Energy-Water Nexus
Eastern Region Workshop

Problems and Needs Summary

Priority Problem: Increasing/Competing Demand..... 1
Priority Problem: Lack of Data and Modeling Tools 1
Priority Problem: Water-Friendly Energy Technologies..... 1
Priority Problem: Water Treatment/Delivery Infrastructure..... 1
Priority Problem: Source Quality and Quantity..... 1
Priority Problem: Lack of Integrated Resources Planning 1
Priority Problem: Lack of Public Awareness..... 1
Priority Problem: Lack of a Water Market 1

Priority Problem: Increasing/Competing Demand

The Eastern Region is home to a rich tapestry of competing (and in many cases increasing) demands for water. Localized increases in demand for water can be seen in Atlanta and surrounding communities, where burgeoning populations are making increasing demand of water resources. Recreational demands, navigational requirements, and the necessity to maintain in-stream flows in the Tennessee Valley are impacting the optimal management of hydropower resources and thus the efficient generation of electricity. And increasing demand from municipalities foreshadows ever greater management of resources in the Delaware Bay region.

Against this backdrop, participants cite a range of problems caused by/related to increasing and competing demand for energy and water:

- Despite reductions in per capita water demand, aggregate water demand for domestic uses is increasing due to population growth.
- Diversions from rivers are causing problems for hydropower management.
- Climate variability is causing (and is projected to continue causing) negative impacts on overall water availability in the region, and to causing greater extremes in water flows—bigger floods and deeper droughts. This instability in water supplies exacerbates the competition for water.
- Population projections are conducted at the state level, not necessarily the watershed level.

Participants note that while most individuals involved with water and energy planning and management acknowledge these problems, their understanding of them is hampered by a lack of models of regional and sub-regional population growth, by a lack of surveys on water use in the Eastern region, and by a dearth of information regarding the value/contribution of competing uses. To alleviate these problems, participants cite the following necessary activities

- **Need incentives for all users to conserve water.** Participants note that at this time there are few incentives for conservation, and that conservation of resources will be an increasingly important component of managing the energy-water nexus in the future. Reviewers also cite a need for studies of the benefits of water conservation on energy conservation (and the potential costs and impacts).
- **Need research targeted to understanding the water resource in the region**. In particular, participants cite a need for data on the number of people served by public water and wastewater systems and the number and location of populations that rely on wells and septic tanks.
- **Need site-specific, science-based quantification of in-stream flow rates** to meet ecological, environmental, and navigation requirements. Participants note the need for quantifications of flow, temperature, turbulence, and flow variability under normal and drought conditions. As a complement to understanding the demand of in-stream flow, participants also note a need to understand the supply side of the equation (i.e., how much water is available for what is needed in-stream?)

- **Need energy- and water-efficient building codes (green building codes)** that can reduce per capita and aggregate consumption of both energy and water, and that facilitate the reuse of water. In conjunction, participants note a need for case studies of water/energy efficient buildings and the development of models that can illustrate the optimization of water use.
- **Need methodology to evaluate the value of competing uses.** Participants note that at present, there is no quantified, systematic method to evaluate the true societal cost (or benefit) of allocating water (and its attendant energy) to one use versus another (power vs navigation, recreation vs municipal, etc.).
- **Need adaptive management tools** to more effectively manage water and energy resources, particularly during times of greater climatic variability and increasing demand and supply stresses.
- **Need a comprehensive, system-level understanding of current and projected water demands from the energy sector,** including the addition of conventional generation and the impacts of large-scale introductions of alternative energy sources such as ethanol and hydrogen. Participants note that the energy sector poses the threat of becoming an increasingly voracious consumer of water; they comment in particular on the significant water demands posed by potential co-location of ethanol production in areas of the region already pressed for water. Not only would such activities continue the agricultural sector's already significant water withdrawals, but it would add a new and significant water draw in the form of ethanol distilleries.

  Participants also note a **need for a systems-level analysis of the energy-cost-water tradeoffs presented by renewable electricity generating technologies** (solar and wind) and renewable liquid fuel production (biomass-sourced ethanol).

Priority Problem: Lack of Data and Modeling Tools

Reliable data, and integrated models built upon that data, are integral to addressing many of the Priority Problems identified in the Eastern Region—without solid data and models, it will be impossible to construct Integrated Resource Plans; to identify water supply constraints and thus identify how much more water-efficient energy generation facilities must become; or to effectively balance the growth in demand from competing users.

Participants in the Eastern Region workshop, like their counterparts in the Western and Central region workshops, repeatedly noted significant gaps in

- The understanding of surface and groundwater resources, including quantity, quality, location, and movement data, and the temporal fluctuations in each.
- The understanding of the hydrologic cycles found in the Eastern region, particularly site-specific groundwater-surface water interactions.
- The availability of suitably detailed and tailored computational models.
- The availability of sufficient data from which to deduce reliable trends in availability and demand.

These same participants note a variety of underlying causes of these gaps, including

- **Wide variations in reporting requirements and data accessibility between states.** They note that data is proprietary in some cases, and thus not available to modelers; in other cases, water withdrawal reporting requirements are set so that much usage may be 'missed' in the data (South Carolina, for instance, only requires quarterly reporting of uses greater than 100,000 gallons per day).
- **Lack of consistent reporting requirements and data standardization.** Participants note that the data collected by Federal, state, and local agencies is largely incompatible—because it is collected to satisfy specific legislation or regulation, most datasets do not use the same parameters (e.g., identifying collection points by latitude and longitude versus grid references) or the same measurements (gallons versus acre-feet). On top of this, participants note that reporting requirements are often not enforced due to a lack of funding and staff.
- **Lack of model integration.** Participants note that there is no shortage of water and energy models, but there is a real lack of integrated models. They note a lack of integration even within disciplines—local water models exist, but watershed models may not; top-down, national-scale energy models exist, but bottom-up, local projections of future demand often do not.
- **Lack of data analysis/reliability.** Participants note that the accuracy of extant data is questionable in many cases; lack of resources makes thorough QA/QC difficult. They also remark that much data is collected but not used in a timely manner due to funding and staffing constraints.
- **Lack of understanding of what isn't understood.** Participants comment that tremendous amounts of data and information are collected, but that it isn't always the information they need. They remark that some modeling needs to be undertaken for the community to understand what data they will need for future

efforts … in essence, they need to put the cart before the horse for just a little bit until a greater understanding and knowledge is generated.

To close these gaps in understanding and build the models that will provide the foundation for rationalized energy-water planning in the Region, participants presented and discussed a range of needed activities:

- **Need a consistent, national database/dataset management system.** To overcome the disparities in existing databases, participants cite a **need for a consistent nomenclature (and definitions) and data standards**. Participants comment that one agency's definition of "impaired waters" may differ from another's, and that it is necessary to reduce such cross-talk. They cite that a national system as proposed should be GIS based, allowing for easier manipulation and analysis of the data. As a component of this system, participants cite a **need to identify good data practices and to incorporate them in the database management system**.
- **Need to understand currently-available data.** As a prelude to creating a consistent management system, participants note that it is **necessary to understand what data is currently available, where it is located, how it is accessed, its characteristics, etc.** Such an activity would lead to a national data clearinghouse and would provide one-half of the information necessary to complete a rigorous data gaps analysis.
- **Need to create integrated energy-water database.** Building on a consistent management system and catalog of currently-available data, participants cite a **near-term need to bridge/fill the data gaps to create an integrated database**. Participants note that a range of information will have to be generated to create a usable database—to wit, information detailing the interaction between ground water and surface water and the determination of sustainable withdrawals and information on regional and sub-regional water balances. Such an **integrated database should also contain quantified water- and energy-related social and economic data** to the extent possible.
- **Need to characterize water use and impacts by user (power, agriculture, domestic, etc.).** It is noted that many organizations responsible for managing or planning energy and water supplies have a limited understanding of how the items in their purview (surface water, groundwater, energy facility siting, etc.) impact, and are impacted by, other entities. **Characterizing (in consistent terms related to quality, quantity, location, etc.) and disseminating impacts is seen as an essential data collection need.** Without such understanding, effective models cannot be built.
- **Need to create integrated, reliable, predictive energy-water model** that can be used at a variety of scales from the broadly regional to that of a tributary watershed. Participants note that such a model should be capable of accurately determining near-term water supply and demand, taking into account seasonal fluctuations in competing demands (energy supply, agriculture, in-stream flow requirements, etc.). The model should also be capable of generating long-term water-energy balance predictions based on climatic data, energy demand

projections, conservation, population growth, demographic shifts, and the range of issues that impact energy-water balances in the region. The model should account for both near-term and long-term cycles.

- **Need cheaper real-time monitoring of surface waters;** participants note that currently, monitoring stations cost $10,000 per year to operate, and that next-generation, predictive models will require about ten times more surface water data than is currently generated (at least one gauging station per sub-watershed). Participants also note the O&M expense of groundwater monitoring ($5000 per year); and that research needs to be conducted to determine the best locations for groundwater monitoring to maximize the return on limited funds.
- **Need energy-water specific modeling of impacts as a result of climate change**. Participants note that hydropower facilities in the Eastern region are subject to significant impacts from precipitation variability, including not only disturbances to traditional flow patterns but also from accelerated sedimentation. They also note that coastal energy facilities may be subject to increased saltwater intrusion in their surface water supplies as sea level rises. Participants feel that any energy-water modeling exercise should include state-of-the-art sensitivity analysis on the impacts of climate change.

Priority Problem: Water-Friendly Energy Technologies

Electricity generation and energy production (coal mining, oil and gas extraction, refining or distilling of liquid fuels) are a significant (and growing) part of the demand side of the water equation; this end-use sector is experiencing significant operational shifts as a result of regulation, scarcity, and national policy.

> Goal: Cut water usage for once through cooling systems by 50%.
> Goal: Cut water usage for recirculating cooling systems by 50%.

- Limits on water discharge temperatures are forcing electric generation stations to move to closed-loop cooling; this equates to lower draws of water, but also increases the water consumed by the plants as none of it is returned to the surface body water from which it is withdrawn (as is the case with once-through cooling).
- The possibility of renewed construction of nuclear power plants portends increased water consumption for cooling (these plants consume more water per kWh generated than coal- or natural gas-fired generation).
- The increased interest in producing ethanol (both conventional ethanol from corn and nonconventional ethanol from biomass feedstocks) may mean an increase in water demand to both grow the feedstock and to distill the fuel.
- The scarcity of water in some locations is forcing new electricity generating stations to move to dry or hybrid cooling; this reduces water demand and consumption, but also comes with a generating efficiency penalty.

Currently, electricity generation consumes on average 21 gallons for each kilowatt-hour produced; participants note that the opportunity to reduce water usage in the generation of electricity is greater than in other end-use segments. In light of these shifts, participants cited the following energy generating technology needs:

- **Characterize (in standardized units and terminology) and model the water demand and use of differing generation technologies** to understand and evaluate the impacts of permitting one facility type over another. Such modeling should also account for a one degree Centigrade change in temperature by 2050, to determine the effects of this on plant efficiency and cooling requirements (in coastal areas, such modeling should also examine saltwater intrusion in surface waters, and how it may impact energy generation).
- **Understand the ramifications (in-plant, and downstream) of utilizing produced waters and wastewater for cooling.** Largely unknown is the minimum water quality that can be utilized, the number of times such waters can circulated through the system, and the disposal ramifications; participants also cite a need for a uniform definition of grey water.
- **Develop waste heat capture technologies** so that the effective work/gallon consumed is increased (thus making better use of each gallon of water and each unit of fuel consumed). Need to investigate/create case studies where waste heat is being used to determine the economics (cost-benefit).

- **Explore the use of less water intensive alternative cooling systems** (including ground cooling) and cooling systems that are tolerant of wider ranges of water qualities (from saline waters to waste waters).
- **Develop water-friendly carbon sequestration technologies** (participants assume the need for carbon sequestration in the future). They cite a need to understand the impacts on groundwater of CO2 injection, to quantify the water required for sequestration activities, and to identify areas where carbon can be used to improve ecosystems.
- **Pursue aggressively the development of renewable energy technologies** that are less water intensive than conventional technologies. Need to understand and quantify the practical limitations of renewable technologies—determine the energy and water contributions to be made in the Eastern region.
- **Develop and promulgate policies and incentives that encourage the development of a market for renewable energy technologies** (a stable tax policy based on a 10 year minimum production tax credit coupled with accelerated depreciation and a loan guarantee program).
- **Streamline the permitting process for renewable energy technologies**; participants cite that creating generic baseline ecological surveys and technology-specific baseline impact statements could accelerate the siting of wind power systems as well as for low head hydro installations.
- **Understand the impacts of large-scale integration of intermittent resources** (solar, wind) into the grid. Along with understanding, participants cite the need for better grid management and control technologies.
- **Research cellulose-to-ethanol conversion processes** to improve yields (and thus lower the water consumed:ethanol produced ratio).
- **Establish demonstration projects** (at the 50KW—50MW scale) to demonstrate stability and control of biomass gasification processes, and to develop processes that can handle variability in feedstocks. Participants also cite a need to understand the impacts on water quantity and quality presented by biomass feedstock cultivation (and by association evaluate the physical and practical limitations of energy crops).
- **Develop models to predict sedimentation rates behind hydropower facilities** given likely changes in flow variability due to climate change.
- **Incorporate water use as an attribute to be considered in the FutureGen program.**

Priority Problem: Water Treatment/Delivery Infrastructure

The infrastructure required to treat and transport water in the Eastern Region is particularly complex—not only is the region home to the nation's oldest urban water systems (Boston and New York City among them), but it is also the site of significant exurbanization in the mid-Atlantic and Southeast states (witness the infrastructure demands of population growth and sprawl surrounding Washington, DC, Atlanta, and the cities of Florida).

Approximately 20% of the energy produced in the United States is used to power water treatment and delivery infrastructures. Participants note that the challenges facing the infrastructure in the Eastern Region will likely grow worse over time; the Environmental Protection Agency has stopped funding infrastructure improvement projects, and notes a $1 billion funding shortfall for infrastructure projects across the nation over the next 20 years.

New and aged infrastructures present different challenges to the energy-water nexus:

- **Water and energy losses.** Aged infrastructures are decaying, resulting in large transportation losses (Philadelphia is reported to lose 40% of the water that leaves treatment plants to leakage before it reaches the end-user). It is not only water that leaks from aged infrastructures, it is also energy—every gallon leaked is a gallon's worth of electricity to pump the water to the point where it was lost and the energy used to treat that water.
- **Water and energy demand increasing.** New infrastructures might not leak as badly, but the sprawl of exurbanization means larger areas to serve, requiring greater energy consumption for pumping. Every new house or business in the exurbs represents not only additional water demand, but also additional energy demand to get that water to the end-user.
- **Increasing treatment demands.** Both new and aged treatment plants face the need to meet increasingly stringent water quality standards, while simultaneously facing challenges presented by decreasing surface and groundwater quality.

Participants discussed a host of discrete near- and long-term needs related to water treatment and delivery infrastructure problems, including:

- **Need to quantify leakage from old water pipes.** This effort should quantify the volume of water lost, the volume of water that could reasonably be captured by reducing leakage, and the energy consumed (and lost) due to distribution losses. Without this quantification, participants feel it will be difficult to make a compelling case for upgrading the infrastructure.
- **Need improved tools to detect and define leaks,** including geophysical methods for locating and inspecting pipe leaks and automatic meter reading and improved meters to define and quantify leakage. Participants note that a new, standard water loss model has recently been released, but that it is not in widespread use.

- **Need improved water monitoring technologies**. Specifically, participants cite the need for online, real-time sensors for contaminants (including current and emerging contaminants and radioactive substances) and analytical tools and methodologies with detection limits at parts per billion.
- **Need improved reverse osmosis water treatment technologies**. As standards become more stringent and treatment plants face the need to remove ever greater numbers of contaminants, participants cite the need to develop more effective, more energy-efficient treatment technologies. They specifically note the need to develop energy-efficient lower pressure reverse osmosis membranes with increased lifetimes, membranes that can treat brackish waters cost effectively, and approaches to reducing fouling of membranes.
- **Need improved disinfection technologies**. Participants identify a need to reduce the energy use of UV and ozone disinfection technologies.
- **Need to commit further research to innovative desalination technologies.**
- **Need to develop funding mechanisms for infrastructure upgrades.** Participants note that many utilities have done a poor job with preventive maintenance, and as a result face steep (and often insurmountable) financial hurdles to improving their infrastructure.

Priority Problem: Source Quality and Quantity

Participants in the Eastern Region note a range of current and emerging water quality and quantity problems

- **Urbanization/sprawl impacts on hydrology.** Participants note that the extensive urbanization and sprawl in the region presents problems for water quantity—in particular a reduction in groundwater recharge due to reduced infiltration from the built environment (run-off from hardscapes)—and for water quality—in particular groundwater contamination from underground storage tanks (MTBE is cited as a particular near-term problem).
- **Saltwater intrusion.** Participants note an increasing problem with saltwater intrusion in both surface and groundwater. While this problem is limited to the coastal region, much of the region's population lies in areas that are, or may be, impacted. Surface water intrusion is seen today during low summer flows and extreme storm events; groundwater intrusion is seen as a result of large freshwater draws. While this is largely a problem in the southeastern states, it has also been seen in the mid-Atlantic states.
- **Interregional pollution.** Participants note significant contamination of the region's surface water, particularly by mercury and acidification (as a result of SOx precipitation). Participants source much of this contamination to coal-fired power plants in the Midwest.
- **Fossil fuel extraction-related impacts.** Reviewers note that large areas of the Eastern Region are impacted by acid mine drainage, and that the region may be impacted by coalbed methane operations in the future, particularly if natural gas prices remain high.
- **Non-point pollution.** Widespread, watershed-specific nonpoint source pollution is identified across the region, with participants noting problems with biological loading, pesticides, and fertilizers among others. They note that such pollution results in eutrophication of lakes and streams and can accentuate existing concerns (may be a source of cryptosporidium, for example). Participants comment that agriculture, livestock, and recreational facilities (such as golf courses) are all culpable in the region. The sources of Participants comment that such pollution increases treatment costs and can impact the use of surface waters for thermoelectric cooling.

To effectively address these problems, participants identified a host of needs, including

- **Develop improved scrubber technology** to reduce mercury emissions at the source. Participants note a need for such technologies to be tested at the 50 megawatt or better scale to obtain real-world data. Complete mercury removal would be an ideal goal.
- **Examine productive/beneficial use of waters** that may otherwise present a pollution concern (coal bed methane waters, mine waters, etc.). Participants see this as a near-term problem that presents a long-term opportunity.

- **Need to research hydrologic cycles** to understand why wells in the Eastern Region are not recharging the way that they should. Also need greater research on fate and transport (atmospheric and aquatic) of contaminants and the impacts of nuclear power byproducts/contaminants on groundwater resources.
- **Need to research the near- and long-term impacts of water-borne contaminants**, including pharmaceuticals, livestock feed additives, and perchlorates among others.
- **Need to develop improved water treatment technologies,** particularly for MTBE remediation.
- **Need to map and characterize non-traditional (impaired, brackish) water sources** in the region as a prelude to its use as a cooling medium in thermoelectric plants or for use as feed water for desalination plants.
- **Investigate costs and benefits of distributed (versus centralized) water treatment, particularly the energy implications of large market penetration of distributed treatment systems.**

Priority Problem: Lack of Integrated Resources Planning

There are many interrelationships between the problems facing energy and water managers in the Eastern Region—as demands for water and electricity increase due to population growth, and as climate change increases the variability of water supplies, the demands on predictive models will increase, requiring more accurate and detailed data to ensure that water quality and quantity concerns are addressed for all users. Participants note that at present, the water resources are not over-allocated as is the situation in other regions of the nation; they note that Integrated Resources Planning may help to forestall that situation.

Participants note that Integrated Resources Planning will be necessary in the near future to balance competing demands; to appropriately plan for climate change-induced variability (by creating water and energy prioritization schema); to provide a vehicle for communicating comprehensive modeling predictions to policy and decisionmakers; to aid in the creation of rationalized water markets; and to effectively manage energy and water resources in the multijurisdictional context.

Effective integrated resource plans and planning structures will be built on the foundations described earlier: Improved data collection and modeling; better information on water quality and quantity; and enhanced understanding of competing uses and the increasing pressures they present. Participants identified discrete, Integrated Resource Planning-specific needs, including:

- **Better understanding of future energy/electricity demand** (and accompanying water demand) in the region so that facility siting can be planned for and rationalized. By developing watershed-specific energy/electricity demand forecasts, planners can anticipate additional water demands from new conventional generation facilities, and can then begin the process of deciding water allocations.

Participants also note that as the energy mix in the region shifts (to perhaps include the introduction of large-scale hydrogen production or biomass-derived liquid fuels), Integrated Resource Plans will be of greater importance to decide upon the feasibility of siting such energy production in a watershed, and to

Participants in all groups mentioned the lack of pricing mechanisms for water, and that this is a significant hurdle to the effective and optimal allocation of water in the region. They cite that the currently low cost of water inhibits conservation in all end-use sectors, noting that water conservation is more a byproduct of energy conservation in the agricultural sector (as pumping costs rise, farmers become more selective in their irrigation). The optimal (from an economics standpoint) solution to this would be the creation of a functioning free market for water, in which water would "flow" to the highest bidder. Recognizing the improbability of this and the imperfections of a free market, participants see Integrated Resource Planning as an effective means to meeting the economic and non-economic (i.e., environmental and ecological) needs of the region.

accommodate the significant new water demands that these energy sources present when sited.

- **Facilitate greater interaction between existing water planning organizations (river commissions, for example) and those responsible for energy planning** at the state level. This will give energy planners a "seat" at the table of those who manage the region's water resources.
- **Develop basin-wide water allocation** models that detail supply, flow rate, water elevation over time on a weekly basis, and demands on water by user (hydropower, fish and wildlife, recreation). Participants note that such models do exist (TVA, for example, is cited as knowing where every drop of their water is at all times), but are perhaps not made widely available.
- **Research and catalog, within each region/watershed, jurisdictional boundaries/conflicts, regulatory or legal redundancies, and competing authorities.** Such a catalog should also contain information on permits and permissions granted for water use.
- **Develop allocation management models** that can be applied at watershed and sub-watershed scales; such models should, at a minimum, account for priority allocations during times of drought.

Priority Problem: Lack of Public Awareness

Participants in all groups identified a lack of public awareness as an overarching problem that impacts all other problems and hampers progress toward meeting needs—quite simply, the participants do not feel that the general public in the Eastern region is aware of (a) the linkages between energy and water, (b) the increasing stresses on surface and groundwater resources, and (c) the creeping cost and supply challenges facing the region.

This is due to a variety of reasons—the Eastern region is generally "wet and green," characterized by significant rainfall throughout the year; droughts are generally rare and fleeting; and water resources are not over allocated, thus conflicts between users are generally limited.

To overcome this lack of public awareness, participants cite a need for

- Aggressive and coordinated outreach to the public regarding water issues. They feel that a consumer oriented water/energy consumption calculator, made available on the Internet and widely publicized, would make individuals aware at least of their own water consumption.
- Education on the cost of treatment, the safe and suitable uses of reclaimed water, and the recyclability of water (one participant notes that for many consumers in the Eastern region, every drop they consume has already been "used" up to seven times).
- Establishment of a water conservation/education tool akin to EPA's EnergyStar.

Priority Problem: Lack of a Water Market

Water is difficult to value—what is the price of the last drop? Water is also a public good—we do not pay for water; rather, we pay for it to be treated and distributed. Water is difficult to trade—it is expensive to move, and an array of laws and institutions are arrayed against its sale. Because of these and other issues, there is no "market" for water in most of the Eastern states.

Participants, almost universally, bemoan the draconian and convoluted water laws and regulations in the region; they note that the custom of "use it or lose it" inhibits conservation (if farmers could sell water they do not use, they would be incentivized to conserve … so goes the argument); they comment that even where farmers are allowed to sell their water rights, they often cannot sell it outside their hydrologic basin, thus severely limiting the "marketability" of the water.

Participants are realistic about market forces, noting that study of market mechanisms should be undertaken to evaluate the costs and benefits of application in the Eastern region. They note an uncertainty of the value of market mechanisms for allocation management and in solving water and energy problems, and question if there are advantages and strengths to be gained by applying market mechanism.

Participants express the hope that market forces will facilitate the application of demand side management to the water sector; that market mechanisms will drive conservation and efficiency and foster the development of water use efficiency options.