SUSTAINABILITY IN A CHANGING ENVIRONMENT

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CONTEXT - CONTRASTING VIEWS

Sustainability is universally sought by individuals and groups. Few people would overtly choose to live in a non-sustainable environment. It is a part of our continually evolving nature to not become extinct in a changing environment. In contrast some people and groups view sustainability as a near static circumstance facilitated by an unchanging environment. According to them, this near original natural environment should and can be maintained indefinitely by careful management and stewardship. In some sense, the original form of nature has become sacred for them, almost worshiping nature. This paper suggests another approach to sustainability. Sustainability is viewed as dynamic concept within a changing environment. This approach permits humans to flourish indefinitely. Sustainability is a process that uses a changing set of "raw materials" and knowledge to provide goods, services, and culture for humans, indefinitely.

The history and pre-history of humans is a record of developing more efficient processes to sustain an increasing human population, in which individuals have increasingly long and productive lives. It is the work of historians, and archeologists to document this process of developing human skills to serve human needs. The major transitions were as follows:

Hunter / gatherer tribes
Agriculturally centered societies
Science and engineering based societies
Information sustained societies

These transitions have been viewed as waves overwhelming each other as illustrated by the book title, "The Third Wave" (Toffler, 1980). I view these transitions as foundations on which new human accomplishments may be supported, Figure 1 (Parker, 2002) not waves. In this present information age we are still dependent upon the basics:

Agriculture for our food
Mining including petroleum production for energy and minerals
Traditional engineering design for our essential mechanical infrastructure

The rate of change is accelerating. The transition to agriculture happened about 10,000 years ago. The industrial revolution started about 300 years ago, and the information age perhaps 60 years ago with World War II computers and information theory developments. Some people might say the information age started with the practical electric telegraph some 160 years ago, as inferred by the book title "The Victorian Internet" (Standage, 1998). The rate of technology change is accelerating rapidly and the rate of change is seen as impacting us directly as suggested by the book title, "Future Shock" (Toffler, 1970). The task of this paper is to partially understand the rapid, technology-driven societal changes as a process for providing sustainability, not the destruction of natural environments and so our sustainable society.

ENERGY USAGE - CENTRAL TO SUSTAINABILITY

Utilization of large quantities of energy is essential for contemporary society, as considered in my previous paper (Parker, 2002). As a specific example, consider how the development of the gasoline powered tractor in the early 1900's transformed our nation from 80 % of our population living on farms, to the present circumstance of having less than 2% of our population providing our nation its large excess of food and natural fibers. This, perhaps unplanned, minimization of our rural population happened due to the gasoline tractor, now frequently a diesel, plus synthetic fertilizer, insecticides, and herbicides, plus improved crop yields resulting from traditional plant breed, and now genetic engineering. "Modernization" of agriculture has contributed to improving the quality of life for many, but the transition from hand labor to large-scale mechanized agriculture has been, and still is, very distressing for those immediately involved.

High levels of energy usage, as exemplified by agriculture above, are now present in all aspects of our society. The result is the near elimination of heavy manual labor, along with the health and safety hazards associated with it. Our energy propelled transportation system has made the whole world and its resources conveniently available to many of us.

Energy, plus materials discussed below, has provided us an unnatural infrastructure of roads, utilities, buildings, etc. This infrastructure provides a safe, healthy and comfortable environment for many of us. Within this artificial physical environment, the more abstract aspects of our human potential are given the opportunity to flourish, such as science, education, the arts, and even our spiritual concerns. We now must learn to personally cope with excesses of food and entertainment, not scarcity and boredom.

The societal mandate to reduce emissions and pollution requires significant additional inputs of energy. As allowed emission levels of a pollutant approach zero, the energy and investment requirements increase vastly. As rich and easily processed ores are utilized, it is necessary to invest more energy and resources for the processing of less convenient ores, and also in recycling. Rational energy conservation is limited both by thermodynamics and investment costs.

Energy consumption is essential to the process of sustainability and many energy sources are available, both renewable and nonrenewable. This essential energy consumption for the sustenance of society is the theme of a previous paper presented at this shortcourse. (Parker, 2002) The choices among energy sources depend on availability, utilization technologies, and economics. In primitive societies wood was the fuel of choice, but developing the technologies to bum coal, about 1700, saved the forests of Europe. Commercial production of petroleum, about 1860, provided a fuel with much greater convenience and flexibility than coal, and so petroleum and natural gas became, and remain, the dominate energy sources. Ever improving technologies for oil exploration and production have maintained an abundant supply of petroleum and natural gas on our planet Earth to date. It is an interesting guessing game, as to when the world petroleum production rate will peak, perhaps 2030, as I have discussed in another paper. (Parker, 2002b) When petroleum becomes truly scarce and expensive there are several other energy sources available. For transportation fuels, coal gasification and Fischer?Tropsch synthesis to liquid fuels appears to be the most economic choice. (Parker, 2001) The hardware for this process has already been proven commercially.

MATERIALS - THE HARDWARE OF SOCIETY

Materials are obviously essential to all of society. Materials are so important that human history is divided according to the dominant materials that we use:

(Natural objects as tools)
The Stone Age
The Bronze Age
The Iron Age
The ________ Age

The Stone Age is distinguished from using natural objects for tools by humans learning to fabricate elaborate objects from selected rocks. These objects were both utilitarian and beautiful, and their invention and production was a major societal accomplishment. Suitable rocks such as flint were critical and essential materials for the Stone Age. Regionally we are reminded of this fact by the Alibates flint quarries north of Amarillo Texas, which are now a national monument not a source of essential raw materials.

The Bronze Age resulted from observing that copper acquired improved mechanical properties when alloyed with tin, a very early example of empirical chemistry. The Iron Age required further developments of technology and engineering to produce metallic iron from oxide ores at very high temperatures, since supplies of native iron were very limited. We normally to not designate a "steel" age, but the transition from cast iron to abundant and economical steel makes has made many of the structures and artifacts of our modem lives possible. This occurred about 1850 in both the US and England (Schubert, 1958).

It is an interesting word game to designate the age in which we live in terms of materials, and so only brief, perhaps individualistic, comments will be made in this paper. We could designate the recent as the aluminum age, since aluminum is now very widely used and its ores have almost infinite availability. Aluminum did not exist in metallic form prior to 1845, and was not easily produced until C. M. Hall's adapted the electrolytic cell to aluminum production. (Chadwick, 1958) The most recent age could be designated as the age of synthetic polymers since they did not exist commercially prior to 1909, L.H. Baekeland's phenolic resins, Bakelite (Shreve, 1944). Other persons would suggest that we live in the silicon age, but semiconductors began with germanium and include many elements other than silicon. Very narrowly, we still live in the Stone Age, since the most used material today is concrete. What material will be selected to characterize our futures ages?

MATERIALS AS A SOCIETAL THEME

Modem society can be characterized in terms of energy utilization, as already suggested in this paper, but modem society can also be characterized in terms of materials. The characterization of society is emphasized in a recent book "Materials Matter: Toward a sustainable materials policy" (Geiser, 2001). This book is useful in that it stresses the continued existence of materials after use. These residues must be as carefully managed as the raw materials used to initially fabricate the objects the author, Kenneth Geiser, stresses. He stresses the recirculation of materials within loops as per Figure 8.1, p. 201 of his book. He targets a sustainable materials policy, as per the title of his book. In this present paper, I view sustainability as a changing process that may require less rigid policies and prescriptions than Geiser recommends, for our continued human progress towards improved human circumstances.

HUMAN INTELLIGENCE-THE THIRD INPUT TO SUSTAINABILITY

The importance of energy and materials for our modem comfortable society has been briefly discussed in this paper. We now focus the third input to our continued societal success and sustainability, human intelligence. General, abstract intelligence is apparently unique to humans. Its development is hidden in our distant past along with the development of large brains and our upright stance. All of these human characteristics gave us a very significant advantage over other creatures from which we evolved. This unique characteristic of abstract intelligence exists, although its source is a matter of varied and divergent speculations, creation myths. It is even very difficult to define human intelligence in a quantitative manner that is acceptable to all individuals, both professionals and laypersons. Even so human intelligence is central to the process of maintaining our sustainability as a species. The use of human intelligence in process of sustainability may be subdivided into three categories as follows:

Communications
Accumulation of knowledge
Accumulation of wealth

Communications One result of our human intelligence is our spoken languages. Recently it has been suggested that our language capabilities resulted from a mutant gene, FOXP2 about 200,000 years ago (Paabo,2002). Our daily activities are greatly facilitated by oral communications. We are able to interact and plan far beyond the activities of animals that hunt and search for food in groups. Spoken language permits great detail in our interactions with each other. We share information, attitudes, and hopes. People with superior verbal skills are not only orators, but also our leaders. Students are frequently graded on their verbal skills.

Today verbal communications extend far beyond the range of our voices, first the telephone and now the cell phone. **A** new means of verbal communication broadcast radio, started in about 1921. TV then added sight to our verbal communications in 1939. We now are inundated with verbal communications, and we should carefully screen what our ears hear. Sustainability can be effectively facilitated with verbal communications or confused with the noise of too many almost random words.

Accumulation of knowledge Written language is just as important as spoken language. Written language allows humans to accumulate an almost infinite store of detailed knowledge. This continued accumulation of knowledge has allowed our intellectual advancement and evolution far more rapidly than genetic evolution. The rate of human intellectual advancement is proportional to the fraction of the population who can "read and write", who are literate. In the distant past only a select few individuals were literate, literally scribes. Much of modem European science began in monasteries and was communicated in the obsolete language of the Roman Catholic Church, Latin. The industrial revolution required and/or resulted in the spread of literacy beyond the Church and governmental institutions. Merchants, manufacturers, and finally even laborers found individual literacy becoming essential to their tasks. Schools became public tax-supported institutions, and attendance became mandatory. Now standardized tests demand that schools be accountable to pupils, parents, and the whole of society. Nations are frequently characterized by the fraction of their citizens who are literate. Minimal literacy is not adequate today. Persons who cannot utilize their limited literacy in daily activities are termed functionally illiterate. Schools are frequently held responsible for this failure, but TV and related technologies may contribute by making entertainment available without the necessity of reading.

Printing made books available to all, resulting in accumulated knowledge being available for all persons. To the dismay of some groups in high places, all individuals could now base their beliefs, actions and even pleasures on what they read. The Protestant Reformation in the 16th century is an example of this circumstance. Printing has become far more sophisticated and economical. Photography provides both facts and beauty for printed materials. Recently "CD burners" have made it possible for individuals to both archive and share their writings very economically. Written communications have also become far more convenient for individuals. Initially, just typewriters and carbon paper were available, but now many persons expect convenient access to computers, copying machines, faxes, and e-mail 24 hours per day at any place on our Planet. The internet permits any individual or group to publish anything very economically. We can each make our "printed" statement to the entire world with our own "web site/URL". Our statement to the world can even exist on our individual computer acting as a server, and it can be changed every hour.

Accumulated knowledge is not beneficial unless it categorized and assessed to be true. In the distant past, the time and effort required to hand copy manuscripts minimized the amount of information that needed to be categorized and assessed. Today individuals must assess the information they see and read. Even erroneous concepts such as "cold fusion" still exist on the Internet. The individual now must categorize and assess the written information that he/she has just read. We cannot individually categorize, access, and utilize the almost infinite amount of information available in the world. We must rely on an array of credentialed professionals to accomplish this task, such as physicians, attorneys, scientists and engineers. Many of us as credentialed professionals, have this categorization and assessment responsibility for our particular fields of knowledge. Unfortunately, many uncredentialed individuals and organizations make contradictory statements about societal problems including sustainability. Again, unfortunately, our elected officials may select among these contradictory statements on the basis of paid lobbyists inputs. The process of sustainability is sustained by effective utilization of categorized and assessed accumulated knowledge by credentialed professionals.

Accumulation of wealth Individuals and nations are poor because they are poor - because they lack available accumulated wealth. The accumulated wealth of a nation or community is evidenced in its infrastructure. This infrastructure includes roads, airports and seaports, sewer and water systems, communication hardware, and public buildings. Natural resources are not accumulated wealth, they only have the potential of becoming accumulated wealth if they are effectively utilized. This statement applies to both renewable and nonrenewable resources. To transform natural resources into accumulated wealth requires accumulated wealth, national-level deferred gratification, and effective, realistic planning.

This accumulated public wealth/infrastructure must be maintained at a considerable financial cost to the citizens of a particular nation or local community. Archeology and history provide us many examples of nations and communities who were not able to maintain their accumulated wealth for a variety of reasons. As a result these nations and communities are now literally ruins. We may observe the ruins, and perhaps meditate about our society and ourselves. Some of the ruins are rather recent, blighted areas in our major cities and in failed "planned economies" around the world.

The concept of sustainability applies to our accumulated wealth. In fact, the process of sustainability includes our present accumulated wealth. For example, the oceans represent four-fifths of the surface of our planet, and the seafloor has the potential of supplying minerals and fossil energy as our deposits that are accessible from land are diminished. To accomplish this task of seafloor mining large amounts of accumulated wealth are essential, in addition to improved technologies. Offshore petroleum production is an existing example of this activity. Liquid fuel requirements, new technologies, and accumulated wealth result in oil production from deeper and deeper water, more and more remote from the shoreline. The "Mad Dog" well is 130 mi (209 Km) from Louisiana shore, in water that is 6,734 ft (2053 m) deep, and it was drilled to a depth of 22,410 ft (6831 m) and may contain up to 800 million barrels (127 million cubic meters) of petroleum (Antosh, 1999). Petroleum and natural gas production from even more extreme environments are reported every few months.

Solar and wind energy are free, except for space requirements. To convert these free, sustainable resources into bulk electric power requires the investment of considerable accumulated wealth. From an economic perspective, these expenditures should make a reasonable return on the investment. From a societal point of view, our limited accumulated wealth must be allocated among a variety of competing needs such as education, conventional infrastructure, national security, health, public welfare, etc.

CHARACTERISTICS OF THE SUSTAINABILITY PROCESS

We have identified three human developments that greatly facilitate the process of sustainability, vocal communications, written language, and accumulation of wealth. Now we will identify some details of the sustainability process that result from these human developments. These details include the following:

- Negative feedback loops
- Learning from societal mistakes

Negative feedback loops Negative feedback loops stabilize the process of sustainability, just as they stabilize particular physical processes. The primary example is the population of the world, and local population densities. **A** simple perspective expects the human population to grow exponentially until unpleasantly constrained by disease and violence. This is not consistent with observed facts. The population of Western Europe and Japan has stabilized, and even is declining slowly in some nations, without the direct constraints of disease and violence. This stabilization has occurred without laws, regulations, or adverse taxes. In some cases tax breaks are utilized to encourage population maintenance. Spontaneous negative feedback loops have constrained population density, in compensation for greatly reduced levels of disease and resulting much longer life spans.

Nonrenewable resources are also managed by negative feedback loops. Seldom is a nonrenewable resource exhausted. Increased extraction costs constrain production, and so production rates decline, perhaps exponentially, just as they increased exponentially. Production rate can be plotted versus cumulative production and extrapolated into the future as shown as illustrated by my extrapolation for world petroleum production in Figure 2 (Parker, 2002b). This empirical curve is known as a Hubbert pimple, after M. King Hubbert, a USGS geologist (Hubbert, 1973). These curves require several choices of parameters, and they cannot anticipate new technologies, so their quantitative details are frequently debated among professionals.

Use of renewable resources is also regulated by external constraints, although the negative feedback feature may not be so obvious. Renewable resources are used when they are cost effective in a particular circumstance. Materials are recycled when recycling costs are less virgin materials. These choices are made within the dynamics of our economy, and the choice is not always the same.

Learning from societal mistakes Our technologies and society are not perfect. Mistakes are made. These mistakes are documented and recorded. Klutz's book, "What Went Wrong? Case histories of process plant disasters," is an example for chemical engineers (Kilts, 1985). Some societal disasters are difficult to detect quickly and may take decades to fully correct. The wide spread use of DDT and its accumulation in the environment is the classic example. Other problems are detected and corrected relatively quickly and painlessly. The replacement of CFC's with substitutes to protect the "ozone layer" is an example. Global warming is the possible societal mistake currently receiving attention with vast not fully understood implications for sustainability and for the economy. Consensus had not been reached among the appropriate professionals on the direct societal effects of possible global warming.

The public generally has an excellent memory for past disasters, but it seldom remembers that changes have been made to avoid similar disasters in the future. **A** related topic regarding the public concerns "perceived risks," risks that have not been documented by the appropriate certified professionals. These public perceptions are renewed and amplified by selectively-informed special interest groups. Nuclear energy, which could greatly facilitate the process of maintaining sustainability, is held hostage by these public misperceptions, in the judgment of many professionals.

PHYSICAL SCALES OF SUSTAINABILITY

Sustainability can be considered on many geographic and political scales, although the ultimate scale is our whole planet Earth. On smaller-scales, the sustainability of a local population may be threatened and/or destroyed when regional circumstances change. Mechanized agriculture has resulted in dramatic declines in rural populations and the decay of the rural infrastructure - schools, health care, etc., but has provided society very economical sources of food. Loss of manufacturing jobs to automation and to overseas locations is another example of local loss of sustainability, but these local job losses are offset by overall gains in productivity. How to manage such regional changes is a concern for both the individual worker and for society as a whole.

INTERDEPENDENCE OF SUSTAINABILITY'S ASPECTS

This paper has focused on natural resources and environmental aspects of sustainability, the traditional definition of sustainability. It important to position this "mechanical" level of sustainability within the multi-dimensional aspects of sustainability. Sustainability includes the following additional dimensions:

Economic
Political
Societal

Economic Continued confidence in the economy is required to make the investments and long-range plans that are necessary maintaining sustainability. Rather expensive maintenance of infrastructure is essential for continued sustainability. Decaying infrastructure is not sustainable, as well as being depressing.

Political Politics is mechanism by which democracies make their decisions, both long and short term. Politics is complex and "messy", but still essential. Rational causes, such as sustainability, must be put forward in this political atmosphere of selfish interests, emotional wailing, and even untruths. Not an easy task, but still a task for which each of us should take some responsibility.

Societal Societal concerns relate to the significance of the individual, and how that individual's significance is support by the whole of society. The individual is equally responsible to the wellbeing of the whole of society. The mutual dependence of individuals and their society is realized in a wide variety of civilizations and religions, evolving over long periods of time. Sustainability is an essential subset of societal concerns.

CLOSURE

Kenneth Geiser (2001b) states in his recent book:

"In order to move toward a sustainable world economy, the industrialized world must progressively reduce its throughput of materials and energy. . . The scale of this transformation and its social and economic implications rival the changes required to move from the Bronze to the Iron Age."

On this basis, Geiser recommends governmental manipulations via taxes and regulations to reduce the flow of nonrenewable resources and waste streams in our society.

In contrast, I have suggested that flexible use of human intelligence is the key for maintaining the sustainability on our Planet. The fruits of human intelligence, both accumulated knowledge and accumulated wealth, can effectively substitute for the reduced availability of nonrenewable resources. This observation is supported by the analysis of publicly available data by Simon (1996) in his 700 page book. These optimistic observations are extended in a recent book whose title is a summary of their book, "It's Getting Better All of the Time: 100 Greatest Trends of the Last 100 Years." (Moore and Simon, 2000). These two books demonstrate that all aspects of our lives are improving - health, education, resource availability, and environment. Frequently, prophets of gloom and doom are just promoting their own perceived risks and special interests.

For this reason, I suggest a minimum of regulations, and continued reliance on our increasing accumulated knowledge and wealth to maintain a sustainable society. Today, 2003, human intelligence cannot predict the details of a sustainable society in 2103; just as the internet, etc. could not have been predicted in 1903. Neither can we predict what materials will be essential in 2103, perhaps materials that do not exist today, and that can be manufactured in abundance.

Optimism has been shown to be a key factor for success for individuals and for society (Tiger, 1979). In contrast expectations of gloom and doom may become a self-fulfilling prophecy. Continued optimism directly supports the sustainability of our planet. This optimism for the process of sustainability is justified by the continued accumulation of human knowledge that adapts existing resources to our societal needs.

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<u>ABOUT THE AUTHOR</u>

Dr. Parker has been involved in energy and environmental related research at many levels:

Phillips Petroleum Company, 1956-1970. Enhanced oil recovery and oil shale.

Engineering Societies Commission on Energy, Washington DC, 1979-81. Evaluation of processes and resources for alternative fuels.

Director - Office of agricultural materials USDA/CSREES, Washington, DC, 1993-1994. Facilitation of agricultural crop usage as energy sources and industrial materials.

Since 1970, he has been Associate and then Full Professor in the Department of Chemical Engineering, Texas Tech University, Lubbock, Texas. His research and teaching interests include energy sources and processes, environmental remediation, industrial uses for agricultural crops, and corrosion prevention. He is the inventor on 84 US patents.

Harry W. Parker received his BS degree "with honors" from Texas Tech University in 1953, and immediately continued at Northwestern University earning his MS and PhD degrees in 1954 and 1956.

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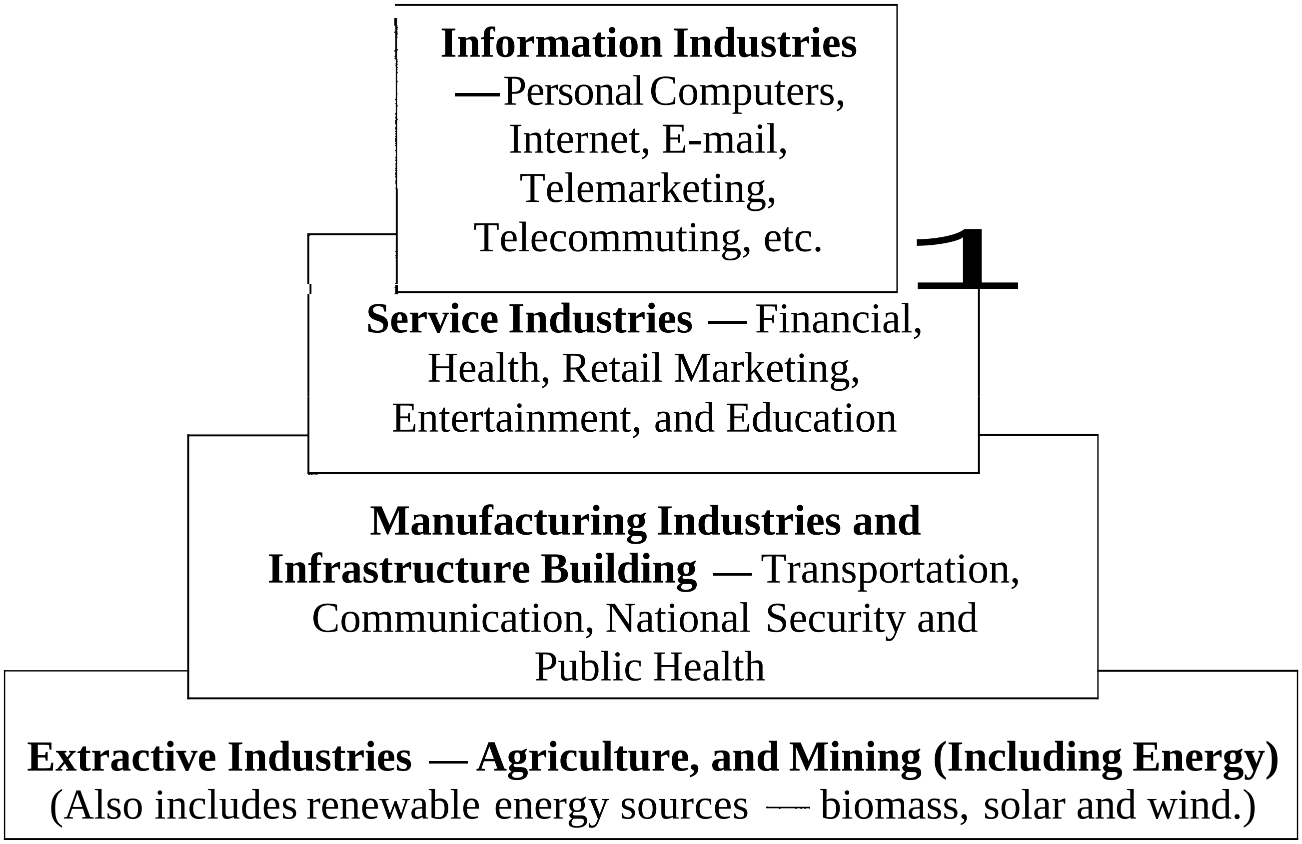

Figure 1 - Foundations on which Society Exists and Serves Humanity

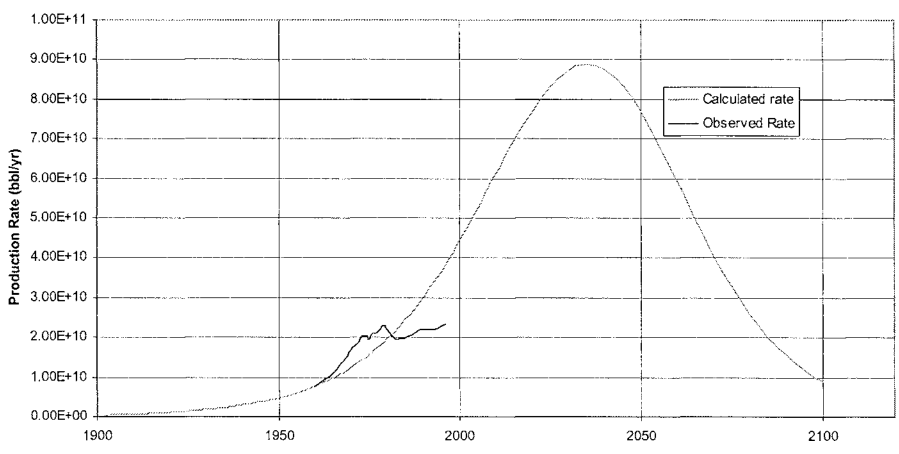

Figure 2 -Actual and Estimated Petroleum Production Rates