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ENTROPY MAN

John Bryant

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Preface

The seeds for this book were sown in the 1970s, four decades ago, when I was then working as group economist for the engineering corporation Babcock International Plc. At that time the group employed about 30,000 people in subsidiaries spread all around the world, engaged in the design, manufacture and installation of capital plant for a variety of industries, including nuclear & conventional power generation, coal mining, gas, chemicals & petroleum, steel, automotive, cement, construction and environmental engineering. Prior to that, my formal university education had included a degree in engineering at University of Bath and a Masters in management science, allied to student sandwich experience with Amalgamated Power Engineering [*now a subsidiary of Rolls Royce*] and ASEA Brown Boveri, Switzerland, followed by working for SKF, the Swedish bearing manufacturer, often considered to be a bell-weather of world economic output.

From the 1980s onwards I worked as director of a consultancy, and subsequently also as an expert witness to the Courts, which roles I continue to the present day. These experiences have taught me to maintain an enquiring, dispassionate and impartial mind regarding the complex workings of human endeavour, the natural world and changes arising thereof.

My particular research interests in those early years concerned the parallels between the disciplines of economics and thermodynamics [*the science of energy & heat*] and how they relate to each other, as a result of which I published two peer-reviewed papers on the subject in *Energy Economics* [1979 & 1982]. Subsequent to these I gave presentations to international gatherings of government ministers, energy industry executives and academia.

Not being based at a university however, and with no research grant at my disposal, my main thrust had been to make a living from consultancy and therefore, until more recently, opportunities to spend time on research were few. Nevertheless, by the turn of the millennium I was able to find time to return to some research and published another peer-reviewed paper in the *International Journal of Exergy* [2007], followed up by several working papers on monetary aspects and energy models. Subsequently in 2009 I wrote a technical book on the subject, to bring together all the facets of the work into a coherent whole: '*Thermoeconomics – a thermodynamic approach to economics*'. The book was subsequently revised, corrected and

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added to, up to a third edition [2012], covering topics such as production and consumption processes, employment, money, interest rates and bonds, energy resources, climate change and sustainability, and including more up to date statistics. It has now been superseded by this book.

Whilst not being tied to a university, government agency, industrial enterprise or other organisation has disadvantages in terms of recognition and time available for research, it does nevertheless have the advantages of freedom to investigate and pursue a course of enquiry of one's own choosing and of drawing conclusions independent of those that pay the piper or who may have pre-set agendas, however well-intentioned these may be.

The nature of the subject requires significant proof for economists and scientists to accept that similarities between thermodynamic and economic phenomena might imply more than just a passing analogy or isomorphism, and relations between the two disciplines have rarely been comfortable, with scientists sometimes having scant regard for the work of economists; and many economists believing that science has little to offer their discipline which, by its nature, can be thought of as anthropocentric rather than eco-centric. One eminent energy scientist advised me that he did not know of an economist who could follow a thermodynamic argument. Certainly a concept such as entropy means very little to most economists, still less to the man in the street – money is their language of communication. The latter is not, however, the language that Nature and the environment converse in.

This book is intended for a mixed readership of scientists, economists and those of an enquiring mind. It is a challenge therefore to convey the nub of the argument in terms that all can appreciate, with particular reference to the effects of potential problems such as 'peak resources', humankind's effect on the ecosystem and the maelstrom that would ensue should resource failure or climate change ever come about to a significant degree.

While some chapters, notably chapters 4 through to 8, do contain some mathematical expressions, explanatory points are included to guide non-mathematicians onwards. Formal proofs and derivations have been relegated to the notes on each chapter.

Although economic man may currently have the ascendancy, he does not actually 'own' the Earth. He is there on sufferance, and the Earth would

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quickly forget him along the ecological timescale, should human civilisation fail or spoil the proceedings.

I am indebted to my wife Alison for all her support and for providing me with an atmosphere conducive to my research.

John Bryant

CHAPTER 2 A SHORT HISTORY OF HUMAN DEVELOPMENT

In the life of planet Earth, which began perhaps 4.5 billion years ago, the evolution of primates at about 60 Ma [*million years ago*] was but a recent development, that came after several near extinction events, of which the Permian-Triassic [*251 Ma*], Triassic-Jurassic [*200 Ma*] and Cretaceous-Paleogene [*66 Ma*] events are the more well-known; the last killing the majority of all species, including the dinosaurs.

Homo-Habilis, the first of the human-like line of primates, evolved at around 2.3 Ma, and it is thought that at some stage the species developed to be able to use stone tools. During the next million years or so a process of brain enlargement occurred culminating in the arrival of Homo Erectus, who spread across Europe and Asia [*Peking Man*]. By this time the use of fire and more complex tools may have developed. The arrival of Homo Sapiens in Africa around 0.25 Ma saw brain size reach about twice those of chimpanzees and gorillas, enabling significant development of learning, language, cultural and music skills by around 50,000 years ago. At this time humans had already begun progressively migrating around the world, to Asia and Australia, to Europe and latterly to the Americas. Availability of water and the ambient levels of air temperature restricted the places on Earth where humans and life could prosper, generally to the more temperate zones away from the poles and the equator.

It is thought that until about 10,000 years ago humans lived primarily as hunter-gatherers, eating what was available from plants and trees and by catching animals. Indeed humans may have played a part in the extinction of the mammoth and other species of mammals. However, with the development of rudimentary farming and agricultural skills – the Neolithic agricultural revolution – came the domestication of animals and the growing of crops on fixed areas of land, followed soon after by the formation of permanent settlements of huts and buildings, often near rivers and the sea where fishing could be carried out. A stage further saw humans develop localised forms of government and religious beliefs.

Throughout this next period of civilisation, the principal means by which humans lived was by their own labour, augmented by the use of domesticated animals in agriculture, travel and transport, conveying and pulling items considered to be of value to humans. Humans could use fire to cook food, could fashion tools and weapons made of metal, and also had the capacity to undertake irrigation projects, construct buildings and alter their habitat to a degree. The wheel was invented in about 5000 BC.

As between animals, humans, singly or in groups, could also engage in conflict, physical or otherwise, with other groups of humans, ostensibly about the control and distribution of resources and food, but sometimes also as a result of beliefs held. See an animal or a bird fight over a carcass or back off in the face of another; humans are not alone in the field of conflict.

Significant civilisations came and went: Sumerian, Babylonian, Minoan, Xia, Shang, Zhou, Indus Valley, Olmec, Mayan, Mahajanapadas, Greek and Roman. But by 0 AD others were rising to replace them, in particular Germanic tribes and the dynasties of Imperial China. There followed others through the middle ages towards what we know as modern history.

Ronald Wright [2004 *A Short History of Progress*] and Jared Diamond [2004 *Guns, Germs and Steel*, 2005 *Collapse: How Societies Choose to Fail or Succeed*], have written very well researched books to deduce the reasons why some societies failed. For example, Wright indicated that the collapse on Easter Island arose from the decimation of trees for logging to move statues, and that the Sumer collapse arose from over-grazing, land clearing and an irrigation system, leading to desertification and famine. Diamond came to a similar conclusion with regard to Easter Island, and cited the same cause with regard to the collapse of the Mayan and Greenland Norse civilisations.

Barter was a common form of exchange of value between humans, grain and cattle being of use. The shekel [*deriving from a weight of barley*] appeared in about 3000 BC in Mesopotamia; and early coinage in about 700 BC, in China, India and around the Mediterranean Sea. Paper money and banknotes came into use gradually from about 1100 AD onwards, and bills of exchange appeared towards the end of the middle ages.

It is estimated that at 11000 BC the world human population stood at about 3 million people but, following slow developments in civilisation and agriculture, it had grown to about 230 million by 0 AD [*Maddison - OECD*], and by 1700 AD it had reached about 600 million, which represents an average compound growth rate of a little over 0.04% per annum – quite small. To this point, despite the advent of the Neolithic agricultural revolution, a number of factors and constraints had combined to keep population growth down to a low level; chief among these were periods of famine, disease & epidemics, natural disasters, wars and high infant mortality. Examples of famine include the Mayan disaster circa 900 AD, and those of India, China, Russia and other countries, continuing up to the present day. Some of the larger historic epidemics of infectious diseases killed off many millions of people, such as:

Smallpox	– Roman Empire, Americas (native population)
Bubonic plague	– Byzantine Empire, Europe/Asia Black Death, Worldwide
Plague	– Italian plague, Great Plague London, Russia,
Cholera	– Asia/Europe, Russia, Africa,
Influenza	– 1918 worldwide pandemic, Asian & Hong Kong Flu,
HIV/AIDS	- Worldwide

Historically natural disasters can be classified under three main headings: floods, earthquakes and cyclones. The following are just some of the many that have occurred:

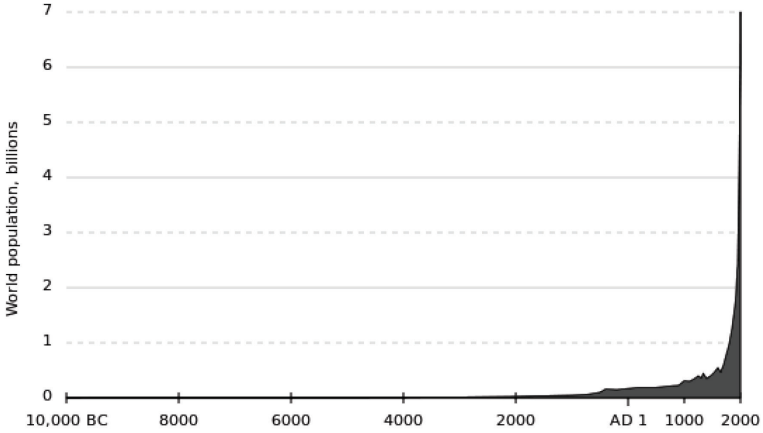
Floods:	- China [1887, 1931]
Earthquakes:	- China [1556, 1786, 1920, 1976]
Cyclones:	- India [1737, 1839], Pakistan [1970]

Global warming, should it occur, which will be looked at in a later chapter, may possibly have the potential to be a significant environmental disaster, effecting continual examples of flooding, cyclones, famine and increased incidence of disease. Because of its potential links with the large scale burning of fossil energy by humans, it may not altogether be described as a ‘natural’ disaster, but one that may have a human cause – anthropogenic.

War, armed conflict and genocide are large scale killers of the human populace, and among the larger incidences are those of China [*AD 184, 755, 1340, 1616, 1851, 1862*], and the Mongol and Japanese conquests [*1206 and 1894 respectively*]. Notable examples elsewhere include the Thirty Years war [*1618*], and more recently the Russian revolution [*1917*], World Wars I and II [*which resulted in many millions of deaths*] and Korea [*1950*]. Major genocides include the colonisation of the Americas [*disputed*], the Holocaust [*1941 – 1945*], the Holodomor [*1932*] and others such as those of Nigeria, Cambodia and Rwanda.

In the past, the surest way of preserving the future of the human species against famine, disease, natural disasters, war, high infant mortality and to cope with low life expectancy was to have a high birth rate and live in temperate zones. And up to about the end of the 18th century the net result of this strategy had been a relatively modest rate of increase in population, not significant in the grand scheme of things, as illustrated by figure 2.1. At the time, a man of the country [*or even an economist!*], blessed with knowledge of the data in the chart to 1700, might perhaps have ventured to project a level of up to 2-3 billion by 4000 AD, but any advance on this might have met with some scorn.

However, since that time, world human population has ballooned, rising to 1 million by 1801, 2 billion by 1927, 4 billion by 1974 and 7 billion by 2012. The annual growth rate rapidly escalated, peaking in about 1974 at 2.1% per annum, but is still climbing inexorably at about 1% per annum to the present day.



*World Human population from 10,000 BC to 2000
Adapted from UN Department of Economic and Social Affairs*

Figure 2.1 World Population.

Table 2.1 adds further detail to show how dramatically events have changed. Latest estimates for 2013 and a medium-range projection of population to 2050 are added to the table – courtesy of UN World Population Prospects.

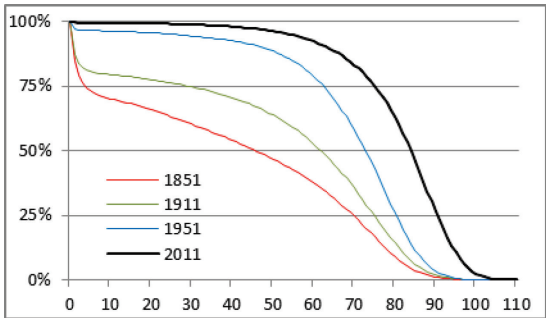
Year AD	0	1000	1700	1820	1950	2013	2050
	<i>millions</i>						<i>Mid forecast</i>
Europe	33	39	127	224	549	742	709
USA Canada & Oceania	1	2	2	11	185	393	503
Latin America	6	11	12	21	168	617	782
Asia	174	183	401	710	1396	4299	5164
Africa	17	33	61	74	229	1111	2393
World	231	268	603	1040	2527	7162	9551

Sources: Angus Maddison, *OECD Development Centre Studies: "World Economy – A millennium perspective"*
UN Department of Economic and Social Affairs

Table 2.1 World Population.

From the 19th century onwards population in Europe rapidly expanded, followed also by expansion into the New World, Oceania and Latin America, arising from emigration from Europe and elsewhere. In more recent times population growth has switched into Asia and Latin America, but now Africa is expected to be the centre of growth to 2050.

OECD/Maddison estimates indicate that average human life expectancy at birth across both sexes for the world at 0 AD was probably in the region of 24 years, and had only marginally increased to about 26 years by 1820. By the end of the twentieth century, however, it had increased to about 66 years, with figures in Western countries in the region of 77-81, and the lowest in Africa at 52 [up from about 23 in 1820]. Figure 2.2 summarises the effect just for England and Wales. In the mid-nineteenth century more than a quarter of the population did not survive beyond a very early age. Once past these danger years, then the likelihood of surviving beyond the average rose significantly, though it was still much below the levels of the 21st century:



Proportion of persons surviving (on a period basis) to successive ages, according to mortality rates experienced or projected, persons born 1851-2011 England & Wales. Source: ONS

Figure 2.2 Survival Rates England & Wales.

In tandem with improvements in survival rates in developed countries there has been a drop in the number of human births per 100 of population over past levels. Birth rates in Western Europe, Russia and Japan are now much lower, to the point at which population is beginning to level off and may decline to 2050 [see earlier table]. Recent UN figures indicate that with the exception of Africa, total fertility rates right across the world have fallen dramatically, from 5 per woman in 1950 down to only 2.5 in 2010, and continuing to fall. This figure is not much above the replacement rate of

2.10–2.33 children per woman. Thus eventually a decline in world population may come about.

	<i>Births per 100 Population</i>	1998
Western Europe	3.74 [1820]	1.00
Russia	4.13 [1820]	0.88
USA	5.52 [1820]	1.44
Japan	2.62 [1820]	0.95
Latin America	4.19 [1950]	2.51
China	4.12 [1900]	1.60
India	4.58 [1900]	2.80
Africa	4.92 [1950]	3.90
World	3.74 [1950]	2.30

*Angus Maddison OECD Development Centre Studies
World Economy – A Millennium Perspective*

Table 2.2 World Birth Rates.

The spark and fuel for the rapid increase in world population and subsequent improvement in survival rates and longevity came from the agricultural and industrial/scientific revolutions, started in the 18th century in Britain, and later in Europe and North America, beginning a process of significant change in the constraints binding the way humans across the globe managed their lives.

Hunter-gatherer man obtained his energy from food and drink he consumed, could use fire to burn wood to cook meat and could conserve energy by wearing animal skins. Early agricultural man took a step further, by commandeering animal muscle power to help him work the soil to grow crops. Later on, humans could utilise wind and water power to help them in agriculture, and use horses, cattle and sailing ships for longer distance travel and movement of produce. Humans still had to work hard physically, with little time left for other non-essential pursuits.

With the dawn of the agricultural and industrial age and associated scientific advances from the 19th century onwards however, matters changed quickly. Crop yields from agriculture began to rise, based on new methods of farming, including the use of fertilisers and the beginnings of mechanisation. A new source of energy – coal – was found and developed that could provide large scale and more intense power than could be derived from the Sun, domesticated animal power or wood burning. Coal could fire boilers that delivered high temperature heat to power steam engines that powered looms, drove ships at sea and locomotives pulling trains on railway tracks; the latter being constructed from iron produced from smelters fired by coal. Coal output in UK collieries for example increased from 17.7m

tonnes p.a. in 1820 to 230m tonnes p.a. in 1900, employing around one million people.

Science produced a cascade of inventions between 1700 and 1900 including: the threshing m/c, flying shuttle, batteries, smallpox vaccination, dynamos and generators, the steam engine, the telephone, the telegraph, gas and electric lighting, the internal combustion engine, the miner's lamp, matches, cement, typewriters, sewing machines, antiseptics, pasteurisation, dynamite, machine guns, iron-clad ships, the motor car and coca cola, just to name a few. Many of these inventions were not directed towards surviving to exist, but to meet or suggest new 'wants' to enhance human life and create a more ordered state for humans. It was the new energy source that enabled such wants to be created and met, and previous constraints to be removed or moderated.

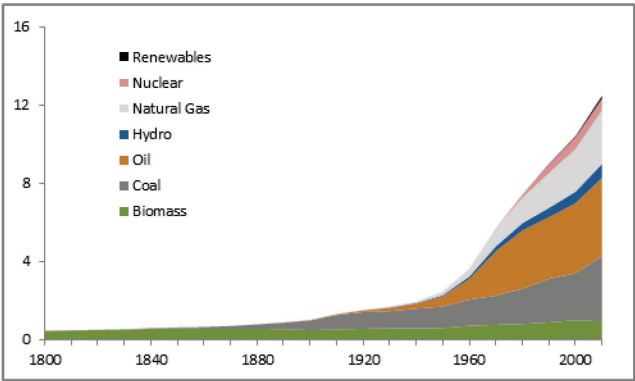
Goods could be transported cheaply and quickly, and increasingly across national borders, fostering trade. The populace accumulated 'financial' surpluses that could be spent on non-food goods, and the surplus 'value' or 'profit' from the production process changes could be re-invested in capital goods designed to improve productivity further and widen the scope of the industrial age. Railway line lengths increased dramatically in Europe, for example, reaching more than 30,000km and 51,000km respectively in Great Britain and Germany by 1900.

Population growth began to rise, and the proportion of the populace in developed countries engaged in agriculture began inexorably to go down, with more and more people being involved in producing goods not directed towards food production, and using energy to do the actual physical work of producing. In Britain for example the proportion working in agriculture dropped from three-quarters down to 2% over the 500-year period to 2000.

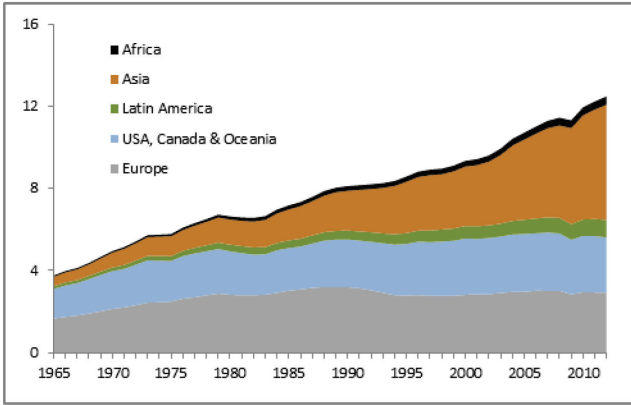
With the discovery of oil and natural gas, having even more energy potential than coal, came a further scientific revolution and by the beginning of the 20th century the dawn of technology man had arrived. Interspersed by two world wars and the Great Depression, there followed another deluge of scientific inventions carrying on into the 21st century, of which the following is just a small selection: theory of relativity, radio, cornflakes, cellophane, robot, insulin, TV, rocket, penicillin, jet engine, aerosol, atom bomb, atomic reactor, laser, transistor, microprocessor, all things computers and printers, mobile phone, credit card, oral contraceptive, world wide web, fuels cells, superconductors, artificial heart – the list will go on, again not just to support basic human existence, but to enhance human life. And

nowhere does this list contribute towards enhancing the well-being of other life forms on the planet, only that of humankind who sits at the apex of the living food chain.

A period of rapid growth in energy consumption ensued to use the technical advances acquired, initially in Britain, Western Europe, North America and Oceania and then post-WW2 in Japan. Within a few decades, however, the process had spread to Korea and more recently to so-called BRICS countries [Brazil, Russia, India, China and South Africa], who have rapidly acquired the same knowledge, starting a shift in the manufacturing centre of the world away from the developed countries, who have now become more service orientated. The key advantage of the BRIC countries, compared to the developed countries, is their relatively low human wage cost for the same industrial output, though clearly with time they too will aspire towards higher earnings and the present consumptive levels of the developed world.



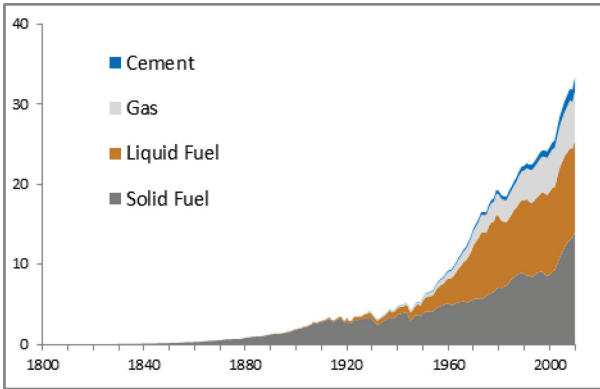
Sources: BP Statistical Review, Vaclav Smil



Source: BP Statistical Review

Figure 2.3 World Primary Energy Consumption – Gtonnes p.a. oil equivalent.

The consumption of fossil energy of course led directly to significant emissions of carbon dioxide [CO_2] into the atmosphere, accompanied by other ‘greenhouse’ gases such as methane [CH_4].



Source: Carbon Dioxide Information Analysis Center

Figure 2.4 World Emissions of CO_2 arising from burning Fossil Fuels Gtonnes p.a.

Alongside the rise in non-agricultural activities stemming from the world industrial and technology revolutions there has also been a rise in urbanisation. The World Health Organisation estimates that one hundred years ago about 20% of people in the world lived in urban areas, though this figure is likely to be an increase on historic levels. More recent estimates of the UN indicate that world urbanisation has risen from 29.4% in 1950 to

51.6% in 2010, with an expected projection to more than 67% by 2050, with the percentages for Asia and Africa rapidly catching up with that elsewhere in the world. There are now 13 mega-cities in the world, each with a human population of more than 10 million, and another 30 cities with a population between 5-10 million.

A possible side effect of the growth of large conurbations is the potential for rapid spread of disease should decreases occur in the quality of living conditions and sanitation. Advances in healthcare, the development of medicines and improvements in living conditions arising from the technological revolution have been good antidotes so far to counteract this. However, misuse of antimicrobial medicines potentially provides avenues for new mutant forms of viruses and bacteria to evolve and develop resistance to existing remedies, such that the latter no longer work, with the potential for large scale spread of pandemic or contagion.

To repeat the exposition, humankind is increasingly corraling and consuming significant amounts of energy and resources of the Earth to its own ends, enabling the creation of large and growing conurbations of people and the maintenance of a level of assets or ‘wants’ much in excess of those necessary just to survive.

Table 2.3, summarising the historic world situation, is instructive of the position humankind has assumed, in terms of the annual gross domestic product, a measure of economic activity familiar to many.

	0	1700	1820	1950	2008
<i>\$bn p.a. 1990 prices</i>					
<i>Europe</i>	\$14.6	\$110.3	\$224.6	\$2097	\$11970
<i>USA Canada & Oceania</i>	\$0.5	\$0.8	\$13.5	\$1635	\$10934
<i>Latin America</i>	\$2.2	\$6.4	\$14.1	\$424	\$4046
<i>Asia</i>	\$78.2	\$229.5	\$411.2	\$986	\$22289
<i>Africa</i>	\$7.0	\$24.4	\$31.0	\$194	\$1735
Total (\$bn)	\$102.5	\$371.4	\$694.4	\$5336	\$50974
Population (m)	231	603	1041	2525	6695
GDP per capita (\$)	\$444	\$616	\$667	\$2113	\$7614

Sources: *Angus Maddison, OECD Development Centre Studies: World Economy – A millennium perspective*
Bolt, J. van Zanden, J.L. (2013). The First Update of the Maddison Project: Re-Estimating Growth Before 1820. Maddison Project Working Paper 4.

Table 2.3 World GDP \$bn 1990 prices.

It is openly admitted in the Maddison study that before about 1500 AD, the element of conjecture regarding GDP estimates is very large indeed, being based on estimated subsistence levels and the relative levels of urbanisation, there being only a few cities with more than 10,000 people in the early years. Nevertheless, whereas the study estimated that between AD 0 and 1820 – approaching two thousand years – world GDP multiplied by a factor of 6.8, enabling population to increase by 4.5 fold allied to only a small increase in GDP per capita, from 1820 onwards to 2008 – under two hundred years – GDP was estimated to have multiplied by a further factor of 73, split between rises in both population and GDP per capita, with the latter the larger of the two. Clearly the ability to satisfy ‘wants’ above subsistence level escalated. That population rapidly grew alongside this is unsurprising, but it was mostly based on the increasing availability and consumption of fossil energy and other resources allied to scientific discoveries.

Much of the human world as it is now structured is built around capital assets that require energy in order to function. By way of example, table 2.4 sets out the ‘*economic value*’ attached to all the plant & machinery, houses, offices, industrial buildings, equipment in transport, mining, power generation and farming, and consumer durables held by the man-in-the-street and by organisations in the USA – the world’s most ‘*developed country*’ – amounting to nearly \$47 trillion in 2007. Nearly all of these assets rely on a continuing supply of energy and electricity for all or part of their operation and maintenance.

	\$bn	Total	%		\$bn	Total	%
Equipment & Software				Structures			
Computers/Software	\$669.9	1.4		Residential	\$18,142.8	38.9	
Communications	\$555.4	1.2		Offices	\$2,247.9	4.8	
Medical Equipment	\$269.2	0.6		Commercial	\$1,868.1	4.0	
Office Equipment	\$188.3	0.4		Hospitals	\$931.9	2.0	
Engines Turbines	\$83.5	0.2		Manufacturing	\$1,242.8	2.7	
Electrical transmission	\$358.4	0.8		Power	\$1,472.0	3.2	
Industrial M/c	\$1,041.0	2.2		Communication	\$485.8	1.0	
Trucks/buses	\$1,577.9	3.4		Petroleum/Nat Gas	\$832.6	1.8	
Autos	\$714.5	1.5		Mining	\$57.2	0.1	
Aircraft, airborne equipt	\$456.5	1.0		Railroads	\$298.7	0.6	
Ships, boats	\$207.7	0.4		Farms	\$307.8	0.7	
Railroad equipment	\$101.5	0.2		Highways/Streets	\$2,634.1	5.7	
Agricultural M/c	\$147.0	0.3		Military	\$391.4	0.8	
Construction M/c	\$149.8	0.3		Transportation	\$532.4	1.1	
Mining/Oilfield Equipt	\$49.5	0.1		Educational	\$1,971.2	4.2	
Videos/Computers TV	\$793.5	1.7		Sewers & Water	\$912.0	2.0	
Appliances	\$204.2	0.4		Other	\$2,030.3	4.4	
Other	\$2,690.7	5.8					
Total Equipt & Software	\$10,258.5	22.0		Total Structures	\$36,359.0	78.0	
Net Capital Stock & Consumer Durables (\$bn)					\$46,617.5	100.0	
Population (millions)					301.23		
Assets/head (\$)					\$154,800		

www.bea.gov Fixed asset tables 3 and 11b

Table 2.4 US Net Stock Fixed Assets & Consumer Durables held by private and gov't agencies in 2007.

The position for other countries and groups of humans is likely to scale down, according to their relative degree of development, consumptive nature and dependence on energy. At the other end of the scale one might imagine natives in the Amazon jungle having little or no assets other than spears and rudimentary shelter of relatively low 'economic' value.

A scientist might say that effectively to the present time humans have increasingly reduced their entropy level and created a significantly more ordered state for themselves by utilising a part of the large increase in entropy generated from the consumption of energy and other resources. A return to human and animal power might be viewed by *Developed Economic Man* as being unimaginable and a retrograde step. Such a step would certainly be dramatic.

Imagine, if you will, a prolonged complete blackout in the supply of electricity (nuclear & renewables) and the availability of gas and oil. Food

would not get to the shops, water pumps would fail, heating would switch off, hospitals and industry would gradually grind to a halt, communications and computers systems would be endangered, and children would be sent home from school to the care of their parents. Roads and railways would cease to have much function. Fairly quickly there would be large scale disruption, and possibly panic actions by the populace seeing their way of life turned upside down. Government would step in to exert some control. In modern times it has happened before to mild levels, for very short-term periods and in localised places, such as the UK fuel tanker and coal mining strikes, and thankfully matters were quickly returned to 'normal'. We have to go back to the last world war, a pandemic disease such as the 1918 influenza outbreak, or localised conflicts in countries such as former Yugoslavia, Rwanda, Iraq, Libya and Syria to see some of the effects.

Thus events can change a lifetime's thinking and doing and we should all be mindful of such.