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World and USA Population Growth
World and USA Energy Consumption Growth
Warming of the Planet and Climate Change

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Unbounded human population growth is known as a Malthusian prediction, after Robert Malthus (1766-1834). Malthus realized that the world population was undergoing continuous growth while the production of adequate amounts of food could not sustain continuous growth. Paul Erlick of Stanford University studied the concept in 1968. Donnelo and Dennis Meadows of MIT published their study, "The Limits to Growth" for Club of Rome (1972). They noted that another fifty years of population growth, consumption, and economic aspiration did not appear possible without drastic consequences.

The world poplation has been expanding at an exponential rate, as shown in Figure 1, derived from the 2008 US Census Bureau, Population Division. The growth is given by the exponential equation $p(t) = p_o e^{kt}$, where e is the exponential function, p_o is the world population of one billion at the start of the energy or industrial revolution in 1775, t is elapsed time, k is about .008, and p(t) is the population at elapsed time. The world population growth is displayed in Figures 1 and 2.

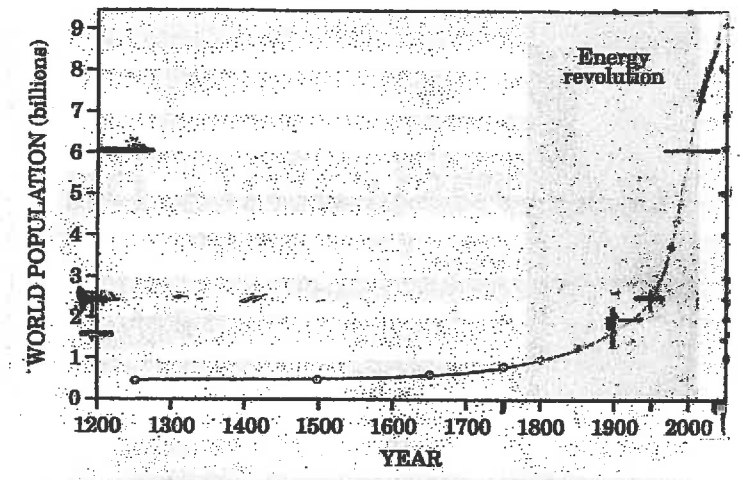

Figure 1. World population growth since the 13th century.

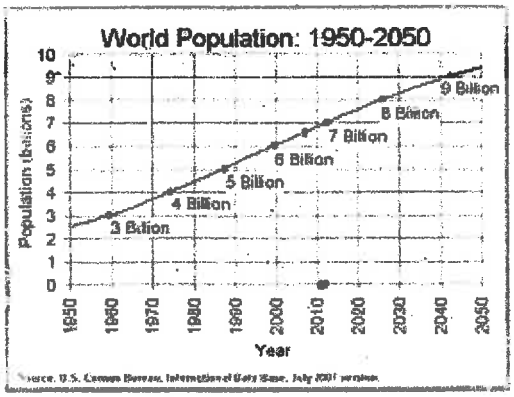

Figure 2. World Population

We have never seen anything like the population explosion of the last 100 years. The 4.4 billion humans have been added to the planet since 1950 and an additional billion is added every thirteen years, which will

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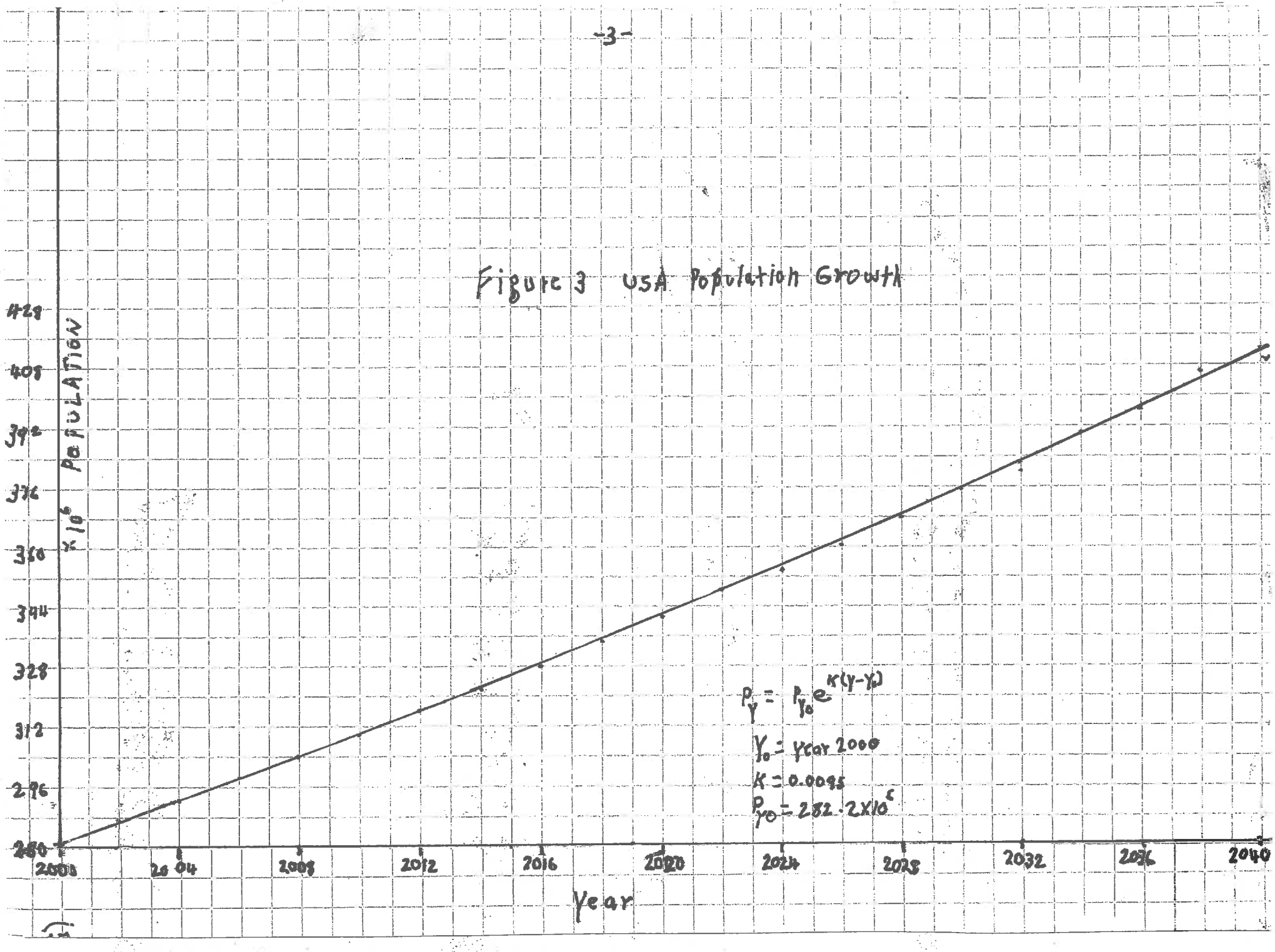
reach 9 billion in 27 years (2040). Much of the population growth of the last 50 years is due to increasing the life expectancy because of advances in medicine and public health. Less developed regions of the globe like sub-Sahara Africa are growing the fastest.[1]

The US Census Bureau, Population Division, reported the US population as 282.2 million in the year 2000. Its estimates for the next seven years is based on exponential growth. Again, the growth is given by the simple formula $p(t) = p_o e^{kt}$ with $k = .0095$ and $p_o = 282.2$ million. The estimated growth is plotted in Figure 3. The population was 301.6 million in 2007. It extrapolates to 319.3 million in 2013 and 412.6 million in 2040 in just 27 years. The approximate 0.95% growth rate of the US is the highest of any industrial nation. The US is the third most populated nation after India (1.2 billion) and China (1.34 billion).[2]

The exponential increase in the world and US populations are accompanied by similar increases in energy consumption. The US Department of Energy predicts the energy consumption of the world will increase by 59% between 1999 and 2020 from about 382 to 607 quads. A quad is equal to about 1 billion billion joules. A joule is the amount of energy required to heat one-fourth gram of water by one degree centigrade. A quad is also equal to a million billion British thermal units (Btu). A Btu is the amount of energy required to raise the temperature of one pound of water one degree fahrenheit. A BTU is equal to 1053 joules. The US consumes nearly 100 quads of energy per year, which is about one-fourth of the world consumption.. Fifty-five percent of the US and world consumption is lost in unused heat due to inefficiency in generation, utilization, and transmission. The US and world consumption is projected to increase by 1.5 percent and 1 percent, respectively, per year. The exponential increase in the world and US populations may cancel a 20-percent increase in energy conservation efforts.

The US is transforming energy from one form to another much faster than any modern country. The exponential growth will expand from 100 quads in2005 to about 141 quads in 2040. The ever increasing expansion in the US population has produced an increase in the

Figure 3 USA Population Growth



demand for the high energy density fuels such as petroleum, coal, and natural gas. In 2005 the US used 40.1 quads of petroleum, of which 24 quads were imported; 22.7 quads of natural gas, of which 3.6 quads were imported; and coal, 22.8 quads, with none imported. These fuels provided 87 perent of our total energy consumption, as shown in Figure 4. The exponetial energy growth, which is increasing by1 quad per year, is shown in Figure 5.

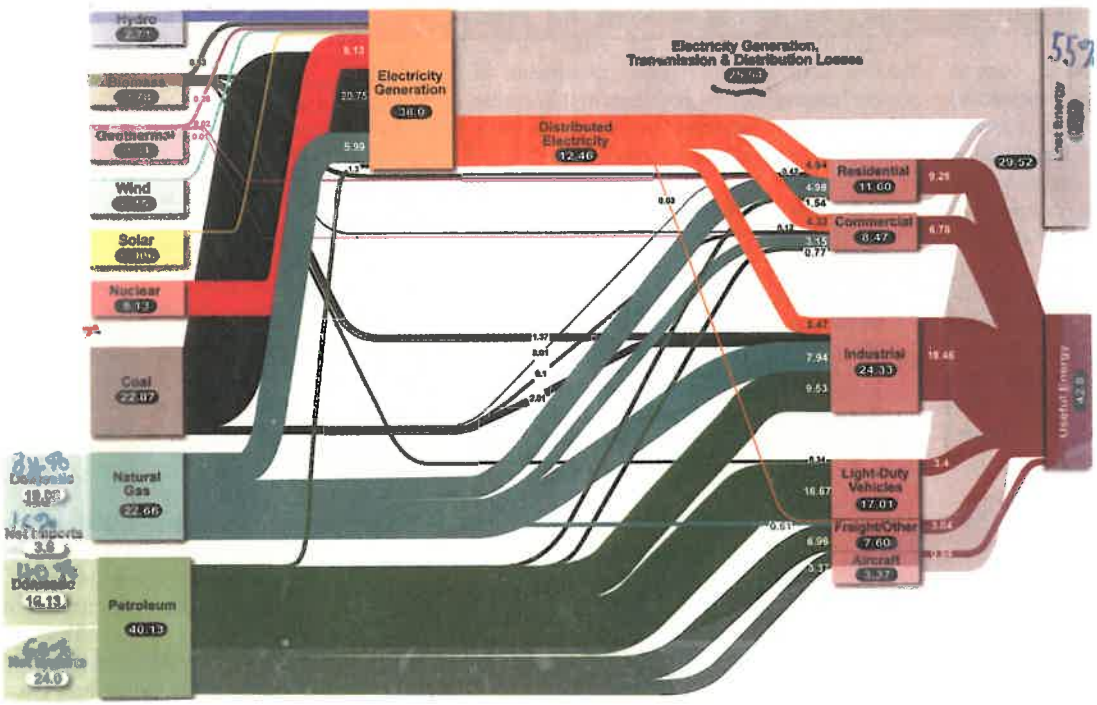


Fig. 4. The complex system of enegy flows in the US in 2005. More than half of energy produced is wasted

Figure prepared by Lawrence Livermore National Laboratory, University of California, and US Department of Energy.

The usage of coal, petroleum, and natural gas for the last 200 years has produced an increase in atmospheric carbon dioxide from 280 ppm to 380 ppm at present. The doubling of the world population nearly parallels the increase in atmospheric carbon dioxide, which has produced a greenhouse effect and warming of the planet by one degree centigrade in the last one hundred years. We now remember our arithmetic: multiplication of population, energy use, and economies; division of available food into smaller increments for the world's multiplying population. We note the subtraction of hydrocarbon fuels from below the surface of the planet, and addition of carbon monoxide, carbon dioxide, sulfur dioxide, nitric oxide, nitrogen dioxide, soot, and methane to the atmospheric environment.

We now list some of the critical demographic and environmental predictors based upon a multitude of scientific publications.

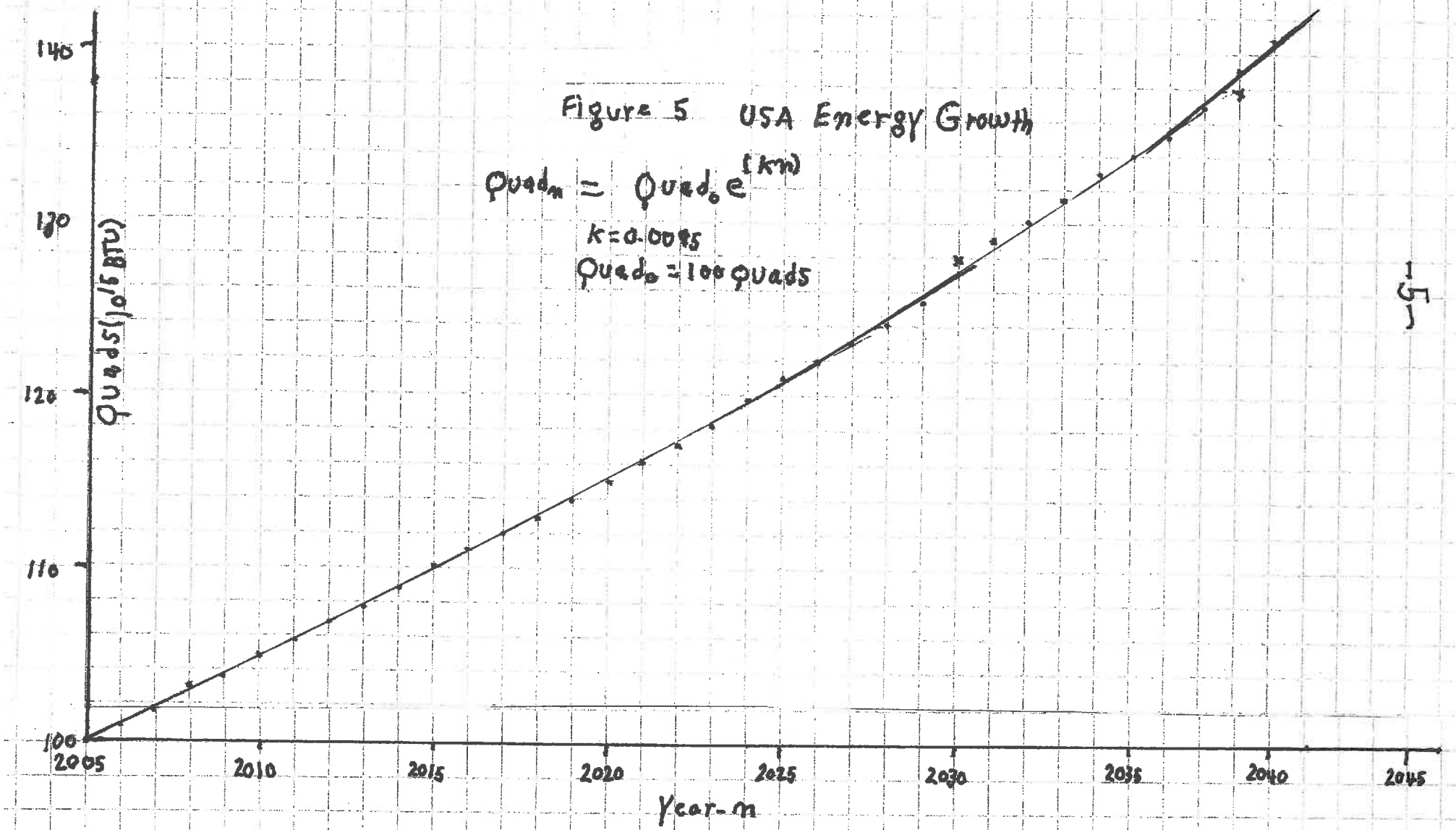


Figure 5 USA Energy Growth

$$Quad_n = Quad_0 e^{(kn)}$$

$k = 0.0085$

$Quad_0 = 100$ quads

There is the finite probability the following will occur:

1. Continuous growth in population.
2. " " " urban and suburban cities.[4]
3. " " " consumptive economies.[4]
4. " " " food consumption.[3,4]
5. " " " pure drinking water.[4]
6. " " " irrigation water.[4]
7. " " " reduction of underground aquifers.[4]
8. " " " pollution of rivers, lakes, and oceans.[4]
9. " " " burning of hydrocarbon fuels.[4]
10. " " " reduction of fertile lands to desert.[4]
11. " " " degradation of land.[4]
12. " " " disappearance of various species.[4]
13. " " " the greenhouse effect.[4]

Thirty percent of the solar energy that comes to the earth is reflected by white clouds and the surface of the earth. A small amount is absorbed by atmospheric water. The seventy percent of the solar radiation that is not reflected or absorbed in the atmosphere strikes the earth's surface and is re-radiated. The outgoing radiation has longer wave lengths than the incoming radiation. The outgoing infrared radiation is absorbed by carbon dioxide, soot, methane, and water vapor. The warming of the earth's surface by the incoming radiation produces the greenhouse effect.[5]

There is also the finite probability the following will occur:

14. Continuous growth in the warming of our planet.[6,7,8]

From the start of the industrial revolution the emission of four trillion tons of carbon dioxide has produced an increase in the temperature of our planet by one degree centigrade. If we emit the same amount of carbon dioxide in the next one hundred years the temperature of our planet will increase by another degree.

There is also the finite probability the following will occur:

15. Continuous growth in extreme weather events, such as hurricanes, tornadoes, forest fires, flooding, drought, etc.[8,10]
16. Continuous growth in acidification of the oceans.

The oceans have absorbed forty percent of the carbon dioxide emitted over the last two hundred years (1.5 trillion tons), which has decreased the Ph of the oceans and the saturation state of calcium carbonate in the shells, skeletons, and reefs of the oceanic life.[11,12]

17. Continuous growth in the melting of Arctic ocean ice with no increase in ocean levels, and the destruction of the habitat for arctic mammals.[13]
18. Continuous growth in the melting of Antarctic and Greenland ice caps, with increases in ocean levels, flooding of coastal areas, and displacement of habitants.[14]
19. Continuous growth in melting mountain glaciers with small increases in ocean levels.[15]
20. Continuous growth in early melting of mountain snow cover.[16]
21. Continuous growth in ocean heat content , which expands the ocean volume and increases seashore ocean levels.[16]
22. Continuous growth in oceanic air temperatures.[16]
23. Continuous growth in land surface temperatures.[16]
24. Continuous growth in tropospheric air temperatures.[16]

Oceanic temperature changes strengthen the evidence for climate change, and are reliable predictors of future warming of the planet.[17] The earth cannot sustain the preceding twenty-four growth indicators in the 21st Century without drastic consequences. Some of these consequences are: great suffering from weather changes, starvation, increased diseases, and others. Either we are able to produce positive solutions or the negative solutions will be provided by the earth.[18] Unfortunately the tragedy of the commons suggests the positive solutions to voluntarily reduce the above growths are contrary to human nature.

Unfortunately the population of the underdeveloped nations, which did little to produce climate change, will suffer the most. Highly developed nations like the US, which produce the major elements of climate change, will suffer the least. As an afterthought, it would require a second earth to bring the living standards to be equal in all nations.

Two ways, among many, to slow down global warming and climate change are:

1. Slow down world population growth.
2. Expand the usage of more efficient alternative energy sources, which are nuclear fission, now producing 8.13 quads per year; hydroelectric, now producing 2.71 quads per year; geothermal, now producing 3 quads per year; wind, now producing 2 quads per year; and solar, now producing 0.02 quads per year.[4,19,20]

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