ENERGY, WATER, AND FOOD-SCENARIOS ON THE FUTURE OF SUSTAINABLE DEVELOPMENT

BY GERALD HARRIS
Introduction

I believe that despite the labored writing and use of archaic word constructions, the basic message of Bucky Fuller above has universal appeal and a heart-touching ring of truth. Though Fuller was a scientist par-excel-lence, his basic message seems to tie in with the beliefs of the great mystics who set the moral foundations of most of today’s societies into place. There is no way to prove that Fuller’s assertions or the beliefs of the mystics are destiny. But there does seem to be a sense of humankind laboring for and desiring a better way to live. There is a sense of crisis in the air. Words like sustainability, ecologically sound development, and natural capitalism are commonly used to express what is being striven for. If we put aside arguing with Fuller and the mystics, then the two questions this article seeks to address are: where do we stand on the evolutionary path we might be destined to follow? And, what might happen over the next 20 years to move us along that path?

There are an infinite number of ways to go at those questions. I am going to approach it as an energy econom-ist from where we are in history, 2002. I am also going to stretch from the field of energy into two other areas that are equally important and integrated in the functioning of an economy, fresh water (getting it and using it), and agriculture (including both plants and live-stock management or meat production). I believe that understanding the pressures for change that exist in these three areas will give valuable insights into some predetermined elements. Whether in highly developed places like the U.S. or Europe, or in the most wretchedly poor third world countries of Africa or Asia, the three areas of energy, fresh water and food are intimately con-nected in daily activity. Look into the highest technology industrial processes in the first world to the back-braking physical labor of the poorest dirt farmer and the intercon-nections pop out at any attempt to explain what’s going on. The miracles of modern energy production in the form of electricity or internal combustion are best appreci-ated by noting that without them we would be forced to do everything by human or animal muscle power. The industrial economy cannot exist without modern energy systems. Most industrial processes use water at some point, either for cooling, chemical, or cleaning/waste disposal purposes. Agriculture and animal farming is

Humanity is moving ever deeper into crisis—a crisis without precedent.

First, it is a crisis brought about by cosmic evolution irrevocably intent upon completely transforming omnidisintegrated humanity from a complex of around-the-world, remotely-deployed-from-one-another, differently colored, differently credeod, differently cultured, differently communicating and differently competing entities into a completely integrated, comprehensively interconsiderate, harmonious whole.

Second, we are in an unprecedented crisis because cosmic evolution is also irrevocably intent upon making Omn-integrated humanity omnisuccessful, able to live sustainingly at an unprecedentedly higher standard of living for all Earthians than has ever been experienced by any; able to live entirely within it cosmic-energy income instead of spending its cosmic-energy savings account (i.e. fossil fuels) or spending its cosmic-capital plant and equipment account (i.e. atomic energy)—the atoms which our Space-ship Earth and its biosphere area structured and equipped—a spending folly no less illogical than burning your house and home to keep the family warm on an unprecedentedly cold midwinter night.

—R. Buckminster Fuller, 1981 from the book, Critical Path
impossible without fresh water for irrigation, feeding, cleaning and processing. Without energy food products could simply not be produced, harvested, transported or delivered to markets. Exhibits 1 [link] and 2 [link] show high level views of some key connections in modern water, energy and agriculture. A central point is that as energy gets cheaper it becomes easier to get clean water and meet human needs for food.

To get a sense of where we stand, I will start by sharing some overview data and insights on the challenges that exist for energy, water and agriculture/food production. I will then present two scenarios about how events might unfold over the next two decades. The scenarios will suggest different two paths the world may take in addressing the challenges identified in the overviews, and weave in the potential affects of three other important factors: population growth, global climate change, and international trade policies. The first scenario called Destroying Forward will argue for slowly unfolding, sometimes painful evolutionary processes that point toward a more sustainable path of world development. The second scenario called Kick Start will argue that after a period of acute pain and suffering, mankind moves quickly on to a revolutionary path of sustainable development.

Challenges in Energy, Water and Food

Key Challenges for the Energy Sector to 2020

It is well known that the sun blasts more energy on the earth in one day that is produced by all man’s activities in year. Simply put there is no shortage of energy, just a shortage of the right technology to capture it or produce it in a way that is not so destructive of the natural environment. The big problem is that from oil and natural gas exploration and development, to nuclear power production, to hydro-electric dams, man's current energy production technologies are environmentally damaging. And, at the scale and large amounts were are using our technologies, there are compelling arguments that we are overwhelming nature's ability to process our waste and sustain healthy ecological systems. The cheapest energy tends to be the most environmentally damaging. This leads to a fundamental question facing mankind about it energy technology and infrastructure: what will it take to move us to the next generation of cleaner, more environmental sustainable energy production technologies? Tied to this question is also the fact that at least 2 billion people in the world have inadequate energy resources to raise their standards of living. So in order to meet their needs, we must create cleaner systems or countenance a further overwhelming of nature and the related health and geopolitical impacts. How do we get to cleaner and more productive energy systems that are sustainable?

There are large impediments in our political economy and in our technology development to an accelerated shift to cleaner energy technologies. They include:

- The sunk and recovered cost of our current energy production assets (especially coal plants) leads to a low marginal cost of production from those assets. It is some of the cheapest power we have. At a time when world economies are weak, replacing it will lead to higher energy costs (though maybe lower total societal costs if we take into the account of externalities like health related cost from breathing particulate matter from coal burning, and acid rain contamination).

- Current renewable technologies, possibly with the exception of large scale wind power, are not cost competitive with alternatives like gas turbine generators. They may have certain niche plays where other values (like cleanliness, noise, portability) may allow them to compete, but for base load applications they simply are not competitive.

- Society and its political leaders have not shown the will to adequately subsidize (for the greater good) cleaner technologies to allow them a foot hold in the market place (and a chance to reduce cost by riding up the production curve). Alternatively, society has not found the will to force existing energy technologies to directly bear their full secondary (or external) and lifecycle costs, thus
lowering the market hurdle for alternative technologies.

- The peaks and valleys of a market-based economy make sustained R&D investment into improved energy technologies difficult. Profit potential drives investment not altruism. Breakthroughs at the most basic level could take years of costly research before commercial products can be created. Government funding helps but is often inadequate.

- Technology development that marginally improves the environmental impact of historical energy technologies and extending their useful lives steadily raises the hurdle for alternative energy technologies. So that even as alternative technologies make improvement their entry into the market is continually challenged.

- Energy systems and energy policy are national security concerns. Being without adequate energy supplies in a hostile situation can be life-threatening. Therefore governments are not prone to take the risks (or bear the costs) that may be involved in an accelerated turnover to a new energy approaches.

- Energy supply choices have a geo-political component; nations want to be supplied by nations they have secure if not friendly, relationships with. The large industrial nations, who control both energy development technology and the large amounts of investment capital needed to develop energy systems, supply the two based on geo-political calculations.

In addition to the effects the above issues can have, there are particular impediments to getting adequate energy supplies to the billions who need it to raise their standards of living (adequate food, shelter and health). They include:

- In many places of extreme poverty there are no natural resources that tie into existing energy production technologies (no coal, oil or natural gas is available). Thus they will have to trade for energy resources and investment, or be the recipients of aid. If these nations have very little to trade or have poor political relationships with developed nations then development of energy systems will be very slow.

- It takes human capital in the form of engineering skills, language skills, management skills and others to build, operate and maintain many parts of even a basic energy system. In some nations the human capital resources are inadequate.

- The existing land use and social patterns may cause resistance to the changes needed to implement a modern energy infrastructure. Changing land use in crowded cities, uprooting sacred burial lands, or drilling off-shore in old fishing areas are just some of the issues that might arise.

As the pattern of human activity changes to adjust to climate change so will the pattern of human energy use. Addressing energy system development (from fuels taken from the nature to conversion to transportation fuels and electric power) in terms of applying new or old technology to meet human needs will be made more complicated by global climate change. Rain patterns may change shifting hydro power patterns and agricultural activity. Land use patterns will change as desert expansion may change everything from forestry to recreation to agriculture. As these changes are occurring energy requirements may increase for some activities (i.e., more air conditioning, more cooling industrial processes, more pumping for water). Energy may also be needed in different places from where it is now requiring the abandonment and building of energy infrastructure like transmission lines or gas pipelines. As these changes are being managed, there will be a simultaneous need to shift to less environmentally damaging technologies. And, of course, there will be market pressures to keep the related cost as low a possible. This portends a clash between those who will want to use established technologies and continue the practice of

\[ \text{In most cases, the average person does not know the natural source of his water} \]
externalizing the full societal costs and those who will want to shift to a new generation of energy technologies. The new generation of technologies will be better able to penetrate the market if established technologies are forced to internalize their full societal costs. The play of out of this decision will be a key issue in the political economy.

Key Challenges for Fresh Water to 2020*

The old adage,”Out of sight, out of mind,” is probably the best way to understand what is happening in the world of supplying fresh water for human activities. For most people in developed countries, clean water flowing from the tap in whatever amounts we chose is taken for granted. In most cases, the average person does not know the natural source of his water. In many cases it is from underground sources that are being rapidly depleted. The average person does not what happens when the flush a toilet (where does it go?) The average worker probably doesn’t know what exactly happens to the waste water generated by commercial or industrial activity. It is unfathomable that this coddled position will ever change. However, it is predetermined to change. This is not to say that people in developed countries will have to view clean fresh water the way billions of other poor people do in undeveloped countries (it is scarce, generally unclean and full of toxic substances, laborious to get, and does not run endlessly from several faucets in the home). But just as average person realized that pushing exhaust into the air was not a free waste disposal site, the ocean, rivers and groundwater are similarly not free waste disposal sites. Note the data below on the supply side of an emerging water crisis:

- Global consumption of water if doubling every 20 years, twice the rate of human population growth
- About 10% of water use is household use, 20% to 25% is industrial use and the remaining 65% to 70% is for irrigation for agriculture
- Particles of human produced pollution may be weakening the hydrological cycle as they cut down on the amount of sunlight reaching the oceans. The resulting reduction in heat means that less water evaporates back into the atmosphere, and thus less rain.
- Extensive pump extraction of groundwater is a phenomenon of the late 20th century because of the availability of electricity and inexpensive equipment
- Twenty-one percent of irrigation in the U.S. is achieved by pumping groundwater at rates that exceed the aquifer’s ability to recharge. The Ogallala aquifer in the U.S., the largest single water-bearing unit in North America, is being depleted at a rate of 14 times faster than nature can restore it.
- Mexico City depends on aquifers for 70% of its water. It is extracting groundwater at a rate 50% to 80% faster than the replacement rate. The City sits on porous, sponge-like soil and thus water pockets are being filled with air. As a result it is sinking at a rate of about 20 inches annually.
- Saudi Arabia depends on groundwater for 75% of its water and is running toward total depletion in 50 years. To become self-sufficient in food, it subsidizes the water cost of its farmers. Every ton of wheat thus takes 3000 tons of water are used—three time the world norm.
- China has over a quarter of the world’s population, but only 6% of its fresh water. Four hundred of China’s six hundred northern cities are facing severe water shortages, as is half the population. The water table below Beijing has dropped 120 feet in the last 40 years. Industrial water use is projected to grow from 52 billion tons to 269 billion tons in the next 20 years to sustain economic development.

According to researchers, ”The biggest threat to fresh water species (including humans) is pollution from thou-
sands of factories, industrial farms, and cities that pour or leak pesticides, fertilizers, herbicides, bacteria, medical waste, chemicals and radioactive waste into our water. If the problems on the supply side aren’t sufficient to push for change, note some of the data on the contamination of existing supplies:

- Water treatment removes fecal coli form bacteria, best known for the deadly E. coli bacteria. However it does not generally remove toxic chemicals which make water unfit to drink or for fish to live.

- About 40% of U.S. rivers and streams are too dangerous for fishing, swimming or drinking. About 37% of fresh water fish are at risk of extinction.

- The New River, stretching from Baja California to the Imperial Valley of the U.S. is laden with more that 100 toxic chemicals. Seventy-five percent of the maquiladora factories on the U.S.-Mexican border dump toxic waste into rivers and streams that families still live on.

- In the U.S., industrial-scale livestock operations produce 130 times more manure than the human waste of the entire population. Millions of gallons of animal feces and urine that has seeped from manure pits has polluted 35000 miles of rivers.

- Ninety percent of the waste water produced in the Third World is discharged untreated directly into rivers and streams.

- In China, 80% of the rivers are so polluted that they no longer support fish, while the Yangtze River is contaminated with 40 million tons of industrial waste and raw sewage every day. The water in the Yellow river is too toxic for irrigation.

- The sacred Ganges River of India, where millions come to purify themselves spiritually is an open sewer, laced with human waste.

- Three quarters of Poland’s rivers are so polluted the water is unfit for industrial use. The same is true throughout Eastern Europe.

- Pesticides, industrial waste, arsenic, and metals all showed up in treated water flowing into the St. Lawrence River in Canada.

- Nearly half the water and sewage treatment systems in Moscow are ineffective or malfunctioning. The Russian Security Council estimates that 75% of the republics lake and river water is unsafe to drink.

- Between fifty to seventy-five percent of all drugs pass through the human body. In Canada, the U.S. and most of Europe, drugs such as ibuprofen, beta blockers, anti-depressants, and various hormones are showing up in water supplies.

- All North Americans are carrying at least five hundred chemicals in their bodies that were unknown before World War I.

Combining the challenges of finding adequate fresh water supplies, the wasteful usage patterns and the toxic contamination problems it is clear that water will emerge, like air pollution in the 1970s, as a big environmental issue with significant cost and technology implications. The cost of fresh water has no place to go but up, even if prices consumers face are moderated by governments. The “out of sight” implications of human water use will not be “out of pocketbook.” As these cost rise and as the health affects are better understood public activism is likely to rise. Regulations will tighten as toxic, environmental and health effects become clearer. Technological fixes that will allow water to used more efficiently (or not at all) in industrial processes and that allow it to be reclaimed for other uses is bound to proliferate because the economic incentives will be there.
Key Challenges for World Agriculture to 2020

The previous discussion have put forth some of the challenges to world agriculture as it relates to water and energy. For water the big issues in most places are clear: will there be enough, at what prices, thus what impacts on food prices? Also, what will be the toxic effects of fertilizers and pesticides on rivers and groundwater supplies, and who will bear those costs? Energy is used in many forms in agriculture and food production, from tractors and trucks to electric power driven food processing equipment. In much of the world human and animal muscle power are the primary energy sources, with their inherent limitations. The issue is not a constraint in the supply of energy but its relative price to other inputs. In poor countries, where oil, fuel, and electricity are costly, the only choice is muscle power. Eventually, as energy technologies change and costs shift, how energy is used in agricultural processes will evolve in both developed and underdeveloped countries. As evidenced in the developed world, energy gets cheaper it will replace muscle power and increase the quantity and quality of food (i.e., better storage) in developing countries.

But even with today’s water and energy challenges in agriculture, it is widely agreed that there is no shortage of food in the world. Hunger and starvation occur because of the failure of our distribution systems. Our distribution systems fail for a number of reasons, mostly because of the economic and political rules they follow. Economically (in a market system) if the price food can be sold for is less than the cost of production and delivery, then some subsidy must be in place to cover the difference. In developed countries governments provide these subsidies. For example in the U.S. every bushel of corn currently has a $.50 subsidy. Very often these subsidies can lead to abundant production that leads to lower market prices. Unfortunately in war-torn Africa, we see the most common uses of food as a political weapon. In places like the Sudan food has been used as a weapon to literally starve enemies to death. War also makes it hard to plant and harvest food and thus leads directly to starvation.

In most local environments, without wars and drought, food production can be managed to meet local needs. Mankind has been at food production for centuries and has mastered it: from high quality seeds, knowledge of soils, use of fertilizers, understanding of seasons, and just about anything else one can think of. The challenge in today’s world relates to the fact that food (plant and meats) are internationally traded. This means local production costs must compete with world production costs. This is where local or national subsidies wreak havoc. Subsidies, like those in the U.S. and European farm systems lead to high levels of production and thus low world prices for many commodities. It estimated that the U.S. farm subsidies in the most recent legislation will deliver $1 billion per day to its farmers. There are strong arguments in favor of this level of support. They include protecting farmers from the vagaries of weather conditions and market prices in order to sustain a healthy diet for the American people. There is a long history of farmers suffering and struggling with the dual forces of unpredictable weather and unstable commodity prices. The current systems of support were built from years of experience. Similar histories and conditions exist in other developed economies, especially in Europe. Food is not only important for life but also for national security. Farmers in developed countries provide some of the highest quality food in the world at relatively low prices for the average family budget. This is significant accomplishment in the history of the world and a foundation for large middle classes.

Unfortunately, for developed countries that have very little to no industrial base, food commodities supported by their low labor cost, are one of the only ways they can trade in the global economy. So subsidies that drive down world market prices undercut their ability to compete and move today more positive balances of trade and generate much needed foreign exchange. Locking many of these countries out of world food commodity markets is essentially locking them out of the world economy. They can thus only be recipients of foreign aid programs and loans they have little hope of repaying. World agri-
cultural and trade policies are thus a cornerstone for world economic development. Closing the gaps between the rich and poor as the world’s economies move toward increasing globalization will require some new thinking around agricultural trade. New levels of trust between nations will be required. Restructuring of rural economies will be required in both the developed nations and developing nations. As farming may decline in developed nations, what will be done with the land and people? As farming is made more productive and distribution systems more reliable and efficient in developing countries will they support different land use patterns as well as a reduction in labor? How will the people thrown out of the farm economy be moved into more productive labor without simply overcrowding cities?

Additional Drivers and Uncertainties for the Scenarios—Population, Climate Change and Trade Policies

Scenarios are stories and not intended to be factual forecasts. They cannot contain all possible factors, and I make no attempt here at total completeness. I am suggesting that a focus on the interrelationships of the activities to maintain adequate fresh water supplies, improve and clean up energy production, and organize the growing and distribution of food will provide some worthy insights on the future. However, I want to add in three additional high level drivers to build a context for scenarios. The three are: population growth, climate change, and international trade policies. These three factors can certainly lead to large changes that will affect policies related to water, energy and food. Exactly how is uncertain and thus good room for scenarios. According to the United Nations the world is expected to grow from about 6 billion people to 9 billion in the next 30 years. Which means during our 20 year scenarios about 2 billion more people will be born, mostly in developing countries? It is now widely agreed that man’s activities, especially the burning of fossil fuels and the related release of heat trapping gases is affecting the global climate by leading to increased warming above the natural rate. Precisely how this will affect global weather patterns is heavily debated and extend from triggering a massive global cooling to higher levels of destructive storms, to a warming of the northern hemisphere. Precisely when these effects might occur is also debated with some suggestions (based on ice cores) of rapid, threshold triggered climate changes that could radically shift weather patterns in a period as short as a decade. International trade policies seem to be on a track toward more openness and lower barriers to facilitate global economic integration. This may not actually be true from the standpoint of a developed country seeing economic barriers to its trade in agricultural commodities and the rules to protect Western industry’s intellectual property rights. There are even arguments that smart protectionism is the only historically proven route to building a strong trading positions from a weak one. Starting from the entry point of what may be commonly believed as the Age of Terrorism it is not entirely clear that truly effective reductions to trade barriers are assured for the next 20 years.

History show that, only when the leaders of the world’s great power structures have become convinced that their power structures are in danger of being destroyed, have the gargantuanly large, adequate funds been appropriated for accomplishing the necessary epoch-opening new technologies. It took preparation for World War III to make available the funds that have given us computers, transistors, rockets and satellites to realistically explore the Universe.

R. Buckminster Fuller, Critical Path, 1981

The Scenarios

Returning to Fuller again sets the second key question of this report in context. Where might we be going along the path to sustainable development over the next 20 years? Will there be a threat so large that it triggers a leap to the next epoch? The Destroying Forward scenario suggest what might happen if the answer is no,
while the Kick Start scenario argues what may happen if the answer is yes.

**Scenario 1: The Kick Start**

This is a world where a combination of man’s inhumanity to man and ignoring warning signs from nature triggers a series of environmental catastrophes which have large regional and global effects. Looking back, researchers will pinpoint the start of these problems from the fires in Asia in 1998 that triggered a short recession. But others occur in the form of destructive storms, heat waves, droughts and water crises, massive poisoning from toxic releases in the environment, and exploding disease. By 2008 the most powerful nations in the world declare a global crisis. The sequence of disasters pinpoint the neglect of natural systems and how that neglect contributed to the crises. Challenges in meeting the need for fresh water resources stand out in particular because they are widespread, touching developed and developing nation alike. Led by the industrialized nations, a broad and feverish effort to address the series of crises creates a technological and political revolution with a shift in human values similar to that following World War II. People pay a terrible price for lessons that open the door to a commitment for more ecologically sound economic development. For about a decade the costs the vital necessities of clean water, energy and food rise in real terms, creating hardships for billions of people, including those in developed countries. Death is so pervasive that world population growth slows dramatically, especially in the developing nations. An explosion of disease grips the world for several years, causing death in both developed and less developed nations. This further galvanizes world technological cooperation. Economic hardship and calamity wreak havoc in the developing nations triggering massive industry restructuring. Many companies fail because they are unprepared to adopt new technologies or are surpassed by new companies that do so more effectively. New technology begins to deliver on its promise by 2012. Over time, learning, experience, and innovation lead to the cost of necessities stabilizing, then falling rapidly portending an age of higher standards of living for the majority of mankind. A key driver for the next level of growth is based on the use of lower cost and clean hydrogen-based energy, renewable energy from solar technologies, and much more efficient use of energy. The work of repairing, protecting, and sustaining the natural environment becomes a driver for economic growth. Competitive advantage in the market place becomes tightly associated with the lowest environmental impact of producing, using, and recycling or disposing of a product. By the year 2018, a worldwide economic boom ensues that proceeds uninterrupted for two decades, similar to the 1950s and 1960s. This growth spreads too many developing nations as well because political values in the advanced nations supports a sustained commitment and longer term investment horizons. The years of global hardship and pulling together set a new geopolitical calculus in place. At the core of this new geopolitics is a “one world” view. The “one world” view is not based on hegemony to a dominant culture but to a belief in a shared set of human rights and values. If those rights are met then it benefits all nations in terms of long term growth opportunities. The idea of values determined only in relation to markets is set aside for a broader and longer view of prosperity. Basic human rights include access to the basic needs of life, including food, shelter and clean water. By 2022 the global economic expansion is in full swing and there is a sense that globalization is working for the benefit of the majority of people in the world.

**Scenario 2: Destroying Forward**

This is a world in which a skeptical and optimistic view of environmental alarm at the turn of the century wins out in the world’s political power centers. A belief in the combination of the resiliency in nature and man’s ability to “do the right thing before it’s too late” allows humankind to continue to harm parts of the nature in meeting the needs and desires of life. Despite warnings that this historical process cannot continue at an unprecedented scale, driven by a population exceeding 6 billion, it does. Despite continuing reports of regional ecological destruction, no global scale environmental crisis emerges. Short and sharp economic recession continue but are addressed through policy and fiscal changes. The
world economy resumes widespread growth in 2004. A political consensus emerges at that time that argues the following. Change toward doing the “right thing” comes primarily from pressures and sensitivities arising from economic and political systems, and as nature bites back with deadly and expensive consequences. These pressures force people to improve their knowledge and technology. As our technology improves we are able to live more in balance with nature. The only short cut in this long term process is to learn faster. The faster we learn, the quicker we can improve our technology. Man-kind’s unprecedented ability to learn faster on a global scale will lead to living in balance in nature—in time. By 2012, the world has added another billion people and the pressures for more clean water, cleaner energy and better food distribution remain. However to address these pressures market oriented economics remains the dominant approach. As these pressures are most acute in the developing world, they remain only marginally addressed by the technological and economic power concentrated in the developed nations. This perpetuates a trickling down affect in economic growth and the spread of technology from rich to poor countries. However, important exceptions exist in the faster developing nations such as China and India. In some cases they manage to leap frog into more advanced technologies in key sectors such as communications. By 2018, the world remains largely split between the have and have-nots. Water continues to be used wastefully in developed nations, but less so as cost rise and lead to more water-efficient technology. Billions of people in poor countries continue to live with shortages of fresh clean water. Energy continues to be produced using polluting technologies, but much less so. In advanced countries energy is being used more efficiently and less intensively in economic activity. The world food supply continues to be robust, but poorly distributed as millions still go hungry in the developing world. The billions fortunate enough to eat well in the advanced nations consume very high quality food in abundance. Though it appears little progress has been made, closer examination reveals a more complex story. In almost every industry productivity has risen substantially and pollution per unit of production has fallen dramatically. Environmental challenges remain because of higher absolute levels of production to keep up with population growth and higher standards of living. Growth is overwhelming per unit gains. By 2022, there is progress to point to in the form of cleaner rivers, cleaner air, and cleaner energy production. Population growth is also declining. The debate in power centers and international institutions is about how fast will the trends of declining population growth and improved technology cross paths to push humankind firmly on the path to sustainable growth. Or, will increasing consumption continue to delay progress?
Energy, Water and Food

Energy

As energy prices fall, more clean water is available through purification and pumping. As clean water becomes scarce more energy will be used to create more.

Clean Water

Energy is applied to increase agricultural productivity and lower costs, higher energy costs mean higher food costs.

Food/Agriculture

Agriculture is the largest user of water, as water supplies fall, food prices rise.

Exhibit 1 [return to text]

Energy, Water and Food

Economic Flows and Relationships

Energy

Tiling, transport, processing,

Groundwater pumping, Purification, Distribution

Hydro-electric power, pollution control

Bio-fuels, dung, chemicals

Irrigation, feeding, pollution control, fish farming

Efficient water use leaves more for residential, industrial and commercial uses

Exhibit 2 [return to text]