facilitators of economics and trade, such as liquid cash, credit, bonds, and equities, currency exchange; and the institutional structures such as banks, markets and infrastructure will become increasingly insecure and volatile. Indeed GDP may lose a lot of its established meaning. In such a context, price might be more meaningfully measured in relation to an asset of direct use. The foundational assets might be energy or food, but could conceivably be the right to emit carbon. As food and energy are likely to be scarce, but are essential for human welfare, we might refer to the price of energy in relation to asset production base.

Rising oil prices, will lead to increasing energy prices in general. More and more of personal

income will go to pay for energy and food, and declining discretionary income will lead to business failure and growing unemployment. Businesses will close, but it will be harder for large-scale new businesses to form as there will be little credit and debt available, and international trade for both imports and exports will be more difficult.

Financial and trade risks will tend to favour smaller businesses with low capital costs, especially ones that service new markets such as repair and re-servicing; energy and food production.

3.3 Debt and Deflation

This current economic period will morph continuously into the next, there may be a recovery from the current recession, but is unlikely to last long. Our financial system is very efficient, very fast moving, but vulnerable to systemic risks, particularly ones which undermine the foundations of the whole market, especially confidence in future economic growth. The speed of a collapse could be rapid, though its precise timing may be impossible to predict.

The main architecture of our economic system will come under increasing stress. As economies cannot maintain growth, our claims on the future of economic growth in the form of debt will become unpayable. Losses on government bonds, corporate and household debt will grow. Banks will be unable to lend, as bad debts eat into their capital, which itself becomes uncertain and their customers' economic future becomes more risky and insecure. The unwinding of debt will mean:

- A deflationary spiral within currencies.
- A growing number of sovereign defaults and a collapse of the bond market.
- Governments will not be able to reflate through debt.
- Growing defaults of personal and corporate debt.
- Growing number of bank insolvencies.
- An inability to access credit.
- Collapse of the long-term debt financing market.
- Exchange rates becoming volatile and opaque.
- Increase in risks of hyperinflation.

International Trade & Balance of Payments

While the costs of international trade may increase, the principle problems are not direct but indirect. The collapse on much of the financial system will mean that exporters and importers will have increasing problems securing payment and credit. Even if payment is secured, the unit of account such as the dollar or euro may seem to be increasingly risky.

Because supply chains have become so complex, involving many country-to-country exchanges, each element of the supply chain will have increasing international financial risks. In addition each business within a country will come under increasing national financial risks. A large number of new risks' factors discussed above and below will increase enterprise risk. And because our current system relies on tightly-coupled networks and just-in-time delivery, a small system problem may lead to cascading failure of whole supply chains.

The most vulnerable goods and services are the ones that are most complex; they have complex supply chains that are highly optimised; they have limited replacement companies for key components (because they are very complex, proprietary technology, high value, small throughput). This includes our food production and distribution system and some of our technology infrastructure.

The possibility of governments running current account deficits based upon debt will become increasingly difficult. As general imports and exports drop due to the demand destruction, the key traded goods are likely to be energy and energy infrastructure, food, and critical infrastructure and basic needs supports. For countries unable to export these sorts of good and services in high enough volume, they could face an inability to pay for important imports. The result could mean energy or food shocks, as well as various types of system failure.

3.4 Second-Round Effects

Social Risks

People have been used to gradually increasing prosperity for many decades. The rise in unemployment, declining government revenues, the increasing relative cost of basic goods, the collapse in savings and pensions, and critical supply shocks to energy or food, could create the conditions for major social shocks.

Public Spending

Declining government revenues, an inability to access debt financing (bonds), and the likely collapse of the national pension reserve and private pension schemes will radically constrain public spending. Furthermore the fundamental uncertainties and volatility will further hinder long-term investment.

Geopolitical Risks

The recently published "Global Trends-2025" by the US National Intelligence Council highlights their view of the increasing risks arising from the competition for increasingly scarce resources (naming energy, food, and water) and the effects of climate change.¹ It is a general feature of human societies that one of the prime reasons for conflict is competition for resources. While cohesion and co-operation within groups may develop, other forms of co-operation between groups may become increasingly difficult to maintain.

It may happen that key resources, in particular energy and food may become more tied up in country-to-country contracts, so reducing open market supplies further. Some of this has begun to happen already. The European Union's attempt to maintain a common front in negotiations for Russian natural gas has proved impossible as some member countries have placed national energy security concerns first. In a similar manner China, Japan and South Korea have been buying up large areas of productive land in Africa and South-East Asia to enhance food security. Ireland, at the end of a gas pipeline should be conscious that in the event of major shortages, those ahead of us in the queue will understandably give precedence to their own national populations.

Government Planning

Abundant energy supplies, the self-organising nature of growing liberal economies, have probably given governments and their populations an over-confident view of the amount of control they actually have over future events.

It was mentioned that our complex civilisation is highly organised and structured, this is a feature of its low entropy, enabled by increasing energy inputs. As energy leaves the system, there will be growing disorganisation and loss of structure. This theoretical argument points to increased

¹ www.dni.gov/nic/NIC_home.html

uncertainty about what is happening and what the future holds as previously understood reference points become unstuck. This is a fundamental uncertainty rather than one that can be rectified by better knowledge.

The financial and economic models used to support policy that were crafted out of data and ideas that evolved in periods of economic growth and financial stability, are likely to break down. Thus, we should be wary of using such models as a basis of policy making.

Network Risks

Network risks are all those risks that arise from stresses in the tightly coupled and complex networks which surround or modern civilisation. It includes many of the risks already referred to. Of particular concern are break-downs in our food distribution networks. There is only 2-3 days food readily available in Ireland, to do the hyper-efficiency of the food production/storage/just-in-time delivery chain. A break-down in this chain for only a few days could have very serious consequences.

Much of the inter-related connections and common energy platforms between our telecommunications, IT, banking system are vulnerable to systemic shocks. These are particular risks that will grow as high cost components, with short life-spans become either too expensive to replace, or supply chains become more vulnerable.

Discounting

Many decisions taken by individuals, governments, companies, and international organisations involve making decisions that compare costs and benefits now with costs and benefits some time in the future. The questions discounting asks would include how much we might be prepared to pay now for a carbon capture and storage given that the benefit will not accrue, in climate change damage avoided for years to come. Most discounting models recognise that we tend to favour present benefits over future ones and that economic growth will mean we will be richer in future so that we will be better able to manage future expenses.¹ The discount rate is a measure of how much we are willing to pay now for a particular benefit as time goes on. A higher discount rate means we value the present and near present benefit more and the future benefits less.

Of particular interest in this section is the behavioural aspect.² We saw in chapter two that our evolutionary past bequeathed to us a preference for the short-term, most people would rather €100 now than €120 next year. One aspect that has been noticed is that as economic difficulties increase and we are in danger of losing benefits we had assumed, our discount rate rises, meaning we tend to favour present benefits even more. At its extreme, we have the example of a family in crisis, cutting down its apple tree for fuel knowing that the next year without apples to sell or a tree for fuel, they will be in even worse straits.

Figure:9 shows a model of actual oil production, what it would need to be for the continuation of economic growth (the Business As Usual case), and the net energy available to society (due to declining EROEI). As the amount of net energy declined, society would have less energy per annum to 'spend'. As the decline progressed, more and more essential energy embodied goods and services would become impossible to support. Let us say the government and society have to decide how to spend that net energy. Some could go on current spending, and some invested for future benefits. The future benefits might be an off-shore wind array, with a large up-front energy cost, and a future energy return spread over many years into the future. The discount rate would be the behavioural

¹ Stern, N. 2007. *The Economics of Climate Change*. Cambridge University Press.

² Streich, P; Levy, J. 2006. *Time Horizons, Discounting, and Intertemporal Choice*. International Studies Association.

aspect of how much of the net energy we invest. From what we understand of discount rates, as economic constraints grow, it would be more and more difficult to invest.

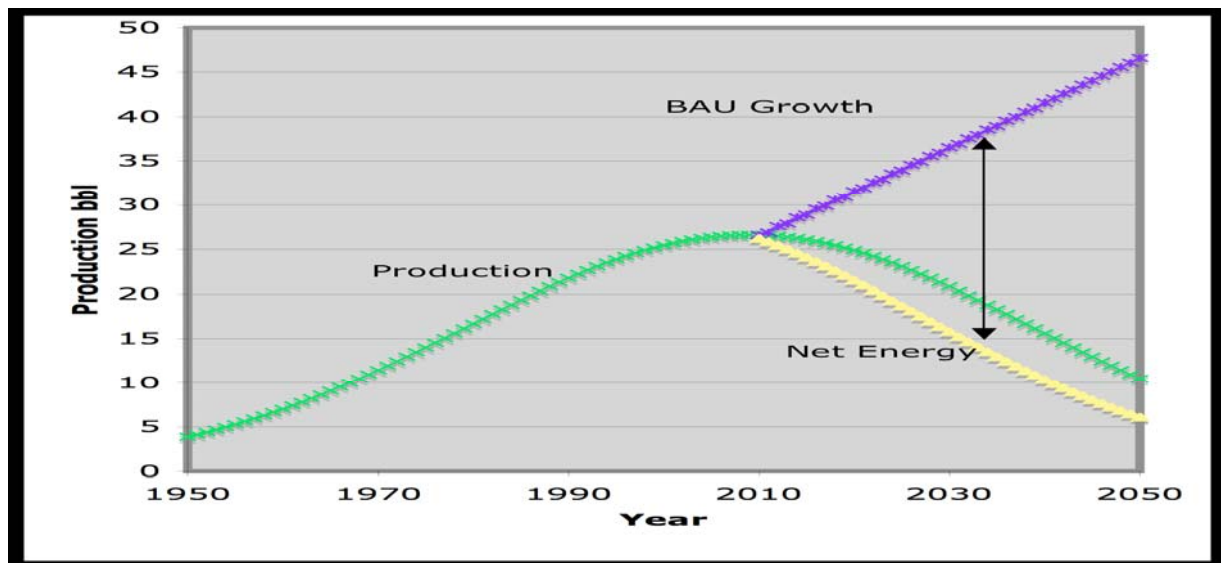


Figure:9 A model of peak oil production, showing the business as usual case, and the net energy available to society.

3.5 Decline as Positive Feedback

As our energy supply declines, and the gap between BAU requirements and net energy widens it will become more difficult to manage the process. Less net energy, growing economic damage, network risks and failing infrastructure will mean our ability to adapt will become more and more difficult. Investing in the future will also grow for the reasons mentioned. This is a positive feedback that will reinforce decline.

3.6 Climate Change in Context

It has been sometimes said that we need a crisis to begin to take our climate and energy issues seriously. What we have seen so far is that by the time a crisis arrives, we will be losing much of our capacity to do very much about it, at least in terms of conventional measures.

The first question might be "will the peak and decline in oil and gas supply reduce our CO₂ emission enough to reduce significantly the risks of climate change. If we convert the total oil/coal/gas production profile in chapter 2, we find that the emissions reductions from fossil fuels amount to only a 40% reduction on 1990 levels. It should be noted that we may not consume fossil fuels at maximum production as the graph assumes, economic damage to society may at times be so great most industrial activity stops, even though more production might be possible at the time. Many established organisations are suggesting we need an 80-90% cut, and James Hanson has argued for net carbon sequestration to bring back CO₂ levels to 350ppm by 2050. In spite of the rough estimate below, it is clear that peak energy will not solve the climate crisis.

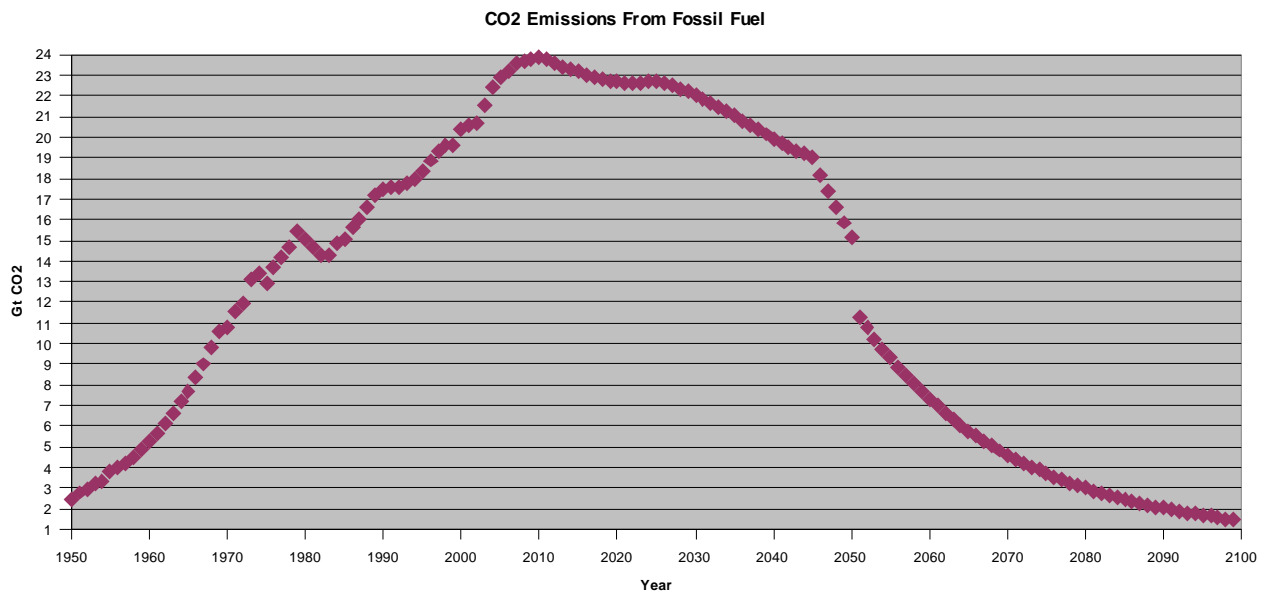


Figure:10 Estimate of fossil fuel emissions derived from the data in figure:5.

Adaptation

Adapting to the effects of climate change will impose a cost (in energy or finance terms) upon society in terms of reinforcing coastal defences, managing flooding risk, and dealing with the effects upon the state arising from climate risks elsewhere. However our economy will be increasingly unable to pay those costs as our economies are undermined by energy withdrawal and its consequences.

The ability to insure against risks will become more and more difficult as the financial markets, where insurance companies manage their assets, collapses. New forms of insurance backing can be developed but they are likely to have a much smaller capital base.

As many of our most vital defences are environmental services which are not properly internalised within the economy now, for example, coastal wetlands, flood plains, and biodiversity, their relative value now should be much higher as in the future we will not have the wealth to substitute for them with man-made capital.

Mitigation

Putting in a renewable energy infrastructure will become more and more difficult for many of the reasons discussed already in this chapter. Debt financing and volatility will make long term investments more difficult. Declining government revenues will make it more difficult to incentivise or support adoption. Huge demand on limited production capacity will continue.

Declining discount rates may push climate change action down the list of important issues. A less fossil fuel intensive agriculture, which is needed for food security could help reduce agricultural emissions.

Carbon trading schemes could be vulnerable to collapse if emissions fall below the cap because of depression.

Globally, the impact of the energy and food crisis could be so severe that the vast forests of Brazil or Indonesia could experience a rush of deforestation with potentially catastrophic consequences.

Chapter 4

Framing Policy for De-growth

We are trapped within growth economics. As our current economic crisis deepens, the strategies to manage it, through a 'new green deal' for example, all involve further debt, and the provision of such debt is itself a statement of faith in the resumption of economic growth. Yet we have seen that such growth cannot continue if our economies energy base is undermined by peak oil, natural gas supply risks, and peak gas. The result of such an energy withdrawal will profoundly effect food production, our financial and economic system, with follow-on consequences for the complex networks that support our modern civilisation.

There is little chance that we can adapt our current system to perform a 'managed degrowth', if such a proposition was ever possible (due to the complexity of such a transition, short-termism, growth momentum, and the political risks for any government), it is too late now. Our civilisation will crash against the earth's resource limitations, the reverberations and feedbacks will bring in a period of serious multi-faceted strife. Even the best preparation now will not mean we avoid the coming crisis, at best it will limit the most severe risks.

The framing question is 'what can we do now, to prepare for that future?'

It has been argued in this report that the easiest time to put in new resilient infrastructure is now, when there is still a relatively well functioning economy. So might this be a moment to cry 'peak energy, crisis at hand, prepare!' But such a cry, were it widely taken up and acknowledged by governments, markets, and individuals, would be likely to precipitate an economic crisis.

In November 2008 Robert Hirsch, the author of the seminal 2005 report "The Peaking of Global Oil Production" for the US Energy Department, and joint author of the Forfas commissioned report for the Irish government, urged 'the peak oil community' in a memo that it "minimize its effort to awaken the world to the near-term dangers of world oil supply". His rationale was "if the realization of peak oil along with its disastrous financial implications were added into the existing mix of troubles, the added trauma could be unthinkable".

Such considerations pose moral and political dilemmas. In the national interest it might be wise to have a serious and activist peak oil policy, without it appearing as such, and so reap the benefits of a still functioning economic system, and first mover advantage. However, having such a policy would also mean borrowing for renewable energy infrastructure say, while knowing that the accumulated debt will eventually be defaulted upon. It would require government to talk from both sides of its mouth on a range of issues.

4.1 Risk and Resilience

Debates on climate change and peak oil have had a tendency to get bogged down in absolutist positions ('I'm right, you're wrong'), thus hindering any action being taken. A more appropriate conceptual model is risk management, which can mandate risk management even allowing for differences in points of view.

Risk management is in this case the application of conceptual and analytic tools to manage current capital expenditure (economic, human, natural) to maximise future benefit and minimise costs. We will consider a broad general definition of risk that incorporates climate change, economic collapse and food shortages. Risk itself can be decomposed into *Hazard*, *Exposure*, and *Vulnerability*. Hazards are not disasters or calamities in themselves (a hurricane on a desert island does not trigger a disaster if there is no property or population), it is a probability distribution of an event happening. Exposure is a measure of that which is exposed to the hazard such as people and property. Vulnerability is defined as the condition resulting from physical, social, economic, and environmental factors which increases the susceptibility of a community to a hazard.¹ Risk is then the expectation value of losses that would be caused by a hazard:

Risk = function (hazard, exposure, vulnerability) = function (hazard, exposure, 1/resilience)

Resilience is a measure of our ability to adapt to, and recover from exposure to a hazard, and is thus the positive mirror of vulnerability. Opportunity can be put in a similar structure (positive risks)

We can give an example applied to peak oil. Figure:11 shows a collection of different estimates regarding the timing of peak oil put together by the Association for the Study of Peak Oil (ASPO). Those who are sceptical about peak oil might say 'well, there is a range of views, Odell says it will happen after 2060, let's wait until the jury is in before doing anything radical'.

¹ Ref: Chapman, D. 1994. *Natural Hazards*, OUP.



Figure:11 A series of estimates for the peaking of global oil production compiled by ASPO.

Rather than pick our favourite estimates (and few people have the knowledge to compare and contrast between them), we can write a probability distribution combining all the above estimates by assuming all are equally likely to be right, and that there is a 95% probability that one of them is right. This is shown below in figure:12. This is our hazard in the risk management model. Our exposure is vast as we have argued in this paper. The combination is the risk which is very high, and growing each year. The argument is therefore because there is a huge risk, it must be managed. It is not an either/or question. Not to manage it becomes not a failure of one's choice of expert, but a failure to risk manage, and is thus negligent. Our framing policy is then (because we cannot change the exposure or hazard meaningfully) to develop resilience, or reduce vulnerability.

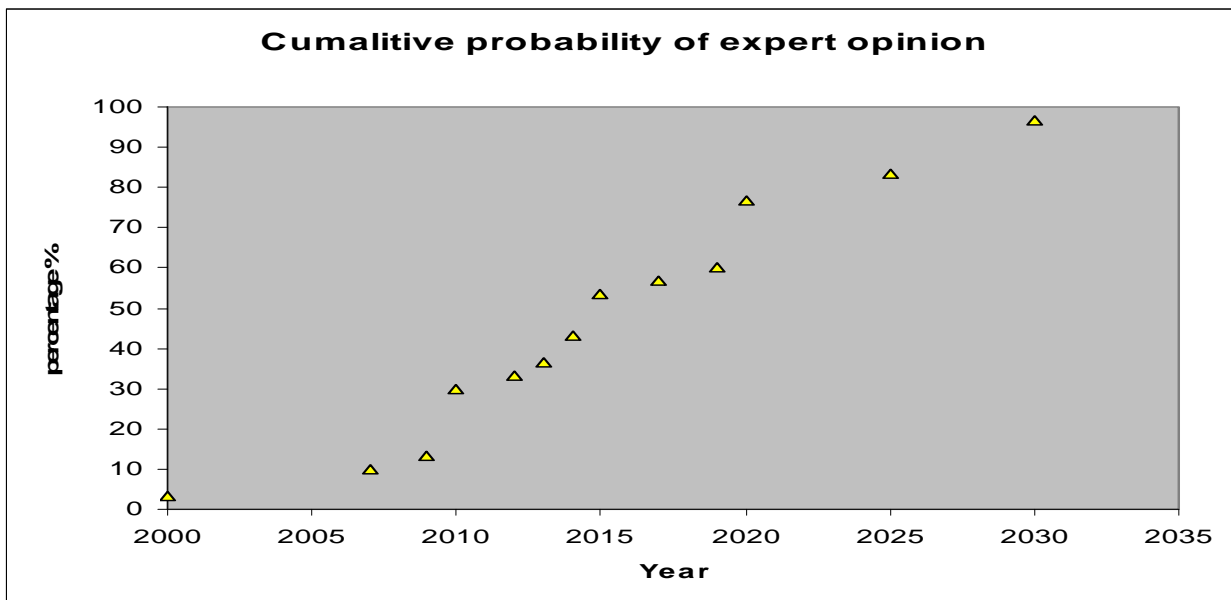


Figure:12 The probability, based upon all expert opinion, that we will have passed a peak in global oil production at any year. Derived from figure:11.

Our current practices are not only self-deluding but are exacerbating the risks- effectively giving

them a value of zero when committing resources. Risks are exacerbated by increasing vulnerability through *mal-adaption*, *opportunity cost*, or *time penalties*. Mal-adaption occurs when we invest in projects on the assumption that the serious risks listed above have a zero or very low value such that those investments add to vulnerability should the risks materialise. For example, much of our recent spatial and planning development has been predicated upon cheap oil and credit. People are now living long distances from places of work, education, and services. Very high oil prices, or resulting economic effects will leave mortgage indebted home-owners with little scope to adapt.

Opportunity costs arise when we invest resources based upon a future with historically understood risks, rather than anticipating the hazards referred to above. For example, building a motorway based upon a cost-benefit analysis that envisions increasing car use (in concert with economic growth) and not accounting for the rising costs of peak oil, may waste massive resources that would be better employed if risks had been anticipated more widely; in this example, by building a low impact rail network, or preserving the land for food production.

Time penalties arise when we are not a front-runner in anticipating and acting upon our awareness of ecosystem risks. Global acknowledgement and willingness to take real action is likely to begin slowly, then accelerate as the hazards and the extent of the risks become clearer. As many of the risks are global, mitigation and adaptation strategies will result in global runs upon key resources, driving up prices in materials and technologies that may never keep up with demand. An example is renewable energy. Solar photo-voltaic cells are energy intensive, and require specialised rare-earth metals. In addition production capacity is limited, as is the ability to ramp-up new production facilities. In addition while 'resource nationalism' is largely associated with oil and gas producers, renewable infrastructure manufacture may come under the same pressure as countries understand the extent of the risks, and move to prioritise their national interest by restricting export.

The first step in building resilience is localisation. Localisation of goods and services reduces many of the network risks discussed; it enhances local economies and employment; and makes cascading shocks to critical goods and services less damaging.

4.2 Hierarchy of Requirements

Because the risks are systemic, we must assume much of our way of life is vulnerable. To aid understanding we can distinguish between short-term shocks such as disruptions to food stocks in the country, oil or gas shortages, credit collapse, or IT systems failure; and evolving constraints such as unemployment, declining government revenues, and declining fossil fuel inputs to agriculture.

In order to assess these challenges we might prioritise those things in our society that are most important, and where our limited resources are best spent. Because the provision of such services have been assumed and uncontested, it is often difficult to know where the risks lie. An example of failure to properly understand such risks is the recent publication delivered to every home in the country from the Office of Emergency Planning asking the public, in the event of a pandemic, to buy at least a week's supply of food. However there is no more than about 3 days supply of food accessible in our system, and as such a rush for food would favour people with personal transport and enough cash to stock up for weeks, many poor would be left facing bare shelves very quickly.

So what is needed is an assessment of what is most important to maintain, where the risks lie, and both emergency and long term strategies to manage those risks. This is a complex problem and one that requires considerable planning. If there is no such planning, the risks to society could be huge, and faith in the ability of government to protect its citizens could be lost.

4.3 Government & Institutions

Demands upon government will grow as their resources decline. The collapse of pensions, growing unemployment, and the management of fraying networks will happen as government income and capacity declines.

Public services will face growing resource constraints. It is probably true that the best way to manage such a decline is not to waste resources fire-fighting evolving failures of unsustainable institutional structures, but re-envisioning a low resource system and investing in its development.

Critical functions will need redundancy built in to them to manage future shocks. For example critical medical supplies (like food distribution, medical supplies depend upon just-in-time delivery) and closed loop power back-up power for sewage works and water pumping.

Waiting for such problems and hoping to manage them on the fly could result in a massive waste in resources, which may not be available again.

4.4 *The Common Purpose & the Purposeful Commons*

The ecosystem challenge we face is unlike anything we have experienced. War could give a sense of common and shared purpose through hard times, partially supported by having a clear enemy and the hope of eventual victory. Severe economic depressions have often been associated with major social unrest as citizens and groups fight over increasingly scarce resources, or fight to preserve their privileges.

Our challenge will evolve over decades ('The Long Emergency'¹ as one author termed it); the energy constraints, climate change impacts, and a host of other risks will grow over time. Our enemy (that is, our own demands upon the planet) will appear diffuse and will not have the definition for a natural rallying cry. And while stronger communities, more free time, and less status anxiety may offer us some psychological benefits; rising insecurities and the difficulties of personal adaption could add great stress.

The strongest framing narratives for the coming crisis, if they are to enhance our collective welfare and society's resilience should be focussed on establishing a sense of common purpose, shared burdens, and transparent processes. However such a vision cannot be maintained if political and social institutions do not manifest those principles in how they operate.

Finally any framing narrative must offer a vision of where we want to move to, one that is hopeful without pandering to false hopes. For this to be believable, there must be a sense of direction, one that demonstrates that options have been considered and good choices made (even if wrong), and actions being taken. For this to happen, we have to think seriously about the future now, to plan and prepare (even if things don't work out as expected). If governments merely react as crises grow and multiply, if they demonstrate no mature understanding or leadership, the political system itself may

¹ Kunstler J H The Long Emergency

be at risk.

Chapter 5

Policy Prior to De-growth

We are close to a period of profound and systemic changes to our way of life, and acknowledging the limitations to preparative action, what can we do now that is supportive of resilience? Some of the problems the country is experiencing now foreshadow future expectations. Among these are deflation, problems accessing short-term credit, and problems accessing finance for investment. We can address some of these issues now in a way that supports localisation, resilience, and is adaptive to future realities.

5.1 Risk Management

The importance of understanding, risk management and planning cannot be underestimated. The number of problems and their complexity is likely to increase, and risks rise. In dealing with matters of such extreme importance, our political system and structural problems within the civil service mean we are at present not up to the task. Resolute leadership is required.

Some of the risks identified are likely to arise unpredictably and within a rapid timeframe, education, risk assessment, policy mapping, and resilience architectures need to begin immediately. This need not be advertised with a fanfare for reasons mentioned, but key individuals and sectors need to be brought on board.

5.2 Asset-Backed Finance for Investment

We have discussed the risks to the instruments in which much of our wealth is stored, namely money, equities, and bonds. Our wealth is most likely to hold its value (relative to actual living costs) if it based upon an asset. By localising that asset, one can reduce many of the geo-political, foreign-exchange, and network risks. By investing locally one is reinforcing local economies, substituting for imported goods and services whose supply will become increasingly insecure, and take pressure off foreign reserves (or physical assets) which may become scarce.

In the Limited Liability Partnership model of asset backed finance the investors contribute finance or other goods and services up front to develop a productive asset. The asset might produce 'x' kWhrs of electricity, 'y' tons of wheat, or 'z' litres of cider. What the investors buy is not a share in the company, the company is owned by a trust or custodian, it has no shareholders to whom it has to return an investment and its role is to ensure the asset is being produced. What the investors do buy is part of the unitised output in the form of a % of the asset produced. The investment is not designed to grow in value in the conventional sense, rather to produce a regular asset 'income'. The unitised shares in output can be traded, but the company itself cannot.

If such a company is not financed by bank debt, its competitiveness is enhanced by not having to repay loans. Because the company does not have to grow in the conventional sense, and the value is in asset production, it will tend to favour long-term forms of asset preservation rather than encouraging management focussing on short-term gains.

The legal structure for asset backed finance is the Limited Liability Partnership; this is not available in Ireland, but it is used in the UK.

5.3 Risk Management of Pensions

The assets upon which the state, through the national pensions reserve fund, companies, and individuals manage their future retirement is through investments dependant upon future economic growth. According to the National Pensions Reserve Fund (NPRF)¹, their target for asset allocation to the end of 2009 is; equities 66%; private equity, property, commodities 20%; and bonds and currency funds 14%. Risk allocation models decide how funds are allocated within these conventional assets, but systemic risk to all such assets is not accounted for. As we have seen, if economic growth cannot be maintained, equities will crash, bonds issuers will default and even converting assets to cash will be increasingly insecure for the reasons already alluded to. Seeing as we have already assessed the risks of such a systemic breakdown as very high, a reappraisal of pension fund allocation is overdue.

In order to manage such risks and build resilience the fund should invest in asset-backed energy infrastructure in Ireland. This has the benefit of having both a return on a real asset of growing scarcity; making the use of that asset available to enhance our collective security; and diversifying current pension reserve fund assets away from ones purely dependent upon economic growth. Finally building such systems could support the economy in its current difficulty by giving employment and ultimately by reducing import bills for energy (and stopping money leakage from the economy).

¹ www.nprf.ie/InvestmentStrategy/investmentStrategy.htm

If the NPRF does not act proactively and quickly, it will face growing risks of a general run on its invested asset classes and their subsequent collapse in prices. The risks are not just of physical declines oil into the economy and its consequences; but that a growing fear of such a risk could crash the market as alluded to by Robert Hirsch in the last chapter.

Action to diversify individual and company pensions is more difficult as it would have to be a 'megaphone warning'. Alternatively, attractive options should be made available for people to choose to put some of their pensions in asset backed investments within Ireland. Such investment schemes could be set up by registered service providers, who could put out calls for funding. If such a programme was initiated, people could invest in a range of unitised asset-backed investments to protect themselves and the countries' resilience.

5.4 Pricing Carbon, Building the Commons

The fall in oil prices, while no doubt temporarily beneficial, is damaging as it is discouraging investment in a low carbon and low energy economy. However as a recent ESRI report demonstrated, a carbon tax would have to be so high to reduce emissions significantly that it would be politically unacceptable.

The Cap & Share¹ proposal would allow emissions and energy use to be reduced by a fixed amount by limiting the right to emit carbon. The total carbon budget would be divided by the population, and be issued as permits to emit. These permits would be issued to every citizen, who would sell them on to importers of fossil fuels into Ireland. The importers would have to cover the downstream emissions from their fuel by buying permits. This would raise the price of all energy intensive goods and services in the economy. For most people in the economy the extra cost of goods and services would be less than the amount they received for their permits. For high carbon users, the net cost would be greater. This would give a proper signal to reduce emissions to everybody. The advantages of such a system are that:

- There is efficient signalling
- There will be a large active constituency for tightening the cap as permit prices will rise.
- As low carbon users are more likely to be poor, it is both progressive and counters fuel poverty.
- As the permit income is spread widely in the economy (currently the carbon permits in the EU-ETS are just given to big polluters), it will be supportive of the economy in general.
- It will reduce fossil fuel imports, but some of the fossil fuel 'scarcity rent' will be kept in Ireland's economy.

This system recognised the right to emit carbon as a commons right. That is, the right to emit is assumed to lie with all of us. There are many other things such as use of our legal system, or intellectual property that could be regarded as a commons for which citizens could be compensated. Commons ownership satisfies one of the conditions in the previous chapter about emphasising common endeavour and common responsibilities.

5.5 Mutual Guarantee Societies

In an era of tightening short-term credit, many businesses are feeling the effect of less money in the

¹ Details can be found on www.feasta.org. Comhar, the National Sustainable Development Partnership, has independently commissioned research available at www.comhar.ie.

system. Businesses can find themselves caught in a liquidity trap as they cannot pay suppliers until they themselves are paid.

A mutual guarantee society would allow members to trade with each other using short-term credit. The credit would be mutually guaranteed by a small percentage of the euros on any transaction being retained. If one party could not pay in the time agreed, then the payment would come from the pool. Such a network would suite initially local trading networks where there is some level of common suppliers and customers. Individual societies could interact together to form mutuals of mutuals.

They would support local trade as it is in ones interest to support the businesses upon whose success depends the strength of you own guarantee. Mutuals of mutuals would have the same effect nationally. Only a small part of the risk assurance paid in as cash in each society would be required in liquid form, and should a mutual receive a major call on its resources, the mutual of mutuals network could supply liquidity. The remaining cash could be invested in asset-backed LLP structures. Again such investments would most likely favour the local as such investments strengthen the local economy and re-inforce the local business environment and mutual guarantee. It would also encourage nearby mutuals to cooperate on larger projects of interest to both.

As credibility and confidence was built up such societies could form the structures of a local money system, but based upon long-term assets and a small level of high velocity credit.

5.6 Energy

We have noted that the ability to put in renewable energy infrastructure is likely to be seriously compromised once a serious depression begins, thus time is off the essence. In addition it should be noted that renewable energy infrastructure and efficiency measures, no matter how earnestly driven are not a solution to peak energy. We have neither the time nor the resources, to replace high quality energy inputs by lower quality ones. Such initiatives will make us somewhat more resilient through the troubled times ahead.

In addition to the measures above, the government is in a position to encourage asset-backed financing from sovereign wealth funds and external pension funds. While they do not offer large growth prospects for investors they do offer security of return, in this sense they are closer to bonds. As the risks to bonds rise, the provision of alternative investments could offer great opportunities for Ireland and these funds. In order to initiate such projects, the government could act as underwriter.

New energy developments in Ireland should ideally be based on a service fee, with the ownership and control of the gas being in the hands of the Irish state. Such reserves should be kept as an emergency reserve, but with the processing and delivery infrastructure in place. The state would be wise to consider the purchase of the Corrib gas field for example as a strategic asset.

There is a four year backlog in wind turbine delivery, and a growing risk of resource nationalism which may include renewable infrastructure. It is therefore important that the state can produce its own infrastructure. Again this could be supported by sovereign funds with technology provided

under licence. This also has the advantage of having a critical export.

5.7 Food

The evolution of a secure and sustainable food industry in Ireland will take time. Very expensive fossil fuel inputs to agriculture will lead to a far greater number of people working on the land and hence the need for expanding organic and bio-intensive agricultural training. Planning policy will have to adjust to a new scenario where good farming land will have much greater value as a critical food source than for other development. We need also to ensure that our food production is resilient to climate change by maintaining and developing biodiversity, and ensuring we have the rights and incentive to store and breed seed varieties as required.

The assumption of a continuing growth in food supply to meet an expected rise in population and the transformation in dietary habits is questionable already without having to consider oil peak, gas supply crunches and peak. If, into this precarious mix, large-scale biofuel production is added as a competitor to food production, the consequences are likely to be severe. As Ireland cannot escape these consequences in a globalised market for food and energy, it would be wise to build resilience now.

Support for local food production is warranted as a security measure. This includes accelerated ‘green procurement’ programmes in public purchasing and planning for urban agriculture such as making provision for allotments, city orchards and community gardens. New marketing and retailing systems to support local producers should be promoted with better prices such as the revival of town fairs and markets, more support for farmers’ markets in urban settlements and community supported box schemes and other urban and rural community partnerships. It should include a reassessment of current agricultural programmes and a shift from intensification based on fossil fuel inputs to extensive, more organic farming that produces food in synergistic rotation with energy and fibre crops.

5.8. Additional Measures

Monetary System

The state needs to have in place the ability to rapidly introduce an emergency currency into circulation in addition to planning for the introduction of a longer term currency. Such a currency should not be debt based, but rather spent into circulation by government.

Trusts

As many decisions will require painful adjustments, some decisions could be taken out of the political sphere and placed under the control of trusts. This is not necessarily removing them from political control; rather the political process defines the terms of reference and requirements upon trustees. The most familiar structures sharing some similarity with the proposed trusts is the setting of interest rates by the European Central Bank, or the Bank of England.

Re-valuing the Natural Environment

The value of many of the ecological services we rely upon will rise as our economy falls. We must

manage them with future risks in mind. This includes water services, wetlands, forestry, fisheries, and biodiversity. Coilte and Bord na Mona have the capacity to cause huge damage if they are just to follow the market competitiveness of the moment. On the contrary if they are managed with future risks in mind they could be a major national resource.

Citizens Income

Cap & Share and a land tax could form the basis of a citizen's income. Such an income, paid equally to each citizen out of commons resources would provide both a level of security in insecure times, and help build an ethic of common purpose.