When Is "Global Peak Energy?" According to Publicly Available Data, Probably Sooner Than You Think

Posted by Prof. Goose on September 10, 2007 - 10:00am
Topic: Environment/Sustainability
Tags: chris clugston, overpopulation, overshoot, peak energy, peak oil, sustainability [list all tags]

This is a guest post by Chris Clugston. Chris has spent over 30 years working with information technology sector companies in marketing, sales, finance, M&A, and general management—the last twenty as a corporate chief executive and management consultant. Chris received an AB/Political Science, Magna Cum Laude and Phi Beta Kappa from Penn State University, and an MBA/Finance with High Distinction from Temple University in Philadelphia, PA.

Energy is the “enabling” resource; most, if not all other natural and manmade resources and their capacities to sustain human life are derived from or dependent upon one or more sources of primary energy. The fact that the amount of energy available to human beings is subject to a limit —*global peak energy*—has profound implications for future human population levels and living standards.

Given humanity’s unquestioned dependence upon energy for survival, answers to the following questions are critical to our long term success as a species:

- When and at what level will global energy “peak”?
- What are the implications of global peak energy for the world’s human population?

The following analysis represents my initial attempt to answer these questions; the primary conclusions are unsettling, but clear: **Based on publicly available data, global peak energy will probably occur between the years 2025 and 2030; total available energy will decline continuously thereafter.**

Global peak energy is the point at which the total amount of useable energy available to the worldwide human population from currently known primary energy sources reaches its maximum.

Global peak energy will be delayed only in the event of:

- The discovery of one or more major new primary energy sources comparable in quantity, quality, and versatility to fossil fuels;
- Significant breakthroughs in the quantity, quality, and/or versatility associated with one or more existing primary energy sources; and/or
- Drastic and sustained reductions in the level of human energy consumption.

The maximum supportable worldwide human population level will peak between

the years 2025 and 2030 as well, and decline continuously thereafter—assuming the continuation following global peak energy of the historic relationship between the total amount of energy consumed by human populations and corresponding population levels and material living standards.

If this relationship holds, the maximum supportable worldwide human population at today's average global living standard will decline from a peak ranging from 7.2 billion to 8.9 billion people, to between 2.0 billion and 5.0 billion people by the year 2100, and between 1.3 billion and 3.3 billion people by the year 2200.

The analysis contains the assumptions, projections, and findings that support these conclusions.

Contents

Why This Study

Much excellent research has been conducted into the projected "peaking" of energy produced from hydrocarbon-based primary energy sources (fossil fuels)—oil, natural gas, and coal. With few exceptions, however, existing research on peaking has failed to capture the attention of policy makers or the mainstream populace. This may be due in part to the lack of tangible—specific and measurable—implications for current and future human populations associated with some existing research.

The following analysis seeks to address this situation by extending into the future the historically established relationship that exists between the total amount of energy available to human populations, and corresponding population levels and average material living standards. The analysis offers tangible conclusions that can be readily understood by both policy makers and the general populace.

The analysis is a synthesis of historic population and energy consumption data, current population and energy availability/consumption estimates, and future energy availability projections, associated with all existing nonrenewable and renewable primary energy sources. Supporting data for the current version of the analysis were obtained and derived from free publicly available sources including the EIA, IEA, HYDE Worldwide Population Database, US Census Bureau, and various organizations and individuals involved with monitoring the national and worldwide energy sectors.

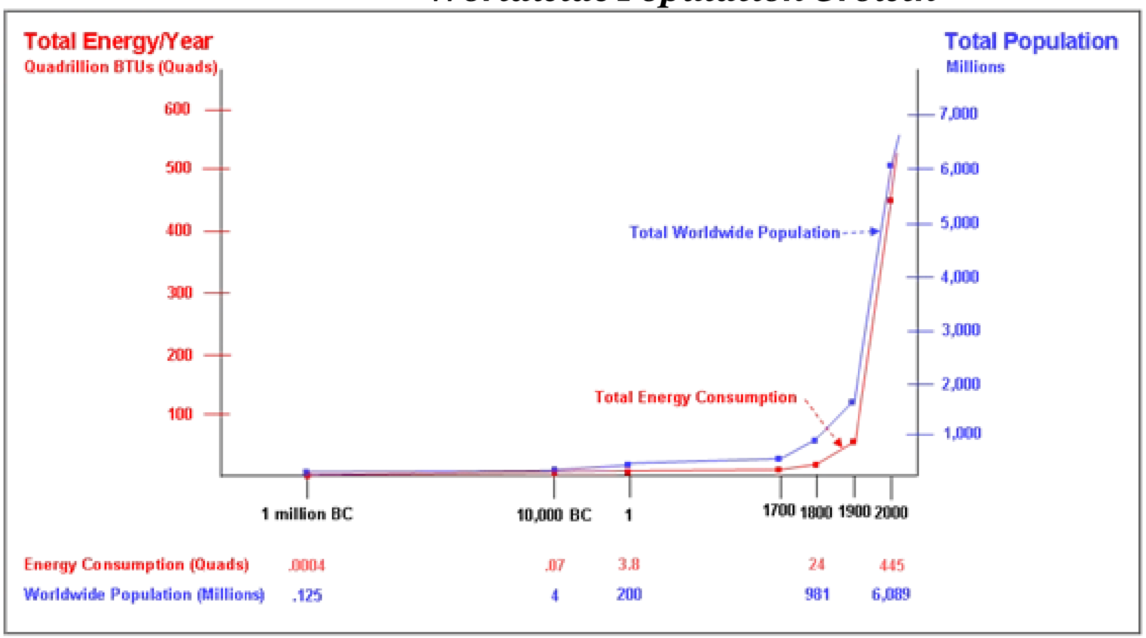
What follows is a "first pass" effort based on personally developed assumptions, estimates, and projections—avowedly not the "best currently available information". My objective in publishing the analysis in its current form is to seek input from those who have access to the best currently available information in order to improve upon its content.

In its final form, I envision the analysis as a tool for creating awareness among both policy makers and the general populace—especially populations within "consuming nations" such as the United States—regarding the specific consequences associated with our current and projected energy consumption behavior—devastating reductions in human population levels and living standards. It is my hope that the quantified conclusions will instill a sense of urgency on the part of "excessively consuming" populations to alter our dysfunctional behavior voluntarily, before it is altered for us.

Historic Global Energy Consumption and Population Growth

Cottrell, Tainter, and Catton are among the many scholars who have argued compellingly that the maximum supportable human population at any point in time is dependent upon the total amount of energy available to the population at that time. Historic evidence supports this contention.

Historic Global Energy Consumption and Worldwide Population Growth



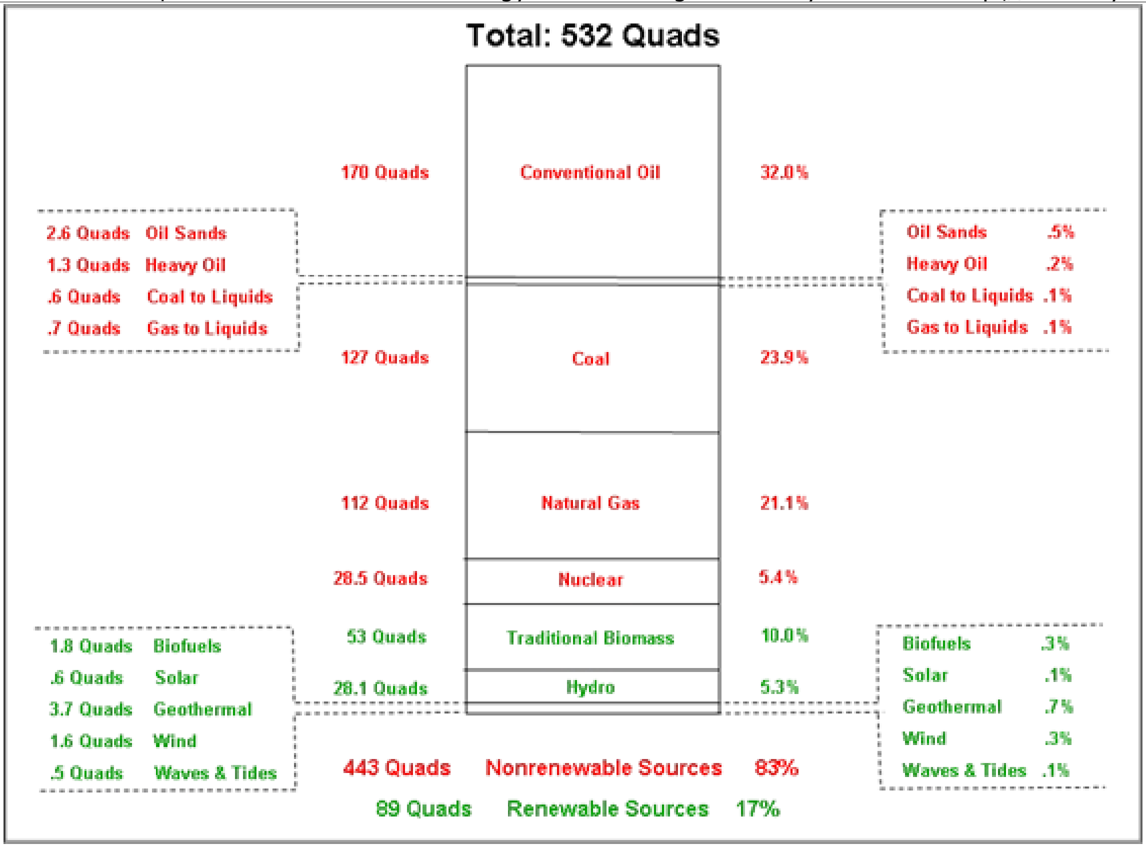
Data sources: US Census Bureau, HYDE database, EIA, Kremer (1993)

It is also clear that the significant improvements in material living standards realized by many of the earth's human inhabitants over time are largely attributable to ever-increasing amounts of total available energy. Dramatic increases in both worldwide human population and living standards are especially evident during the past several hundred years, coincident with the availability of hydrocarbon-based primary energy sources (fossil fuels).

Current Global Energy Availability and Population Estimates

During the year 2007, an estimated 532 quadrillion BTUs of energy will be produced globally from currently known primary energy sources, and consumed by a worldwide human population that is expected to exceed 6.64 billion by year end.

Estimated 2007 Global Energy Availability



Data sources: EIA, IEA, US Census Bureau, HYDE database, various industry sources

Future Global Energy Availability Projections

Underlying Assumptions

Projections regarding the total amount of energy available globally between the year 2007 and the year 2200 are derived from the following assumptions regarding the amounts of energy to be produced from each currently known primary energy source. Two sets of assumptions were developed: a Conservative Scenario and an Optimistic Scenario.

Assumptions Regarding Global Energy Availability per Primary Source (Conservative Scenario)

Primary Energy Source	**Annual Growth Rate: 2007 to Peak**	**Peak Year**	**Annual Decline Rate: Post-peak**
Nonrenewable Energy Sources			
Conventional Oil	N/A	2007	2% until 2025 4% thereafter
Oil Sands	4.7%	2025	0% until 2050 1% thereafter
Heavy Oil	4.2%	2025	0% until 2050 1% thereafter
Coal to Liquids	13.1%	2025	0% until 2050

			3% thereafter
Natural Gas to Liquids	5.5%	2025	0% until 2050 5% thereafter
Natural Gas	1.5%	2015	3% until 2025 6% thereafter
Coal	2.2%	2025	2% until 2050 4% thereafter
Nuclear	1.4%	2025	0% until 2050 2% thereafter
Renewable Energy Sources			
Traditional Biomass (wood, waste)	1%	2050	0%
Hydro	1.8%	2025	0% until 2050 1% thereafter
Biofuels	5.8%	2015	2%
Solar	6%	2030	0% until 2050 1% thereafter
Geothermal	5%	2030	0% until 2050 1% thereafter
Wind	5%	2030	0% until 2050 1% thereafter
Waves and Tides	5%	2030	0% until 2050 1% thereafter

Data sources: EIA, IEA, Deutsche Shell, synthesis of various industry sources

Assumptions Regarding Global Energy Availability per Primary Source (Optimistic Scenario)

Primary Energy Source	**Annual Growth Rate: 2007 to Peak**	**Peak Year**	**Annual Decline Rate: Post-peak**
Nonrenewable Energy Sources			
Conventional Oil	1.1%	2020	2%
Oil Sands	4.7% until 2025 2.35% 2025 until 2050	2050	1%
Heavy Oil	4.2% until 2025 2.1% 2025 until 2050	2050	1%
Coal to Liquids	13.1% until 2025	2050	1.5%

	4% 2025 until 2050		
Natural Gas to Liquids	5.5% until 2025 2% 2025 until 2050	2050	2.5%
Natural Gas	1.5% until 2030	2030	3%
Coal	2.2% until 2025 1.1% 2025 until 2040	2040	0% until 2050 2% thereafter
Nuclear	1.4%	2040	0%
Renewable Energy Sources			
Traditional Biomass (wood, waste)	1.5%	2050	0%
Hydro	1.8% until 2025 .9% 2025 until 2050	2050	0%
Biofuels	5.8% until 2025 2.9% 2025 until 2050	2050	0%
Solar	6%	2050	0%
Geothermal	5% until 2025 2.5% 2025 until 2050	2050	0%
Wind	5% until 2025 2.5% 2025 until 2050	2050	0%
Waves and Tides	5% until 2025 2.5% 2025 until 2050	2050	0%

Data sources: EIA, IEA, Deutsche Shell, synthesis of various industry sources

Global Peak Energy

Applying the assumptions regarding future global energy availability to year 2007 global energy availability estimates yields the following *global peak energy* projections.

Projected Total Global Energy Availability (Quadrillion BTUs)
Conservative Scenario

Primary Energy Source		**Peak Year**				
	2007	**2025**	**2050**	**2100**	**2150**	**2200**
Nonrenewable Sources						
Conventional Oil &	170.0	118.0	15.0	2.0	0.3	0.0

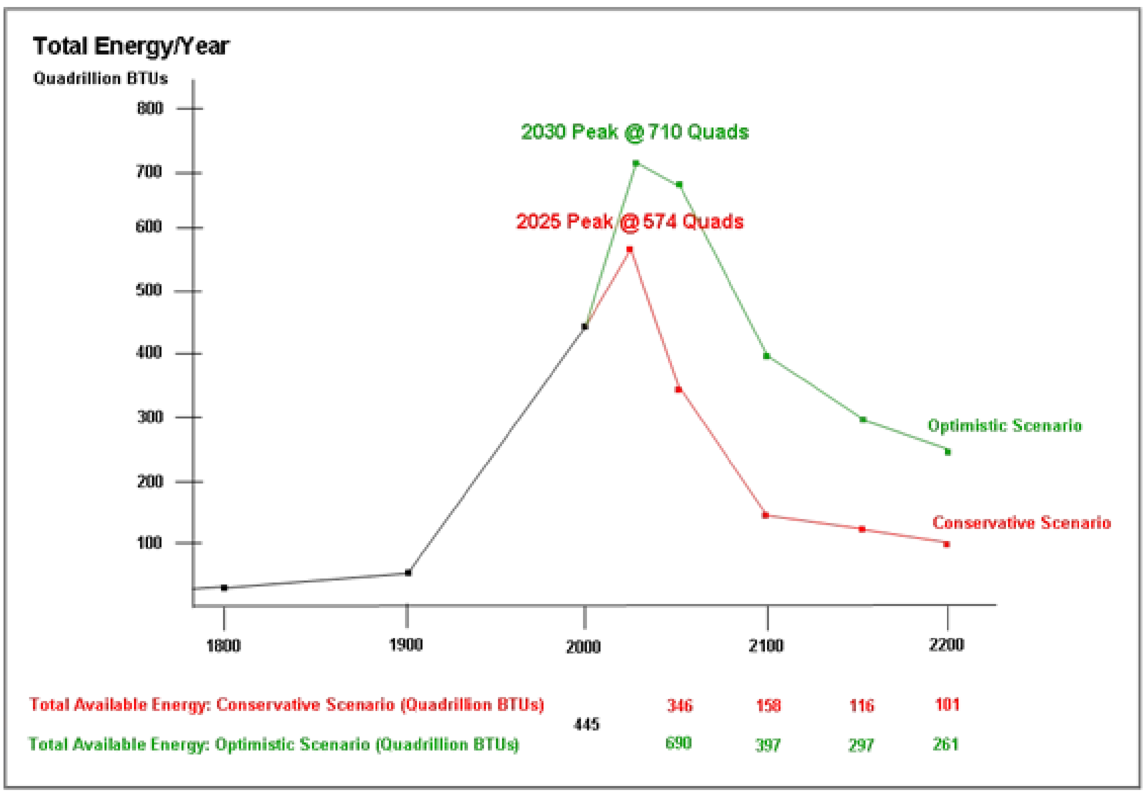
Condensates						
Oil Sands	2.6	6.0	6.0	3.6	2.2	1.3
Heavy Oil	1.3	2.7	2.7	1.6	1.0	0.6
Coal to Liquids	0.6	5.5	5.5	1.2	0.3	0.1
Gas to Liquids	0.7	1.8	1.8	0.1	0.0	0.0
Natural Gas	112.0	93.0	20.0	0.9	0.0	0.0
Coal	127.0	188.0	113.0	15.0	2.0	0.3
Nuclear	28.5	37.0	37.0	13.0	5.0	2.0
Subtotal Nonrenewables	**442.7**	**452.0**	**201.0**	**37.4**	**10.8**	**4.3**
Renewable Sources						
Traditional Biomass	53.0	65.0	83.0	83.0	83.0	83.0
Hydro	28.1	39.0	39.0	23.6	14.3	8.7
Biofuels	1.8	2.3	1.4	0.5	0.2	0.1
Solar	0.6	1.7	2.3	1.4	0.9	0.5
Geothermal	3.7	8.9	12.5	7.6	4.6	2.8
Wind	1.6	3.9	5.4	3.3	2.0	1.2
Waves and Tides	0.5	1.2	1.7	1.0	0.6	0.4
Subtotal Renewables	**89.3**	**122.0**	**145.3**	**120.4**	**105.6**	**96.7**
Total Available Energy	**532.0**	**574.0**	**346.3**	**157.9**	**116.4**	**100.9**

Projected Total Global Energy Availability (Quadrillion BTUs)
Optimistic Scenario

Primary Energy Source		**Peak Year**				
	2007	**2030**	**2050**	**2100**	**2150**	**2200**
Nonrenewable Sources						
Conventional Oil & Condensates	170.0	157.3	105.0	38.0	13.8	5.0
Oil Sands	2.6	6.6	18.2	11.0	6.7	4.1
Heavy Oil	1.3	3.0	4.5	2.7	1.6	1.0
Coal to Liquids	0.6	6.7	14.7	6.9	3.2	1.5
Gas to Liquids	0.7	2.1	3.1	0.9	0.3	0.1
Natural Gas	112.0	158.0	85.9	18.7	4.1	0.9
Coal	127.0	198.8	222.0	82.5	30.7	11.4
Nuclear	28.5	39.2	45.1	45.1	45.1	45.1

Subtotal Nonrenewables	**442.7**	**571.6**	**498.5**	**205.8**	**105.5**	**69.1**
Renewable Sources						
Traditional Biomass	53.0	74.3	100.0	100.0	100.0	100.0
Hydro	28.1	39.7	48.0	48.0	48.0	48.0
Biofuels	1.8	5.8	10.2	10.2	10.2	10.2
Solar	0.6	2.3	7.4	7.4	7.4	7.4
Geothermal	3.7	10.1	16.5	16.5	16.5	16.5
Wind	1.6	4.4	7.2	7.2	7.2	7.2
Waves and Tides	0.5	1.4	2.2	2.2	2.2	2.2
Subtotal Renewables	**89.3**	**138.0**	**191.5**	**191.5**	**191.5**	**191.5**
Total Available Energy	**532.0**	**709.6**	**690.0**	**397.3**	**297.0**	**260.6**

Global Peak Energy



Source: Wake Up Amerika!

In the Conservative Scenario, "*global peak energy*"—the point at which the total amount of energy available to the worldwide human population from currently known primary energy sources reaches its maximum—occurs in the year 2025, at 574 quadrillion BTUs (Quads). In the Optimistic Scenario, global peak energy occurs only 5 years later in the year 2030, at 710 Quads.

In the Conservative Scenario the total amount of energy available globally declines to 158 Quads by the year 2100, and further declines to 101 Quads by the year 2200. In the Optimistic Scenario, the total amount of energy available globally declines to 397 Quads by the year 2100, and further declines to 261 Quads by the year 2200.

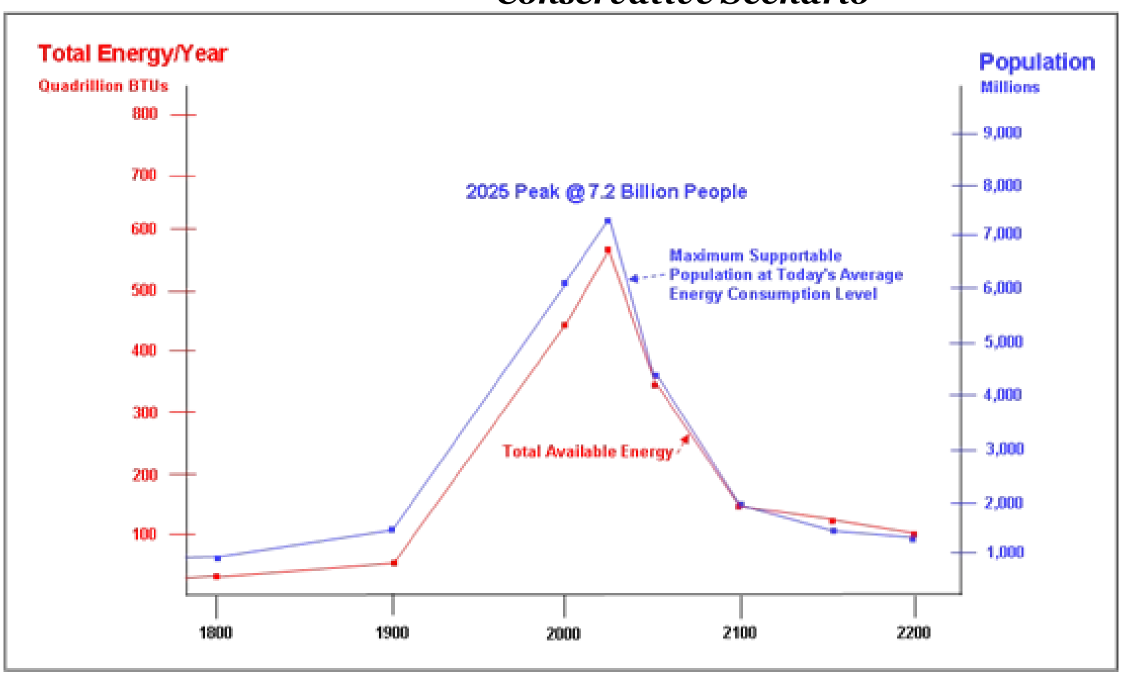
> ***Note*** *that by calculating "total available energy" as the simple sum of the energy produced by each existing primary energy source, the analysis implies infinite substitutability among primary energy types—that is, every energy source is equally capable of producing energy for every energy-consuming application. Since this is obviously not the case (You can't run millions of cars on wind or hydro...), the analysis may overstate the total amount of "useable" energy available at any given time, which may optimistically bias the projected timing and level of global peak energy. That is, global peak energy could occur sooner and at a lower level than the analysis indicates.*

Implications of Global Peak Energy for Worldwide Population

Worldwide Peak Population

Worldwide peak population is determined by dividing the total amount of energy expected to be available during the global peak energy year by the average amount of energy expected to be consumed per capita during that year.

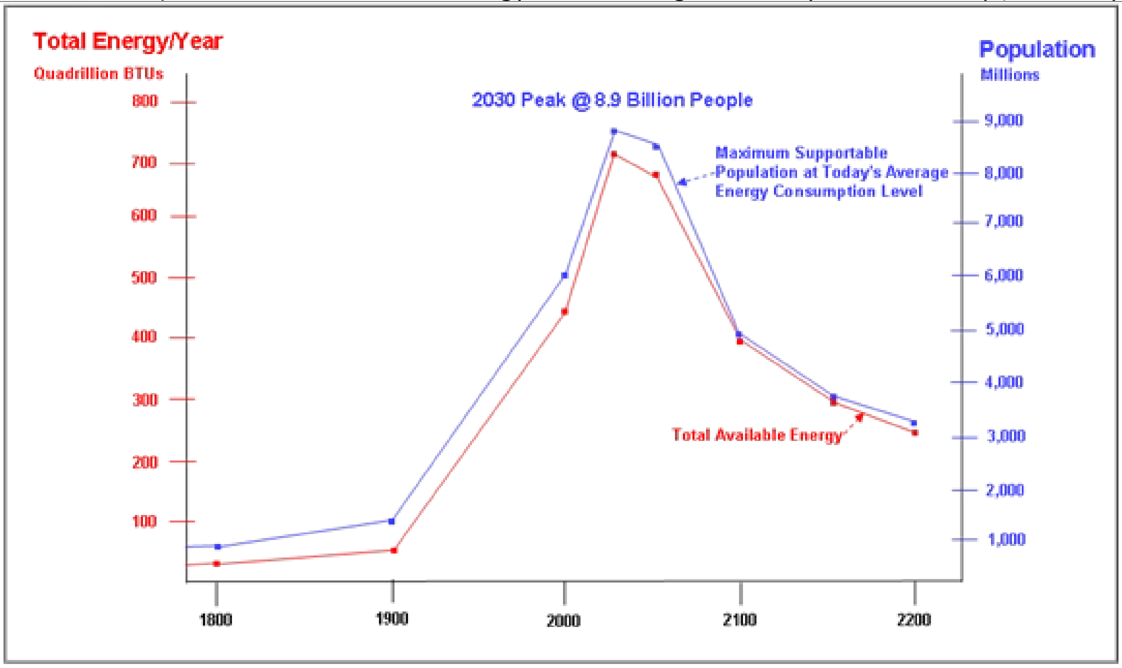
Worldwide Peak Population
Conservative Scenario



Source: Wake Up Amerika!

In the Conservative Scenario, the maximum supportable worldwide population at today's average global living standard reaches a year 2025 peak of 7.2 billion people, who consume the projected 574 Quads of total energy available that year at today's average annual rate of 80 million BTUs per capita.

Worldwide Peak Population
Optimistic Scenario



Source: Wake Up Amerika!

In the Optimistic Scenario, the maximum supportable worldwide population at today's average global living standard reaches a year 2030 peak of 8.9 billion people, who consume the projected 710 Quads of total energy available that year at today's average annual rate of 80 million BTUs per capita.

The "Population versus Living Standard" Tradeoff

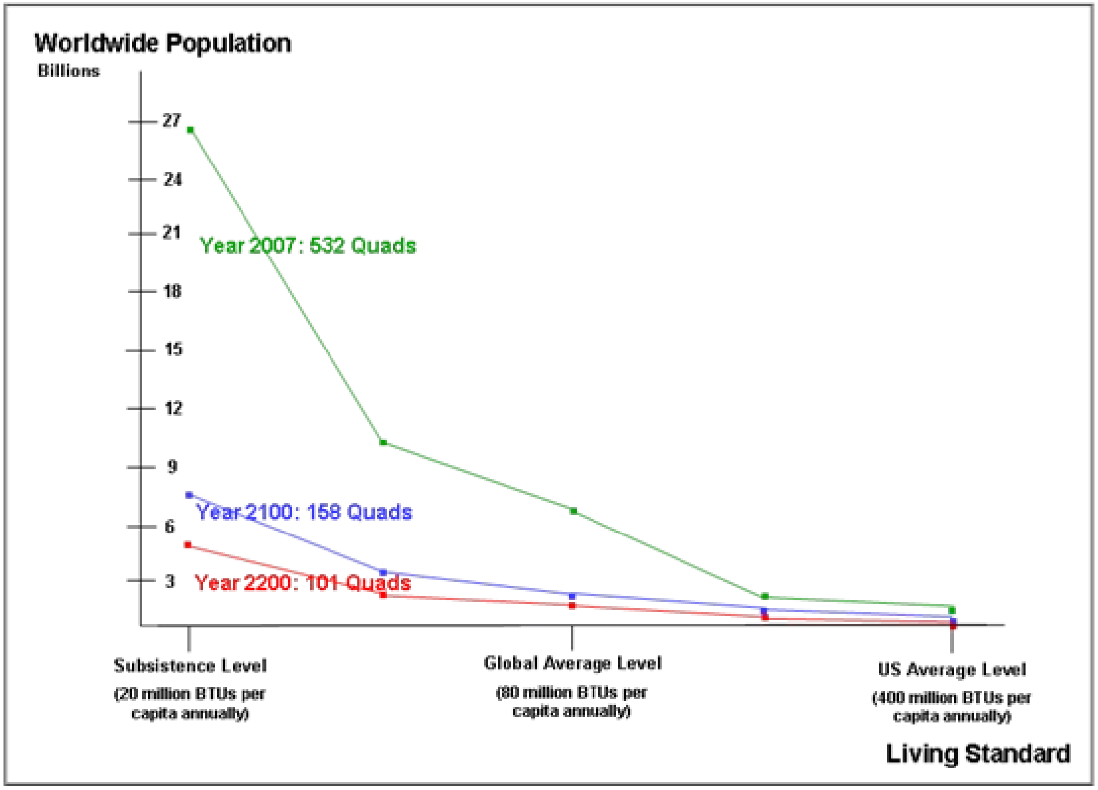
At any level of total available energy, the maximum supportable human population and the maximum attainable average human living standard are a "tradeoff". That is, a higher average living standard necessitates a lower population level; a lower average living standard enables a higher population level.

The analysis examines the ranges of supportable worldwide population for the years 2007, 2100, and 2200, by considering three increasingly affluent "material" living standards, each of which is characterized by the annual per capita energy consumption level associated with its respective population:

1. Today's Subsistence Living Standard: 20 million BTUs of per capita energy consumption annually, which is 25% of the 2007 global average, was about the average global per capita energy consumption level at the time of Christ, and is exemplified by the living standard associated with today's residents of Zimbabwe, India, and Angola.
2. Today's Average Global Living Standard: 80 million BTUs of per capita energy consumption annually, which is the 2007 global average and is exemplified by the living standard associated with today's residents of Panama, Romania, and Serbia.
3. Today's Average US Living Standard: 400 million BTUs of per capita energy consumption annually, which is 5 times the 2007 global average and is exemplified by the living standard associated with today's American middle class.

The following graphs depict the range of tradeoffs between the "maximum supportable population level" and the "maximum attainable 'material' living standard"—as defined by per capita annual energy consumption—for the years 2007, 2100, and 2200, given the total amount of available energy projected for each of those three years.

Population versus Living Standard Tradeoff
Conservative Scenario



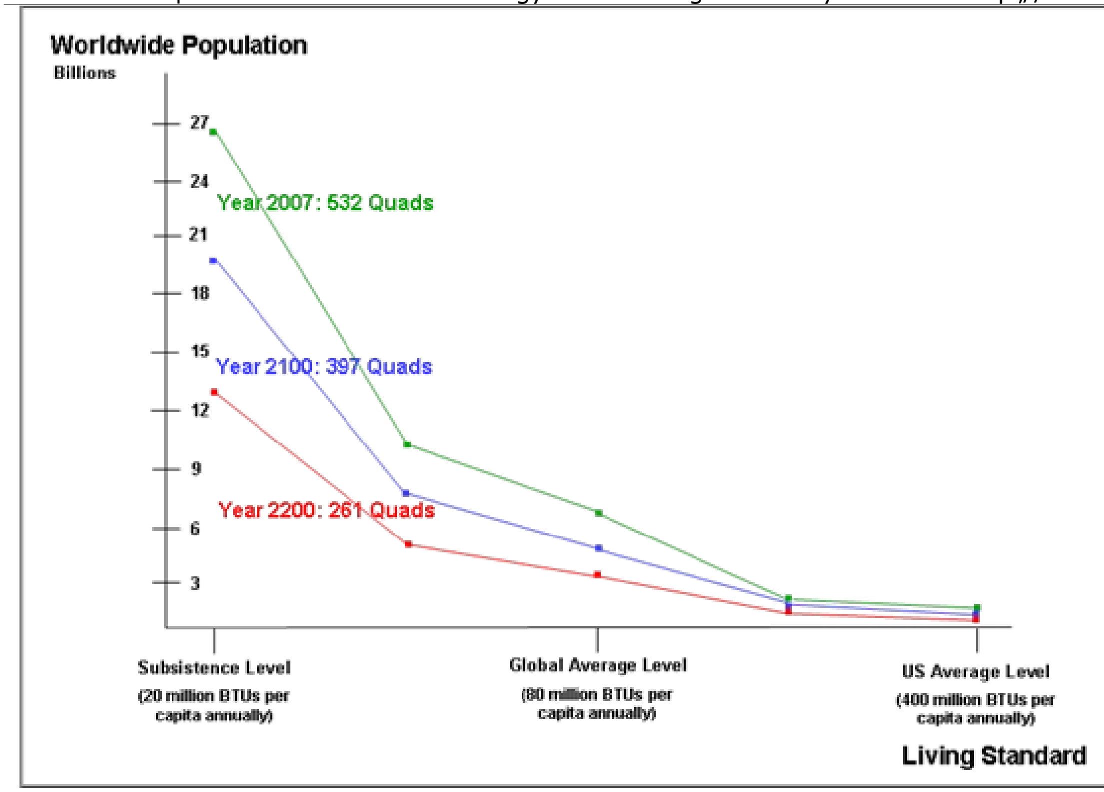
Source: Wake Up Amerika!

In the Conservative Scenario, the maximum supportable worldwide population at today's (2007) total available energy level of 532 Quads ranges from a theoretical high of 26.6 billion at today's subsistence living standard, to 6.6 billion at today's global average living standard, to 1.3 billion at America's current average living standard.

By the year 2100, the maximum supportable worldwide population at the projected total available energy level of 158 Quads ranges from 7.9 billion at today's subsistence living standard, to 2.0 billion at today's global average living standard, to 400 million at America's current average living standard.

By the year 2200, the maximum supportable worldwide population at the projected total available energy level of 101 Quads ranges from 5.0 billion at today's subsistence living standard, to 1.3 billion at today's global average living standard, to 300 million at America's current average living standard.

Population versus Living Standard Tradeoff
Optimistic Scenario



Source: Wake Up Amerika!

In the Optimistic Scenario, the year 2007 "population versus living standard" tradeoff function is identical to the year 2007 Conservative Scenario function.

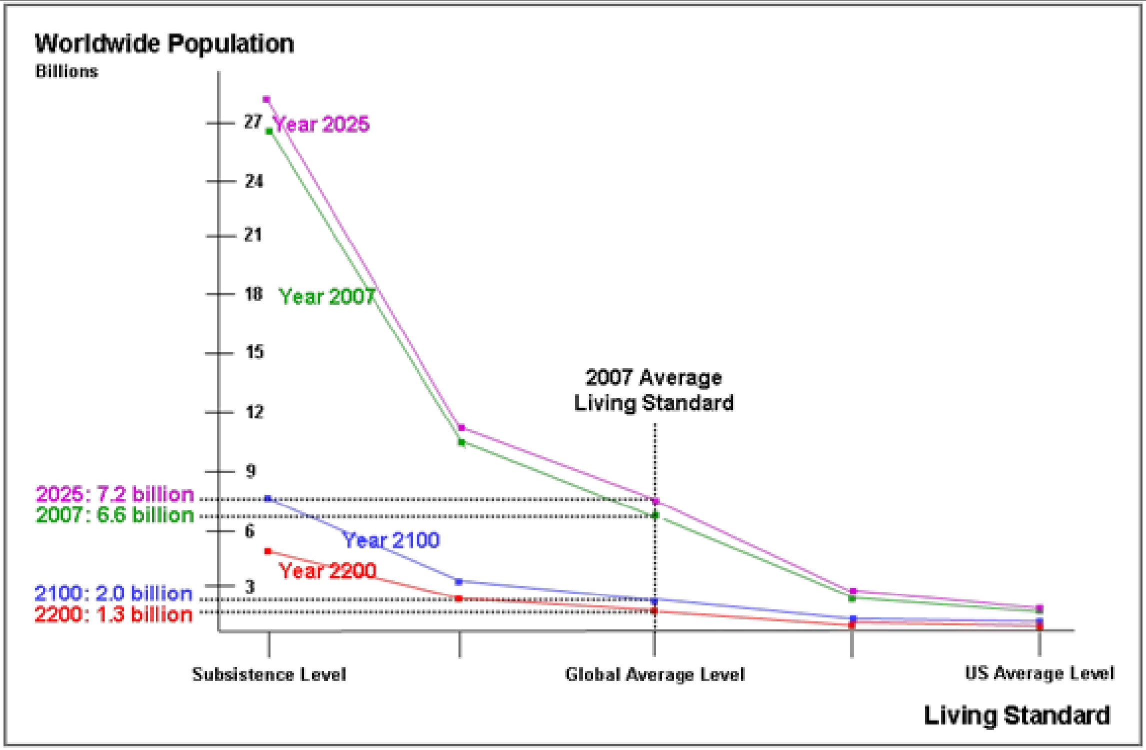
By the year 2100, the maximum supportable worldwide population at the projected total available energy level of 397 Quads ranges from a theoretical level of 19.9 billion at today's subsistence living standard, to 5.0 billion at today's global average living standard, to 1 billion at America's current average living standard.

By the year 2200, the maximum supportable worldwide population at the projected total available energy level of 261 Quads ranges from a theoretical level of 13.0 billion at today's subsistence living standard, to 3.3 billion at today's global average living standard, to 700 million at America's current average living standard.

Supportable Worldwide Population

If the post-peak average living standard were to be held constant at today's global average, maximum supportable worldwide human population levels would decline continuously and irreversibly from the time of *global peak energy* until well past the year 2200. The analysis projects future maximum supportable worldwide population levels at today's (2007) average global living standard—the living standard typical of existing populations in Panama, Romania, and Serbia.

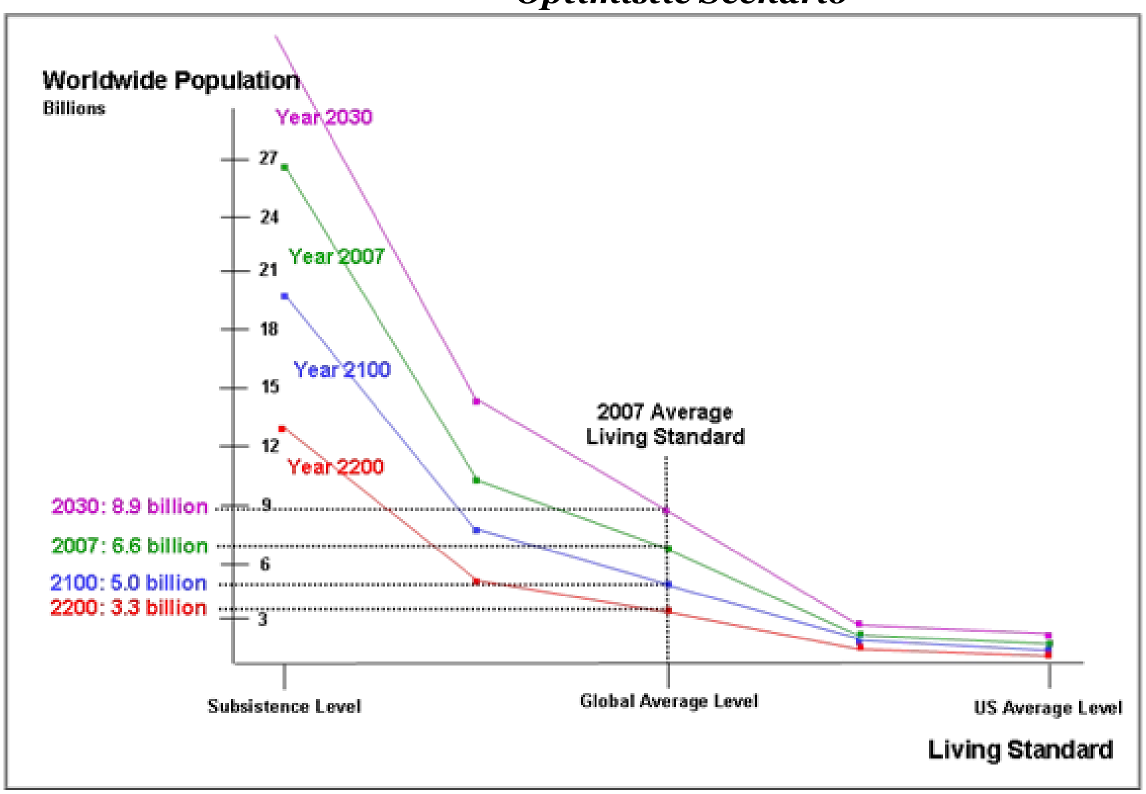
Supportable Worldwide Population at Today's Global Average Living Standard Conservative Scenario



Source: Wake Up Amerika!

In the Conservative Scenario, the maximum worldwide human population supportable at today's global average living standard reaches a peak of 7.2 billion in the year 2025, declines to 2.0 billion by the year 2100, and declines further to 1.3 billion by the year 2200.

Supportable Worldwide Population at Today's Global Average Living Standard Optimistic Scenario



Source: Wake Up Amerika!

In the Optimistic Scenario, the maximum worldwide human population supportable at today's global average living standard reaches a peak of 8.9 billion in 2030, declines to 5.0 billion by the year 2100, and declines further to 3.3 billion by the year 2200.

Conclusions

Pre-peak

- If the energy availability assumptions outlined in the preceding analysis hold true, the total amount of energy available globally will continue to increase for the next 20-25 years, implying additional capacity for increasing human population during that time. At issue, however, is whether the "energy mix" going forward will support existing population levels, much less population growth; and whether other resources critical to human survival, such as water and food, will be available in sufficient quantities to support existing population levels, much less population growth. (Liebig's Law of the Minimum)

Peak

- In the absence of 1) the discovery of one or more major new primary energy sources comparable in quantity, quality, and versatility to fossil fuels, 2) significant breakthroughs in the quantity, quality, and/or versatility associated with one or more existing primary energy sources, and/or 3) immediate and drastic reductions in the level of human energy consumption; *global peak energy* will probably occur between the years 2025 and 2030.
- While the amount of energy produced from energy sources such as the sun, wind, falling water, waves, tides, and the earth's core is phenomenal, the percentage of such energy that is realistically accessible to human beings is very small, and is likely to remain so in the future due to low or negative returns, ROI and ERoEI, associated with attempting to harness such energy on a practical scale. Additional energy from these sources and from other "alternative" energy sources such as biofuels will certainly be produced in the future, but, barring one or more major breakthroughs, the total contribution from all existing alternative energy sources combined will never come close to offsetting the declining energy production associated with fossil fuels.
- Maximum supportable worldwide population will also quite probably peak between the years 2025 and 2030.

Post-peak

- Following the occurrence of global peak energy and worldwide peak population, the total amount of energy available to human beings will decline continuously and irreversibly, as will some combination of worldwide human population and human living standards.
- Worldwide population and/or living standards will continue to decline as the total amount of energy available globally declines until "equilibrium" is achieved. Equilibrium will be achieved when total human energy consumption reaches a level that is consistent with global biocapacity; that is, when the total amount of energy consumed by human beings is derived entirely from renewable primary energy sources.
- To the extent that the decline in energy available from fossil fuels negatively impacts the amount of energy available from "alternative" energy sources, due to the loss of "fossil fuel subsidies", the total amount of energy available globally and the maximum supportable worldwide population level could decline at rates exceeding those projected in the Conservative Scenario.
- The goal of achieving an "American standard of living" for all or even a majority of the world's current population is preposterous. The "optimistic peak" worldwide human

population supportable at America's current average living standard is less than 1.8 billion. Ironically, the maximum worldwide human population supportable at America's current average living standard by the year 2200, even in the Optimistic Scenario, is only 300 million—today's US population.

- Humanity has never experienced a trip down the post-peak (decline) side of the Total Available Energy Curve—facing continuous and irreversible declines in the resource that serves as the basis for our very existence; we have only traveled up the pre-peak (growth) side. There has always been "more", and an expectation of "more"—never "less". The psychological implications associated with an "inverted expectation paradigm", in which things always get worse instead of always getting better, are unprecedented.

The methods by which human populations react to these circumstances—especially populations in developed countries who will feel the impact of global peak energy most severely, and especially reactions as they relate to "forced" or "involuntary" population level reductions—will be pivotal in determining not only whether we survive as a species, but whether we survive as a civilized species.

Limitations

The existing analysis suffers from several limitations, some of which result from its incipient stage of development, others from scope limitations, methodology limitations, uncertainties regarding supporting data, and my inexperience in the energy sector:

- The underlying data upon which the analysis is based is subject to uncertainty, and may be inaccurate. Publicly accessible information sources may be wrong, outdated, or incomplete; I undoubtedly missed the "best available" data in some instances; data sources vary, sometimes widely-errors and bias result from the specific data set selected; and some of the "best" data is not available to the general public. Input from additional sources will mitigate this limitation, but it can never be totally eliminated.

- The assumption of "infinite substitutability" among all energy types noted in the report probably serves to bias the results in an "optimistic" direction, by implying the existence of more "useable" energy than may actually be the case at any point in time. (Optimally, "total available energy" would consider the specific applications for which each primary energy type is suitable, and depict the actual "useable available energy total". Such complexity was beyond the scope of this analysis, and would not, in any case, result in delaying the projected timing of global peak energy.)
- The analysis focuses specifically on the relationship between total available energy and supportable human population levels and living standards. Other factors, such as the availability of food, clean water, and breathable air also certainly impact supportable human population levels and living standards. Energy is considered exclusively in my analysis because the historic relationship between energy availability and human population levels and living standards is well documented-and because global peak energy appears to be imminent. The analytical focus is not meant to detract from the gravity associated with potential shortages associated with food, water, air, or any other resource critical to human survival.
- The analysis assumes implicitly that the historic "pre-peak" relationship between total available energy and supportable human population levels and material living standards will hold true in a "post-peak" environment. While this assumption cannot be tested until the occurrence of peak global energy, it is intuitively obvious that, while the specific "decline functions" associated with available energy, human population levels, or human living standards may not be known with certainty, supportable human population levels and/or material living standards will

certainly decline in some manner and to some degree as a result of continuously declining energy availability.

Despite these limitations, which I expect to be mitigated by input from industry experts and yet-to-be-tapped information sources, I believe that the current version of the analysis is “close enough” regarding its assumptions, projections, and findings to evoke concern on the part of rational human beings, and to warrant the effort to improve upon its existing contents. I expect the final version of the analysis to yield similar conclusions regarding global peak energy and its implications for human populations-based upon more credible underlying assumptions and associated projections.

Data Sources

The data and information upon which my analysis is based-historic population and energy consumption data, current population and energy availability/consumption estimates, and future energy availability projections-were obtained and derived from free publicly available sources including the EIA, IEA, HYDE Worldwide Population Database, US Census Bureau, and various organizations and individuals involved with monitoring the national and worldwide energy sectors.

My underlying assumptions and projections regarding future energy availability associated with each nonrenewable and renewable primary energy source represent a synthesis of the information obtained from the above mentioned sources. The specific projections associated with the two scenarios presented in the analysis, Conservative and Optimistic, are derived from assumption sets regarding future energy availability believed by me to be “conservative” and “optimistic”.

(Note that in the final version of the analysis, the Conservative Scenario will depict the global peak energy/population scenario that lies approximately one standard deviation to the “conservative side” of expected peak scenario; and the Optimistic Scenario will depict the global peak energy/population scenario that lies approximately one standard deviation to the “optimistic side” of expected peak scenario.)

Population Data Sources

- **Pre-1700:** I used Michael Kremer estimates; he was frequently quoted by “early population” sources. As the following source indicates, early population projections seem to be comparable, irrespective of source: http://econ161.berkeley.edu/TCEH/1998_Draft/World_GDP/Estimating_World_GDP.html
- **1700-2000:** I used the HYDE Worldwide Population Database, which contained an array of historic worldwide population estimates (http://www.mnp.nl/hyde/bdf/population/); estimates varied relatively widely from source to source, so I adopted the HYDE “mid-range” from the following spreadsheet: http://www.mnp.nl/hyde/Images/pop_summary_tcm63-22929.xls
- **Current:** I used the US Census Bureau projection for estimated 2007 world population: http://www.census.gov/ipc/www/idb/worldpopinfo.html
- **Cross-checking:** I also cross-checked my “selected” historic population data against US Census Bureau data (http://www.census.gov/ipc/www/worldhis.html), and against Jay Hanson’s estimates (http://dieoff.org/); all were in the same ballpark.

Energy Data Sources

Historic global energy consumption

- Pre-1800: I obtained my early historic energy consumption data from a project document used by Western Oregon University: http://www.wou.edu/las/physci/GS361/electricity%20generation/HistoricalPerspectives.htm .
  Their data tracked well with spot check estimates on other websites

- Post-1800: I used a synthesis of HYDE data http://www.mnp.nl/hyde/Images/total_energy_cons_tcm63-23030.xls;
EIA data http://www.eia.doe.gov/pub/international/iealf/table29.xls;
and a diagram created by Deutsche Shell: http://www.spiegel.de/international/spiegel/0,1518,grossbild-685811-429968,00.html

2007 total global energy consumption estimates

I used the EIA *2007 International Energy Outlook* as the basis for my estimates: http://www.eia.doe.gov/oiaf/ieo/excel/figure_11data.xls, 482 Quads for 2007.

I cross-referenced against similar IEA estimates, http://www.iea.org/textbase/nppdf/free/2006/key2006.pdf, which were close in most respects, with the exception of hydro and "traditional biomass".

The primary reason for the biomass discrepancy is that the EIA considers only "marketable" energy in their data. Since much of the wood and waste used for cooking and heating globally is simply gathered and burned, it is never actually "marketed" and does not appear in EIA data. I therefore assumed that the EIA understates actual traditional biomass use.

Data from the IEA, the Shell diagram referenced above, and from the Bioenergy Feedstock Information Network http://bioenergy.ornl.gov/faqs/index.html suggested use of traditional biomass in excess of 50 Quads/year in 2004, so I increased the EIA 2007 estimate of 482 Quads to the 2007 Clugston estimate of 532 Quads.

(I never did determine the reason for the EIA/IEA discrepancy in hydro energy consumption. I used the EIA estimate because other sources that I spot checked pegged hydro energy consumption/availability to be on par with nuclear, as did the EIA.)

2007 energy consumption per primary energy source estimates

Again, I used EIA data from their 2007 *International Energy Outlook* as the basis for my projections. The EIA provides a comprehensive breakdown of estimated nonrenewable energy consumption by source; however, they present only an aggregated total for renewables energy source, as far as I was able to determine: http://www.eia.doe.gov/pub/international/iealf/table29.xls and http://www.eia.doe.gov/oiaf/ieo/excel/figure_32data.xls.

The EIA does provide detail on estimated US consumption of energy per renewable source http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_17.xls, and Wikipedia offered a comprehensive article on worldwide energy consumption by primary source that drew upon sources including the IEA, DOE, BP, and various energy related industry associations: http://en.wikipedia.org/wiki/World_energy_resources_and_consumption.

Based upon data obtained from these sites and from "confirmation spot checks" to websites associated with renewable energy sources, I derived the 2007 Clugston estimates for energy availability per primary energy source.

Future total available energy projections

I used the near-term growth rates contained in the above referenced EIA documents as the basis for my projections regarding both nonrenewable and renewable primary energy sources. I spot checked against IEA growth projections, which were very similar: http://www.iea.org/textbase/nppdf/free/2006/key2006.pdf.

Longer term "pre-peak" growth rate projections (beyond 2030), "peak" projections, and "post-peak" decline rate projections associated with both the Conservative Scenario and Optimistic Scenario are simply syntheses of the scores of studies, reports, websites, and interviews that I have read and heard over the past year and a half.

(Note that energy derived from each nonrenewable primary energy source is assumed to peak at some point, and then decline thereafter. Energy derived from each renewable primary energy source is assumed to reach a "practical limit" [peak] at some point, and then to decline or plateau thereafter.)

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Chris Clugston launched Wake Up Amerika! (www.wakeupamerika.com) in 2006 to investigate the nature and causes associated with the impending ecological and economic disasters currently confronting the United States, and to define timely and meaningful actions to mitigate the severity and duration associated with the lifestyle disruptions that will inevitably result.

Prior to founding Wake Up Amerika! he spent over 30 years working with information technology sector companies in marketing, sales, finance, M&A, and general management—the last twenty as a corporate chief executive and management consultant.

He received an AB/Political Science, Magna Cum Laude and Phi Beta Kappa from Penn State University, and an MBA/Finance with High Distinction from Temple University in Philadelphia, PA.

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