

AGRICULTURAL MANAGEMENT SYSTEMS, INC.

Can We Survive?

Changes Required to Deal Effectively with Global Warming

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Status quo thinking provides significant barriers to recognizing and deploying existing solutions for keeping global warming and associated problems within limits mankind can tolerate. This paper identifies the impediments, explains their nature, proposes a way around them, and describes several existing solutions that have yet to be widely recognized.

Introduction

Four significant, highly coupled physical problems are likely to reach critical stages over the next two decades. They are: (1) global warming and environmental degradation; (2) depletion of key resources including oil, gas and potable water; (3) pollution caused by use of fossil fuels with current technologies; and, (4) a world population that has grown beyond Earth's carrying capacity if the other three problems are to be held to tolerable levels.

Keeping these problems within tolerable limits will require definition of the actions that must be taken, the sequence in which they must be taken, and, rapid deployment of the largest set of integrated, knowledge-based changes the world has ever seen. Included in these changes is deployment of certain "survival" technologies; much of this article will discuss fundamental impediments to their creation, adoption and deployment.

Compartmentalization of knowledge along with various cultural, economic and business mores have severely limited understanding and implementation of optimum choices, actions, technologies and other changes necessary for our survival. These mores are: economic self-interest; profit motive as the sole determinant of action; lack of proper institutions to promote and manage the required changes; limitations, imposed by their own specializations, on the range of practical solutions that experts can create; and limitations associated with (non-expert) decision-makers formulating decisions that require expert knowledge.

We will suggest an institution designed to orchestrate solutions to the first three of the above four problems, and work around these impediments. The institute's role regarding the fourth would be to promote understanding of the need for population reduction as necessary for human survival and to help create improved birth control technology that enables it.

The Nature of Survival Technologies, with Examples

Coupling of these basic physical problems renders the creation of survival technologies exceedingly difficult and not always achievable by those possessing a narrow range of specialized knowledge. By survival technologies we mean those that are sustainable and provide to a significant extent for: human needs for energy, fresh water and population reduction; reduced human impact upon the environment;

keeping global warming within tolerable limits; and technologies that enable adjustment to negative environmental changes caused by global warming.

Survival technologies must be sparing in their use of nonrenewable resources and perform their function without producing much pollution or harming the environment. The wish list of survival technology characteristics also includes their being: robust, relatively low cost, rapidly deployable if possible, and compatible with existing infrastructure. As short hand we will refer to a survival technology with these characteristics as “practical.”

But even this formidable list is incomplete for energy technologies. Practical energy technologies must also have a high “energy gain.” Using gasoline as an example, the energy gain is the energy obtained by burning a gallon compared to the amount expended to obtain that gallon.

The amount of energy expended is that required to drill, produce, transport and refine oil, but also the energy required to make pipes, oil drilling platforms, construct refineries, and so forth. For other forms of energy such as electricity generated by wind power we similarly need to compare the total energy generated by a wind turbine over its lifetime to the energy needed to mine the metals, forge the blades, build the generator and the support structure of the turbine, and other factors related to its generation.

Unless all of these parameters are favorable, technologies upon which we will be totally dependent for our survival will at some point fail us.

Finally, since global warming is synonymous with climate change we must be certain that proposed survival technologies, in regions where climate change will occur, do not diminish the resources needed by the survival technology to function.

As a first example, a recent summer drought in Western Europe diminished water supplies needed to cool nuclear reactors. As a consequence, power levels of the reactors – and the electricity generated by them – had to be reduced, leading to limitations on air conditioning using reactor-generated electricity. This, in turn, resulted in the death of several thousand elderly people who could not adjust to the sudden heat stress they had to endure.

Consequently, the water-cooled nuclear reactor must not be considered a future survival technology in any region expected in the future to have significantly less fresh water unless the reduced water supply can be replaced in a practical manner.

A second example: Australia is presently suffering the worst drought in its history and a significant portion of its crops have failed. There has been speculation that the drought is due to global warming and may represent a permanent climate change. Such a change may result in the need to relocate up to six million people, but no one has suggested where.

Third: Some areas that grow much of the world's food are predicted to become hotter and drier due to global warming. In North America this includes the American Midwest, Southwest, and Far West. These regions in the future may no longer be able to support high yield agriculture because of lack of water.

In addition to reduced future rainfall, agriculture in the Midwest and South Central region of the US has depended upon the Ogallala aquifer, now approaching depletion. And much of the West and Southwest and parts of California get 80% of their water from mountain runoff of melting snow that has declined substantially because of global warming.

Finally, the growth of cities has increased their need for water; cities now compete with agriculture for this resource. Most of the water in the Imperial Valley, for example, formerly a major producer of fruits and vegetables, has been transferred to cities in Southern California. Imperial Valley farmland is being converted to housing developments that have less need for water. Thus, what was once a major food producing area is in now in the process of being permanently destroyed.

The technology that could enable humans to adjust to this climate change and maintain food production would be a practical, extremely low cost, energy conserving method of desalting vast quantities of ocean water.

Another example of a survival technology, that enabled population reduction, would be an injection that rendered humans sterile until another counteracting shot was administered. Wide adoption of such a technology would slow the growth of population to stabilize it or even reduce it below present levels.

Global Warming and Why It Requires Immediate Deployment of “First Round” Survival Technologies

Normally we like solid proof of outcome before acting on a major issue. But some aspects of global warming require us to deviate from this requirement. Global warming is a high value problem that, if it becomes pronounced enough, will put mankind's future on the planet in doubt. Given that potential, there are certain aspects of global warming that must be addressed in advance – like the quantity of greenhouse

gases in the atmosphere, their rate of increase, and the potential for global warming to become self-sustaining.

It is accurate to now describe the advance of global warming as being out of control. Recently published data for the years 2000 through 2004 show an astonishing average annual rate of increase of atmospheric carbon dioxide of 3.2 percent -- almost three times the annual rate of increase of 1.1 percent during the 1990's. The worst case of six scenarios of the Intercontinental Panel on Climate Change (IPCC), that predicts a 6.1 degree C increase in temperature over pre-industrial levels, has already been exceeded.

The time during which mankind can hold global warming to tolerable limits may be short: A common, privately-held view among the 3,000 climate researchers who participated in the recently-ended five year international study of global warming is that the time left is fewer than ten years. Not that global warming will be full blown within a decade, but that progressive and irreversible effects associated it will be locked in by then, beyond humans' ability to prevent them from eventually going to levels that mankind cannot tolerate.

In addition to the rapid increase of greenhouse gases in the atmosphere, and to irreversible environmental damage that is occurring, the aspect of global warming we find most disturbing is its potential to become self-sustaining. As Earth's temperature rises due to additional global warming, for example, the rate at which some natural sources put greenhouse gases into the atmosphere also increases; this, in turn, increases the Earth's temperature; and this increases the rate at which natural sources of greenhouse gases enter the atmosphere; and so on.

Such processes, well known to physicists and engineers, are characterized as having "undamped positive feedback upon the input." They are common in nature, not all of them related to increase in atmospheric content of greenhouse gases, and potential sources of unstable equilibria that, pushed too far, will continue to spontaneously drive environmental parameters beyond limits that humans can tolerate.

If tipping points are reached where natural sources of greenhouse gases continue to increase sufficiently and are self-sustaining, then the biggest contributor to additional global warming will be global warming itself. Although there is great uncertainty in global warming models as to how fast the following effects will develop, consider the following two examples of positive feedback of greenhouse gases:

The small amount of global warming that has occurred is causing permafrost frozen since the last ice age to begin melting. Permafrost contains large quantities of the greenhouse gases methane and

carbon dioxide, which (along with other natural and manmade sources of greenhouse gases) contributes to global warming which, in turn, contributes to more rapid melting of permafrost, and so forth. (One continuous deposit of permafrost in Asia is larger than the areas of France and Germany combined.)

As a second example, it has recently been found that soils are a depository of carbon dioxide and that the small amount of global warming that has occurred has increased the rate at which soils emit the gas. England has reduced its carbon dioxide output from manmade sources more than any other nation. Even so, by the end of 2006 the amount of additional carbon dioxide emitted by English soils due to global warming slightly exceeded the total amount saved by all emissions-cuts made in England up to that time. As far as future emissions cuts are concerned England has already made all of those that are technologically easy to achieve. Globally, soils may now be supplying as much as 30% of the carbon dioxide that enters the atmosphere.

A third serious example of undamped positive feedback of atmospheric greenhouse gases, currently under discussion, is the possible future release of loosely bound methane from our oceans. The ice covering the Arctic Ocean, for example, will essentially be gone in about 30 years. The melting of ice absorbs heat without causing a temperature rise and hence, may currently be retarding temperature increase of the Arctic Ocean as it melts. But after the ice is gone it is a different story and the ocean's temperature will begin to rise. Also contributing to the rise in ocean temperature will be replacement of the ice on the surface of the ocean by water; ice reflects 90% of the light falling upon it but ocean water absorbs 90% and changes it into heat.

At the bottom of the ocean is a solid form of the greenhouse gas, methane, in the form of hydrates, which are very temperature sensitive. If the temperature of the ocean water at the bottom increases sufficiently the methane will be released and enter the atmosphere. Molecule for molecule methane is 20 times as efficient as carbon dioxide in promoting greenhouse warming. And there is a lot of it; 10 trillion tons – much more than all the oil and coal on Earth.

The last time this happened some 50 million years ago life had a very hard time maintaining its existence and higher life forms tended to die out.

These and other examples suggest that both manmade and natural sources of greenhouse gases must be immediately addressed. And it doesn't matter what percentage of carbon dioxide comes from man-made versus natural sources; we know enough about the carbon cycle to know the ending if we allow

carbon dioxide in the atmosphere to continue to increase at its present rate of about 3.2% per year, and this rate appear to be accelerating.

In principle there are two approaches. One would be the use of techniques to reduce the output of some natural sources – difficult because most natural sources are distributed over large areas. The other approach would be a practical survival technology or technique that removed and sequestered greenhouse gases after they enter the atmosphere, irrespective of whether they come from manmade or natural sources.

In our opinion, capture and long-term sequestration of greenhouse gases from the atmosphere is the most important emergency measure that can be taken to compensate for fundamental problems of environmental destruction, global warming, population increase, conventional methods of energy generation and use, and so on. But it is an emergency measure only and, although tempting, we cannot rely indefinitely upon it and other compensating techniques by using them to avoid dealing with basic causes while we continue with life as usual.

Many of the necessary changes and technologies, however, will require timeframes longer than the time we have left to keep global warming within tolerable limits or prevent changes from being locked in that will eventually drive environmental parameters beyond limits that are tolerable. A conceptual solution is to immediately deploy certain “first round technologies” to buy us more time, such as instituting technology for large scale capture and long term sequestration of greenhouse gases from the atmosphere. The additional time bought by rapid deployment of first round technologies must be used to develop and deploy other necessary technologies, and make other necessary changes that, by their nature cannot be accomplished quickly.

Because there is no time left for research and development of first round technologies, their effect must be achieved by (1) employing technologies (or slight modifications of them) that already exist and are capable of being rapidly deployed; and (2) synthesizing optimized systems created from such existing technologies

Finding the Skills Required to Create Survival Technologies

The advantage of achieving a given capability through (slight) modification, synthesis and use of existing technologies is that the process is rapid. But not every desired capability can be achieved this way.

Some can only be achieved by the discovery of new science through basic research and its subsequent application, a process that can take decades.

Although there is much overlap, these two approaches call for different skills, different knowledge-sets and different ways of thinking. A few individuals can do both: most who are productive with one methodology however, are less adept at the other.

Specialization is, simultaneously, powerful and limiting in terms in terms of the range of solutions that an expert is able to generate. When an expert is assigned a particular problem the solution he comes up with usually falls within his or her area of expertise. But, if an *optimum* solution does not exist within the expert's area of expertise then we end up with a result that is less than optimum, and this result is not acceptable for survival technologies that must quickly satisfy a large number of criteria.

The skills of the "technologist" that enable generation of desired capabilities using existing science and technologies require practitioners who are, in a sense, the opposite of experts. To produce and apply the first round survival technologies needed today technologists must be generalists, versed in many different areas of science and technology needed as the elements for synthesis. Such individuals need not, however, be versed in any particular area of knowledge to the same depth as a specialist doing research in any one of the given areas.

The ability to choose the right science and technologies to achieve a specific capability in a way that is practical, and the insight to make practical changes to facilitate synthesis or introduce additional capability, is a partially unconscious process that can be improved with practice.

The first technologists learned their skills in the early 1950's, a time in our history that was very favorable to technology, through bootstrap trial and error. After that, their skills were passed on to others by apprenticeship. Teaching these skills by apprenticeship required high quality development programs in which just a handful of scientists and engineers worked the entire program; for, among other skills, there were system related "tradeoff" skills to master.

By the mid 1960's, however, the training of technologists began to decline; for compartmentalization of technology-development – first begun in the defense industry to make spying more difficult – increasingly became the practice in most large corporations, defense contractors and government programs.

Because few new technologists were being trained, as time went on technologist's skills became nearly extinct. They remain in a small number of aging individuals, some of whom have perfected first-round survival technologies in selected small, high tech companies.

Compartmentalization of technology development programs in multinational corporations, defense contractors, and government labs has had another significant negative effect besides preventing the training of new technologists. Encouraging experts within a development program to easily and frequently interact can compensate, to some degree, for knowledge germane to the development effort being distributed in different minds. Not only is such communication not encouraged today by the culture and structure of most organizations' research and development departments, but in some companies (certain large oil companies for example) it is forbidden.

These organizational features result in technologies developed by multinational corporations, defense contractors, and government labs lacking the characteristics required of a survival technology. To make matter worse, there are also other significant factors within these institutions that discourage or prevent development of first round survival technologies.

What is generally missing in these organizations are three requirements: technical people and management possessing the knowledge and skills needed to create or allow survival technologies to be created; internal development programs organized in a manner that encourages their creation; and institutional goals, mandates, and self-interests that promote their creation.

Sometimes the goals that are the publicly stated or implied, for example, in television ads, are the very opposite of the real ones existing within these organizations. Some oil companies claim to be environmentally responsible while being sued for significant environmental damage brought about by careless extraction of oil and improper waste disposal in developing nations. Other corporations claim in their commercials that their companies are attempting development of alternate energy sources in a manner that gives the public the illusion of progress and falsely suggests that, if large corporations with their vast resources can't do it, then nobody can.

Often small high tech companies are set up around the technology after it is initially developed. Such small high tech companies can avoid all of these three barriers, especially if the company includes as an influential member the technologist or technologists who developed the technology. But access of such

companies to capital sufficient to successfully commercialize and deploy their technologies is today virtually nonexistent.

The logical conclusion, to be discussed in greater detail, is that as long as the status quo persists there are few places left where survival technologies can be created and deployed.

A Cluster of Survival Technologies Developed and Perfected in Selected Small, High Technology Companies

Laymen often believe that all technologies within a particular category are roughly equivalent. However, this is not always the case. In what follows we discuss three survival technologies that run counter to this perception: a microorganism-mediated production of cellulosic ethanol; an inexpensive, large scale, energy-conserving method for desalinating sea water; and, a sensing and information technology that enables significant reductions in the use of energy intensive inputs to agriculture while simultaneously increasing yields in some crops.

A. Microorganism-mediated production of cellulosic ethanol

One first round survival technology, developed by a system-oriented technologist in a particular small high tech company, is a process for producing microorganism-mediated cellulosic ethanol.

In cellulosic ethanol production, not only are the sugars in the plant fermented into ethanol (as with corn-based ethanol production), but the cellulose, which is most of the plant's mass, is broken back down into sugars and also fermented into ethanol. So, cellulosic ethanol production is able to utilize almost the entire plant to make ethanol, resulting in many fewer plants and much less acreage needing to be used to make a given amount of this fuel.

Two methods of breaking cellulose back down into sugars are the use of a different enzyme for each different form of cellulose, and the microorganism-mediated process, which uses a different microorganism for each step but can handle all forms of cellulose with the same set of microorganisms.

The microorganism-mediated process is unique in its ability to make ethanol because it can do so with the input of extremely small amounts of energy -- which in turn results in little or no pollution, a large energy gain, and, an extremely low cost per gallon for ethanol produced by this process.

Furthermore, there are two existing biocrops requiring minimum cultivation that can provide respectively an astounding ten, and up to nineteen thousand gallons of cellulosic ethanol, annually per acre. In the US, these crops must be grown in southern states like Louisiana, Florida, and South Texas. Another biocrop, forage sorghum, however, can be grown throughout much of the US and yields sufficient cellulose

per acre to enable cost-effective commercial production (and use) of cellulosic ethanol to become local throughout much of the US.

The microorganism-mediated process of cellulosic ethanol has the following practical characteristics that make ethanol produced by this process the first desirable replacement for oil without any significant negative tradeoffs:

(1) The microorganism-mediated process, like other processes of cellulosic ethanol, can replace all oil imported into the US with specified biomass grown on no more than 10% of the acreage currently devoted to US agriculture. That is, unlike “corn ethanol” – which would require more agricultural acreage than exists in the US to replace all imported oil – no significant tradeoff of acreage is required for growing food versus biomass for fuel.

(2) The energy gain – the amount of energy produced in the form of ethanol compared to the energy needed to grow the biomass and turn it into ethanol is about 11:1. (Energy gain for corn ethanol is only 1.3:1);

(3) There is almost no pollution generated by the microorganism-mediated process when turning biomass into ethanol.

(4) Growing biomass for the process can be rendered truly sustainable if it's done right, even after oil and gas are gone or their use curtailed because of global warming.

(5) A simple, low cost, energy conserving step during manufacture removes all water to yield ethanol that is 200 proof.

(6) The microorganism mediated process of cellulosic ethanol production can use any mixture of cellulose –biocrops grown for the process, prairie grasses, straw or stubble left in the field after harvest of other crops, sawdust, scrap paper, etc. Other processes of cellulosic ethanol use dedicated enzymes to decouple cellulose molecules back into sugars. Enzymes are expensive, however, and each form of biomass requires a different enzyme.

(7) An additional step, applicable to some other biofuel production processes as well, can render this ethanol “carbon negative” during its manufacture – in the sense that the three processes, of growing the biomass, changing it into ethanol and burning the ethanol together remove more carbon dioxide from the atmosphere than they introduce. This is accomplished by: (1) growing biomass that requires minimum energy intensive inputs for its cultivation; and, (2) suitably capturing the copious amounts of carbon dioxide

that are released during the ethanol manufacturing process. After suitable capture the carbon, which is no longer in gaseous form, can be sequestered in a manner that will keep it sequestered for a millennium or longer. Once a biofuel has been rendered carbon negative during its manufacture it can be burned at all sites throughout civilization without having to capture any *additional* carbon dioxide produced by burning the fuel at each site – unless one wished to remove even more carbon dioxide from the atmosphere. In this sense carbon negative biofuels are compatible with all existing infrastructure.

(8)The cost of producing microorganism-mediated cellulosic ethanol is significantly lower than any other process of ethanol production -- well under US \$1 per gallon – providing substantial margin for rendering the biofuel carbon negative and then sequestering its carbon. (Current processes of cellulosic ethanol produce the fuel at around US \$2 per gallon.)

Thus, microorganism-mediated cellulosic ethanol is a practical replacement for most energy applications of oil and has a dual set of environmental benefits: The ethanol itself can be rendered carbon negative but also, to the extent it replaces oil, it eliminates one of the most carbon positive enterprises on earth – oil and its support industries and technologies.

Finally, this process of carbon negative energy production may hold significant worldwide potential for satisfying mankind's energy needs – even for nations without agricultural land on which to grow biomass – while contributing to reduction of atmospheric carbon dioxide. Simple, practical techniques (with suitable environmental safeguards) appear to be available to for stimulating growth of ocean algae and harvesting it for use as biomass.

B. Low cost, low energy desalination

Another survival technology, developed by a small high tech company, is a simple process, based on one hundred year old science, for large scale water desalination. It requires input of very little energy and produces fresh water at a cost of about 10 cents US per gallon low enough to use the water for irrigated agriculture. The company hopes to have a unit for public demonstration in about six months. The technology that is presently used for large scale desalination, mostly in desert regions, is based on reverse osmosis through membranes. However, it is energy intensive and the water it produces too costly for irrigated agriculture, about 300 cents US per gallon

C. Airborne remote sensing of plant health

A third survival technology introduced through the small high tech route is a set of breakthroughs in the field of remote sensing from low-flying aircraft with the practical potential of significantly reducing energy intensive inputs to agriculture, such as fertilizer and protective chemicals, and at the same time enabling increased yields in some crops.

The advances for this system were initially at the theoretical and process levels. They enabled significant increases in signal to noise, suppression of “artifacts” in the imagery, a unique scanner design that was more robust and more appropriate to agriculture, and a significant reduction in the cost of such systems. Use of the imagery in agriculture was also nonstandard.

These advances, in a practical sense, satisfied all but one point on the wish list for application of remote sensing to agriculture. They ensured that virtually every problem and condition of an agricultural nature was detected in its pre-visible or early visible stage, without artifacts appearing in the imagery to either mask or mimic agricultural problems. This enables inputs to agriculture, in many instances, to be used only when and where they are needed in the field and only in the quantities needed. The system never failed to detect a problem of interest to growers, as far as is known. This technology also lowers the cost and increases the efficiency of many aspects of agriculture.

Other important examples can be provided, but these and other significant technologies developed by small companies have essentially no chance of being recognized for what they are and successfully commercialized and disseminated. The reasons for their poor prospects are all related to lack of adequate capital.

Fundamental Factors That Discourage Creation and Deployment of Survival Technologies

As the above illustrates, creation of survival technologies in selected small, high tech companies is not a problem. But access to capital with which to commercialize them is. Let us first discuss the present inability of most small high tech companies to obtain capital with which to commercialize and deploy the technologies they develop.

Technologies developed by small high tech companies, the research and development personnel within such companies, and their positions and accomplishments before joining these companies, have, with one exception, essentially zero credibility with external decision-makers such as venture capitalists. The exception may be small, high tech companies in which key technical personnel are simultaneously researchers at selected universities.

There is usually no way around this lack of credibility. Most technologies do not function as simply and decisively as a light bulb being switched on and off. For example, the microorganism-mediated ethanol technology described above has been demonstrated along with appropriate measurements to potential, non-technical investors on many occasions. But investors were either unsure of what was being demonstrated or suspected that a trick was involved. The business plan was also not relevant to them because it had meaning only if the technology was real and unflawed, something they were not in a position to judge.

What about potential investors hiring someone with the proper knowledge to evaluate the technology for them? Over a period of several decades we have encountered only one instance in which a person with the proper knowledge and experience was brought in. The reason for this is that, in order for an investor group to choose a person with the correct knowledge and experience its members must already know something about the subject. And if representatives of the high tech company provided perspective investors with a list of individuals capable of making a proper evaluation, collusion was typically suspected. If you cannot assure others on the basis of knowledge presented to them because they cannot understand it, and if the situation is one in which trust is not possible, then there is really no way of assuring investors that the conclusions presented to them are valid.

There are two other serious problems associated with decision-makers having to deal with knowledge in which they are not directly versed. One is that solutions proposed by such leaders are often improperly framed. That is, a solution within the framework they have chosen will not be optimum, practical, effective, sustainable, or even possible.

As an example, Richard Branson, the Englishman who started Virgin Airlines and Virgin Mobil, offered a prize to anyone who could come up with a machine to capture and sequester large amounts of carbon dioxide from the atmosphere. One of the requirements to enter the contest was a detailed machine-design to be submitted on-line via the contest website.

Those with proper knowledge realized that a man-made machine would be far from an optimum practical and effective solution. The best approach to atmospheric carbon dioxide capture and sequestration was stimulation of a particular natural process, under specific conditions, followed by careful, long term monitoring of the results. It proved impossible, however, to communicate to Branson that although his goal was valid, he had framed the problem in a manner that rendered a practical and effective solution

unlikely. At one juncture a lower echelon employee stated that, "It was Branson's money and he could spend it any way he wanted."

This illustrates the need for society to have a means of first recognizing the best solutions irrespective of their origin, and then being able to communicate them with credibility to leadership.

US management – most often technologically unknowledgeable – frames the approach by which technical problems are to be solved and technology developments are to be implemented. At one time this was valid for development of commercial products; it is not valid, however, for the development of survival and first round survival technologies. Our survival is now coupled with commercial product and technology development by the fact that deployment of non-optimum commercial technologies and products use up nonrenewable resources and contribute to pollution.

As an example of these difficulties, contrast the early commercialization of reverse osmosis membranes for water desalination at DuPont, an excellent job of product development for its time, with the recent development by a small high tech company of the alternative, low-cost, energy-conserving method discussed previously as a survival technology.

Someone at DuPont, likely in marketing, realized that if reverse osmosis films could be perfected, they could be used for large scale desalination of sea water and DuPont would then have a new ongoing product to sell – membranes that periodically needed replacement that couldn't, for some time, be manufactured by others because of the know-how required and the patents that were likely to be acquired by DuPont. This development required professionals with state-of-the-art knowledge of reverse osmosis films and backgrounds in inorganic, polymer, and physical chemistry, and other specified areas of expertise that were either hired or transferred internally to the project.

By contrast the question asked by one of the technologists at the small company that developed the alternative method was, "What is the best way (i.e., quickest, sustainable, energy conserving, low cost and having the least environmental impact) to achieve large scale desalination." By virtue of the creative process, and the technologist's practical experience and way of thinking, developed in areas completely different from desalination and reverse osmosis, he devised a simple method based on very old science that could be implemented in a practical sense with a slight modification to existing technology.

Note that the same question of, "What is the best way ..." could not even be asked in any large company, and certainly not at the technical level. For one thing, no one would know what skills to assign to

the project if the question was asked that way. In addition, once the approach – reverse osmosis – had been chosen, and people skilled in implementing it were put in place, a “better, cheaper way of doing it” was no longer relevant and could not even be raised. Finally, some of the characteristics of the “better” method would not have established a marketing advantage based on know-how and patents. Consequently the path that was possible and natural at the small high tech company would not have been considered “better” in a business sense within any large corporation. Therefore, this vital survival technology could not have been developed at any large corporation.

Large corporations are not in the business of creating survival technologies, even if some have personnel capable of doing so and even if the disadvantage of their organizational structure for development programs could be overcome. They are in business to earn a profit and secure a marketing advantage, technology-based or otherwise, that increases the length of time over which that profit can be earned.

Finally, there is one other significant limitation associated with decision-makers having to deal with knowledge in which they are not directly versed: We all know that extreme descriptions and strong conclusions are almost invariably wrong or exaggerated because the real world doesn't usually work that way. But what of the rare situations in which an accurate description of a high value problem requires a strongly stated conclusion?

If, for example, we do have fewer than 10 years left to do the things necessary to hold global warming within tolerable limits, then a strong conclusion and set of immediate survival technology recommendations would be necessary to accurately describe the situation, its consequences, and the necessary responses to the problem. However, arguments describing the threat can be made with maximum credible impact only to those with the knowledge and background to understand the details of the argument and what they imply. To others, including most of our technologically unknowledgeable leadership, a strong conclusion and recommendation sounds like an exaggeration, and this may limit their understanding of the need for strong and timely responses – such as the need to immediately deploy first round survival technologies. (This limitation, together with short term economic self-interest, may explain the behavior of some industrial and financial leaders who deny the existence of global warming, or wish to continue using fossil fuels without the cost of carbon capture and sequestration for as long as possible.)

In general, most decision-makers in the US – political, financial and industrial – are technologically illiterate. (The same is not true for industrial leadership in some nations like Japan and Germany.) Given the survival needs of our time, we have leadership that does not possess the dimension of knowledge necessary to lead us effectively.

One of the authors christened this phenomenon the “knowledge barrier” in the 1970’s, when its primary recognizable effect was economic: delaying or preventing commercialization of technologies that could have significantly improved the economy; enabling commercialization of non-optimum technologies that used up nonrenewable resources and subsequently contributed to our present environmental problems.

The knowledge barrier was one of the more important factors leading over a period years to the decline of the US auto industry. People in charge do, allow to be done, and are able to manage effectively those functions that they understand and with which they feel comfortable. The functions emphasized by American auto companies were marketing, finance and sales. Although the so-called research budget at one of the big three was massive – at one time larger than the GDP of some small nations – any meaningful technical development, for example to improve mileage, manufacturing efficiency, and vehicle quality, and today lessen environmental impact, was given short shrift for decades.

By contrast the CEO of Toyota was a world class engine designer, and many of that company’s top management also have significant engineering credentials and experience to this day. This has resulted in greater manufacturing efficiency and quality – ideas originally brought to Japan by American statistician Dr. W. Edward Deming after they had been rejected by Detroit – along with technology development relevant to successfully increasing Japanese auto makers’ market share. Deming’s contribution was considered so significant in Japan that their Government raised a statue of Deming to honor him, thereby demonstrating a much more favorable attitude toward technology and manufacturing at the time than their US management counterparts.

The knowledge barrier as regards technology manifests itself everywhere: One of the authors sent a published paper to Al Gore’s office in Tennessee on the practical consequences of microorganism-mediated cellulosic ethanol that also contained a description of how to render cellulosic ethanol and other biofuels carbon negative.

The result, claimed in the paper, is a carbon-negative, low-cost practical replacement for all imported oil, compatible with existing infrastructure, and with no significant negative tradeoffs. Also included was a simplified version of the paper, written for laymen, that avoided jargon used in the field of biofuels. A phone call was made to one of Mr. Gore's many assistants to flag the importance of the paper and request that it not be lost in the large volume of mail that they receive. After failing to hear back for several months the author again called and was informed that all mail beyond the date that the paper had been received had been processed. When asked about the paper he was told that it had been thrown away because "... they had no one capable of evaluating it."

This story is not meant to diminish Al Gore's commitment to sounding the alarm about the seriousness of global warming. You could substitute the name of most any other political leader in the US and the result would have been the same.

In broader terms, specialization, which originally gave civilization a jump start, may now be one of the key factors that limit its advance or even brings it to a close. Many of the currently proposed so-called solutions for global warming, for example, are simplistic, improperly framed, incomplete, impractical, and will only be marginally effective even if adopted.

We return to small, high tech companies and their battle to achieve credibility in order to illustrate some important additional points concerning the ineffectiveness of our system of research, development and deployment of survival technologies.

Obtaining a federal research grant is not a pathway to credibility for small companies since granting agencies will not certify the success or value of the research. But federal grants, because of changes in the laws governing them, come with two significant drawbacks for small companies. All details of the research must be disclosed to the granting agency which will take no responsibility for protecting it except on a "best efforts" basis – legally almost meaningless. In addition, any federal agency, even one not involved in the grant, has the right to "co-use" the fruits of supported research without compensation, and this has often resulted in handing research results over to a multinational corporation to use on the government's behalf. Thus, government grants are no longer very useful to small companies as a vehicle for generating and retaining proprietary knowledge or technology.

When patents are granted, no judgment is made of the correctness of the science or technology involved. Nevertheless, patents are a significant source of credibility to prospective investors. The problem

is that recent changes in patent law make the process of applying for a patent extremely risky for small companies if the technology they wish to patent is a threat to a large corporation.

Six months to two years before an examiner reviews any patent application, it goes onto the internet for everyone to see including one's stated date of invention. But any large corporation has the resources to create a false history of invention that predates the date that is stated on-line, and then to claim the patent for its own, either to use the technology or, more likely, to suppress it. (At seventy dollars a barrel, for example, there are some seventy trillion dollars worth of oil estimated to be still in the ground – more than sufficient grounds to steal a patent representing a practical replacement for oil.)

Small companies are thus obliged to hold technologies that can cause significant change as trade secrets, because patents, as a practical matter, are effectively denied to them. And again, using the microorganism-mediated process of cellulosic ethanol as an example, any small company claiming to have developed such a technology without even having a patent to back up the claim, is non-credible to investors.

It is now easy to understand how survival and first round survival technologies can be created by small high tech companies and go unrecognized. They go unrecognized because of: (1) the general technological ignorance on the part of decision-makers throughout our society; (2) the lack of credibility of technologists, scientists and engineers who are associated with most small, high tech companies; (3) the lack of a widely credible designated institution, with the knowledge to judge these technologies, to review them and establish their validity for the rest of us; and, (4) as explained, the danger of losing the patent for any small company applying for one that would threaten the products or markets of a multinational – which invariably includes survival and first round survival technologies. (This renders the patent an impractical vehicle for protecting the intellectual property of small high tech companies.)

One final factor can suppress small company products or technologies that threaten a multinational. As a last resort such companies can be purchased by the multinational if it appears that the small company's product or technology might be able to reach the marketplace and succeed.

A small biotech firm, for example, recently developed an artificial version of high density cholesterol that, in an early test, showed promise of being able, with a limited number of treatments, to sweep clogged arteries free of plaque -- thereby reversing or even curing cardiovascular disease. This posed a threat to

manufacturers of statin drugs used to lower cholesterol -- which are much more profitable than the new technique would have been because they have to be taken continually for a lifetime.

This small biotech company was purchased for twice its current value by a manufacturer of one of the statin drugs, and the new technique has not been heard of since then.

To complete the picture we must examine the ability of defense contractors and government labs to create survival and first round survival technologies. We need to make a few additional points concerning formal venture capital and IPO's. In addition, we will discuss the current ability of most multinational corporations to develop survival technologies that was begun with the old example of reverse osmosis films being perfected at DuPont.

Formal "venture capital" as it exists today is a misnomer. By virtue of current investment criteria, capital for growth can generally be obtained only after the risk to the capitalist of investing in an unknowable technology, and after the early marketing risk, have both been eliminated. So-called venture capital is thus incapable of providing funding to small companies at the point when they need it move their technology toward initial commercialization.

Using ethanol production as an example, a small company with a new process, in order to meet eligibility requirements for venture capital, would first need several tens of million of dollars to construct a commercial plant that used its new process, and then sell its ethanol successfully, to demonstrate that its technology and business models were both sound. But, a small high tech company with a new ethanol process does not have several tens of millions of dollars with which to build its first commercial plant.

The goals of formal venture capital have nothing to do with backing survival or first round survival technologies. Today, each venture capital firm specializes in only one or two business areas and, if the small company cannot find a firm that specializes in the business area represented by its technology -- which was the case for one of the survival technologies described in the previous section -- then venture capital, even in principle, is unavailable to it at any stage of the commercialization process. Formal venture capital firms no longer care to get too far ahead of current technology and markets because they judge that doing so would increase their investment risk.

A small IPO, say on the NASDAQ, is also unavailable. Capital for publicly traded companies can be raised only for proven technologies -- and survival and first round survival technologies do not initially fall into that category.

Most multinational and large companies in most US industries have divested themselves of research and development operations, and consequently, of domestic research and development personnel. In many cases they have also given up some or all of their manufacturing to external organizations or sent it abroad. Consider as an example one segment of telecommunications, the US cell phone industry:

For the sake of short and intermediate term profit these companies have slowly transferred, on a contract basis, development, design and manufacturing of cell phones to independent companies in India as they simultaneously reduced and finally eliminated their own in-house development, design and manufacturing personnel.

At first they were still able to quote specifications for the next generation of cell phones to their Indian contractors, but even that capability has now been lost. They are now dependent on independent contractors in India for specifying, developing and manufacturing each successive generation of cell phones. The only functions these cell phone companies have retained are marketing and finance, which suits the skills of their company management. Their costs have been lowered, and design and manufacturing, which were always a headache for non-technically oriented higher management, were transferred out of the company. But, judged from the perspective of maintaining employment for those corporate technical personnel who might have been capable of creating survival technologies, something else was lost in the transfer:

The development of the next generation of cell phones is an example of small step linear development. The process can be reduced to a series of small steps, each one of which is obvious. Indian engineers have the skills to develop the next generation of cell phones; but not the ability to achieve big conceptual jumps often involved in creating survival and first round survival technologies. Since alternate technical employment is no longer available to US engineers or scientists who lose their jobs due to outsourcing, transferring development and manufacturing abroad may have professionally destroyed some of the few technologists left who are capable of creating survival technologies.

What are probably cultural limitations to technology development are recognized in some circles. Foreign companies that manufacture technical products in China know that you never do product design in China. The Chinese are proficient at theory but lacking when it comes to experimental science and design. Similarly, Japanese scientists and engineers are superb at linear research and development but not at the

big conceptual leaps. To their credit the Japanese recognize this limitation and have partially compensated for it by providing substantial financial support to several top tier American universities in exchange for the patents that come out of basic research at these schools.

There has been greater than a ten to one contraction in the number of private defense contractors and, consequently, the loss of a tremendous amount of expertise that resided in the minds of technical personnel who are no longer employed in the defense industry (or, for that matter, elsewhere in technical positions). In addition, the mind-set in the defense business is at the opposite extreme of the practical mindset required for development of survival technologies. Knowledge possessed by individuals in the defense sector tends to be deep but narrow, and compartmentalization of knowledge in development programs is extreme. Such factors are not conducive to creation of first round survival technologies.

Research funding at government labs has been extremely tight for years, and it now determines who can continue to work in their profession. Alternate positions are essentially nonexistent for laid-off scientists in virtually all sectors. Given this situation, the self-interest of people in such institutions to maintain as much research funding as possible for as long as possible, has become paramount.

Let us examine biofuels research at government labs, at a private lab doing research in biofuels for the Department of Energy, and at several university departments that have become centers for biofuel research. We will limit our discussion to the first significant practical development in biofuels, cellulosic ethanol.

These government-supported labs claim that it will take five to seven years before cellulosic ethanol is developed to the point where it is ready for commercialization. Their stamp of approval is vital to investors, and to small high tech companies seeking investment capital for cellulosic ethanol, because it confers *credibility* to the technology for investment purposes.

These labs appear to have sold Congressional Committees responsible for research funding on the five to seven year delay, during which time they will continue to receive research funding. But, if we only have less than ten years in which to contain global warming, we cannot wait for their approval so that our investors feel comfortable about investing in cellulosic ethanol.

Meanwhile, there are over a dozen foreign companies that have either gone commercial with cellulosic ethanol, building full sized plants of up to one hundred million tons per year, or are about to do so. But, to my knowledge, none of their cellulosic ethanol technologies are survival technologies because the

primary goal of these commercial companies is earning a profit – which, by itself, does not require that consideration be given to sustainability, pollution, a high energy gain, or any of the other requirements leading to a survival technology. One company even burns coal to power its ethanol manufacturing process.

Most of the activity at government labs in cellulosic ethanol is filling in details of approaches that have already been well-defined – for example, developing specific enzymes to decouple various forms of cellulose back into sugars, etc. These labs have at times shown hostility and, at best, disinterest in the microorganism-mediated process because the research for it has already been done. If they officially recognized it for what it is, then there would be no need for their own programs, and their research funding for cellulosic ethanol would probably be eliminated.

The reasons are complex and varied but, as things currently stand, we have few institutions from which first round survival technologies can be created and deployed. Models have been presented that seek to explain various aspects of the impediments but the forest should not be lost through the trees. The above claims of the existence of survival technologies that have no way of becoming verified, commercialized and disseminated should serve as a warning that our system, as currently structured, is unlikely to fulfill our needs for survival. It is, therefore, imperative that this claim be taken seriously and verified by some credible individual or institution in the position, by virtue of knowledge and resources, to do so.

A Proposal for Recognition, Creation, and Deployment of Survival Technologies and Promoting Other Necessary Changes

First round survival technologies are an important part of the answer to the problems of global warming and the other three problems but they do not encompass all of the changes required for mankind's survival.

We propose formation of an institute manned by academic scientists, engineers and technologists, since all three skill sets are needed to implement the survival mandates of the institute. One of its primary mandates would be to actively promote the deployment and dissemination of existing first round survival technologies as well as new ones created internally and in cooperation with other organizations.

Another primary mandate would be a study of the four major physical problems of our time and specification of practical, integrated ways of dealing with them in terms of technologies, the order and time frame for their deployments, and other changes that are required; in other words a systematic plan for mankind's survival.

Functions would include examining and certifying existing survival technologies to render them credible to investors, and, if necessary, deploying and disseminating such technologies if private capital and institutions are unable or unwilling to do so in a manner that would insure their proper use. The same would apply to newly developed survival technologies.

Another significant function would be communicating with legislators regarding legislation necessary to enable some survival technologies to be deployed and, once deployed, to ensure that all were utilized in the manner intended. Discussions would also include other changes required for survival and the legislation needed to promote them. This function would constitute, "Humanity's Survival Lobby."

Since communication concerning matters of science and technology will be a problem, legislators would be encouraged to hire technology aides with the proper knowledge and background to interface with institute personnel. The institute could help legislators chose aides with the proper knowledge and background so that interfacing could be done with understanding.

A teaching function of the institute would make science and technology professionals and other interested parties aware of the criteria required for survival technologies.

Implementing many survival technologies and techniques involves system changes. A single kind of company, however, is usually unable to introduce all of the changes that are necessary. Thus, the institute would work with other groups involved in the desired changes to educate them, help them understand the need for the changes requested of them, and, where applicable, show how the changes would enhance their profit margin. As an example, optimizing production of cellulosic ethanol in a given area depends upon manufacturers having local access to suitable biomass crops grown by independent local farmers.

Finally, we need to consider where the seed capital to start the institute can be obtained. The institute can later become self-sustaining, financially; for example, through agreements obligating companies whose technologies it helps disseminate, to contribute later to the institute's financial support.

We use as a template here Albert Einstein's appeal to Franklin Delano Roosevelt concerning the scientific possibility of building the first atom bomb. Einstein's letter to Roosevelt resulted in funding of the Manhattan Project. In the present case, an academic with credibility could approach one of the world's philanthropists for initial funding for an institute to develop and enable deployment of integrated solutions to the world's four major problems. Such an institute, in our opinion, represents mankind's best chance to ensure its survival.

Ensuring the Proper Use of Survival Technologies after They are Developed

Impediments exist beyond the creation of survival technologies, and here there is ample need for the skills of legislators, international negotiators and diplomats to ensure that: (1) some survival technologies can be deployed in the first place; and (2) all technologies, after their deployment, are used in the way in which they were intended -- to promote survival. Two of the survival technologies already discussed will be used in the following examples:

Without legislation requiring it, or the government paying for it, there is no profit motive associated with atmospheric carbon dioxide capture and sequestration. It will, therefore, not be accomplished without mandating legislation.

Similarly manufacturers of biofuels will probably view the extra step of rendering their fuels carbon negative as an added expense without additional profit. Consequently, they are unlikely to do it unless it is mandated. This situation is analogous to auto companies that, for many years, had to be required by legislation to include various safety features that protected occupants in the event of an accident – but with much more at stake and with much less time to achieve results.

As another example, the hole in the ozone layer around the South Pole is alive and well, presumable because of the bootleg manufacture of CFC's in Mainland China and their illegal use in South America. Present treaties to phase out CFC's appear not to have been effective everywhere and cooperative actions between national governments must put a halt to this practice because the world has no other institutions capable of doing so.

As a final example, the clearing of the Amazon rainforest -- to grow biomass for current generation biofuels, and natural oils to be added to fossil fuels -- has become one of several significant factors for the rain forest's destruction. This is a problem for domestic Brazilian legislators and for international negotiators since destruction of the Amazon rainforest would have significant negative environmental consequences for much of the rest of the world.

Summary and Conclusion

Whatever time we have to keep global warming within tolerable limits, our response must take into account that human existence and much of the biosphere is ultimately at stake. And global warming is highly coupled with three other major problems any one of which, by itself, poses a significant threat to

humankind. Therefore, if we are to err, prudence dictates that it be on the excessive side regarding actions necessary to keep global warming and associated problems within tolerable limits.

Part of the solution is creation and dissemination of what we have called survival technologies. But we have a system that discourages this and a category of skills required to create them that is on the verge of extinction.

As we learned more about global warming in recent years our understanding of the severity of the threat has increased. Certain effects, not expected for many years, have already arrived as have others that were never anticipated. One reason for unpleasant surprises is the highly coupled internal nature of the environment. When one significant element of the environment becomes perturbed it invariably affects others. Because of significant coupling between elements of the environment, and between the environment and the other three problems, it is very unlikely that adequate solutions will emerge piecemeal. This is a powerful argument for creating an institute that can take a systematic approach to the changes necessary for our survival. The other argument is the need for an organization that can make an end run around the impediments to creating and deploying survival technologies.

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Dr. Paley is a physicist and Mr. Oister is an electronics engineer. They have spent most of their professional careers in research, development, and technical management in multinational corporations, defense contractors, and small high tech companies. In the latter settings each of them contributed to the development of several important new technologies. Dr. Hull, despite having been trained as a philosopher, has participated in the development of some technologies with Paley and Oister, chiefly as an investor.

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