Triple Threats for the Human Future

Will Civilization Arrive?

L. David Roper

Forward by Michael Abraham

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Forward

> *Saudi Arabian proverb: "My grandfather rode a camel, my father drove a car, I fly a jet plane, my son will ride a camel."*

Special.

As the twenty-first century dawns, citizens of the planet earth benefit from amazing technologies. The Hubbell space telescope and radio interferometry array telescopes bring us views of our universe that boggle the imagination. Intergalactic distances, fabulous supernovae and black holes warping time and space indicate a universe of unfathomable energy, size, and scope.

Yet what astronomer Carl Sagan called our Pale Blue Dot, the starship Earth, stands apart, special.

Special, as a verbal construct, is arguably the most browbeaten word in the lexicon. It's been diced and sliced, mashed, trampled and marginalized. Special delivery! Special: two for one! Special offer; act today!

Before we assaulted it, special meant this: distinguished by some unusual quality; especially: being in some way superior. And no word better described our home planet, for, as far as we know, it is the only one that supports life. That's it. As far as we know, we're utterly and completely alone.

In the universe, energy is everywhere, grand and fabulous in places, scarce in others. Life, however, is excruciatingly rare. Energy can and does exist without life, but life cannot exist without energy. The story of life on earth, of microbes and mastodons, of amoeba and apples and antelopes, of condors and cornstalks and caterpillars, of bacteria and broccoli and bears, is about the use and consumption of energy.

Paradoxically, what's so rare in the universe is almost overwhelming in profusion here on earth. Life here is so tenacious, fecund, and resolute; it's sometimes easy to take for granted. Always there. Like so many things we experience in profusion, it's difficult to grasp the specialness.

And maybe that's the root of our problem.

Millennia ago on the steppes of Eurasia emerged a new species, one destined to impact the earth, its other species, and itself in unprecedented ways. *Homo sapiens*, wise man, was neither bigger, more agile, nor faster than the proto-humans from which he evolved, yet he possessed many competitive advantages that would serve him well. He had an opposed thumb, making grasping tools easy. He had an uncanny, unprecedented ability to communicate with other members of his species. And he had reasoning and thought powers as never before. He was omnivorous, shrewd and adaptable. His range spread and his populations grew, withstanding periods of feast and famine, heat and cool. He used the last Ice Age to his advantage, bridging to the New World and further expanding his numbers and predominance.

But in spite of his successes, when the glaciers retreated ten thousand years ago, worldwide human population numbered some five million, less than the current population of my native state of Virginia. When Christ sat with his disciples at his final Passover Seder, merely 250 million souls populated the earth. It took 1800 more years to hit a billion. Since then, the population has exploded nearly seven-fold and growth continues unabated.

In the 1995 essay, *Energy and Human Evolution*, David Price tells the tale of a planned introduction of a herd of 29 reindeer introduced to St. Matthew Island in the Bering Sea in 1944. With an untouched bounty of the lichen on which they feed, by 1957 the population, given ample food and no predators, reached 1350 and by 1963 was 6000.

We'll revisit this herd in a moment, but let's return to our human population.

Competing theories vie for acceptance as to how and why human populations soared, beginning about 200 years ago. Did humans become more fecund? No, offspring production was about the same as before. Were humans suddenly smarter? No, the human brain reached its current size and acumen thousands of years earlier. The correct answer is simple and intuitive: humans found and exploited a new energy source, fossil fuels. This endowment, always buried literally beneath their feet, had always been there for any species at any time to use, but neither the grasshopper, the dog, the housefly, nor the jellyfish had the intelligence, the dexterity, or the need to make use of it, as neither did humans theretofore.

So profoundly important was the discovery and use of energy from fossil fuels, particularly petroleum, in the population explosion that we might see humans as having almost literally evolved into a new species, *Homo petroleum*: Oil Man. Oil Man, not in the J. R. Ewing, Boone Pickens, or Jed Clampett model, but in the form of John Q. Consumer, physically resembled *Homo sapiens*, but clearly different in his prodigious appetite for food, clothing, recreation, travel, refrigerators, color TVs, and all the other accouterments of what we now think of as everyday modern life.

Oil Man's newfound gift of coal, oil, and natural gas let a farmer grow enough food not to feed a few as before but to feed hundreds. Furthermore, Oil Man could build skyscrapers, interstate highway systems, particle accelerators, microwave ovens, space telescopes, and so much more. Oil was quickly put to use not solely in food production, but in plastics, fabrics, pharmaceuticals, and notably transportation. Oil Man radically re-engineered his living environments to consume fuel in frantic, profligate ways. Heat trapping greenhouse gasses, previously encapsulated in these fuels, were liberated into the atmosphere in unprecedented quantities, blocking radiant energy from breaching into the near infinite heat sink of space. Oil Man competed aggressively for land and other resources with many species, driving untold numbers to extinction. Most measures of environmental health of the planet have become significantly negative, including top soil, fisheries, aquifers, and surface fresh-water.

Oil Man's skyrocketing numbers resembled the reindeer on St. Mathews Island; the bounty in fossil fuels was to Oil Man what the untouched lichen were to the reindeer. Oil Man was like a newly introduced species on his own planet, feasting voraciously on an energy source, always there but never before touched.

“Growth, growth, growth – that’s all we’ve known… World automobile production is doubling every ten years; human population growth is like nothing that has happened in all of geologic history. The world will only tolerate so many doublings of anything – whether it’s power plants or grasshoppers.”
M. King Hubbert, 1975

Today informed, sentient, and rational Oil Men almost universally conclude that a crossroads is at hand. We occupy a society in which growth is revered, worshipped by politicians, economic developers, and demographers, and accepted as a normal condition of existence. The emergence of a competing view, that the only thing that grows unrestrained is cancer, is sacrilegious, blasphemous. Yet growth has only been possible with a continuously expanding availability and consumption of fossil fuel energy. Oil Man is in nature’s crosshairs, standing like a blinded deer in the headlights, facing an impending collision between continually escalating demand and peaking supply.

Thirty years ago, Professor David Roper wrote a book entitled, “Where have all the metals gone,” documenting the peak in production of scores of valuable minerals and energy sources. Domestic production of gold, silver, mercury, lead, and many others were found to already be in “highly depleted” states even then. As alarming as his conclusions were, the sky didn’t fall. Our economy, lifestyle, and consumptive patterns have continued unabated. We’ve always been able to find ready substitutes. Oil, because of its amazing energy density, transportability, and versatility, will be different. Its looming scarcity will not be easily replaced.

Many esteemed oil production geologists believe the peak of worldwide oil production is neigh. And with the peak in oil discovery forty years ago, who can doubt them? The “when” and “how disruptive” questions of Peak Oil are open to debate, but the “whether” is a certainty.

The threat is real, imminent, and dreadfully, frightfully serious.

Dr. Roper, in this volume, lends his thorough, analytic and mathematical voice to the growing choir of alarmists, warning us in his use of the tools of scientists: charts, graphs, and displays, of the impending threats of Peak Oil, Global Warming, and the next Major Ice Age. It is important and valuable that he has done so, as the issues are complex and the means of understanding vary from interested person to person.

The trifecta of impending maladies of which Dr. Roper writes is completely predictable. Our ability, or inability, as a society to begin the process of adequate preparation will define our generation.

Incidentally, the reindeer herd on St. Mathews Island effectively consumed all the lichen on the entirety of the island and collapsed in one season from 6000 to 41 females and “one apparently dysfunctional male.”

Nature doesn’t care if we’re having a nice day.

Michael Abraham, Blacksburg, Virginia April 2006

Preface

References are often made to “Western Civilization” or “civilization” in books, magazines, newspapers and speeches by politicians. When I encounter the word “civilization” I often wonder what is meant by the word.

The on-line encyclopedia http://www.wikipedia.com defines “civilization” as follows:

> By the most minimal, literal definition, a *civilization* is a complex society. Technically, anthropologists distinguish civilizations in which many of the people live in cities and get their food from agriculture, from band and tribal societies in which people live in small settlements or nomadic groups and subsist by foraging, hunting, or working small horticultural gardens. When used in this sense, civilization is an exclusive term, applied to some human groups and not others.

The second definition is widely used; for example, as in the title of the book ***The Clash of Civilizations and the Remaking of World Order*** by Samuel P. Huntington.

I would transfer the conventional definition for “civilization” to be part of the definitions for “industrialization” and “urbanization.”

There is a computer game called “*Civilization*.” It involves game players as nations accruing resources for their survival and vanity and involves much fighting over control of those resources. That is, it is a somewhat realistic game about what happens in the real World.

I prefer a loftier simpler definition of “civilization” not mentioned in Wikipedia:

> **A civilization is a society in which the basic needs (shelter, sustenance and meaningful contributing work) of all its members are achieved through cooperation among its members.**

The smallest unit of a civilized society is a household (often called a family) working together for the good of all members of the family. The next smallest unit of civilization is a local community with its members cooperating for the good of all, then regional communities, then continental communities and, finally, a cooperating planetary community. For the World to be “civilized” by my definition cooperation for mutual benefit among humans would have to occur at all of these geographical scales. It appears that being civilized becomes more difficult the larger the geographic region involved. Words that also describe a civilized society are a “nurturing community.”

By my definition no truly “civilized” society has ever existed in the World. Proto-civilizations have existed to varying degrees of being civilized. See Chapter 7.

The degree to which humans are civilized will be sorely tested in the near and far future as the “Triple Threats” discussed in this book plague humans.

Many books have been written with the theme “Can Civilization Survive?” For example: ***Global Warming: Can Civilization Survive?*** by Paul Brown. Since by my definition no civilization has ever existed, I think a better question to ask is “**Will civilization arrive?”**

So, the question this book addresses is “Will civilization **arrive**?” as human societies try to cope with the extreme stresses that they will undergo as the end of the Petroleum Age, increasing Anthropological Global Warming and the next Major Ice Age occur. See Chapter 1.

However, the messages of this book are not all distressing. I show that there is hope if humans come to understand the dangers and act now to make survival of humans more likely in the future. The remaining half of crude oil and natural gas must be used to develop the infrastructure for renewable energy sources and recycling of materials. If the current rates of growth of wind power, photovoltaic power and biodiesel production are enhanced by reasonable amounts, these renewable sources of energy can provide replacements for declining crude oil and natural gas extraction and make it possible to slowly and carefully use some coal and nuclear energy to help further develop infrastructure for eventual sustainable renewable energy and recycled materials use. Other minor sources, if increased in magnitude can fill in to make the vision of a Multi-Source-Distributed-Energy System (MSDES) future possible. For such an energy system to work, World population must be stabilized and eventually reduced by pre-conception birth control and education of women. In any case, World population will be reduced, either by intentional more pleasant means or by very undesirable means. If fact, the latter is already happening.

My emphasis is on the survival of humans into the far and not-so-far future on Earth. Of course, plants and other animals must also survive, if humans are going to survive. The current rapid extinction of other animals and plants by human activities must be curbed. Wilson (**Wilson, 2002**) and Benford (**Benford, 2000**) discuss possible ways to assure survival of a complex biodiversity into the far future. This book presents a more comprehensive view of the threats to the survival of humans (and plants and other animals) into the near and far future than any other book that has been published.

This book presents much data and discussion of those data. I have read too many books that discuss quantitative data without presenting the data for the reader to see; so I prefer to err on the side of perhaps too much data. The best way to present so much data is by graphs. Study carefully the many graphs that I present, as they contain a wealth of information, not all of which I discuss.

Some mathematical equations are occasionally used. A reader can skip over them.

This book refers to many Internet web pages. Since the average lifetime of an Internet web page is probably only a few years, some of the Internet references may not be valid in the near future. One can often find another version of a specific page by “backing up” on the web address to parent directories or search for a title or collection of words.

My training and professional life was in theoretical particle physics, but I also did research in theoretical biophysics and resources depletion. I am a scientist who is capable of putting together information from several fields of study, some of which are often neglected by the specialists in the separate fields involved. The interactions of data between different fields are often more important for human welfare than are the isolated data from the separate fields. I believe that this book presents a more unified view of the interactions of the triple threats that are its theme than any other book that has been published.

The author has benefited from discussions with his beloved wife, Prof. Jeanne Baril Roper, Prof. Richard A. Arndt, Prof. Linda Hinov and Michael Abraham.

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Chapter 1. Triple Threats for the Human Future

Introduction

Homo sapiens face some formidable troubles within the next few years, the next few decades, the next few centuries and the next few millennia. Close cooperation between peoples of all nations of the Earth will be necessary to deal adequately with those troubles. Without close cooperation our species may not survive those troubles. Certainly without close cooperation many humans will die unnecessarily. Human population of the World will reduce either by intentional birth control or by much more undesirable means.

This chapter will outline what I call the **Triple Threats for the Human Future** on three time scales. Other chapters will discuss the Triple Threats in greater detail.

1. **The next few years to decades**: Crude oil and natural-gas availability for the World will start declining soon, with probable dire consequences for social organization. This is Threat 1.
2. **The next few decades to centuries**: Anthropogenic Global Warming (see Glossary) will cause drastic changes in climates and may even cause the third Threat to happen sooner than centuries or millennia. This is Threat 2.
3. **The next few centuries to millennia**: The next Major Ice Age (see Glossary) will probably begin within the next 1000 years, one of the many Major Ice Ages that have occurred about every 115,000 years for, at least, the last million years. About 10,000 years from now, the Earth's temperature will be several Celsius degrees colder than at present. This is Threat 3.

Threat 1: The End of the Oil Age

It has been known for several decades that World crude oil extraction would peak shortly after the year 2000. Chapter 3 discusses in detail the situation for United States and World crude oil extraction and other nonrenewable sources of energy, and how they must be quickly replaced by renewable sources of energy.

The most versatile of the nonrenewable sources of energy is petroleum, especially as a fuel for transportation. The United States peaked in crude oil extraction at about 1970 and the World is peaking about now (2006). It will be excruciatingly difficult for human societies to adjust to less petroleum per capita than it has been accustomed for the last century, which decline has already begun. (See Figure 3-5.)

Threat 2: Anthropogenic Global Warming

The Intergovernmental Panel on Climate Change (IPCC) issued a report in 2001 (**Houghton, 2001**) with the conclusion that Anthropogenic Global Warming (see Glossary) is real. The consequences will be dire if it is not stopped. Chapter 2 discusses Neolithic Global Warming, Modern Global Warming and Future Global Warming (see Glossary) and some of their consequences.

Threat 3: The Next Major Ice Age

Were it not for Neolithic Global Warming, the Earth probably would be headed already into the next Major Ice Age, because solar energy striking the Earth (insolation) has been declining for almost 10,000 years. Neolithic Global Warming and Modern Global Warming have delayed the entry into the next Major Ice Age. However, the next Major Ice Age is inevitable because of the huge amounts of energy changes involved, including large Atlantic Ocean currents (**Colling, 2002**). After most of the fossil fuels are burned within the next few hundred years the next Major Ice Age will begin. In fact, it may begin much sooner if Future Global Warming turns off some or all of the North Atlantic Ocean currents (**Houghton, 2001**). Chapter 4 discusses these issues.

Troubles Ahead

Rich highly-developed nations will probably not give up their dependency on using more than their share of the World's resources. Rich nations may continue their long-standing practice of killing people in poor nations to capture their resources in order to maintain the high standard of living in the rich nations. (**Klare, 2001**)

Nuclear weapons and other weapons of mass destruction and weapons of indiscriminate destruction may be used again as they have been used in the past if the rich nations deem their use necessary to guarantee those nations' access to the remaining resources of the World.

Suburban life will become difficult because of the difficulty and expense of traveling large distances for perceived and real necessities. City life will become difficult because of the energy required to bring in real and perceived necessities. Mostly self sufficient communities with surrounding farm lands and expertise at growing food and other survival techniques are the best bet as survival locations (for example: Blacksburg VA and other small university and college communities). See *The End of Suburbia: Oil Depletion and the Collapse of the American Dream* DVD.

Starvation will be widespread. Mass migrations from poorer nations to richer nations will probably occur, with many people dying along the way and in conflicts after reaching their destination. In fact, that is already occurring.

Much knowledge may be lost about how to survive in a less energy-intensive World and about how to create better living conditions. (**Benford, 2000**)

How Can Humans get from Now to 1000 Years from Now?

The following is a brief outline of how humans can make life easier in the future. More details will be given in later chapters.

- Eliminate nuclear weapons and other weapons of mass destruction by all countries, including the United States. This implies a high degree of World cooperation, not go-it-alone by each nation. (**Klare, 2001**) When developing nations are commanded by developed nations that they are not allowed to construct nuclear weapons, they must in turn demand that the developed nations destroy their nuclear weapons.
- Emphasize pre-conception birth control and education of women to try to stabilize and peacefully bring down World population.
- Safely store knowledge for future use, including survival knowledge tribal groups accumulated before industrialization. (**Benford, 2000** (See Chapter 6.)
- Use energy and materials much more efficiently.
- Recycle materials to a high degree.
- Change from nonrenewable to renewable energy sources. (See Chapter 3.)
- Use the remaining fossil fuels and uranium to develop infrastructure needed to use renewable energy sources.
- Depend more on local sources of energy, food and materials. Support farmers' markets that sell locally-grown food.
- Reduce waste and use organic waste to create soil and biofuels.
- Live closer together in self-sufficient communities.
- Change from mostly individual/family transportation to mostly shared transportation (for example, railroads and shared personal vehicles instead of interstates/motorways). (See http://www.carsharing.net and http://www.cooperativeauto.net .)
- Store carbon dioxide, and perhaps methane, now and in the future in a way so that humans can recover it later to release it into the atmosphere to ameliorate the plunge into the next Major Ice Age. (**Roper, 2004**)

Are humans informed and intelligent enough to realize these huge problems and to do these things quickly enough? (**Kuntsler, 2005**) That is, "**Will civilization arrive?**"

Chapter 2. Anthropogenic Global Warming: It Started Long Ago

Introduction

In recent years many books, articles and news programs have discussed the concept that human activities have caused Global Warming within the last two hundred years (Modern Global Warming). The latest definitive scientific study by several thousand scientists concerning Anthropogenic Global Warming was reported in 2001 (**Houghton, 2001**), with the conclusion that Anthropogenic Global Warming is real.

Without human interference the Earth's atmospheric temperature is largely determined by insolation (solar energy per time per area that strikes the upper atmosphere) magnitude, which can be calculated very accurately, and the turning on and off of different states of energy storage in the Earth and its atmosphere other than as atmospheric heat (measured by temperature). For example, North Atlantic Ocean currents can store and transport energy, especially in the times of Major Interglacials (see Glossary). The turning on and off of those ocean currents can cause changes in the climate. This has been the pattern for at least the last one million years. See Chapter 4. (**Colling, 2002)**

Figure 2-1 shows North-Pole summer insolation (**Berger, 1991**) and Vostok Antarctica temperature versus time as determined by deuterium concentration in ice cores (**Petit, 1999**). North-Pole summer insolation is an important factor because accumulation of ice on the land in the Arctic region is crucial to the existence of Major Ice Ages and summer is when the ice can melt. (There appear to be time-scale problems between the insolation calculation and temperature measurements for the earlier times. Times are more difficult to determine for deeper ice cores; that is, for earlier times.) Vostok Antarctica temperature data are used because they are the best data available and they show the same major features as do data from Greenland ice cores near the Arctic. They also extend farther back in time than do the Greenland ice cores; that is, the cores are deeper.

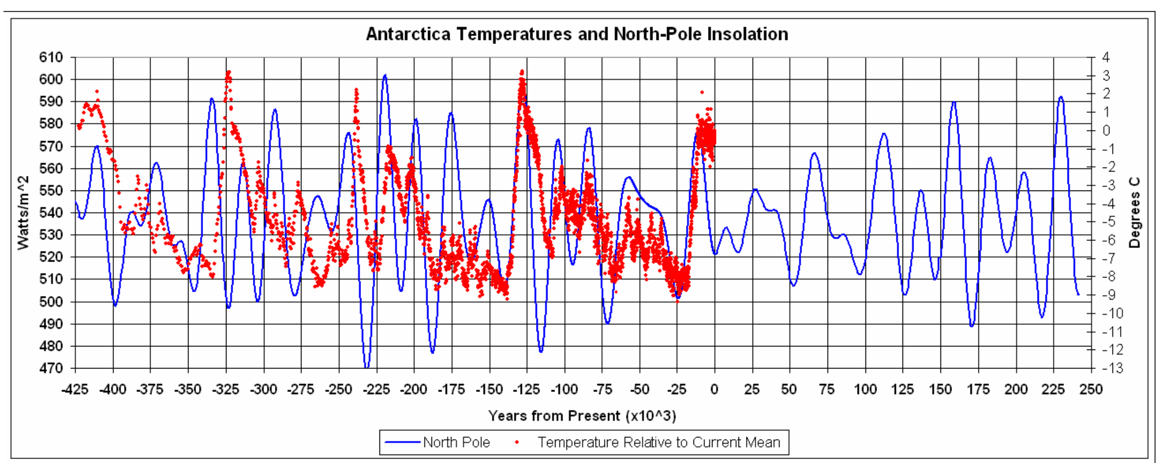


Figure 2-1. Vostok Antarctica atmospheric temperature (right axis) from -425,000 years to now as determined from deuterium concentrations in ice cores (Petit, 1999) and North-Pole summer insolation (left axis) from -425,000 to +250,000 years calculated using the Berger code (Berger, 1991).

About 11,000 years ago North-Pole summer insolation began falling and it is calculated to gradually fall for another 500 years into the future. Figure 2-2 shows the North-Pole summer insolation for the last 15,000 years and 10,000 years into the future.

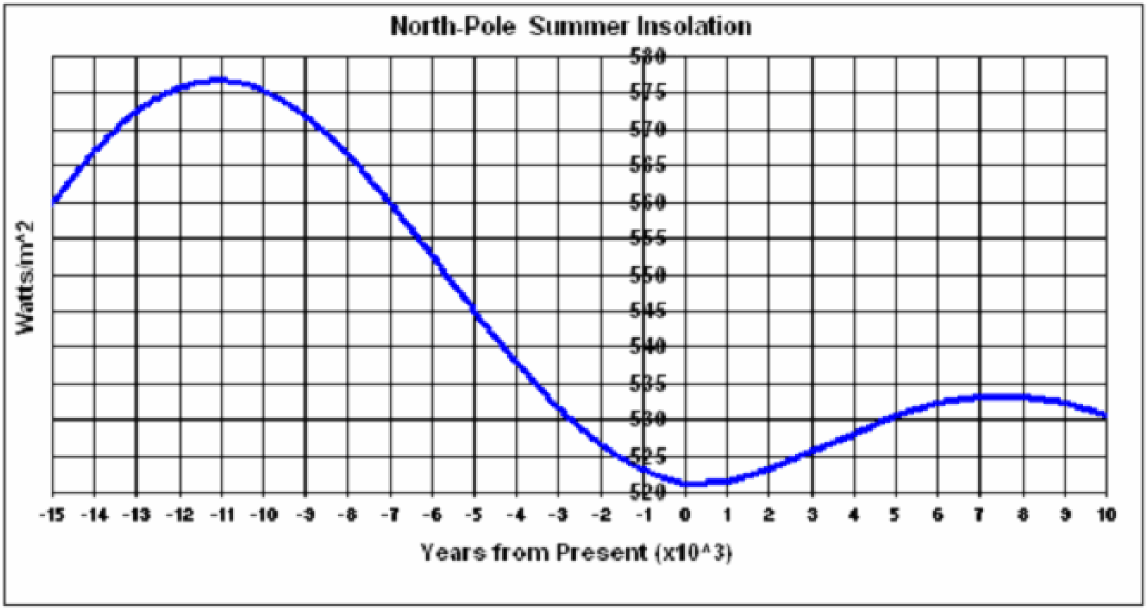


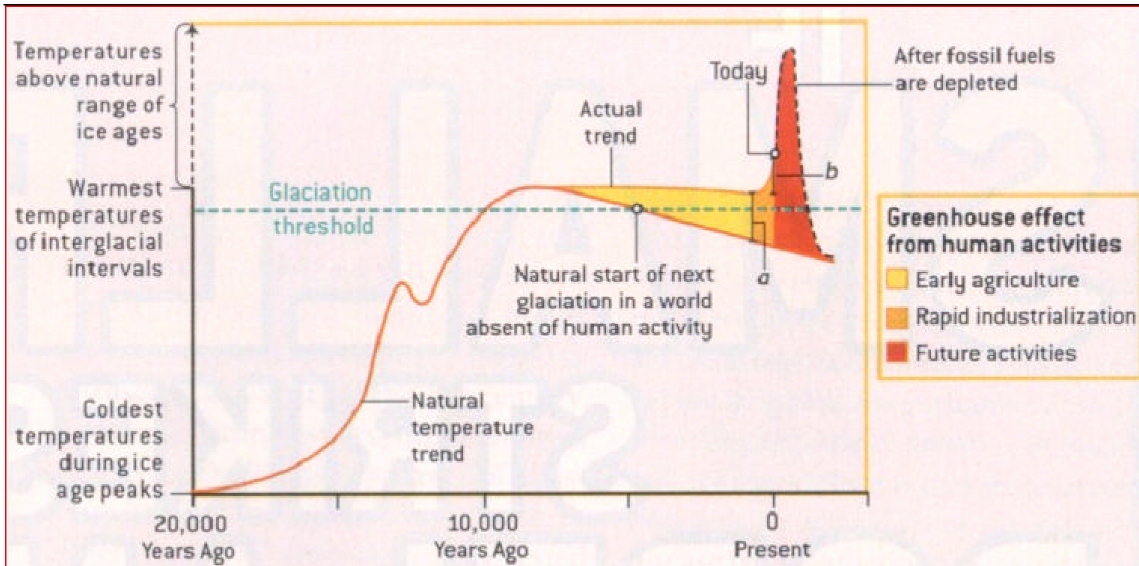
Figure 2-2. North-Pole summer insolation from -15,000 years to 10,000 years into the future.

Neolithic Global Warming

A recent study by Professor Emeritus William F. Ruddiman of University of Virginia (**Ruddiman, 2005**) makes a convincing case that Anthropogenic Global Warming began about 8,000 years ago.

Ruddiman presented strong evidence that carbon dioxide and methane in the upper atmosphere should follow insolation, but about 8,000 years ago, instead of falling with falling insolation, carbon dioxide started rising because humans began to farm extensively and about 5,000 years ago, instead of falling with falling insolation, methane started rising because humans began to flood land for rice farming. The increases of these two potent greenhouse gases in the upper atmosphere caused the Earth's temperature to fall only slightly instead of the more rapid fall that would have occurred had extensive agriculture not begun.

Figure 2-3 taken from Ruddiman's *Scientific American* article, illustrates what I call the "**Neolithic Global Warming**" effect. Ruddiman surmised that the Earth would have already entered into the next 115,000-year Major Ice Age had not Neolithic Global Warming occurred. The sharp peak at the right is an estimate of Future Global Warming due to the massive burning of fossil fuels accompanied by a large increase in human population, which mutually affect each other.



GREENHOUSE EFFECT from human activities has warded off a glaciation that otherwise would have begun about 5,000 years ago. Early human agricultural activities produced enough greenhouse gases to offset most of the natural cooling trend during preindustrial times (*yellow*), warming the planet by an average of almost 0.8 degree Celsius. That early warming effect (*a*) rivals the 0.6 degree Celsius (*b*) warming measured in the past century of rapid industrialization (*orange*). Once most fossil fuels are depleted and the temperature rise caused by greenhouse gases peaks, the earth will cool toward the next glaciation—now thousands of years overdue.

Figure 2-3. Neolithic Global Warming. This is taken from Ruddiman's *Scientific American* article. It illustrates the thesis that the entry into the next Major Ice Age, that without Neolithic Global Warming would have happened about 5,000 years ago, has been delayed

Figure 2-4 shows the time interval for Anthropogenic Global Warming in order to show the three components: Neolithic Global Warming, Modern Global Warming over the last two centuries and Future Global Warming. Note the estimated rapid plunge into the next Major Ice Age after the burning of nonrenewable fuels peaks a few hundred years from now.

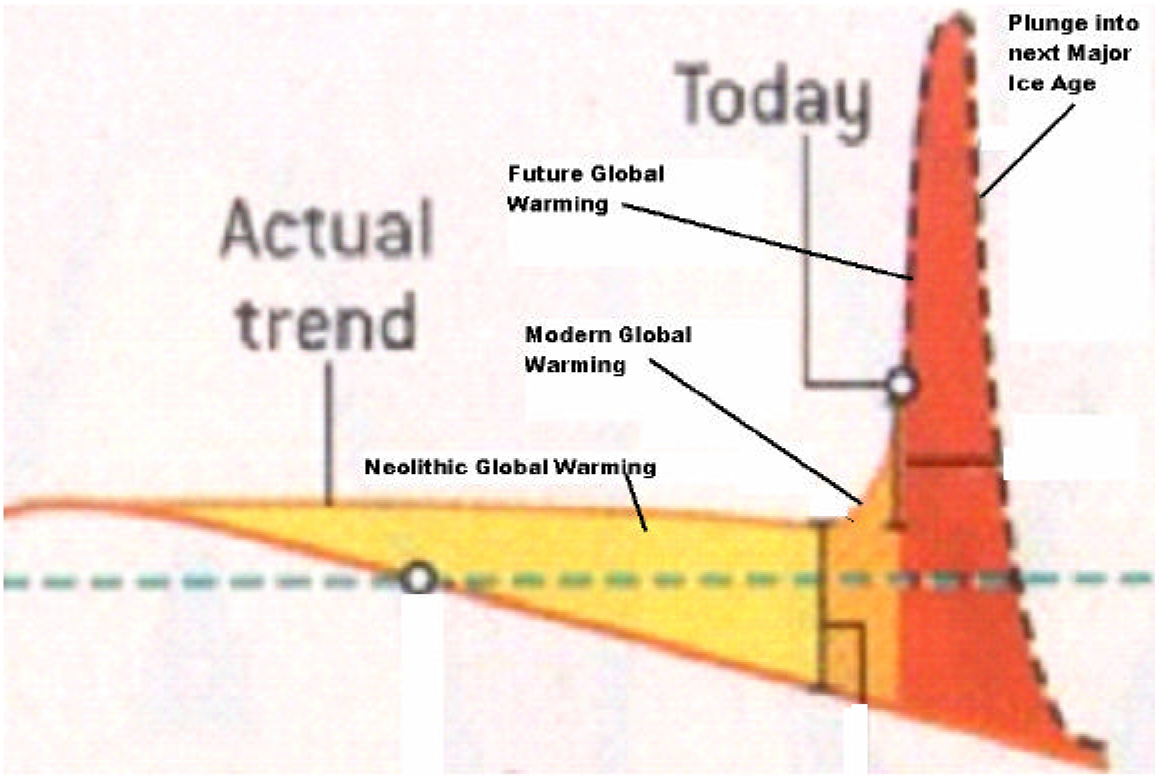


Figure 2-4. Neolithic Global Warming, Modern Global Warming, Future Global Warming and the plunge into the next Major Ice Age.

There are many adverse effects of Future Global Warming, among which are:

- Rapid changes in temperature cause agriculture possibilities to switch from one area of the World to another. Thus, many people will die due to lack of food where they live and as they try to migrate to areas where food might be available.
- Rapid increases in temperature cause more severe weather to occur, such as hurricanes and other strong storms. Thus, many people will die (have already died!). See Figure 2-8 below.
- Rapid increases in temperature cause the glacial ice at the North and South Poles to melt and ocean waters to expand, raising sea levels; which will flood many major cities of the World.
- Rapid increases in temperature may cause North Atlantic Ocean currents to turn off, plunging the Earth into the next Major Ice Age.

North Atlantic Ocean Currents

Perhaps the most important effect of Future Global Warming is that the fast rise in temperature may trigger the next Major Ice Age sooner than it would otherwise occur, due to switching off North Atlantic Ocean currents (http://en.wikipedia.org/wiki/Thermohaline_circulation) (**Houghton, 2001**). Figure 2-5 and Figure 2-6 contain two different representations of the Atlantic Ocean currents.

In Figure 2-5 note that the Brazilian coastline deflects most of the South Equatorial Current into the northern hemisphere, which results in a large transfer of heat from the southern hemisphere into the far northern hemisphere. There are several different branching North Atlantic Ocean currents. The Isthmus of Panama that connects Central America and South America keeps the Atlantic Ocean currents from going into the Pacific Ocean. It closed about 4 million years ago due to continental drift, enabling the periodic Major Ice Ages of about 115,000 years duration.

Figure 2-5. North Atlantic Ocean currents as depicted in **http://www.fiu.edu/~srimal/Currents_files/v3_document.htm.**

In Figure 2-6 note the Great Ocean Conveyor Belt's (GOCB) release of energy into the atmosphere in the Antarctica area, as well as the North Atlantic (Gulf Stream), and the Atlantic and Pacific Oceans' absorption of energy from solar insolation and the atmosphere all over the Earth to drive the GOCB.

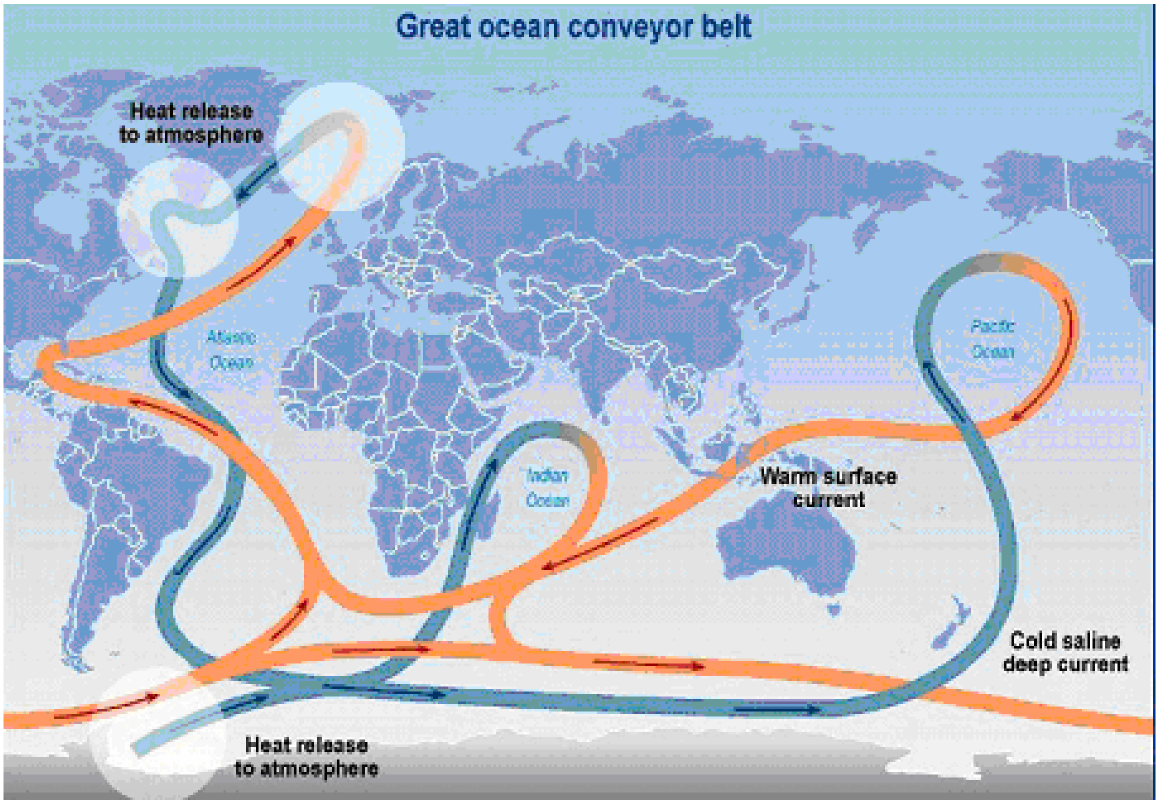


Figure 2-6. The Great Ocean Conveyor Belt (GOCB). This diagram is taken from (http://www.ipcc.ch/present/graphics/2001syr/small/04.18.jpg) (Houghton, 2001). Surface currents flow from the east and then from the south; then they sink in the Arctic region to form deep ocean currents back toward the south and the east.

Figure 2-7 illustrates what might happen if the rapid rise in Future Global Warming turns off some or all of the North Atlantic Ocean currents. The black curve on the right is an estimate of how rapidly temperatures might fall. (See the movie *The Day After Tomorrow,* whose time scale is probably much too short.) The reason that a sooner plunge into the next Major Ice Age might occur is that the North Atlantic Ocean currents are what keep ice from forming in the Arctic region, which ice creation causes positive feedback to start the ice age. Some factors to consider are:

- Earth temperature will probably drop about as fast as it has risen over the last few hundred years, or faster.
- Will humans desperately try to increase burning of fossil fuels to try to ameliorate the fast temperature drop, instead of using them to develop infrastructure needed for long-term human survival?

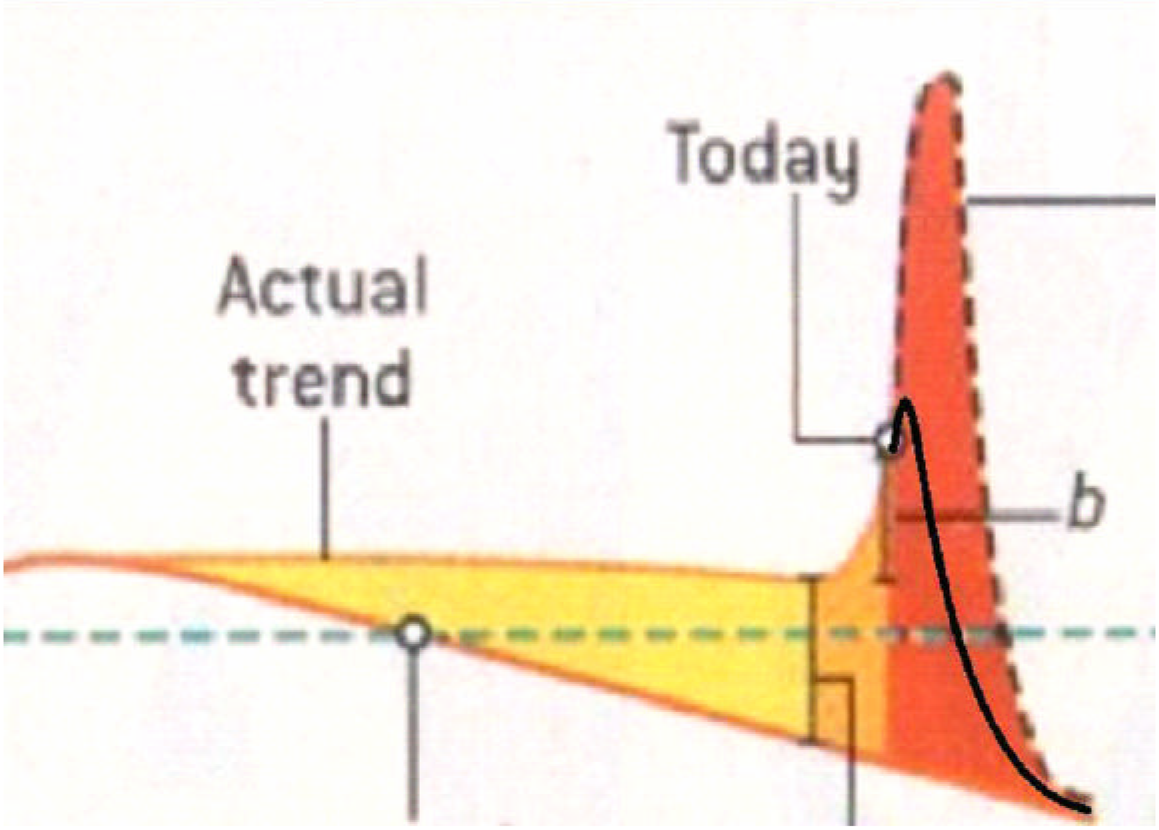


Figure 2-7. Future Global Warming may trigger the next major ice sooner than it would otherwise occur, due to switching off Atlantic Ocean currents. The dark curve on the right is an estimate of how rapidly temperatures might fall.

The following is a short explanation of why Future Global Warming could turn off North Atlantic Ocean currents (**Colling, 2002**):

- In the tropics warm surface water evaporates, leaving greater salt concentration in the surface water.
- Salty water travels north and becomes cooler by releasing energy into the atmosphere by evaporation and radiation.
- At some point the salty cool surface water becomes denser than the water underneath it, so it sinks to lower ocean levels and then travels south as deep ocean currents to complete the circuit.
- When the northern ice cap melts by Global Warming or otherwise, fresh water flows into the North Atlantic.
- At some point the water ceases to be salty enough to sink at a specific location.
- The sinking of cold salty water in the North Atlantic Ocean is what drives the North Atlantic Ocean Currents.

Global Warming and Hurricanes

It is well known that warm surface ocean water is a major causative factor in creating hurricanes. (http://en.wikipedia.org/wiki/Hurricane) The increase in hurricane power dissipated (PDI) versus sea surface temperature (SST) in the North Atlantic Ocean is shown in Figure 2-8. Strong correlation between ocean surface temperature and hurricane power is obvious.

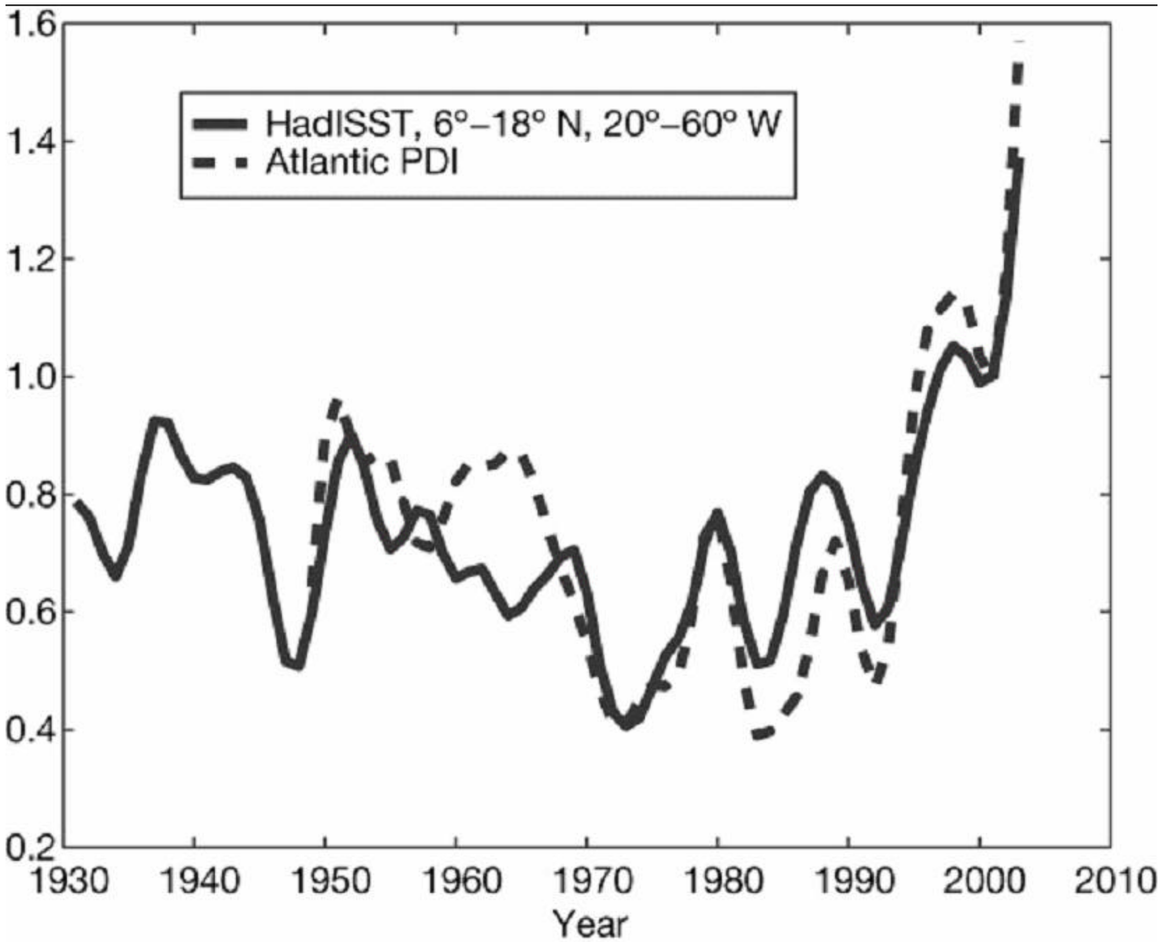


Figure 2-8. Hurricane power dissipated (PDI) versus sea surface temperature (SST) in the North Atlantic Ocean (http://www.realclimate.org/index.php?p=181#more-181)

Some hurricane experts have stated that the increase in power dissipated by Atlantic hurricanes in recent years is due to an Atlantic hurricane cycle independent of Anthropogenic Global Warming. However, the power dissipated by hurricanes/typhoons is a World wide phenomenon, and no hurricane cycle has been determined for the other oceans (http://zfacts.com/p/49.html). It seems clear that the World can expect much more energetic hurricanes in the future as long as Anthropogenic Global Warming increases.

Can Humans Control Future Global Warming?

Can humans control Future Global Warming to ameliorate entry into the next Major Ice Age? Figure 2-9 illustrates how humans might control Global Warming somewhat by slowing the rate of burning fossil fuels, storing the carbon dioxide, and other greenhouse gases produced by using fossil fuels, to be released later more slowly and by reducing population. (See Chapter 6.) This would give more time for developing the infrastructure needed for humans to survive into the next Major Ice Age. (See Chapter 4.)

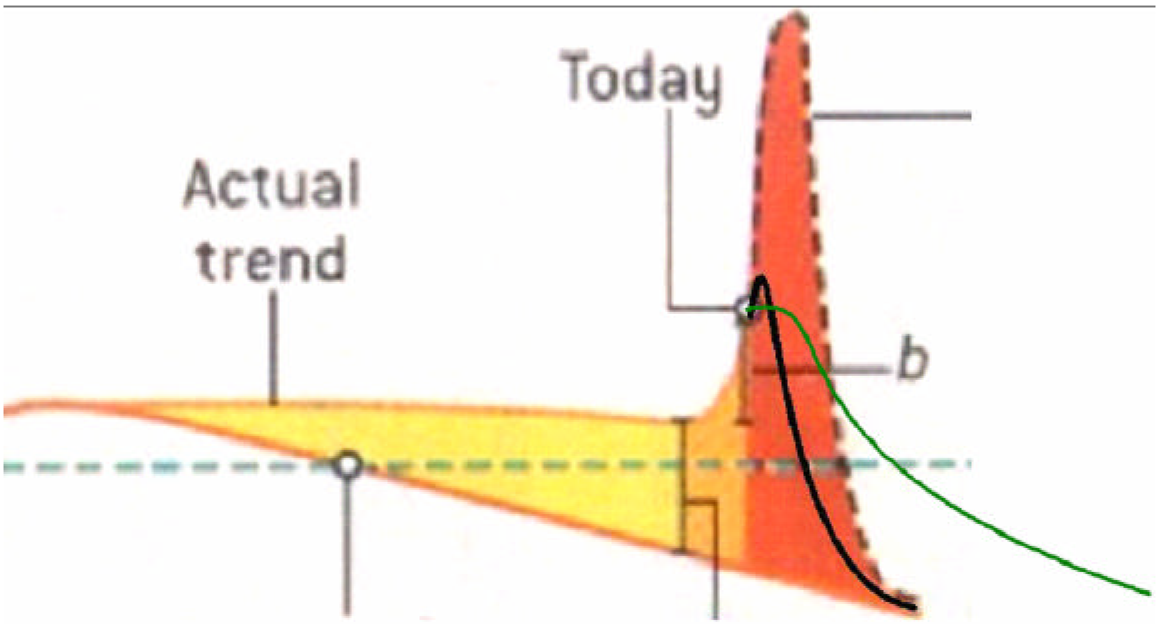


Figure 2-9. Controlled entry into the next Major Ice Age, represented by the stretched out curve, by slowing the rate of burning fossil fuels, storing carbon dioxide to be released later more slowly and reducing population.

The major question is: Can humans co-operate enough Worldwide to reduce population peacefully, reduce the rate of burning fossil fuels and store carbon dioxide in the Earth to be released at a controlled rate later? (**Roper, 2004**) That is, **will civilization arrive**?

Figure 2-10 shows the Earth's temperature data for the last 1000 years. The slight drop in temperature until about 150 years ago was due to insolation decreasing. The rapid rise in temperature during the last 150 years is due to burning fossil fuels (Modern Global Warming). This is expected to continue for several hundred more years (Future Global Warming) if humans continue to burn fossil fuels (mostly coal after petroleum runs out); unless the Atlantic Ocean current(s) are turned off by the rapid rise in temperature.

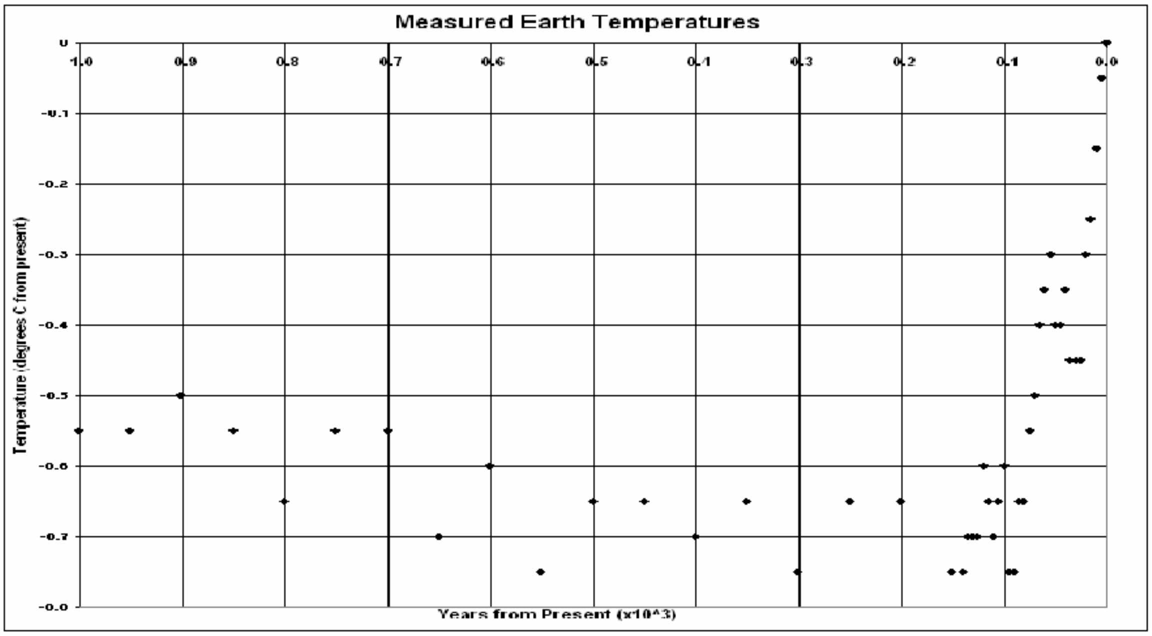


Figure 2-10. Earth temperature data for the last 1000 years. (Data from IPCC) The slow drop until about 150 years ago was due to falling solar insolation.

Compare the Earth temperature rise for the last 100 years to the change in Earth average temperature, relative to 1990, over the entire current Major Interglacial of 10,000 years duration in Figure 2-11

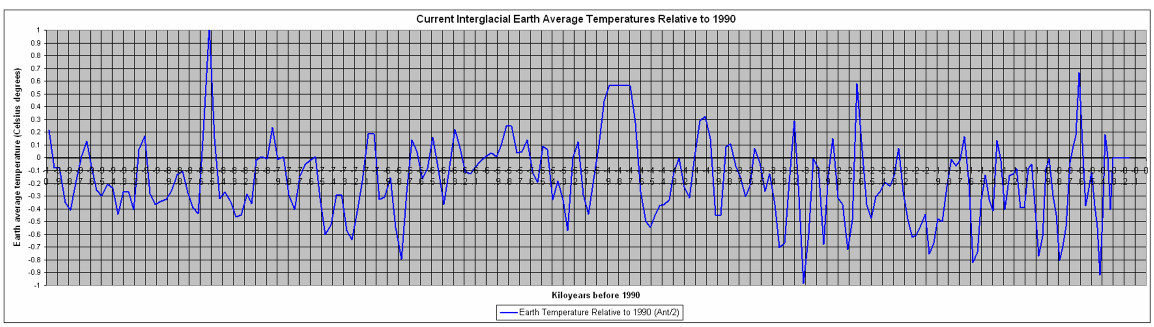


Figure 2-11. Earth average temperature difference (relative to 1990) for the last 10,000, assuming it is one-half of the Antarctica temperature difference.

It is seen that only rarely were the temperature differences relative to 1990 as large as the recent temperature rise (about 0.6 Celsius degrees). Over the next century the Earth average temperature rise will be much larger than any rise in the last 10,000 years.

Figure 2-12 shows Earth temperature data and human population data for the last 200 years. Note the close relationship between the two sets of data. One way to reduce the rise in temperature with time is to reduce the rise in population by pre-conception birth control and education of women. (See Chapter 6.)

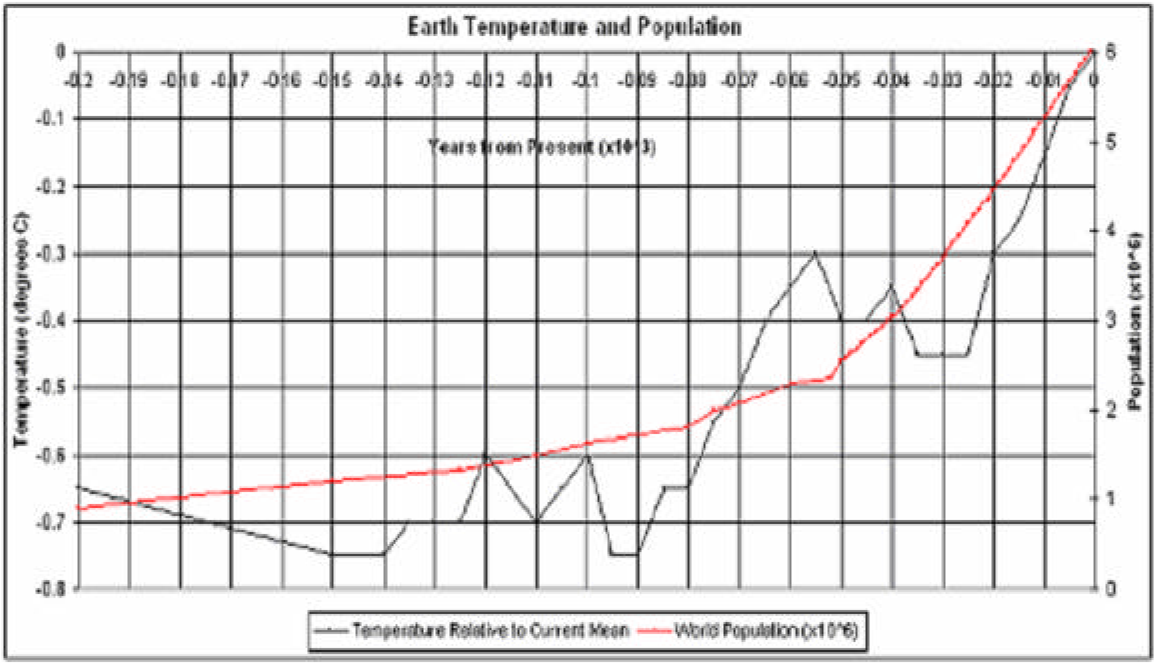


Figure 2-12. Earth temperature data (left axis) as reported by IPCC and human population data (right axis) for the last 200 years.

One can calculate the ratio of temperature to population for the last 25 years and fit a parabola to it to predict the temperature for the next 50 years by using the projected population (**Roper, 2006**), as shown in the top graph of Figure 2-13. It is seen that, if the population grows as projected, the temperature will rise by about 0.5 Celsius degrees in 50 years. Compare this to the drop in temperature of about 0.2 Celsius degrees in the last Little Ice Age (c1350-c1850) as shown in Figure 2-10. Such a temperature rise by itself will cause drastic changes in the climate, but the danger of such a temperature rise turning off some or all of the Great Ocean Conveyor Belt (GOCB) is perhaps greater (**Houghton, 2001**). Turning off the GOCB will cause temperatures to drop by several degrees C, perhaps ushering in the 100,000-year cold interval of the next Major Ice Age sooner than it would otherwise occur.

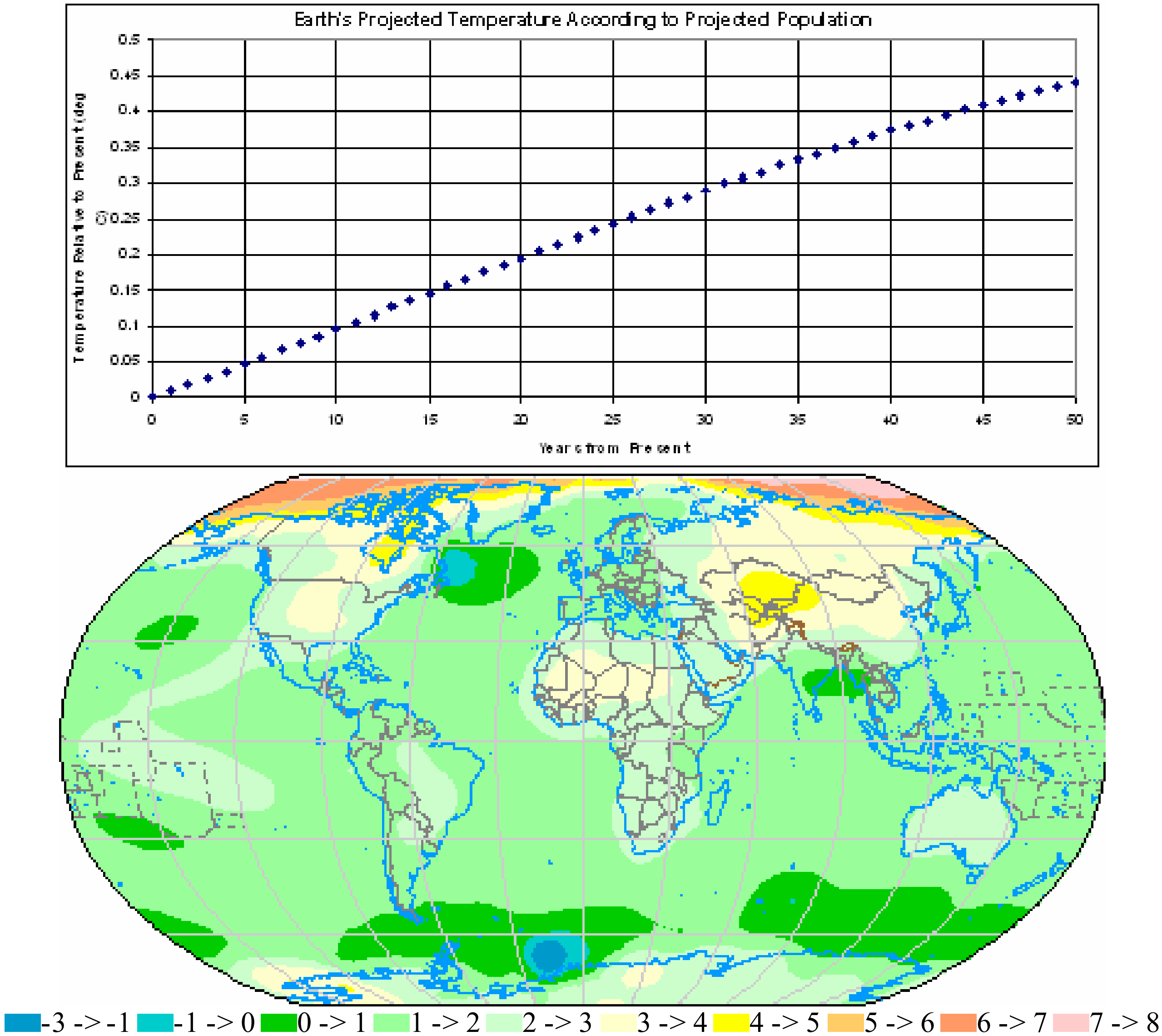


Figure 2-13. Top: Prediction of Future Global Warming by projecting the World temperature/population ratio. Bottom: Future Global Warming predicted by climate models.

Of course, Global Warming is not only a function of increasing population; there are other factors. In fact, climate models predict that the average temperature increase by 2050 will be about 1 to 2 Celsius degrees depending on geographic location, as shown in the bottom graph of Figure 2-13. (http://atlas.gc.ca/site/english/maps/climatechange/scenarios/globalannualtemp2050) Thus, Earth's temperature will probably rise faster per population than it has in the past, due to increased insertion of greenhouse gases into the upper atmosphere. For a discussion of the effects of greenhouse gases on global warming see http://www.roperld.com/science/CO2_Temp.pdf.

Figure 2-14 shows the calculations of the Intergovernmental Panel on Climate Change in 2001 for Earth temperatures since 1860 and compares them to the measured temperatures. This makes a convincing case that the recent rise in temperature (Modern Global Warming) is due to human activities.

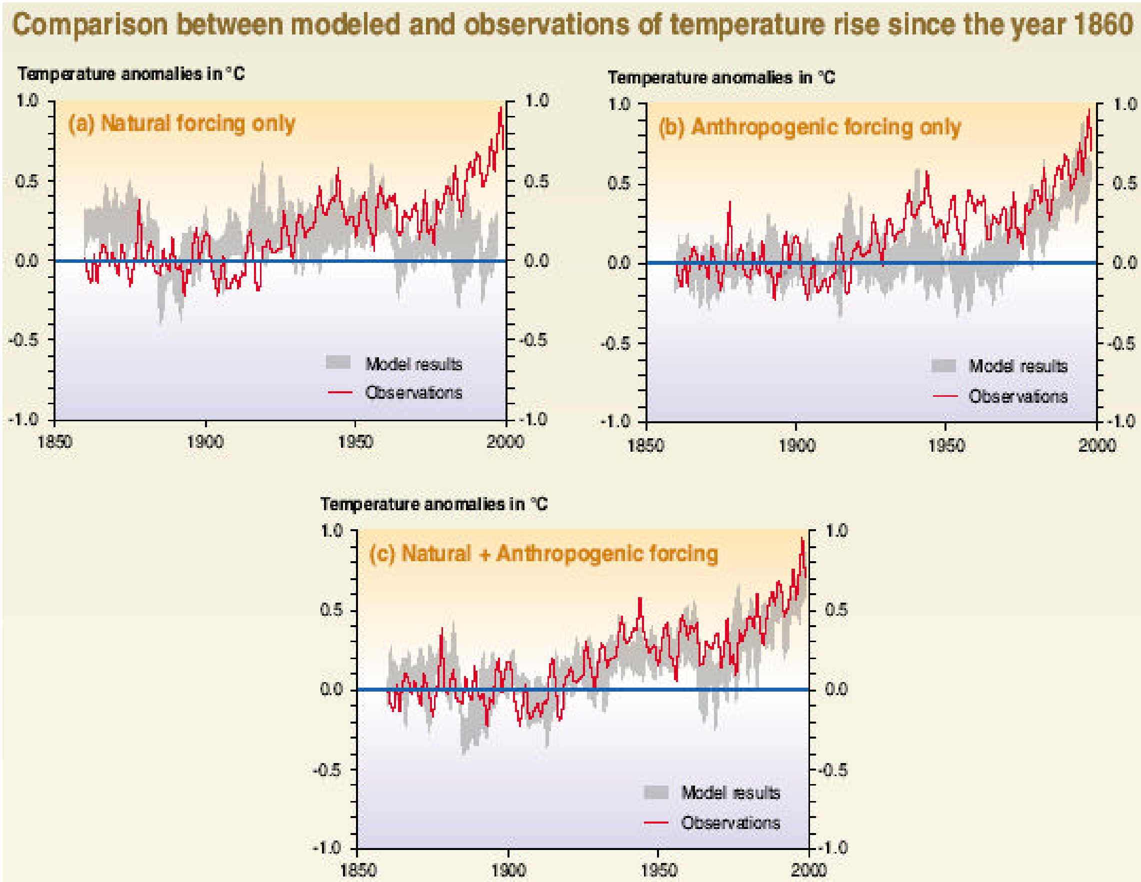


Figure 2-14. Intergovernmental Panel on Climate Change calculations for Earth temperatures since 1860 compared to measurements. Note that anthropogenic forcing is the main cause of the recent rapid rise (Modern Global Warming), rather than "natural" forcing. (http://www.ipcc.ch/pug/un/syreng/spm.pdf)

The oceans currently contain unbalanced heat energy relative to the atmosphere, which will cause atmospheric temperatures to rise for another century even if humans quit putting greenhouse gases into the atmosphere now. (http://www.nasa.gov/vision/Earth/environment/Earth_energy.html ; http://www.realclimate.org/index.php?p=148)

The Next Major Ice Age

The next Major Ice Age will occur no matter whether humans quickly use all the fossil fuels or not. Figure 2-15 shows several models' predictions for the next two Major Ice Ages. (**Roper, 2004**) *Homo sapiens* will undoubtedly evolve greatly over the next Major Ice Age of about 115,000 years duration, due to the extreme stresses of cold climate, as they did during the last Major Ice Age. (See Chapter 4.) (**Kurzweil, 2005**) Earth average temperature change is about one-half Antarctica temperature change. (**Houghton, 2004**)

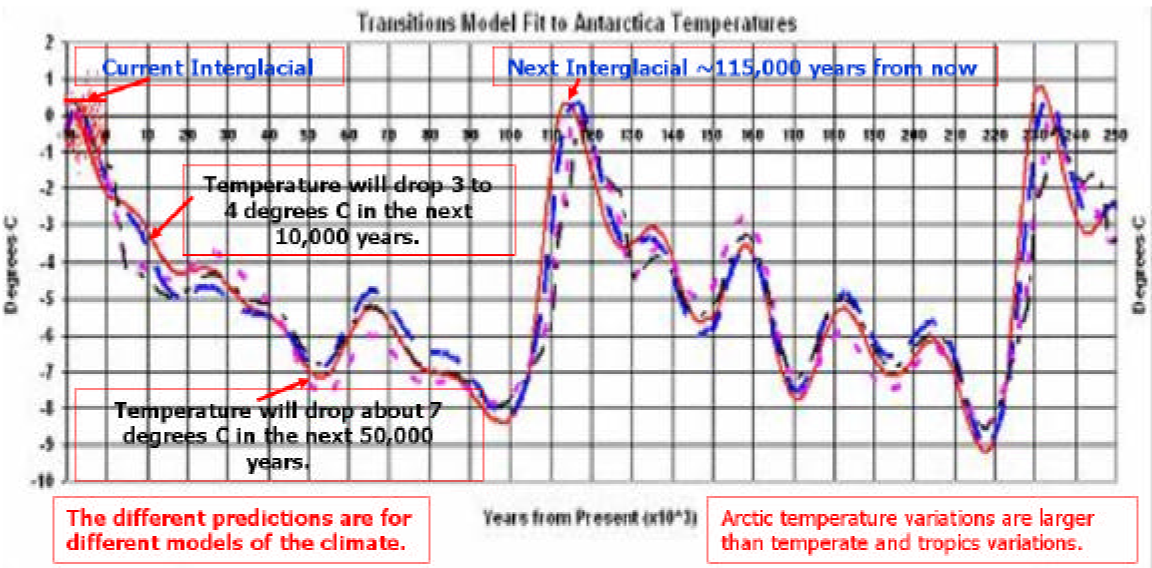


Figure 2-15. Different models' predictions of Antarctica temperature for the next two Major Ice Ages of about 115,000 years duration. (Roper, 2004)

Chapter 3. A World Energy Plan Now and for the Future

Introduction

It has become obvious to many citizens of the World that there is something wrong with the World energy-supply situation. The prices of energy from almost all nonrenewable sources rose dramatically within the last decades of the twentieth century. And "energy crisis" after "energy crisis" have occurred since 1970 when crude oil extraction peaked in the United States.

United States President Jimmy Carter during his administration of 1977-1981 recognized that there was a severe problem and instituted a plan to conserve energy and develop renewable energy sources. (http://www.pbs.org/wgbh/amex/carter/filmmore/ps_energy.html)

Then Ronald Reagan became President of the United States for eight years and cancelled the entire Carter program and renewed the emphasis on using mostly nonrenewable energy sources; which will redound to his great discredit into the far distant future.
(http://www.4president.org/speeches/reagan1980convention.htm)

Since then no United States president has developed a viable energy plan for the future. The current President G. W. Bush (2006) is even worse than Reagan was in understanding the problems with the energy supply now and in the future.

The economy of the World is highly dependent on using petroleum distillates (gasoline, diesel and kerosene) to move its people and goods across the huge expanse of the World and on petroleum to produce the products, including food, that are transported. This chapter will show that this dependence cannot continue much longer and, indeed, should not continue, since petroleum is needed to develop the infrastructure for using renewable energy sources that will be needed to assure human survival into the distant future, including the next Major Ice Age.

Also there will need to be a smaller population of humans on the Earth, which perhaps could be achieved by pre-conception birth control and education of women. If it is not achieved intentionally it will occur very unpleasantly.

This chapter will discuss nonrenewable energy sources (crude oil, natural gas, coal and uranium), concluding that oil and gas will have been fully extracted within the next century and that coal and uranium will have run their course within about 200 years. It will show that even a "miraculous" energy source will not allow unlimited growth of energy use, because of the limited capability of the Earth to radiate the energy released. A Multi-Source Distributed Energy System (MSDES) will be proposed utilizing many renewable sources of energy. The importance of hybrid vehicles, especially biofueled plug-in hybrid vehicles will be discussed. It will be shown that the recent rapid growth in biodiesel production, wind power and photovoltaic power lend some hope that the growth rate can be increased, with undivided governmental and business attention, in time to replace crude oil and natural gas as energy sources.

Nonrenewable Energy Sources

Crude Oil Extraction in the United States

The rate of crude oil extraction ("extraction", not "production"!) in the United States is shown in Figure 3-1. (**Heinberg, 2003**) It peaked about 1970, got a slight boost from Alaska extraction in the 1980s, but has declined steadily for the last twenty years and will continue to do so with possible short-lived small peaks. The Verhulst function fit (**Roper, 1976**) to the data gives a reserves value 1.5 times the 2003 proven reserves, which probably is about right for predicting the future.

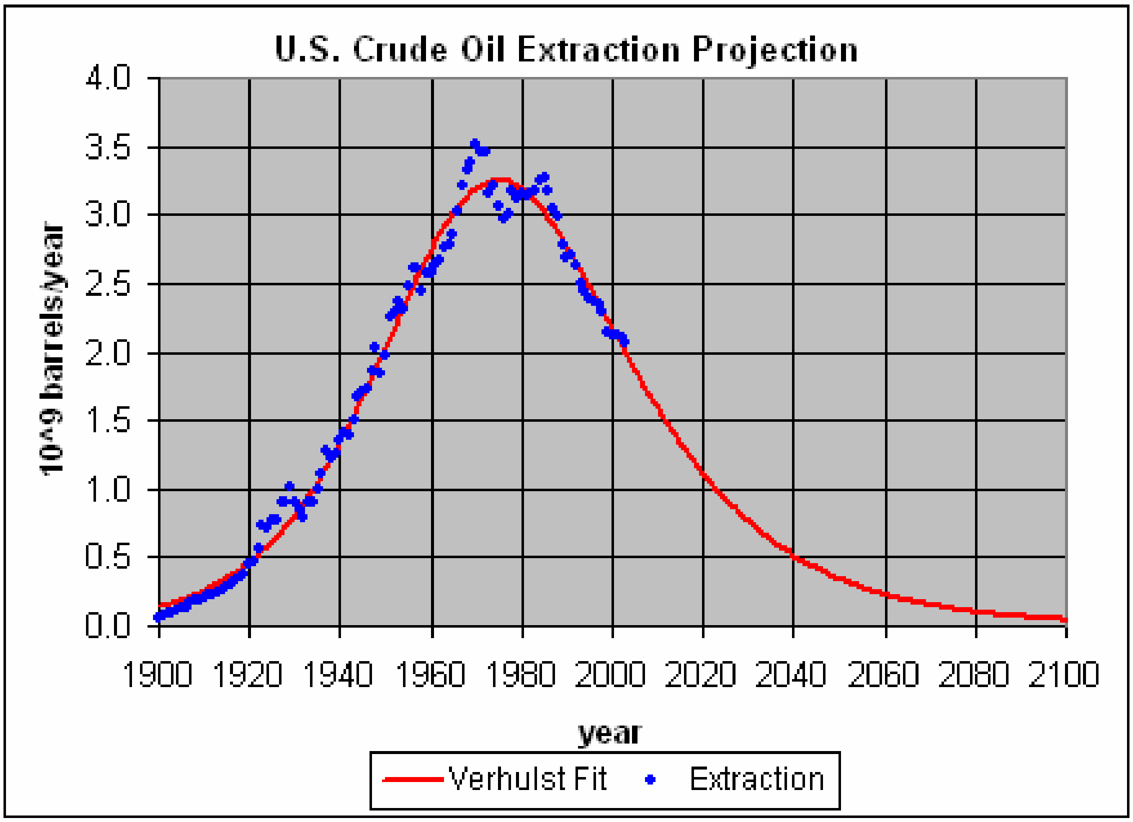


Figure 3-1. United States extraction rate of crude oil, a fit using the Verhulst function and the fit's projection into the future. Data are from http://www.eia.doe.gov .

Note that the extraction curve is not symmetrical; it is skewed toward future times. This is to be expected as Herculean efforts will be made to extract crude oil in the future.

Figure 3-2 shows the crude-oil extraction rate along with the Alaskan extraction rate (which is included in the total rate), the consumption rate and the imports rate for the United States. Note that Alaskan extraction peaked only ten years after it started and was down to about half its peak rate in 2005. The proposed (2006) ANWAR Alaskan extraction would be an even smaller blip, with total eventual extraction equal to only about one year's consumption for the United States (~10^{10} barrels=10 billion barrels). (http://www.inforain.org/Northslope/anwr_3.htm)

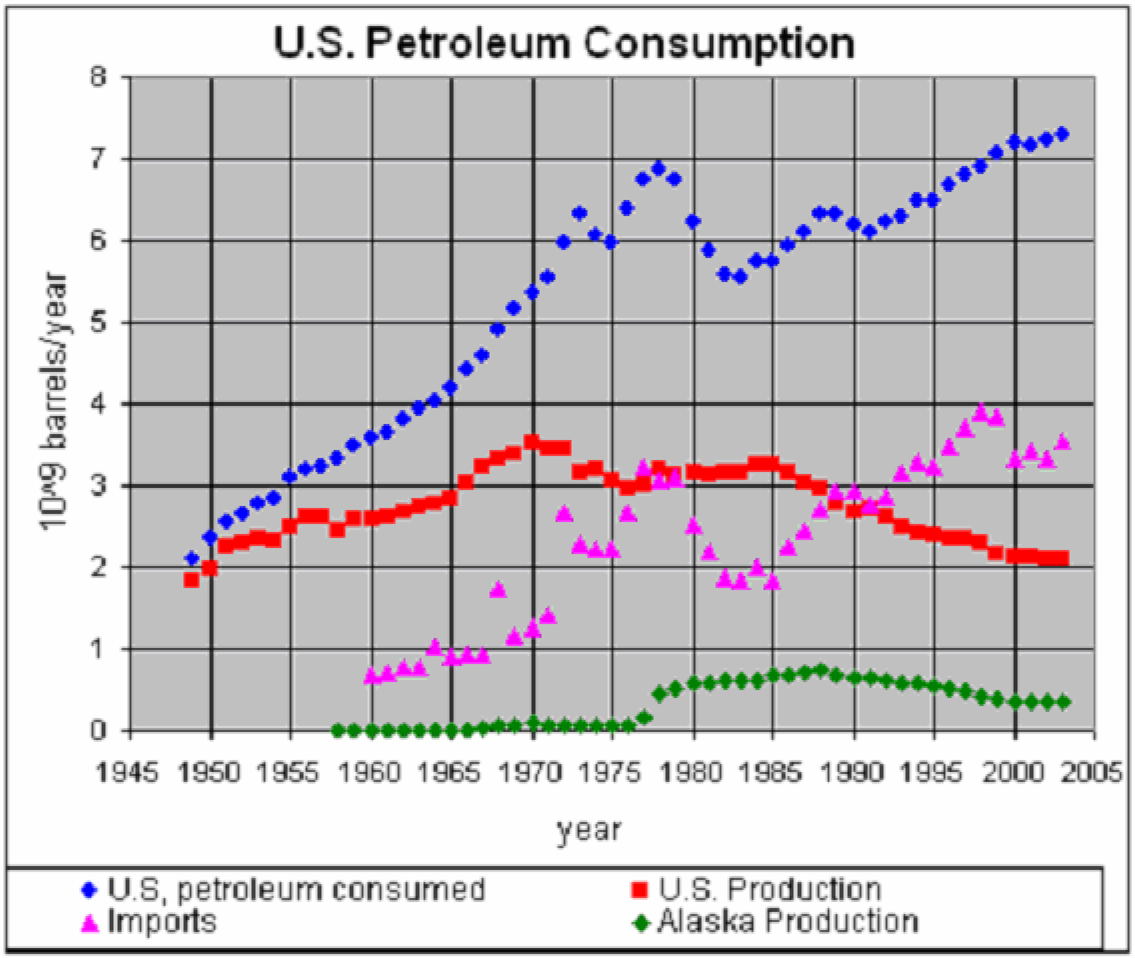
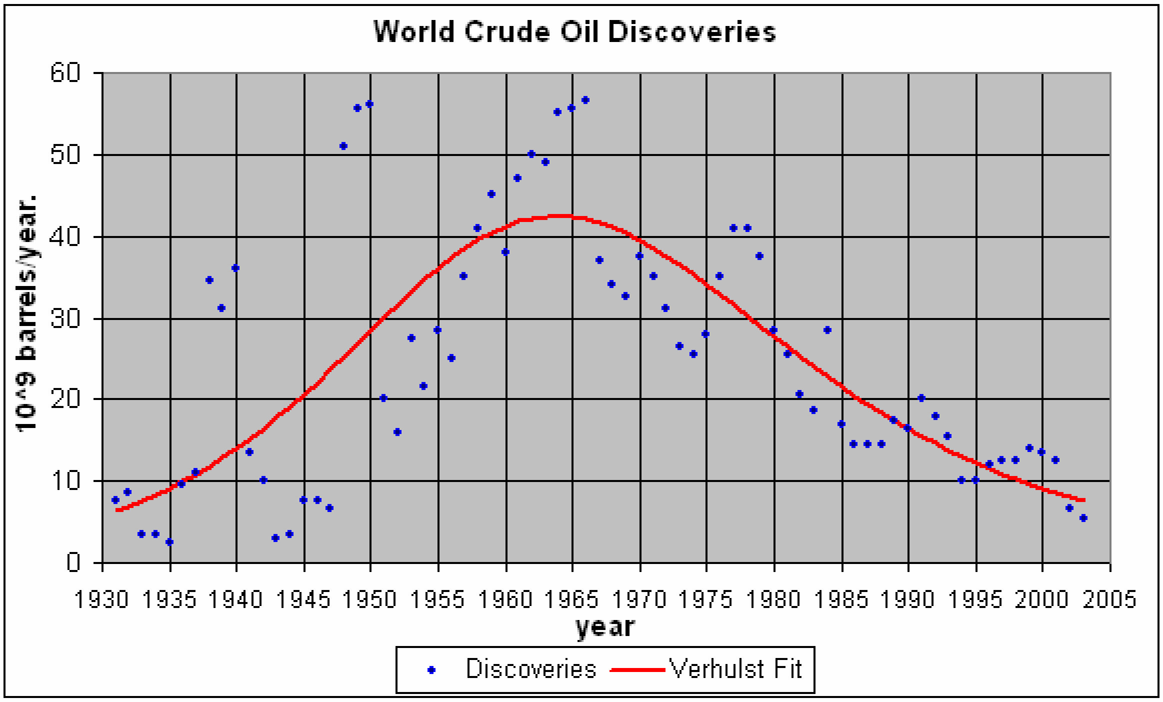


Figure 3-2. United States crude oil consumption rate, extraction rate, imports and the Alaskan component of extraction. Data are from http://www.eia.doe.gov .

Crude oil Extraction for the World

Figure 3-3 shows crude oil discoveries rate and the discoveries rate per capita for the World. [Population extrapolation into the future is taken from (**Roper, 2006**).] Note the peak in discoveries at about 1965 and the rapid fall since about 1975. The Verhulst function fit (**Roper, 1976**) to the discoveries data gives the total amount of crude oil to be extracted as slightly less than 2 x 10^{12} (2 trillion) barrels. Obviously, World crude oil discoveries have been meager and declining for the last thirty years.



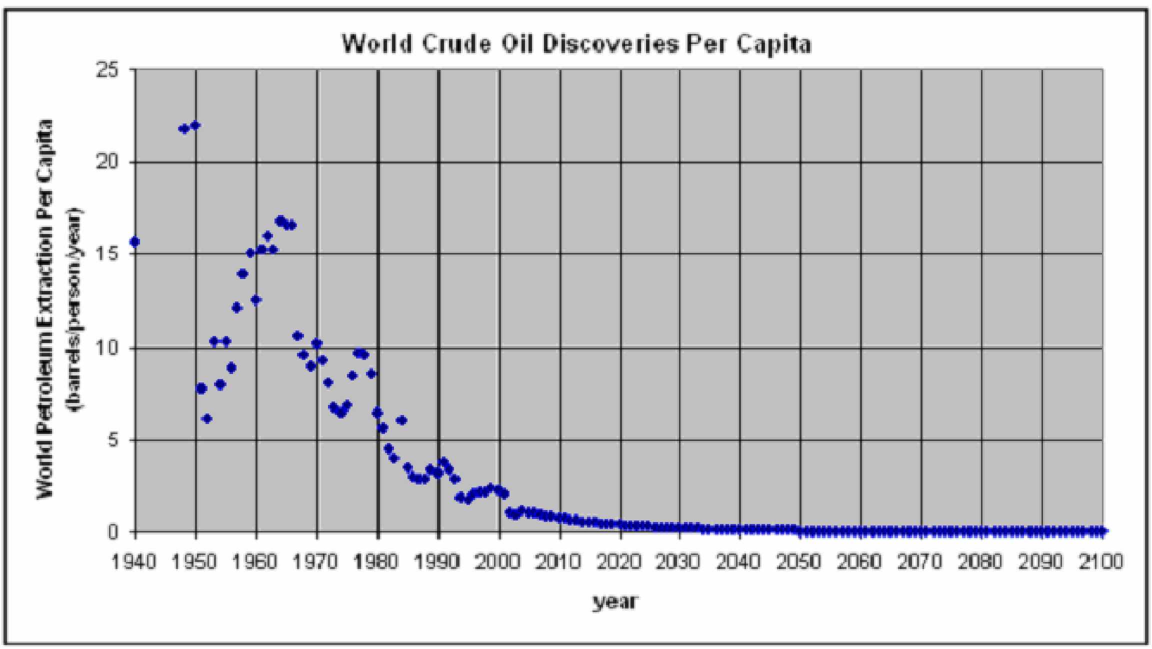


Figure 3-3. Top: World crude oil discoveries rate and a Verhulst-function fit to the data. Bottom: Crude oil discoveries per capita. Data are from http://www.durangobill.com/Rollover.html .

A recent (2006) discovery of an oil field 28,175 feet below the water surface of the Gulf of Mexico, estimated to contain 3 to 15 billion barrels of oil, falls neatly on the declining tail of the discoveries curve in the top part of Figure 3-3. Just to overcome gravity to bring the oil to the surface of the Gulf cost about 20% of the energy content of the oil. (For a barrel of crude oil (http://www.oilegypt.com/Webpro1/Oil/approxEnergyContent.asp):

$$\frac{\text{Energy to bring to surface}}{\text{Energy content}} = \frac{mgh}{6.1\times10^9 \text{ Joules}} = \frac{\left(93{,}000 \ \frac{\text{kg}}{\text{m}^3}\bullet 0.159 \text{ m}^3\right)\left(9.8\frac{m}{s^2}\right)(8588 \text{ m})}{6.1\times10^9 \ \frac{\text{kg}\bullet\text{m}^2}{s^2}}$$

$$= \frac{1.245\times10^9}{6.1\times10^9} = 0.204 \text{ or } 20\% \text{ .)}$$

Of course, friction losses in the pipes and pump systems will increase this, probably double it. Then there are the energy costs to transport the oil to the shore and to the refinery, to refine it and then transport it to filling stations. It is not clear that any net energy will finally emerge from that Gulf of Mexico discovery.

The same formula can be used to calculate the maximum depth from which oil can be pumped such that the energy required to overcome gravity is just equal to the energy content of the oil:

$$h = \frac{E}{mg} = \frac{6.1\times10^9 \text{ Joules}}{\left(95\times10^3 \frac{kg}{m^3}\bullet 0.159 \text{ m}^3\right)\left(9.8 \ \frac{\text{m}}{\text{s}^2}\right)} = \frac{6.1\times10^9 \frac{\text{kg}\bullet\text{m}^2}{s^2}}{1.48\times10^5 \frac{\text{kg}\bullet\text{m}}{s^2}} = 41200 \text{ meters} = 135000 \text{ ft} = 25.6 \text{ miles.}$$

The actual energy required to bring the oil to the surface is probably at least twice the amount needed to overcome gravity, which reduces the maximum depth to about 12 miles. The top of the new Gulf of Mexico field is 5.3 miles.

Oil discovered on the declining tail of the discovery curve steadily yields less energy per barrel as time progresses. At some point the energy used to get it is equal to the energy gained; then further oil extraction for energy will cease. Oil probably still will be pumped for the hydrocarbon chemicals that humans desire to use.

Extraction rates for crude oil are typically about forty years behind discoveries rates. So, the World crude-oil extraction rate is expected to peak at about 2005.

Figure 3-4 shows the World crude oil extraction rate and two mathematical fits to the data. The two Verhulst function fits (**Roper, 1976**) were obtained by fixing the total amount of World crude oil to be extracted at 2 x 10^{12} (2 trillion) barrels, an amount consistent with the fit to World crude oil discoveries discussed above and shown in Figure 3-3 and at 3 x 10^{12} barrels, 50% more than the amount that fits the discoveries rate data.

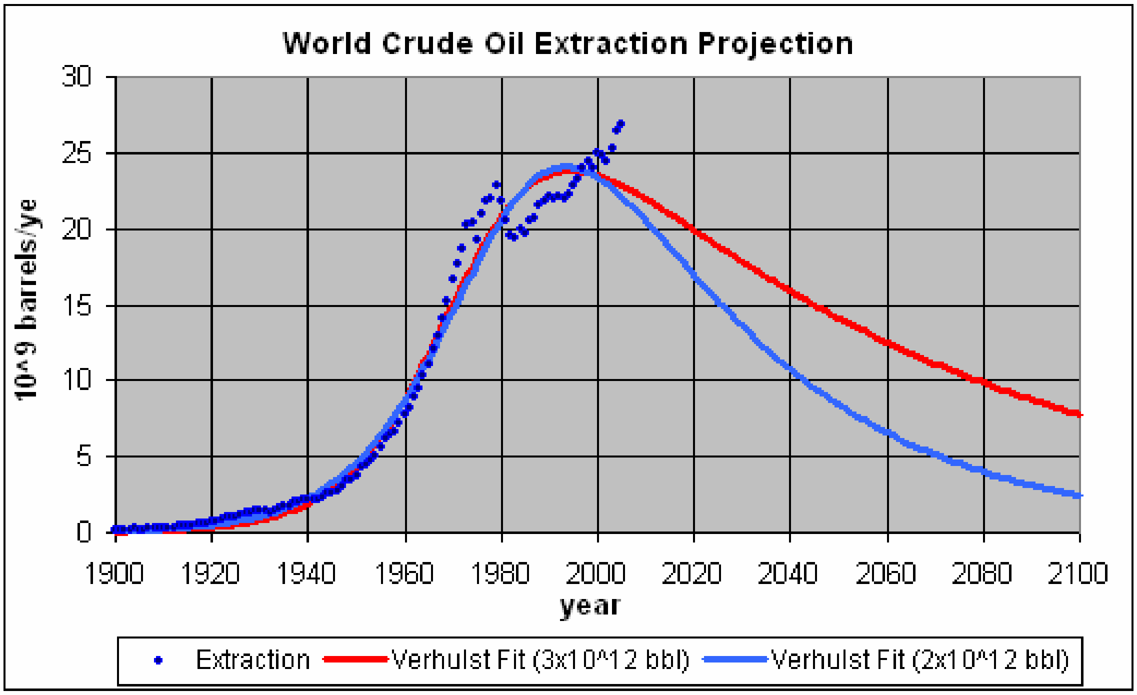


Figure 3-4. World crude oil extraction rate, two fits using the Verhulst function and projection of the fits into the future. Data are from http://www.eia.doe.gov .

The peak has been predicted by many geologists to be between 2000 and 2010. (**Deffeyes, 2005**)

Whether the peak of crude oil extraction has already occurred or will occur in the near future, the message is the same: The World, led by the United States, must use the remaining crude oil mostly to develop the infrastructure needed for the use of renewable energy sources beginning now and into the future.

Another way to look at the dire straits the World is in with regard to crude oil extraction is to study the World crude oil extraction rate per capita, as shown in Figure 3-5. Since 1979 the crude oil extraction rate per capita for the World has been falling most of the time, and the prediction is that it will continue to fall as the extraction rate falls and the population rises.

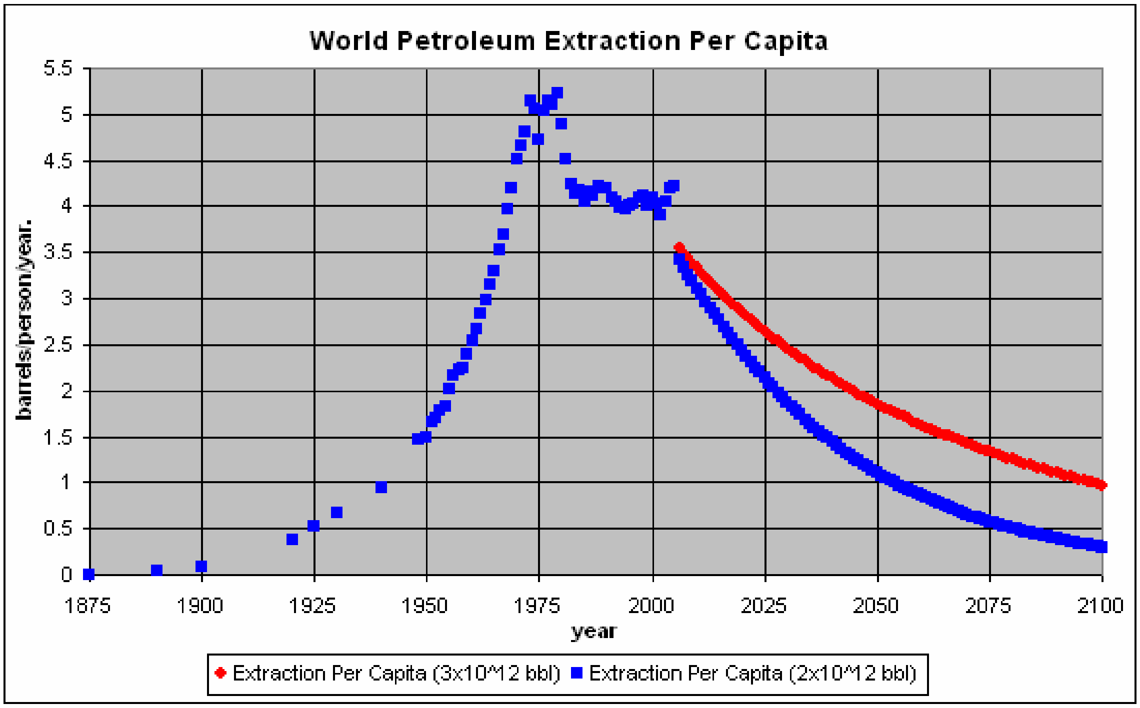


Figure 3-5. Worldcrude oil extraction per capita using the Verhulst fit to the data with 3 x 10^{12} barrels eventual extraction.

By the year 2100 there will be less than one-fourth as much crude oil per capita as there was in 2005. The smooth curve after 2005 is calculated using the fits of Figure 3-4 and a fit to the World population extrapolated to 2100 (**Roper, 2006**).

Obviously, one way to keep the fall in crude oil per capita from being so drastic would be to have World-wide adoption of pre-conception birth control and education of women to stabilize and then eventually reduce human population.

World Crude Oil Prices

Yet another way to observe the peak of crude oil extraction for the United States in about 1975 and the peak for the World shortly after 2000 is to study the price of a barrel of crude oil as shown in Figure 3-6 and Figure 3-7.

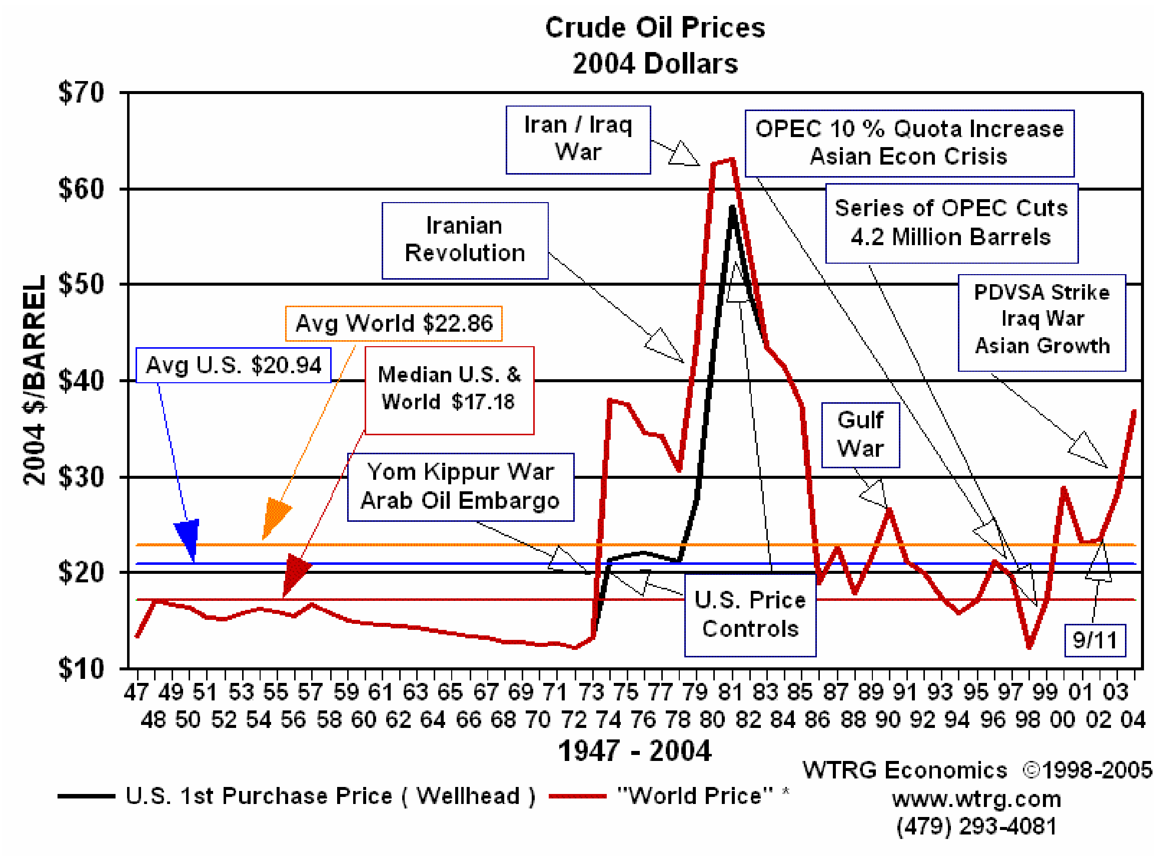


Figure 3-6. Worldcrude oil prices from 1947 to 2004. Taken from http://www.wtrg.com/oil_graphs/oilprice1947.gif

Crude oil prices from 1947 to 2004 in Figure 3-6 show the sharp rise in price near the United States' peak, which was accompanied by several Middle-East conflicts **(Klare, 2001)** and the beginning of a sharp rise in price near the World's peak, which is shown to have continued through 2006 in Figure 3-7.

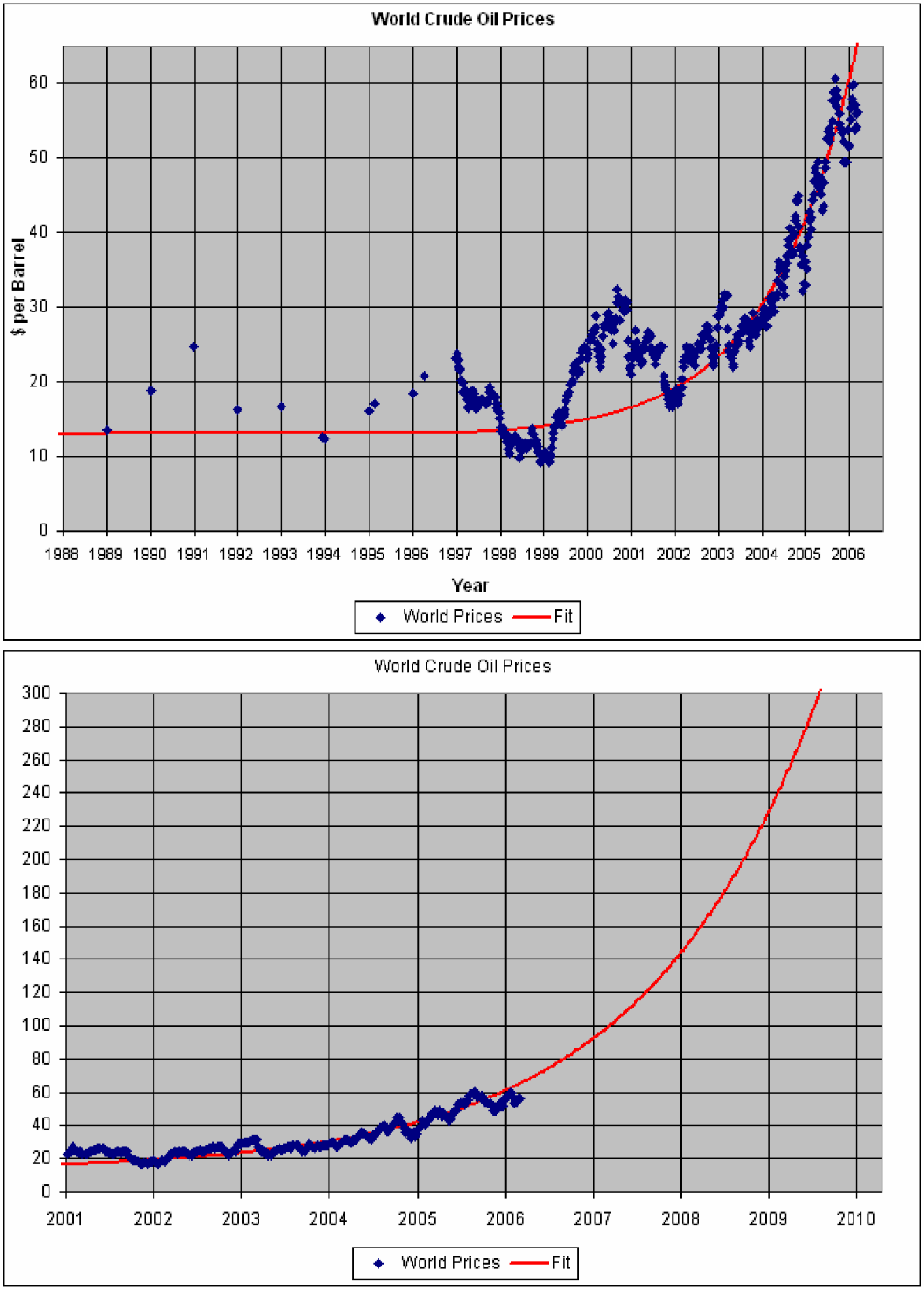


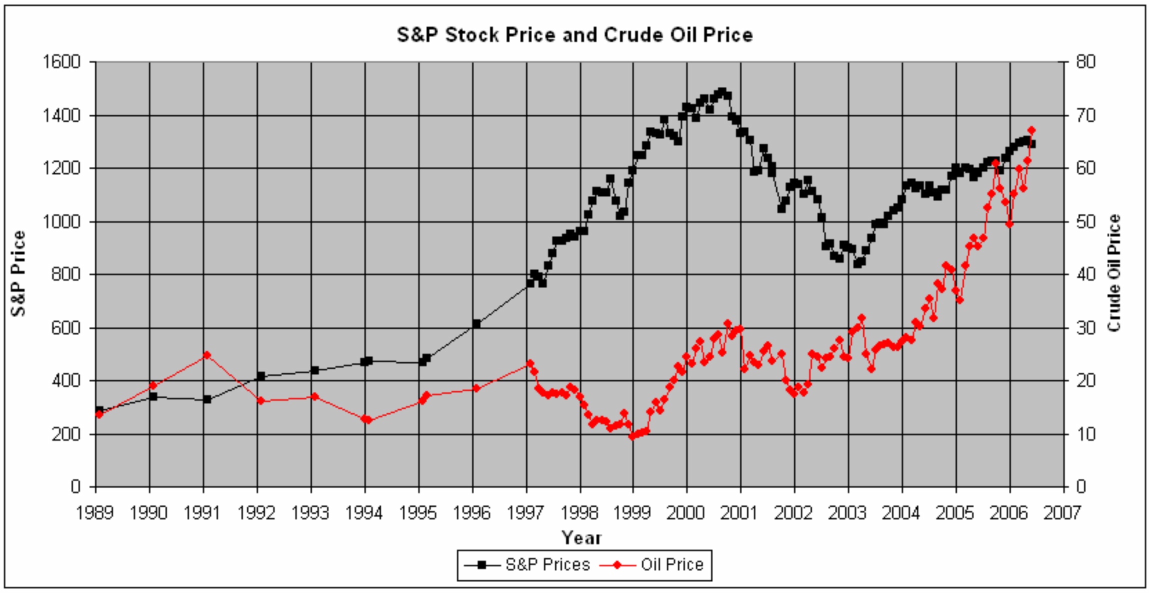
Figure 3-7. **World crude oil prices and an exponential fit to the data since January 2002. Data are from http://www.eia.doe.gov .**

The daily prices for crude oil can be found at http://www.wtrg.com/daily/clfclose.gif .

A World economic slump or collapse will probably keep crude oil prices from rising this rapidly. Eventually the price of oil will approach some asymptote after only the dregs are left to be extracted from the Earth and after humans quit burning it and recycle it as useful chemicals instead.

Stephen and Donna Leeb (*The Oil Factor: Protect Yourself and Profit from the Coming Energy Crisis*, 2004) have done a study that shows that the years when oil price has risen 80% or more correlate with years when the stock market is bear and the years when oil price has risen 20% or less correlate with years when the stock market is bull. Given the central role of energy in the economy and of oil in energy consumption, that result is almost a logical conclusion.

Figure 3-8 shows data for Standard and Poor's (S&P) stock-market prices used in Robert J. Shiller's book *Irrational Exuberance* (2006) and World crude oil prices given above and the ratio of S&P prices to oil prices.



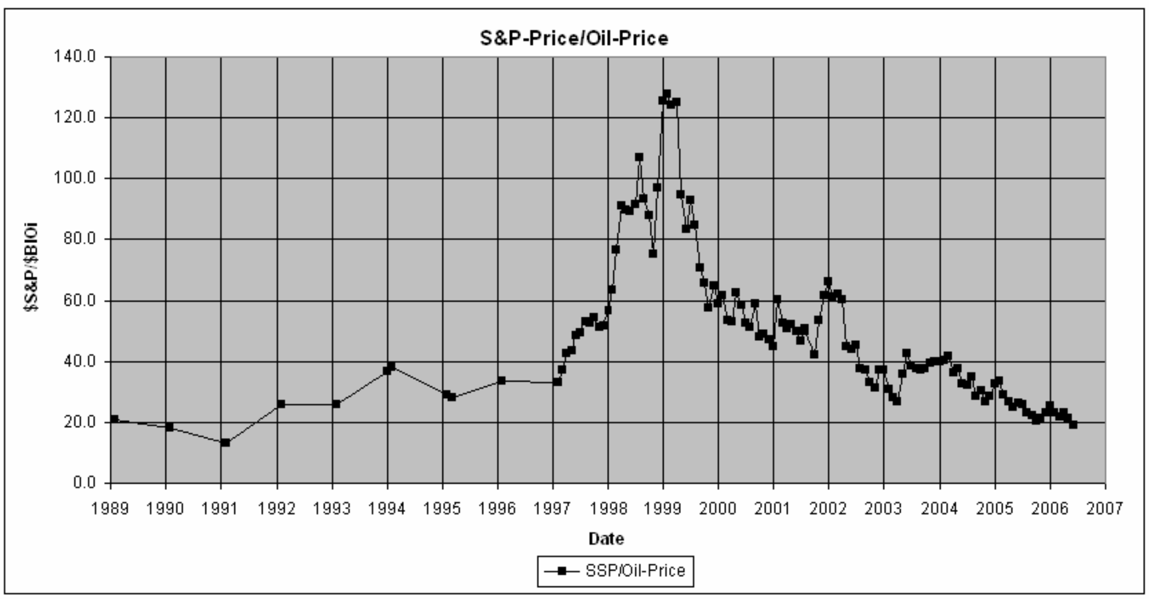
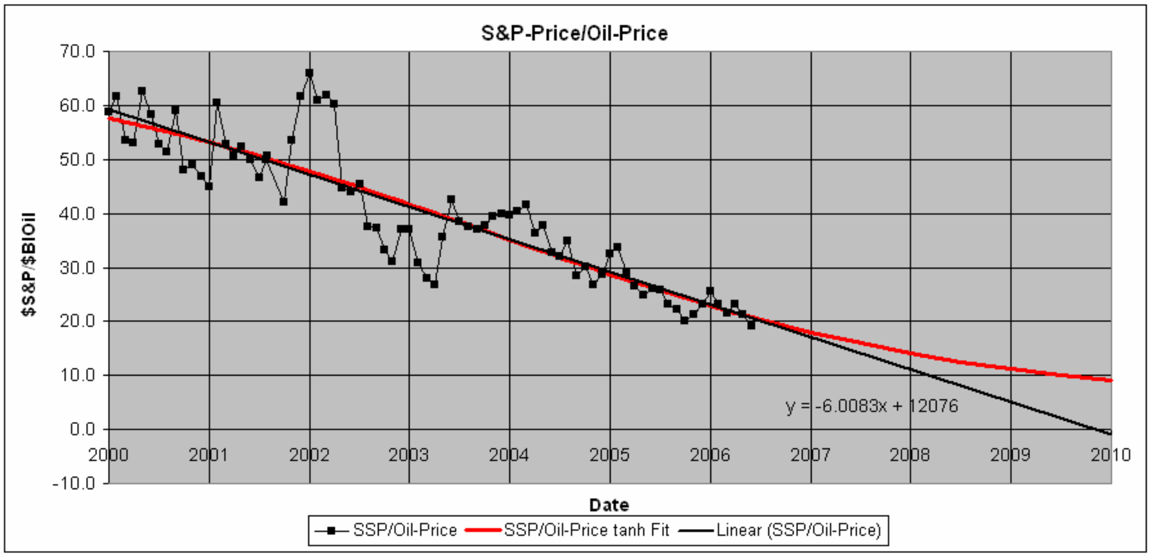


Figure 3-8. Top: Standard and Poor's stock prices (http://www.econ.yale.edu/%7Eshiller/data.htm and http://finance.yahoo.com/q/hp?s=%5EGSPC) and World crude oil prices. Bottom: Ratio of S&P/Oil-Price.

The connection between stock prices and oil price was fairly benign until about 1997, when the ratio of S&P price to oil price began a sharp rise as oil price declined quickly and then began to rise more quickly in 1999. Then the ratio began a downward trend as oil price generally rose. This behavior is as predicted by Leeb mentioned above.

The question is: What will be the ratio of S&P prices to the oil price from now on. From 2000 to 2006 one can fit a linear function or the hyperbolic tangent function to the S&P-price/Oil-price ratio to yield the fits shown in Figure 3-9. A hyperbolic tangent function often occurs in nature when an asymptotic ratio occurs. It is expected that, as the oil price rises, stock prices either will collapse in a depression or adjust to an asymptotic relationship with the oil price. The hyperbolic tangent fit represents a "soft landing" for stock prices relative to increasing oil price and the linear fit represents a "hard landing."



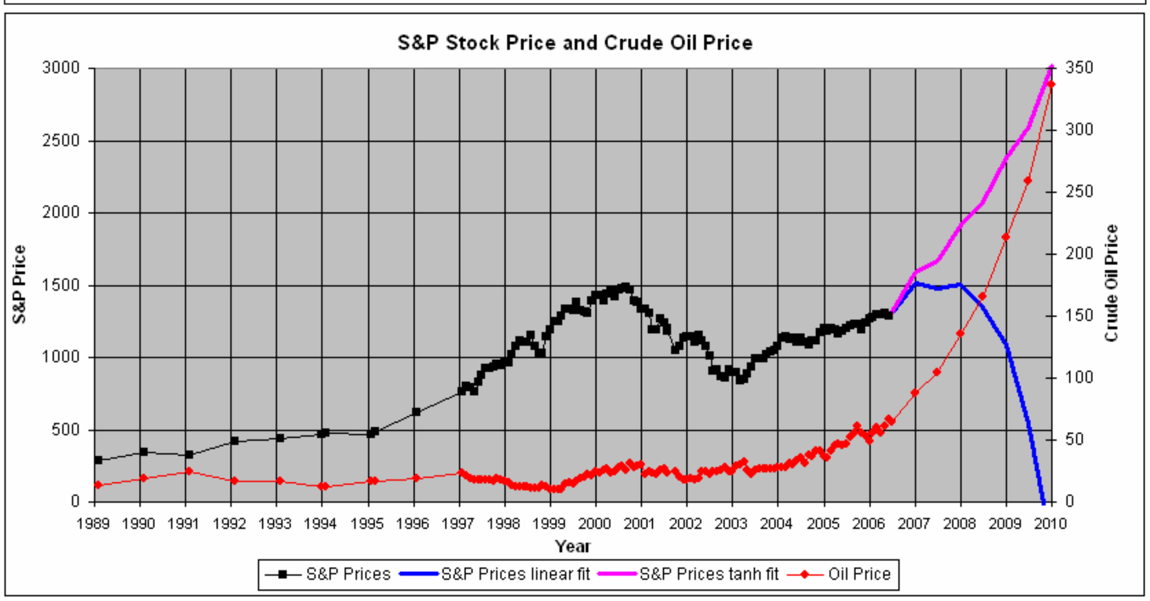


Figure 3-9. Top: Linear and hyperbolic tangent fits to the S&P-Price/Oil-Price ratio. Bottom: projection of S&P stock prices according to the fits to the S&P-Price/Oil-Price ratio assuming oil price continues to rise according to the fit to recent oil prices.

The fitted functions are:

$$\frac{\text{S\&P-price}}{\text{Oil-price}} = 37.29 - 32.70\tanh\left(\frac{t - 2003.67}{5.02}\right) \text{ and}$$

$$\frac{\text{S\&P-price}}{\text{Oil-price}} = -6.00841 + 12076\,t\,.$$

The bottom graph of Figure 3-9 shows the calculated projected S&P stock prices according to the fits to recent oil prices and ratio of S&P-price/Oil-price. Note the “soft landing” for the hyperbolic tangent fit and the “hard landing” (collapse of the stock market) for the linear fit. I suppose that question is: Can human organizations “engineer” the soft landing instead of the hard landing?

It may turn out that the price of crude oil will not rise exponentially for the next several decades as humans learn that life can go on without huge consumption of it. A fit can be made to the crude-oil price data with a final price of about twice the current price, as shown in Figure 3-10.

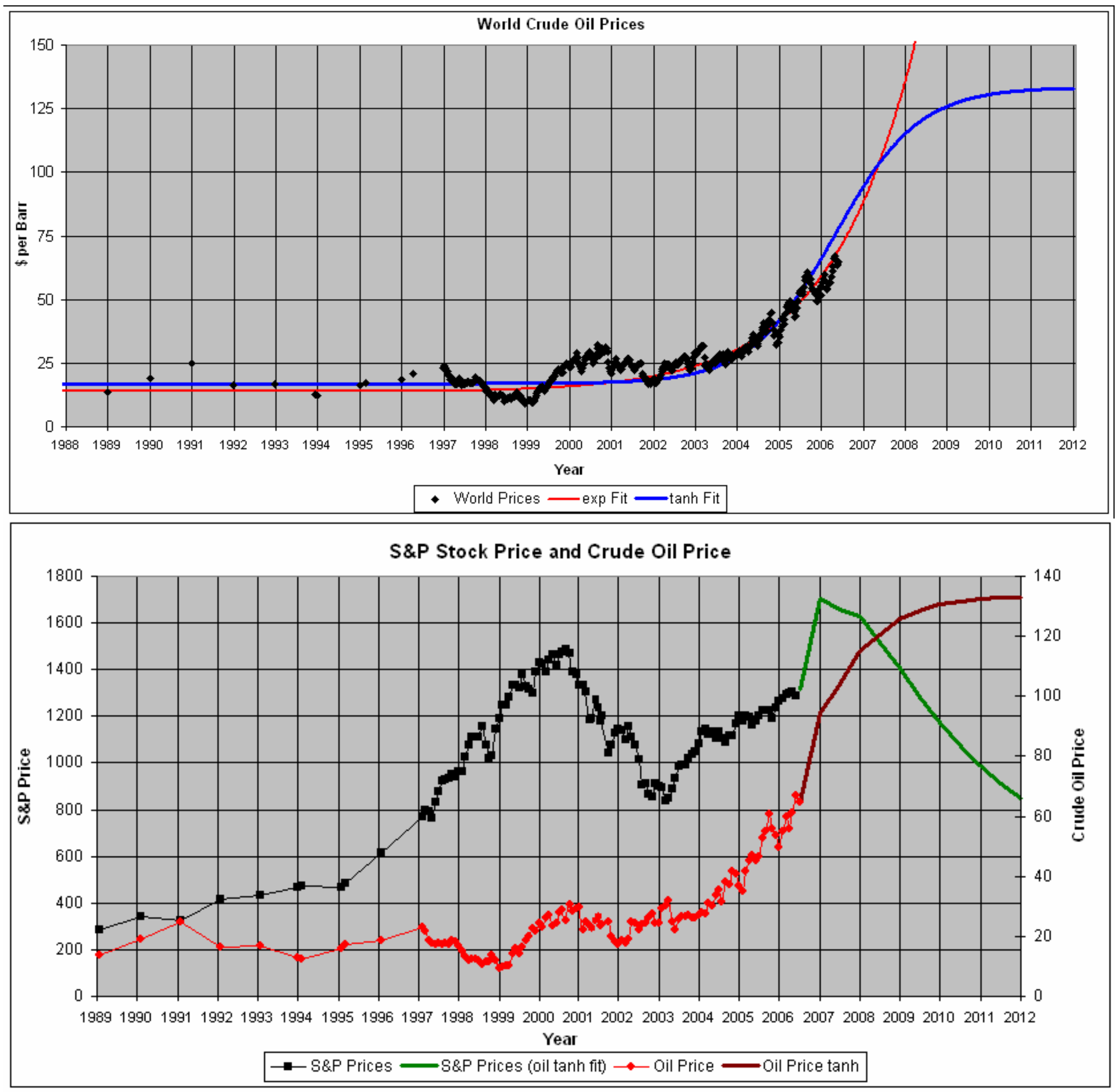


Figure 3-10. Top: Exponential and hyperbolic-tangent fits to World crude oil price. Bottom: Hyperbolic tangent crude-oil price and a possible depressive reaction of the S&P price without a complete collapse.

Saudi Arabia Crude Oil Extraction

A discussion of the World situation for crude oil extraction is not complete without discussing the situation for Saudi Arabia as an example of a major supplier of crude oil to the rest of the World. Figure 3-11 shows the extraction data and a Verhulst function fit (**Roper, 1976**) to the data. In the fit the total amount to be extracted is fixed at the sum of the amount already extracted (105×10^9 barrels) and the proven reserves (263×10^9 barrels). (**Simmons, 2005)** (total of 368×10^9 barrels)

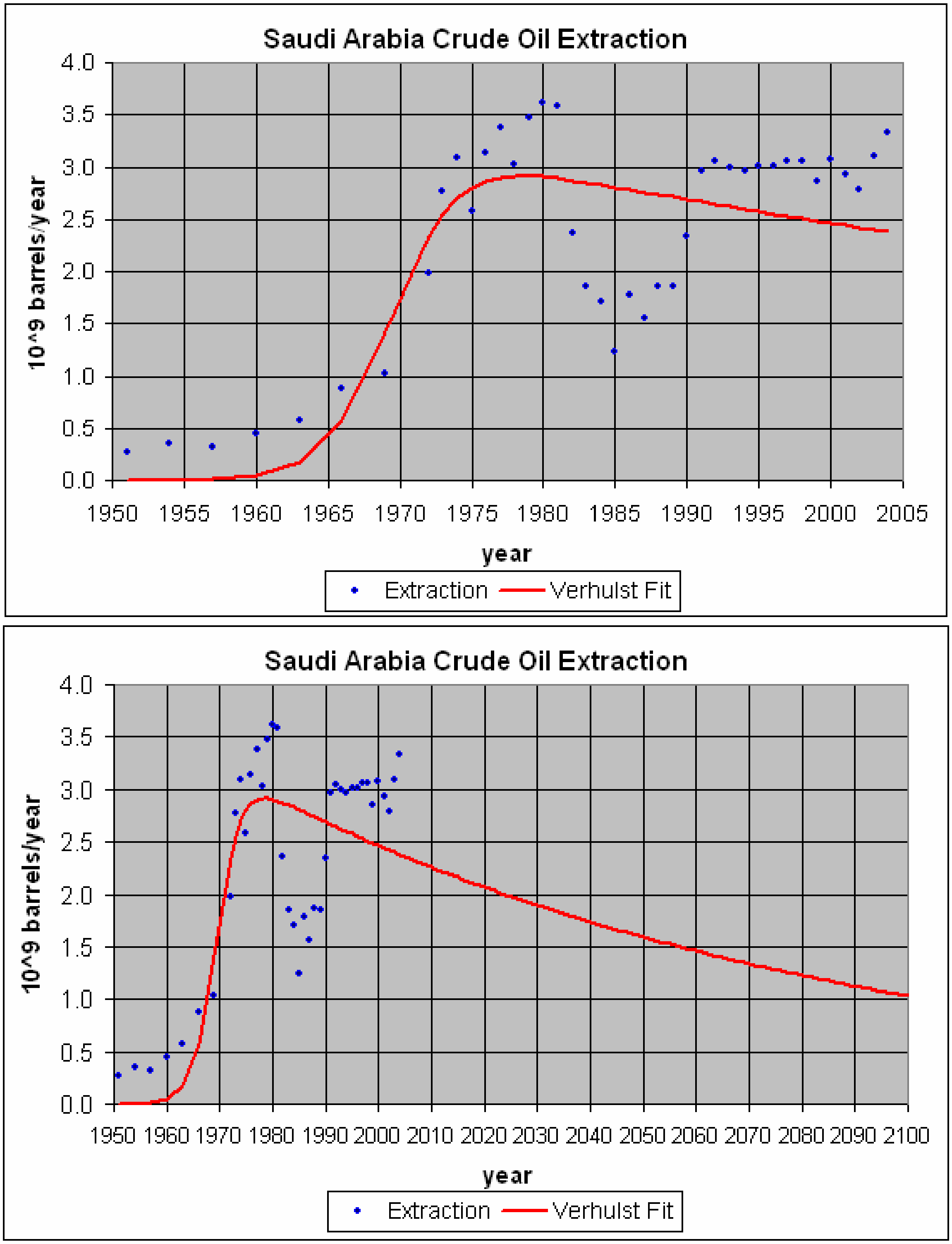


Figure 3-11. Top: Crude oil extraction data for Saudi Arabia and a Verhulst function fit to the data. Bottom: Extrapolation of the fit into the future. Data are taken from Simmons (Simmons, 2005).

Comparing Figure 3-11 for Saudi Arabia crude oil extraction rate to Figure 3-4 for World crude oil extraction, it is clear that Saudi Arabia will remain a major supplier of crude oil well into the middle of the 21st century. However, it may be that the "proven reserves" for Saudi Arabia are exaggerated

(**Simmons, 2005**). For example, suppose the total amount to be extracted would be 200x10[9] barrels; that is, about half has already been extracted. Figure 3-12 shows the projected crude oil extraction for Saudi Arabia for this case.

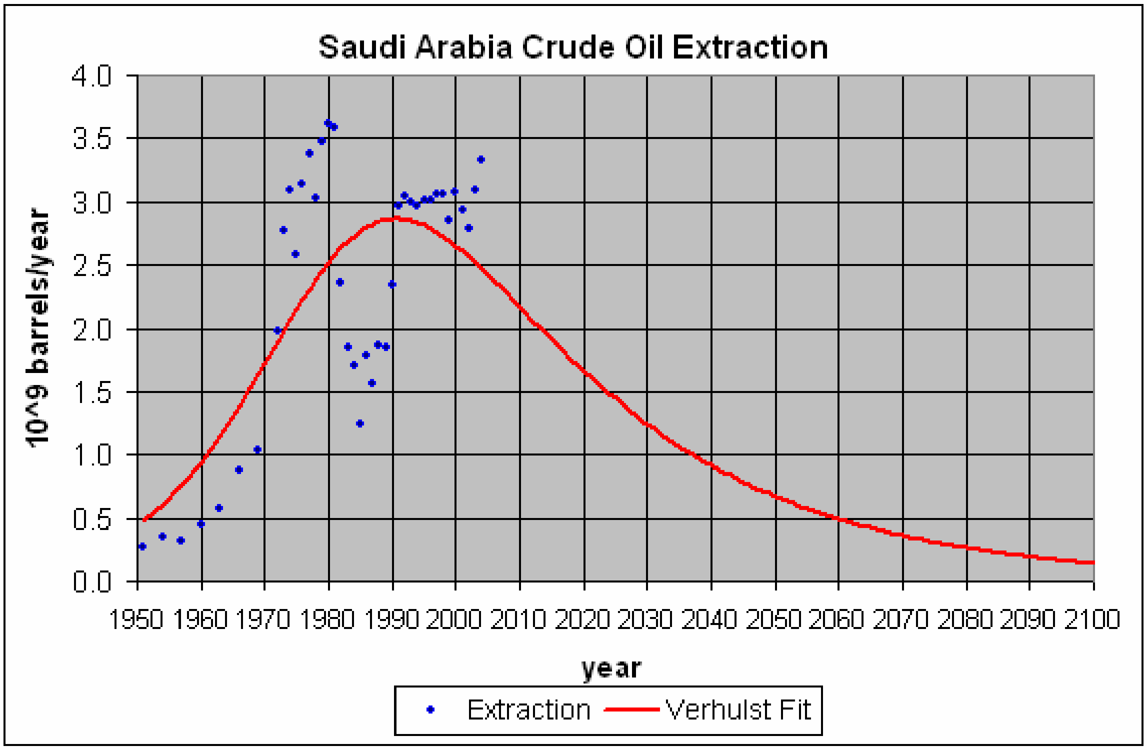


Figure 3-12. Crude oil extraction data for Saudi Arabia and a Verhulst-function fit to the data, with the total amount to be extracted equal to 200x10[9] barrels, and extrapolation of the fit into the future.

In this case, Saudi Arabia would provide only about 10% for the World's crude oil in 2030. (Compare to Figure 3-4.)

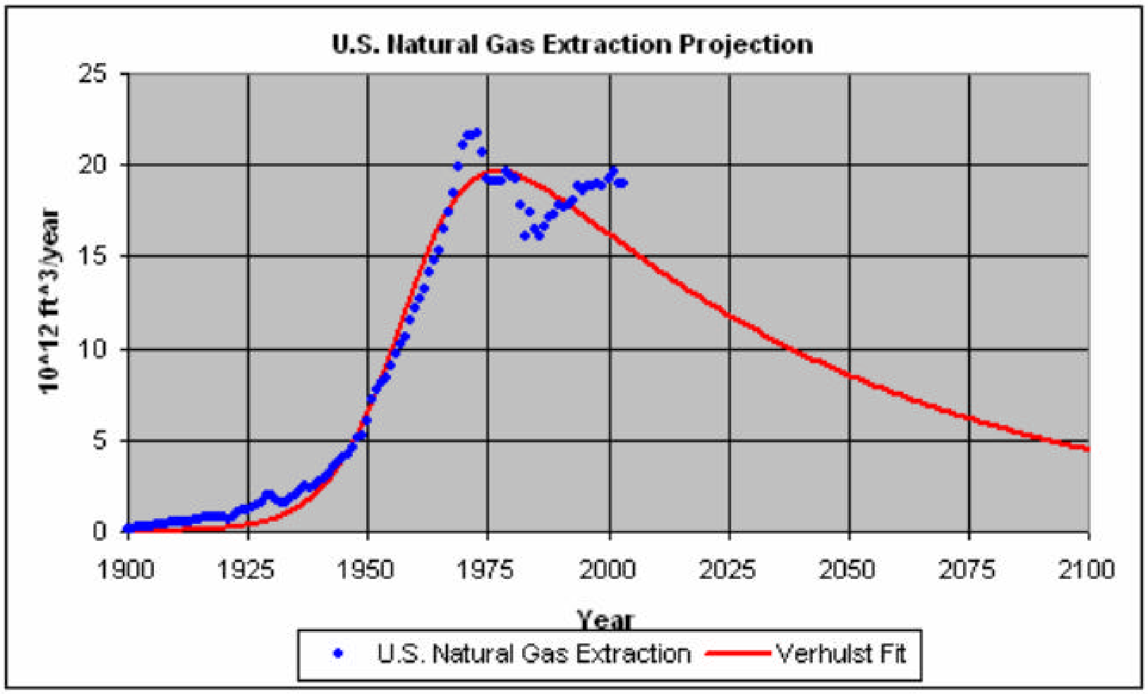
For analyses of crude-oil extraction data for Venezuela and Mexico see http://arts.bev.net/roperldavid/minerals/crudeoil.htm .

Natural-Gas Extraction

Natural gas (70 to 90% methane = CH_4) is widely used to generate electric power and will be used more for that purpose in the future because it produces much less pollution than does crude oil, coal or nuclear energy. Since one can use natural gas for transportation, can the World just switch to natural gas for transportation when crude oil extraction declines? (I drove tractors, cars and trucks that burned propane and butane, small components of natural gas which are easily liquefied, when I was in high school and college in the1950s.) See the section below about using natural gas to produce methanol for vehicle fuel (**Olah, 2006**).

In the early years of the petroleum age the natural gas that is often exhaled from the Earth when crude oil is extracted was flared into the atmosphere or burned. That still occurs at some locations. Flaring natural gas puts the very potent greenhouse gas methane into the atmosphere, enhancing global warming. When it is burned the potent greenhouse gas carbon dioxide is put into the atmosphere.

Natural gas extraction has peaked for the United States as shown in Figure 3-13. (**Darley, 2004**) A Verhulst function fit (**Roper, 1976**) to the United States extraction data gives a reserves value about 5 times the 2003 proven reserves, so it is probably too optimistic for predicting the future. The total ultimate extraction in the fit to the World extraction data was set at 10,000x10^{12} (10 quadrillion) ft^3, which is very optimistic (http://www.hubbertpeak.com/gas).



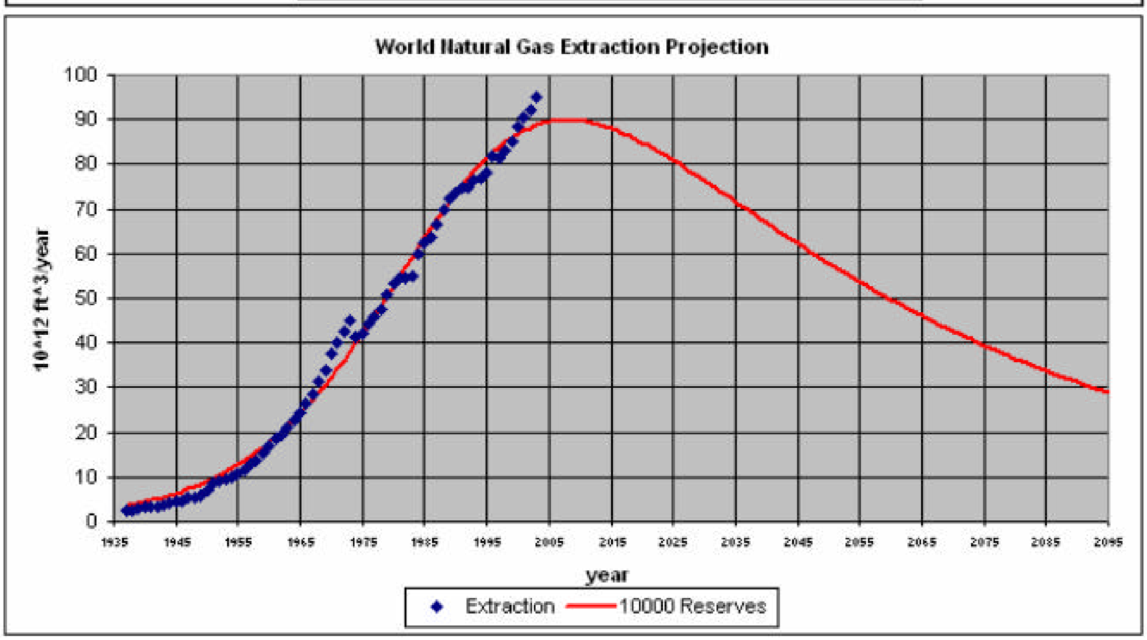


Figure 3-13. United States (top graph) and World(bottom) natural-gas extraction rates, fits to them using a Verhulst function and projection of the fits into the future. Data are from http://www.eia.doe.gov .

Natural gas is a cleaner fuel than crude oil, but it is more difficult to transport across vast continents and oceans. So, even if World natural-gas extraction does not peak for several more years, it may not be of great use to most nations except those that are near where it is extracted. Transporting it across vast oceans as Liquid Petroleum Gas (LPG) is very expensive and dangerous, which makes it vulnerable to accidents and terrorism. It can be converted to methanol, a liquid at normal temperatures, which is much easier and safer to transport (**Olah, 2006**), which will be discussed in a later section.

The main nations for natural-gas extraction in the future will be Russia, Iran and Qatar.

Figure 3-14 shows the World natural-gas discoveries and extraction (incorrectly called "production") rates. Discoveries rate has a very sharp peak at about 1971 and an extremely rapid decline. This led Darley (**Darley, 2004**) to predict that the extraction rate will have a similar peak at about 2010, which is consistent with the prediction of Figure 3-13.

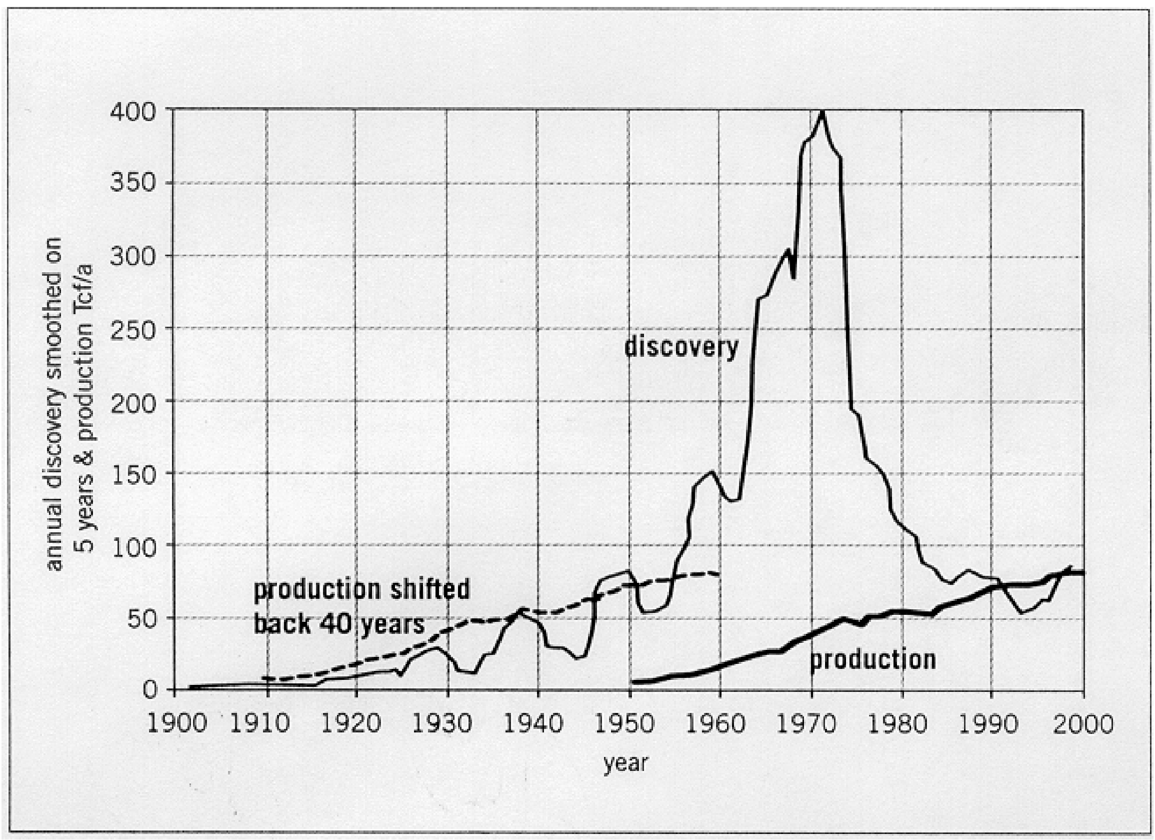


Figure 3-14. World natural-gas discoveries rate and extraction rate in 10^{12} (trillion) cubic feet per year. Taken from Darley, p. 92. (Darley, 2004)

Many nations, including the United States, are moving rapidly toward using more natural gas for electric power generation, because of it burns much cleaner than crude oil or coal.

The conclusion is that the social shock of natural-gas rapid decline may be worse than the social shock due to crude oil extraction decline, especially if the World puts much hope in natural-gas as its energy salvation.

Natural gas is not readily delivered to the customer. Pipelines must be built for the transport of the gas, which can take many years for "stranded" natural-gas fields. (**Darley, 2004**)

Figure 3-15 shows the United States price per thousand cubic feet of natural gas at the wellhead. The natural-gas price dynamics is very similar to the price-dynamics for crude oil as shown in Figure 3-7.

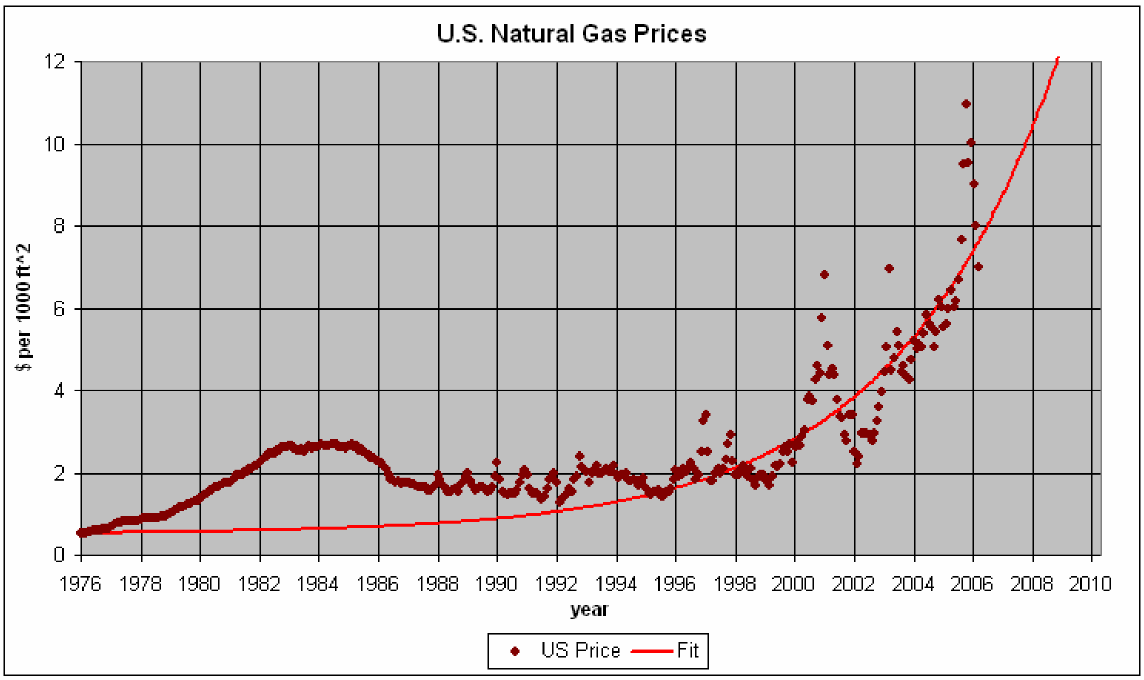


Figure 3-15. World natural-gas prices and an exponential fit to the data since January 1999. Data are from http://www.eia.doe.gov .

Daily prices for natural gas can be found at and http://www.wtrg.com/daily/ngfclose.gif .

Methane Extraction from Methane Hydrates

The possibility of extracting a huge amount of methane from methane hydrates under the permafrost in the Arctic and on continental shelves has greatly excited petroleum companies and governments. (**EIA, 2003**) The exact amount of methane that exists in hydrates is not well known and the amount that might be extractable with a net energy gain is even less well known. Numbers like 1,000 to 10,000 times conventional natural gas reserves are mentioned.

However, the locations are the most sensitive areas for environmental degradation by headlong attempts to extract methane: the Arctic region and the under-water continental shelves. In addition, note that methane release into the upper atmosphere plays a key role in Global Warming. See http://www.geotimes.org/nov04/feature_climate.html and (**Kennett, 2003).**

A massive program to extract methane from methane hydrates may be terribly dangerous for the existence of humans on Earth if massive amounts are accidentally released into the atmosphere. We must proceed very slowly to give time to study these and other possible consequences.

See The Next Major Ice Age section for a discussion of a role methane hydrates may play in the beginning and ending of Major Ice Ages. It may be possible for humans to slow the usual rapid entry into the next Major Ice Age by causing the release of methane from methane hydrates during the entry.

Coal Extraction

Coal is mostly used to generate electric power. Why not use coal to produce a liquid fuel to drive vehicles in the United States? The short answer is that it costs much energy to convert coal to a liquid and any way coal is used for energy is very detrimental to the environment.

Figure 3-16 shows the situation for coal extraction in the United States and a Verhulst function fit (**Roper, 1976**) to the data, fixing the total amount to be extracted at 350×10^9 (350 billion) short tons. Note the rapid rise in extraction rate until petroleum was discovered and put to use as fuel. With the decline in petroleum extraction in the United States since the 1970s, the coal extraction rate started to rise again, and will continue to do so in the future, as guessed by the solid curve on the right connected to the data. I show the extraction as rising rapidly as World crude oil and natural gas decline in extraction; then a sharp decline as the disastrous effects of burning coal begin to be realized; then rising with better pollution controls on burning coal and, finally, falling as World coal becomes depleted. I may have exaggerated in my prediction of the dip around year 2050.

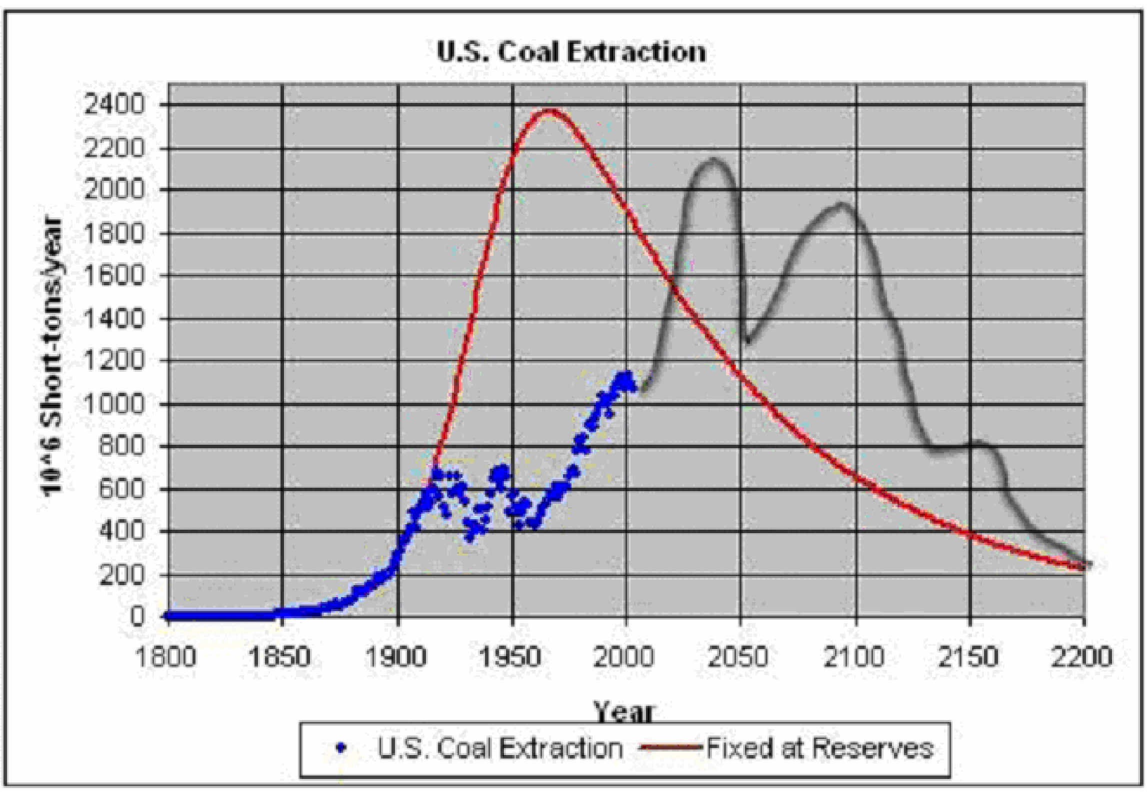


Figure 3-16. Coal extraction rate in the United States. Data are from http://www.eia.doe.gov .

Of course, a major problem with coal is the pollution it produces when used as fuel for electric power plants or when liquid or gas fuel is made from it. With Future Global Warming as a major problem (See Chapter 2.), coal is not a very attractive way to get a fuel for transportation. It is better used in electric-power generation at specific locations where the polluting particles and chemicals can be captured. Large quantities of water, fuel and electric power are needed to produce liquid and gas fuel from coal and tar sands.

In any case, it appears that extraction of coal in the United States will decline after about 2100 and be mostly finished by about 2200.

For a different analysis of United States coal extraction see http://www.fromthewilderness.com/cgi-bin/MasterPFP.cgi?doc=http://www.fromthewilderness.com/free/ww3/052504_coal_peak.html .

Figure 3-17 shows the World and United States coal extraction data and Verhulst function fits (**Roper, 1976**) to the data, fixing the total amount to be extracted for the World at 1.5×10^{12} (1.5 trillion) short tons, the estimated amount of total eventual extraction (http://www.eia.doe.gov/emeu/iea/coal.html), and at twice that amount.

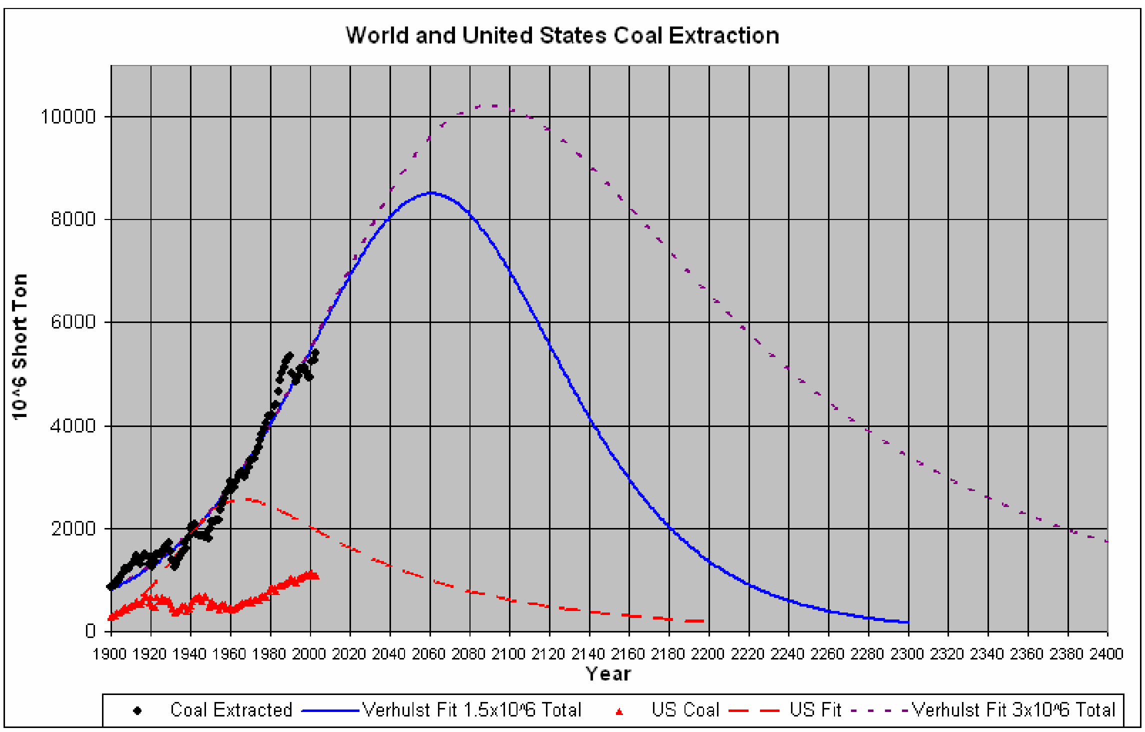


Figure 3-17. World and United States coal extraction rate and Verhulst fits to the data. The solid curve is for 1.5x10^12 short tons total extraction for the World and the dashed curve is for 3.0x10^12 short tons total extraction for the World.

The conclusion is that coal will be available for the World in increasing amounts for about fifty years and then will decline rapidly in amount until it is effectively gone about two hundred years later.

Uranium Extraction

Some propose that more nuclear power plants be built for generating electric power. This has been done on a large scale in France (about 75% of electric power in 2005), although the United States obtains more power from uranium than does France.

The electric power generated could be used to charge energy storage devices in vehicles for transportation.

Figure 3-18 shows the uranium extraction data for the World and a Verhulst function fit (**Roper, 1976**) to the data in order to extrapolate into the future. The total amount to be eventually extracted used for the fit is 15,000x10^3 tonnes (1 tonne = 1000 kg), which is about 3,000 x10^3 tonnes more than the known and estimated undiscovered uranium resources (6260x10^3 tonnes, http://www.nea.fr/html/pub/newsletter/2002/20-2-Nuclear_fuel_resources.pdf) plus than the amount already extracted (5691x10^3 tonnes) (total of 11,951x10^3 tonnes).

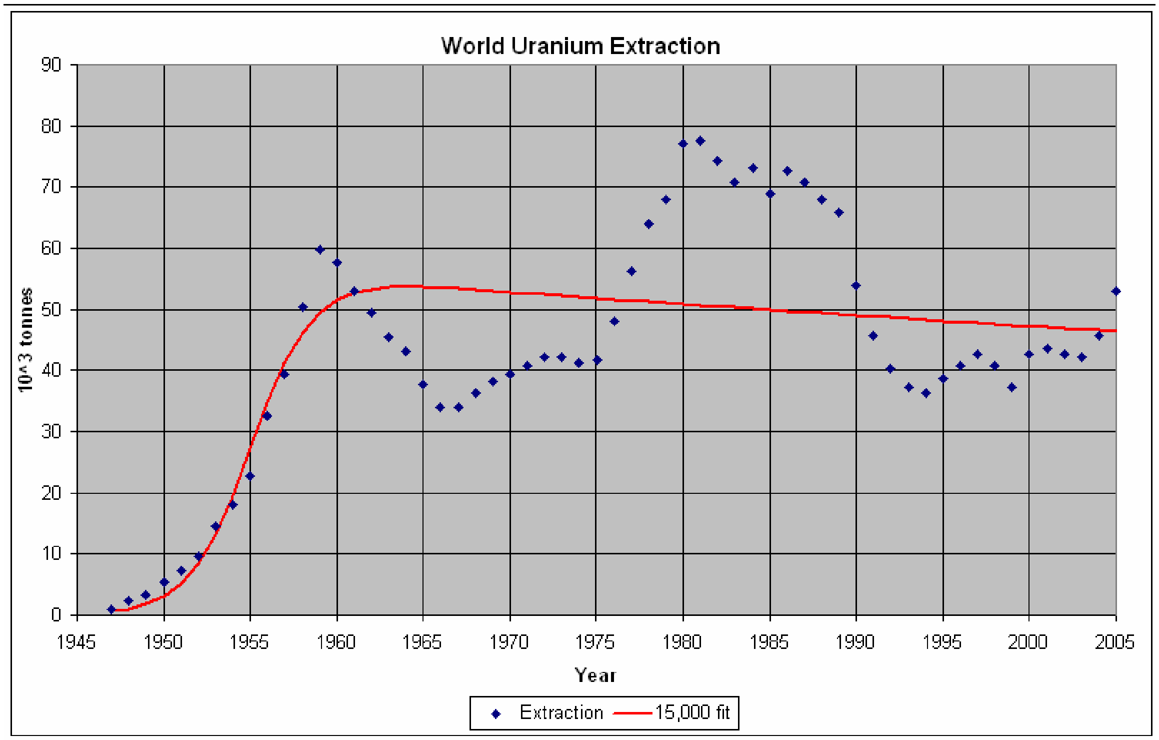


Figure 3-18. Uranium extraction rate for the World and a Verhulst function fit to the data.
http://www.globeuranium.com.au/index.php?id=22&PHPSESSID=bb901a92b43b2edca8f0667673e64b39

Note in Figure 3-18 the two big pushes (1955-1965 in the United States and Western Europe and 1975-1990 in Eastern Europe) to extract uranium during the Cold War, most of which went into building huge amounts of nuclear weapons by the United States and the Soviet Union. There is a program of the United States and Russia, called the "Megatons to Megawatts Program" (http://en.wikipedia.org/wiki/Megatons_to_Megawatts_Program), for converting high-enriched uranium used in weapons into low-enriched uranium to be used for electric power.

Figure 3-19 shows the extrapolation of the fit to 2300 and also a fit to the data without the data for the two Cold War peaks. Both fits have the total amount to be eventually extracted as $15{,}000 \times 10^3$ tonnes. Of course, the latter fit will stretch out in time the availability of uranium for generating electric power, since more uranium will become available by extraction from nuclear weapons.

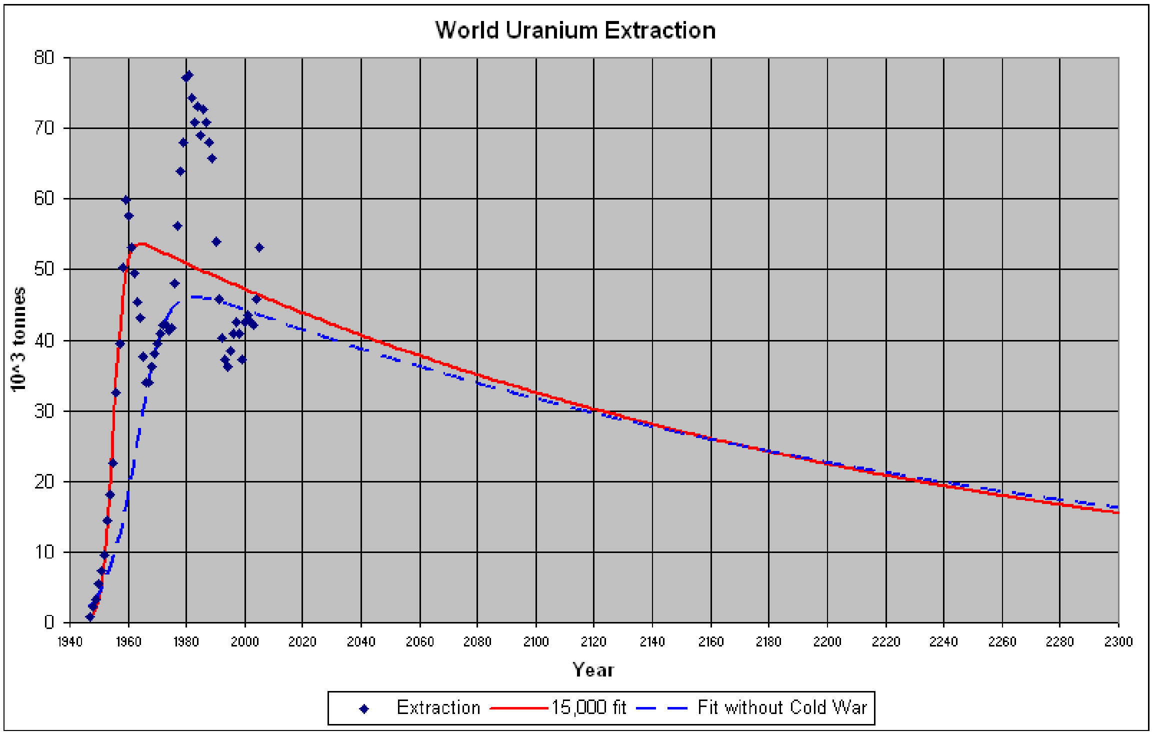


Figure 3-19. Uranium extraction rate for the World and Verhulst function fits to the data and their extrapolations into the future. The solid curve is for the total amount to be extracted equal to $15{,}000 \times 10^3$ tonnes and the dashed curve is for a fit to non-Cold-War data with the total amount to be extracted equal to $15{,}000 \times 10^3$ tonnes.

However, (**SLS, 2006**) shows convincingly that uranium ores of low uranium concentrations will not produce net energy. Using the ore reserves for only concentrations greater than 0.05% mass-% U_3O_8 and adding a little to be optimistic, Figure 3-20 shows a fit to the uranium extraction data for an eventual extraction amount of 7500×10^3 tonnes.

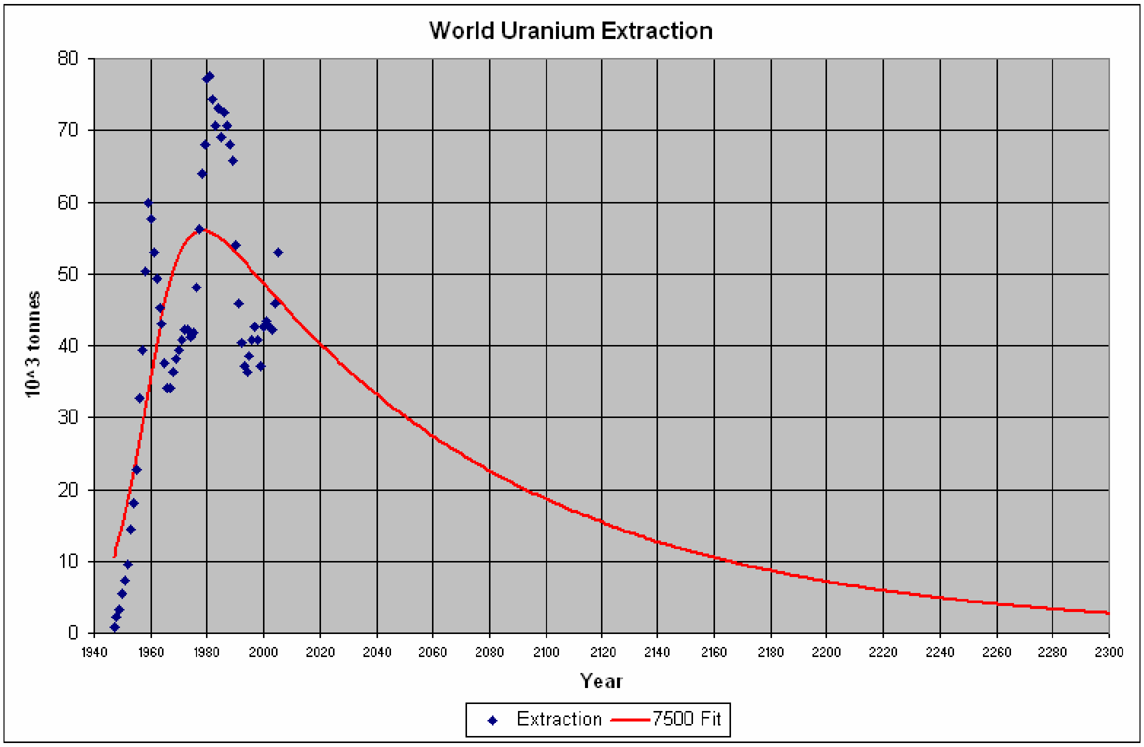


Figure 3-20. Fit to uranium extraction data using only 7500x10^3 tonnes total eventual extraction.

I expect that there will be a large peak in uranium extraction in the next few decades as crude oil and natural gas extraction decline (Figure 3-4 and Figure 3-13), followed by a possible sharp dip after a major nuclear-reactor accident or terrorism involving a nuclear reactor, and then a rise again to then follow the declining curve of uranium depletion.

The four major extractors of uranium are Canada, Australia, Commonwealth of Independent States (11 states of the former Soviet Union, http://en.wikipedia.org/wiki/Commonwealth_of_independent_states) and the United States.

The recent rising demand for uranium is indicated by the recent fast rise in the price of uranium oxide as shown in Figure 3-21. The price on 30 January 2006 was $37.50. Price per pound is expected to reach $50 per pound in the near future.

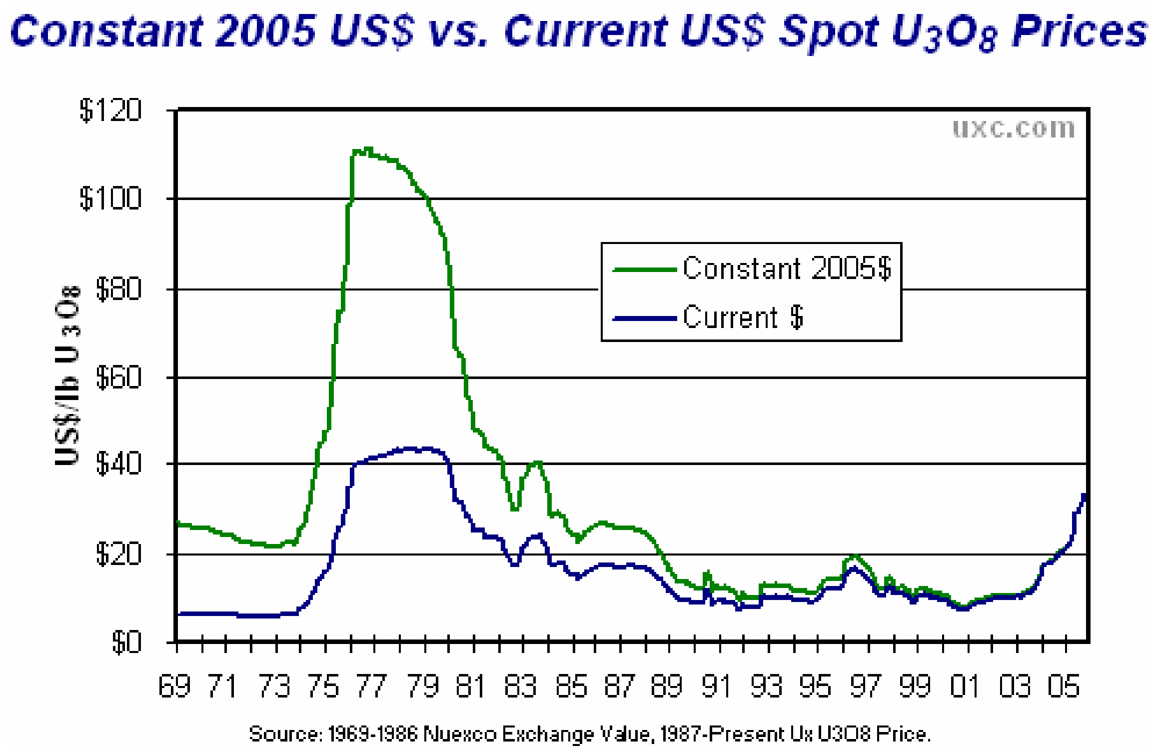


Figure 3-21. Spot prices per pound for U_3O_8. http://www.uxc.com/review/uxc_g_hist-price.html . Note the huge Cold War prices.

One can see why uranium price has been rising at a fast rate by comparing the extraction rate to the usage rate in the Western World, as shown in Figure 3-22.

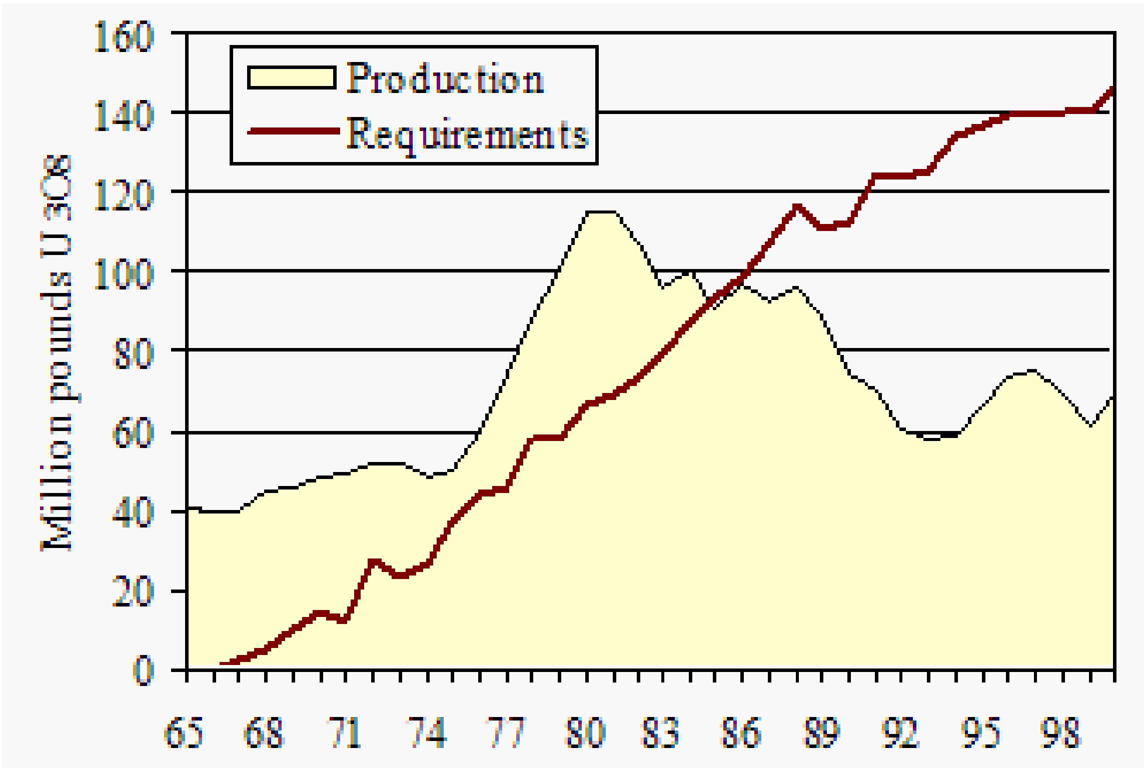


Figure 3-22. Western World uranium supply versus demand. (http://www.uxc.com/cover-stories/uxw_18-34-cover.html)

The environmental situation for use of uranium as an energy source is very problematical:

- Safe storage of radioactive waste for tens of thousands of years is required, which is well into the next Major Ice Age. It is a major problem. (**Benford, 2000**)
- Use of uranium for weapons of mass destruction, for radioactive terrorism, as armor for military weapons and in the tips of warheads of standard weapons are major problems. Uranium-tipped weapons were used extensively in the Gulf War, Bosnia War, Kosovo War and Bush Iraq War by the United States armed forces. See (**NEIS, 2003**) for descriptions of the inhumanity of such weapons.

Benford (**Benford, 2000)** relates the history and details of attempts to design warning systems for humans up to 10,000 years from now regarding underground storage sites for radioactive nuclear wastes. It is interesting that this time period is about the time to the first minimum of the next Major Ice Age. (See Chapter 4.) Perhaps humans will dig up the radioactive wastes to try to use them to keep warm or for religious rites. Read about how an event similar to the latter happened in Brazil: http://arts.bev.net/roperldavid/GRI.htm.

For a more positive view of nuclear power, see http://en.wikipedia.org/wiki/Nuclear_power.
For a more negative view of nuclear power including a net energy analysis, see (**SLS, 2006**).

Comparison of World Energy Minerals Extraction Rates

Figure 3-23 shows a comparison of the World extraction rates of coal (Figure 3-17), crude oil (Figure 3-4), natural gas (Figure 3-13) and uranium (Figure 3-19 and Figure 3-20). They are all normalized to 1 at year 2000.

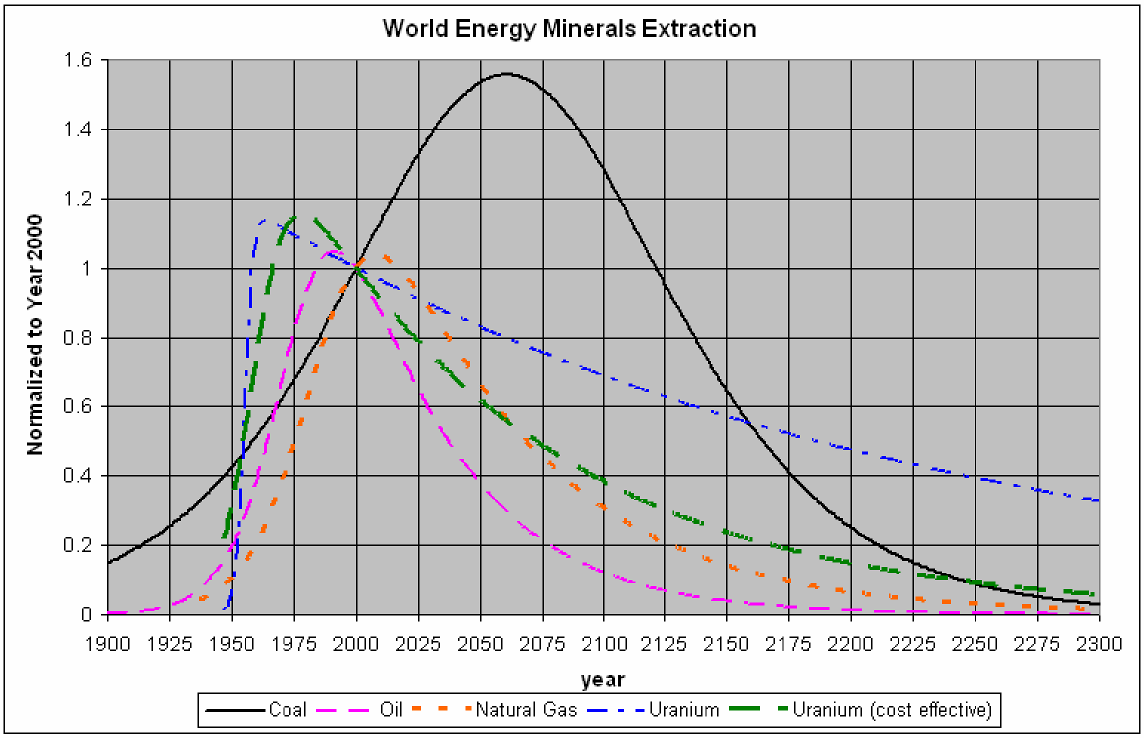


Figure 3-23. Comparison of World extraction rates for coal, crude oil, natural gas and uranium, all normalized to 1 at year 2000.

The purpose of Figure 3-23 is to give a visual feel for the peak times and the longevity for the different energy minerals. The main conclusion is that coal is the big hope for the future for concentrated non-renewable energy sources, but that it, too, will be in declining extraction mode after about 2050. At first glance uranium looks promising until net energy is considered, then it is about like natural gas. A net energy analysis for coal, similar to that done for uranium by (**SLS, 2006**), needs to be done for coal.

Figure 3-24 shows the consumption of energy by resource for the United States; the consumption for the World should be similar.

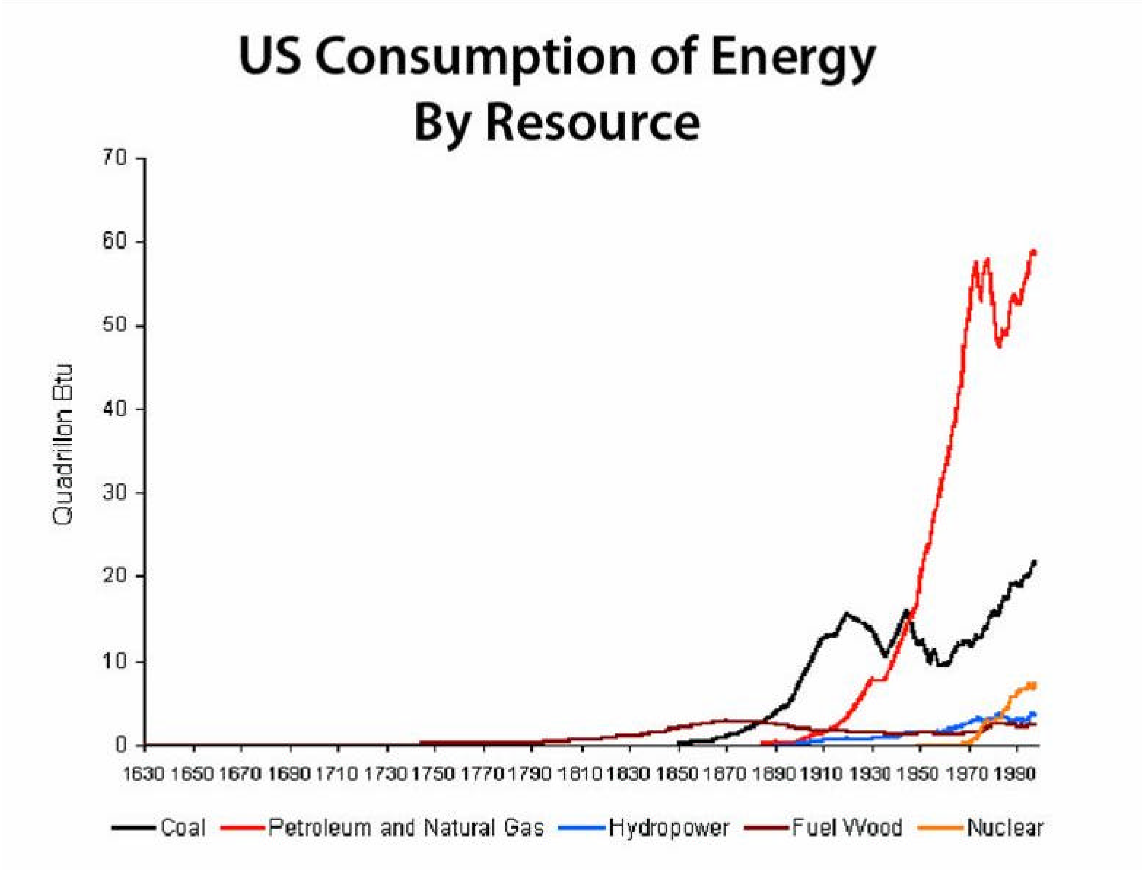


Figure 3-24. United States consumption of energy by resource.
(http://www.theoildrum.com/story/2006/8/2/114144/2387)

Obviously, the World economy will be in big trouble as oil and natural gas extraction begin to decline. There is no way around the fact that World population must be reduced, energy use must be made more efficient and renewable non-concentrated energy sources must be developed on an accelerated scale.

Miraculous Energy Sources

There are many who blindly state that humans will find some miraculous energy sources to make life even better in the future than now with the extensive use of petroleum. Some of the miracles wished for are:

- Fusion energy or even cold fusion energy at low cost. See *Bad Science: The Short Life and Weird Times of Cold Fusion* by Gary Taubes.
- Breeder nuclear reactors that are safe and that do not contribute to increasing the availability of nuclear weapons.
- Petroleum from extreme depths of the Earth.
- Uranium from seawater.
- Uranium from coal dust.
- Violation of conservation of energy for a closed system (1st Law of Thermodynamics). (http://en.wikipedia.org/wiki/Laws_of_thermodynamics)
- Violation of entropy (a measure of disorder or energy not available to do work) increase for a closed system (http://en.wikipedia.org/wiki/Entropy) (2nd Law of Thermodynamics).

Suppose an extremely huge source of power (energy per time) were found by humans and it were easily accessible. What would that portend for the future of the Earth? If it occurred soon, its use would grow extremely rapidly, in which case the waste heat from its use would cause extreme Future Global Warming.

The Earth radiates waste heat at a fixed rate depending on its average temperature. The power per area radiated depends on the fourth power of the absolute temperature according to the Stefan-Boltzmann law (http://en.wikipedia.org/wiki/Black_body_radiation). So an extreme amount of heat energy put into the Earth at a rapid rate would raise the absolute temperature of the Earth by one-fourth power of some fraction of that amount of the power per area. See http://www.roperld.com/science/earthradiation.pdf. (Some would go into changing Earth states, such as melting ice and vaporizing water.) Figure 3-25 shows the heat energy per time released by humans on the surface of the Earth for different final changes in temperature (Celsius degrees) from 2002, the Stefan-Boltzmann law, a hyperbolic-tangent time variation in energy release and a set of reasonable parameters. The equation being plotted is

$$P_{\text{man}}(t,\Delta T) = \tfrac{1}{2} P_{\max}(\Delta T)\left\{1 + \tanh\left[\frac{t - t_b(\Delta T)}{2t}\right]\right\},$$

$$\text{where } t_{\text{b}}(\Delta T) = 2000 + 2t \ \text{atanh}\left[1 - \frac{2P_{\text{man}}(2000)}{P_{\max}(\Delta T)}\right],$$

$$\text{and } P_{\max}(\Delta T) = esA\left[287.6 + \Delta T\right]^4 - P_{\text{nonman}}.$$

The parameters used are:

e =0.59	sA = 8.65x10^{11}	t =20 years
P(2000) = 3.99x10^{17} BTU/year	P_{solar} = 2.03x10^{21} BTU/year	P_{nonman} = 3.45x10^{21} BTU/year (Calculated from the Stefan-Boltzmann law.)

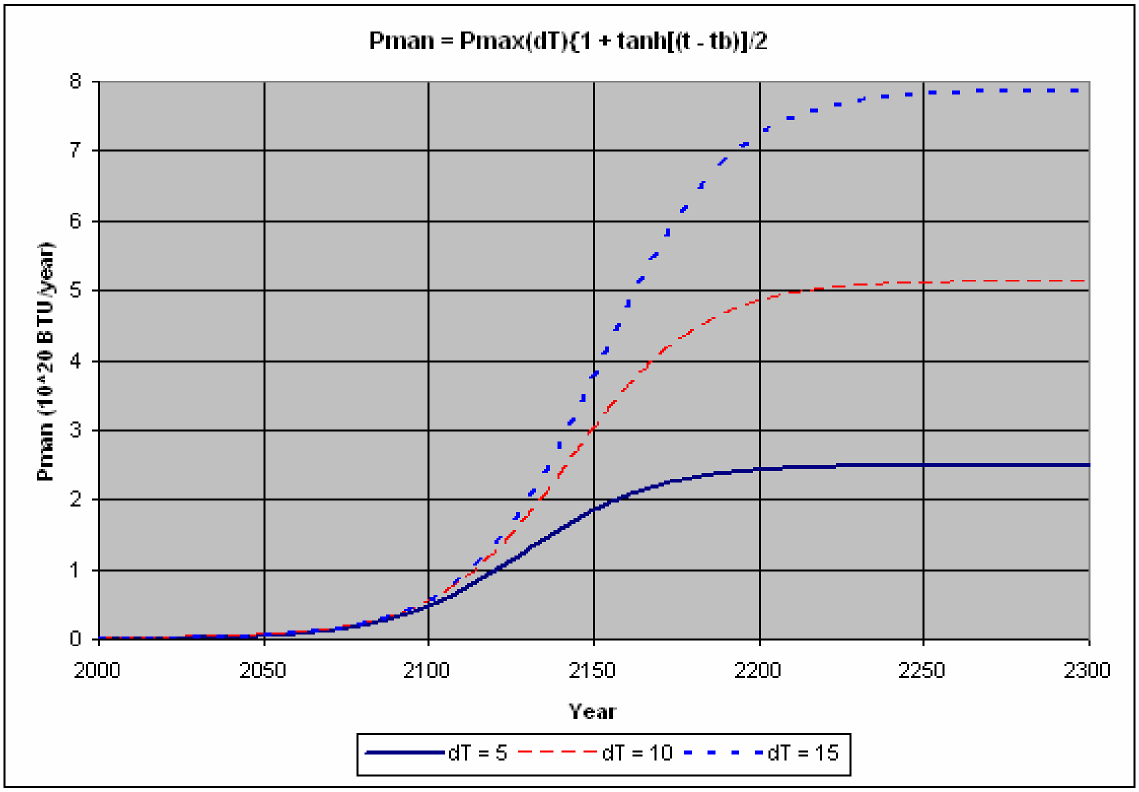


Figure 3-25. Heat energy per time released by humans on the Earth's surface for three different temperature increases using the Stefan-Boltzmann law, a hyperbolic-tangent time variation in energy release and a set of reasonable parameters. dT = the final change in the Earth's temperature in Celsius degrees.

This is a huge amount of energy compared to the energy used by the World in 2006, about 0.5x10^{18} BTU/year. (See Figure 3-38.) That amount of heat energy put into the Earth soon would probably greatly affect the North Atlantic Ocean currents, which would probably cause the next Major Ice Age to start sooner than it would otherwise (**Houghton, 2001**). Then there would be a competition between the natural energy systems of the Earth tending toward a Major Ice Age and the "miraculous" human energy system trying to stop it. Would the Major Ice Age win or would humans be able to control the climate of the Earth with a huge access to power?

Note that the Sun is a source of a huge amount of energy, but not a huge amount of power per area. It doles insolation (power per area) out at a rate to which humans must adjust. If it put out an extreme amount of power per area on the Earth, the Earth would be too hot for human existence on it.

Need for a Multi-Source Distributed Energy System

The rest of this chapter will describe a vision of an energy system for the World that involves many renewable sources of energy at many locations, a **Multi-Source Distributed Energy System** (**MSDES**), rather than the concentrated sources of non-renewable energy that humans now use. Vaitheeswaran calls this the **Energy Internet** (**Vaitheeswaran, 2003).** The following is an outline of some of the components of such a MSDES:

- Fuel cells, solar photovoltaic panels, hydropower, wind power, geothermal power, and biofuel electricity generators at homes, work sites and parking garages to charge electric and hybrid (fuel/electric) vehicles' batteries, provide electric local power and feed energy into a continental electric grid. All possible fuels are used for the fuel cells. That is, a **Multi-Source Distributed Energy System** to supplement, and eventually replace, large coal, natural gas and nuclear electric power plants. (See Wind Power, Photovoltaic Power, and Biodiesel for Vehicle Fuel and Heating sections later in this chapter.) Vaitheeswaran (**Vaitheeswaran, 2003**) calls the creation of local power systems the **micropower revolution** and their connection in a local grid a **microgrid**.
- Plugged-in electric and hybrid vehicles that **automatically connect to the national electric grid and local energy sources** for battery charging when parked at homes, work sites and parking garages. (Here "battery" refers to any device for storing energy; it could be a high-energy flywheel [http://en.wikipedia.org/wiki/Flywheel_energy_storage] or a supercapacitor [http://en.wikipedia.org/wiki/Supercapacitor] or hydraulic energy storage [http://en.wikipedia.org/wiki/Hydraulic_accumulator], as well as an electric battery.) These vehicles serve as **national/local grid energy storage devices** when at rest and drive away as fully charged vehicles for travel. They also serve as electric power backup at the home location. Since they can use electric power alone for most local travel, the electric power serves as backup for liquid and gas fuel for local transport.
- Use **biodiesel, methanol and ethanol made from new and recycled vegetable/animal oils and other wastes** as fuels for long-distance hybrid-vehicle travel between recharging sites. But, the biofuels must be made in a renewable fashion; that is, **using no petroleum-based fuel or fertilizer**. And the soil and water table must not be depleted or harmed. (See Biodiesel for Vehicle Fuel and Heating, Ethanol for Vehicle Fuel and Methanol for Vehicle Fuel sections later in this chapter.)
- Use the remaining fossil fuels to **develop the infrastructure** needed to accomplish the items given above on a large scale, instead of merely as fuel for general transportation and electric power.

Hybrid Vehicles

In May 2005 I bought a Toyota Prius hybrid car similar to the one shown in Figure 3-26, after much study about which hybrid car I should buy. (At that time the options were the Prius, the Honda Insight [a two-seater that I could not find to buy] and the Honda Civic.) In May 2006 I bought a Toyota Highlander Hybrid, a mid-sized SUV.

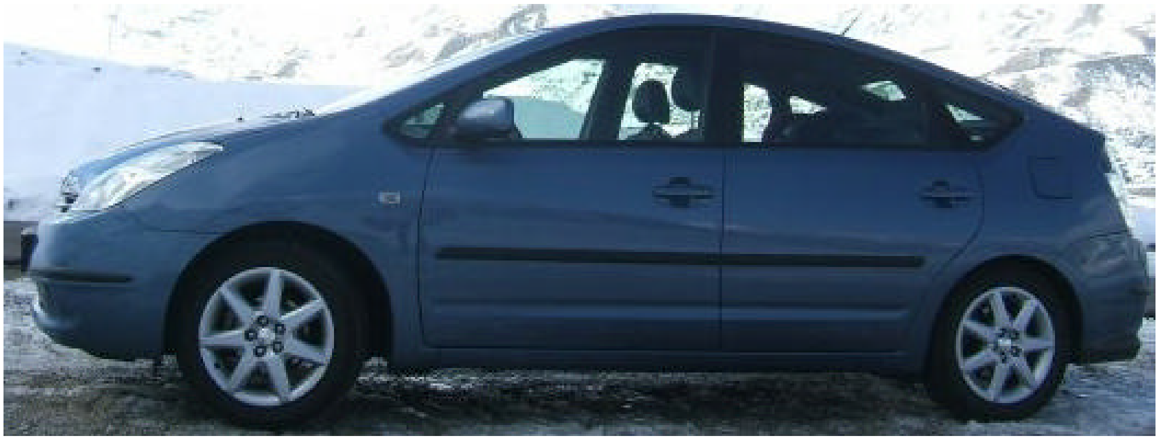


Figure 3-26. The 2005 Toyota Prius. Taken from http://photos.groups.yahoo.com/group/prius_technical_stuff .

I am much impressed with the ingenious hybrid technology marriage of mechanical and electronic technology (Toyota Hybrid Synergy Drive: HSD) that was first used in the Prius. In 2006 HSD was also used in the Ford Escape Hybrid, the Lexus 400h, the Toyota Highlander Hybrid, the Mercury Mariner Hybrid, the Lexus GS450h and the Toyota Camry Hybrid. (The Honda Insight, Honda Civic Hybrid and Honda Accord Hybrid vehicles do not use the HSD.)

The main reason I bought the Prius is its very low emissions (SULEV and PZEV in California). In 2005 there were several low-emissions gasoline cars, but gasoline cars are not able to achieve low emissions with high vehicle performance comparable to hybrid vehicles.

I developed a course about hybrid vehicles for the Virginia Tech YMCA Open University, which PowerPoint lecture is available on request. I am available to present this three-hour course to interested groups.

The essence of the Toyota Hybrid Synergy Drive of the Prius is the way the Electronic Continuous Variable Transmission (ECVT) is achieved by electronic controls managing the interplay through the Power Split Device (PSD) (a planetary gear set) of the 57-kiloWatts (76 hp) gasoline engine (connected to the planetary carrier), the large 50-kiloWatts (67 hp) motor/generator (connected to the ring gear along with the power train) and the small 25-kiloWatts (34 hp) generator/motor (connected to the sun gear).

The small PSD is shown in Figure 3-27. Note that it is about the size of a soda can.

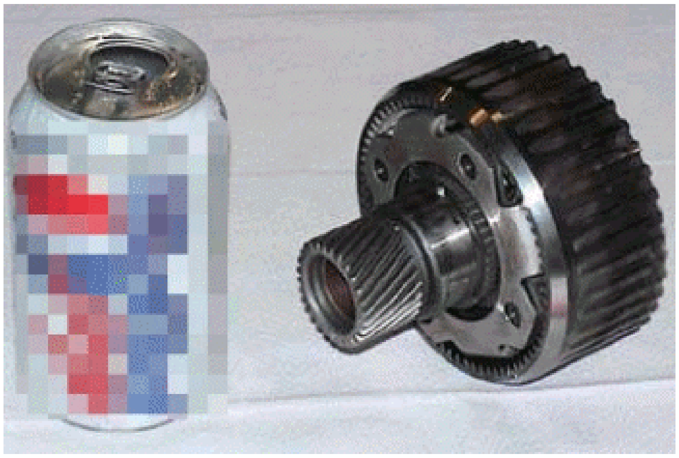
Prius Power Split Device	Prius Power Split device taken apart
	

Figure 3-27. The Power Split Device of the Toyota Prius. The ring gear is the largest outer gear, the sun gear is the smallest inner gear and the planetary carrier is in the middle. Taken from http://photos.groups.yahoo.com/group/prius_technical_stuff/lst .

The PSD's location relative to the engine, the large motor/generator and the small generator/motor is shown in Figure 3-28.

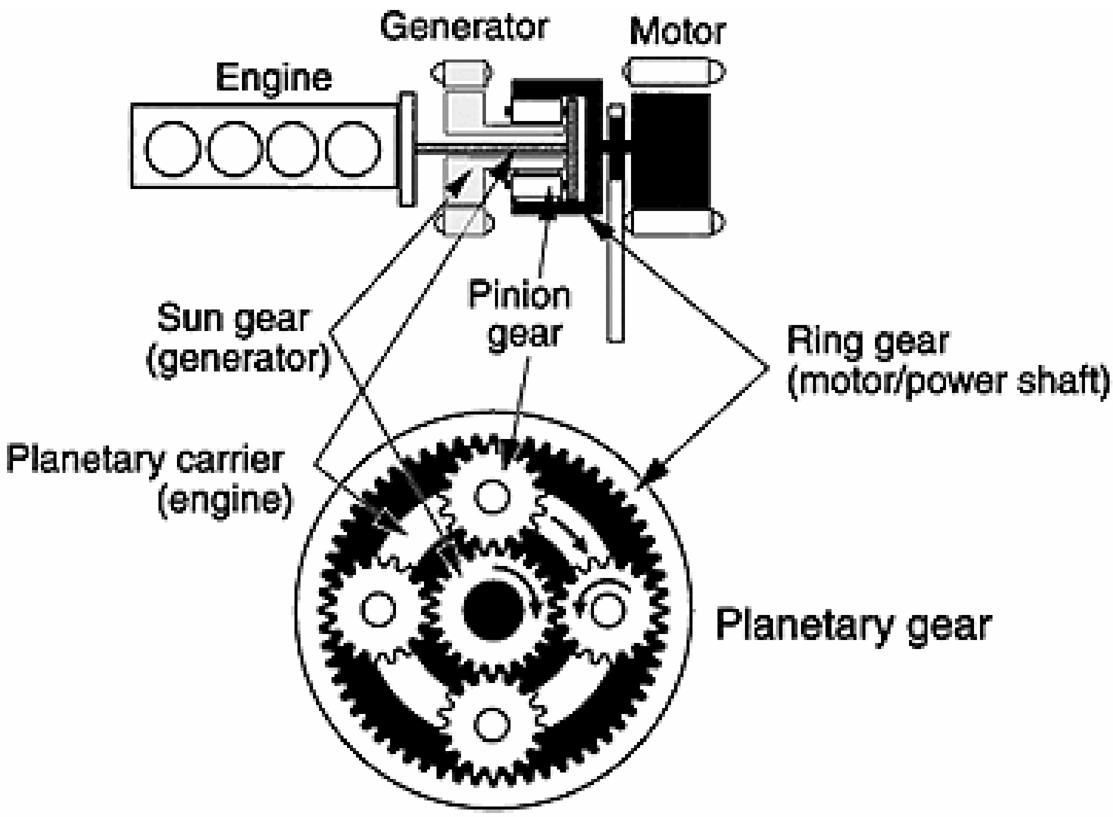


Figure 3-28. The arrangement of the Power Split Device (planetary gear set), the engine, the large motor/generator (Motor) and the small generator/motor (Generator) in the Toyota Prius. Taken from http://www.toyota.co.jp/en/tech/environment/ths2/hybrid.html .

The schematic of the network connections of the five main computers (Electronic Control Units; ECUs) and other components in the Toyota Hybrid Synergy Drive is shown in Figure 3-29.

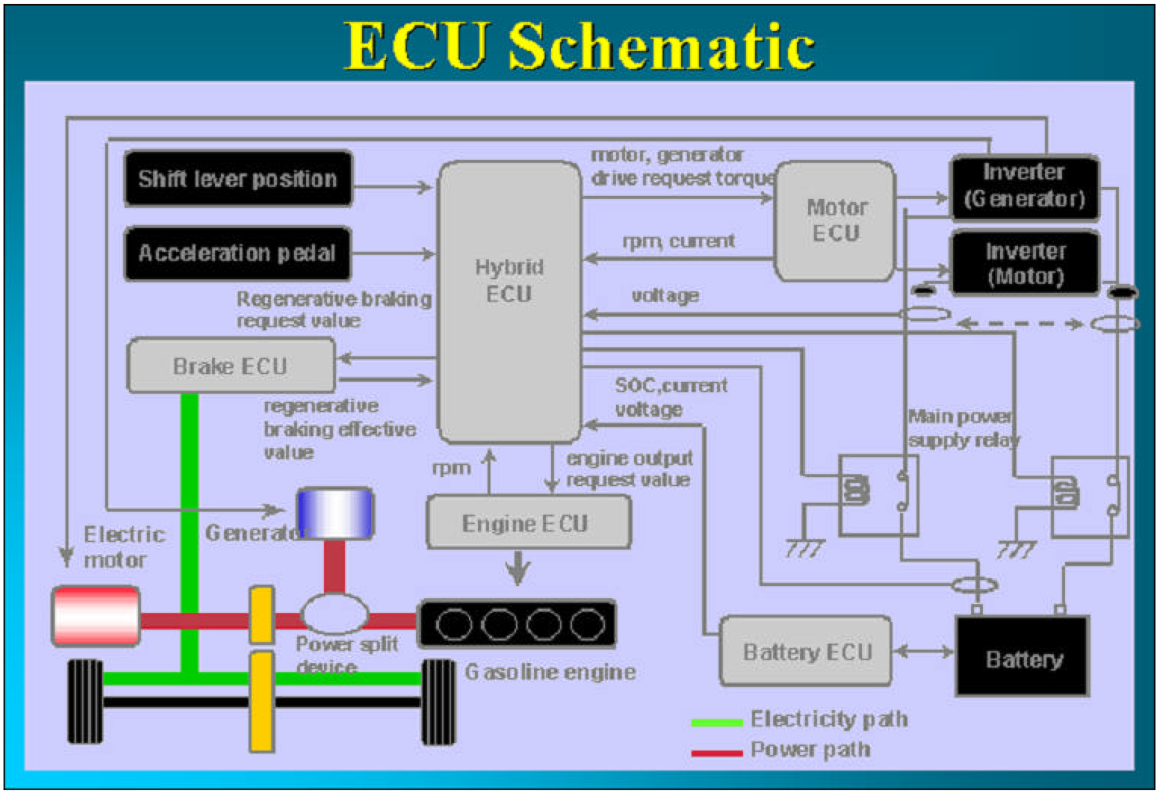


Figure 3-29. The Toyota Hybrid Synergy Drive electronic-control networking of the five computers with other components. Taken from Toyota Motor Company.

The main performance feature of hybrid vehicles is that the motor/generators have high torque and power at low rpm, which allows the engine to be designed for low emissions and high efficiency instead of high power/torque at low rpm as in a conventional gasoline or diesel engine vehicle.

The main reason I purchased a hybrid car was to **achieve low emissions** to reduce my contribution to pollution and Future Global Warming. The emissions ratio of an equivalent gasoline car to the Prius ranges from 1.5 to 2.5 for most greenhouse gases. Of course, high miles-per-gallon (mpg) helps achieve low emissions. My Toyota Prius achieves 35-45 mpg driving around the small town of Blacksburg, Virginia and achieves 45-55 mpg on long interstate trips, depending on the air temperature and driving conditions. For stop-and-go slow driving in the middle of large cities it should achieve even higher mpg. (The EPA ratings are not to be trusted for hybrid vehicles because they were created for gasoline vehicles.)

I also own a 2006 Toyota Highlander Hybrid, a very powerful mid-size SUV. It is rated as a Super Low Emissions vehicle and gets about 25-30 mpg, about 10 mpg more than an equivalent gasoline SUV.

Plug-in/Gridable Hybrid and Electric Vehicles

More powerful batteries of appropriate physical size for vehicles (comparable to the physical sizes of the Toyota Prius or Ford Escape Hybrid batteries) are now available, so plug-in or gridable hybrids that can travel 25-50 miles using only battery electricity and achieve 80-100 mpg for all trips will become common within a few years. Such short trips comprise about 75% of the trips made by most drivers.

A plug-in module by Hymotion (http://www.hymotion.com) for the 2004-6 Toyota Prius hybrid (and the Ford Escape SUV) was started being offered in 2006. It is shown in Figure 3-30.

Figure 3-30. The Hymotion plug-in module for the 2004-6 Toyota Prius.

Some important features of this modification are:

- No factory parts are replaced or taken out.
- Increases electric capacity by a factor of 5.
- Extra weight: Prius: 160 lbs; Escape: 325 lbs.
- Lithium ion polymer battery in addition to the standard NiMH battery. (http://en.wikipedia.org/wiki/Lithium_polymer_cell)
- Battery capacity: Prius: 5 kWh (compared to 1.3 kWh for original NiMH battery). Total: 6.3 kWh.
- Charging time (120 V, 15 amps): Prius: 5.5 hours; Escape: 12 hours.
- Cost: $8,300 for fleets/governments in 2006; $4,400 for fleets/governments and individuals in 2007 for the Prius.
- Electric range: Prius: 30 miles; Escape: 48 miles.
- Electric only maximum speed: 33 mph.
- MPG: Prius: 100 mpg/500 mpg for short trips; Escape: 60 mpg.
- Interlock to prevent vehicle movement while plugged in.

Another company that plans to market a plug-in addition to the Toyota Prius is eDrive (http://www.edrivesystems.com/news.html)

Plug-in hybrids are a major link in a Multi-Source Distributed Energy System.

Of course, such powerful batteries make it possible to have pure electric vehicles for local travel. In the near future households will have a biofueled plug-in hybrid car and, perhaps, one electric car for local travel. Some cities will have a fleet of electric vehicles for use by its inhabitants and visitors. (See http://www.carsharing.net and http://www.cooperativeauto.net .)

The World energy system should have automatic arrangements for connecting hybrid and electric vehicles into the local and continental electric grids at home garages, parking garages and work sites. The connection could be an induction connection (http://www.copper.org/innovations/1998/02/ev_intro.html) or a guided hardwired connection (perhaps similar to the automatic parking feature on the Toyota Prius in Japan: http://news.bbc.co.uk/1/hi/technology/3198619.stm). Each vehicle will have an identification code so that energy that is downloaded from the grid at any location can be properly debited and any temporary storage or energy it provides for the grid can be properly credited. At home locations the plug-in hybrid and electric vehicles could serve as emergency power backup for the home, and the electric grid could serve as emergency transportation fuel backup. Local power generators (photovoltaic, wind generators, fuel cells, etc.) can be used to recharge the vehicles' batteries and feed energy into the local and national electric grid.

Figure 3-31 shows a day's possible time scale for a plug-in hybrid or electric vehicle battery that is recharged at work and at home during off-peak times for the electric grid and provides storage and power to the electric grid during on-peak times.

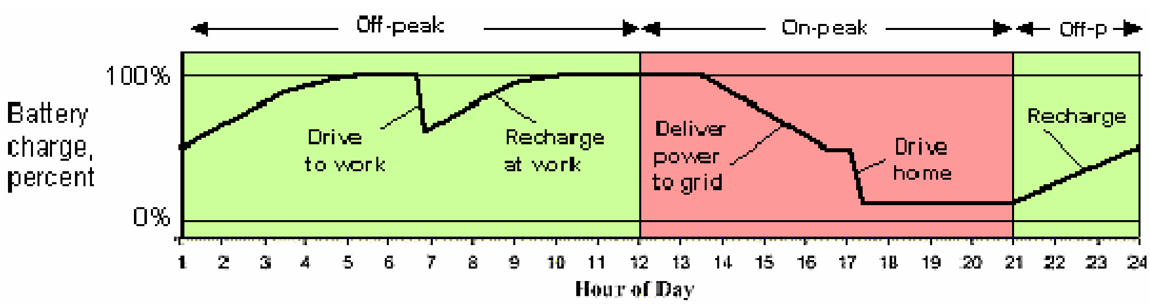


Figure 3-31. State of charge of the battery of a plug-in hybrid vehicle. (http://www.udel.edu/V2G/V2G-Cal-2001.pdf)

Wind generators are ideal for charging plug-in hybrids because winds are typically higher at night than at day.

There is a national consortium for promoting development and sales of plug-in hybrids: http://www.pluginpartners.com .

Biodiesel for Vehicle Fuel and Heating

Diesel vehicles made in Germany in 2006 achieved high mpg, and competed with gasoline engines with regard to emissions. The much lower emissions of hybrids make them more desirable than diesel engines. Also, better driving performance can be engineered into hybrid vehicles than for a comparable emissions conventional gasoline or diesel vehicle.

There is another form of diesel made from plants: biodiesel (http://en.wikipedia.org/wiki/Biodiesel). It is a mixture of long-chain esters. Biodiesel can be used as fuel for diesel vehicles without any engine alteration or it can be mixed with petroleum-diesel. (The usual mixture is B20: 20% biodiesel.) It is slightly less efficient than diesel, but more efficient than gasoline. It produces much less vehicle emissions than diesel. Most biodiesel is made from plants that are planted and harvested by burning gasoline or diesel in farm tractors and with fertilizer, all made from petroleum; this needs to be changed drastically so that biodiesel production is carbon neutral.
(http://www.unh.edu/p2/biodiesel/media/NHSTA05.ppt)

A major problem with using biodiesel as a vehicle fuel is that it becomes a gel at temperatures below about 4 °C (40 °F). Blending biodiesel with petro-diesel can alleviate the problem. For plug-in hybrid vehicles, it should be possible to use a small amount of battery energy to prevent gelling.

We can look forward to **biodiesel hybrid vehicles** in the future when more efficient biofueled and bio-fertilized farming methods are used to produce biodiesel.

Probably the best renewable fuel for the future is biodiesel. For the reasons see Pahl. (**Pahl, 2005)** Using data taken from Chapter 5 of that book, Figure 3-32 shows the biodiesel production history data for the World, most of which has been in Western Europe, and a mathematical fit to the data to use for projection into the future. The function used to fit the data is

$$4750 \tanh\left(\frac{\mathrm{t} - 1991.7}{4.005}\right) + \begin{cases} 0 \\ 965 \exp\left(0.731[\mathrm{t} - 1999.3]\right) \end{cases} \mathit{for} \begin{cases} t \le 1999.3 \\ t > 1999.3 \end{cases}.$$

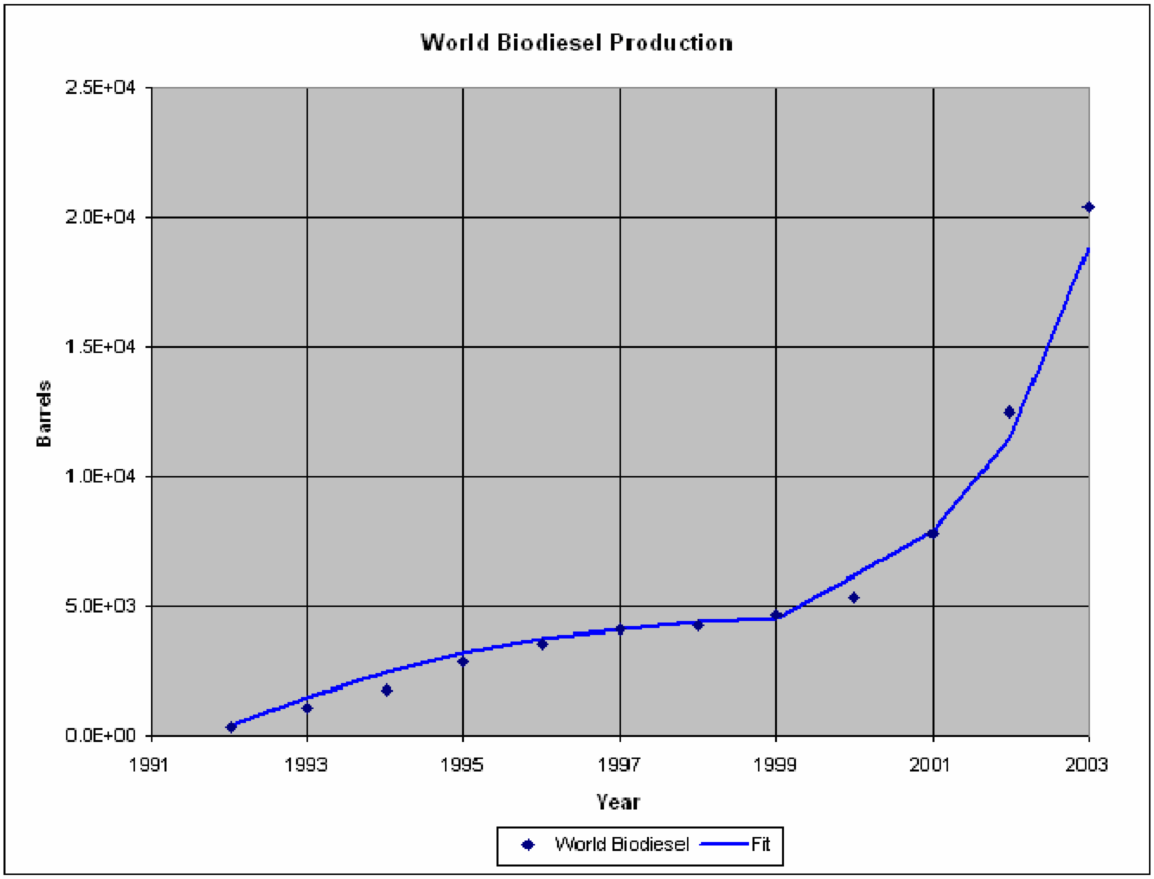


Figure 3-32. World biodiesel production rate and a mathematical fit to it. (barrel = 42 US gallons). Data are from (Pahl, 2005).

Note that the fit is conservative for predicting the future; it does not rise as rapidly as do the data.

The mathematical fit to the data allows projection into the future, which is shown in Figure 3-33 along with the World crude oil extraction projection from Figure 3-4. Note that biodiesel production growth at about 73% growth rate will equal crude oil extraction by about the year 2022. Government incentives and grants could make this crossover point occur sooner. A 25% increase in the rate would move the crossover point with World crude oil extraction to about the year 2017.

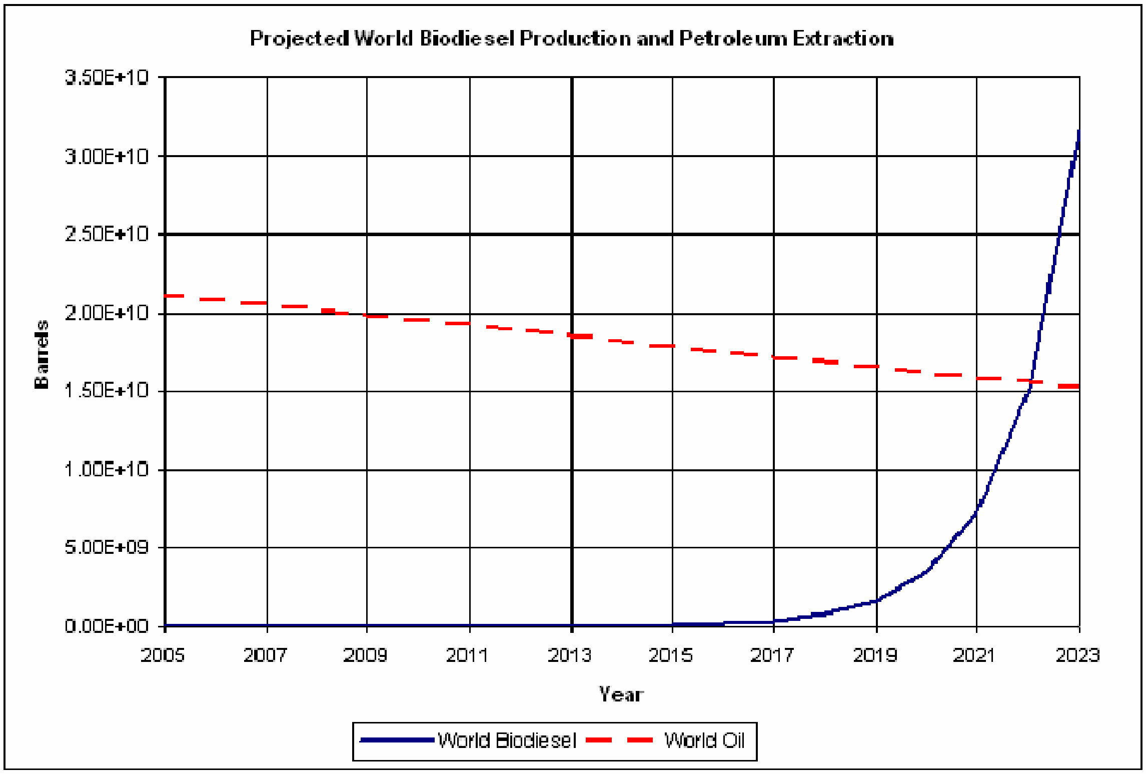


Figure 3-33. Projection of World biodiesel production rate into the future compared to the projection of World crude oil extraction rate.

Biodiesel can be used in heating buildings in place of petroleum fuel oil. In fact, biodiesel will clean the combustion crud out of an old furnace. (It takes some time after starting to burn biodiesel in an old furnace, changing the fuel filter often, to clean out all of the crud.)

One of the most promising crops for producing biodiesel is algae. (**algae, 2005**) Calculations show that, because of the high concentration of oil (over 50%) in some algae species, enough biodiesel to replace petroleum for transportation fuel can be grown on a few percent of the farm land in the United States. Marginal farm land, such as desert land, works just fine. It can be grown as seaweed in coastal waters. (http://en.wikipedia.org/wiki/Seaweed) Perhaps algae farming in desert countries would be a way to improve living standards there. Algae can grow in almost any water environment.

Some important features of algae for fuel are:

- Over 50% of algae mass is oil. Contains over 30 times more oil per growing area than other fuel plants (for example, soybeans).
- There are both fresh-water and salt-water algae.
- Algae have the most efficient photoreceptors of all plants.
- Liquid environment allows better access to carbon dioxide, nitrogen and minerals needed for growth.
- Arid zones are ideal because of high solar exposure.
- The algae farms can be locate beside power plants to absorb the carbon dioxide produced instead of venting it into the atmosphere as a greenhouse gas and to use the heated water to enhance growth..
- Commercial bioreactors for producing oil from algae are expected soon.

Another plant, mustard, can be grown to provide biodiesel feed stock, alcohol feedstock for the 10% alcohol needed to process biodiesel, and organic pesticides.

Some alcohol (ethanol or methanol) is required to produce biodiesel from vegetable oils and animal oils: 10 parts of natural oil + 1 part of alcohol -> 10 parts biodiesel + 1 part glycerin. The glycerin is sold as a byproduct.

Ethanol for Vehicle Fuel

Ethanol (C_2H_5OH) is a possible biofuel to replace gasoline. Two mixtures of gasoline and alcohol are available at some fuel stations in the United States: E10 = 10% ethanol by volume and E85 = 85% ethanol by volume. Unfortunately, World production of ethanol for fuel has not been increasing very rapidly, as seen in Figure 3-34.

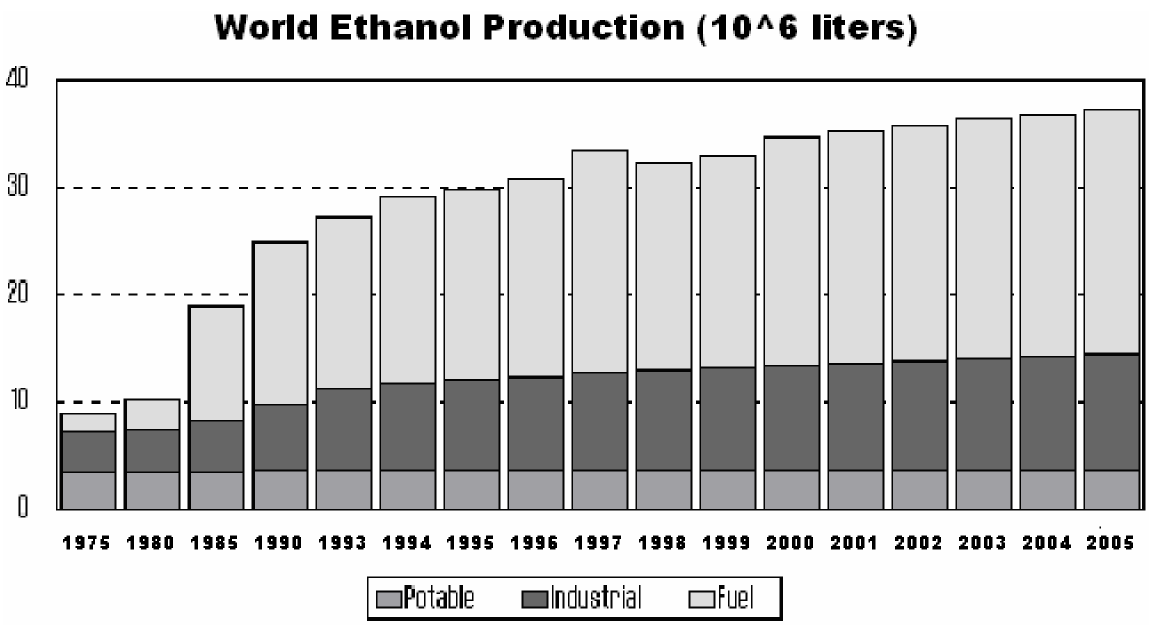


Figure 3-34. The top light-gray bars are World fuel ethanol production rate. Taken from http://www.distill.com/berg .

All vehicles built in the United States since the 1970s are capable of burning E10, but E10 filling stations are not widely available. Figure 3-35 indicates the availability of E85 filling stations in thirty-five states in the United States.

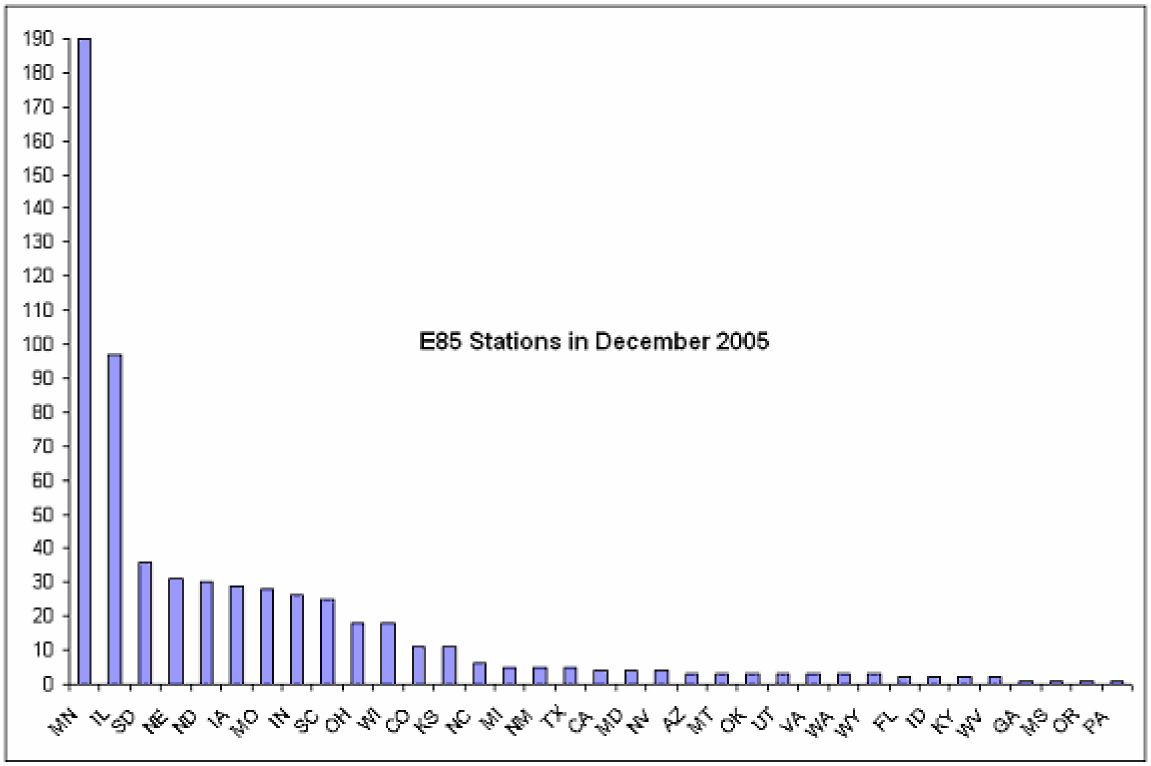


Figure 3-35. Number of E85 filling stations in 35 states of the United States in December 2005. The states not listed have zero stations. Data are from http://www.e85fuel.com/database/search.php .

There are a few pioneering states, such as Minnesota with 190 E85 filling stations. More states need to make E85 and E10 filling stations available in each county. Perhaps farmers' cooperatives could be subsidized to do this.

Of course, one could create E10 at E85 filling stations by putting in about 8.35 gallons of gasoline for each gallon of E85, as calculated from $0.1 = 0.85e/(g + 0.15e)$ where e = amount of E85 and g = amount of gasoline.

Vehicles that can use E85 as well as gasoline are called "Flexible-Fuel Vehicles" (FFV). A list of FFVs can be found at http://www.e85fuel.com/e85101/flexfuelvehicles.php . In 2006 General Motors made 6 FFVs, Daimler Chrysler made 5, Ford Motor Company made 5 and Nissan made 1. General Motors and Ford Motor Company are promising more FFVs in the future. (**FFV, 2005**)

Some vehicle manufacturers are considering producing **FFV hybrid vehicles**, which would be very important for reducing Future Global Warming. (http://www.carlist.com/autonews/2006/autonews_245.html) Then after that should be plug-in FFV hybrids!

For an optimistic view of ethanol as a vehicle fuel and FFV vehicles, listen to the lecture by venture capitalist Vinod Khosla (http://video.google.com/videoplay?docid=-570288889128950913).

Figure 3-36 shows a comparison of the energy input and output for corn ethanol and soybean biodiesel and the greenhouse-gas emissions of corn ethanol, gasoline, soybean biodiesel and diesel.

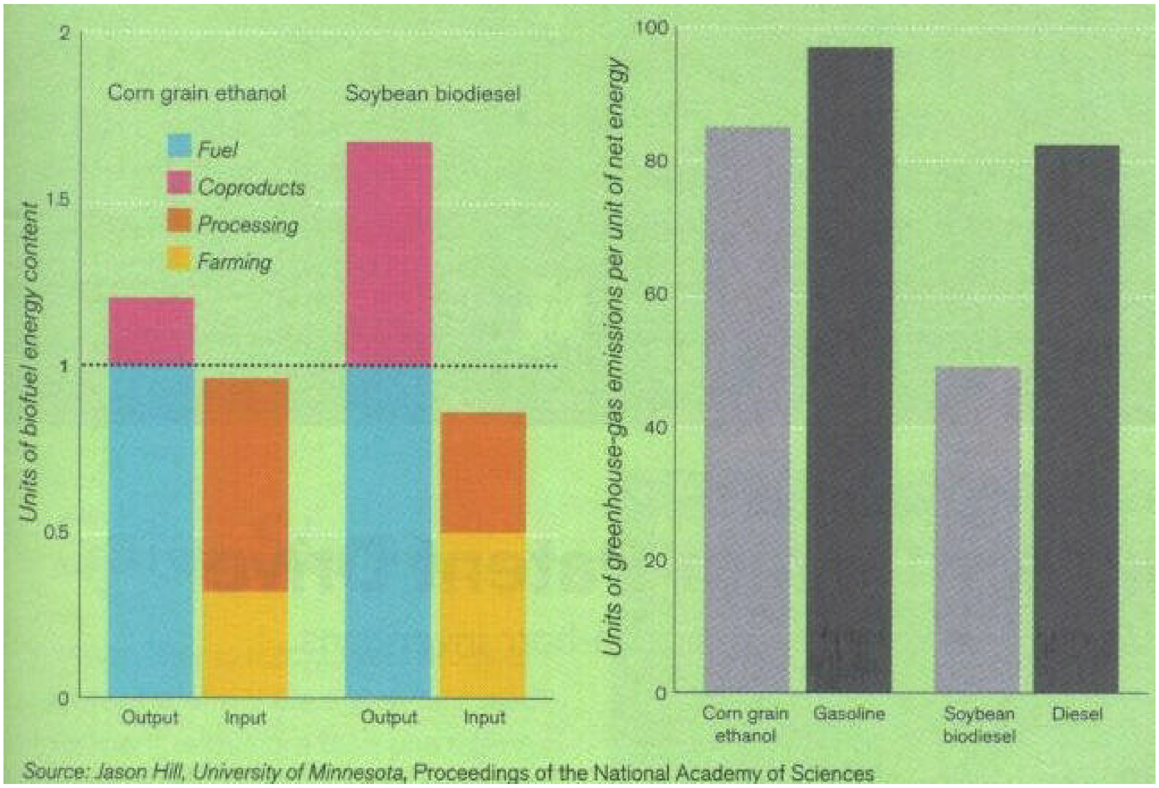


Figure 3-36. Comparison of the energy input and output for corn ethanol and soybean biodiesel and the greenhouse-gas emissions of corn ethanol, gasoline, soybean biodiesel and diesel. (Technology Review Sep/Oct 2006, p. 17)

It is seen that from these to considerations soybean biodiesel is a better fuel than corn ethanol.

Figure 3-37 shows a rough comparison of the emissions of different types of vehicles that use renewable sources of energy versus those that use nonrenewable sources of energy.

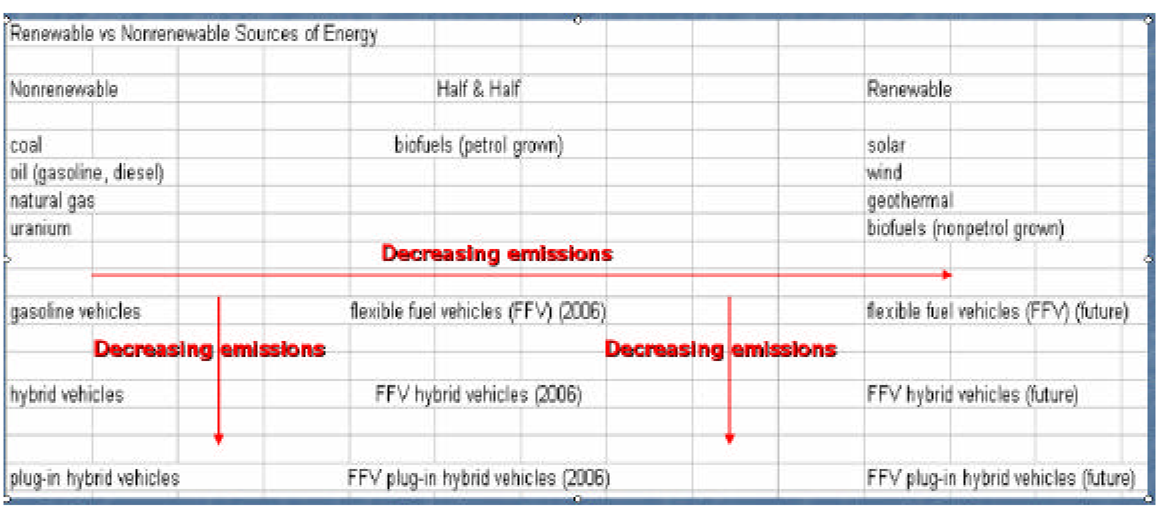


Figure 3-37. Comparison of vehicle emissions for renewable versus nonrenewable sources of energy and different types of vehicles.

Methanol for Vehicle Fuel

Olah (**Olah, 2006**) has proposed that methanol (CH_3OH) be used for vehicle fuel to replace gasoline. The filling station infrastructure can be used with very minor changes, which is not the case for hydrogen as a fuel. (To replace diesel use dimethyl ether made from methanol as follows: $2CH_3OH \rightarrow CH_3OCH_3 + H_2\mathrm{O}$.)

The energy producing reaction for using methanol in either an internal combustion engine or a fuel cell is

$$2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2\mathrm{O}\ .$$

So, where does one get the methanol? It can be made from natural gas, which is mostly methane (CH_4) as follows:

$$2CH_4 + O_2 \rightarrow 2CH_3OH$$

Instead of shipping natural gas as a dangerous liquid (LNG) across oceans from a producing country to a consuming country, the natural gas can be converted to liquid methanol and shipped much less dangerously. Of course, energy must be used to make the conversion, but perhaps not as much energy as would be used to assure safe transportation of LNG.

Of course, ethanol could be similarly made from natural gas: $2CH_4 + O_2 \rightarrow C_2H_5OH + H_2O$, but less efficiently since water is also made. The reaction conditions must be controlled such that methanol is greatly favored over other reaction products, such as ethanol.

Since natural gas is a nonrenewable fuel and World extraction of it will peak soon, other sources of methanol are needed for a long term future of fueling vehicles with methanol. Methanol can be made by using electricity to cause the reverse of the methanol combustion reaction given above:

$$2CO_2 + 4H_2\mathrm{O} \rightarrow 2CH_3OH + 3O_2\ .$$

A major part of Olah's proposal is to extract CO_2 from electric power plants or from the atmosphere to use in methanol production. Of course, the combustion reaction in vehicle engines then puts the CO_2 into the atmosphere, unless some method is developed to capture it in the vehicle for later recycling to make more methanol.

There is a greenhouse gas problem here: Carbon dioxide is much easier to capture and store at a single power plant than it is in millions of vehicles. If electric power is made in a renewable fashion, from solar panels/collectors, wind generators or geothermal generators and used to power electric or hybrid vehicles, then there is no carbon dioxide to worry about from that part of the vehicle "fuel."

Another problem is that CO_2 needs to be stored for possible use later to slow down the plunge into the next Major Ice Age, as described in Chapter 4. Using CO_2 to create methanol for vehicle fuel such that it is dispersed into the atmosphere not only causes Global Warming but also eliminates its possible use to ameliorate the plunge into the next Major Ice Age.

Of course, another way to get the methanol is by making it from crops, similar to making ethanol. If the farming is done without using petroleum fuels and fertilizers, it will not contribute to global warming.

Hydrogen Fuel Cell Vehicles?

I do not think that hydrogen fuel cells will be feasible as on-board power systems for highway transportation on a large scale for many reasons, including the simple reason that hydrogen fuel cells produce large amounts of water. A simple calculation shows that about 2.4 times as much water per energy released is produced by hydrogen fuel cells than is produced in a gasoline engine. (**Roper, 2005**) And the water is usually emitted at lower temperatures, often as visible steam or liquid water, than in gasoline combustion. So, it is likely that millions of vehicles dumping such huge amounts of water on the highways will cause great danger in any weather, but especially during cold weather. It is not feasible for vehicles to carry the water to be discarded in tanks at the next hydrogen fueling station. If the water is heated to be released as high temperature vapor, energy is used to heat it and it then becomes a very potent greenhouse gas.

Two modes of transportation that might make good use of fuel cells are railroads and water transportation. In both cases the water can be used for drinking, cooking and cleaning. In the railroad case the pure water might be cooled and then poured out on the sides of the tracks to moisturize the surrounding land. In the water-transportation case the water can be cooled and poured into the water already there, ameliorating pollution already there.

Hydrogen fuel cells at fixed locations may be very useful for electric power at those locations, for recharging hybrid vehicles at those locations and for providing power for that site and to a continental electric grid. The pure water generated also can be put to good use.

For a detailed discussion about the many problems of using hydrogen for a fuel see Romm's book, *The Hype about Hydrogen* (**Romm, 2005**).

Multiple Energy Sources

There should be many sources of energy available at many locations in a continental energy system. Fuel cells, running on many different fuels that contain hydrogen, probably will be one of those sources. Photovoltaic arrays and wind generators will be widespread.

In the long run the sources must be renewable. Before discussing the two major renewable sources of electric energy (wind and solar photovoltaic), first look at the history of energy consumption for the World, as shown in Figure 3-38. A linear fit to the data was done in order to be able to project approximately energy usage into the future, so that some calculations can be done about how fast wind and photovoltaic power would have to grow to supply an appreciable amount of future energy usage.

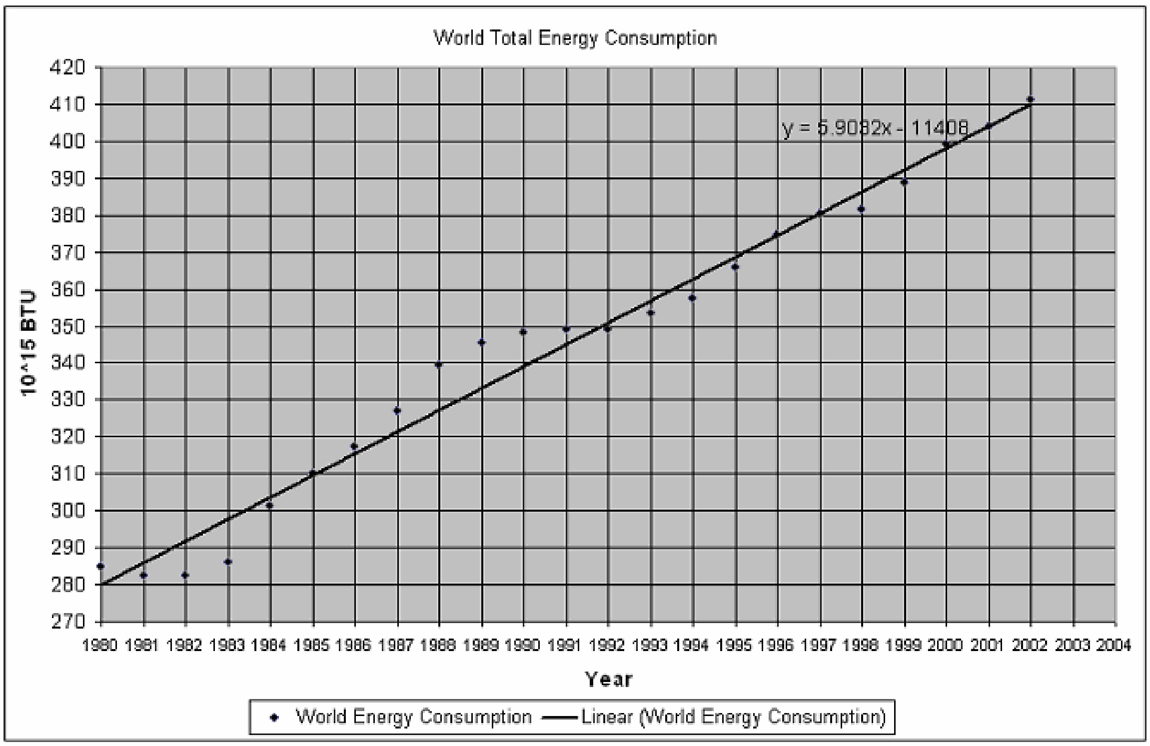


Figure 3-38. A linear fit to the World energy consumption data to allow projection into the future. Data are from http://www.eia.doe.gov/pub/international/iealf/tablee1.xls .

In Chapter 5 it is shown that World population is trending toward a stabilized population of about 9.9×10^9 (billion) people. Assuming that will be the case and using the projection of World energy use given by Figure 3-38, the World energy consumption per capita would be as shown in Figure 3-39.

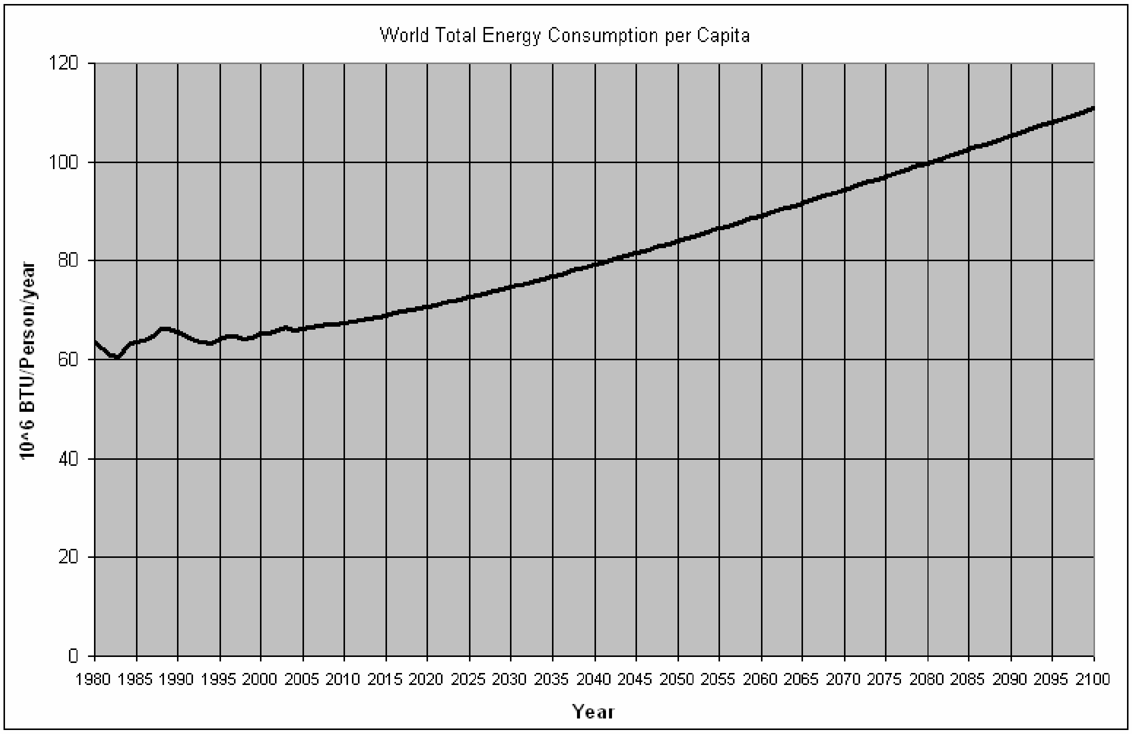


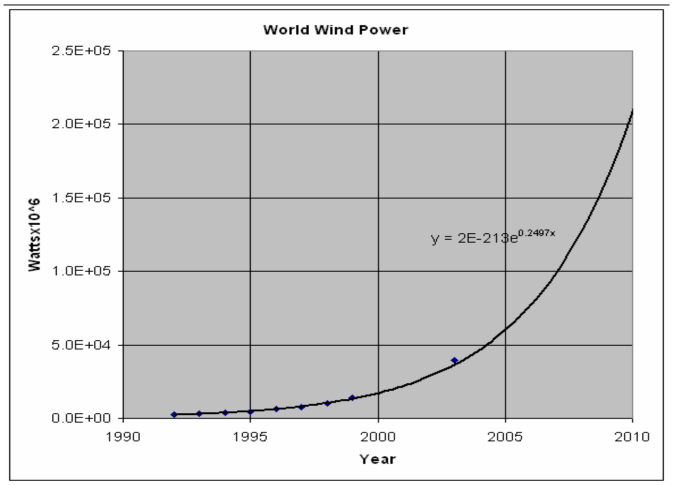
Figure 3-39. World energy consumption per capita as projected using the projected energy consumption and projected population.

We see that there is some hope for the future if humans can manage to keep reducing the population growth rate and keep increasing the energy consumption rate as has been the case up to now. The big problem is in increasing the energy consumption rate, as is shown clearly in this book.

Of course, at some point in the future the growth in energy use, other than solar energy, has to become zero to keep from overheating the Earth, as discussed above in the section on Miraculous Energy Sources. That is, eventually all the increase in energy use has to be solar energy, and that has an upper limit, also.

Wind Power

Figure 3-40 shows an exponential fit to the World wind-power data and a comparison of the projected World total power and wind power. The function used to fit the data is $2\times10^{-213}\exp(0.2497t)$. Raising the growth rate by just 1% would lower the crossover year with World total power projection from 2028 to 2008! Surely, some modest increase in government subsidies for encouraging wind power could bring about extensive wind power much earlier than 2028.

<table>
<tr><td>Below is an exponential fit to World wind power data (rate of growth is 25%):</td><td>Below are curves for the World projected total power and wind power:</td></tr>
<tr><td>


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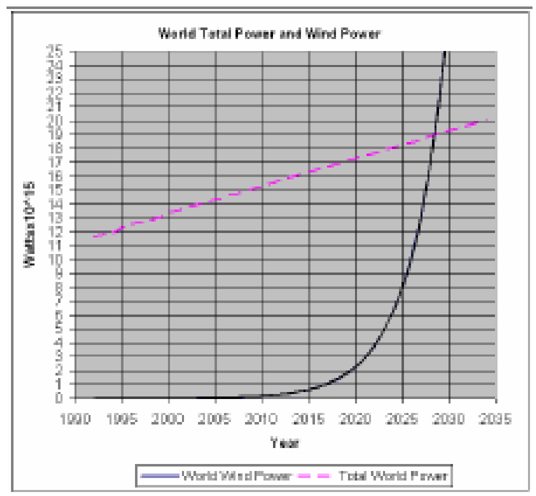

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Figure 3-40. A 25% rate of growth would make World wind power equal to World total power by about 2028. Data are from http://www.ecotopia.com/apollo2 .

As the Earth moves into the next Major Ice Age within 1000 years or so, winds will **increase** greatly rushing south off of the growing northern ice sheets; then much more wind power will be available, but in different locations than now. (The wind chill will be terrific!)

Of course, the winds will stir up much dust, which will make it difficult to use photovoltaic power in the areas where wind power will be constant. All in all, locations nearby and south of the ice sheets may not be viable for human life.

Photovoltaic Power

Figure 3-41 shows an exponential fit to the World photovoltaic power data and a comparison of the projected World total power and photovoltaic power. The function used to fit the data is $2\times10^{-268}\exp(0.3104t)$. Raising the growth rate by just 1% would lower the crossover year with World total power projection from 2036 to 2015! Surely, some modest increase in government subsidies for encouraging photovoltaic power could bring about extensive photovoltaic power much earlier than 2036.

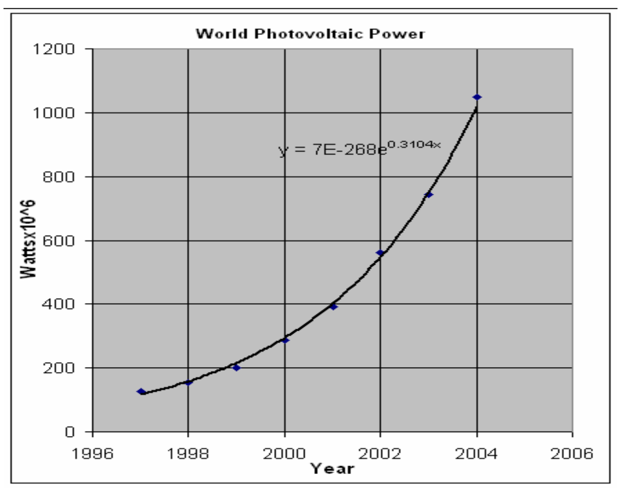
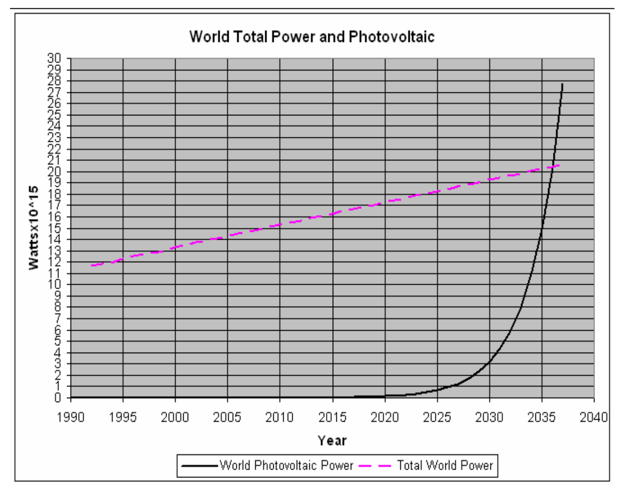
Below is an exponential fit to World photovoltaic power data (rate of growth is 31%):	Below are curves for the World projected total power and photovoltaic power:
	

Figure 3-41. A 31% rate of growth would make World photovoltaic power equal to World total power by about 2036. Data are from http://www.ecotopia.com/apollo2 .

There are photovoltaic systems available for homes and buildings that integrate the photovoltaic cells with the structural roofing material (panels or shingles).
See http://www.uni-solar.com/interior.asp?id=74 and http://www.etmsolar.com/roof.htm and http://www.oksolar.com/roof . Such electric power systems provide electric power for the home and to charge the batteries of electric or plug-in hybrid vehicles and could be connected with a local/continental power grid to sell power to the grid.

All new buildings should be built with a photovoltaic roofing system and all new roofs that face the Sun should be photovoltaic. See http://en.wikipedia.org/wiki/Solar_roof .

As the Earth moves into the next Major Ice Age within 1000 years or so, cloudiness will **decrease** greatly, so that a larger fraction of solar power will be available for use by humans.

At about year 2500 North-Pole summer insolation will begin an increase for about the next 10,000 years. (See Figure 2-2.) That increase coupled with the decrease in cloudiness, will cause solar energy striking the Earth to be a reliable source of energy during that 10,000-year period of the next Major Ice Age in many regions of the Earth, although it will oscillate with a period of about 10,000 years as the Major Ice Age progresses. (See Chapter 4.) In some regions south of the glacial boundaries, especially in the centers of the Northern-Hemisphere continents, solar power striking the surface of the Earth will be reduced by much dust in the atmosphere whipped up by high winds blowing to the south off of the glacial ice. At those locations wind power will be more beneficial.

Some humans may find it advantageous to live on the ice north of the glacial boundaries during the next Major Ice Age to use the solar energy and wind energy available there, without the dust. Of course, useful materials, except for ice, will be more difficult to obtain there.

Taking into account all considerations, the tropics will be the best places for humans to live during the next Major Ice Age.

General Solar Power

How much of the Earth's land surface would have to be devoted to collecting solar power of all kinds for human use to replace the use of nonrenewable power? General solar power includes photovoltaic, solar heating, wind, water waves, tidal power and ocean temperature difference with depth. It does not include geothermal.

To give a rough answer to this question, parameterize the human use of solar power by the Verhulst function (http://arts.bev.net/roperldavid/depletth.pdf):

$$P_{\text{solar}}(t) = P_{\max}\left\{\left[1+\left(2^n-1\right)\exp\left(\frac{t-t_b}{t}\right)\right]^{-\frac{1}{n}}-1\right\}.$$

The four variable parameters are:

- $P_{\max}$ = final steady amount of solar power that humans will use.
- t_b = break point year = peak of the power-growth curve.
- t = rise time constant of the power-growth curve. [% growth = 70/(0.69 t).]
- n = asymmetry parameter (fall time constant of the power-growth curve = nt).

$P_{\max}$ is calculated by using the average amount of solar power that reaches the surface of the Earth (342 W/m², http://en.wikipedia.org/wiki/Solar_energy) and the **land** area of the Earth (148,939,063.133 km², http://en.wikipedia.org/wiki/Earth). Then

$$P_{\max} = \left[(\text{\% of land})\times(\text{efficiency})\right]\left(148{,}939{,}063.133 \text{ km}^2\right)\left(342 \text{ W/m}^2\right)\left(10^{-6}\right) \text{ in units of } 10^{12}\text{Watts}.$$

So, the parameter is now the (% of land)x(efficiency) used for collecting solar power instead of $P_{\max}$.

Figure 3-42 shows the comparison of the projected total World power and a possible growth of human use of solar power for the parameters:

- (% of land)x(efficiency) = 0.1 %. This corresponds to $P_{max} = 50.9 \times 10^{12}$ Watts $= 1.52 \times 10^{18} \frac{BTU}{year}$.
- t_b = year 2049.
- t = 4 years (about 25% growth rate; % growth = 70/(0.69 t).
- n = 10 (about 2.5% decline rate).

These parameters were adjusted to yield about the current human use of solar energy, so that a small fraction of the land is used for solar power collection and a reasonable growth rate.

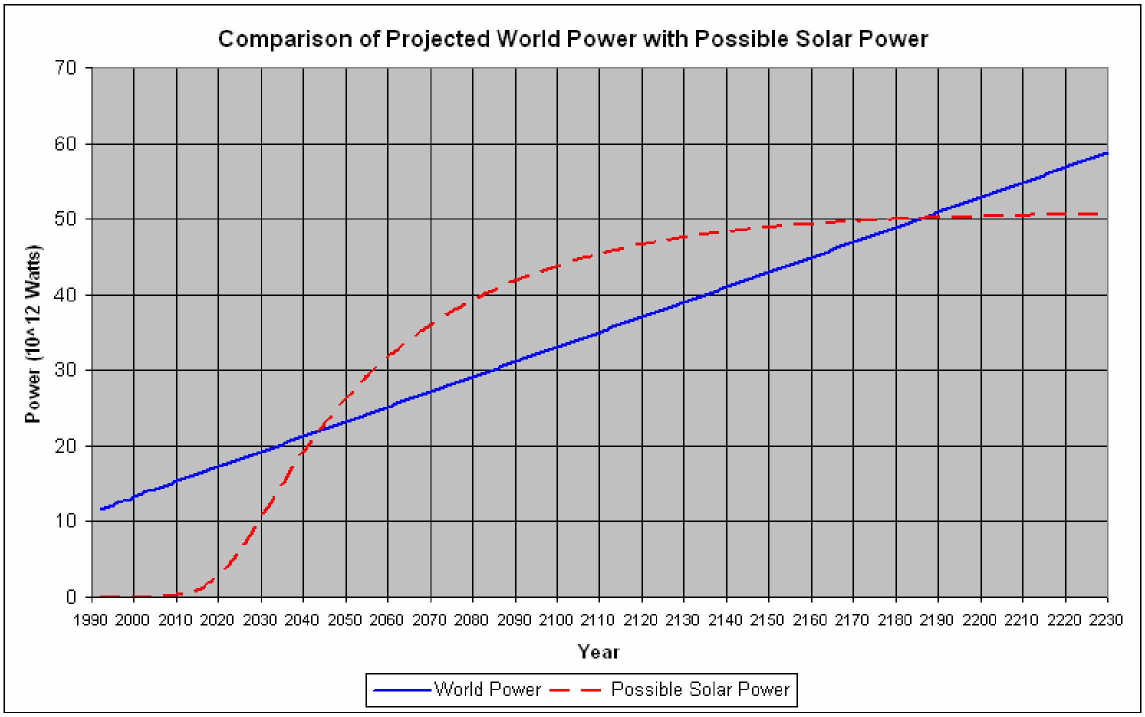


Figure 3-42. Comparison of the projected total World power and a possible increase in solar power by humans. To convert the power to BTU/year multiply by 29,900.

Many normal human activities can occur underneath solar-power collectors, so perhaps a larger fraction of the land could be used for collection, allowing a large amount of solar power collection.

So we see that a rather small percentage of land devoted to collecting solar power can reach the projected total World power by about the year 2150 for a solar-power growth rate of about 7%. Of course, a higher growth rate would be better, allowing solar power to provide more power for human use sooner.

Renewable power, most of which is solar power, must level off eventually into a steady amount of power with a constant amount of land used to collect it. Growth cannot continue forever. (**Bartlett, 2004)**

Geothermal Power

It is usually considered that geothermal power, energy per time derived from heat inside the Earth, is only available in regions that have volcanic activity. Certainly large power stations, such as are prevalent in Iceland, are in volcanic regions. See http://geothermal.marin.org/pwrheat.html#Q2 .

But, geothermal power on a smaller scale can be taken from inside the Earth at most locations using heat pumps. See http://www.ees4.lanl.gov/hdr and http://hotrock.anu.edu.au for information about converting geothermal energy from depths of 3 to 5 kilometers in beds of hot dry granite rocks. Figure 3-43 shows a Hot Rock geothermal system.

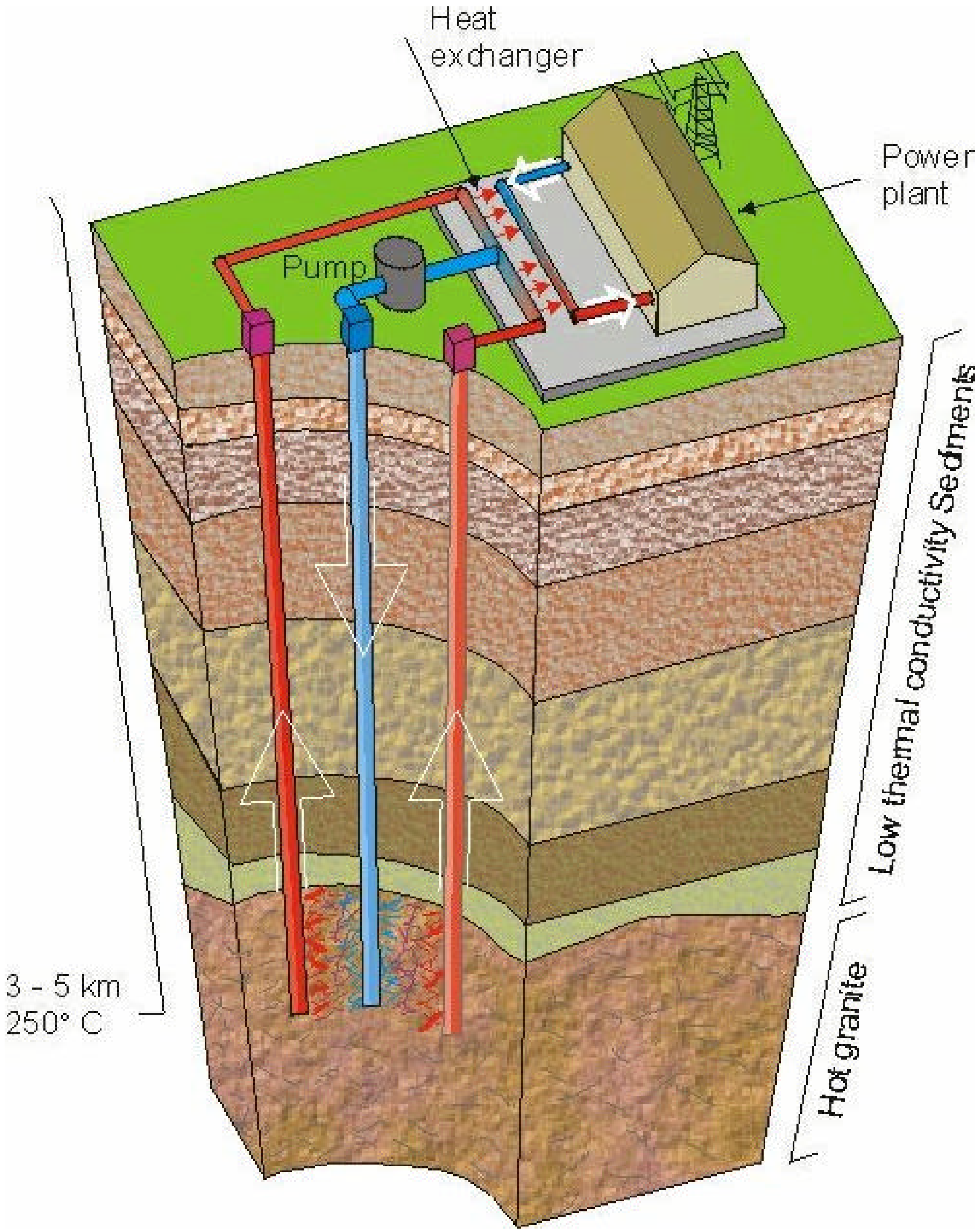


Figure 3-43. Hot Rock geothermal energy system. Taken from http://hotrock.anu.edu.au .

Obviously, the long pipes and powerful pumps add greatly to the cost of a heat pump system.

Conservation as an "Energy Source"

It was demonstrated during the administration of United States President Jimmy Carter that it is possible for a society to prosper while reducing its energy consumption.

Amory Lovins and co-workers at the Rocky Mountain Institute (**Lovins, 2005**) have presented many ways that conservation can be an "energy source." Figure 3-44 shows some of their results.

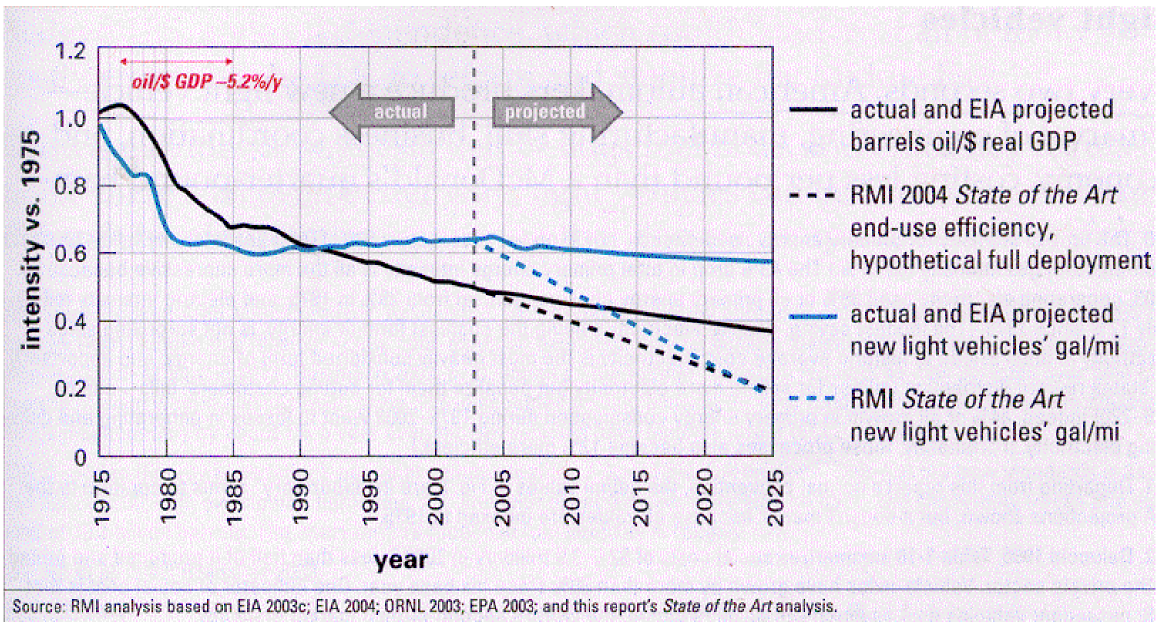


Figure 3-44. Lovins' calculations (Lovins, 2005) (Figure 8) showing how the United States' ratio of use of oil (barrels) to real GDP ($) (top curve on left and bottom curve on right) has declined since 1977 and how gallons per mile for light vehicles has changed with time. The dashed lines indicate how the two ratios could improve by using state-of-the art technology.

Note how greatly the two ratios declined during the administration of President Jimmy Carter (1977-1980). Then after President Ronald Reagan came into power, the rate of declined lessened for oil/GDP ratio and became essentially flat for gallons/mile for light vehicles for the next two and one-half decades. The dashed lines are Lovins' estimates of how the two ratios could be greatly reduced in the near future by using state-of-the art technology.

Reay (**Reay, 2005**) gives some good advice about how individuals can conserve energy and materials.

Conclusion

If conservation practices are put into place quickly, the current rates of growth of wind power, photovoltaic power and biodiesel production will allow the World to have reasonably adequate multiple sources of renewable energy by about 2030, or perhaps a decade sooner if government subsidies are used to spur the growth. (See Figure 3-33, Figure 3-40 and Figure 3-41.)

To get from now to then is the problem. Of course, the rates of growth of conservation and wind and photovoltaic power and biodiesel/ethanol production must continue, which will require continued infusion of resources, including petroleum. Very helpful would be a stabilization and eventual reduction of World population perhaps by widespread use of pre-conception contraception and education of women.

Countries that quickly rearrange their industry to supply the infrastructure for a Multi-Source Distributed Energy System will be the countries that lead the world into the energy future. Here are some key items of action to look for in the early stages of such a country:

- Large subsidies for individual consumers to put the systems into place at their homes and work places. The incentives would involve:
    - Massive photovoltaic roofing for homes and office buildings, with easy linkage into the local electric grids.
    - Flexible-fuel plug-in hybrid vehicles for families and businesses with easy connection to local electric grids.
    - Biofuel pumps at ready locations in every town.
    - Wind generators on the roofs of every Town Hall and other governmental buildings.
    - Biogas generators at every local waste dump.
    - Town gardens, including greenhouses for winter growing of food, in different neighborhoods of towns.

For more information about the subject of this chapter and information about the depletion of other nonrenewable resources, see (**Youngquist, 1997**).

For a more pessimistic view of the human future with regard to energy availability see (**Price, 1995**).

Chapter 4.   The Next Major Ice Age

The last Four Major Ice Ages over the last 425,000 Years

Ice core data from Vostok Antarctica yield temperatures for the atmosphere over Antarctica for the last 425,000 years, which includes four Major Ice Ages with Major Interglacials at ~415,000 ybp, ~334,000 ybp, ~244,000 ybp, ~128,000 ybp and the current Major Interglacial. (ybp = years before present, yap = years after present) (**Petit, 1999**) Earth average temperature change is about one-half Antarctica temperature change. (**Houghton, 2004**)

Figure 4-1 shows Vostok Antarctica temperature data and summer insolation at the North Pole. (North-Pole summer insolation is used because accumulation of ice in the Arctic region is crucial to Major Ice Ages cycles and summer is when the ice can melt.) The temperature data were "tuned" to the insolation calculation, since they lagged excessively at earlier times and the temperature measurements are more prone to error for earlier times (deeper ice cores); thus the calculated lag of temperature to insolation of about 5000 years has been eliminated.

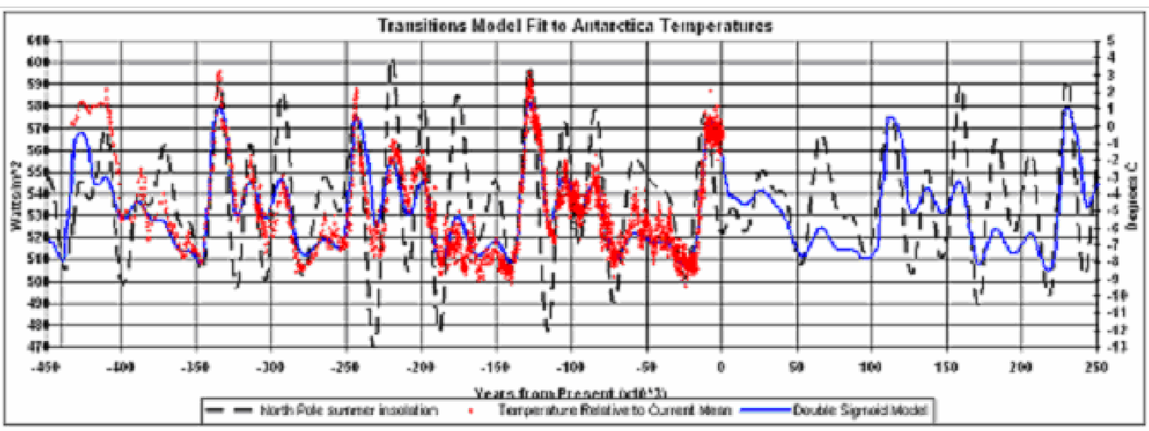


Figure 4-1. Antarctica temperature data (right scale) for 425,000 ybp to the present (present=0 on horizontal scale), which shows four Major Ice Ages of about 115,000-years duration. The dashed curve is the precisely calculated solar energy per area that strikes the Earth's upper atmosphere (insolation) (left scale) at the North Pole in the summer. The solid curve is a model fit to the temperature data for four previous Major Ice Ages (Roper, 2004), which is extrapolated into the next two Major Ice Ages up to 250,000 yap. (http://www.roperld.com/science/tempsolinsatc.pdf)

Also shown is a rough model fit to the temperature data for the last four Major Ice Ages and its extrapolation into the next two Major Ice Ages with Major Interglacials at ~115,000 yap and ~230,000 yap. (**Roper, 2004**) The next Major Ice Age is inevitable despite what humans may do.

Of course, a collision of a large asteroid or comet onto the Earth could drastically change the Earth's long-term climate. The average time interval for sch large collisions is about ten million years. (See *Impact: The Threat of Comets and Asteroids* by Gerrit L. Verschuur.) One of the last really big ones about 35 million years ago formed the Chesapeake Bay, sending tsunamis all the way, 250 miles, to the Appalachian Mountains. See http://www.space.com/scienceastronomy/astronomy/east_coast_asteroid_010320.html and *The Chesapeake Invader: Discovering America's Giant Meteorite Crater* by C. Wylie Poag.

Evolution of Homo sapiens

Homo sapiens evolved from an earlier humanoid in Africa as a result of the extreme stresses of the last two Major Ice Ages. (**Klein, 2002**) (**Calvin, 2002**) (**Stanley, 1998)** Figure 4-2 shows some major events for *Homo sapiens* during the last Major Ice Age. Probably the extreme cold at ~140,000 ybp followed by the fast warming into the last Major Interglacial had a large part to play in the evolution of *Homo sapiens*. At that time *Homo neanderthalensis* was well established in Europe, starting about 750,000 ybp, but disappeared from Europe at about 28,000 ybp, about 10,000 years after *Homo sapiens* first arrived there.

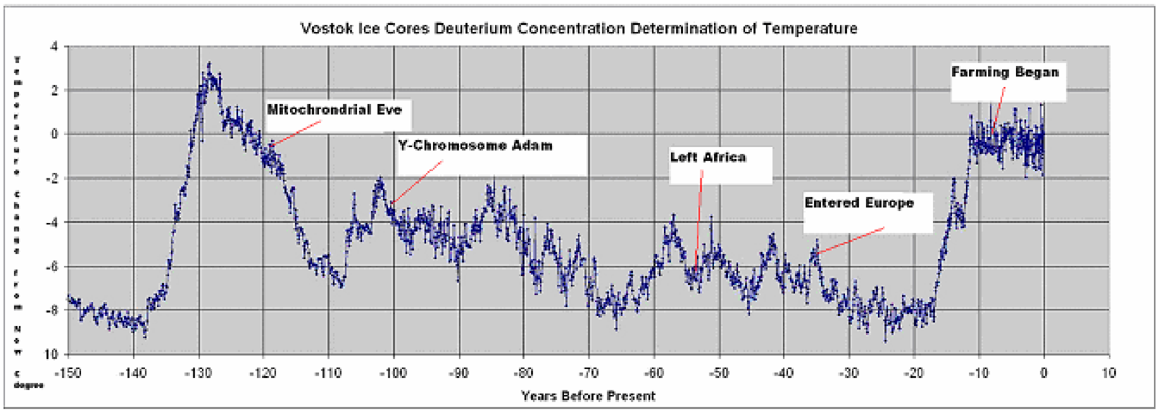


Figure 4-2. Some major events for *Homo sapiens* during the last Major Ice Age.

The dates for these events were estimated by determining some of the genetic structure of mitochondrial DNA and Y-chromosome DNA of living humans (**Wells, 2002).** Note that *Homo sapiens* left Africa at a relatively cold time and entered Europe at a relatively warm time in the approximately 10,000-years cycles of Minor Ice Ages in between the last and the current Major Interglacials. (The Minor Ice Ages follow closely the North-Pole summer insolation.) In the very cold time about 65,000 ybp humans probably left the interior of Africa to populate the eastern shore where there was ample seafood; then probably at the next cold time about 55,000 ybp they migrated over the short expanse of water into Asia.

Mitochondrial Eve is the mother of all living *Homo sapiens* and Y-Chromosome Adam is the father of all living *Homo sapiens.* The reason that all humans stem from those two individuals is that there was a "bottleneck" of low human population then due to the extreme climate stresses. (http://en.wikipedia.org/wiki/Population_bottleneck)

See Calvin's book (**Calvin, 2002**) for an excellent discussion about human evolution and abrupt climate change.

Predictions for the Next Two Major Ice Ages

Figure 4-3 shows some models' predictions for the next two Major Ice Ages. (http://www.roperld.com/science/tempsolinsatc.pdf).
The current Major Interglacial is at the top left. Anthropogenic Global Warming is not shown because it is negligible compared to the long-term effects of the Major Ice Ages.

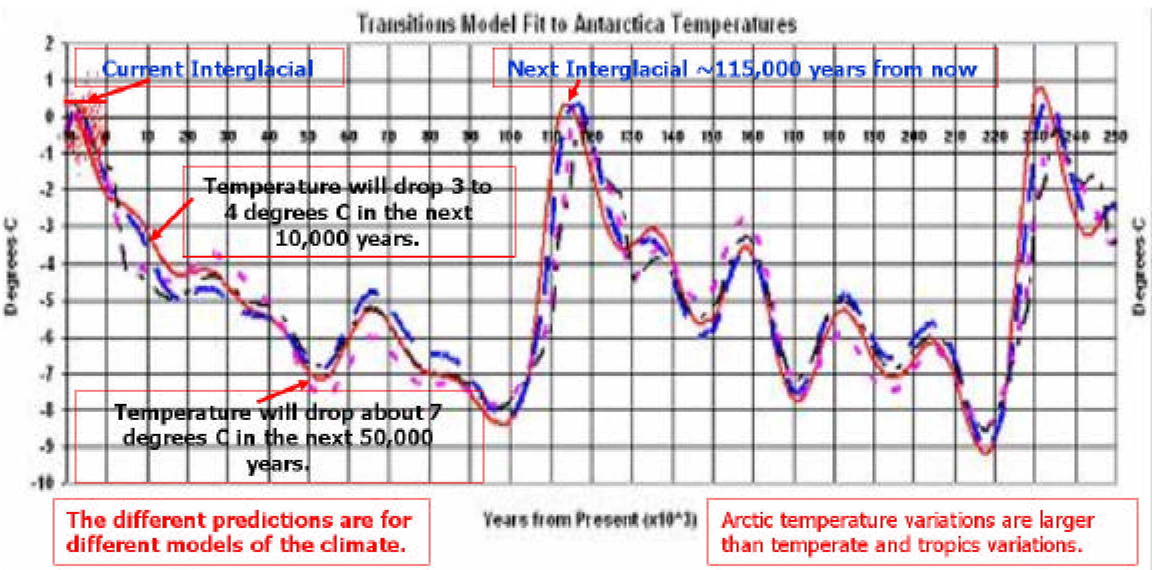


Figure 4-3. Models' predictions for Antarctica temperatures for the next two Major Ice Ages of about 115,000 years duration.

These predictions are made from fits of a mathematical function (**Roper, 2004**) to the Antarctica ice-core temperature data for the last four Major Ice Ages (**Petit, 1999**) as shown in Figure 4-4. The function has a term proportional to the North-Pole summer insolation and one or two terms that represented Earth-states transitions in the time vicinity of the Major Interglacials.
The mathematical function is:

$$T(t) = C + F \cdot I(t) + \sum_{i=1}^{N} s_i \frac{1}{2}\left[\tanh\left(\frac{t-c_{1i}}{w_{1i}}\right) - \tanh\left(\frac{t-c_{2i}}{w_{2i}}\right)\right]$$

= temperature in degrees Celsius,

where $I(t)$ = calculated summer North-Pole insolation at time t in $\frac{Watts}{m^2}$;

DHTF parameters: s_i = strength, c_{ni} = position, w_{ni} = width;

and N = number of DHTFs used in the fit.

(DHTF = double hyperbolic tangent = double sigmoid.)

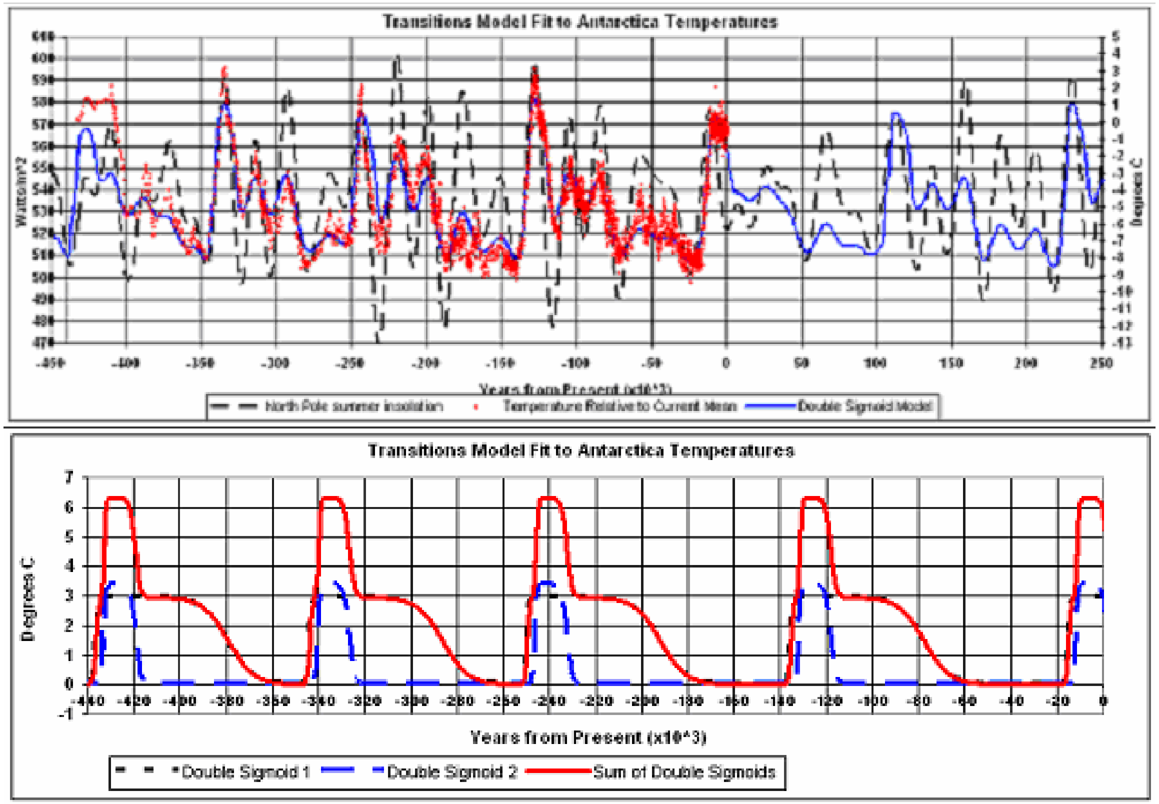


Figure 4-4. Fits to Antarctica temperature data for the last four Major Ice Ages (Petit, 1999) by a mathematical function involving the North-Pole summer insolation and two Earth states transitions in the time vicinity of the five Major Interglacials (Roper, 2004). The fit is then projected into the future for the next two Major Ice Ages. The bottom graph shows the two Earth states transitions and their sum (solid curve).

To be able to predict future Major Ice Ages, it was assumed that the last four and the current Major Interglacials had the same two transition functions. Note that the fit is worse for the fourth last Major Interglacial, whose temperature data were taken from deep in the ice core where the measurements are most subject to error. Also, some minor tuning of the data peaks to the insolation peaks was done before the fitting, thus eliminating any time lags that probably existed.

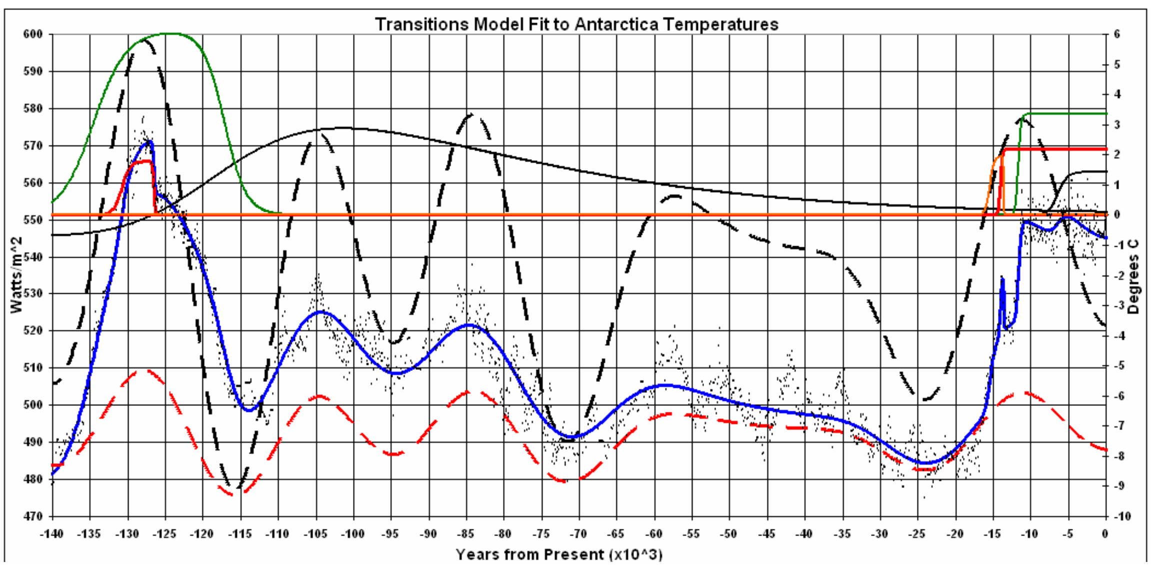
There are several Earth states that could be transitioning in the time regions of the Major Interglacials, some of which are:

- Several different Thermohaline Ocean Currents turning on and then off (**Houghton, 2001**).
- Massive release of the very potent greenhouse gas methane from methane hydrates in the oceans and then reformation of the hydrates by chemical reactions in the atmosphere and decomposition of minerals and plants. See http://healthandenergy.com/methane_hydrate.htm and (**Kennett, 2003).**
- Massive release of the greenhouse gas carbon dioxide from the oceans and land and then re-absorption and decomposition of marine shell animals in the oceans and plants and animals on the land.
- Melting of ice in the polar regions and then freezing of water. This is coupled with the amount of water vapor in the upper atmosphere, which is a very potent greenhouse gas, and in low clouds, which tend to reduce atmospheric temperatures.

All of these have positive feedback effects, so that when they start they tend to perpetuate the increase in temperature and when they stop they tend to perpetuate the decrease in temperature.

Then, at some point in the positive feedback of one or more of these states, one or more of the other states is triggered to stop. Then negative feedback can take over to reduce temperature.

By allowing different Earth-states transitions for different Major Interglacials, one can get reasonably good fits to the Vostok Antarctica temperature data. (**Roper, 2004**) Figure 4-5 shows an example for the last Major Interglacial using three Earth-states transitions and the current Major Interglacial using four Earth-states transitions, including Neolithic Global Warming as an “Earth state” (the last “on” transition for the current Major Interglacial). One of the Current-Major-Interglacial Earth states turned off 13,500 ybp and then another turned on after about 2,000 years. (This off-on phenomenon is called the “Younger Dryas” event, which is seen in many climate records all over the Earth.) These two states could be the same state turning on and off.



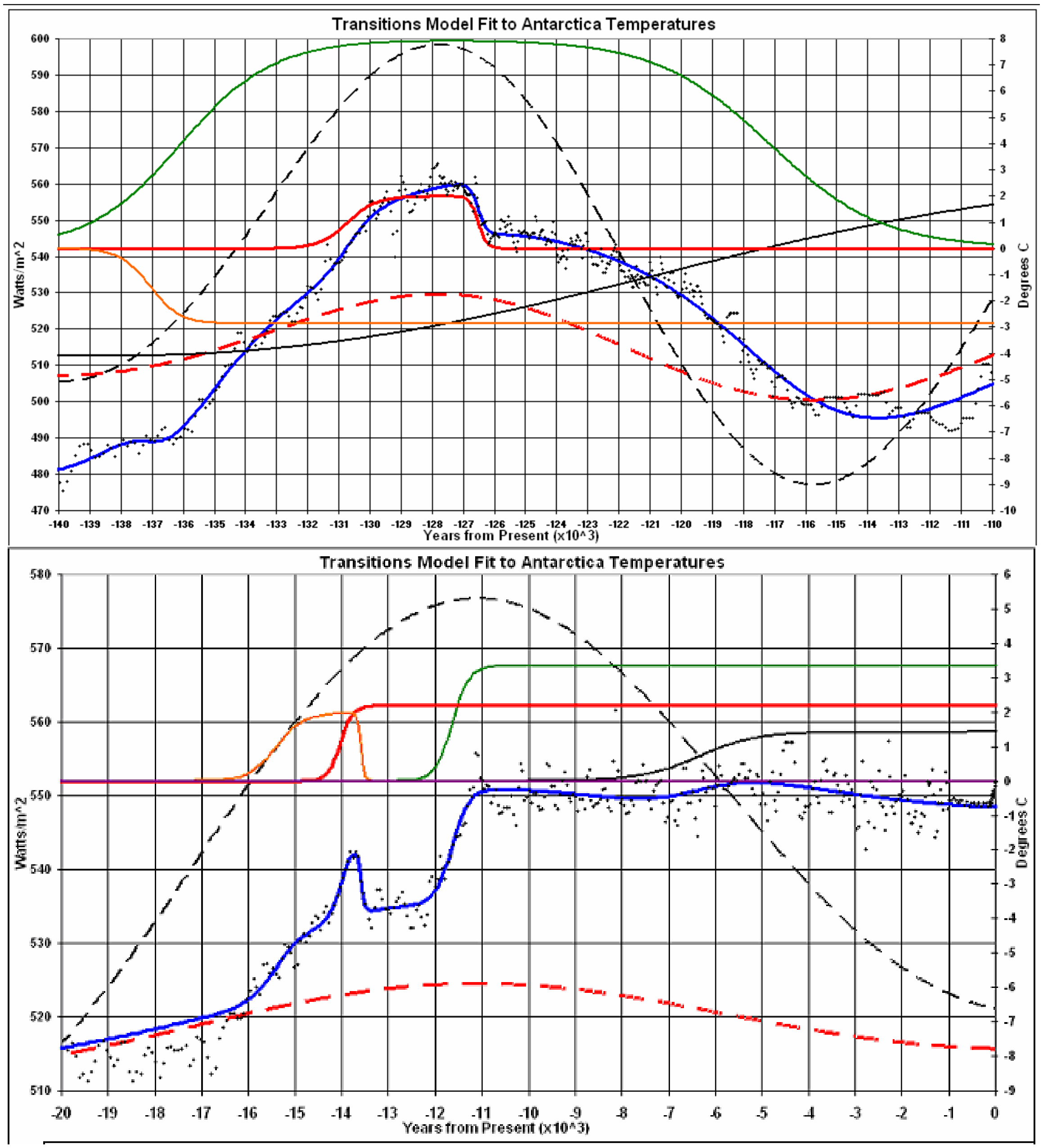


Figure 4-5. An example of fitting (blue curve) the last Major Interglacial using three Earth-states transitions and the current Major Interglacial using four Earth-states transitions. The dashed red curve is the contribution of the North-Pole summer insolation to the temperature. The dashed black curve is the calculated North-Pole summer insolation. The far-right transition curve in the bottom graph is Neolithic Global Warming which began with the onset of agriculture about 8,000 ybp. The other curves are the transitions' components in the fit.

Since there are no data for the future, it is unknown when most of the Earth states for the current Major Interglacial will turn off.

There is more than one way to fit the temperature data for the last and the current Major Interglacial using Earth-transitions states. The main point is that the data can be fitted reasonably well by Earth-transitions states.

A recent analysis of deeper ice cores from Antarctica (Dome C location) **(EPICA, 2004)** extends measurement of Antarctica temperatures back to 740,000 ybp. Figure 4-6 shows the new data to 650,000 ybp and the older data (location Vostok Antarctica) (**Petit, 1999**) back to 425,000 ybp. The lower graph in that figure shows the calculated North-Pole summer insolation (**Berger, 1991**).

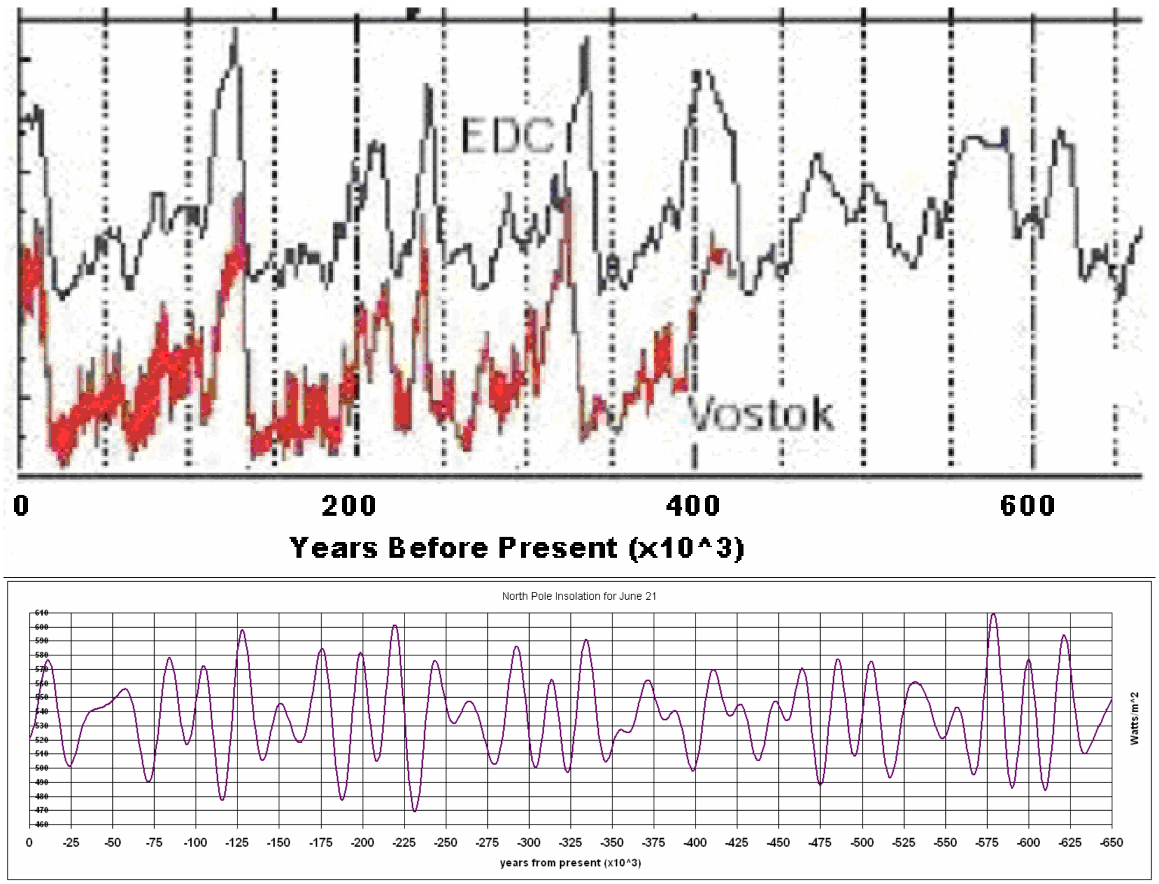


Figure 4-6. Antarctica temperatures for two different Antarctica ice cores: Older data (Vostok location) (Petit, 1999) back to 425,000 ybp and recent data (Dome C location, labeled EDC) (EPICA, 2004) extend Antarctica temperatures back to 740,000 ybp. The lower graph shows the calculated North-Pole summer insolation (Berger, 1991). These graphs start at 650,000 ybp; the scale is right-to-left in time according to the custom of ice-core measurements.

Note the visual correlation between the temperatures and the North-Pole summer insolation in Figure 4-6, particularly for the last three or four Major Ice Ages, which is born out by analyses (**Roper, 2004**). Deeper cores have more possibilities for error in the measurements. (**Alley, 2000**) In my view the newer data are more likely in error because they are from a great depth (earlier time) near the bottom of the ice sheet; they seem to be too flat compared to the North-Pole summer insolation. Even if they are mostly correct, I see no reason for surmising that the next Major Ice Age will be like them rather than like the last three Major Ice Ages.

EPICA (**EPICA, 2004**) argues that the current Major Interglacial may be similarly long as the Major Interglacial around 415,000 ybp because the northern summer insolation curves are similar for those two time regions. Figure 4-7 shows the North-Pole summer insolation and upper bars indicating the locations of the Major Interglacials according to the EPICA data. (There are time shifts between the Major Interglacials of the Petit and the EPICA data in Figure 4-6, which is further evidence of the inaccuracies of temperature measurements in deep ice cores.)

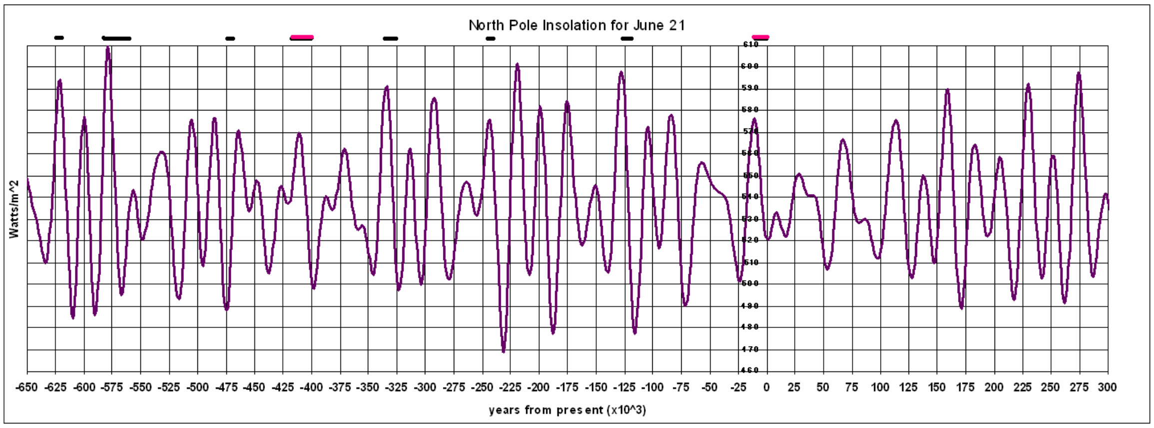


Figure 4-7. North-Pole summer insolation (Berger, 1991) for 450,000 ybp to 300,000 years from now. The short bars at the top approximately represent the time intervals of Major Interglacials according to the EPICA data. The two red bars are the -415,000 and the current Major Interglacials.

However, note in Figure 4-7 two bars near the top which represent the current and the 415,000 ybp Major Interglacials' time intervals. With time moving from the left to the right, I do not see much similarity between the North-Pole summer insolation for those two Major Interglacials. I think the long time length of the current Major Interglacial is better explained by Neolithic Global Warming (See Chapter 2.) than by similarities of current insolation to the insolation at the 415,000 ybp Major Interglacial.

Figure 4-8 shows Antarctica temperatures relative to 1990 for the current and the last four Major Interglacial periods. The last four are shifted in time to make their peaks about the same point in the graph. The last three are much more to be trusted for accuracy than is the one at the end of the ice core.

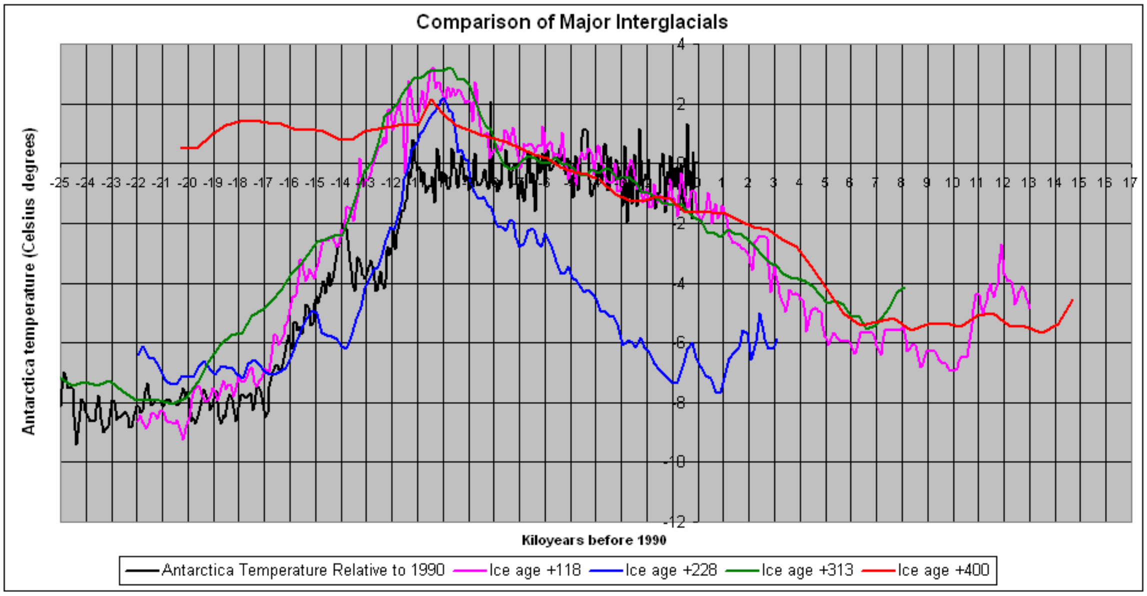


Figure 4-8. Antarctica temperatures relative to 1990 for the current and last four Major Interglacials, which are shifted in time to make their peaks at about the same point in the graph.

Note that peaks for the last three Major Interglacials are about 2000 to 5000 years in length, with a long tail extending to future times of about 10,000 years in length. The current Major Interglacial is certainly very anomalous being so flat for about 11,000 years.

For more details about the current Major Interglacial, see http://www.roperld.com/CurrentMajorInterglacial.pdf.

The next Major Ice Age will occur no matter whether humans quickly burn up all the fossil fuels or not. *Homo spiens* will undoubtedly evolve greatly over the next Major Ice Age of about 110,000 years duration, due to the extreme stresses of cold climate, as they did during the last Major Ice Age.

In fact, the next Major Ice Age may begin sooner than it would with only Neolithic Global Warming, if Future Global Warming turns off some or all of the North Atlantic Ocean currents (**Houghton, 2001**). But that is negligible compared to the 10,000-years time scale of Major Ice Ages' oscillations. See Chapter 2 for a discussion of this possibility.

Can Humans Keep the Next Major Ice Age from Occurring?

Some technophiles may claim that humans will figure out how to keep the next Major Ice Age from occurring by some new fantastic technology. That would require that some method be devised to keep the North Atlantic Ocean (NAO) currents from turning off and perhaps some of the other Earth-states transitions mentioned above from reverting back to their long-term Major Ice Age behavior, which would involve a huge amount of knowledge and energy. The NAO currents are about 500 times the maximum current of the Amazon River at its mouth. Chapter 3 demonstrates that humans do not have that amount of energy available.

It might be possible for humans to turn off the Major Ice Ages cycle of the last four million years by using massive nuclear weapons explosions to blast a hundred-miles wide channel across the Isthmus of Panama, which would allow the warm Atlantic Ocean currents to pass into the Pacific Ocean instead of into the North Atlantic Ocean where it keeps ice from forming in the Arctic during Major Interglacials. (See Figure 2-4 and Figure 2-5.) With such a channel there would be no Major Interglacials and Major Ice, as was the case about four million years ago before continental drift closed off the Isthmus of Panama. The question is whether the steadier climate will be cold one or a hot one as judged by temperature ranges needed for human survival. The explosions would put a huge amount of particles into the atmosphere which would cause, at least, a "nuclear winter" for a few years; it might trigger an ice age that lasts for millions of years. Discounting the possibility of a nuclear winter, Figure 4-9 indicates that the Earth's temperature would probably be warmer than now, if it returned to what it was four million years ago.

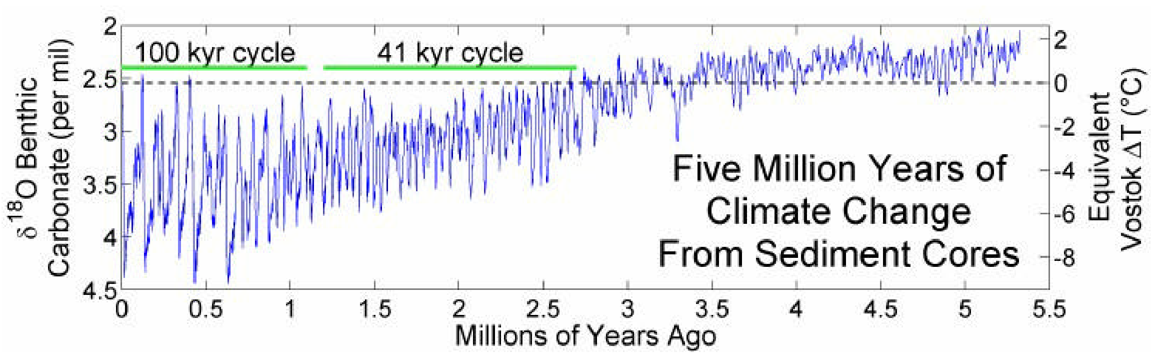


Figure 4-9. Antarctica temperatures for the last five million years. (http://en.wikipedia.org/wiki/Image:Five_Myr_Climate_Change.png)

Chapter 5. World Population Control

Introduction

Throughout this book I have mentioned the need to stabilize and then reduce the population of the World by pre-conception birth control and education of women. For example, Figure 3-5 shows that World crude oil extraction per capita is projected to fall to about one-fourth its current value by the year 2100. Since it is not possible to increase the crude oil extraction rate (in fact, it will decrease), the only way to stabilize or increase the crude oil extraction rate per capita is to reduce the population.

For a study of World population see Roper (**Roper, 1977**). An extension of that analysis yields **Error! Reference source not found.**. The inverse-tangent function used to fit the population data is

$$P(t) = P_{\max}\left\{\frac{1}{2}+\frac{1}{p}\arctan\left[\frac{t-t_{\frac{1}{2}}}{t}\right]\right\} \text{ and } P_{\max} = 9.91,\ t_{\frac{1}{2}} = 1986 \text{ and } t = 37.0.$$

(An antisymmetric version of the inverse-tangent function was tried, but did not fit the data as well as the standard function did.)

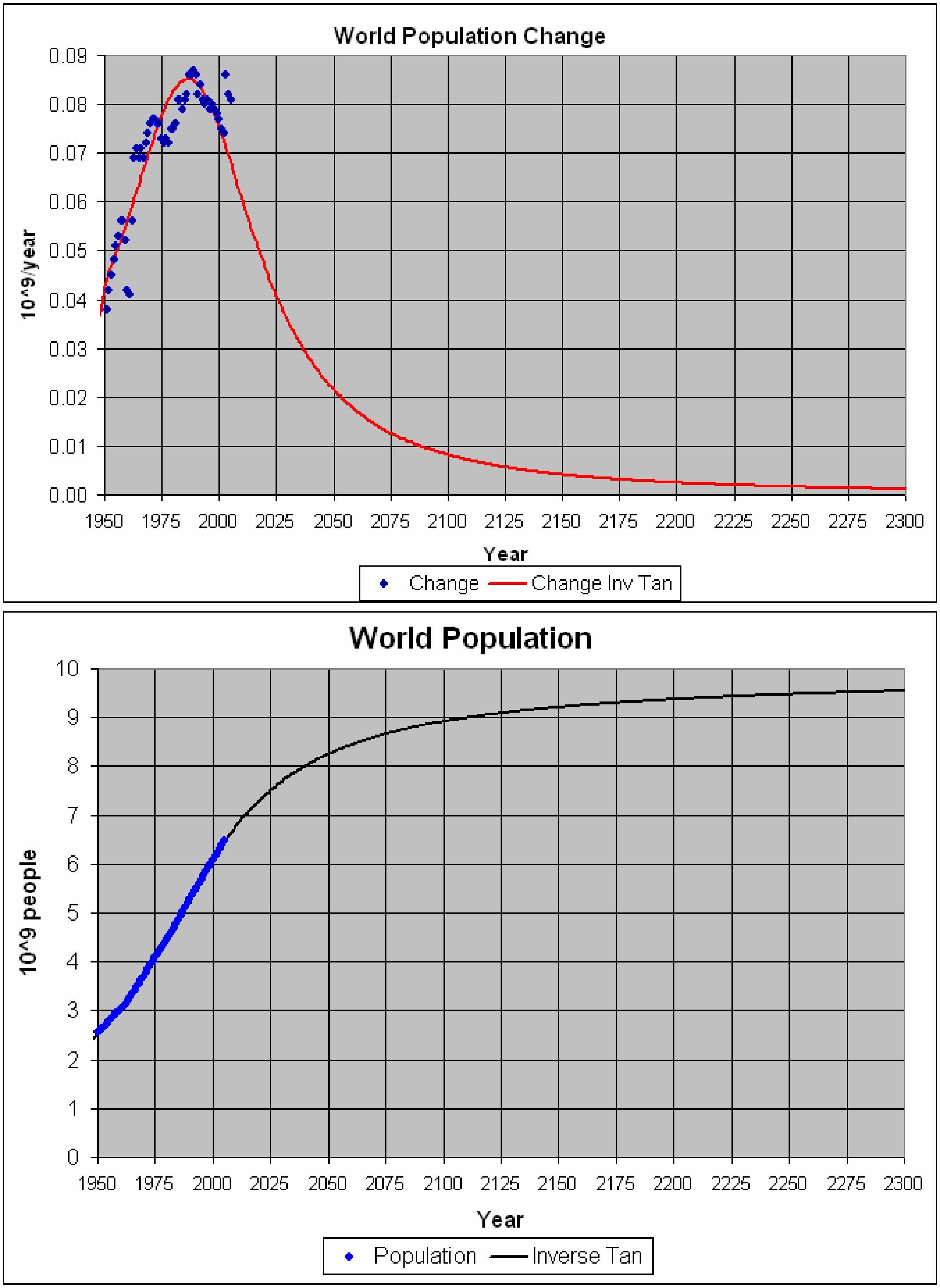


Figure 5-1. **World population change (top graph) and World population (bottom graph) and their projection into the future by fitting the data from 1950 to 2005 with an inverse-tangent function.**

The World population data give some hope that population will stabilize in the next few hundred years. However, it seems clear from the data concerning energy use, Anthropogenic Global Warming and the next Major Ice Age presented in this book that stabilizing the population will not be enough. The World population will be reduced, either by conscious action of human individuals and societies or by undesirable consequences of physical limits.

Pre-Conception Birth Control

I emphasize pre-conception birth control because there are thorny moral problems with post-conception birth control. Despite some religions' objections to pre-conception birth control I cannot arrive at a moral reason to oppose it. In fact, this book makes clear that there are moral reasons to promote it. I do not see any logical difference between sexual abstinence, coitus interruption and using a condom or a diaphragm during the sex act. Surely most rational people of the World can agree that many methods of pre-conception birth control are morally acceptable.

Post-Conception Birth Control

With regard to post-conception birth control, I also cannot fathom moral arguments that a five-cell collection of undifferentiated cells (a blastocyte) is a living human being. The tricky question is: **When does a blastocyte become a viable human being?** Some cell-division steps to consider when trying to answer this question are:

1. When a blastocyte connects to the womb wall. (Millions of them are flushed out every day in menstrual blood. Similarly, hundreds of thousands are destroyed by fertility clinics. *See Sex, Drugs and DNA: Science's Taboos Confronted* by Michael Stebbins, Macmillan, 2006.)
2. When a blastocyte becomes an embryo, which begins as the cells begin to differentiate in function?
3. When an embryo becomes a fetus, which begins as the cells begin to resemble an adult human?
4. When a fetus is able to live on technological life support outside of the mother's womb? This changes with time as new biological techniques are developed.
5. When a fetus is able to live without technological life support outside of the mother's womb?

Logically, one could make a strong case that human viability occurs only at step 4, whose time interval after conception would depend on the technology available to keep a fetus alive, although emotionally the case is stronger at step 3. Many regard a human egg to be a human immediately after it is fertilized by a sperm and is a single cell; thus they oppose the "morning-after pill" (http://en.wikipedia.org/wiki/Morning_after_pill). Would they also regard a system of an unfertilized egg and a sperm swimming on a trajectory toward the egg as a human? I guess they do if they oppose humans using condoms or other barriers to sperm reaching an egg.

It may be that science will someday be able to create, at least, simple single-cell life from the basic chemicals. Or the next Major Ice Age may come before that can happen, perhaps stopping major scientific advances. If science is someday able to create a human egg from basic chemicals, then item 3 given above will be totally altered!

Since there is so much dissension about abortion at the various cell-division steps, I think that the main hope of stabilizing population by birth control is in the pre-conception stage.

Educating Women

Many studies have indicated that one of the best ways to stabilize and eventually reduce population is to educate women. See *The United Nations Girl's Education Initiative*, http://www.ungei.org/whatisungei/index.html . A discussion about the research findings and criticism about this method of achieving population control are in http://www.hsph.harvard.edu/Organizations/healthnet/SAsia/depop/Chap11.html .

Chapter 6. Storage for the Future

Carbon Dioxide Storage

A major research project is underway by the Intergovernmental Panel on Climate Change about storing carbon dioxide that is released by using fossil fuels. (http://www.ipcc.ch/activity/srccs/index.htm) There is no component in the research program to assure that the carbon dioxide can be later recovered.

The main method of storage being pursued is pumping liquid carbon dioxide into oil wells after the oil is removed. In some cases that helps to remove more oil from the highly depleted wells.

Possibly the carbon dioxide could be pumped out again when it is needed in the distant future to ameliorate the plunge into the next Major Ice Age, thereby giving more time for humans to develop the infrastructure for more people to survive the extreme cold temperatures. (See Chapter 2 and Chapter 4.)

Knowledge Storage

10,000 years from now the Earth's atmospheric temperature will be about 5 Celsius degrees colder than now. That is, the Earth will be well into the coldest parts of the next Major Ice Age of about 110,000 years duration. About 50,000 years from now the Earth's temperature will be about 7 Celsius degrees colder than now. See Figure 4-3.

There are many interesting questions one could ask about what human life will be like in that very cold time about 10,000 years from now and between now and then.

Some of such questions are:

- What will be the population of the World then?
- Will millions have died fighting, possibly killed by nuclear weapons, for the dwindling nonrenewable resources? (Cartoon in 19 December 2005 *The New Yorker*, p.8: "I'm an optimist. I have every confidence that global warming will be nullified by nuclear winter.")
- Will there be a "population bottleneck" during the plunge into the next Major Ice Age as there was during the plunge into the last Major Ice Age when most humans died. (That bottleneck about 100,000 ybp is the reason that Mitochondrial Eve and Y-Chromosome Adam, the ancestors of all who are now living, lived at about that time instead of at some much earlier time.)
- Will any of the knowledge of how humans barely survived the last Major Ice Age be available to humans during the next Major Ice Age?
- Will any of the technological advances developed during the current Major Interglacial be available to humans during the next Major Ice Age?
- What are the essential things that humans need to know to survive in such a cold climate?
- What are the best ways to store information about the knowledge needed to survive in a much colder climate?
- What kinds of technologies could be developed now that might be available to make it easier for humans to survive in the next Major Ice Age?

The problem of transmitting knowledge into the future for the benefit of future human generations has been discussed at length by Benford (**Benford, 2000**). From Benford's book and from *The Story of Writing* by Robinson (**Robinson, 2000)** some possible ways to pass on survival information to future humans are:

- Create an ideographic writing system specifically for easy-to-read survival documents. Translate each survival ideographic document into current English, Spanish, French, German, Arabic and Chinese or, at least, English, Arabic and Chinese.
- Create documents on various topics needed for survival in very cold climates, such as migration routes to possible refugia. People who now live in cold climates could help create these documents.
- Deeply scribe the documents in miniature onto hard stone tablets placed inside stone containers with stone lids. Place several glass magnifiers in each container that are sufficient to make the ideograms visible to the human eye.
- Bury the stone containers about 25 feet underground with an obelisk on the surface above it and slightly to one side with ideograms on it instructing when (10,000 years BC, the approximate time of the first temperature minimum of the next Major Ice age) and where to dig up the survival manuals. Bury them at least at locations where humans could most likely survive (refugia) during the coldest times of the next Major Ice Age. (European refugia during the last Major Ice Age are shown in Figure 6-1.) They also should be buried at other locations approximately equally spaced about 1000 miles apart about 1000 miles below the southern boundaries of the glacial ice during the last Major Ice Age in Europe, Asia and North America.

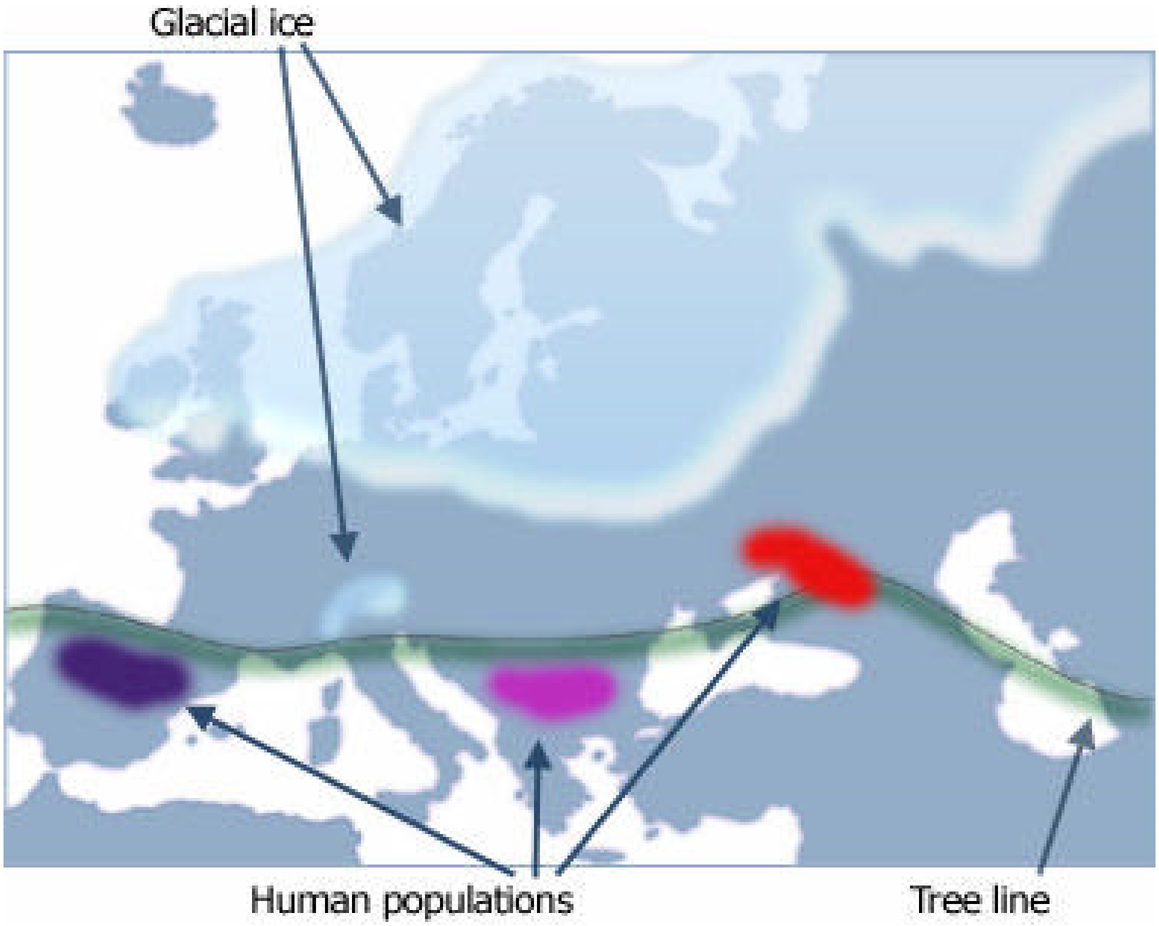


Figure 6-1. Human refugia in Europe during the coldest time, ~18,000 ybp, of the last Major Ice Age. (http://www.dnaheritage.com/masterclass2.asp)

Of course, a big task will be deciding what should be in the survival documents. Perhaps the information about how early humans survived during the last Major Ice Age as documented by Weatherford (**Weatherford, 1994**) and Stanley (**Stanley, 1998)** would be helpful. Allowances will have to be guessed about how *Homo sapiens* will further physically evolve between now and then. Another uncertainty is how social evolution will play out when the next Major Ice Age is in full force. Still yet one must consider whether the "transcending of biology" as discussed by Kurzweil (**Kurzweil, 2006**) will have occurred by then and, if it has, will it still be in effect.

Do I think that humans will create such a message system to help their descendants get through the next Major Ice Age? No! The fact that we do not try to help those future generations will probably just pile onto the huge blame that we will deserve for profligately using the gift of fossil fuels rather than saving some for them when ready fuels will really be needed.

It is interesting that:

- If humans had not discovered fossil fuels, the next Major Ice Age probably would already be well underway.
- However, the fossil fuels may be all used up before the next Major Ice Age begins, so those fuels might not be available to help humans survive during that cold time.
- If humans really understood the long-term future of their species and had a strong inclination to preserve the species in the long term, they would have saved some of the fossil fuels for when they would be most needed.

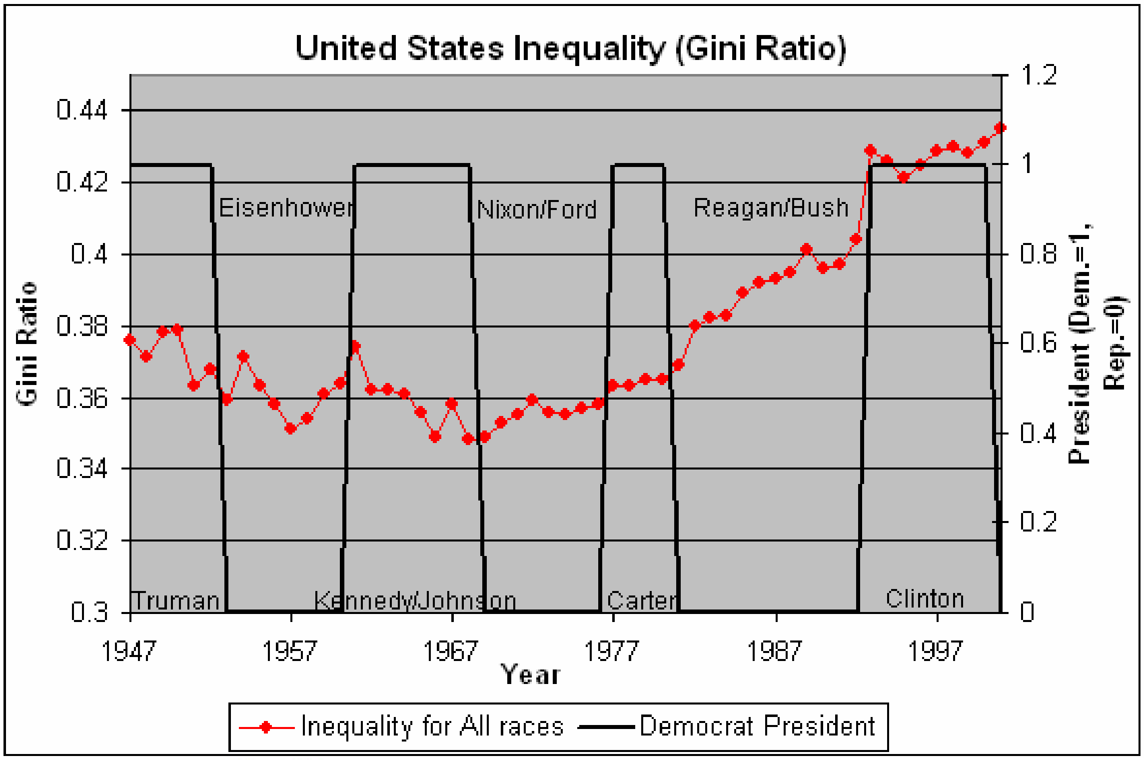
Chapter 7. Will Civilization Arrive?

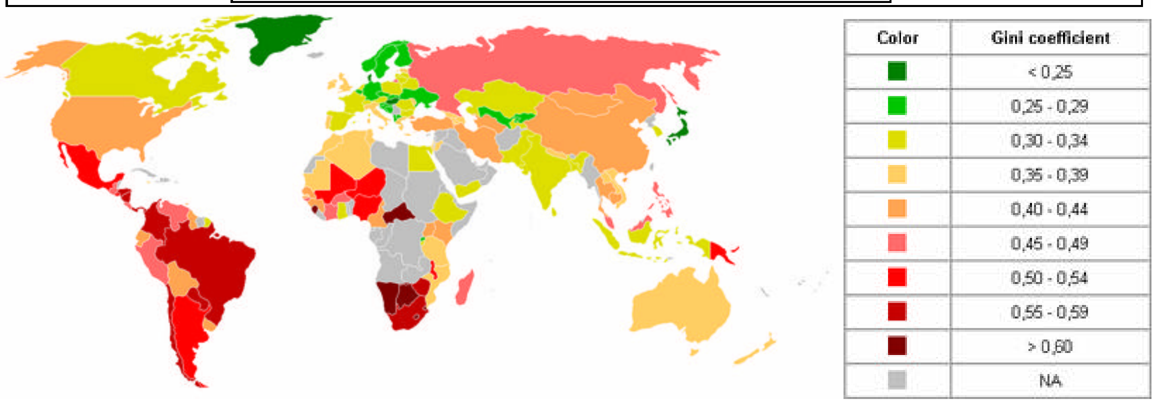
Given all the threats for the human future discussed in the previous chapters of this book, it is difficult to have much optimism that humans can achieve a social organization that has the features of a "civilization" defined by:

> **A civilization is a society in which the basic needs (shelter, sustenance and meaningful contributing work) of all its members are achieved through cooperation among its members.**

One could be convinced that civilization is a long way off by recent events:

- Genocide in African and Eastern European countries was rampant during the 1990s and early 2000s.
- Civil wars in ethnically-divided nations have been common.
- Human slavery is a thriving business in many countries around the World. (http://www.infoplease.com/spot/slavery1.html; http://www.antislaveryinternational.org)
- Thousands of people in many countries have gotten so discouraged with their lives that they have used their bodies as walking bombs to kill other people. (See the movie *Paradise Now*.)
- Religious adherents in many countries, including the United States, are trying to force all citizens to participate in their religious rites and pledge allegiance to their doctrines. (A friend of mine told me that I should include religious fundamentalism as a fourth threat to the human future. This includes fundamentalism in all religions.)
- Weapons designed to kill people are increasingly allowed in more places of social interaction in the United States, including schools, where disappointed and careless people can easily use them to kill other people, and increasing are doing that.
- In March of 2003 President George W. Bush ordered the United States armed forces to attack Iraq without any indication that Iraq was a danger to the United States or any country of the World. Many tens of thousands of people were killed.
- Even in the developed countries, especially the United States, millions of people do not have adequate health care and, thus, die at young ages. In the undeveloped countries the situation is much more serious.
- Eight countries have nuclear weapons of mass destruction: United States, Russia, United Kingdom, France, China, India, Pakistan and Israel. Two other countries are trying to develop nuclear weapons: North Korea and Iran. The existence of such weapons will be very dangerous for the survival of *Homo sapiens* as competition for resources increases in the temperature fall into the next Major Ice Age.
- The United States used uranium-tipped weapons of indiscriminant destruction in the 1991 Gulf War, the 1996 Bosnia War, the 1999 Kosovo War and the 2003-6 Bush Iraq War. See http://arts.bev.net/roperldavid/politics/WeaponsRadioactive.htm and (**NEIS,** 2003) for descriptions of the inhumanity of such weapons.
- The ability to provide shelter and food for families is increasingly becoming more difficult for more people as wealth is being concentrated increasingly in a small fraction of the population. See Figure 7-1 for income inequality data for the United States and the World.


United States Inequality (Gini Ratio)
Gini Ratio
President (Dem.=1, Rep.=0)
Year
Truman
Eisenhower
Kennedy/Johnson
Nixon/Ford
Carter
Reagan/Bush
Clinton
Inequality for All races
Democrat President


Color
Gini coefficient
< 0,25
0,25 - 0,29
0,30 - 0,34
0,35 - 0,39
0,40 - 0,44
0,45 - 0,49
0,50 - 0,54
0,55 - 0,59
> 0,60
NA

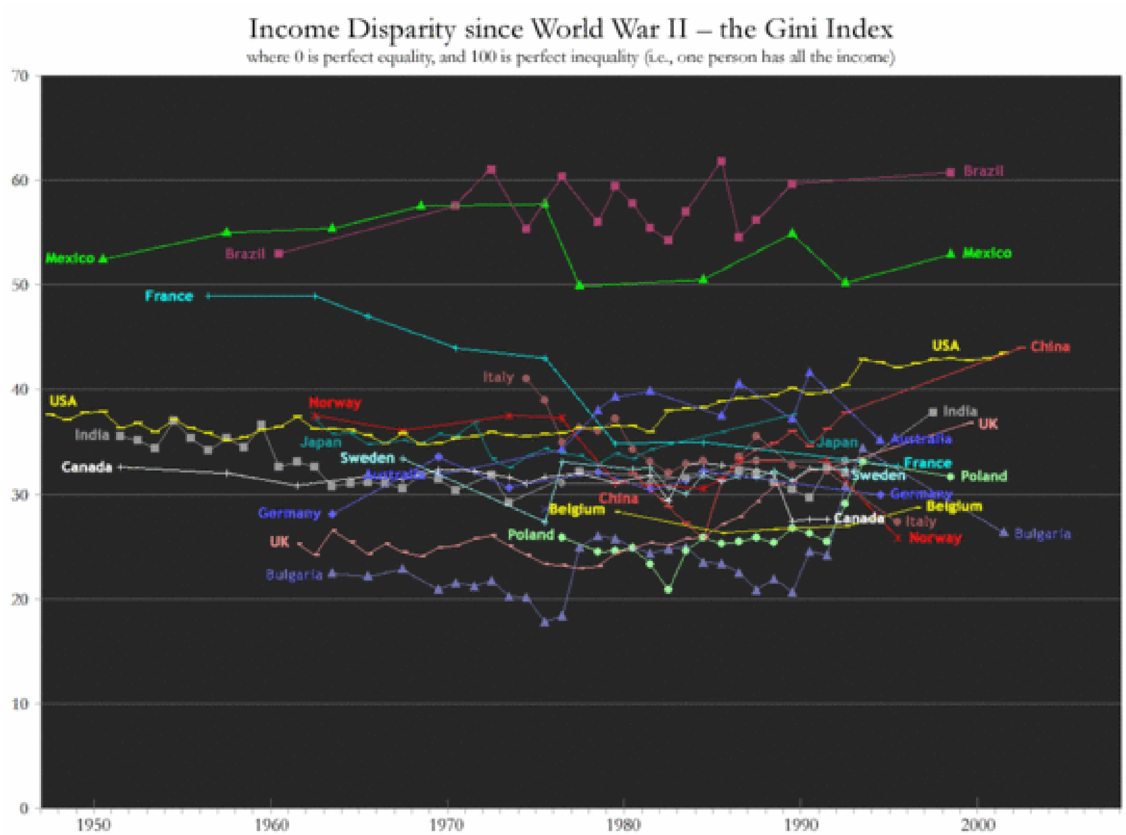


Figure 7-1. Income inequality measure (Gini Coefficient: http://en.wikipedia.org/wiki/Gini_coefficient) for the United States from 1947 to 2001 (top graph) and the World(bottom two graphs). (G = 0 for full equality = equal income to all people, G = 1 for full inequality = all income to one person) See http://arts.bev.net/roperldavid/politics/inequality.htm. Data are from the United States Census Bureau.

All has not gotten worse with regard to the possibility for civilization arriving. There is also a long list of movements toward civilization, some of which are:

- Slavery has been ruled against the law in all nations. See http://innercity.org/holt/slavechron.html for a timeline on slavery.
- The rights of women have been progressively increased; although, some religions are working hard to reduce them.
- Representative democracy has made gains as a political system in many nations, although the concentration of wealth to a small fraction of people in the United States has diminished its democracy.
- Many diseases have been under control Worldwide for some time, although their resistance to some of the drugs used to control them is increasing. The United Nations World Health Organization has been very helpful in this regard.
- The United Nations has been instrumental in maintaining peace in many nations after their civil wars. For example, in Guatemala.
- The United Nations has been helpful in getting nations to discuss their differences rather than going to war about them.
- Worldwide communications have made it possible for people around the World to better understand each other.

- Many religious groups have joined together to try to make living easier for low-income people.
- Environmental awareness has increased among citizens of many nations.
- Some improvement has been made in decreasing some environmental degradation in developed countries.
- The Intergovernmental Panel on Climate Change has increased the awareness of people to the reality of Anthropogenic Global Warming. World news agencies are doing a better job of informing people about this problem.
- The International Atomic Energy Agency of the United Nations works to keep more nations from developing nuclear weapons. Now it needs to work to get all nations to eliminate nuclear weapons.

One could use these negative and positive items and other similar ones to measure how civilized the World is now and in the future.

The tribulations ahead for humans due to the Triple Threats described in this book will probably make things worse, unless we begin to understand what we are facing and come to the realization that the way we interact with each other must be drastically changed.

The final question is: **Will evolution's "The Survival of the Fittest" govern our behavior toward each other and the Earth on which we live, or will we "transcend" evolution by intelligence and knowledge to bring about a true civilization?**

I am not sanguine that humans will transcend evolution to make civilization arrive. I am deeply discouraged with the high probability that the coming troubles will enhance the fighting among humans for scarce resources instead of improving the cooperation among humans for their mutual survival and well being.

However, we must try our best to make the latter happen instead of the former.

Afterward: Advice to Earth from An Extraterrestrial

President of the United States
Secretary-General of the United Nations

Dear Earth Leaders:

I know that this letter will be a great shock to you, so it probably would be best to have everyone but you leave your two offices before you read this letter. I suggest that the two of you immediately begin constant communications with each other about the contents of this letter, and how to accomplish what it recommends.

I am writing to you as an emissary of a colony of living beings on a planet in a different star system than the one in which you live. That is, I am an extraterrestrial.

The purpose of this letter is to inform you of some facts that you and most of your fellow humans do not seem to know (or do not act as if you know) for the purpose of helping you change individual and societal behaviors to make it more likely that your *Homo sapiens* species on your planet can survive into the long-term future.

We have been observing your planet for several millions of your years. We have observed your *Homo sapiens* species evolving from less-intelligent species, and we have come to the conclusion that it is probable that your species is not evolving fast enough in intelligence to survive beyond the next Major Ice Age. We barely made it ourselves several hundred thousands of your years ago.

We are not very hopeful that this letter will convince individuals and societies on your planet to change their behaviors, but we felt that we must try. We had some help ourselves, so we are passing the favor on to you.

This letter is divided into four parts:

1. The need to limit and eventually reduce the population of your planet.
2. The need to use nonrenewable energy resources extracted from your planet to develop the infrastructure needed to use renewable (solar-based) energy sources into the future.
3. The need to recycle nonrenewable materials as much as possible.
4. The need to use much of your material and energy resources to prepare for the next Major Ice Age, which you will begin to experience within the next 1000 years, or perhaps much sooner if you do not stop burning fossil fuels in your vehicles, factories and power plants.

The need to limit the population of your planet

We have been pleased that your rate of population increase has been slowing down, but it is not doing so nearly fast enough. Actually, you need to decrease human population in a peaceful manner.

You need to spread information and materials rapidly around your planet that will enable people to use pre-conception birth control to stabilize Earth's population and, finally, to reduce its population to at least half what it is now. Thankfully you have a United Nations organization that can do this rapidly and efficiently.

Reducing your population is most urgent, because, if you do not, the remaining items listed below probably will be impossible to do.

The need to use nonrenewable energy resources for developing infrastructure for using renewable energy sources

You need to use nonrenewable energy resources extracted from your planet to develop the infrastructure needed to use renewable (solar-based) energy sources into the future.

You have been very profligate in using the very valuable nonrenewable energy resources extracted from Earth for very frivolous purposes. You must change this to use them mainly for preparing infrastructure for using renewable solar-based energy sources, since your Sun will supply you energy for a long time into the future.

It is encouraging that you have been growing in using wind energy at about 25% per year and in using photovoltaic energy at about 30% per year in recent years, but from a very small base. Even at that fast rate of growth it would take several decades for those two renewable energy sources to replace the nonrenewable energy sources that you mostly use now. You will not have several decades to make this major change. You need to initiate a World-wide massive project immediately to switch from nonrenewable to renewable energy sources.

Both the peaking of extraction of crude oil and fast increasing Global Warming due to burning fossil fuels make it imperative that you develop solar-based energy sources as fast as possible.

You need an energy system that is widely distributed, as solar-based energy is, and that is multi-sourced (wind, photovoltaic and several different biofuels.

The need to recycle nonrenewable materials as much as possible

The materials you can extract from the Earth are small compared to the needs for materials and energy for your population size. As your population grows the amount of available energy and materials per capita is getting smaller. (There is a very small amount of material that daily hits your planet from outer space, but it is so widely dispersed that it is unusable.)

You must quit designing items that are considered as trash after a short time of use. And you must design items so that the materials used to make them can be easily recycled to make other items. And, of course, you need to think more intelligently about whether you should be making frivolous items.

This includes waste biological materials; they need to be used as fertilizers for your crops and as sources of fuels for transportation and other energy uses, rather than using nonrenewable fossil resources for those purposes. You need to change drastically the way you grow your crops by not using nonrenewable fossil fuels and fertilizers for that purpose.

The need to use much of your material and energy resources to prepare for the next Major Ice Age, which will begin within the next 1000 years, or perhaps much sooner if you do not stop burning fossil fuels in your vehicles and power plants

It appears that you and most of your citizens do not know that the inevitable cycle of Major Ice Ages with a period of about 115,000 years will plunge your planet into an approximate 100,000-year very cold period probably within the next 1000 years or sooner.

The last time this happened about 125,000 years ago, many humans died from the extreme shocks and *Homo sapiens* evolved very rapidly as those few with the attributes to survive the shocks became your fathers and mothers.

It appears inevitable that many humans will die at young ages as the next Major Ice Age begins. You could minimize the number of deaths by reducing population by pre-conception birth control and by preparing infrastructure to make survival more likely.

You could perhaps give yourselves more time to make the changes needed by storing underground the greenhouse gases that you are now releasing into the atmosphere, so that you can release those gases more slowly later to make the entry into the next Major Ice Age occur more slowly. This needs extensive study by your scientists. (We have done this very effectively on our planet several times; we also have a cyclic ice-age climate.)

Many of your more intelligent and knowledgeable scientists have been telling you that the continuing burning of fossil fuels, which is creating Global Warming, may trigger the next Major Ice Age, sooner than it would otherwise occur, by turning off some or all of the North Atlantic Ocean currents that keep ice from forming in your North Polar region. You need to quit burning fossil fuels for transportation and other uses for that reason, as well as for the reason that you need them to develop the infrastructure to use solar-based energy sources and for human survival into and beyond the next Major Ice Age.

Do it now!

It is encouraging that you are finding ways to do things using less energy, but this must be greatly increased. You have not yet reached the point of diminishing returns with regard to energy conservation, not by a long way; keep working on it.

Since transportation is a major use of your fossil fuels, you need to accelerate greatly the use of more energy efficient vehicles. Fossil-fuel/electric (hybrid) vehicles followed by biofuels/electric hybrid vehicles and electric-grid-connectable hybrid vehicles is a good path to follow. You should be able to move eventually to pure electric vehicles as you develop better ways to store energy than you are now using. There are better ways.

Development of energy conservation technologies and decreased vehicle, factory and power plant emissions need to be accelerated greatly.

We may provide you some information to help you in this monumental effort to conserve energy and materials and develop renewable energy sources, if we later perceive that there is hope for your long-term survival.

Finally, what is perhaps a sensitive issue to you: You need to be vigilant about maintaining individual freedom while assuring individual and societal security as the hard times ahead try your patience. It is not an easy thing to do, but it is worth the effort.

Yours sincerely in hopes of the survival of your species,

Your concerned neighbor, emissary of a planet in another star system.

P.S. As evidence of the authenticity of this letter being from a planet in a different star system than yours, have the paper and ink analyzed by a small number of chemists and physicists to show that it is not made of any molecular arrangement than is available on your planet. We suggest that you do this before you reveal the contents of this letter to other inhabitants of your planet, including most of your close advisors. If you can unravel the details of these materials it might help you in developing your technology.

P.S.S. Do not worry, you have nothing to fear from us. We will not contact you again in any way unless we see that we can help you in increasing your knowledge to help achieve your long-term survival.

Glossary

I capitalize Earth, World and Sun because they are the names of objects. It is long past time when humans must regard the Earth as a special place rather than regarding it as a matrix for unfettered human activity. I capitalize Global Warming, Major Ice Ages and Major Interglacials because they are the names I give well-established scientific concepts.

If the reader needs a definition and discussion of any topic in this book, I recommend trying to find such at http://www.wikipedia.org .

Anthropogenic Global Warming: Global Warming caused by the activities of humans.

Biodiesel: A fuel made from plants that can replace petroleum diesel. See http://en.wikipedia.org/wiki/Biodiesel . A common blend is B20, which is 20% biodiesel and 80% diesel.

Civilization: A society in which the basic needs (shelter, sustenance and meaningful contributing work) of all its members are achieved through cooperation among its members.

E85: A fuel blend of 85% ethanol and 15% gasoline. E10 = 10% ethanol and 90% gasoline.

Ethanol: See http://en/wikipedia.org/wiki/Ethanol_Fuel .

Global Warming: The increase of the average temperature of the Earth due to greenhouse gases (carbon dioxide, methane, etc.) being put into the upper atmosphere by geophysical processes or by the activity of humans.

Hybrid Vehicle: A vehicle whose motive power is provided by two different sources of power. The usual hybrid vehicle uses gasoline and electricity as the two sources.

> **Series Hybrid Vehicle:** A gasoline engine provides power, through a generator, to charge a battery, which is then used to provide power to an electric motor that then provides motive power to the vehicle.
>
> **Parallel Hybrid Vehicle:** Either the gasoline engine or the electric motor (**Mild Hybrid**) or both (**Full Hybrid**) can provide motive power to the vehicle. The Toyota Prius is a full hybrid, which uses an planetary gear set and complex computer electronics to control the use of the low-emissions gasoline engine and two electric motor/generators through a planetary gear set.

Insolation: Solar energy per time per area (Joules/second/m^2 =Watts/ m^2) that strikes the upper atmosphere.

Little Ice Age/Interglacial: Within the Minor Ice Ages and Minor Interglacials are "Little Ice Ages" and "Little Interglacials" with pseudo-cycles periods of one to two thousand years and amplitudes of about $1C^{\circ}$ in size. The last Little Ice Age temperature minimum occurred at about 1500-1850 BC.

Major Ice Age: A time interval of about 115 kiloyears duration between two higher-temperature Major Interglacials. The temperature differential between the low point (Glacial Maximum) of a Major Ice Age and the Major Interglacial that follows it is about 9-12 degrees Celsius.

Major Interglacial: A time interval of about 5-15 kiloyears duration when the Earth's temperature is at a high maximum at the edges of Major Ice Ages. The temperature differential between the low point (Glacial Maximum) of a Major Ice Age and the Major Interglacial that follows it is about 9-12 degrees Celsius. The Las Major Interglacial is called the Eemian Interglacial.

Minor Ice Age: Within a Major Ice Age are several "Minor Ice Ages", also called **stadials**, with pseudo-cycle periods of 10,000 to 20,000 years, during which the temperature is about $2C^{\circ}$ colder than the warm periods (Minor Interglacials).

Minor Interglacial: Within a Major Ice Age are several "Minor Interglacials", also called **interstadials**, with pseudo-cycle periods of 10,000 to 20,000 years, during which the temperature is about $2C^{\circ}$ warmer than the warm periods (Minor Ice Ages).

Mitochondrial Eve: The mother of all living *Homo sapiens*. She lived about 125,000 ybp.

Modern Global Warming: Global Warming caused by the activities of humans in the last two hundred years.

Neolithic Global Warming: Global Warming caused by human agriculture putting carbon dioxide (starting about 8,000 ybp) and methane (starting about 5,000 ybp) into the upper atmosphere.

North Atlantic Ocean Current: North Atlantic thermohaline ocean currents (NAOC) due to cold and salty water plunging to lower depths in the Arctic. (http://en.wikipedia.org/wiki/Thermohaline_circulation)

yap: years after the present

ybp: years before the present

Y-Chromosome Adam: The father of all living *Homo sapiens*. He lived about 100,000 ybp.

References

algae, 2005: Biodiesel Production from Algae: http://www.unh.edu/p2/biodiesel/research_index.html , http://ebiomedia.com/prod/algaeguide1.html; http://www.greenfuelonline.com/news/algaefuel.pdf .

Alley, 2000: *The Two-Mile Time Machine: Ice cores, Abrupt Climate Change, and Our Future*, Richard B. Alley, Princeton Univ. Press, 2000.

Bartlett, 2004: *The Essential Exponential!: For the Future of Our Planet* by Albert A. Bartlett, Univ. of Nebraska

Benford, 2000: *Deep Time: How Humanity Communicates Across Millennia*, Gregory Benford, Perennial, 2000.

Berger, 1991: *Insolation values for the climate of the last 10 million years*, Berger, A. *et al*., Quaternary Science Reviews 10, 297-317, 1991.

Calvin, 2002: *A Brain for All Seasons: Human Evolution & Abrupt Climate Change*, William H. Calvin, University of Chicago Press, 2002.

Colling, 2002: *Ocean Circulation*, Angela Colling, Butterworth Heinemann & The Open University, 2002.

Darley, 2004: *High Noon for Natural Gas: The New Energy Crisis*, Julian Darley, Chelsea Green Pub. Co., 2004.

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

EIA, 2003: Energy Data Sources:
http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/natural_gas_1998_issues_trends/pdf/chapter3.pdf,
http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/hydrates/pdf/update.pdf,
http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/hydrates/pdf/update.pdf

EPICA, 2004: Eight Glacial Cycles from an Antarctic Ice Core, EPICA Community, http://www.esf.org/articles/85/nature02599.pdf; *Nature* 429, 10 June 2004.

FFV, 2005: Flexible-Fuel Vehicles:
http://www.gm.com/company/gmability/environment/e85/index.html
http://media.ford.com/newsroom/feature_display.cfm?release=21949 .

Heinberg, 2003: *The Party's Over: Oil, War and the Fate of Industrial Societies*, Richard Heinberg, New Society Publishers, 2003.

Houghton, 2001: Houghton, J. T., *et al. Climate Change 2001: The Scientific Basis*, Intergovernmental Panel on Climate Change (IPCC), Cambridge Univ. Press, 2001.

Houghton, 2004: Global Warming: The Complete Briefing, Third Edition, Cambridge University Press, 2004

Kennett, 2003: *Methane Hydrates in Quaternary Climate Change: The Clathrate Gun Hypothesis*, James P. Kennett, Kevin G. Cannariato, Ingrid L. Hendy and Richard J. Behl, American Geophysical Union, 2003

Klare, 2001: *Resource Wars: The New Landscape of Global Conflict*, Michael T. Klare, Henry Holt and Company, 2001.

Klein, 2002: *The Dawn of Human Culture: A Bold New Theory on what Sparked the "Big Bang" of Human Consciousness*, John Wiley & Sons, 2002.

Kuntsler, 2005: *The Long Emergency: Surviving the Converging Catastrophes of the Twenty-First Century*, James Howard Kuntsler, Atlantic Monthly Press, 2005.

Kurzweil, 2005: *The Singularity is Near: When Humans Transcend Biology*, Ray Kurzweil, Viking Penguin, 2005

Lovins, 2005: *Winning the Oil Endgame: Innovation for Profits, Jobs, and Security*, Amory B. Lovins, E. Kyle Datta, Odd-Even Bustnes, Jonathan G. Koomey and Nathan J. Glasgow, Rocky Mountain Institute, 2005. Also available on-line: http://www.oilendgame.com .

NEIS, 2003: *The Trojan Horses of Nuclear War*, NEIS, 2003; on-line at http://www.uraniumweaponsconference.de .
Also: http://arts.bev.net/roperldavid/politics/WeaponsRadioactive.htm

Olah, 2006: *Beyond Oil and Gas: The Methanol Economy*, George A. Olah, Alain Goeppert, G. K. Surya Prakash, John Wiley & Sons, 2006.

Pahl, 2005: *Biodiesel: Growing a New Energy Economy*, Greg Pahl, Chelsea Green Pub. Co., 2005.

Petit, 1999: *Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica*, Petit, J. R. *et al.*, *Nature* **399**, 429-436, 1999. A shorter on-line version is available at http://cdiac.esd.ornl.gov/trends/tem/vostok/jouz_tem.htm .

Price, 1995: *Energy and Human Evolution*, David Price, http://dieoff.org/page137.htm .

Reay, 2005: *Climate Change Begins at Home: Life on the Two-Way Street of Global Warming*, Dave Reay, Macmillan, 2005

Robinson, 2000: *The Story of Writing: Alphabets, Hieroglyphs & Pictograms*, Andrew Robinson, Thames & Hudson, 1995.

Roper, 1976: *Depletion Theory*, L. David Roper, http://arts.bev.net/RoperLDavid/minerals/DepletTh.htm . Also L. David Roper, Amer. J. Phys. 47, 467 (1979) and (**Bartlett, 2004**) p. 151.

Roper, 2004: Models of Major Ice Ages, L. David Roper: http://www.roperld.com/Science/TransitionsModelMIA.pdf , http://www.roperld.com/science/tempsolinsatc.pdf , http://www.arts.bev.net/roperldavid/AmeliorateGlobalWarming.pdf and http://arts.bev.net/roperldavid/MajorIceAges.htm

Roper, 2005: *Fuel Cells are not Pollution Free: Where Will the Water Go?*, L. David Roper, http://www.roperld.com/science/fuelcellspollution.htm .

Roper, 1977: *Projection of World Population*, L. David Roper, http://arts.bev.net/roperldavid/WorldPop.htm .

Romm, 2005: *The Hype about Hydrogen: Fact and Fiction in the Race to Save the Climate*, Joseph J. Romm, Island Press, 2005.

Ruddiman, 2005: *Plows, Plagues & Petroleum: How Humans Took Control of Climate*, William F. Ruddiman, Princeton Univ. Press, 2005. A shorter version is in William F. Ruddiman, *Scientific American* Mar 2005, p.34.

Simmons, 2005: *Twilight in the Desert: The Coming Saudi Oil Shock and the World Economy*, Matthew R. Simmons, John Wiley & Sons, 2005.

SLS, 2006: *Nuclear Power: the Energy Balance*, Jan Willem Storm van Leeuwen and Philip Smith, http://www.stormsmith.nl .

Stanley, 1998: *Children of the Ice Age: How a Global Catastrophe Allowed Humans to Evolve*, W. H. Freeman and Company, 1998.

Vaitheeswaran, 2003: *Power to the People: How the Coming Energy Revolution will Transform and Industry, Change Our Lives, and Maybe Even Save the Planet*, Vijay V. Vaitheeswaran; Farrar, Straus and Giroux, 2003.

Weatherford, 1994: *Savages and Civilization: Who Will Survive?*, Jack Weatherford, Crown Publishers, 1994.

Wells, 2002: *The Journey of Man: A Genetic Odyssey*, Spencer Wells, Princeton Univ. Press, 2002.

Wilson, 2002: *The Future of Life*, Edward O. Wilson, Vintage Books, 2002.

Youngquist, 1997: *GeoDestinies*, Walter Youngquist, National Book Company, 1997.

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Author

Leon David Roper was born in Shattuck OK in 1935. He earned a BA with Honors from Oklahoma Baptist University (physics/mathematics major, chemistry minor) in 1958 and got his PhD in theoretical physics from Massachusetts Institute of Technology in 1963. The "Roper Resonance" was discovered by him in his Ph.D. research (http://arts.bev.net/roperldavid/roperres.htm). He was a postdoctoral appointee at Lawrence Livermore Laboratory, Livermore, California for two years. He taught physics at Kentucky Southern College in Louisville, Kentucky for two years, and was on the faculty at Virginia Polytechnic Institute and State University in Blacksburg, Virginia for 31 years, spending several sabbaticals at universities and research laboratories in several other countries. He lives in Blacksburg and can be contacted at roperld@vt.edu . More information about the author is available at http://arts.bev.net/roperldavid .

2 October 2006