In recent years there has been a growing understanding and acknowledgment that water and energy issues are inseparable. This understanding did not come easily.

Water and energy are as basic as it gets—access to both is critical to poverty reduction, sustainable economic development, and national security. It is also clear that policy goals associated with providing adequate energy supplies and supplies of clean water are often in conflict. This is the conundrum. Can we satisfy increasing demands for both as global population and material wealth increases? Are there necessary tradeoffs? This paper provides a context for examining these questions and thoughts on some possible answers.

The water context

"Water is life" is a truism. Without water life as we know it would not exist, and the hard reality is that there are no substitutes for water. If you don't have water you die. It is also true that we live on a water-rich planet—more than 300 million cubic miles of the stuff, with each cubic mile containing more than one trillion gallons—and the amount of water on the planet hasn't changed over millions and perhaps even billions of years. So why is there a problem with water supply?

The biggest problem is that 96 percent of all the water on earth is found in the oceans, with an average salt concentration of 35,000 parts per million. It is salty, and human beings and animals are harmed when drinking water that has more than about 500-1,000 parts per million of dissolved solids. Until the human organism and other organisms can ingest salt water safely, something that would require genetic changes that take a while to take hold, we have to deal with available supplies of fresh water or pay the price, energy- and cost-wise, for converting saline to fresh water. This identifies part of the conundrum.

With regard to freshwater, which constitutes the remaining 4 percent of water on the planet, most is not easily available for our use. Some is tied up in icecaps and glaciers (although we seem to be addressing that part of the problem), a chunk is tied up as water vapor in the atmosphere, and the rest is in groundwater, lakes and rivers. The result is that 99.7 percent of all the water on earth is not available for human and animal consumption. And of the remaining 0.3 percent, much is inaccessible due to unreachable locations and depths. Thus the good news and the bad news is that we make productive use of much less than 1 percent of our global water resources.

Another problem is that fresh water is not distributed uniformly around the globe. Some areas have lots, some have little to none. The struggle to control water resources has shaped human history, and water has been a source of tension wherever water resources are shared by neighboring peoples. In addition, precipitation patterns that bring much of the water will change as the climate does. And how those patterns will change is something we are desperately trying to understand. We must also ask how the demand for fresh water is changing and what the implications of not having enough are.

Current global annual demand for fresh water is estimated to be about 1,000 cubic miles, approximately 30 percent of the world's total accessible fresh water supply, and has more than tripled in the past 50 years. Some estimate that under business as usual this fraction will increase to 70 percent by 2025. Population growth and economic development are driving a steadily increasing demand for new water supplies, with agriculture accounting for three quarters of global water use on average. Over-pumping of ground water by the world's farmers, from aquifers in India, China, the US and elsewhere, already exceeds natural replenishment by more than 4 percent of withdrawals and is growing.

The implications of too little fresh water are significant. The World Health Organization estimates that, globally, more than 1 billion people lack access to clean water supplies and more than 2 billion lack access to basic sanitation. The amount of water deemed necessary to satisfy basic human needs is 1,000 cubic meters per capita annually. In 1995, 166 million people in 18 countries lived below that level. By 2050, experts project that the availability of potable water will fall below that level for 1.7 billion people in 39 countries. Water shortages plague almost every country in North Africa and the Middle East.

These shortages have significant health effects. Water-borne diseases account for roughly 80 percent of infections in the developing world. Nearly 4 billion cases of diarrhea occur each year, with diarrheal diseases killing millions of children. Another 60 million children are stunted in their development as a result of recurrent diarrheal episodes. In addition, 200 million people in 74 countries are infected with the parasitic disease schistosomiasis, intestinal worms infect about 10 percent of the population in the developing world, and an estimated 6 million people are blind from trachoma, with an at-risk population of 500 million.

The gender implications of fresh water shortages are also serious. Women head one-third of the world's families (in parts of Latin America families headed by women are the majority) and frequently are the financial mainstays of and principal water providers for their families. They are responsible for half of the world's food production, and produce between 60 and 80 percent of the food in most developing countries. To produce adequate sanitation and food they must first 'produce' water. As the principal water providers women and girls in developing countries spend up to 8 hours daily finding, collecting, storing and purifying water. This reduces significantly the time they might otherwise use for education, community involvement and cottage industries. If safe and reliable water sources do not exist nearby they are forced to pay exorbitant prices to street vendors or rely on unsafe local water resources. This has major implications for hygiene and the spread of diseases among poor women and their families. Finally, poor women's access to water is less than that of poor men because decisions are most likely made by men and the water needs of women are often ignored or undervalued. This has led to a situation where women are among the poorest of the poor in most parts of the world, leading to a "feminization of poverty."

The energy context

It is often said that energy is the lifeblood of modern societies, but energy in various forms has been critical to human activities over the centuries. What is true is that modern societies provide a high level of energy-dependent services to their members, and are totally dependent on energy sources that go well beyond human and animal power.

In the 20th century, population growth, increased affluence and expectations, and increasing urbanization led to a rapid rise in electrification and dramatically increased global energy demand. Transportation proved to be the fastest growing consumer of energy supplies, with well over 90 percent of transportation energy needs provided by petroleum. This pattern is continuing in the 21st century.

Projections by the International Energy Agency, the European Commission, the World Energy Council, the US Energy Information Administration, and others all point to the same general conclusions: there will be increased consumption of all primary energy sources over the next several decades; fossil fuels will remain dominant, accounting for most of the increase in energy use; natural gas demand will grow fastest, but oil will still be the largest individual fuel source; nuclear power will grow, but slowly; global emissions of carbon dioxide will grow more rapidly than primary energy supply; and use of renewable energy will grow rapidly but will not displace fossil fuels as the principal energy source.

Specifically, the US Department of Energy's Energy Information Administration, in its International Energy Outlook 2010, projects that, under business-as-usual, total world energy demand will rise from 510 quads today (a quad is one quadrillion BTUs) to 740 quads in 2035. Coal will provide 28 percent of total, petroleum 30 percent, natural gas 22 percent, nuclear 6.6 percent, and renewables (solar, wind, …) 13.4 percent. Most of this growth will take place in the developing world.

These projections mask four central issues: When will world oil production peak, with attendant impacts on oil price and competition for resources? How urgent is it to reduce growth in global energy demand and related emissions of carbon dioxide and other greenhouse gases? How vulnerable to disruption is our energy infrastructure on which we depend so heavily? How quickly can renewable and advanced nuclear energy technologies be brought on line to replace fossil fuels? The answers to these questions will determine the energy system our children and their children and grandchildren will have to deal with.

Defining the conundrum

The conundrum poses the following question: As we progress into the 21st century, and global demands for energy and potable water increase, can we provide what is needed in a timely and environmentally safe manner, given that water and energy policy goals often conflict? The conflict arises from the fact that water and energy issues are intimately linked—energy is needed to ensure delivery of water services, and water is needed to produce fuels and energy—and as demand for one increases so does the demand for the other. This was not a problem in 1900 when the world's population was 1.8 billion, but with today's population of 7 billion, estimated to reach 8-10 billion in 2050, a serious and perhaps overwhelming problem exists. What can we do to meet these global needs? How do we ensure water and energy security?

A useful starting point is to recognize that people do not value energy; they value the services that energy makes possible—heating, cooling, lighting, communication, transportation, and commercial and industrial processes. Thus, energy security must ultimately rest on two principles: using the least amount of energy to provide a given service, and access to technologies that provide a diverse supply of reliable, affordable and environmentally benign energy. This implies that the first priority of any national energy policy must be the wise, efficient use of whatever energy supplies are available, whether fossil, nuclear or renewable. The next priority is new supplies that meet cost, sustainability and environmental requirements. These statements apply equally well to water.

It is also important to recognize that on a global basis energy is not in short supply. The sun, a modest star sitting 93 million miles from earth and powered by nuclear fusion, pours 6 million quads of radiation annually into the earth's atmosphere, and this is only 4 parts in 10 billion of the sun's total output. While some of this radiation bounces off the earth's clouds back into space, most of it enters the atmosphere and becomes part of the earth's energy balance with the sun. When too much solar energy is captured by the earth rather than reradiating into space as infrared radiation, we get global warming and associated climate change. There is also considerable energy under our feet in the form of hot water and hot rock heated by radioactive decay in the earth's core. Thus, the reality is that energy, like water, is not in short supply on the earth. What is in short supply is inexpensive energy and water—energy and clean water that people can afford to buy.

What are the realities of global fossil fuel supplies? Today's world is powered largely by fossil fuels (coal, oil, natural gas) at 80 percent, and their use will eventually be constrained. Nevertheless, despite periodic warnings about running out, and the vulnerabilities associated with their use—price increases and volatility, increased geographic concentration of supplies, environmental impact, and vulnerability to natural disasters, terrorist attacks and other disruptions—the truth seems to be that there is still lots of oil and natural gas to be found and extracted, and the world is rich in coal. Thus, fossil fuels will likely play a major, even a dominant, role in 21st century energy supply if we continue on our current energy path. The crucial question then becomes: Is it in the global interest to let this happen?

How are energy and water related? Central to addressing issues of water security—defined as the ability to access sufficient quantities of clean water to maintain adequate standards of food and goods production, sanitation and health—is having the energy to extract water from underground aquifers, push water through pipes and canals, manage and treat impaired water for reuse, and desalinate brackish and sea water to provide new fresh water supplies. Many aspects of energy production depend on the availability of water including hydropower, cooling of thermal power plants, fossil fuel production and processing, biofuels, carbon capture and sequestration, and hydrogen production. The inseparable linkage between energy and water is clear, but it hasn't always been recognized.

Other, indirect, linkages exist as well between water and energy. Energy production and use can lead to contamination of underground and surface water supplies. If competing water uses limit use of waterways for transport of goods, rail and truck will require more energy to move those goods. Another critical linkage is that energy production and use are major contributors to greenhouse gas emissions which have the potential to disrupt the hydrological cycle and impact global water resources long before other impacts are felt. By altering the timing of winter snows, snowmelt, and spring rains, climate change could overload reservoirs early in the season, forcing releases of water and leaving areas like California high and dry in late summer. Coastal areas and island nations also face a serious threat from rising ocean water levels that destroy property and flood low-lying areas, causing salt-water intrusion of fresh water supplies and putting the drinking water of millions at risk.

Addressing the conundrum

From the statements above, it is clear that water and energy are in abundant but not necessarily inexpensive supply. We will not run out of water or energy, but we will undoubtedly have to pay more for both. This creates the dilemma that makes it hard to address the conundrum—government officials are too often reluctant to tell people the hard truths if it involves higher costs and adverse political reaction. People want more energy and clean water but are reluctant to pay more for them. The issue is not technological but economic and political. The good news is that we have options, but they are not cost free, and many parts of the developing world lack the means to make the necessary investments. Developed counties often face similar constraints.

The responses to these challenges clearly imply an inevitable transition to a global energy system that, over time, will rely less and less on traditional fossil fuels and more and more on renewable energy resources (solar, wind, geothermal, biomass, hydropower, ocean energy), which offer important advantages: stabilization of long-term energy costs, reduced market uncertainties, reduced international competition for energy resources, reduced greenhouse gas emissions, enhanced job creation, and the ability to keep an increasing share of payments for energy supplies at home where they can be used for domestic investment. A thoughtful discussion of these issues was first put forward in 2004 by Don Aitken in his white paper entitled "Transitioning to a Renewable Energy Future." Nuclear power may also play a major role in our future energy system if safety, waste storage and nonproliferation issues can be adequately addressed. The long-term nuclear power hope is fusion. The world's oceans contain enough deuterium to supply endless amounts of power, but reproducing the sun's energy process on earth is proving to be mankind's most difficult technological challenge.

However, the transition will take time, as has been true of every other major energy transition in the past. Issues of overdependence on imported petroleum, particularly for transportation, will be with us for many more years as electrification slowly penetrates the transportation sector. There is no quick fix, but there is a fix for our children and grandchildren if we are willing to moderate our behavior, stimulate innovation, and invest for their futures.

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