Chapter 3

Exploring the linkage between water and energy

What seems obvious upon reflection, but has been little discussed until fairly recently, is that there is an inextricable linkage between water and energy. This linkage has been given a name, the water–energy nexus. It recognizes explicitly that making water available to consumers requires the use of energy to extract water from underground aquifers and move it through pipes and canals, to desalinate brackish water or seawater, to treat used water so that it can be recycled, and to disinfect contaminated water.

At the same time it also recognizes that many forms of energy production and use depend on the availability of water, for example, hydropower sites where the kinetic energy of falling water is converted to rotary motion and electricity in a turbine generator. It includes the use of water to cool the thermal exhausts of steam-driven turbine generators, as in fossil fuel, nuclear, geothermal, and concentrating solar power plants. Water plays an important role in fossil fuel extraction via

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injection into conventional oil wells to increase production; in production of oil from tar sands; in the extraction of oil and natural gas from fracking of underground shales; and in the conversion of petroleum into products such as gasoline, diesel fuel, and plastics. In addition, water is essential to the growth of biomass, increasingly seen as a source of alternative liquid and gaseous fuels. Finally, if in the future we move toward greater use of hydrogen as an energy carrier and energy storage medium, large quantities of water will be required to provide the needed hydrogen via electrolysis.

3.1 INDIRECT LINKAGES

Other, indirect, linkages exist as well. The production and use of energy creates emissions and waste products that can pollute surface and underground water supplies. Energy production is also recognized as a major contributor to global warming and climate change (see Chapters 4 and 10), which can disrupt the hydrological cycle and affect global water resources long before other impacts are felt. A US National Assessment in 1998 stated that 'In many cases and in many locations, there is compelling evidence that climate changes will produce serious challenges to our water systems'. The 2008 Intergovernmental Panel on Climate Change (IPCC) 'Technical Paper on Climate Change and Water' stated that 'Observational records and climate change projections provide abundant evidence that freshwater resources are vulnerable and have the potential to be strongly impacted by climate change.' By altering the timing of winter snows, snowmelt, and spring rains, climate change could overload reservoirs earlier in the year than usual, forcing unanticipated releases of water that leave areas like the Himalayas and California dry later in the year. Coastal areas and island nations also face a serious threat from global warming: elevated sea levels, which destroy property, flood low-lying areas, and cause infusions of seawater into freshwater supplies, putting the drinking water of millions of people at risk.

Another concern is that competition for water resources is already limiting electricity production: operating licenses for some thermal power plants have been denied or issued with water use restrictions. An additional concern is that a significant fraction of goods are moved by freight on inland waterways. If competing demands for water limit the depth of such waterways, more energy will be required to move these goods by less efficient rail and truck.

3.2 THE POLICY LINKAGE

A further linkage exists in the recognition that energy and water policy can be expressed in exactly the same terms. Energy security requires that we use the least amount of energy to provide energy services, and that we have access to technologies that provide a diverse supply of reliable, affordable and environmentally benign energy. This implies that the first priority of an energy policy must be the wise, efficient use of whatever energy supplies are available (whether fossil fuel, nuclear or renewable). The next focus must then be on finding new energy supplies that meet sustainability and environmental requirements. The same words, with water replacing energy, can be used to describe water policy.

3.3 THE CONUNDRUM

It is clear that the energy security of a nation is closely linked to the state of its water resources. No longer can water resources be taken for granted if energy security is to be achieved or maintained. At the same time, water security cannot be guaranteed without careful attention to the energy issues involved in provision of water services. Built into this relationship is a conundrum: policy goals associated with providing adequate supplies of energy and clean water are often in conflict. As we move further into the 21st century, when demand for one increases so does demand for the other. Given their linkage, can we satisfy increasing demands for both as global population and human welfare increase? Are trade-offs necessary between the two? This was not a problem at the beginning of the 20th century, when the world's resources supported fewer than 2 billion people, but today's population of more than 7 billion, and heading higher, presents a vastly different situation.

3.4 ADDRESSING THE CONUNDRUM

When one looks at how to address the conundrum, one must start with the understanding that water and energy are in abundant but not necessarily inexpensive supply. The world will not run out of water nor of energy, but we may – and most likely will – have to pay more for one or both. Complicating this situation is that government officials are too often resistant to telling people the hard truth if that truth involves higher consumer costs and risks negative political reactions. Generally, people want more clean water and more energy, but are reluctant to pay for it. This tells us that the issue is not technological, but economic and political.

An interesting example of how we might deal with the conundrum is associated with desalination. In the early days of large-scale desalination, thermal distillation was the norm. The needed thermal energy was provided by the waste heat from the combustion of fossil fuels for electricity generation: for example, via the combustion of oil in Saudi Arabia and of natural gas in Qatar. The irony is that the CO_2 released into the atmosphere by this combustion increases global warming and results in changed rainfall patterns that often reduce freshwater supplies. Addressing this conflict requires breaking the link between the use of fossil fuels and supplies of clean water.

Breaking this link can be achieved in two ways: replacing electricity powered by fossil fuels with nuclear power, and facilitating the inevitable transition to a global energy system that, over time, will rely less on fossil fuels and more on renewable energy sources. These latter technologies – solar, wind, hydropower, geothermal, biomass, ocean power – offer a large energy resource, reduced water requirements, the possibility of reduced energy costs (and their long-term stabilization), reduced market uncertainties, reduced international competition for energy resources, reduced greenhouse gases, enhanced job creation, and the ability to reduce energy imports and keep an increasing share of the payments for energy supplies in one's country for domestic investment.

Nuclear fission power offers some of these advantages (it is a large, non-CO_2 emitting energy source), but faces several serious problems – safety, cost, radioactive waste storage, weapons proliferation – that must be addressed if it is to play an important role in our future energy system. The long-term hope for nuclear power is nuclear fusion, which involves the fusion of two hydrogen isotopes (deuterium and tritium) into the heavier element helium, with a mass loss that is converted to energy. The world's oceans contain enough deuterated water (D_2O) – roughly 1 part in 6000 – to supply endless amounts of energy. In addition, the radioactive waste problems associated with nuclear fusion are much less than those with nuclear fission. Both technologies are discussed in Chapter 7.

3.5 THE NEED FOR PARTNERSHIP

Let me close this discussion with one further word on the emerging understanding of the close relationship between water and energy. Until fairly recently most people in the energy community thought about water in limited ways – hydropower and cooling of power plant exhausts – while many people in the water community rarely thought about the energy needed to provide water services. This may have worked well enough in the 20th century but will not work in the 21st as populations and demands for both water and energy continue to grow. If we are to optimize our use of these essential resources we cannot treat water and energy issues as separate entities. Rather, we must create effective partnerships between those in government who have responsibility for water and energy security. This new understanding also suggests a related research agenda that requires government and private sector support:

- Reducing the energy requirements of desalination
- Developing improved technologies for water treatment and reuse
- Reducing the water requirements of agriculture
- Reducing the water requirements of thermal power plants
- Understanding the impact of global warming and climate change on spatial and temporal variability of water resources
- R&D to understand the water requirements of emerging energy technologies (to be discussed in succeeding chapters:
    - biofuels from biomass
    - oil and natural gas from fracking of shale deposits
    - oil extracted from tar sands
    - carbon capture and sequestration
    - concentrating solar power
    - the hydrogen economy.

The conundrum presents serious challenges, but many promising options to address these challenges exist.