Energy – Water: Entangled Strategic Goods Analysis

Introduction

Energy and fresh water are both finite natural resources with economic value. Water is an integral part of energy development, production, and generation; energy is an essential part of water supply and disposal systems. Water is also used extensively in resource extraction, refining, and processing. Current water use tightly intertwines with energy consumption for energy-related applications, including electric power generation, petroleum refining and coalbed methane extraction.

Some energy intensive industries are simultaneously intensive users of fresh water. In the coming decades, as the demands for energy and water continue to increase to meet increasing population growth and to support economic development, a better understanding of the interdependencies between these two natural resources is needed. Trends in water demands and water use for future energy development emerge along with the trends in the availability and reliability of fresh surface water, ground water, water from aquifers, water in the biosphere, and non-traditional water resources. Combined, these trends require energy and water be treated as entangled strategic goods.

Quality data – by subwatershed and by subaquifer – should be available to support the analyses of these trends, especially as these strategic goods inevitably move upward along their supply-decline curves. A thorough understanding of water location, quantity and quality is vital for energy development. Water is used in energy resource extraction and refining, hydroelectric and thermoelectric power generation, and energy transportation. Anticipated growth in U.S. energy generation and increased use of alternative domestic supplies for transportation fuels, both of which will require significant water resources, will occur within the context of an already constrained fresh water supply. Also of significance is the likelihood of new power plant designs that move away from once-through cooling toward closed-loop cooling. This shift will result in less water withdrawal; however, more importantly, the transition will result in greater water consumption. Simply stated, planning and growth in the energy sector cannot be done without comprehensive water resources data and characterization.

Collaboration is considered essential when dealing with this issue, and is complicated by the lack of funding at all levels, broad citizen awareness is insufficient for making informed decisions, and the data is too widely scattered; it takes many skills and many people to cover the turf. These collaborative efforts are needed to ensure proper evaluation and valuation of water resources for all needs, including energy development and generation.

Conclusions

- Collect and organize valid national and international “energy – water” data.
- Provide appropriate and quantifiable quality control on the data.
- Make all data available by subwatershed and by subaquifer.
- Create scenarios to identify potential future shortfalls.
- Apply business intelligence techniques in analyzing the interrelationships of energy and water.

Background

While water behind dams is used directly in hydroelectric power generation, more water is lost to the atmosphere by thermoelectric power plant cooling and air emissions control than is lost by any other industry, except agriculture. While dams were built primarily for flood and drought mitigation, they also have environmental impacts on the biosphere. Large electric pumps can move water from dams' reservoirs to distant fields for irrigation – or urban consumption. Small pumps with deep bore holes collectively use large quantities of irreplaceable connate water from aquifers for agricultural use, too.

An estimated 25 percent of all daily non-agricultural fresh water consumption in the United States is used by the energy sector as water withdrawals for cooling water for thermoelectric power generation. This estimate excludes the current power plants return of cooling water to the source for reuse downstream. EIA projections to 2030 show an increase of electric power sales by roughly 40 percent, increases that will put additional stress on water supplies.

Regionally, much of this growth is expected in the Southeast and West, significantly increasing water demands for energy growth in regions with already stressed water supplies. Overall, this includes a major growth in coal-fired power plants, modest growth for natural gas and renewable power, and a slight growth in nuclear power. The quantities of local water needed to meet this growth in electric power generation will depend on the type and number of power plants built, cooling technologies used, and air and carbon emission requirements.

Traditional domestic petroleum supplies are projected to remain fairly constant, while alternatives to traditional domestic petroleum supplies are projected to grow substantially to meet the roughly 40 percent increase in demand for transportation fuels. In the future, the U.S. will produce more ethanol and biodiesel fuels, and more alternative fuels from oil shale. The additional water needed to meet this growth will depend on the type and quantity of alternative fuels produced.

Reasonable estimates of the increased water consumption for energy development can be made using a few assumptions:

- Current trends in evaporative power plant cooling will continue.
- Carbon emission requirements will not be imposed.
    - However, water consumption could increase during a transitional period if carbon emission caps are implemented.
- Projected petroleum, oil shale, coalbed methane and biofuels development will occur.
- Irrigation of biofuel feedstocks will occur, depending on crop market conditions, oil prices, crop by-product markets, existing land set-aside programs, and incentive policies.

In addition to population growth and economic development, the projected growth in energy consumption for water use is another driver for future energy demands. Contributors include:

- Irrigation water for the agricultural sector is moved using electric power. Close to an estimated 20 percent of California's electricity consumption is used in water systems.
- Desalinization, an energy intensive process, transforms briny water into usable water.
- Wastewater treatment facilities are energy intensive, but allow reuse of water.

The projected growth in fresh water demands for future energy development is occurring at a time the nation's water supplies are seeing increasing stress from surface-water storage limitations, depletion of groundwater, depletion of aquifers, in-stream ecological needs, and uncertainty about climate variability impacts on water resources. Coalbed methane extraction stresses fresh water supplies in areas used to undisturbed water. Some subwatersheds and subaquifers will be stressed more quickly than others, and with varying timetables. Distant users treat water use as a readily available externality, both domestically and internationally, creating "virtual water" issues. Citizen awareness has been growing more slowly than might be considered appropriate.

The projected regional growth in water consumption for energy is a major driver for future water demands. These new water demands will be increasingly met by the use of nontraditional water resources. Energy demands for this water production could alone outstrip available nonagricultural fresh water supplies by 2035.

These interdependencies between energy and water are being recognized for their strategic impact on future economic growth. For example, in mid-2005 Congress funded the Department of Energy to develop an Energy-Water Report to Congress to help identify and quantify emerging energy and water challenges and issues: "*Energy Demands on Water Resources - Report to Congress on the Interdependency of Energy and Water*" (DOE, 2007).

Energy – Water Roadmap

The Energy-Water Roadmap process identified and evaluated regional and national energy-water issues and needs. A gaps analysis compiled all the energy-water problems, issues, and challenges, identifying the gaps between the current and emerging needs and current programs. To help reduce water concerns for future energy development, consideration is encouraged for:

- Improving fresh water use efficiency in electric power generation production.
- Improving non-traditional waters use in place of fresh water - in new energy developments.
- Developing approaches and tools to improve the joint planning, management, and development of energy and water resources.

These major research and development concerns include:

- Reducing fresh water use and improving water use efficiency in electric power generation through low fresh water use cooling and scrubbing, and application of low water consumption renewable energy sources.
- Reducing fresh water use and improving water use efficiency in alternative domestic fuels production such as biofuels and oil shale.
- Developing treatment technologies and modeling tools to improve applications of produced and other non-traditional waters for energy and other development while minimizing environmental impacts.
- Improving the characterization, data collection and management, and understanding of the availability of fresh and nontraditional water resources to support energy, water, and natural resources system analysis.
- Building decision support tools for Integrated Resources Planning and Management, supporting agencies in implementing beneficial technologies and approaches for energy and water management, as well as transferring new process and technology research and development to reduce fresh water use and consumption in the energy sector.
- Improving collaboration among stakeholders on energy and water planning and development, technology transfer, and commercialization requirements with industry, science, research and citizens concerned about water.

A thorough understanding of water location, quantity and quality is vital for energy development. Water is used in energy resource extraction and refining, hydroelectric and thermoelectric power generation, and energy transportation. Anticipated growth in U.S. energy generation and increased use of alternative domestic supplies for transportation fuels, both of which will require significant water resources, will occur within the context of an already constrained fresh water supply. Also of significance is the likelihood of new power plant designs that move away from once-through cooling toward closed-loop cooling. This shift will result in less water withdrawal; however, more importantly, the transition will result in greater water consumption. Simply stated, planning and growth in the energy sector cannot be done without comprehensive water resources data and characterization.

State of the Data

A considerable data foundation already exists in the area of domestic water resources characterization in the U.S. The U.S. Geological Survey (USGS) National Water-Quality Assessment Data Warehouse provides access to sometimes outdated and somewhat sparse surface and ground water resources data. Through this effort the USGS investigated the occurrence, quantity, quality, distribution, and movement of surface and underground waters, and disseminates the data to the public, state and local governments, public and private utilities, and other Federal agencies involved with managing domestic water resources. The USGS ground water database contains ground water site inventory, ground water level data, and water-quality data. Watershed, subwatershed, aquifer and subaquifer data is not generally available, though some are well characterized.

The USGS National Water Use Information Program (NWUIP) is a source of information about water use in the Nation. The principal product of the NWUIP has been its five-year national summary of estimates of aggregated water use. This report is a source from which some spatial and temporal trends in water use in the United States are derived. Underlying these aggregated estimates are somewhat sparse but sometimes more detailed site specific data about water use, in which individual water withdrawal locations are tabulated, the types of water use determined, and the amounts of water use estimated. At this site-specific level of water use, the source of surface water or ground water for each water-use site may be identified, and the link between water use and water resources might be established.

However, site-specific data are not always available and estimates of water use are made at varying spatial scales. The water-use categories for which data are being compiled by the NWUIP are aquaculture, industrial, irrigation, livestock, mining, public supply, self-supplied domestic (private household sources of water), and thermoelectric power. Commercial use, wastewater treatment releases, reservoir evaporation, and hydroelectric power are no longer being tracked. Neither are consumptive use, reclaimed wastewater use, and industrial or commercial deliveries from public supplies. And in the future it is possible that thermoelectric water withdrawals will quit being tracked. Other energy intensive industries, including the fertilizer production that intertwines with agriculture, have never been tracked. The loss or absence of many of the water-use categories has obvious implications for future local and regional studies of water availability and of how human use of water, such as for energy development, impacts the quality, quantity, and sustainability of water resources.

In 2006, EPA mandated a requirement for counties and cities to plan and prepare water supply studies. Responses to this unfunded data call are being developed.

Some states are turning to citizen action groups to help provide the information needed to maintain water quality. Collaboration is considered essential when dealing with this issue, and is complicated by the lack of funding at all levels, broad citizen awareness is insufficient for making informed decisions, and the data is too widely scattered; it takes many skills and many people to cover the turf. These collaborative efforts are needed to ensure proper evaluation and valuation of water resources for all needs, including energy development and generation.

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