NPG Negative Population Growth, Inc.

A GEOMOMENT OF AFFLUENCE BETWEEN TWO AUSTERE ERAS

An NPG Forum Paper

by Walter Youngquist

During most of human history austerity has been the norm. Only recently have some segments of world population enjoyed an affluent life. But these are very unusual times, far from the norm. It now appears human history can be broken into three distinct eras. First, the long march from the millennia of the hunter-gatherer economy to the time of the beginning and then widespread use of fossil fuels and other nonrenewable resources.

This ushered in a second era, a Geomoment of Affluence, a moment in Earth and human history based on the extensive use of Earth's nonrenewable resources at an unprecedented increasingly unsustainable rate. It is a time in which we now live, lasting only a little more than 300 years. It will be only a unique brief moment, hardly measurable in the scale of geologic time, and brief even in the scale of the 200,000 years of modern human existence.

In essence, this is the Olduvai Theory proposed by Richard Duncan — that humans came from a primitive state (early human remains found in Olduvai Gorge in Africa) to a highly advanced state (the current Geomoment of Affluence) and then will inevitably revert to a further primitive state. It was the discovery and extensive use of fossil fuels that has made much of this Geomoment possible.

From abundant high density energy of fossil fuels combined with discovery and widespread use of a great array of both metals and nonmetals, humanity has developed an advanced technological civilization with huge benefits for those in the industrialized world. A few of these advances have reached less developed economies, for example, the increasing use of motor vehicles for transport. Many medical advances such as open-heart surgery are largely confined in use to the developed economies, and may never reach the majority of world population.

> *No substance has so profoundly changed the world in so many ways and rapidly as has the use of oil in its various derivatives.*

It is noteworthy that many of the technologies we have today are directed toward the exploration for, and the development, processing and use of nonrenewable resources. Without these our current industrialized economies with all their benefits could not exist.

Very important has been the development of many and various machines for the use of the derivatives of oil — gasoline, diesel and jet fuel. They include cars and trucks, railroad engines, ships, airplanes, and many small engines in various machines such as chain saws, outboard motors, and lawn mowers. In marked contrast to earlier times, by means of these devices one person can control a huge amount of energy. By moving a lever or two an individual can command the energy to move a mile-long freight train, or hurl a fully loaded Boeing 747 35,000 feet into the air and across a continent or ocean at 500 miles per hour. Electricity is not an option for this use. A gallon of jet fuel has about 46 megajoules of energy per kilogram. Lithium-ion batteries can store only 0.5 megajoules of energy per kilogram. The weight of the batteries needed to power an airplane preclude electricity as a power source.

No amount of ingenuity will put more resources into the ground. Something cannot be made from nothing.

True, an airplane with very limited load capacity and a huge wingspan covered with solar panels generating electricity has been experimentally in flight. But cloudy days and the day/night cycle of solar energy availability and exceedingly limited load capacity make such an airplane totally inadequate for commercial use. No energy source other than jet fuel provides the energy to do this.

Think also of the amount of energy controlled by individuals who drive the now more than 800 million motorized vehicles on the world's roads. Just twenty gallons of gasoline or diesel will propel a 2500-pound vehicle with a mileage efficiency of just 20 miles per gallon for 400 miles over both mountainous and level terrains. How many humans would it take to do that? More than by anything else, economies are now defined by how much energy they have available and how they control and use energy.

It is in the realm of agriculture that the greatly increased use of energy has had the most important effect. Prior to the use of fossil fuels, human and animal muscle power was the only energy available for agriculture. As a result only a relatively few acres could be cultivated to grow food for human consumption. Much land had to be given over to summer pasture for draft animals and hay land from which to provide a winter supply of fodder. It was a life at subsistence level.

Use of fossil fuels to power farm machinery eliminated the need for pasture and hay land and marked the end of extensive use of draft animals. A farm tractor can pull a gang plow over many acres every day, and, unlike horses, mules or oxen does not get tired. This has allowed much more area to be cultivated by relatively few people to the extent that now approximately two percent of the U.S. population is engaged in agriculture providing food for the rest of the population with, at times, surplus crops available for export. This freed large segments of the population to move to urban areas and engage in manufacturing and many other occupations. Great medical advances were made. These, with increased food supply, fostered a huge growth in population which trend continues today.

No substance has so profoundly changed the world in so many ways and rapidly as has the use of oil in its various derivatives. It is not only now the chief source of energy, it is also employed in the form of petrochemicals for many non-energy uses. Much of the Geomoment of Affluence some of us enjoy today is largely the result of the widespread and varied use of oil.

Any decline in the price of oil will be a temporary situation for oil has many important end uses and will always be in demand as long as it is available. But the Earth's supply of economically recoverable oil is limited. Over the long term, oil demand is projected to increase. The only question is if the increased demand can be met. It cannot. Major oil companies are finding it increasingly difficult to replace their reserves.

Earlier it was relatively easy to find the super giant oil fields (greater than five billion barrels of economically recoverable oil). The East Texas field was found in 1930 and the Ghawar field of Saudi Arabia in 1938, which even now still supplies half of Saudi Arabia's production. These discoveries did much to propel us into the affluent time of the Age of Oil we have only recently known.

Such remaining major oil fields as may yet be discovered are in remote areas and deep water regions which are difficult and expensive to explore. Finding super giants as in the past is very unlikely. The rate of oil discoveries has been in decline since the mid 1960's and return on money invested in oil exploration has been in decline for several years. In brief, we are investing more to find less and less oil. Put it another way, the amount of oil found per foot drilled is declining. Inevitably, longer term the price of oil can only go up, ultimately to the point where it can only be used for high value end purposes such as medicines and petrochemicals. By the year 2100, and probably before, the oil industry as we know it now will no longer exist.

Currently some fossil fuel energy is used to find more fossil fuel energy and exploit other Earth resources as never before. In turn these resources are used to provide the high standard of living associated with developed economies. But, based on nonrenewable resources, especially fossil fuels, it is a time of Earth and human history affluence destined to be brief.

High quality low cost fossil fuels and metals and nonmetallic minerals have enabled our industrialized success. And we seem to have come to the mistaken belief that, through human ingenuity, we can perpetuate our industrialized success indefinitely. The general public has been mesmerized by scientific progress, so that the answer to nearly all problems including Earth resources limitations is the "The scientists will think of something."

By the year 2100, and probably before, the oil industry as we know it now will no longer exist.

But there are limits to substitutions, and Earth resources are limited. No amount of ingenuity will put more resources into the ground. Something cannot be made from nothing. Ironically, the more vigorously we pursue the utilization of nonrenewable natural resources the more quickly we will deplete these resources and hasten the ultimate decline of the Geomoment of Affluence that some of us have today. In some regions of the world, particularly in Africa and India, many people will be largely bypassed by these brief affluent times.

As nonrenewable resources are depleted this will foster increasing conflicts over remaining nonrenewable resources and the renewable resources such as groundwater and fertile soil. These are now being exploited everywhere at unsustainable rates and can be renewed only over centuries, if they can be renewed at all. Once a groundwater aquifer collapses it is lost forever as several have done, including in some portions of the San Joaquin Valley of California where the ground surface has dropped as much as 29 feet.

The third era of human history is just beginning to unfold. It involves coming generations facing a future of less, especially with the predicted rise in population when more and more people must then divide limited depleting resources. We have plundered the planet to provide for little more than three centuries of continually rising physical living standards based almost entirely on nonrenewable resources. As such this trend is unsustainable, a fact that will become apparent before the end of this century. It may eventually become clear to all that there is an inevitable and inescapable control of Earth resources over nations and individuals. Nature bats last. Human ingenuity cannot create more water or more minerals.

All estimates are that population growth will continue to increase for several decades more at least.

With the current and projected increased rate of exploitation of essential nonrenewable Earth resources it is probable that by the year 2100 nearly all will be so depleted that what remains in the Earth will be of such low quality it will no longer be economic to recover them. This is a very important impending reality.

The fracking technology is likely to extend the time of fossil fuels for a very short interval. The additional amount of oil contributed by this method is small compared to world total oil production (approximately 92 million barrels a day). Also, the fracking technology benefit to oil production may have a shorter life expectancy that is now generally recognized. The North Dakota Geological Survey expects that the Bakken-Three Forks fracking oil play will peak by 2016 or 2017 with production from that technology to be not more than 1.5 million barrels a day, and with production declines of 60–70 percent the first year.

The ongoing depletion rate of existing oil fields will ensure the end of significant commercial oil production before 2100. The world now uses about 33 billion barrels of oil a year. Sustaining consumption at that level is difficult and may represent the peak or close to the peak year of world oil production. The current oversupply of world oil is a short-lived anomaly caused by the slight drop in oil demand combined with a brief increase in world oil supply from unconventional oil such as from fracking shale and ultra deep water sources.

Overshadowing all of this is the United Nations prediction that world population, now 7.3 billion, will increase to nearly 11 billion by 2100. It is currently increasing at the astounding rate of 237,000 a day, a million more people in just slightly more than every four days (Population Reference Bureau 2014). Some estimates are that a variety of factors will prevent this predicted population growth. However, all estimates are that population will continue to increase for several decades more at least.

The additional demand on nonrenewable natural resources from any population increase means that current depletion rates are the minimum to be expected. Depletion to uneconomic quality and quantity of these resources will continue at an even faster pace than at present and scarcities of critical nonrenewable Earth resources are likely to become a harsh reality well before the end of the century. Phosphate, a mineral nutrient essential for plant growth and vital component in fertilizers, is one such resource with a looming early shortage.

Although the details of the future cannot be fully visualized now, the broad framework of the future is apparent. All human activities will eventually have to operate within the limits imposed by use of renewable natural resources. An increase in world population by any amount further complicates the problems of achieving a sustainable economy and a stable society on renewable resources.

As recently as 1930 world population was no more than two billion. At the start of the industrial revolution (1750) it is estimated to have been no more than 0.8 billion. Beginning about the year 1900, with medical advances and increased food supply, population has grown exponentially to now 7.3 billion, and growth continues. It is now recognized by many that world population growth is the number one problem.

Albert Bartlett noted the increasing difficulties of solving our problems caused by the overwhelming mass of people now here as compared with preindustrial times. His observations are highly relevant:

> *"Can you think of any problem on any scale, from microscopic to global, whose long-term solution is in any demonstrable way aided, assisted, or advanced by having larger populations at the local level, the state level, the national level, or globally?"*

Even aside from the important use of fossil fuels as building blocks for a host of important chemicals, the replacement of the high density fossil fuels, oil, natural gas, and coal, will be extremely difficult, for they are energy sources unequaled by any other. Enthusiasts for solar and wind energy, the principal renewable energy alternates offered for fossil fuels, ignore their serious limitations and tend to mislead the public. An example is the closing statement in a comprehensive book describing the depletion of nonrenewable resources including fossil fuels, stating that eventually "...we can fully embrace the energy source that is abundant, reliable, and always there — the sun." But the facts are quite different.

Beyond the intermittent availability of solar energy caused by the day/night cycle during the 24-hour period, the time of the availability of sunshine and its intensity varies markedly with latitude and seasonally. Also, there are cloudy days almost everywhere, sometimes persisting for weeks at a time, greatly reducing the intensity of sunlight. Even at their best both wind and sunshine are low density energy sources, and no way has yet been found to store large amounts of electricity generated from any source over long periods of time. For the most part electricity has to be used when it is produced, or stored briefly in batteries.

To produce industrially needed amounts of solar-generated electricity, large land areas would have to be covered with solar cells. These must be continually kept clean so that the original efficiency of the solar cells can be retained. Where solar energy is most available, desert areas, these regions are subject to frequent dust storms. Wind also is intermittent, and, as with solar capture devices, is dependent on the use of a variety of nonrenewable metals including rare earth metals in the equipment manufacture.

In contrast, fossil fuels are available on demand in their full energy intensity 24 hours a day, and are not affected by the seasons or by variable weather conditions. Also, fossil fuels can be transported to where they are most needed, even to remote areas such as the Arctic, and can be stored indefinitely in whatever quantities they are needed. Fossil fuels have no comprehensive substitutes.

> *The replacement of the high density fossil fuels, oil, natural gas, and coal, will be extremely difficult, for they are energy sources unequaled by any other.*

The Paris-based International Energy Agency states that currently only about 0.4 percent of global energy consumption is supplied by solar photovoltaics and windmills. The IEA expects that in 2040 these low density energy sources will provide only a miniscule 2.2 percent of the world's energy.

In considering wind and solar energy, which produce electricity as a substitute for oil-derived energy, this is often confused with the idea of wind and solar energy as a complete substitute for oil. This is far from the facts. About 20 percent of oil is used for other purposes than energy. These include fertilizers, insecticides, plastics, pain medicines and many other end uses.

For these electricity is not a substitute. Also, a very important use for the end product of oil refining, asphalt, is for paving and maintenance of millions of miles of the world's roads. There is no replacement of asphalt for this purpose. Here also electricity is not an alternative options.

The integrity of all important world ground transport infrastructure is in jeopardy, and will most certainly be in critical disrepair this century. Repair of the current world asphalt roads is already becoming an expensive problem.

The enthusiasm for both solar and wind as replacements for fossil fuels is not justified by realities. Yet, these low density energy sources are chiefly what we will have to depend on eventually. The current abundant, relatively cheap, reliable, and always available high density energy from fossil fuels supports nearly all facets of our industrial civilization today. Their exhaustion will be a major turning point in human history, and will be an important factor in the inevitable reduction of population.

People generally do not understand the critical importance of energy to support their existence. Without energy from some source, nothing happens. Only recently have we enjoyed the benefits of an abundance of high density energy sources, and that the energy returned on energy invested is large. The concept of the energy returned on energy invested is expressed in abbreviated form: EROEI.

This concept has been pioneered and promoted by Charles Hall who notes that the EROEI worldwide is declining. An example is all important oil where initially from shallow easily exploited oil fields the EROEI was 100 to 1, or more. As oil exploration has had to drill deeper or go offshore the EROEI is now estimated overall for oil to be about 10 to 1. Drilling in several thousand feet of water and then below the ocean floor for thousands of feet more is energy intensive, not including the energy costs of mining, refining and processing all the metals needed in manufacturing the equipment required for such a venture. It now takes a large oil discovery to provide a surplus of energy from the EROEI.

Hall has stated that civilization requires a substantial energy return on investment. "You cannot do it on some kind of crummy fuel like corn-based ethanol with an EROEI of around 1:1." He adds "A big problem we have facing the alternatives is they all have so low an EROEI... We may not be able to sustain our civilization on those alternative fuels."

The decline in quality of our nonrenewable resources means that it takes more energy to recover them, copper in the United States being an example. From the native (pure) copper deposits of the Upper Peninsula of Michigan, now mined out, we have now gone to the 4/10ths of one percent copper in the ore of Bingham Canyon, Utah. Similarly, Chilean copper deposits are now exploiting one percent copper ore, in contrast to the three percent or better copper content of ores mined initially.

So we now face the double problem of declining quality nonrenewable resources, and at the same time there is a decline worldwide in the energy returned on energy invested. It is taking more and more energy to recover Earth resources of declining quality. As this circumstance closes in on us, maintaining industrialized civilization will be increasingly difficult.

The political and industrial bodies continue to promote "growth" as the goal of economies. "We need more growth" is the continuing mantra. No growth is taken to mean a stagnant situation rather than a stable situation and never considered as an option. But continued economic growth now requiring more and more nonrenewable resources is the problem, not the solution. The decline of both the EROEI and quality of nonrenewable Earth resources is mostly neither understood or ignored. Eventually, and probably very soon, it will mean the end of growth, a new no-growth economic paradigm will emerge for which we are currently unprepared, for economic growth is the engine that now empowers our industrial economies.

It is taking more and more energy to recover Earth resources of declining quality.

In these impending realities, what elements of civilization should we most urgently strive to preserve into the future? Foremost among these surely are the outstanding medical advances made in the past two hundred years. These have made life much more pleasant than it would be otherwise. The vaccines and antibiotics discovered have largely protected populations from the scourges of diphtheria, smallpox, polio, typhoid fever, and other diseases. Perversely, this has served to greatly enhance population growth. But surely one would not want these scourges to return to control population as they have so tragically done many times in the past, causing great suffering.

Much better would it be that the world had a smaller stable population benefiting from these medical advances to make the lives of the population then safer and much more pleasant. Ideally it would be all the benefits of modern medicine bestowed on a smaller population, living sustainably within the limits prescribed by renewable resources. We are far from that now.

There are two major differences between the previous time of austerity and the impending situation. The first is that there were many fewer people in the earlier circumstances whereas we are now faced with the survival demands of several billions more people than only two centuries ago.

The second difference is that the first period of austerity was on an upward trend of increasing affluence that culminated in the current Geomoment of Affluence. This is no longer the trend. We are now beginning to bump against the resource limits of a finite Earth to support demands of a larger and still growing population. By some estimates, population size is already beyond what the supporting resources one Earth can sustainably provide, as we are now living on a depleting inheritance from the geologic past. Fossil fuels are a prime example of this predicament.

The coming austerity does not eventually lead, as before, to more affluence but to less. There is no culmination to another affluent era but simply a road of continued austerity with no apparent end in sight. Making the transition, and doing it in an orderly fashion and without travail will be difficult, for there is no precedent for reducing populations and changing economies to fit a paradigm of fewer people living on renewable resources. However, this transition is inevitable.

Eventually, and probably very soon, it will mean the end of growth, a new no-growth economic paradigm will emerge for which we are currently unprepared.

How well people can manage to live exclusively on renewable resources is yet to be determined, and will evolve over several decades. It may be chaotic at times for the changes demanded from our current living standards are numerous and large, and will not come easily, especially as the world's affluent people attempt to preserve their lifestyles.

The only demonstrable sustainable lifestyle is that of the hunter-gatherer. Hopefully, some technologies will be devised to sustain future generations above the level of the hunter-gatherer. But that is not a given. The success of such a paradigm would almost certainly require a smaller population. In the past, a reduction in population locally or regionally, has been done by disease and/or famine. Reason is the alternative, but will it prevail? That very important question has yet to be resolved and is an area in which humans have the opportunity now to greatly affect the course of our future.

It has been the widespread use of fossil fuels, most importantly oil and its derivatives, that has made this Geomoment of Affluence possible. Two hundred years ago these affluent times did not exist. A hundred years from now, with the intervening certain decline of the importance of oil, and greatly reduced quantities of other economically recoverable nonrenewable natural resources, this Geomoment of Affluence cannot be repeated.

Ω

Dr. Walter Youngquist has worked both as a petroleum geologist and a minerals geologist in the United States and abroad. He has visited more than 70 countries, observing the ongoing problem of continued population growth and declining supporting Earth resources. A Fellow of the Geological Society of America and the American Association for the Advancement of Science, he is the author of *GeoDestinies* and several NPG Forum papers.