OPTIMUM POPULATION TRUST

JOURNAL OCTOBER 2009

Vol. 9, No 2, compiled by Andrew Ferguson

Page

The current financial debacle is really not a "liquidity" crisis as it is often euphemistically called. It is a crisis of overgrowth of financial assets relative to growth of real wealth — pretty much the opposite of too little liquidity. Financial assets have grown by a large multiple of the real economy — paper exchanging for paper is now 20 times greater than exchanges of paper for real commodities. … To keep up the illusion that growth is making us richer we deferred costs by issuing financial assets almost without limit, conveniently forgetting that these so-called assets are, for society as a whole, debts to be paid back out of future real growth. That future real growth is very doubtful and consequently claims on it are devalued, regardless of liquidity.

Herman Daly, 2008, from a short piece *The Crisis: Debt and Real Wealth.*

The Optimum Population Trust (UK): Manchester

<www.optimumpopulation.org>

INTRODUCTION

The eight page instalment of Martin Desvaux's synopsis of Clive Ponting's *Green History of the World* is longer than usual, but Chapter 16, *Polluting the World*, covers a vastly important aspect of overpopulation. As Clive Ponting makes clear, even when population was much lower than in the last half century, it was an ongoing battle to stop life becoming intolerable due to pollution.

In getting to the roots of the problem that human society faces, second only to Ponting's *Green History of the World* is the book first published in 1979, *Food, Energy, and Society* by David and Marcia Pimentel. Although this instalment, from the 3rd edition, 2008, is short, the matters raised are vitally important.

The October 2008 issue (8/2) of the OPT Journal contained an article on *Rutledge's Hypothesis*. Its essence was that the analytical methods applied successfully to estimating peak oil could be applied to coal. Using that hypothesis, and after bringing much evidence to support it, the conclusion was that the peak of coal production will be reached within decades. It is a plausible, albeit not necessarily correct, hypothesis. When John Nunn and I investigated whether the geological community was trying to counter the arguments put forward by Rutledge — to the effect that most previous estimates of coal reserves made by geologists were grossly wrong — we could find no such evidence. Although this follow-up article bears my name as author, much of the research was done by John Nunn, who is a multi talented scientist, interested both in ancient Egyptian medicine and geology.

On page 18 is a brief report based on a review written by Sandy Irvine of the film *Age of Stupid* (the full review being on his website). Sandy Irvine was for many years the editor of the magazine *Real World.* One thing which Sandy's review brings out is the unwillingness of those making the film to address the subject of migration.

The next article, pp. 19-23, by Jim Duguid and myself is on the vitally important subject of *International Migration and Overpopulation*.

On pages 24-25, there is a brief review of a paper by Charles Hall and John Day, *Revisiting the Limits to Growth After Peak Oil*. My thanks to Walter Youngquist for sending me this paper, comprising a concise insight into the problems facing the world.

The April 2009 issue (9/1) of the OPT Journal contained an article, *So What Can We Do About It Now*, which showed that nations which could reduce their total fertility rate to 1.3, as 16 countries have already done, while ensuring only balanced migration, could chart a safe course to sustainability. The algorithm used was somewhat simplistic. Eric Rimmer was concerned to introduce more reality by establishing death rates for each decade. When he had obtained the data, we tackled the task. I am glad to say that the simplistic algorithm had worked pretty well, but the more sophisticated one throws up some points of interest, which are to be found on pages 26-27, *Four Paths to a Sustainable World Population.*

When I heard that there was an experiment going on in Germany to see what could be achieved by integrating several forms of renewable energy, by a model based on actual data from various experiments, I was delighted that at last someone was investigating this matter. Unfortunately, the extent of reliance on pumped storage indicates that the results would not be scalable, as explained in *Scalability of a Trial Renewable Electrical System.*

As usual, this issue is a joint effort, and it is an invidious task to pick out particular names, but I would like to thank David Pimentel for his unfailing support and Yvette Willey for her careful proof reading and for taking most of the work of distribution from my shoulders. The author of *GeoDestinies*, Walter Youngquist, plays an important part in keeping the journal well supplied with interesting subjects to tackle, by sending me a steady stream of valuable material, from amazingly diverse sources.

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CLIVE PONTING'S *A GREEN HISTORY OF THE WORLD.* Part 8

A synopsis by Martin Desvaux PhD CPhys MInstP

Introduction: In 2007 Clive Ponting published *A New Green History of the World* – a revised edition of his great work. This synopsis refers to the 1991 version. The final instalment of this synopsis will appear in the next OPT Journal. Later issues of the OPT Journal will contain an overview of changes that appeared in the 2007 revision.

Chapter 16: Polluting the World

This, the longest chapter, opens with the shortest statement in the book: "*Pollution has a long history.*" With it, Ponting underlines that waste – an unavoidable consequence of life and indeed any physical process – has been taken to new heights by humans:

> The creation of wastes has been one of the distinguishing characteristics of every human society. For thousands of years the chief struggle was over sanitary arrangements and the main challenge was to obtain unpolluted water supplies. These problems became ever more acute as human numbers and urban life increased, but widespread industrial production and the use of new technologies introduced new pollutants and brought new risks to human health and the environment. Contamination was at first essentially localised – generally confined to a city, river, waste dump or mine. By the late twentieth century pollution had increased to an unprecedented scale – affecting industrial regions, oceans, entire continents and even global regulatory mechanisms. Human understanding of the consequences… has always tended to lag well behind the release of pollutants into the environment. In earlier societies it is possible to find evidence of many of the features which characterise the response to contemporary pollution: fatalistic acceptance of pollution as an inevitable consequence of human activities; authorities balking at prevention or control measures; lack of foresight and technical understanding; the problem of allocating responsibility; a preference for short-term local fixes rather than long-term solutions and a failure of individuals or companies to take responsibility for their actions. Attempts to control pollution are as old as the problem itself but the response has usually been belated and inadequate with a poor record of co-operation and enforcement.

The only upside to the accumulation of so much detritus was through archaeology, which has uncovered so much knowledge of human societies going back hundreds of thousands of years. Early societies only produced low-level waste such as mainly animal bones and blunt tools. Disposal of excrement without contaminating water supplies and causing human health issues was the earliest waste problem. For hunter-gatherers leading a nomadic existence, this problem will rarely have arisen, since sites were only occupied for limited periods. However, the advent of settled societies inevitably brought many instances where water supplies from local streams and rivers were contaminated by human and animal waste. These persisted in areas around small rural settlements (possibly even to the present day), but for larger conurbations the problem had to be solved by transporting water over longer distances via major underground and bridged aqueducts, as in the case of the Roman and Greek cities where "…*they were soon a familiar sight in their elevated form across the ancient Mediterranean from Spain and southern France to Carthage and Alexandria*". As cities became established in the north and west of Europe, the water supply problem followed and solutions to it developed. Lead pipes were used in London (1236). Hollow logs became the conduits of preference in e.g. Zittau (1374) and Breslau (1479). As cities grew, their water supply and effluent disposal problems outgrew local natural resources leading, after a trail of many disasters, to the use of artesian wells, the creation of reservoirs and the development of filtration plants. Water usage still remained limited up until the early 20th century: it was supplied to distribution points within the towns and cities from which it had to be carried to houses in containers. For those of us who complain if the water supply is turned off for a couple of hours, consider this:

> In eighteenth century Paris water was taken round the city by 20,000 water carriers using buckets. In mid-nineteenth-century London out of 70,000 houses in the centre of the city 17,000 depended on their own wells and the rest relied on standpipes in the street, about one for every twenty or thirty houses, which normally supplied water for about an hour a day for three days a week.

With increasing population and technical developments in water and sewage treatment, the global consumption of water quadrupled in the 50 years prior to 1990. Such a simple statistic hides the fact that, in 1990, the average American consumed 7200 litres per day – 288 times more than the average Indian. Water shortages have not been confined to the third world:

> Oklahoma and Texas had lost 18 per cent of their irrigated farmland by the 1980s and 2,300 square miles in Colorado, Kansas and Nebraska had also gone out of production due to lack of water. Using modern technology Saudi Arabia has been able to irrigate large desert areas but this relies on underground aquifers which are being used up at a far faster rate than they are being replenished.

Today, the predominant problem of human waste disposal has taken second place to the much larger problems presented by modern industrial and agricultural pollution. The extensive use of chemicals, pesticides and fertilisers causes run-off into rivers, aquifers and the seas.

The whole history of waste management centres on the incremental approach to the solution of man's excremental issues: *"There is no doubt that someone living in the industrialised world in the twentieth century who was transported back in time to a city at any period earlier than about a century ago would be horrified and overwhelmed by the smell. This came from piles of rotting rubbish and human and animal excrement mixed with pools of urine, which often blocked the streets or were occasionally swept into the local stream or river to decompose there."* The lack of lavatories led to people using any available open spaces. *"In eighteenth century Paris a row of yew trees in the Tuileries provided an open air toilet and when the authorities drove people away they simply used the Seine instead."* Other types of waste had their problems. Some choice descriptions leave us to consider one of the upsides of 20th century life. Jacques Caille on his visit to Rabat in early nineteenth century: *"the streets of the city often show a layer of liquid mire more than ten centimetres deep. When waste matter has been removed it is thrown into the sea; or often it is simply heaped up at the gates to the city, where it forms a veritable cess pool."* Frederick Engels wrote of an area of working class Manchester in the 1840s which boasted a single, open privy serving 200 people: *"This privy is so dirty that the inhabitants can only enter or leave the court by wading through puddles of stale urine and excrement."*

After 1815, the interlaced problems of sewage and water supply began to be solved when waste flushed with water could be transferred to surface streams, thus transferring the sewage into open rivers. This only moved the problem and did not eradicate it. By the second half of the nineteenth century, the start of sewage treatment gradually led to alleviation of the problem in the industrialised world over the next century or so. The slowness of universal purification can be ascertained from these snippets: *"Dundee in 1910 only had three hotels and two private houses with water closets (and even then they only worked with buckets of water)… As late as 1960 two-thirds of urban homes in the Soviet Union were not connected to a sewer… In Paris, in 1925, half the houses had no sewage system… In 1974 over half the population [of Tokyo] did not possess mains drainage…"*

In the third world, problems of treating waste still persist. Ponting states that: *"In Manila, untreated domestic sewage now makes up seventy percent of the volume of the Pasig river. In total, eighty per cent of the people in the Third World (in other words an overwhelming majority of the world's citizens) have no sanitary facilities and therefore still suffer from the disease and squalor that this causes."*

Some pollution problems have disappeared. An example of a transient problem is that of horse droppings. Always a limited irritant, it became almost unbearable in medieval cities up to the mid 20th century as the horse was the main source of transport within cities. Once the motor car became the favoured means of transport that problem was replaced with another invisible and possible more insidious one.

The advent of coal, as wood became in short supply, brought another pollutant: coal smoke. In London, a ban imposed in 1307 was largely ignored and the west end of the city became more desirable to live in as the prevailing westerly winds tended to keep the air clean. Provincial cities such as Sheffield and Newcastle fared no better; *'Even in Oxford … classical marbles brought back to England were damaged very quickly'*. By 1880, London homes had well over three million coal-burning fireplaces which under adverse conditions produced smog on foggy days. In February of that year over 2000 people died as a result. Only after 1952, when 4000 people died, was the clean air act introduced, in 1956. Similar developments occurred in other major cities around the world.

Industrial processes have always caused pollution, especially of waterways, the traditional conduit of industrial waste. In Roman times, mining and processing of lead and gold created noxious and deadly fumes and poisonous rivers. In Japan, pollution from the Ashio copper mine led to its closure in 1790. When opened later, the waste caused the death of fish, people and animals and left a legacy of 100,000 acres of contaminated land. Tanning of animal hides, linen bleaching, cotton dying, starch making and other processes all left their mark on the local communities and rivers: *"In the sixteenth century, the Thames near London still contained barbel, trout, bream, dace, gudgeon and flounders but by the eighteenth century they were extinct, killed by the increasing pollution.*" The industrial revolution in the late eighteenth century caused a 46-fold increase in world coal consumption and a 60-fold increase in iron production. Growing chemical industries produced large amounts of sodium carbonate and hydrogen chloride. These processes led to a massive increase in pollutants and emissions. Inspectorates, set up to control the efflux, were slow to act and mainly ineffective against the industrial lobby which often won the day in disputes. Despite the obvious damage to people and the environment, the drive for economic growth in the twentieth century produced only *regulated* pollution of rivers and waterways. The result was large areas of contaminated waters and wasteland in countries all over the world. As one mid-nineteenth-century Englishman observed*: "The sturdy hawthorn makes an attempt to look gay every spring; but its leaves… dry up like tea leaves and soon drop off. Cattle will not fatten…and sheep throw their lambs. Cows too cast their calves; and the human animals suffer from smarting eyes, disagreeable sensations in the throat, an irritating cough, and difficulties of breathing."*

During the second half of the twentieth century, conditions in the former Soviet Union, China, Japan and Brazil were significantly worse than in nineteenth century European industrialised cities. The size of the problem was much larger due to the drive for economic growth – at any price – and pollution was more deadly. In Most (Czechoslovakia) children had to carry portable respirators since sulphur dioxide (SO_2) levels were twenty times higher than WHO maximum recommended levels. Conditions in Krakow typified many growing cities in unregulated economies. There, the levels of sulphur dioxide were one hundred times the recommended maximum:

> …170 tons of lead, 7 tons of cadmium, 470 tons of zinc and 18 tons of iron are dumped from the atmosphere onto the historic city of Crakow [sic] every year. On over a third of the days in the year there are smog conditions, almost two-thirds of the food produced in the area is contaminated and unfit for human consumption and 70 per cent of the water can not be drunk. A third of the rivers are devoid of all life, the Vistula is unfit even for industrial use over two-thirds of its length because it is so corrosive and offshore an area of 100,000 square kilometres of the Baltic is biologically dead from the poisons brought down by the rivers.

The roll call of environmental destruction continues: in Tokyo (1960) fish were extinct in three-quarters of its rivers; in Chinese industrial cities sulphur dioxide levels are seven times over the WHO limit; in Cubatao (Brazil) the air pollution level is twice the WHO lethal limit and 80 per cent of plant life has been destroyed.

Pollution was often *exported* intentionally or otherwise by being carried on airstreams and in waterflows well beyond national boundaries, as exemplified by acid rain, which was first identified in Manchester as far back as the 1850s. Acid rain is produced by dissolution of SO_2 and nitrous oxides in atmospheric moisture (all generated from coal-burning power plant) to produce sulphuric and nitric acids. These ubiquitous pollutants, with which we all grew up in the last century, were taken as a fact of life since they 'had always been there'. Unknown to almost all, it was a devastating invader on the environment with shocking statistics which was not tackled until the late 1980s.

> Global sulphur dioxide production rose from about 10 million tons a year in 1860 to 50 million tons in 1910 and to over 150 million tons by the 1970s… ninety per cent of the sulphur dioxide in the air over Europe now comes from human created sources and in just ten years the Sudbury copper and nickel smelter in Ontario, Canada emitted more sulphur dioxide than all the volcanoes (the main natural source) in the history of the earth… Highly acid rain has been noted on a number of occasions, often as low as a PH of 2.1 (vinegar is 2.4) and once at Wheeling, West Virginia, in the heart of one of the most polluted areas of the United States, a PH of 1.5 (battery acid is 1) occurred.

Acid rain affects buildings, attacking limestone, and such damage is evident in many historic buildings in Eastern Europe. It begins to affect wild life when PH falls below 6.0 (PH 6.5 is neutral) especially when combined with heavy toxic metals; *"In water with a PH of 5.5 salmon are affected and molluscs are rare. Between 5.5 and 5.0 there is severe damage to eggs and larvae and snails can not survive below a PH of 5.2. Fish can not live much below a PH of 5.0 and at a level of 4.5 even the flora is badly affected."*

Accumulation of acidified snow has devastating results in the spring melt when water courses and thus lakes receive a burst of acidity. This happened in Sweden and Norway as a result of receiving much acid rain from Britain throughout the latter half of the twentieth century. The PH of Swedish lakes, 6.0 in the 1950s, fell to below 5.0 by the 1980s – 130 years after the problem of acid rain had been noted. Only then were steps taken to mitigate the problem in some countries. In 1984, some industrialised countries agreed to cut their sulphur dioxide emissions by 30 per cent by 1993, and Austria and Switzerland actually cut theirs by 50% by the late 1980s.

From the 17th century to the mid 20th century many people died of industrial pollution. Exposure to lead (pottery glazing), antimony (glass making), mercury (hat trade), lint (cotton mills) and exposure to coal and oil caused a range of illnesses from ulcerated lungs, various types of consumption and cancers. In heavily industrialised areas, the population at large – not just the workers – were also affected by coal burning and the presence of heavy metals. This was exacerbated by poor diet and living conditions. Infant mortality in upper Silesia, for example, was 4.4 per cent; in Katowice: *"Over a third of all children in*

Katowice have symptoms of lead poisoning and overall cancer rates are 30 per cent higher and respiratory disease rates are 47 per cent higher than in the rest of Poland. ... one in five of the Polish population face serious health hazards from high sulphur dioxide levels in the atmosphere."

In the second half of the twentieth century, pollution from synthetic chemicals rose dramatically and disproportionately to population growth. Their toxicity and resistance to natural degradation meant they posed lasting and serious threats to the environment and biodiversity. Apart from plastics and synthetic fibres, chemical companies developed energy-hungry detergents which yield higher profit levels (50%) than the natural alternative of soap (30%). Resulting phosphate pollution levels in water supplies rose dramatically: *"The scale of these changes can be judged by the figures for US synthetic production, which has increased from one billion pounds weight in 1945 to 400 billion pounds in the 1980s."* Two of the biggest problems were generated by pesticides and polychlorinated biphenyls (PCBs). Highly toxic pesticides (DDT and organophosphates) had to be sprayed in large quantities to ensure contact with the targets. Many pests eventually became immune e.g.: "*Twenty-five out of the thirty-six pests that attack cotton are now resistant and there are twenty-four types of mosquito resistant to DDT."* But: *"The increasing use of pesticides has not, in practice, reduced crop losses – they rose from 32 per cent to 37 per cent in the United States between the 1940s and the 1980s."*

PCBs are one of the most carcinogenic chemicals known to us. Developed in the 1930s, they were used in large oil-filled transformers and other appliances as well as an additive in products such as paints. After being banned in Japan and the USA in the 1970s, they continued to be exported to the EC until ten years later when they were banned there as well. "*By then about two million tons had been made and about sixty-five percent of the total is still in use."* The 35 per cent removed has "*…been dumped in the oceans or left to rot in toxic waste dumps, where residues have contaminated water supplies."* Their ubiquity and toxicity can not be overstated: *"They are very stable… highly dangerous… and tend to accumulate in the fatty tissues of animals. PCB contamination has been found in human milk across the industrialised world, and even small traces have resulted in birth defects. …and in the Wadden sea off the Netherlands about half of the seals are sterile because of PCB poisoning.*"

Major industrial accidents on a large scale have also exacted a toll on human and animal life and the environment. Major oil spills (e.g. Torre Canyon – 1967; Exxon Valdez – 1989) and chemical incidents (e.g. Seveso, Italy – 1976, Bhopal, India – 1984) have occurred.

The disposal of waste and obsolescent products became a growth industry, as increased amounts of packaging and non-returnable containers became standard practice. As examples, Ponting cites that in the USA when *"...beer consumption rose thirty-seven per cent ... the number of non-returnable beer bottles increased by 595 per cent."* Also: "*In the 1940s the United States produced about one million tons of hazardous waste. Forty years later the total had risen to over 250 million tons a year."*

Only after the 1970s were any attempts made to control the toxic waste problem. One involved 'exporting' the problem to eastern Europe and the third world where regulations were more lax – or nonexistent. The longer term effects of dumping are manifold. Schools and homes built on landfill have had to be demolished in Holland and North America; asbestos dumped in Hebden Bridge, Yorkshire, resulted in over seventy deaths; methane leaking from the Georgswerder dump in Hamburg caused an explosion in 1984 and still releases over 100 million cubic metres of gas each year.

The medieval practice of polluting rivers, lakes and oceans continues. *"Many states such as Britain and the United States also dump untreated sewage sludge and since the 1960s incineration of toxic chemicals at sea (which produces toxic gases and residues) has become widespread – 100,000 tons are burnt in the North Sea alone."*

The advent of nuclear power since 1945, has brought with it threats associated with nuclear radiation which Ponting describes in alarming terms. The safe level of radiation dosage is unknown although, as a naturally occurring mineral ore, uranium has always been with us and is responsible for low level radiation. By contrast, the mining and processing of uranium ore to generate fuel creates highly-concentrated radioactive rods which have extremely high and dangerous radiation levels and which, when 'spent' in reactors, still have to be disposed safely, making the protection of workers and the public a major issue.

Several nuclear disasters have occurred since the inception of nuclear power. Leaving aside the use of nuclear weapons which are designed to wipe out people, several civil reactors and associated sites have caused major alerts and radioactive and problems (see table).

Nuclear Disasters

Date	Place	Reason	Outcome
1957	Windscale, UK	Fire in core:	Major release of radioactivity – two million gallons milk destroyed.
1957	Kyshytm, Soviet Union	Waste dump explosion	150 square miles of land contaminated; 270k evacuated; est'd 10k deaths;
1979	Three Mile Island USA	Partial core meltdown	No known deaths. Reactor entombed in concrete.
1986	Chernobyl, Ukraine	Reactor explosion	Major radioactive contamination over Europe. 220 villages abandoned.

The fallout of 458 nuclear explosions between 1945 and 1985 has had unknown effects on humans. Ponting states that many deaths have occurred from mining and processing uranium fuel: *" …in the twentieth century half of all uranium miners have died of lung cancer – a rate five times higher than that of the population as a whole. …milling of uranium ore causes about 4,000 deaths a year from lung cancer in the United States alone."*

Attempts to dispose of waste via dumping have also caused major problems: "*In 1949 the Soviet authorities started releasing liquid nuclear waste into the Techna river near Sverdlovsk. By 1952 it had reached Lake Karachai near Kyshytm, where the heat from the decaying radioactive material dried out the lake and the radioactive bed of the lake had to be covered in concrete to stop wind erosion spreading the dangerous pollution any further.*"

The internal combustion engine has been an increasingly major contributor to pollution since World War II, emitting carbon dioxide, smoke, nitrous oxides, carbon monoxide as well as other toxic organic compounds. These react in the air to produce ozone and peroxides which can adversely affect photosynthesis and breathing. Burning motor fuels produced photochemical smog and vast quantities of lead until lead free fuels were introduced. Measures were taken to reduce pollution from the refineries by 90 per cent in the 1940s and 1950s but we had to wait until the 1970s for the availability of lead-free petrol and for catalytic converters to be developed and fitted to motor vehicles. The first smog occurred in Los Angeles (which has a natural inversion layer) in 1943 and by the late 1980s it affected over 100 American cities. Los Angeles itself suffered from it for over 200 days in a year. In Tokyo, 50,000 people were disabled by it in 1972 and in Mexico City there were 312 days of smog in 1988. Catalytic converters helped remove the most harmful chemical from exhausts, but they could do nothing about the major pollutant – carbon dioxide.

Photochemical smog illustrates the cocktail effect of pollutants. When the whole gamut of pollutants – exhaust fumes, CFCs, acid rain, heavy metals, excess ozone and other toxic chemicals such as tetrachloroethylene (dry cleaning fluid) and trichloroethylene (lubricant) – mix together in various combinations, there is generated a range of 'cocktails' which can adversely affect many things, in particular trees. Tetrachloroethylene, for example, reacts with ozone and UV light to produce the herbicide TCA. Consequently:

> Most of the great industrial areas were rapidly deforested… In Norway fluoride emissions from aluminium smelters have killed all pines within a four mile radius … no trees grow for twelve miles downwind of the magnesite brick factory at Satke in the Urals … In West Germany 8 per cent of the conifers were damaged in 1982, 50 per cent by 1984 and 87 per cent two years later ... in Poland three-quarters of all forests are affected (about 100 million trees) …Overall more than 20 million acres of forest in Europe had been damaged by the mid-1980s (an area equivalent to a third of the British Isles).

Wildlife all over the world has been affected by artificial chemicals. DDT has been a major culprit as, when sprayed, it can be carried on the wind over vast distances. *"When in 1983-4 the East Germans sprayed DDT...residues were detected over a 1,000 mile range from North of Stockholm to the south of France."* Food chains were affected, as illustrated by the attempt to use DDT at one part in 50 million to clear gnats at Clearlake, California, in 1949, 1954 and 1957:

> The level of DDT found in plankton was 250 times greater than in the water, in frogs it was 2,000 times more, in fish 12,000 times and in the grebes who fed on the fish 80,000 times greater. As a result the grebes at the top of the food chain had 1,600 parts per million of DDT in their bodies; their eggshells became so thin that they cracked under the weight of the bird and of the 1,000 pairs of grebes in the area not one hatched a chick between 1950 and 1962. It was the implications of this ecological disaster, which had been repeated elsewhere with other chemicals, that led Rachel Carson to write *Silent Spring.*

Pollution knows no bounds on earth: "*Even cores from the Antarctic ice sheet, supposedly the last wilderness on earth and even more remote from the industrial centres of the northern hemisphere, show that lead levels have quadrupled since the eighteenth century."*

Another pollutant is ozone. An enemy at ground level where it attenuates plant photosynthesis, it is an ally 18 miles into the stratosphere where it absorbs damaging ultra-violet rays from the sun. Unfortunately, it is vulnerable to CFCs which produce chlorine, one atom of which can destroy 100,000 ozone molecules. CFCs were invented in the 1920s since when they have been used in refrigerators and spray cans among other applications. When sprays were used or refrigerators scrapped, the discharged CFC gas would find its way up to the stratosphere and break down the ozone layer. Production of CFCs rose from 100 tons in 1931 to 650,000 tons over 55 years. The result was a thinning ozone layer which, by 1982, became a hole with an area of the United States which drifted around over the lower southern hemisphere. With the UV protection gone, skin cancer became rife in Australia and South America. With growing public awareness of the problem, CFCs were eventually banned by international agreement. It is likely, however, because of the long life of CFCs, that the hole will persist well into the 21st century.

Carbon dioxide, methane, nitrous oxide and CFCs are all greenhouse gases which, when present in the correct concentration, maintain a stable average temperature of the atmosphere, but when present in excess will cause it to warm. Many of these are produced when fossil fuels are burnt to provide the ever-increasing energy demands of mankind. Ponting notes that: "*Annual consumption of coal is now over one hundred times greater than it was in 1800 and annual oil consumption has increased more than two hundred-fold in the twentieth century.*" The waste from these processes has been primarily carbon dioxide, about half of which is absorbed in the oceans with the remainder going into the atmosphere to be used in plant growth. *"The net result of these various human activities is that the amount of carbon dioxide in the atmosphere has risen by a third in the last two hundred years – from about 270 parts per million in 1750 to 350 parts per million in the late 1980s."* The increase in carbon dioxide emissions arising both from industrialisation and the conversion of forest to agriculture and paved areas has resulted in temperature increases: *"Meteorological observations suggest that in the course of the twentieth century global temperatures have increased by 0.5^{o}C, with the 1940s being warmer and the 1950s and 1960s cooler than the average. The 1980s were the warmest decade since records began …1990 was the warmest on record."*

Methane, generated by animals, paddy fields and decaying vegetation further promotes global warming and as the tundra melts vast quantities are released, causing positive feedback to the whole process. A report from the UN IPCC (Intergovernmental Panel on Climate Change) estimates: *'…emissions of greenhouse gases will be equivalent to a doubling in current levels of carbon dioxide in the atmosphere by 2030. This, according to the panel of experts, is likely to produce a temperature rise of between 1.4 - 4.5 ^{o}C with 2.5 ^{o}C the most likely outcome, above pre-1850 levels by 2030.'* It goes on to conclude that: *"…consequences of global warming on this scale will be profound for the whole of the world. Climatic patterns are likely to alter drastically but unevenly. … The most likely outcome is that the earth's vegetation belts will shift towards the poles, but in an uneven way.'* With areas such as the Mediterranean and the North American plains getting drier, the contrast with earlier periods of climate change "*will be not just the magnitude of the change (more than ever experienced before by settled societies) but the rate of change.*"

The social effects of the change could be migration on an unprecedented scale, especially from flooding as: "*A 2.5^{o}C rise in temperature is likely to cause sea levels to rise significantly across the world, although the effects will vary from area to area. Among the areas most at risk of coastal flooding and salt water infiltration into drinking water are the Nile delta and Bangladesh, and low lying islands such as the Maldives could even disappear altogether. Ocean currents could also shift in unpredictable ways leading to further changes in temperature and rainfall across the globe.*"

Ponting ends the chapter by putting our polluting activities into historical context:

> Ecosystems all over the world have now been affected to varying degrees by pollution of various types. Even Antarctica has been polluted, so far-reaching has been the spread of industrial pollutants. Evidence about how resilient plants, animals and humans are to the risks and long-term stresses associated with pollution is still accumulating. It is, however, already apparent that the effects of pollutants have become more threatening. Actions have been taken with very little thought for the consequences, particularly in the case of highly toxic chemical and CFC production. The output of greenhouse gases is likely to have the greatest and most widespread effects of all the pollutants so far produced by humans. After ten thousand years of settled societies and only two hundred years of substantial industrialisation, human activities and the pollution they generate threaten irreversible changes on an unprecedented scale to the world's climatic system.

FOOD, ENERGY, AND SOCIETY (3rd edition), Part 2

by David Pimentel and Marcia H. Pimentel, compiled by Andrew Ferguson

Hunter-Gatherers and Early Agriculture (continued)

52.8 When the New Guinea community was studied, the village numbered 204 inhabitants and occupied about 830 ha. Only about 364 ha of this land was suitable for cultivation. The village annually planted about 19 ha of crops, but because some crops required 2 years before they could be harvested, about 37 ha were cultivated at any one time. As a result, nearly 90% of the village croplands lay fallow each year. The villagers' food was almost entirely (99%) of plant origin. …

The adult person's diet averaged about 2400 kcal/day and contained about 35 g of protein, mostly of plant origin. This protein intake is low by current Food and Agriculture Organization (FAO) standards, which recommend a daily intake of about 40 g of protein per day for an adult living under these conditions. …

From the 11.4 million kcal/ha harvested, as noted, 45% (5.1 million kcal/ha) was fed to the pigs. If 65 kcal were required to produce 1 kcal of pork, the yield would be only 78,461 kcal/ha. This 78,461 kcal, added to the 6.3 million consumed directly by humans, provides a total yield of food energy of 6.4 million kcal/ha [i.e. enough to support 7 people per hectare at 2400 kcal/day; but note that if it is necessary that 90% of the cropland should lie fallow, then 1 hectare of the area suitable for cropland supports less than one person; as is also obvious from the fact that in order to allow sufficient fallow periods, 204 people need 364 ha of land suitable for cultivation.] Rappaport (1968, 1971) mentions one advantage to pork production: Keeping pigs was a practical way to store some of the excess food during productive years. When crop harvests were poor, the villagers slaughtered some of the pigs to provide the needed food.

59.1 The Dodo tribe illustrate the important role that livestock can play in providing food for humans. First, the livestock effectively convert forage growing in the marginal habitat into food suitable for humans. Second, the herd serve as stored food resources. Third, the cattle can be traded for sorghum grain during years of inadequate rainfall and poor crop yields.

61.1 …the total energy input to till 1 ha by human labor alone is about 200,000 kcal.

Oxen, small hand tractors, and 50-HP tractors all require a greater total energy expenditure to till the same hectare of land. However, it should be noted that all these other power systems can complete the tilling task in far less time than the human can. For example, two oxen take only 65 h but expend almost 50% more energy than a human does. The oxen must be fed and need a person to guide them as they work. Likewise 6-HP and 50-HP tractors take much less time — 25 and 4 h, respectively — to till 1 ha than humans. But they use far more energy than either humans or oxen because of the large input of petroleum needed to run the engines. [The table shows that humans take 400 hours, and that the two tractors use total energy that amounts to 441,000 and 553,000 kcal respectively.]

62.8 Many nations have replaced draft animals with tractors and other machinery. For example, when the United States was first settled in 1620, human muscle power was the prime power source for work, but by 1776 an estimated 70% of the power was supplied by animals and only 20% by humans. By 1850 animal power had declined to 53% and man power to 13%. By 1950, about 100 years later, animal and human power had declined to only about 1%, and fossil-fuel-powered engines provided 95% of the power. Thus, a dramatic change with far-reaching consequences has taken place, as humans continue to consume ever-increasing quantities of non-renewable fossil fuels.

Animal Food-consumption Patterns

63.5 Throughout history animals, either hunted or husbanded, have been valued by humans for food. Even so, the majority of humankind has had to depend primarily on plant materials for energy and other nutrients. Even today most of the world's people live on about 2500 kcal/day and obtain most of their food energy and protein from grains and legumes.

63.8 A study of 12 rural villages in southern India showed that individuals consumed, on average, between 210 and 330 g of rice and wheat, 140 ml of milk and 40 g of pulses and beans per day. This diet provided about 1500 kcal and 48 g of protein per day, with a major share of both calories and protein coming from plants. …

In central America, laborers commonly consume about 50 g of corn per day. Along with the corn they eat about 100 g of black beans per day, and together these staples provide about 2118 kcal and 68 g of protein daily. The corn and beans complement each other in providing the essential amino acids that humans need. Additional food energy is obtained from other plant and animal products. …

A sharp contrast to all these examples is found in the United States, where the daily protein intake is 112 g, of which 75 g is animal protein. U.S. per capita animal and animal protein consumption is among the highest in the world, although similar consumption patterns appear in many highly industrialized nations in Europe. In 2006, annual U.S. per capita meat consumption was 92 kg.

Nutritional Quality of Protein Foods

65.3 One of the important considerations in evaluating the relative value of plant and animal protein sources is their nutritional content. A broad comparison shows, for instance, that one cup of cooked dried beans (190 g) is quite similar to an 85 g serving of cooked ground beef in the amounts of protein, iron, and important B vitamins. Further, the beans contain no fat, no cholesterol, and no vitamin B_{12}.

Although these foods contain similar amounts of protein, the nutritional quality of the protein differs in terms of both the kind and amounts of "nutritionally essential" amino acids. Animal proteins contain eight essential amino acids in optimum amounts and in forms utilisable by humans for protein synthesis. For this reason, animal proteins are considered high-quality proteins. … In addition, some plant proteins are deficient in one or more essential amino acids. … Fortunately, it is possible to combine plant proteins to complement the amino acid deficiencies. Thus, when cereal and legume proteins are eaten together, the combined amino acid supply is of better quality than provided by either food eaten alone.

More attention and thought must be given to planning a diet that is either limited in or entirely devoid of animal protein. Variety is of prime importance in achieving a nutritionally balanced diet under such constraints. Further, because B_{12}, an essential vitamin, is not found in plant foods, this must be taken as a supplement.

ESTIMATING THE PEAK OF WORLD COAL PRODUCTION

by Andrew R.B. Ferguson

Abstract. Estimates of coal reserves and resources, based on even the most careful geological assessments, have often been wrong by a factor of three or more. This makes it hard to refute the arguments put forward by David B. Rutledge of the California Institute of Technology, and the Energy Watch Group — using a sounder methodology — that coal production will peak around 2025 (or be only slightly delayed from that by the economic downturn). The world needs to prepare for the prospect of living with a reducing supply of fossil fuels. On present evidence that means having a far smaller population to support.

Although the focus of this paper is coal, it is necessary to start by looking at oil and natural gas in order to see the similarities and the differences. As early as 1956, Shell geologist M. King Hubbert argued that oil production in the USA would peak in 1970. He later went on to estimate the peak of world oil production as likely to occur around the year 2000. In both cases he used methods which had not been employed previously. Almost no one believed him until the peak of production in the USA actually did occur at the time that he had predicted.

After that, many people turned their attention to applying Hubbert's techniques to predicting the peak of world oil production. The story is well told by petroleum geologist Colin J. Campbell in *The Coming Oil Crisis* (1997). Other people involved in similar efforts include A.A. Bartlett, K.S. Deffeyes, R.C. Duncan, L.F. Ivanhoe, J.H. Laherrère, Walter Youngquist. They generally predicted the peak as likely to occur around 2005-2007. While it would be untrue to say that no one believed these 'peak oilers', as they became known, it was certainly the case that the media gave equal weight to those who said that the peak was at least forty years away (and that was quite long enough to ensure that politicians would think it unnecessary to take any action!). Others, who should have known better, the *Economist* for example, encouraged the boom by predicting that oil would soon be down to $5 a barrel.

The current financial problems make it difficult to be certain, but it seems likely that without the recent sudden slow down in economic activity, the 2005-2007 estimate for a peak would have been correct. Until economic activity picks up again, we are likely to experience a plateau in production.

Kenneth Deffeyes knew Hubbert well. In one of his books, *Beyond Oil* (2005), he has done more than anyone to explain the various techniques Hubbert employed. He sums up the situation, on page 35 of the book, thus:

> Even today, Hubbert's methodology is widely misunderstood. Hubbert inadvertently contributed to some of the confusion. His early oil papers have kind of a take-it-or-leave-it flavor. Not until 1982 — when he was seventy-nine years old (what I now call "mid-career") — did he publish his reasons for preferring certain formulas. The 1982 paper is pure Hubbert; he never hints whether he knew the 1982 explanation all along or whether he worked out the derivation long after the fact. Also, Hubbert never points out that the graphical method he explained had already been in use for some years by population biologists.

The simplified interpretation of Hubbert's 1982 paper as given by Deffeyes is also explained on pages 20-21 of OPT Journal 8/2, *Growth Rate Plots: An Introduction to the Concept*. What is distinctive about Hubbert's 1982 methodology is that it uses past rates of production to predict the oil remaining to be extracted, rather than relying partially on the intractable estimation of reserves, and resources that might become reserves.

Natural gas is more difficult to predict than oil, because gas occurs in a much greater set of environments than does either coal or oil, and because recent technological developments have greatly increased the potential for production. However, the *Association for the Study of Peak Oil*, and Jean Laherrère in particular, have made fairly definite predictions of a peak for gas about twenty years after the peak in oil production. Gas has similarities to oil, but both are different from coal. For coal, the main problem is how much can be extracted from what are thought to be the resources. The term 'resources' is used with somewhat different meanings, but here we will use a broad definition, "The quantity of coal in situ, 50 percent of which at most can eventually be recovered." As we will see later, "at most" is critical, and the amount of coal that is classified as a 'resource' changes greatly; the trend is markedly downwards.

As we will also see later, coal reserves, too, tend to drop. The situation with oil and gas is the opposite. With oil and gas, because there will be further discoveries, one would expect reserves to increase as time passes. And indeed this is what has always happened; with oil companies encouraging their shareholders by pointing out each year that they are increasing their reserves — although in recent years they have only been able to do so by indulging in a certain amount of 'cheating'!

What makes coal so entirely different from oil and gas is that although the resource appears to be vast, there is great difficulty in deciding how much will be extracted. This problem is something that David B. Rutledge, chair of Engineering and Applied Science at the California Institute of Technology in Pasadena, tackled in his Earnest C. Watson lecture, *Hubbert's Peak, the Coal Question, and Climate Change*, given on 19 October 2007. It is available on CD and also, together with the Excel file, is available to view and download at http://rutledge.caltech.edu; the huge Excel file which is the basis of Rutledge's presentation is a valuable resource. An outline of Rutledge's presentation was given on pages 22-28 of the OPTJ 8/2. Now we will look further at his arguments, with particular reference to coal.

The UK is a useful case in point because, starting around the time of the book by economist Stanley Jevons, *The Coal Question*, 1865, extensive efforts have been made to assess the amount of coal that would be extracted in the future (and hence could be classified as reserves). We now know fairly accurately the total amount of coal that will be extracted in the UK, about 27 billion tonnes (27 Gt), so we can see how good the estimates were. Rutledge's Excel graphs show that two Royal Commissions, in 1870 and 1904, put the ultimate total of UK coal that would be extracted at 95 and 111 Gt respectively. In 1955 the National Coal Board reduced this estimate to 66 Gt. Lower estimates were also made around this time, but only from 1984 did the World Energy Conference and World Energy Council's estimates get close to reality, by all being below 30 Gt.

Rutledge gives similar examples for coal in the USA. In 1922, an estimate made by Marius Campbell, published as a USGS Professional Paper, indicated that the ultimate total of US coal that would be extracted would be 2300 Gt. By 1952 Paul Averitt et al. had reduced that estimate to 890 Gt. By 1973 Paul Averitt had produced a revised estimate based on demonstrated (measured and indicated, but not inferred) coal — with many restrictions related to practical problems of extraction — of about 230 Gt. Since then the

Energy Information Agency (EIA) annual coal reports have shown slightly higher estimates for the ultimate total of US coal that would be extracted, about 300 Gt.

In summary, what Rutledge shows is that these estimates of reserves, made with every care to allow for the many problems of coal mining, requiring many man-years of work, often proved wrong by a factor of three or more. The conclusion is that efforts to estimate reserves of coal by such methods have very little validity.

So another method is needed. What Rutledge demonstrates is that by applying Hubbert's technique of looking at changes in the rate of production, a fairly accurate estimate of UK coal could have been made with considerable confidence by about 1920. Rutledge then applies this technique to all coal mining areas in the world where there are sufficient data to warrant application of the method. Where data are lacking, he falls back on reserve estimates. In his lecture, he arrived at a figure for the remaining world coal to be extracted of 435 Gt, at an average 21 gigajoules per tonne (GJ/t). In a subsequent communication he has indicated that his latest estimate, for 2008, is 376 Gt (at 21 GJ/t). Based on 435 Gt remaining, as per his lecture, Rutledge indicated a peak of coal production at about 2020.

Using a slightly different approach to Rutledge, the Energy Watch Group (EWG), in their impressive 47 page analysis (2007), provide a graph (p. 19) which puts the peak (in energy units) of coal production in the year 2025. The graph finishes at 2100. Analysis of the graph indicates that the coal to be extracted between now and 2100 will amount to 570 Gt (at 21 GJ/t). Werner Zittel, one of the two people responsible for the paper, kindly confirmed the correctness of this estimate that I extracted from the graph. Extrapolating the curve indicates that the coal still to be extracted is about 600 Gt (at 21 GJ/t).

The difference in time between the peak estimated by Rutledge (2020) and by EWG (2025) may seem too small, considering the differences in the estimation of the amount of coal that remains to be extracted, but as annual coal production is estimated to peak at 7.2 Gt/yr (at 21 GJ/t), the small difference in timing of the peak is explicable (as a rough approximation the extra coal needs to be divided by two and divided by the annual rate, to estimate the displacement of the peak).

The actual difference between the estimates of Rutledge and the EWG is not at all surprising within the context of this statement in the EWG paper (p. 5): "Even though the quality of reserve data is poor, an analysis based on these data is deemed meaningful. According to past experience, it is very likely that the available statistics are biased on the high side and therefore projections based on these data will give an upper boundary of the possible future developments."

There is some difference in the methodology of Rutledge and the EWG. Rutledge is essentially using Hubbert's 1982 approach to predict, *on the basis of changes in rates of production*, the amount that remains to be extracted. EWG, on the other hand, as stated on p. 25, adopts this methodology: "A bell shaped curve is fitted to the historical production data and to the available proved reserve for each country. These production profiles do not take account of possible restrictions such as coal quality…." Thus the EWG is approximately following Hubbert's earlier procedure.

The estimates made by both Rutledge and EWG call into question the validity of the range of reserve estimates made by all the major organizations that give reserve figures for coal, as per Table 1. These figures are all much higher than either Rutledge or EWG estimates, but as has already been shown, there is little doubt that reserve estimates made according to even the most detailed and careful geological assessments have proved again and again to be vastly in error.

Table 1	Date	Type of coal			Total (Gt)
		hard coal		sub-bit and lignite	
Energy Information Agency	1990		not specified		1174
Energy Information Agency	2000		not specified		1083
Energy Information Agency.[1]	2006	474		465	939
Chow et al	2002		not specified		983
World Energy Council[2]	2002	479		430	909
BP Stat Rev World Energy	2004/6	479		430	909
World Energy Council	2005		not specified		848
Thielemann et al[3]	2005		not specified		954
BP Stat Rev World Energy	2007	431		417	848
World Coal Institute[4]	2007		not specified		847

1. These sub-divisions of total coal have been derived from the mean percentage of categories in the world's five major producers.
2. Cited in Energy Watch Group, 2007, p.11.
3. Thielemann includes sub-bituminous in "hard coal"; lignite was 207 Gt.
4. Derived from their Reserve/Production ratio on the basis of a production of 6.36 Gt/year.

What remains for further enquiry is whether any significance should be attached to the sometimes huge figures that are given for coal *resources*, which tend to be presented with an unspoken intimation that a substantial part of those resources will in time be turned into reserves, i.e. be made available for use. Both EWG and Rutledge show that there is no, or little, evidence for this. They make essentially the same two arguments. EWG shows, p. 11, that in 1976 coal resources (including reserves) were being estimated at 14,000 Gt (at 21 GJ/t); 29 years later, in 2005, the estimate had been reduced by 55% to about 6,000 Gt (at 21 GJ/t). Thus the first argument is that resources have been declining dramatically, and the fact that they now stand at about 6 times what are conventionally accepted as 'reserves' is a matter of little consequence, when set in the context of the second argument, namely that far from being replenished from resources (as oil and gas have been until recently) the reserves are declining. The point is well made by EWG (p. 5):

> Indian hard coal reserves have been upgraded over time from 12.6 Mt in 1987 to 90 Mt in 2005. Australian hard coal reserves have been upgraded from 29 Mt in 1987 to 38.6 Mt in 2005. All other countries have individually downgraded their hard coal reserves by a combined 35% over the same period. In the global sum, hard coal reserves have been downgraded by 15%. Adding all coal qualities from anthracite to lignite reveals the same general picture of global downgradings. The cumulative coal production over this period is small compared to the overall downgrading and is thus no explanation for it.

A search of the literature reveals only a paper by Thielemann et al (2007) which is clearly focused on addressing the question of coal reserves. It is the only one on the subject in the *International Journal of Coal Geology*, from the year 2007 up to the present, giving detailed consideration to the future availability of coal. Nothing comparable was found in the journal *World Coal* over the same time scale. Thielemann's team was based in the Federal Institute for Geosciences and Natural Resources in Stilleweg, Germany. They specifically addressed the question of whether there was an immediate threat to the supply of coal. They include sub-bituminous coal in their definition of "hard coal" and present lignite separately. For the years stretching from 2005 to 2100, they present their data and predictions for reserves and production from which it is possible to calculate the expected replenishment of reserves from resources as shown in Table 2.

Table 2	Reserves Gt	Production Gt/yr	Cumulative production since 2005 Gt	Remaining reserves *without* replenishment from resources (Gt)	Replenishment of reserves from resources (Gt)
2005	746	5.0	0		
2020	672	7.2	92	655	18
2030	642	8.2	169	578	65
2050	576	9.8	349	398	179
2100	321	10.5	856	-110	431

As is apparent from the last column, Thielemann et al. are taking the view, contrary to the EWG and Rutledge, that resources can be turned into reserves on a substantial scale. Were the last estimate of resources, as given earlier, 6000 Gt (at 21 GJ/t), to be true, then it is clear that production could continue at 10.5 Gt/yr for hundreds of years. It is thus vital to know whether there is likely to be any truth in the proposition that there are resources available to replenish reserves. Thielemann et al. advance no reasons for believing that this refurbishment of reserves from resources will exceed the downgrading of reserves. Yet we have strong arguments by the EWG to the effect that rather often, if not invariably, reserves are diminished over time by amounts that exceed the amount that has been extracted, indicating inadequate replenishment from resources. In opposition to this, no one, including Thielemann et al., appears to have put forward a counter argument. It is of course possible that coal gasification will play a significant role in making it possible to use more of the resources, but until that, or other technological solutions, are clearly established as being practical, it cannot be wise to assume success, but instead we should plan for the possibility that, as Rutledge indicates, half of *all* extractable fossil fuel will have been used by 2021 and 90% by 2076. It is true that these estimates would be affected by a prolonged global depression, but that is a way of postponing the problem that is not going to commend itself to the public. The urgency of reducing populations to levels that could be sustained in moderate comfort without fossil fuels must be a primary objective.

References

Campbell, C.J. 1997. *The Coming Oil Crisis*. Essex, U.K.: Multi-Science Publishing Company & Petroconsultants S.A. 210 pp.

Deffeyes, K.S. 2005. *Beyond Oil: The View from Hubbert's Peak.* New York: Hill and Wang.

Energy Watch Group. The latest update of the March 2007 report is available at: http://www.energywatchgroup.org/fileadmin/global/pdf/EWG-Coalreport_10_07_2007.pdf

OPTJ 8/2. 2008. *Optimum Population Trust Journal*, Vol. 8, No 2, October 2008. Manchester (U.K.): Optimum Population Trust. 28 pp. Archived on the web at www.optimumpopulation.org/opt.journal.html

Thielemann, T, Schmidt, S, Gerling, JP. 2007. Lignite and hard coal: Energy suppliers for world needs until the year 2100 — An outlook. *International Journal of Coal Geology* 72 (pp.1-14).

AGE OF STUPID

Report on a review by Sandy Irvine, NE England Green Party, http://www.sandyirvine.pwp.blueyonder.co.uk/ , of the film *The Age of Stupid*

For many years, Sandy Irvine was editor of a magazine *Real World*, a worthy precursor of the OPT Journal, like it focusing on population. That effort terminated some time ago, but he now brings his background of experience in media technology and teaching to managing his own *Ecological Sustainability* website, the address of which is given above.

One of the many interesting items on his website is a review of a film that attempts to tackle a recurring theme of the OPT Journal, namely that most of the world is behaving with singular stupidity in remaining oblivious to the nature of the crisis that the human race is racing towards. The full review of the film – 5 pages – can be accessed at the *Ecological Sustainability* website. Based on Sandy's review, taking substantial segments from it, here is a brief overview.

The Age of Stupid has a fictional linking device in which an old man (Postlethwaite) looks back from 2055 to the world of today and wonders why people did not take due action over climate change. Computer-generated-imagery is used to communicate what has happened in the decades before 2055. Some sections also employ more traditional animation. The film leaves the audience in no doubt about the threat posed by climate change, with its potential to wipe out humankind. However this is not just a different version of Al Gore's documentary presentation of the dangers of climate change. Instead it attempts to look at many individual reactions. It presents these well enough, but it is not obvious whether *The Age of Stupid* team has a clear vision of just what we will have to give up.

Like the vast majority of documentaries and other media products, even including many publications from the 'world development' movement, *The Age of Stupid* virtually ignores the population 'elephant in the room'. The growth of human population over the century is briefly mentioned but its significance is ignored. Of course *The Age of Stupid* team is not alone in suffering Overpopulation Denial Syndrome. George Monbiot frequently uses his *Guardian* column to sneer at those who recognise the threat from human numbers. The political weakness of the film is shown in other ways. It leaves open the door to the illusion that salvation can be found by new technology.

Immigration is a related issue, pregnant with adverse ecological consequences. But the film has nothing to say on that vital matter. Hence it does not tackle a subject which recurs in the OPT Journal, but which people in general seem even more eager to avoid than the subject of population in general. Yet that subject is plain commonsense. It is evident that the whole world is not going to wake up to the complicated problems of overpopulation and degradation of the environment and take appropriate action. Indeed even if India woke up, and went so far as to implement a policy of population control as draconian as that used for many decades by China, it would do little more than alleviate India's problem, because, as is evident from China's experience, with a population spread in which younger people vastly predominate, it will take half a century before actual population decline starts to occur. Thus the unwelcome truth — which no one wants to face — is that although there is a *possibility* of civilization being preserved in some places, it will not be preserved *anywhere* without the ability of some nations to prevent themselves being swamped by immigrants from less prescient countries.

Sandy Irvine sums up his view of the film in these terms: Rather weak ecology, overly populist politics, and too much laxity in the editing suite have led *The Age of Stupid* team not to make the most of the opportunity.

INTERNATIONAL MIGRATION AND OVERPOPULATION

by James P. Duguid and Andrew R.B. Ferguson

OVERPOPULATION. Overpopulation is the primary and neglected cause of most of mankind's troubles. The number of people in the world is now too great to be fed adequately by the output of food, and it is still growing. The Population Reference Bureau's 2008 Data Sheet (PRB 2008) gives the world's population at mid-2008 as 6705 million, and its Total Fertility Rate (TFR) as 2.6 births per woman. That TFR is well above the replacement rate of TFR 2.1 for a stable population with a low mortality. The annual growth (births minus deaths) is 1.2%, which adds 80 million extra people a year.

NET IMMIGRATION INTO THE MORE DEVELOPED WORLD. PRB 2008 estimates that the **more developed nations** now have 1227 million people, with a TFR of 1.6, yet projects the *addition* of 42 million people by 2025. This is because net immigration is currently at the rate of 0.3% per year, which negates any easing of numbers through the current low TFR. Were this 0.3% rate to continue, population would increase by 62 million by 2025. Thus the addition of only 42 million indicates that with balanced migration population would *fall* by 20 million by 2025, to 1207 million.

The extent of the problem, within some representative developed nations, is shown in Table 1. The degree to which net immigration is preventing the developed nations from achieving a much needed reduction in population is apparent from the table. In all cases, the chief cause is net immigration, including illegal immigration, which though hard to quantify can be of even greater importance than legal net immigration, as it is in the USA. The need to have balanced immigration can hardly be exaggerated, because few of the less developed nations are showing any inclination to achieve population levels that will be sustainable when fossil fuels become scarce, yet several developed nations have success within their grasp (because they have cylindrical 'population structures' and low TFRs) *provided only they do not allow their efforts to be overwhelmed by net immigration*.

Table 1. Annual rates of growth from 'natural' increase and immigration, as a percentage.

Country	Natural rate of increase % [a]	Net immigration [b] (legal + illegal) %	Therefore total rate of annual increase %
United Kingdom	0.3	0.3 + 0.1	0.7
Italy	0.0	0.8 + ?	0.8 + ?
USA	0.6	0.3 + approx 0.7	1.6 (approx) [c]
Canada	0.3	0.7 + ?	1.0 + ?
Australia	0.7	0.9 + ?	1.6 + ?

a. Figures for natural increase (births minus deaths) include the number of births to new (first generation) immigrants when in the receiving country.

b. Official figures for the net immigration do not include those for illegal immigrants. Estimates for illegal immigration into the UK are about 50,000 a year, adding about 0.08% to net immigration. Those for the USA fall within the range of 2 to 3 million per year (0.7% to 1.0%).

c. In an October 2006 paper, *Census Bureau Distortions Hide Immigration. Real Numbers Much Higher*, published in *Population-Environment Balance* (http://www.Balance.org), Professor Virginia Abernethy showed that there is a massive undercounting of illegals, so that the actual rate of increase of population in the USA is likely to fall in the 1.4%-1.7% range.

Italy illustrates a case where legal net immigration appears to be the *sole* cause of population increase; figures for illegal immigration are not available. Efforts have been made to study the extent of illegal immigration into the USA; illegal immigration has been put in the region of 2 to 3 million. Based on the lower estimate, that still amounts to double the legal immigration. In handling these levels of immigration, the USA is experiencing social difficulties similar to those later to be outlined for the UK.

The lack of foresight of governments is astonishing. Heating is imperative in the very cold winters of Canada, yet the Canadians are burning up their natural gas to produce oil from tar sands, while at the same time allowing net immigration to increase their population at twice their natural rate of increase. Australia has already seen the problems that it may soon encounter through water shortage exacerbated by climate change, yet allows net immigration to exceed the current natural rate of population increase.

HIGH TFRs. The problem for the less developed world is usually not net migration but high Total Fertility Rates, or, as with China, a recent past of high fertility.

Less developed nations excluding China have 4154 million with a TFR of 3.2, and are expected to add **1101** million extra people by 2025 (a 25% increase). Births average 2.6% of population a year, far exceeding deaths of 0.9% despite high child mortality.

Asia excluding China has 2728 million people with a TFR of 2.8, and is expected to add **589** million by 2025 (a 22% increase).

Africa has 967 million people with a TFR of 4.9, and is expected to add **391** million by 2025 (a 40% increase).

Latin America/Caribbean has 577 million people with a TFR of 2.5, and is expected to add **110** million by 2025 (a 19% increase).

China, with 1325 million people and a one-child-family policy, has a TFR of 1.6, the same as the more developed nations, but despite the low TFR, on account of its excess of women of childbearing age, it is projected to add **151** million by 2025 (an 11% increase).

Total world population is expected to rise from 6705 million in 2008 to 8000 million in 2025 (a 19% increase). Predictions for 2050 vary from 8000 million to 11,000 million, the lower figure reflecting a rapid decrease in rate of growth from the current 1.2% per year to an average, over the whole period, of 0.4% per year.

FOOD SUPPLY. Malnutrition is widespread, especially in the less developed countries. In 2003, the UN Food and Agriculture Organisation (FAO) estimated that of the world's 6000 million people, 840 million were very deficient in calories and proteins, and another 2000 million deficient in particular vitamins or minerals, e.g. iodine and selenium. Over subsequent years there has been no sign of improvement. About ten million children die each year from infections enhanced by malnutrition. This death rate substantially lowers the population growth that would occur otherwise, and is of course a manifestation of the checks to population growth envisaged in 1798 by T. R. Malthus. Whether or not the PRB consciously include this factor in their projections for a population of 9,300 million by 2050, it is likely to be an important factor.

After 1750, advances in agricultural technology raised the output of food sufficiently to support a ten-fold growth of the global population from about 600 million in 1750 to 6700 million in 2008. This increased production depended on a heavy use of fossil fuel, mainly petroleum oil, for mechanised cultivation and transport, and for the production of artificial fertilizers, weed-killers and pesticides.

There are some promising ways to improve food supply, particularly in the less-industrialized world. For instance, it was reported in the March 2008 *Ecologist* that "in an analysis of more than 286 organic conversions in 57 countries, the average yield increase was found to be an impressive 64 per cent." Nevertheless there are many contrary factors.

Petroleum oil is the most convenient and versatile fossil fuel, easily transported, and so far it has been abundant and cheap. But output has now either peaked or reached a plateau. High oil prices will pose a growing burden and impediment on food production.

The cereals wheat, maize and rice are man's main foods. Output increased after 1960 through the use of new breeds, but output per inhabitant fell after 1985.

Climate change may cause the **flooding of low lands** and droughts in other areas. Much of the world's food production depends on **irrigation**, and this production is being restricted by shortages of water and the salination of land irrigated without drainage. Piped drip irrigation in dry areas would increase production, but would require much energy and labour to install widely.

About 70% of the world's **fresh water** is used for agriculture, and 30% for homes and industry. The WWF Living Planet Report 2004 noted that withdrawals from surface and underground sources almost doubled between 1960 and 2000. Large rivers are now drying up in rainless periods and underground aquifers are being depleted faster than they are being replenished. Many countries are becoming stressed by **water shortage**. The UN estimates that by 2025 two-thirds of the world's population will be living in countries with inadequate water resources.

Intensive cropping or grazing, with the removal of trees and wind-breaks, is leading to the **erosion of top-soil** by wind and rain, so reducing its depth and fertility. Much land is being lost to urban developments. Small, efficient farms are being replaced by agribusinesses which monocrop large areas in ways that reduce fertility. The minerals needed for plant growth are being leached from the soil into the rivers and seas, and a substantial proportion of the minerals that are eaten and excreted are piped to the sea in sewers. Sewage sludge is used as a complete fertilizer, but its contamination with toxic metals from towns and industries can limit its use.

The WWF Living Planet Report 2004 shows that **over fishing** has reduced landings in most areas by up to 12% since 1970. Cod and tuna caught in the North Atlantic fell by two-thirds between 1950 and 2000, so raising prices.

Animals reared for food are fed on grain and vegetables which contain much more energy than is provided in their carcases. Change to a vegetarian diet would enable the same amount of land to feed about three times as many people, but it is an open question as to how far people can be persuaded to cut down on their meat intake.

NEED FOR POPULATION CONTROL. The present and growing mismatch of population to food supply has convinced some researchers of the urgent need to reduce the global population. Some think that a reduction to a third before 2100 would be needed to avoid famine. By 2100 most of the remaining accessible fossil fuel will have been used, so that there will not be enough left to carry out even the basic tasks of farming, including providing pesticides and fertilizers. Reduction in population to a tenth would be needed to return the population to its size before the time, 1750, of extensive use of fossil fuels.

Other harms from overpopulation. Overpopulation degrades the environment. It requires a restriction of civil liberties to preserve order. It engenders many angry, unhappy people prone to crime, destructive violence, or terrorism. And it leads to conflicts and wars for the control of productive territory, such as the violent conflicts between the Hutus and Tutsis, and between the Israelis and Palestinians.

Harmful Aid. The governments and charities of rich nations give aid in food, money and medicine to poor countries *without requiring effective birth control*. Such aid has bad effects. It enables more children to survive and so increases the number of poor people without increasing their wealth. For example, Ethiopia received huge amounts of aid following the 1984 famine, and in the twenty years from 1985 to 2005 its population increased from 44 million to 69 million, while both its life expectancy and average income (GDP) per head were reduced, but its births remained at about 6 per woman.

THE EFFECTS OF NET IMMIGRATION

Migration and global population. Most migrants leave poor, crowded, less developed countries in which they have no prospect of being able to feed and rear a family. They add to the population of the recipient countries, but their departure does not reduce the population in their homeland, for they are quickly replaced by the survival of more of the large excess of children born there.

Migration and receiving countries. As noted on page 19, PRB 2008 gives the annual net immigration (immigrants minus emigrants) into the developed countries as 0.3% of the total population of 1227 million people. This results in an inflow of 3.7 million a year. Over a generation (25 years) this amounts to 92 million people. The impact is great, as the immigrants increase their consumption of energy per head far above that in their homeland, and so add much to the global emission of greenhouse gases. Although in time they will adjust themselves to the norms of the recipient countries, initially their birth-rate has been demonstrated to be substantially higher than that of the indigenous population.

IMMIGRATION INTO UK. The UK is vulnerable to future hardship because its population of 61 million is already too large for its natural resources. The UK has to import 40% of its food (27% of indigenous types), about 80% of its wood, and much fuel and fibres. Import costs will rise as a result of competition with the growing demands of other nations. Yet the UK has a large and growing deficit in the current-account balance of its overseas trade in goods and services, which was £46.9 billion in 2005.

Assuming the present rate of annual net legal immigration into the UK, 0.3% of the population of 61.3 million, or 184,000 per year, 3.1 million people will have been added by 2025. When this is combined with natural increase, itself bolstered by net immigration, the PRB expects a population of 68.8 million by 2025. The PRB figures on net immigration echo reports from the UK's Office for National Statistics (ONS) that net immigration was 170,000 in 2006, and that it is now about 190,000 a year. There are higher estimates and these figures do not include illegal immigrants, who may number up to 50,000 a year.

ONS figures show that net immigration became positive only after 1985. It was about 50,000 a year until 1997, but it then soared as the new government relaxed controls, e.g. by abolishing tests for the abuse of marriage for the purpose of immigration, and when from 2002 it greatly increased the issue of 'work permits', done in the mistaken belief that immigrants were needed to boost the economy. In the ten years since 1997, 2,500,000 known immigrants arrived and 700,000 Britons left, i.e. a net gain of 1,800,000.

The UK's resident population has a sub-replacement fertility rate. Its TFR was 1.65 in 2000, but rose to 1.9 in 2007, this rise being largely due to the births in immigrants. Rates in Bangladeshi, Pakistani and Black African immigrants have been about twice that in the resident, mainly white, population. Foreign-born mothers now provide 25% of live births. Though entry from EU countries is now largely free, most immigrants (68% in 2006) still come from non-EU countries, e.g. Bangladesh, Pakistan, India, Africa and the Middle East. As will be considered in the next section, there are financial burdens of immigration, but the chief thing to worry about is the effect of net immigration in thwarting any efforts made by far-sighted people to put the UK's population on a downward trend towards sustainability.

Burdens of immigration in the UK. The Government has claimed that immigration gives an economic advantage, but its figures show that any advantage is trivial, for the increase of production is matched by the increase of population and the immigrants' consumption. Growth of the Gross Domestic Product (GDP) per resident is claimed to be about 62 pence a week. And GDP calculations do not fully reflect the costly burdens imposed on the housing, health, education and police services, and many paid interpreters are needed in dealing with immigrants who speak little English.

Probably the worst effects of admitting large numbers of unskilled immigrants willing to work for low pay is that it depresses pay levels and makes many Britons prefer to live on welfare and unemployment benefits rather than seek the small advantage in after-tax pay from training and work. Unemployment at 2,000,000 is now rising, and another 2,700,000 non-workers are on incapacity benefits. In 2004 the then Minister of Work said a third of the latter were fit to return to work immediately, and another third later. About 1,250,000 young people aged 15 to 24 are not in employment, education or training ('NEETS').

The admission of skilled migrants, such as doctors, reduces the incentives and opportunities for skilled Britons, as well as denying to the countries from which those skilled migrants come, the due benefits for bearing the cost of education and training.

Of course the UK needs to be able to accept refugees and asylum seekers, but natural emigration from the UK leaves room for this.

In summary, it is clear that the UK has already achieved a fertility rate which, in the absence of net immigration, would result in a much needed reduction in population, so the essential first task of Governments should be to achieve only balanced migration.

IMMIGRATION INTO THE USA. PRB 2008 gives annual net immigration into the USA as 0.3% of the resident population of 305 million, i.e. 915,000 a year. Many immigrants come illegally, mainly from Latin America over the Mexican border: the illegals are estimated by Virginia Abernethy to be in the region of 2 to 3 million annually (footnotes b and c to Table 1). Birth rates in the USA residents are about the replacement level, TFR 2.1, but those among the immigrants *when in the USA* are much greater. The Centre for Immigration Studies has given a TFR of 3.5 for Hispanic immigrants in the USA, and Spanish speakers may soon dominate the South-Western states.

Recently the US Census Bureau has revised its 1996 estimate that US population would rise to 394 million by 2050, to a figure of 439 million (average increase of 3.2 million a year), giving a clear indication that there is truth in the idea expressed by Virginia Abernethy, among others, that the Bureau consistently underestimates the flow of illegals.

CONCLUSIONS. The conclusions can be condensed into two items:

1) The population of the world is growing rapidly. It is already too large for its supply of food, which is more likely to fall than to increase. About half the people are suffering from some degree of malnutrition and many children are dying from infections enhanced by malnutrition. Most nations that currently have high birth rates needed to initiate action fifty years ago. It seems vanishingly unlikely that nations with long-standing high birth rates, and hence many women of child-bearing age, will be able to make sufficiently rapid changes, but the necessary *aim* must be to reduce the size of the global population to about a third by the end of this century.

2) The UK, USA and other developed nations have spontaneously reduced births in their residents to close to replacement level, but their populations are being increased by net immigration, placing stress both on key resources and social cohesion. They need to cut net immigration, including illegals, to zero, and then encourage, rather than thwart the reduction in their population to sustainable levels; those levels are probably in the region of 20 million in the UK and 200 million in the USA.

REVISITING THE LIMITS TO GROWTH AFTER PEAK OIL

by Charles A.S. Hall and John W. Day Jr.; reviewed by Andrew Ferguson

The *Limits to Growth* that is referred to in the title of Hall and Day's paper (*American Scientist* May-June 2009, pp. 230-237) relates to the Limits to Growth model of the 1970s, made famous under the soubriquet Club of Rome. The prognostications it contains concerning the growth of population and demand, resulting in excessive pollution together with shortage of resources, were set out in a book published in 1972.[1] In 2004 there was a 30-year update.[2] That went a long way to establishing that the original report was essentially correct, but now, in 2009, when it has become apparent that we are either past or at peak oil, a further overview is to be welcomed. The current situation is summed up in this paragraph:

> Although many continue to dismiss what those researchers in the 1970s wrote, there is growing evidence that the original "Cassandras" were right on the mark in their general assessments, if not always in the details or exact timing, about the dangers of the continued growth of human population and their increasing levels of consumption in a world approaching very real material constraints.

There are some striking diagrams in the paper. One of them shows that in the 1970s, when the supply of Middle East oil was politically constrained, the annual rate of drilling in the USA for oil and gas increased by a factor of about three. Five years later, all this effort produced merely a slight upward blip in domestic energy production from oil and gas, after which it quickly resumed its previous declining trend line, as though the blip had never happened. This is as good example as there could be that economists are deluded in thinking that market forces and technology will always be able to overcome the problem of shortage of supply.

Another diagram points at the process by which oil production goes into decline. In the 1930s US domestic oil was being produced with an energy return on energy invested (EROI) of about 100 to 1. By 1970, this had dropped to within the range of 20 to 1 to 35 to 1. By 2000 the ratio was down to 10 to 1. If the EROI of only newly discovered oil were to be assessed, the ratio would be even lower; the paper suggests that in a few decades it is likely to be down to 1 to 1. At a ratio of 1 to 1, the most that is being achieved is to change one type of energy into another, as is approximately the case with producing ethanol from maize: about the same amount of energy has to be put into producing the ethanol as is contained in the ethanol, but a liquid fuel is thought to be so desirable, that some people, at least, argue that the process makes sense.

The final paragraphs of the paper sum up the essence of the problems that the world faces due to civilizations being so dependent on energy and certain vital materials. It makes it amply clear that the intractability of the problems is largely due to human failings.

> The failure today to bring the potential reality and implications of peak oil, indeed of peak everything, into scientific discourse and teaching is a grave threat to industrial society.
>
> The concept of the possibility of a huge, multifaceted failure of some substantial part of industrial civilization is so completely outside the understanding of our leaders that we are almost totally unprepared for it. For large environmental and health issues, from smoking to flooding in New Orleans, evidence of negative impacts has historically preceded general public acceptance and policy actions by several decades. There are virtually no extant forms of transportation, beyond shoe leather and bicycles,

> that are not based on oil, and even our shoes are now often made of oil. Food production is very energy intensive, clothes and furniture and most pharmaceuticals are made from and with petroleum, and most jobs would cease to exist without petroleum. But in our university campuses one would be hard pressed to have any sense of that beyond complaints about the increasing price of gasoline, even though a situation similar to the 1970s gas shortages seemed to be unfolding in the summer and fall of 2008 in response to three years of flat oil production, assuaged only when the financial collapse decreased demand for oil.
>
> No substitutes for oil have been developed on anything like the scale required, and most are very poor net energy performers. Despite considerable potential, renewable sources (other than hydropower or traditional wood) currently provide less that 1 percent of the energy used in both the U.S. and the world, and the annual increase in the use of most fossil fuels is generally much greater than the total production (let alone increase) in electricity from wind turbines and photovoltaics. Our new sources of “green” energy are simply increasing along with (rather than displacing) all of the traditional ones. If we are to resolve these issues, including the important one of climate change, in any meaningful way, we need to make them again central to education at all levels of our universities, and to debate and even stand up to those who negate their importance, for we have few intellectual leaders on these issues today. We must teach economics from a biophysical as well as a social perspective. Only then do we have any chance of understanding or solving these problems.

The essential point of the paper is to emphasize the degree of inattention by nearly everyone to fundamental world problems. This is stated early thus:

> Despite our inattention, resource depletion and population growth have been continuing relentlessly.

If there is any criticism to level at the paper it is that it fails to introduce one vital matter. While there is no logical argument which can be used to predict human reactions, surely a general awareness of human capacities indicates that the whole world is not going to address these problems in a sufficiently draconian way to make much difference. If that is so, then the question becomes this: are there any societies which could, like the famous example of Tikopia, constrain their population and use of resources so as to continue to live on their resources for millennia?

That omission apart, it would be hard to over praise this paper. It puts its finger on the most essential problem that the world faces, namely a human population which access to cheap energy has allowed to become vastly overblown, and a failure of most people in the world to recognize the nature of the problem. It is conceivable, albeit not likely, that some new energy source will appear to prevent the great dieoff which must inevitably follow a substantial decline in available energy. But no one who is slightly aware of the problems associated with untried energy sources would put their trust in such a hope.

It only remains to thank Walter Youngquist for having brought this important paper to my attention.

1. Meadows D H, Meadows D L, Randers J. 1972. *The Limits to Growth*. Signet.
2. Meadows D, Randers J. 2004. *Limits to Growth: the 30-year Update.* White River, VT: Chelsea Green Publishers.

FOUR PATHS TO A SUSTAINABLE WORLD POPULATION

by Eric Rimmer and Andrew Ferguson

Abstract. In an article in the OPT Journal 9/1, *So What Can We Do About It Now*, the consequences of changes in Total Fertility Rate (TFR) were shown graphically. The current paper improves on the simplifying assumptions used there. Taking a look at the world as a whole, four variations are considered, including what may be the most likely one, namely that the world succeeds in doing *very little* about reducing population. On present evidence, world population is going to have to reduce to 2 billion, or thereabouts, but as this analysis makes clear, it is an open question how that is going to happen.

In an article titled *So What Can We Do About It Now*, in OPT Journal 9/1, April 2009, there was a graph, on page 24, showing how the world population would change if a Total Fertility Rate (TFR) of 1.3 were to be achieved without delay. What was not revealed was that the graph was based on a bravura simplification, namely that no one died before the age of 70, and everyone dropped dead on their 70th birthday! We now know that this simplification works surprisingly well, but one of us, Eric Rimmer, was far from satisfied that this was so, and both of us had doubts. We wanted to include those over 70, but that implied taking proper account of the fact that people die at different rates throughout their lives. Eric Rimmer took on the task of finding out the world mortality rates for each decade of life. His data enabled a more precise graph (Figure 1) to be drawn. Some points worth discussing arise from it.

As stated in the previous article, 16 countries have a TFR of 1.3. However let us start with a more modest aim, namely to achieve a TFR of 1.5. *This could probably be accomplished if no woman had more than two children, while (as happens now) a significant proportion were childless*. As the curve "TFR 1.5 + High Infant Mortality" (line with hollow circles) of Figure 1 shows, it would take until 2160 to achieve a sustainable population of 2 billion. We will not pause to discuss why a population needs to be 2 billion to be sustainable, because that has been covered frequently in earlier issues of the OPT Journal. A weakness in that particular "TFR 1.5 + High Infant Mortality" curve is that it assumes that the current situation — with about 8% dying before reaching ten — will be maintained. That is not a sensible objective. Indeed the opposite is required, for when people are uncertain about the survival of their offspring, many will choose to have *more* rather than *less* children.

Let us therefore assume that mortality in the under tens is reduced to the level which currently obtains in those who are in their teens — a much more respectable 1%. As the "TFR 1.5" curve (squares) of Figure 1 shows, a consequence of this otherwise good news is to delay for 30 years, until 2190, the time to reach a sustainable population of 2 billion.

Maybe that is another clue that we should be aiming for a TFR of 1.3. As the "TFR 1.3" curve (smooth line) of Figure 1 shows, we would then get down to a sustainable population of 2 billion by 2145 — a safer prospect — *and achieved with improved infant mortality of only 1% dying during the first decade*. As the previous article suggested, there is much to be said for this target of a TFR of 1.3; moreover it is one which is easily obtainable in many countries, if the 'opposing forces' — to which we now turn — can be countered.

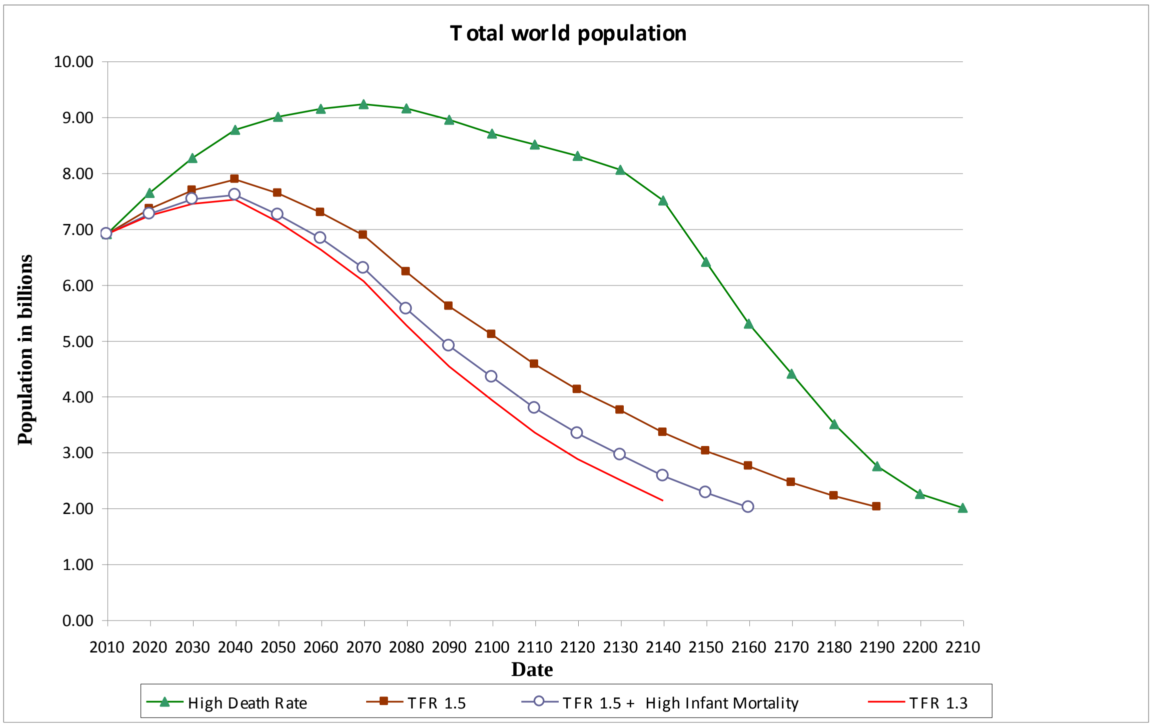
The three curves discussed so far represent desirable courses of action. The 'opposing forces' to be feared are politicians, economists, and the commercial world, all of whom will try to encourage the population to continue to grow, or at the very least remain at its present inflated state. We certainly need to fear them, for the foresight and wisdom that has been shown by Chinese leaders is almost an aberration in human history. Such wisdom would surely have surprised Edward Gibbon, who regarded history as "little more than the register of the crimes, follies, and misfortunes of mankind."

Such being the case, the more likely prospect is *no effective action* until Mother Nature steps in. It seems unlikely that we will achieve a TFR much below 2 any time soon (in 2008, TFR was 2.6). The precise outcome is largely guesswork, particularly concerning when the crash will occur. One persuasive estimate is that 90% of all fossil fuels will have been used up by 2076 (*Rutledge's Hypothesis*, p. 25, OPT Journal 8/2). Moreover it seems unlikely that renewable energy will replace more than a fraction of the energy that we obtain from fossil fuels — but only *unlikely*, not certain, making prediction hazardous.

For a time, politicians will persuade people to eat less, become vegetarians, and put on woolly sweaters instead of heating their houses. But without significant sources of energy, the time will come when all these efforts at economy are irrelevant to the scale of the problem, and society will disintegrate. Population will crash, somewhat on the lines shown by the "High Death Rate" curve (triangles), which is based on a TFR of 2.0 until the crash commences. Note that in this curve, population is controlled by a *high death rate* not a low birth rate. The crash will last until population gets down to a sustainable level, somewhere around 2 billion, or maybe even lower due the chaos of the crash itself.

There are many variant paths, but something along these lines is likely to happen if there is a continued failure to realize that the present high level of human population is largely a result of easily available energy, and that easily available energy is very likely to come to an end as fossil fuels run out. It has to be said, too, that the curves showing desirable developments are slightly optimistic, as it takes time (not allowed for by the algorithm) to reduce TFRs. If all this seems just a path to the Slough of Despond, then recall the conclusion of the previous article, namely that there *are some countries* (with already low TFRs) which are in a position to save themselves. Civilization might be preserved.

Figure 1. Four paths to a sustainable population.



SCALABILITY OF A TRIAL RENEWABLE ENERGY ELECTRICITY SYSTEM

by Andrew R.B. Ferguson

The German Economics Ministry funded an experiment which involved three companies and Kassel University. The experiment, called *Combined Renewable Energy Power Plant*, aimed to asses the potential contribution of a combined pumped storage, wind, solar and biogas plant, scaling it to represent a 10 000th part of the electricity demand in Germany. For this assessment, I rely mainly on the data supplied in a brief report on page 23 of *Renew*, Natta Newsletter 188. The report stated that:

> The network was capable of generating 41 gigawatt hours of electricity a year.

Presumably the meaning is that the network would manage to generate 41 GWh were it to be run for a whole year, an *average* 4.7 MW, i.e. 4.7 MWy during the course of year. However note that 4.7 MWy/y is actually closer to a 14 000th part, as electrical production in Germany is of the order of an average 65 GW (i.e. 65GWy/y).

The report states that "36 decentralised plants were linked and controlled by a central computer," and that pumped storage was available. Let us now look at the details given regarding the plant that was used in this trial.

> Over the period of the experiment 61% of the electricity came from eleven wind turbines (total 12.6 MW).

The use of wind power on that scale immediately makes the need for pumped storage evident. The peak output from the wind turbines, even if as widely spread as those over the 800 km of the wind turbine network of the large-scale utility operator E.ON Netz, is likely to be at least 80% of full capacity of all the wind turbines, i.e. 0.8 x 12.6 = 10 MW, which is more than double the *average* demand of 4.7 MW. The next figure referred to biogas, and it was stated that 25% of the electricity came from:

> Four biogas CHP plants (total 4 MW capacity).

Of course there is no problem with excess electrical output from biogas provided that the CHP plant is fully controllable. CHP can probably be regarded as largely controllable plant, and perhaps the only point to make is that to produce 25% of electricity from biogas does not appear at all likely to be possible on a nationwide basis (the power density of producing biogas is too low). There is also a considerable amount of photovoltaic (PV) generation in the power plant:

> 14% from 20 PV installations (5.5 MW).

Once again the need for pumped storage is evident from that figure. The capacity factor of PV in Germany is unlikely to be higher than 12%, so to produce 14%, the PV capacity required would be (4.7 x 0.14) / 0.12 = 5.5 MW (and that is the capacity shown). Countrywide sunshine is not too unusual, so peak output from the system can be full capacity (individual plant can go above the nominal capacity), and as 5.5 MW is above even the *average* demand of 4.7 MW, there is an evident need for more pumped storage.

What was not reported in *Renew* was the amount of pumped storage that was available. I wrote to *Erneuerbare Energien e.V.* and was told that the pumped storage available to the project was a simulated 84.8 MWh. If that is scaled up by a factor of 14 000 it becomes 1170 GWh. The largest pumped storage facility in the UK is Dinorwig, offering 9 GWh of storage. All three pumped storage facilities in the UK offer 30 GWh. Thus the requirement for scaling nationwide in Germany would be 130 Dinorwigs, or 39 times the pumped storage currently available in the UK.

It looks unlikely from the above analysis that the project is scalable.