1.0 Introduction

As required by 2005 Congressional appropriations,[1] three regional Energy-Water Needs Assessment Workshops were held in late 2005 and early 2006 to further the Department of Energy's (DOE's) Energy-Water Roadmap Program. The Energy-Water Roadmap is intended to help guide the DOE's efforts and funding to further research, development, demonstration, deployment (RDDD), and commercialization of technologies and science to help provide adequate water resources for future energy production in the future in the United States.

The three regional Needs Assessment Workshops (held in the western, central, and eastern United States) were designed to identify anticipated national and regional energy and technology needs, along with the water resources necessary to meet those needs. Integral to being able to identify energy and water needs in the workshops is the need to understand or identify the underlining policies that support or hinder RDDD efforts—for example, the legal, regulatory, and economic incentives and constraints that affect the success of the DOE's efforts.

The regional workshops provided an understanding of the relationship between technology/science and underlying policy through the participants' identification of needs or gaps that have either a technological or scientific solution, or that have no such solution but still require resolution in order for a specific technological or scientific solution to be implemented effectively.

Workshop participants provided input regarding underlying policies, including:

- regulatory constraints or gaps;
- legal issues (federal, state, or tribal);
- economic issues, constraints, and incentives; and
- the need for additional or clarified policies (federal, state, or tribal).

These issues were captured in notes taken during the workshops and breakout sessions.

This document summarizes the legal, regulatory, and economic incentives and constraints related to technological needs identified during the three regional workshops. Results are discussed within the six topic areas established in the National Synopsis of the Energy-Water Needs Assessment Workshops. Needs that were identified outside the scope are presented in sections 3.7 and 3.8.

2.0 National Topic Areas

The National Synopsis of the three regional Energy-Water Needs Assessment Workshops identified six areas of technology/science/information needs common to all workshops. To maintain a degree of continuity and to enable cross-issue/regional identification, this synopsis of legal, regulatory, and economic issues is organized according to the six areas identified by the National Synopsis. However, it should be noted that the National Synopsis was not designed to capture, in the same manner, the legal, regulatory, economic or policy issues the workshop participants brought-up. Therefore, the issues (technological/scientific and legal/policy) are initially separated in these two documents for ease of analysis.

Most participants felt that in order for technologic and scientific development to be effectively advanced both federal and state agencies first must address the identified legal and regulatory constraints/issues, along with overall policy direction in key areas. While it was found that a majority of participants felt legal, regulatory and policy issues were as important, if not more important, than technologic and engineering issues, the primary

[1] The legislation, in part, mandates the Department of Energy to address energy-related issues associated with adequate water supplies and water-related issues concerning adequate energy supplies.

purpose of the workshop was to identify technological, scientific and engineering needs and only identify coupled substantive legal, regulatory, policy and economic issues.

While the National Synopsis did not capture the non-technology needs it is important to understand that the breakdown of the technologic, scientific and informational needs also corresponds directly to the non-technological needs. For example, policy needs were found to be required in the technological area as much as in the information management area. See the chart below. Also, the National Synopsis captures only a few of the economic needs in the technology needs arena; additional economic needs are summarized in this document.

The needs highlighted in the National Synopsis for (1) technological/scientific solutions; (2) information (databases, information management systems, maps, and other data requirements); and (3) economic evaluations yielded the following generalized results, in which T = technological/scientific needs, I = information needs, and E = economic needs. Note that the National Synopsis did not include legal, regulatory, policy, or most economic issues and that the separation of needs into three categories is subjective. The following table, however, is intended to indicate how the needs identified by the participants can be divided; noting that legal, regulatory, policy and economic needs are an integral part of each technologic/scientific and engineering need.

Eastern Region:

- T = 37% of the total identified needs for the eastern workshop only
- I = 49% of the total identified need for the eastern workshop only
- E = 14% of the total identified needs for the eastern workshop only

Central Region:

- T = 41% of the total identified needs for the central workshop only
- I = 53% of the total identified need for the central workshop only
- E = 6% of the total identified needs for the central workshop only

Western Region:

- T = 44% of the total identified needs for the western workshop only
- I = 38% of the total identified need for the western workshop only
- E = 18% of the total identified needs for the western workshop only

Overall combined percentages for all three workshops:

- T = 41%
- I = 45%
- E = 14%

3.0 Topic Areas

The topic areas identified in the National Synopsis and utilized below do not necessarily reflect the relative importance of the legal, regulatory, economic, and policy issues of each topic area as identified by workshop participants. The six topic areas are: (1) long-term and integrated resource planning; (2) extracted and produced water; (3) information management systems, databases, and modeling; (4) water intensity considerations (technologies, efficiencies, and alternative sources); (5) management of the nation's surface and groundwater resources; and (6) a realistic cost basis for water use.

The needs identified within each topic area are discussed in sections 3.1 through 3.6, below. Thereafter, Section 3.7 summarizes policy needs/constraints that were identified by workshop participants but that have no scientific or technological "fix." Section 3.8 captures economic issues/constraints/incentives that have no scientific or technological fix. Although the needs/gaps identified in sections 3.7 and 3.8 have no technological fixes, workshop participants considered it critical to record them in the workshop notes, because unless those needs are met, it may prove impossible to implement the technologies.

3.1 Long-Term and Integrated Resource Planning

Virtually all workshop/breakout groups discussed the need for long-term and integrated resource planning, especially concerning development and siting of power grids, producing facilities, and plants along with infrastructure interfaces for both water and energy issues. Several participants stated that it is difficult to site power plants near reliable water sources. In addition, it may take a decade to obtain licensing. The issues surrounding procuring water rights, permitting, and public opposition mean that bringing a new facility on line is extremely costly and time-consuming. Current power production facilities and distribution grids may be vulnerable, suggesting that decentralized systems should be considered where appropriate. Participants also noted that the current electrical power distribution system has a demonstrated inability to respond quickly to changing conditions. In addition, alternative energy sources may foster development of better energy storage technologies. Overall, the groups concluded that several basic policy decisions must be made in order to meet and secure the requirements for future energy production.

Potential policy approaches to dealing with energy production issues were, at times, hotly debated in breakout sessions. Several groups emphasized that a national policy was necessary in order to move toward a decentralized power generation and distribution system. Additionally, almost all breakout groups discussed the need for increased federal attention to policies that could increase grid access for alternative energy sources. Other groups identified the need for a national policy supporting the increased development (both in terms of technology and regulatory support) of cogeneration.

Underlying the identified needs for policies was an awareness that complex laws and regulations currently make it difficult to develop new energy resources and to invest in technologies for saving energy or water. Thus economic, policy, and legal analyses are needed to determine when and where new energy- and water-saving technologies are cost-effective and should be developed. In addition, because energy often is required for new water projects and water is required for new energy investments, there is a need for integrated resource planning (including air resources) to determine the cost-effectiveness of proposed energy and water technologies.

3.2 Extracted and Produced Water

Certain resource extraction processes produce water of generally poor quality—for example, the water produced by separating interstitial water from mined fossil fuels. Produced water raises technology needs and economic and policy issues, such as the needs to:

- develop a cost-effective technology to treat produced or extracted water to a specified standard for reuse by other sectors;
- determine the value of produced water to other sectors after it is treated to various levels of purity;
- identify appropriate measures to induce state regulatory agencies to require treatment of produced waters;
- determine the ownership of pre- and post-treated water.

Mining fossil fuels can generate significant volumes of water. One participant commented that 11 barrels of water are produced for each barrel of fuel. With increasing demand for coal and coal bed methane (CBM), greater volumes of produced water are expected.

Produced water provides a good example of the legal and economic impediments to efficient use of water and energy resources. Ambiguity surrounds the regulation of low-quality produced water. The mining industry currently is not compelled to treat the water to a quality acceptable for agricultural or urban consumption; rather, the water is discarded in the least costly manner allowed by the regulatory agency. Generally handled as a waste, produced water usually is injected back into an aquifer of similar quality or is allowed to evaporate. With treatment, such water could become usable and a resource for potential appropriation. Conversely, treatment requirements raise the cost of production and may act as a disincentive to production.

Several producers of CBM pointed out the ambiguous nature of the ownership of produced water, especially if it is to be treated. They noted that if a mining company owns the water, the company may find it economically beneficial to treat the water to a reasonable discharge standard. If not, the economics skew toward disposing of

the produced water as waste. Treating produced water as a water right brings additional complexity of regulation and may implicate the notion of impairment of another's right.

3.3 Information Management Systems, Databases, and Modeling

Workshop participants identified a significant need to create realistic and usable databases and modeling programs that would be made available to water users without agency barriers or segmentation. The groups that discussed this issue stressed that the federal government must make the policy decision that creating such databases and modeling programs is necessary and sufficiently important to warrant funding.

As several groups discussed, the basic water allocation scheme in the West dates back to times before accurate data or real-time communications were available. Even today, accurate data and access to information continue to be issues. New, basinwide data on surface and groundwater are needed; current data were considered inadequate. An often-cited example was the over-allocation of Colorado River water. New and improved data and databases would enable water to be managed in accordance with modern needs and forecasts (including climate forecasting).

Several participants suggested that new computer technologies and data access protocols may provide an opportunity for agencies having sophisticated computer expertise, such as the national energy laboratories or the U.S. Geological Survey, to collect critical data while insuring the confidentiality of those data. These same agencies can utilize remote sensing technologies, enabling more cost-effective collection of water resource data.

The need for expanded collection and dissemination of groundwater information also was noted in all regional workshops, although participants frequently mentioned that these needs have been known since the 1970s.

3.4 Water Intensity Considerations: Technologies, Efficiencies, and Alternative Sources

Workshop participants identified the need for more efficient water treatment systems (having lower energy consumption and operational costs) and increased water-use efficiencies, including at thermal power production facilities. Treatment is necessary to increase the amount of water available for urban and industrial uses. Many participants stated that methods could be developed to match water of a specific quality to an appropriate use, rather than treating all water to drinking water standards. In addition, more efficient (less water-intensive) designs, systems, and equipment could decrease water requirements in agricultural, urban, and industrial processes. One example given was agriculture's use of center-pivot irrigation, which entails inherent losses that could be lowered by other available spray systems. Several groups proposed that new methodologies, regulations, or policies should be employed to increase water conservation. Currently, because groundwater irrigation tends to be energy-intensive, conservation occurs largely in response to energy costs rather than the cost of water.

Technology or process improvements are needed to increase thermal efficiency in water- and air-cooled thermal power plants. New, efficient treatment technologies are needed to provide water for reuse or clean discharge. Several groups, primarily in the western workshop, stated that a federal policy for thermal power generators, backed by adequate funding or incentives, was vital for engendering the drive to develop innovative technologies that could decrease the need for water and/or increase the amount of power generated per volume of water used or consumed. Representatives of power generators stated that although they would welcome such technology development, for the most part it is not economically feasible for them to undertake it. Many noted the most important part of the DOE program might be to support development of new technologies that are beyond the acceptable risk limit for private companies.

Workshop participants agreed, almost unanimously, that better energy storage, such as via voltaic batteries, is necessary to enable alternative energy technologies to provide practical solutions. It was also agreed that the developing battery storage technology should receive additional funding. No one, however, either had current funding numbers or could recommend the amount of funding required. One group advanced the idea that if water was available at an alternative energy site, hydrogen gas could be produced as a storable energy resource. However, it was also noted that several technical issues regarding hydrogen storage cells must be resolved first.

Both western and eastern workshops identified the need for increased water conservation in large urban water delivery systems. Participants stated that water utilities in western states typically experience a 15-percent loss from distribution systems, as compared to a 40-percent loss from some older eastern systems. Leaking and inefficient urban water systems received less attention in the western workshop, which focused more on agricultural efficiencies. In the West, water usage is seen as being based on antiquated agricultural management models dominated by a "use it or lose it" doctrine. Several participants stated that the prior appropriations model of water management discourages conservation because conserving water may threaten water rights.

Energy production, especially thermal power production, requires the reliable availability of significant amounts of water. Reliability of water supplies is becoming a major issue in hydropower throughout the West because of current climate conditions, along with silting [behind dams?] and ecological requirements that diminish expected stream flows. These issues must be addressed by the federal agencies in order to create a usable framework for future development and for sustaining current hydroelectric power production.

3.5 Management of the Nation's Surface and Groundwater Resources

For all workshop, understanding the interactions among all water resources was seen as key to the rational management of the nation's water resources and energy production/needs. Rational management also requires efficient and functional regulatory and permitting requirements. A number of participants identified the need for both a fundamental understanding of the interaction between ground and surface water and a revamping of the current licensing and regulatory system to eliminate waste, increase the probability of getting power plants on line, and provide a starting point for allocating water to power plants based on a rational priority scheme.

Most groups found that the maze of licensing/regulatory requirements makes it difficult to develop new power production facilities. The concept of centralization, discussed at length in the eastern workshop, emerged as a western issue also. The issue concerns not only in which regulatory regime a facility is located, but also how to integrate requirements of the Federal Energy Regulatory Commission (FERC) and other agencies. Some groups noted that lead times for new power plants can prove prohibitive and can discourage innovation while encouraging centralized, magnitude-of-scale facilities as opposed to localized or off-grid supplementary sources. In addition, innovation is discouraged because the utility must bear all of the regulatory risk.

Overall, most groups identified a need for more detailed information on groundwater, with data available in a centralized database or databases. Many participants noted that overdrawing groundwater affects surface water, and over-pumping is not sustainable. In most areas, however, groundwater availability, withdrawal, and recharge rates are not well quantified, and pumping is not monitored effectively. The technological ability to monitor water resources more accurately and effectively, along with better databases, was seen as supporting the development of more effective water policies in general and specifically for policies regarding energy production.

3.6 Realistic Cost Basis for Water Use

Because the water markets are relatively underdeveloped and because water laws and regulations vary from state to state, there is no commonly accepted estimate of the cost or value of water. An economic analysis is needed to identify the cost of water inputs to new power facilities and the value of water saved by water-conserving technologies. Perhaps the most prominent issue that lacks an easy technological solution, and one that was common to all workshops, was that water effectively is subsidized because the cost of water does not include environmental and other hidden costs. Participants suggested that a multi-component computer program is needed to calculate the relative true cost of water at any point in time with respect to local/basin costing factors, which include applicable regulatory and policy functions, e.g., compliance with a state's National Environmental Policy Act (called mini-NEPAs) or the federal Endangered Species Act (ESA).

Along with proper costing of water comes the need for increased conservation and efficiency and the need for integrating water conservation and efficiencies into water rights. Underlying the resistance to water conservation in the western states is the "use it or lose it" maxim that governs most water rights. Participants proposed that

water rights ought not to be lost because of non-use through conservation. Although tax incentives were mentioned as an economic carrot for water conservation and efficiency, workshop participants appeared to find that generally an uninteresting solution. Tax or other economic incentives would need to counteract the possible loss of a water right. Several groups discussed the issue of water rights in the permitting and licensing of power production facilities—specifically, the need to gain sufficient and reliable water rights for the life of the plant.

Although not directly addressed, an underlying issue concerns how to economically value water in a way that will drive conservation, result in best use, and provide for sustainable development. For example, there was general interest in establishing an equivalent to the Energy Star certification to encourage a consumer-based demand for water savings. Another proposal was to create better marketing strategies for water rights. It was postulated that market incentives could alleviate some industrial concerns, e.g., how to procure sufficient water capacities from a myriad of right holders having various seniorities and complex mitigation requirements, as well as private individuals who often consider their water rights to be part of their net worth. As such, these private rights may be similar, economically, to homeownership, which Congress traditionally encourages and subsidizes through tax incentives. Various workshops explored a number of potential solutions to this issue.

3.7 Legal/Regulatory/Policy Issues Lacking a Technological Solution

Several breakout groups noted that as water rights developed, in response to geographic restraints and population growth, each state adopted its own design for water management and its own allocations of surface and ground waters. Each state, while perhaps generally applying the theory of prior appropriation, created its own set of rules. When siting large-capacity power production facilities, laws governing trans-basin water transfers become complex because they usually involve several states, numerous regulatory issues, and interstate water compacts, along with interstate environmental concerns.

All breakout groups expressed concern that current water regulations are based on century-old technologies, populations, and information. The system (including allocation of water rights, groundwater data, pumping volumes, recharge rates, and beneficial uses) is considered archaic and burdensome. Most groups stated that although the system currently continues to function, future water demands could break it. Increased availability of and access to information would further the overall understanding of the true status of the nation's water resources.

Several participants noted that Native American water rights, which are becoming a significant issue in the West,[2] must be integrated into overall regulatory and policy planning. Tribes, which are distinct political entities that strive to co-exist with the competing interests of state and local governments, seek a balance between cultural preservation and economic development. One tribal participant identified a need to address the broader socioeconomic issues in Indian country before implementing power projects. Several participants in the central and western workshops noted that a number of tribes are now asserting their legal rights concerning water and construction of power plants.

Western water law is based on the doctrine of "first in time, first in right." Because Indian tribes established water usage prior to western expansion and settlement, tribes usually hold the oldest and therefore most valuable water rights in the water-poor West. The Supreme Court has recognized Indian water rights to have existed since "time immemorial." Certain participants stated that the special status of Indian water rights may turn tribal nations into the new power brokers for water in the West.

A couple of central and western breakout groups noted that selling of water rights currently comes with a cultural cost to rural and agricultural communities across the drier West. Smaller towns and the economic network surrounding them cannot sustain the loss of water due to diversion to other uses, such as urban development. Even without the sale of agricultural water to urban and industrial users, agriculture is dealing with an unsustainable supply in areas that depend on groundwater for irrigation. Given the many competing uses for water, some participants proposed that a central energy and water policy sensitive to human needs, natural

[2] See, e.g., *California v. Arizona*, 530 U.S. 392 (2000) (certain tribal and government claims to water rights not precluded by prior Supreme Court holding; Special Master to determine final outcome).

ecology, and constitutional requirements might be necessary to sustain economic growth and environmental quality in the United States.

3.8 Economic Issues

Most workgroup participants identified a strong need to determine whether proposed technologies for conserving water or energy are cost-effective. They considered this task to be necessary, albeit complex because the value of water and energy vary widely—by location, across time, and by level of risk—and because many economic, market, and legal issues impede the development of efficient water- and energy-conserving technologies. Each workshop devoted significant attention to addressing the following economic, market, and legal impediments to implementing efficient technologies.

- There is no realistic basis for estimating the cost of obtaining new water supplies in many areas, given externalities and lack of water markets.
- Because the laws governing the ownership and transfer of water often are complex and differ among states and regions, there is uncertainty about the cost and ease with which water may be purchased or transferred.
- Complex regulations and overlapping regulatory jurisdictions delay licensing and prevent development of new power facilities. This complexity creates uncertainty about both the value and the cost of water supplies for these facilities.
- In many areas information about ownership, quality, and quantity of water resources is poor or nonexistent. It is difficult to assess water resources without robust data and models that incorporate such data.

Detailed economic, legal, and policy analyses could determine whether the value of water and energy saved with conservation technologies exceeds the cost of developing those technologies. Similarly, the complex legal and regulatory environment governing those resource technologies implies a need for thorough legal and policy analyses—to determine where, when, and how soon new conservation technologies can be developed.

In general, the most prominent threads of discussion concerning the economic underpinnings in all the Regional Workshops were:

- the lack of water markets and the need for realistic water costing;
- a realistic, usable database covering all water resources; and
- the need for economic incentives to conserve water, increase power production using current water resources, and foster technology development.

4.0 Conclusions

Certain workshop issues can be characterized as primarily regional, e.g., the issue of produced water in the West, the deterioration of the water distribution infrastructure in the East, and the disparate water availability issues in the central states. Most participants found that water issues for power generation (both thermal and hydro) arise today because of geography, population growth, and climatic realities that disallow the consideration of water as a free or inexpensive resource. Virtually the same policy, legal, and regulatory issues were identified in all three workshops, as were the expressed needs for better data and databases and for developing a realistic basis for water pricing. All groups expressed that today's challenge is to effectively transition the existing framework for water allocation and power production into a system that can both grow and be sustainable.

Participants also found a definite need for economic, legal, and policy analyses to determine whether the value of water and energy saved with conservation technologies exceeds the cost of developing the technologies. Additionally, a number of workshop participants found the need for a thorough legal and policy analyses to determine where, when, and how soon new conservation technologies can be developed.