The Shift Point

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The Shift must reframe the perception of society, to at once validate everything that has happened to bring us to this point, while at the same time making it self-evident to everyone how we must each now radically change course in the light of this newfound perspective.

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Leaving a World for Our Children

We are about to traverse the most critical lifespan in the history of life on Earth. What we do in this lifetime will either insure that all future generations have the possibility of living in Eden, or forever deny that possibility to all future generations. This may seem like a strong statement. Here's why it appears to be true.

Tapping into the fossil fuel reserves of the planet has given humanity a onetime burst of energy, which has allowed the population to grow exponentially over the last two hundred years. This expansion has both made possible, and in turn been made possible by, a virtual explosion of scientific knowledge and technology. That combination of technology and abundant energy has allowed us to rapidly consume, and to a large degree carelessly destroy, the biosphere. We are currently using approximately 60% of the biological output of the Earth for human purposes. Ten years ago it was about 40%, and the rate is still accelerating. Thus, what happens over the next decade will irrevocably determine the outcome of the entire enterprise of life on this planet.

There are only two possibilities given the situation. Either, we will find a way to make the rapid adaptations necessary to stabilize a new super-high efficiency life support technology, or we will over-consume and effectively crash the biosphere. The latter possibility would not just mean a dark age followed by some new civilization as it has in the past when isolated civilizations have collapsed. We are now in danger of permanently destroying the capacity of the entire biosphere has to recover. All of the species of plants and animals that we extinguish now will never be replaced within the timeframe of human experience. Evolution took millions of years to develop the diverse life forms we see all around us. This means that if we do too much damage in our brief lifetime all future generations will be denied the possibility of an intact biosphere. At first glance it may be easy for us to say that this is no big deal, we can live without a few obscure plants and animals. But, a consensus of biologists are telling us that if we do not change course we will lose half of the plant and animal species on Earth within less than fifty years. The biosphere is an intricately woven web. We do not even understand it well enough to know if humanity could survive that kind of assault on the life support system of the Earth. We take for granted that the Earth will provide conditions that support human life. But we do not understand it well enough to know how fine that balance is. Even if we could continue to survive, we don't know how devastating that kind of ecological impoverishment of would be to the health, much less the psychic and spiritual sense of well-being of future generations.

At the same time, the cheap plentiful energy that has allowed this explosive growth and consumption is coming to an end. There will never be another point like this in human history. We only get one burst of accumulated fossil reserve energy on the planet. It took hundreds of millions of years for the Earth to develop the deposits of fossil hydrocarbons that have allowed us to evolve our current technological momentum. Now we are at the peak of their consumption. In fifty years, either we will be well on our way to a sustainable world and will value the remaining biodiversity so highly that we will carefully preserve what is left of it, or, we will have failed, and the world will be teetering on the brink as vast human populations chase increasingly scarce resources. If we fail, humanity will descend into violent anarchy with most of the population dieing off in the process, but destroying what is left of nature before we go, and thereby denying a viable world to all future generations. This is what is at stake in our lifetime.

That account is not intended to cause panic, but rather to urge us to wake from our slumber. At present there is a wide gulf between the ecological limits to growth camp, which argues that we are dangerously beyond the carrying capacity of the Earth and racing toward catastrophe, and the advocates of globalization who argue that market forces and technology will somehow save us. As John Stuart Mill said, in most arguments both sides are right in what they affirm and wrong in what they deny. The growth based technology advocates are correct in that the only way out is through; we cannot solve the problem by going backwards. Unfortunately, most people in the business camp have so far failed to acknowledge the reality of finite natural resources and the need to develop a viable global life support strategy. Serious questions remain as to whether the market as currently constellated will be capable of effectively responding to the survival imperatives of humanity without fundamental changes.

An Evolutionary Perspective

It may be possible for the global system to undergo a change in state, a fundamental shift from one of increasingly intractable interrelated crises to one characterized by mutually reinforcing synergetic solutions.

The global situation has become like a Gordian knot wherein it appears that all attempts to solve any one crisis in isolation only makes others worse. We face myriad crises, all aspects of an unprecedented breakdown in many global systems that is already coming to a head and will become acute within a decade or less. Spiraling debt, the impending end of abundant oil, global warming, overpopulation, mass extinction and a general acceleration of change verging on chaotic instability can all be seen as part of a pattern of converging indicators at a unique moment in history. Many of these trends (enumerated in more detail below) are still accelerating and are apparently characterized by logarithmic curves.

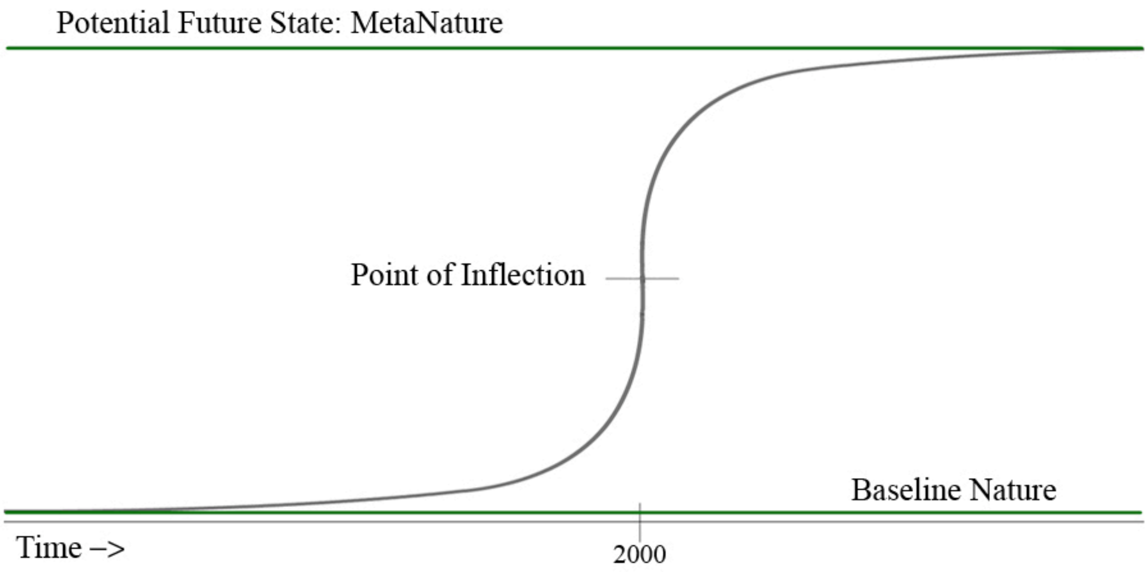
Log Curves

Mathematically, a “log curve” approaches vertical as it accelerates toward infinity. When the log curve describes a finite trend such as population growth, or the rate of consumption of renewable resources, a serious problem is implied. For example, in many species such as bacteria in a Petri dish, or rabbits on an island, given a sufficient food supply the population will first spike with a growth rate following a log curve, and then crash. This overall pattern is known as the “J-curve.”

It is easy to imagine how the current trajectory of our civilization could also turn out to follow a J-curve. Indeed, many analysts who have examined global trends in detail would say that a purely rational assessment of the situation indicates that we are most likely headed toward some sort of collapse or crash. Many of them would argue that the great majority of people who don’t share that view are in denial, or are at best operating on blind faith. Most of those arguing that we are currently headed for catastrophe insist that the only way to avoid it would be for society to make a massive U-turn. This seems exceedingly unlikely to happen. However, there is one other plausible scenario. At a critical point, key trend lines could shift from curving one way, representing ever accelerating but increasingly instable change, and cross over to begin to curve the other way, representing deceleration toward a state of greater stability.

The S-Curve

Mathematically, this phenomenon would be described as an S-curve, and the point where the curvature changes from facing one way, to facing the other, is called the "point of inflection". At this moment of transition the trends represented by the curve are changing so rapidly that the situation may feel dangerously unstable, but this point also represents the unique moment of opportunity when even the slightest shift can profoundly affect the trajectory of the whole system.



Viewed from this perspective, a whole range of trends, some usually seen as positive, and others negative, might make sense when viewed together as part of a larger phenomenon, one that is in the deepest sense hopeful, and yet also profoundly challenging. Many of the trends, described below, represent the culmination of the first industrial revolution that began in the 1700's as a direct result of the scientific revolution of the 1600's. The end of that acceleration phase, reaching maturity at the cusp of the millennium, represents the inevitable shift that must occur from a system based on extractive resource use, to one characterized by closed loop cycles of material flow. As we will see, this adaptive transformation is strikingly similar to one biological nature adopted three billion years ago. In this framework, a potential plateau is implied, a new dynamic stable-state analogous to an octave of nature, that could be described as ***Meta-Nature***.

Challenging Global Trends

A number of global trends must turn out to be characterized by S-curves and Bell Curves instead of Log curves or J-curves if we are to survive. The most challenging phenomena include:

Over Consumption of Biological Resources: While many natural resources are theoretically renewable, we are currently using up, and irrevocably destroying, many of them at extremely unsustainable rates. If we do not rapidly change course we will use more than all of the available biological output of the planet for human purposes within less than twenty years.

Mass Extinction: Biologists are already calling the current loss of biodiversity *The 6th Extinction*, as it can only be compared with the five previous periods in the history of life on Earth when meteor impacts or other cataclysmic events caused massive extinction spasms. It took hundreds of millions of years for biodiversity to re-establish itself on Earth after each of those. By contrast, humans have only been around for two million years, and civilization for a few thousand. If current trends were allowed to continue it is estimated that we could lose half of all the plants and animal species on Earth within 30 years. Climate change alone could cause the extinction of an additional 30% of all terrestrial plant and animal species.

Population Plateau: While debate continues about exactly what the final figure will be and when it will occur, there is universal recognition that the population must stabilize in coming decades if we are to have any hope. The acceleration of population growth has actually reversed and began to decelerate in the 1970's. AIDS has not actually had much effect the total, but a pandemic of other new lethal diseases such as bird flu could change the size and timing of the peak population.

Peak Oil: The drop off in new oil and gas fields heralds the end of the fossil fuel age and the transition to solar and other clean renewable energy sources. Some analysts say we have already reached the top of the curve, while others say it may be as much as a few decades away. But the argument is now over when, not if, it is happening. What is not clear is how steep the other side of that curve will be, though all indications are that it will be more abrupt than many expect.

Global Warming / Climate Change: Even if we had more fossil fuel, we are running out of atmosphere faster than we are running out of oil. Coal poses an even more serious threat than oil to increase CO_2 levels, especially because both the U.S. and China have a lot of coal.

Global Markets: While debate rages as to whether free trade is in fact fair trade, for better or worse, the world is rapidly being transformed into one unified economic system. The negative consequences of current "globalization" may have more to do with unfair effects in the fiscal and economic rules that govern the process, than with the fact that it is becoming one global system.

Hopeful Global Trends

At the same time we are facing these challenges a number of other trends are emerging just in time to potentially allow us to effectively address them. These include:

Transformation in Technology: Given the advances we have seen over the last 100 years, it is likely that we can develop the scientific insight and technological capacity to achieve the order of magnitude increase in energy and natural resource use efficiency that will be required for the entire plateau population to enjoy a satisfactory level of material well being, support and comfort.

Information & Communication Technologies: The Internet, personal computers, cell phones, satellites, digital radio and television are all part of a revolution in digital communications, which is both enabling and driving massive changes in global culture, awareness and education.

Cross-cultural Understanding and Cross-fertilization: We are living at a unique moment of rapidly accelerated cross-cultural mixing, novelty and vitality.

Rise of Democracy: Throughout the world vast numbers of people are expressing a universal aspiration for political freedom and self-determination, often for the first time.

Growing awareness of the Interconnectedness of All Life: Catalyzed by revivified spiritual aspirations and identity, local grassroots movements striving to protect cultural and ecological resources are sprouting all over the globe. The image of the Earth from space symbolizes a new collective global experience marking this moment in history as different from all previous times.

Beyond The Solar Age – An Evolutionary Perspective

While many authors have pointed to the transition from the fossil fuel age to solar age, most discussions have lacked the larger context of what the dawn of the solar age actually represents in the evolutionary context of life on Earth. If we examine the industrial revolution as if it were an extension of the same natural, and indeed possibly inevitable, process of evolution that has guided biological evolution, several important and perhaps comforting themes emerge.

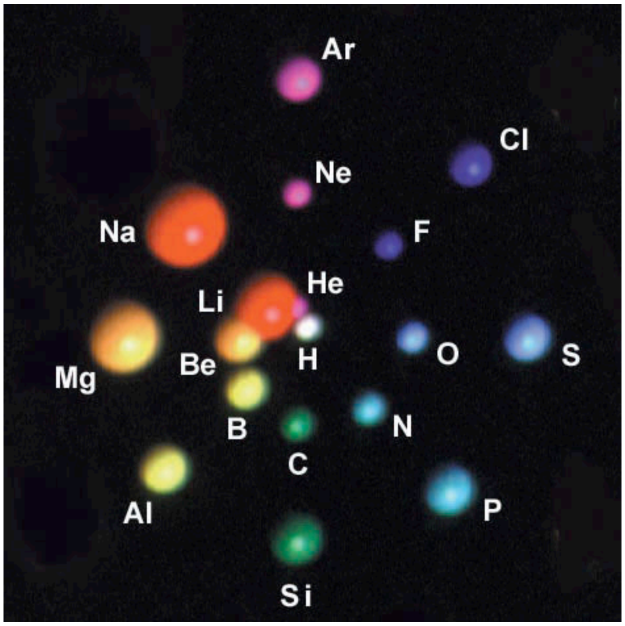
Peak oil and atmospheric CO_2 build up actually represent the second climate crisis and perhaps the third energy crisis in the biological history of life on Earth. The first energy crisis came when early life used up all of the freely available high-energy chemicals for food and had to suddenly invent/discover photosynthesis in order to capture and use energy from sunlight. The first climate crisis, the O_2 crisis (as in too much oxygen), came when these photosynthesizing bacteria had eventually released so much oxygen into the atmosphere that, after it had rusted all of the available iron, oxygen rapidly built up to such a concentration in the atmosphere that organisms apparently started spontaneously combusting. In response to this dangerous new energy source available in the atmosphere new organisms invented/discovered respiration. Ever since then photosynthesizing plants and respiring animals, bacteria and fungi have maintained the carbon cycle, thereby keeping the ratio of oxygen and carbon dioxide in the atmosphere in balance.

> ***Just as early organisms virtually exhausted available resources before discovering how to establish and maintain cyclic loops of material flows, humans have done the same with our industrial technology. We will either figure out how to make this transition like those successful organisms that survived, or go extinct like those that did not.***

Viewed in the context of the carbon cycle, all human energy combustion technologies are like hyper-animals; they are all on the respiration side of the balance between plants and animals. Like animals, our machines burn oxygen to consume hydrocarbons and give off carbon dioxide and water vapor. Actually, even human agricultural activities have moved the balance in that direction. As a result, we can see evidence that the atmosphere first began going out of balance long (in the human time scale) before the industrial revolution. Humans started shifting the atmospheric balance toward more CO_2 beginning with the first agriculture, ten or twelve thousand years ago, as we both reduced the total amount of tree cover and increased the overall rate of burning and decay.

Today, as the atmospheric balance suddenly appears dangerously out of balance to us, it is hard not to regard this trend with a great deal of distress, as the situation now, just as the one faced by our ancestors the microbes, puts our species under considerable evolutionary stress. Yet, seen from another perspective, what is occurring now may be just as natural, and possibly inevitable, as what happened at the dawn of photosynthesis or respiration. Moreover, just as at those moments in evolutionary history, we have already invented/discovered new ways to arrange matter that will allow us to harvest the energy we need.

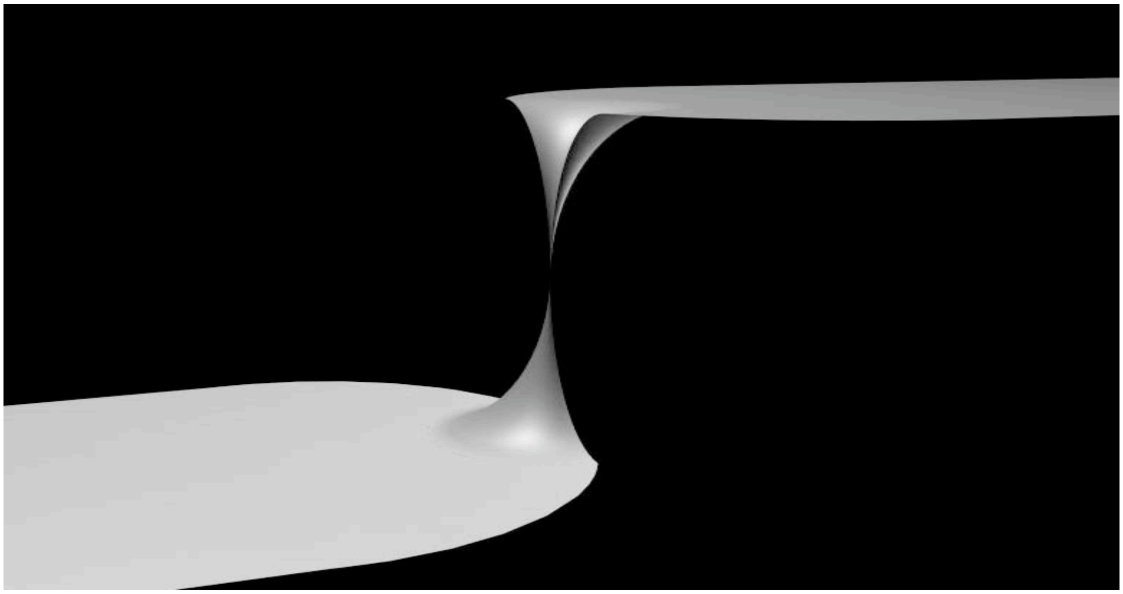
This time it is humanity's turn to perform the same kind of feat nature did millions of years ago and figure out how to capture sunlight in matter and transform it into a useful energy. Now, instead of doing this with carbon we are using silicon, which is in a sense the next octave of carbon, directly below it in the same central column on the periodic table.



This time, as with each of these previous evolutionary turns on the spiral, matter has arranged itself (now through humans) in a pattern that captures ten times as much of the energy from sunlight as photosynthesis. Silicon photovoltaics are an order of magnitude more efficient than plants. Granted green plants, like all biological forms in nature, solve many problems at once without any toxic or high temperature processes, and can reproduce themselves at ambient temperatures without external equipment. However, the illustration remains useful.

Meta-Nature

Silicon photovoltaics may be seen as the first example of a new class, or a new phase of human industrial artifacts, which express a level of coherence and elegance in their design approaching that found in nature. Indeed, these and other new technologies may point to a whole new class of human technologies drawn from a deep understanding of the same underlying geometric patterns and coherence found in nature's forms and expressing the same degree of chemical elegance in their composition and resource flows. Such technology might be described as being like an octave of nature, or ***Meta-Nature***, a set of solutions to the puzzle of matter as elegant as those found in nature, which like nature, already exist in potential in matter, and yet composed from a realm that may not assemble itself through biology except through the intervention of humanity.



We may gain further insight into the natural trajectory of energy technology by observing that over the last few hundred years the primary fuel source for human technology has progressed from wood, to peat, to coal, to oil, to natural gas, and since 2000, has been widely recognized as inevitably converging on hydrogen. What is most interesting about this sequence is that each form of energy storage has fewer carbons in relation to hydrogen until one arrives at pure hydrogen and has nowhere left to go. With hydrogen, one has arrived at the smallest, lightest carrier for chemical potential energy possible in matter. Thus, coincident with all of the other trends described at the outset, we seem to also be arriving at some sort of inevitable logical end point in the sequence of ways in which to store chemical potential energy in matter.

The Point of Inflection in Technological and Human Transformation

Humanity may actually be on the verge of suddenly recognizing that we have just turned the corner and are already rapidly headed toward a plateau where we will have achieved clean, sustainable closed-loop very long-term solutions for our fundamental energy and life support technologies. From this perspective, the transformation of energy technology that is occurring at the end of the oil age takes on a larger meaning. Fossil fuel begins to look more like an analog of the white of an egg, an energy reserve sufficient to allow a new organism to grow rapidly to a state of maturity at which point it makes a fundamental transformation to a state of sustainable self-reliance. The long-term solar-hydrogen technology will literally be born out of the nourishment of the fossil fuel age.

> ***For all of human evolution Nature was something with teeth and claws that could jump out of the dark and eat you. Now, in a single generation that situation has been inverted. Nature is suddenly something fragile that we must protect lest we perish.***

Those who suddenly understand this new imperative may feel dismay at our apparent failure to make this transformation rapidly enough. Yet, once one has glimpsed an even larger perspective, it seems perhaps inevitable that, like biological organisms near the point of birth, the global system can only make the transformation necessary by going into a dangerous period of rapid growth and turbulence to achieve escape velocity. The portion of the S-curve as it traverses the point of inflection may be so steep that it appears to be a log curve taking off to infinity. During the relatively brief period that the system traverses this highly accelerated and dangerous process, none of the existing systems can be sustainable because all transitional systems are appropriate only to that momentary period and are still too inefficient to be retained for long after. Once we begin to come out the other side of that brief period the technology for fundamental life support needs will start to become both increasingly efficient and increasingly durable. In the long run, only very efficient solutions will be appropriate to retain for the long-term, and only very durable solutions will be worth investing in, as the return on investment will increasingly be measured over longer and longer periods of time.

Efficiency and Longevity

As we pass through the point of inflection, begin to see where we must go and begin to adapt accordingly, we will discover that the technologies created during the disposable growth mode of the late 20th century were so inefficient that it will be very easy for us to suddenly make huge advances in efficiency. While these solutions will make huge strides they will still be a long way from the maximum efficiency theoretically achievable. They will not even begin to contemplate the durability that will theoretically be achievable in the future. This describes the life support technologies characterized by the portion of the S-curve from the point of inflection up to the middle of the curve. This period might be like the inverse mirror image of the industrial revolution. It might be expected to span a symmetrical period of time in the future, following the millennial fold point, as the industrial revolution represented preceding it. This could take a couple of hundred years to largely complete, though any termination would be impossible to define and therefore date. However, just as the rate of change has accelerated up to this point we might expect it to actually turn out to decelerate from roughly this point forward.

The section of the S-curve where it begins to flatten out as it approaches the horizontal asymptote represents fundamental life support technologies approaching an exceedingly stable long-term plateau, an analog or octave of nature that we are referring to as Meta-Nature. This plateau would be characterized by the advent of technologies that are so efficient, durable and elegant that they would be retained for generations, as it would become increasingly difficult to improve upon each successive iteration. And there would be no incentive to do so. For example, a perfectly doped silicon photovoltaic panel designed and assembled at the nano-geometric scale and perhaps encapsulated in pure silica. Such technology could be expected to last a very long time, such that one could imagine humanity living with it for seven generations and beyond.

A Shift in Consciousness

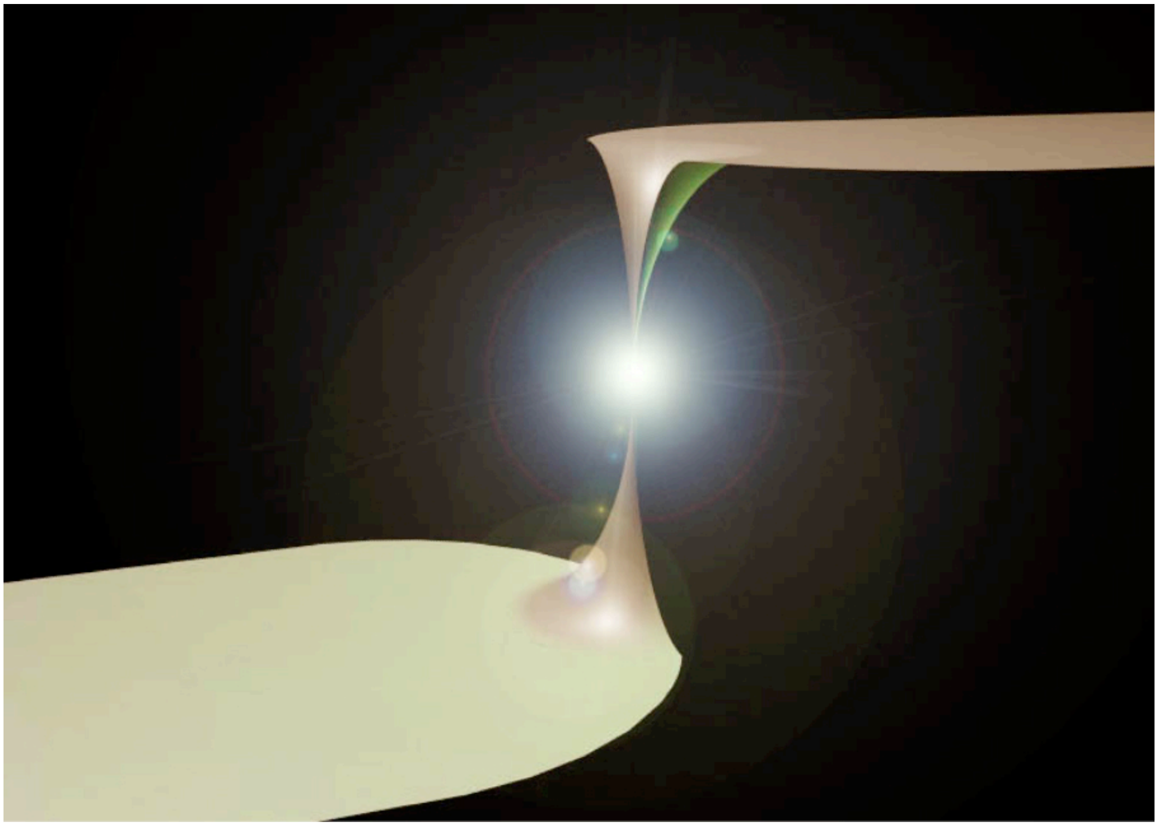
The point of inflection in the S-curve is also characterized by the point at which key individuals begin to recognize, and become aware of what is happening in the overall system and where it could be going if we successfully traverse the point of inflection. From this new perspective, it immediately becomes clear to them how their previous behavior in the absence of this new vantage point had in fact been necessary, appropriate, and perhaps even inevitable, to bring the system to its current state. But at the same time, those behaviors would now become counterproductive and even dangerous if they did not shift their actions to steer the system in a slightly different direction toward a stable long-term future. The shift necessary at his point is subtle, yet profound, as the vary recognition of the possibility of the long-term state will itself act as an attractor helping to make it self-evident to players how to adjust their behavior to bring that future into being more rapidly.

Climax Technology

One of the best and most optimistic examples of a climax technology breakthrough is carbon sequestration/utilization based on charcoal. The process can use a combination of biomass and coal to make an ammonium bicarbonate fertilizer and hydrogen. It has been demonstrated at a small scale that this approach can actually remove CO_2 from the air while returning carbon to the topsoil where it is needed. The same process can also continue to be used with biomass alone in the future to make bio-diesel and hydrogen along with the ammonium bicarbonate fertilizer. This technology creates a complete loop that functions like an industrial analog of the carbon cycle in nature, one that makes it plausible to not only reduce, but to reverse global warming in time. We will examine this in greater detail in the next section.

Many of the other technologies in question would be low-tech in their implementation, but pay tremendous dividends for much of the global population if they could gain access to useful and appropriate information. Examples of these include inexpensive bio-sand filters that allow people to gain access to cheap safe drinking water without electricity; or “swales”, contour ditches that allow people to reforest otherwise barren desert by catching seasonal rainfall and storing it as ground water that trees can tap into; or a host of permaculture and aquaculture techniques that can allow a peasant family to live sustainably on three hectares of spent land, rather than slashing and burning a hectare of virgin rainforest every year for meager subsistence.

The potential for all people to find a new sense of purposefulness and determination when given the mandate and the opportunity to rise to a meaningful challenge is immense. We have most often seen this in time of war when whole populations have reorganized themselves almost literally overnight. It is even more apparent in the face of natural disasters when people most selflessly pull together for the common good in the face of adversity. We have also seen it to some degree in the US with the New Deal and even the Apollo space program. It is very likely that the challenges of the coming decade will dwarf these examples and call for an even greater response, for we are entering the period of the greatest shift humanity has ever known.



The perspective outlined here is reassuring, as it suggests that even human technological activity can be seen as a natural and indeed inevitable process wherein everything that everyone has done up to this point was perhaps necessary. Evolutionary systems seem to naturally move toward higher states of coherence. Nature does this by itself, and thus what we're doing can be seen as part of a natural process. Once seen in this manner, that vary understanding also compels us to act differently in the light of this new vantage point, as we, as humans, have both a unique opportunity and responsibility to choose.

Peak Oil, Global Warming and Biomass

Two looming crises have recently emerged into public consciousness, “peak oil” and global warming. These two interrelated phenomenon are both signs of a larger phase-change in both human industrial energy transport and atmospheric chemistry. Both represent risks to the continuity of the global system as well as evolutionary drivers that will force the system to make adaptive transformations. Few recognize the full scope of the transformations that will be required, and virtually no one has articulated the upside opportunity of these adaptive changes. Some fear that given the inertia of the industrial infrastructure we might not have the time that we need to adapt. In any case we have very little time and the risks are increasingly clear.

Virtually all discussion of our response to global warming so far has cast the situation in terms of gradually reducing the growth in our overall output of greenhouse gasses. Yet, it is already clear that in coming decades the issue will not be a matter of slowing the growth in emissions, but of actively reversing the atmospheric level of CO_2. The consensus among the scientific community is that the effects we are already beginning to see now have been brought about by releases fifty years ago, and the effects of what we have already done in the intervening decades will be far more serious. A number of atmospheric scientists believe that a global temperature rise of even one degree centigrade could be enough to release the vast deposits of methane trapped in the permafrost. Methane is an even more potent greenhouse gas than CO_2, so such a release would set off a catastrophic positive feedback loop that would end civilization, if not outright extinguish humanity and much of the higher life forms on Earth. There is almost certainly already enough CO_2 in the atmosphere to bring us dangerously close to that level of warming. This suggests that we will need to intervene to remove carbon dioxide from the atmosphere to avoid catastrophe.

Peak Oil

Even many of those who remain in denial about climate change have begun to recognize the reality of peak oil. Peak oil is a relatively new term, at least to the mainstream, referring to the point in time when total world oil production “peaks” at its maximum level. The problem is not that production will suddenly cease following that point; it will taper off for many years. But from that point forward, the actual cost of producing the remaining oil will rise steadily, as it will require more and more energy, and become increasingly expensive, to extract oil from the remaining oil reserves as well as less desirable alternatives such as oil sands and oil shale. At the same time, the market price will continue to rise due to global demand exceeding supply. Energy prices will continue to rise until conservation sufficiently reduces demand and/or other alternatives become cheaper and more abundant than oil.

There is considerable debate as to exactly when peak oil will occur, with estimates ranging from 2000 to 2037, but 2037 is an extreme outlier, and many estimates are in the range of 2005 to 2010. In addition, perverse incentives in the way the accounting of oil industry reserves work makes it likely that each player has systematically over-counted their own reserves, thus inflating the overall estimate of global reserves. Each oil company's share value is tied in part to its stated reserves, so management has an incentive to publish the largest and most optimistic possible reserve numbers. In addition, the only way to estimate total global reserves is by doing meta-statistical analysis of the overall global rate of discovery of new fields over time. To do this, all of the discoveries throughout the world must be added together in a huge statistical model. However, for this model to be valid it is important not to double-count new discoveries within already known reserves. Yet, from each company's point of view, every new discovery is a good PR opportunity for share prices, etc. So, there is a natural inclination not to include a new discovery within the context of any previously known reserve.

In addition, the actual amount of a theoretical reserve that can ultimately be produced will be reduced if the oil is extracted faster than a field can geologically accommodate. In other words, if we pump it out too fast, we will not be able to pump as much of it out in the long run. Both the pressure on the gulf states and other producers from the United States government to keep oil cheap and abundant, and the pressure from shareholders to make high immediate profits as prices increase, have served to induce both oil companies and oil producing countries to extract oil faster than their oil fields can actually support. As a result, most producers will probably not be able to actually extract all of their stated reserves.

Global Warming

The conventional alternatives to oil are natural gas and coal, while natural gas does produce less greenhouse emissions than oil, its supply is also limited, and it will peak sometime soon after oil. Coal is abundant, but with such serious greenhouse gas emissions that it appears suicidal in the face of global warming. This raises serious concerns about global warming for many observers as the advocates of coal within the current US administration appear to be in complete denial about the reality of global warming. Oil sands are also abundant, but almost as bad as coal.

From this perspective, the situation appears frightening if not verging on hopeless. On the one hand, many observers suggest that peak oil will precipitate global economic upheaval and wars over control of remaining oil. We are apparently already seeing this in Iraq and may be just beginning to see it in the price at the pump. On the other hand, the consensus of scientific opinion warns that we face immanent destabilization if not catastrophic collapse of the atmospheric balance due to climate change. We are already seeing the first minor signs of climate instability in the spate of hurricanes in Florida, record heat, cold and flooding in the UK and western Europe, melting of the North Poll sea ice, loss of glaciers and a major ice shelf in Antarctica as well as droughts and advancing deserts throughout the world.

The Effect of Agriculture on Soil Carbon

Before outlining a little known cause for optimism around CO_2, we should touch on one other larger long-term dimension of the situation. The industrial revolution and the so-called green revolution combined have actually caused two fundamental imbalances in the natural flow of chemical elements in the biosphere. It is now increasingly well understood that excess carbon dioxide released into the atmosphere is causing an imbalance. Global warming is a household word today. However, the other serious imbalance is far less widely recognized even though we have known about it for several decades longer. There is an imbalance of too little carbon in our soils due to the excess use of petrochemical fertilizer and pesticides in industrial agriculture as part of the so-called *green revolution*. The resulting depletion of the soils could be as threatening to human civilization as peak oil. For the most part, soil depletion does not make headlines, as it is a slow pernicious condition, which few of the parties' involved wish to even acknowledge.

The affect of human agricultural practices on both the atmosphere and the soil are tightly coupled. As stated earlier, the first evidence of human effects on the balance of CO_2 in the atmosphere appear not at the time of the industrial revolution, but all the way back at the dawn of agriculture 10 or 12 thousand years ago. When we first started reducing tree coverage in favor of open fields and increasing the rate of burning and decay, we began to slightly increase the relative concentration of CO_2 in the atmosphere. This trend clearly accelerated with the invention of fossil fuel combustion technology. Yet the act of tilling the soil is itself an act of combustion. The suddenly exposed soil is oxidized in a manner that it would not have been otherwise, releasing excess CO_2 in the process. What a chemist would describe as oxidation is the same as "burning," i.e. exothermically removing cat ions with an oxidizing agent, in this case oxygen, which combines with carbon and hydrogen atoms to form CO_2 and H_2O. We can see that both industrial combustion of fossil fuel and agricultural activity, particularly when practiced with industrial equipment, rapidly accelerated the transfer of carbon into the atmosphere. In the case of agricultural practices, this trend was also further exacerbated by the introduction of large amounts of urea based nitrogen fertilizer. While plants do need nitrogen, they also need a balance of healthy soil organisms to maintain aerobic balance and to prevent both erosion and compaction of the soil. When large amounts of nitrogen are added with very little carbon from organic matter, in conjunction with pesticides and herbicides that kill not only harmful pests but also healthy soil organisms, the result is a systemic, and at times catastrophic, loss of soil carbon.

Thus, we can see that just as industrial combustion technology has created an imbalance in the concentration of carbon dioxide in the atmosphere, industrial agriculture has also contributed to that condition through by oxidizing carbon from the soil where it is needed, and creating even more atmospheric CO_2 in the process. In addition, the vast amounts of concentrated nitrogen fertilizer applied to agricultural lands do not stay there. Especially in the absence of healthy aerated soil with high carbon content, nitrogen tends to leach out and wash off to become a pollutant in waterways and even in the oceans. The nitrogen runoff in the water creates conditions for algae bloom and overpopulation of aquatic plants. Algae blooms then use up dissolved oxygen in the water causing fish die off in rivers and lakes and even the ocean.

The point is not to demonize industrial agriculture or industry in general, but rather to show that these modes of activity have natural limits. Going beyond those limits has caused imbalances that have now become dangerous to the well being of the biological system as a whole. The fact that a large number of these trends are becoming super-critical at the same moment can be seen as evidence that the system is reaching a point at which it needs to jump to a higher order of coherence. The exact nature of both the imbalance we face and of the characteristics of the new modes we must adopt may be understood by examining the cycles of exchange of the simplest chemical compounds in the atmosphere, soil and water.

Now we are ready to look at a fundamental new class of solutions to atmospheric CO_2, soil carbon and energy, which are as yet almost completely unknown even to most experts in the field.

Carbon Sequestration

Recently, there has been a great deal of interest in carbon sequestration—in how to get rid of the carbon after we get the energy we want out of fuels that contain it. Many even look at biomass this way. The assumption has been that if we want to correct the problems associated with global warming we will need to somehow store a lot of carbon somewhere to keep it out of the atmosphere. The carbon comes off as CO_2 gas from combustion, so the first, most simpleminded, efforts have concentrated on injecting this gas underground. It can actually be injected to help extract more oil from oil fields in those locations where a power plant is in close proximity to an oil or gas filed. In addition to being inelegant at best, many of these schemes would actually consume so much energy in the process of trying to sequester the carbon that they would make little sense in terms of energy, much less economics. There are a number of other approaches to making inert, but essentially worthless materials, such as calcium carbonate by combining the CO_2 flue gasses with calcium. This is essentially limestone, the main constituent of cement before it is calcined, or heated to make it into cement, and may offer a viable solution, though it is not clear whether the thermodynamics will allow this approach to be viable at the scale required. The problem is that all of these approaches also require significant additional energy and therefore costs, both in dollars and in extra CO_2 production, to achieve the desired sequestration objective. However, there is also a new set of technological solutions that offers a fundamentally different approach to the problem. These focus on charcoal as a beneficial soil amendment.

Soil Carbon from Charcoal

When the first Europeans sailed up the Amazon in the early 1500's, the first accounts told of cities of millions of people inhabiting parts of the Amazon basin. But when the next expedition returned two decades later they found nothing. The first visitors had apparently brought small pox and other virulent diseases previously unknown in the New World and within a few years these plagues had decimated a densely connected population devoid of immunity to European diseases. Until very recently the scholarly consensus on those first accounts had held that they could not possibly have been true and must instead have been grandiose fabrications of an adventurer. That view was based on the assumption that Amazonian soils were simply too poor to allow the agriculture necessary to support large populations.

However, in recent decades soil scientists and then a few anthropologists began to investigate the *Terra Preta* or "black earth" soils that still persist to this day in large patches throughout the area.

These soils are clearly of human origin, containing dense deposits of pottery fragments and one key ingredient—charcoal. Once established, not only are these soils still exceedingly fertile more than five hundred years later, but they also grow back. In places landowners actually harvest them regularly as they will regenerate themselves over a few decades if a layer is removed. Nobody completely understands this in detail yet, though soil scientists around the world from Japan to Brazil are now intensively studying the effect of charcoal on soil fertility. So far, these early studies indicate that most soils will absorb 10%-15% charcoal with steadily increasing fertility as the concentration is raised up to that level. In addition, investigators have learned that the charcoal must be made at what by industrial standards is considered low temperature, less than 600 degrees centigrade. This appears to be due to the resulting physical characteristics of the charcoal, which when made at low temperature contains tiny pores in its structure. These then act in a manner similar to a coral reef, creating a home for a complex eco-system of symbiotic bacteria and microrisal fungi which are highly beneficial to plant fertility.

Charcoal and Hydrogen from Pyrolysis

The traditional method of making low temperature charcoal is to build a wet heap and use a slowly smoldering fire to heat wood in the absence of oxygen. This works to create the agricultural charcoal, but a few years ago an American researcher chose to take a different approach. Danny Day had previous experience with producing charcoal under industrial conditions, so he chose to use a process called *pyrolysis* whereby a source of biomass, such as wood chips or peanut hulls, is heated in a closed vessel in the absence of oxygen. Relatively low temperature “waste heat” from another industrial process, such as a power plant, could be used as the source for this heat. The biomass gives off a mixture of hydrogen (H_2), steam, (H_2O) and a small amount of carbon dioxide (CO_2), while converting almost all of the carbon into charcoal, which is virtually pure carbon (C).

Once one understands that charcoal can be used as a soil amendment, this approach by itself is a valuable departure from other carbon sequestration schemes if used with biomass. By simply making charcoal and burying it in the soil most of the carbon from the biomass is locked up in a solid form, while the hydrogen can be separated and used for energy in a fuel cell, or recombined with CO_2 to make green-diesel or ethanol. However, what really makes this approach to biomass exciting is the sequestration of CO_2 from a fossil fuel source that can be achieved by adding an additional step to this process.

The Eprida Process

Here's a summary of the chemistry involved in the full Eprida process that Danny Day developed in conjunction with a Chinese scientist working at Oak Ridge National Labs. First, biomass is heated to 600 degrees centigrade in a sealed vessel to make charcoal, hydrogen and steam, by pyrolysis. The hydrogen is separated from the steam and other volatile organic oils. About 70% of that hydrogen is available to be used for energy, either directly in a fuel cell, or to make green-diesel or ethanol. The other 30% of the hydrogen is used to make ammonia (NH_3) by fractional distillation of nitrogen from the air. This step is the same as the Haber-Bosch process that is currently used by the fertilizer industry to make ammonia using natural gas. The ammonia is then combined with the charcoal and a source of CO_2 gas, such as the flue gasses from a coal-fired power plant. When combined in the presence of charcoal, the ammonia and CO_2 react and precipitate out to form a solid ammonium bicarbonate fertilizer on the charcoal.

Unlike the conventional urea based petrochemical fertilizers commonly used today, ammonium bicarbonate fertilizer returns carbon to the soil, and the charcoal adds much more carbon. In fact, when used with biomass by itself, the process stores virtually all of the carbon that the biomass removed from the air in the soil in a stable form. Thus, the process actually removes net CO_2 from the air when used with biomass by itself. When used in conjunction with a fossil fuel, such as coal, the process will offset virtually all of the CO_2 as well as all of the NO_X and SO_X (nitrogen and sulfur compounds) that would have been produced by the coal plant alone. The pyrolysis process converts almost all of the carbon from the biomass into charcoal, which becomes a stable form of carbon in the soil. In addition, creating the fertilizer scrubs about 60% of the CO_2 out of the flue gases from the coal-fired power plant. Thus, a large part of the carbon returned to the soil also comes out of the CO_2 from the coal plant. This is all removed from the atmosphere when it becomes fertilizer in the soil. Net carbon returned to the soil also represents a net reduction in atmospheric carbon dioxide. This by itself would be impressive, but as it turns out there is also an even larger transfer of carbon to the soil, which continues to occur long after the charcoal is added to the soil. The charcoal acts like a coral reef for soil organisms and microrisal fungi, setting in motion a burst of organic activity that will pull even more CO_2 out of the atmosphere for many years in the process of growing out a whole micro ecosystem in the soil.

In addition to scrubbing CO_2, the process also scrubs the NO_X and SO_X out of the power plant flue gasses, turning these compounds, which would otherwise be pollutants responsible for acid rain if they were released into the air, into useful additions to the solid fertilizer. These contribute additional nitrogen and a small amount of sulfur to the fertilizer where these elements are actually beneficial. The only remaining pollutants from the coal-fired plant are the small amounts of mercury and other heavy metals that must first be scrubbed out using activated charcoal, which is already a well-understood technology. The process also does not, of course, address other collateral environmental damage cased by extracting the coal, but that is a separate issue with other possible solutions if the coal industry were to internalize those additional costs.

Summary

The new Eprida technology offers a smooth pathway to retrofit existing power plants to use coal as a transitional fuel for many decades, stabilizing CO_2 releases to the atmosphere in the process. When used with biomass alone the process can actually be carbon negative, removing net CO_2 from the atmosphere and reversing damage that has already been set in motion by industrial activity over the last fifty years. The new biomass infrastructure that will be built up as part of this transitional process, does not deplete the soil and actually returns more carbon than it removes from the soil when used in conjunction with fossil fuel, helping to restore the carbon balance in the soil as well as the air. The process produces hydrogen from biomass, thereby creating a smooth transitional process to establish the long-term hydrogen infrastructure. This builds a new biomass-based infrastructure as the source of hydrogen that will be used in the sustainable long-term closed loop energy economy. The fossil fuel plants continue to produce electricity for the existing electrical grid as well as cement and steel where the same retrofit can also be used to stabilize the carbon impact of these industries on the atmosphere. Of course, wind, and ultimately solar, as well as possibly ocean thermal, deep geothermal and even tidal will also all comprise growing percentages of the overall energy supply as components of the long-term renewable energy mix.

Another transitional pathway with the Eprida biomass-based approach is making green-diesel. The European vehicle fleet is almost half diesel powered at this point, and next generation diesel technology offers exceedingly clean emissions. For the coming decades small clean diesel motors powering lightweight hybrid vehicles may offer the best transitional pathway for much of the vehicle fleet, and diesel may remain the optimal fuel in the agricultural and trucking sector for many decades, if not indefinitely. It is the ability to implement a transitional set of solutions that can at once incorporate exiting capital equipment and infrastructure, while actually removing CO_2 from the atmosphere and restoring needed carbon to the soil, that are the key features that separate the Eprida breakthrough from all other strategies under consideration.

A New Carbon Nitrogen Cycle

The preceding explanation was still framed within the context of our current worldview. However, we can also understand the transition to this new integrated carbon cycle technology in a larger context. The Eprida process represents an analog of the carbon cycle in nature for human energy technology. That is, it represents a truly cyclical closed-loop relationship between energy extraction transformation and transport, soil chemistry and atmospheric chemistry that resembles the elegance found in the carbon cycle and nitrogen cycle in nature. This is a profoundly important transition for human technology. It represents a solution which achieves the basic theoretical criteria that any truly sustainable human energy technology must attain. At the same time, like the carbon cycle, this characteristic is a good indication that virtually all future energy transport and combustion technology will utilize these same basic chemical pathways. This is not to say that the exact design of the infrastructure to facilitate these reaction pathways will not continue to evolve and change to achieve a growing level of sophistication and efficiency. But like the carbon cycle, involving photosynthesis and respiration, where the basic chemical reactions have remained virtually unchanged while being embodied in a wide and ever-changing spectrum of organisms, it is reasonable to expect that the basic chemistry of energy exchange will continue to use this same basic set of chemical pathways. There is simply nowhere else to go within the spectrum of the chemical elements, and no need to. We have arrived at the dawn of the truly sustainable climax technology.

New Economic Game Rules

The most fundamental shift that would both enable and require new approaches to the Global situation would not involve technology so much as changes in the social-economic “game rules.” These rules constrain and dictate virtually everyone’s behavior within the current system.

At some point in any discussion of a sustainable future or adaptive alternatives to our existing short-term practices, the discussion turns to the constraints of the economic system and financial markets. While many economists take for granted that the existing money system is inevitable, like the laws of physics, and that no other alternative is possible. It is more accurate to regard our economic system as a human construct; a set of game rules, which are actually only maintained through carefully orchestrated efforts and have many potential variations, each with a set of likely consequences. It is an open question among some observers whether stability can be preserved in that system, and for how long. The increasingly speculative nature of the vast flows of wealth, deepening social inequity and unprecedented ecological crises will all pose serious challenges to the system. From this perspective, it is quite plausible that the global monetary system could suddenly go into crisis due to its own inherent instability before anyone can intervene. Fortunately, the same innovations which could help to alleviate the myriad local economic problems racking the system now would also be most likely to help recover from a global crisis.

The current monetary system is based on “fiat” money. That is money created by fiat out of nothing based on collective trust in the system. Central banks create the money supply by lending money into existence. Thus, our money is debt-based; it comes into existence with interest attached. In addition, fiat money must, by definition, be scarce to have value and thus bring with it positive interest rates. It can be shown mathematically that positive interest necessitates short-term thinking by rapidly discounting the future. This by itself requires all players to act in an unsustainable short-term manner toward nature, and human labor.

Debt-based fiat money is very good for doing industrial revolutions. So, to the extent we have not concluded the transition from the oil age to the solar age, we may still need this kind of money for the second industrial revolution. However, it was primarily appropriate when scarce capital equipment, and to some degree human labor, were what constrained us most and natural materials were abundant. Now that the situation is inverted our continued adherence solely to debt-based money is threatening to destroy the life support capacity of the biosphere.

One approach to help gradually and smoothly shift the situation would be the introduction of a commodity-backed currency. Bernard Lietaer, designer of the Euro, proposes a trading unit called the *Terra*, backed by a "basket of commodities", i.e. a bushel of wheat, a barrel of oil, an ounce of gold, etc. In many ways the Terra is simply a rationalization of the massive existing barter counter-trade already conducted between and among multinationals, in part as a hedge against currency fluctuations. But the Terra would have the advantage of being counter-cyclical. That means it would be a hedge against economic volatility: in an economic downturn companies holding excess inventories of the constituent commodities could generate liquidity by converting them into Terras, in boom times they would convert their Terras back into commodities and use them as raw materials for production. Such a system could suddenly become the safety net in case of loss of faith in fiat money in a financial meltdown, but could also potentially have other indirect benefits in helping to transform financially driven time horizons. With debt-based money the future is literally discounted. The interest rate is also called the discount rate, the rate at which the future value of money must be depreciated. By contrast, with a commodity based trading currency, or trade credit, backed by warehouse receipts, currency is no longer a good store of value because the underlying commodities have storage costs. If I bring my receipt back to redeem commodities after a period of time has elapsed I will get less back than I left on deposit as part of it went to pay for the storage costs of the actual underlying commodities. Thus, the trade credit effectively has a negative interest rate. Such a credit is very safe and thus very useful for trade, but is more like a hot potato that you want to use for exchange, but never hold as a store of value. This type of money was used in ancient Egypt and in medieval Europe when the cathedrals were built. As we can see, under such a system there is a natural tendency to create truly enduring stores of value.

Complementary Currencies

Systems that facilitate the local exchange of goods and services based on either mutual credit, or time dollars, are also promising for invigorating local sustainable economies, transforming social services and alleviating health care crises. The Japanese government has been studying and experimenting with complementary currencies intensively for several years as a way to avert bankruptcy in their health care system. These represent a topic for another large section, which will be included in subsequent versions of this work.

Externalities

The second major source of dysfunction in our current economic system is the existence of externalities, i.e. costs which individual entities, usually corporations, are permitted to force the rest of society to absorb, rather than internalize in their own pricing and balance sheet. This systemic situation could be solved by international agreement changing the global rules of trade.

For example, a simple approach would be to phase in a new trade provision specifying that, any corporation that fails to fully account for, and internalize, all costs associated with the production and sale of their goods or services shall be responsible for a multiple of the actual cost avoided. The penalty could be imposed as an import tax. The rate might start as a tiny percentage of the avoided cost and grow steadily to 200% or more over a period of a decade. If managers knew that this cost was going to predictably increase over time they would incorporate full cost accounting into their normal operations and make investments in plant and equipment to change practices so as to avoid these penalties. All competitors within a given industry would face the same challenge, so it would not give any one company an unfair competitive advantage, though inherently dirty and costly industries would suffer in comparison to cleaner and less costly alternatives. Any company that could document that an error was made in good faith would have a valid claim against their own insurance (but might also pay higher future rates accordingly). Violations found to have been made with malice of intent would be a liability that would come directly out of shareholder equity in the company. In this manner, it becomes the responsibility of every corporation in each industry to insure that it has accounted for all costs associated with its activities. Lawyers would police the system earning lucrative settlements, at least until the system adjusted and violations became increasingly rare as executives rapidly restructured in response to shareholder pressure to avoid costly violations.

The Map

In thinking about the state of the world and the transformation we must bring about in our lifetime it will be useful to have a map, a way of categorizing what to pay attention to and how it all fits together. These five key variables in the system represent material indicators that will determine the fate of the world.

- Biodiversity
- Population
- Technological Efficiency
- Biological Resources
- Energy

In very simple terms humanity must to do three things to make it:

1. Maintain Biodiversity (maximize)
2. Stabilize human population (minimize)
3. Improve efficiency of technology (maximize)
   (minimize use of energy & biological resources)

This short list is meant to serve as a compass. It may not always be useful for making day-to-day decisions, and yet it does provide guidance about what to focus on first. It will also be useful to make some distinctions within each of these categories and then to work backwards up the chain of causation toward the three high level outcomes.

All three are linked in a classic equation describing the overall impact of the human population:
Total Consumption Impact = Total Population x (Affluence divided by Efficiency)

This says is that with a sufficient increase in the technological efficiency of energy and resource use the entire population of humanity could potentially live sustainably in sufficient abundance.

What is not adequately recognized is that if we fail to do so, the large portion of the population currently left out due to poverty would destroy the biosphere, but a much smaller portion that is both rich and inefficient would destroy the biosphere even faster. We are all in it together.

While the actual phenomenon represented by the three objectives outlined above are complex and interconnected, in general terms the business sector is likely to be effective in dealing with the third goal, increasing energy and resource efficiency. The first goal, biodiversity preservation, and to a large degree the second, population stabilization, should be the responsibility of governments, but in the United States at least the federal government has not only abdicated responsibility, but seems to be actively going in the wrong direction. This leaves philanthropy and the NGO sector as the only societal institutions actively working to address the most critical issues determining the future of humanity.

Given increasing energy prices the private sector will adapt appropriately with increased efficiency both in reducing energy demand and in developing and deploying alternative sources of supply. Thus, everything from insulation to hybrid vehicles to wind, solar and fuel cells will happen almost automatically given sufficient price signals. To some degree other adaptive collateral changes will also follow. For example, industrial agriculture will have to reduce the massive energy inputs as the price rises beyond a certain threshold and this will drive adaptive changes in the direction of more sustainable practices. Unfortunately, while there may also be some benefit from increasing the transportation costs involved with rampant extraction and destruction of virgin forests, there is no sign that the existing economic system as currently constellated will generate appropriate price signals until a natural resource has already been effectively exhausted. For example, fishing fleets are largest and most economically efficient producing at the maximum rate at the last moment before a fishery finally crashes. The cost of (over) production is not actually tied to the rapidly approaching scarcity of a natural resource until that resource has actually been so depleted that it can no longer be extracted. In the case of a biological resource at the global scale this may be the point where the underlying ecosystem is suffering massive extinction of species.

Thus, with government frequently co-opted by money from those seeking to prolong their short-term advantages from unencumbered extraction, the only institutions in a position to resist these trends and buy some time are NGO's and their philanthropic backers. The most critical factor for the survival of humanity could be the capacity of philanthropists to recognize the scale of the challenge we are facing and the need to act to intervene decisively over the next decade to insure and viable world for all future generations. If the goal of philanthropy is to establish a lasting legacy, one could not hope for a greater opportunity, or challenge.