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PREPRINT

Energy-Water Nexus -- Meeting the Energy and Water Needs of the Snake/Columbia River Basin in the 21st Century

Science and Technology Summit Conference

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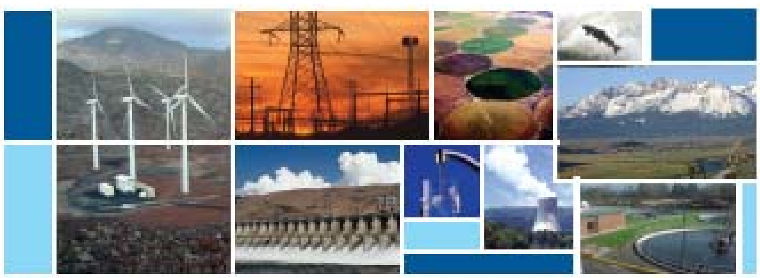
Idaho National Laboratory

Energy - Water Nexus

Meeting the Energy and Water Needs of the Snake/Columbia River Basin in the 21st Century



Science and Technology Summit
Conference Results

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Conference Organizers

- Center for Advanced Energy Studies
- Columbia Basin Trust
- Idaho National Laboratory
- Idaho Water Resources Research Institute (University of Idaho)
- Institute for Water and Watersheds (Oregon State University)

The Energy-Water Nexus

Electricity and water are at the heart of the U.S. economy and way of life. National defense, food production, human health, manufacturing, recreation, tourism, and the daily functioning of households all rely on a clean and affordable supply of electricity, water, or both.

Energy production requires a reliable, abundant, and predictable source of water—a resource that is already in short supply throughout much of the U.S. and the world. The electricity industry is second only to agriculture as the largest user of water in the U.S. Electricity production from fossil fuels and nuclear energy requires 195,500 million gallons of water per day, accounting for 48% of all freshwater withdrawals in the nation.[1] That means U.S. citizens may indirectly depend on water for turning on the lights and running appliances as they directly depend on water for taking showers and watering lawns. According to the 2001 National Energy Policy, our growing population and economy will require 393,000 MW of new generating capacity (or 1,300 to 1,900 new power plants—more than one built each week) by the year 2020, putting further strain on the nation's water resources.

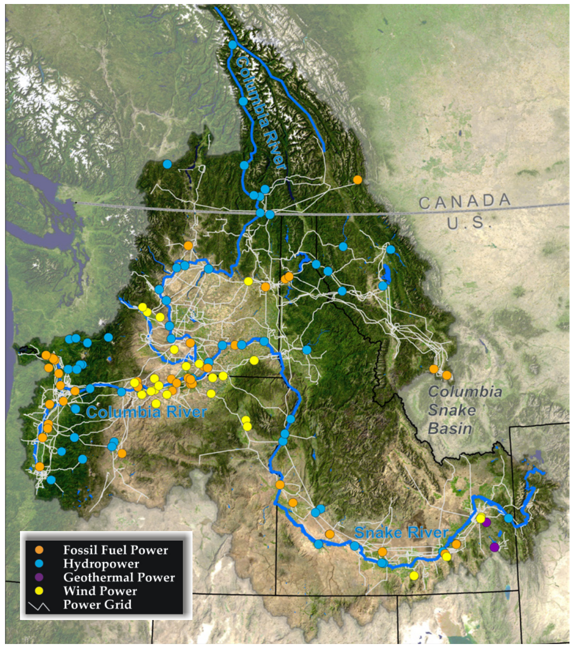
Energy and water are inextricably linked and vital to our economic sectors and our citizens' health and welfare.

Several related factors bring into question whether a stable, affordable supply of water will exist to support the nation's future electricity demands:

- While U.S. population is expected to rise significantly, accessible freshwater supplies are not. Moreover, population movement and energy demand do not always track well with water availability. During the 1990s in the U.S., the largest regional population growth (25%) occurred in one of the most water deficient regions, the mountain west. Water availability is also becoming a serious issue in the southeast, where population has increased by nearly 14% since 1990. By comparison, the water-rich northeast has experienced only a 2% growth in population.[2]
- An increasing population will not only need more electricity but also more food, pushing the nation's two largest water users into potential competition for limited water resources.
- Proposed restrictions on the use of water for power generation to protect fish and other aquatic organisms could result in increased costs of electricity or potential energy shortages.
- Because the energy required for treatment and delivery of water accounts for as much as 80% of its cost, an insufficient supply of affordable energy will have a negative impact on the price and availability of water.

The Snake-Columbia River Basin

The Snake-Columbia River Basin includes over half of Washington and Oregon, part of British Columbia, nearly all of Idaho, a small portion of western Montana. The Pacific Northwest's primary water system, the Snake-Columbia River system provides water for power, irrigation, transport, recreation, wildlife, and many other uses. From sources in British Columbia and Yellowstone National Park to the Pacific Ocean, this river system sustains the region's industry, agriculture, ecosystems, and continuing population growth.



The Snake-Columbia Basin includes parts of Idaho, Montana, Oregon, Washington, and British Columbia.

Many rivers within this system are fully appropriated and many aquifers are heavily pumped, yet new demands continue to increase, threatening both present and future uses. Population growth in the region continues to increase dramatically, further increasing the need for new sources of power and water. Between 2000 and 2030, the population in Idaho, Montana, Oregon, and Washington is projected to increase to 143%. Idaho, Oregon, and Washington are all in the top 10 states for expected population growth.

Supporting this growing population will require more energy. In the Pacific Northwest most of the electricity—82% of installed capacity in 1999, according to the Energy Information Administration—is generated from hydroelectric plants. While hydroelectric plants do not need the large water withdrawals, the continuous supply of water is obviously important. Considering that the projected demand for both water and energy is expected to grow substantially over the next 25 years, the magnitude of the challenge facing us—to manage the energy and water nexus—is enormous. The critical question is

What science and technological improvements and breakthroughs are necessary to meet the needs of planners, policy-makers, and decision-makers to optimize the generation and use of energy and the allocation and use water in the system while minimizing their impacts on the environment?

To address the pressing needs, a science and technology summit was held. The results of this conference are presented in this report. The strategies produced in this report will be distributed to regional lawmakers, regional resource managers, federal and state agencies, and the private sector to develop future research and technology programs.

The Water-Energy Summit

In June 2007, representatives from federal, state, and academic institutions met to discuss the role of innovative science, technology, and policy in meeting future energy and water demands in the Snake-Columbia River Basin. Conference members assessed the state-of-the-science, technology, and associated research to develop cost-effective and environmentally sound methodologies and technologies to maximize the production of energy and availability of water and to minimize the consumption of both water and energy in the Snake-Columbia River system. Information on all phases of science and technology development, theoretical analysis, laboratory experiments, pilot tests, and field applications were relevant topics for discussion.

Five focus groups discussed the science, technology, and policy needed to meet future water/energy demands in the Snake-Columbia Basin.

An overview of current management needs was presented the first day. On the second day, five focus groups were created:

- Energy Generation and Use
- Water Allocation and Use
- Energy/Water Storage
- Environmental Considerations
- Social, Economic, Political, and Regulatory Considerations.

Each group started with a list of status items and trends, and discussed the future challenges and research needed to reach four goals:

- Balance energy production and resource consumption
- Balance water availability and competing needs
- Balance water consumption/energy production and competing needs
- Balance environmental impacts and water use/energy production
- Balance costs and benefits of water use.

The resulting initiatives were further broken down into three categories of importance: critical, important, and nice to do but could be delayed. Each initiative was assigned a number of dots to show a more refined ranking.

The results of each focus group are given in the pages that follow. These results are intended to help local and regional researchers

1. Develop a technical strategy for developing cost-effective science and technology to predict, measure, monitor, purify, conserve, and store water and to maximize power generation, storage, and efficiency in the region
2. Evaluate methods and technologies for reducing the impacts of energy and water development and use on the environment.

Energy Generation and Use

Status and Trends

- What should be and will be the dominant sources of electrical energy demand and where will they be located in 2030?
- What will be the likely electrical energy generation capacity and where will it be generated in 2030?
- What fuels will likely be produced within the basin in 2030?

Challenges

- Water constraints may limit energy production in the region. There is an increasing population, energy demand, and water demand in the Snake Columbia Basin which are unsustainable under current supply and use conditions. The water supply is already fully appropriated for agriculture or otherwise being put to beneficial use. The growth in population will create demand for both energy and water. Full appropriation of the available water supply has the potential to limit industrial and municipal growth and could limit increasing energy generation capacity. Compounding the net increase in demands due to population growth energy demand per capita is increasing and the region has comparatively high per capita water consumption. The relatively low cost electricity in the region is a disincentive to conservation and efficiency further increasing per capita demand. Limited places for placing power plants due to a variety of constraints (e.g., water availability, environmental, public opinion) can also limit power generation expansion. Climate variability is causing variation in the extent and timing of precipitation in the region, changing the availability of water for energy production. Predicting the changes in climate and the impact on precipitation will be key to managing energy and water and designing the future energy water system of the region. Adaptation of current resource management practice to changes in climate and population will be a key challenge over the next few years. Determining the best use of water and energy resources now and into the future will be a continuing challenge.
- Future carbon constraints may impact energy production and availability. Thermoelectric energy production using fossil fuels is likely to be constrained by carbon emission limits. Alternatives to thermoelectric production hold the promise for increasing regional electrical production. However challenges exist for each alternative. To be fully effective, wind or other intermittent resources need to be integrated into a hydro-based power system for optimal water use. For instance, the transmission infrastructure needs to be developed for remote generation sources (e.g., wind and geothermal)and intermittent resources need to be integrated into a hydro-based power system to optimize water use. Nuclear energy production of electricity is not greenhouse gas emitting. However, nuclear is a thermoelectric method of producing electricity and requires water for cooling and is constrained by water limitations.
- Transboundary political constraints limit the ability to develop regional solutions. Water in the Snake Columbia Basin crosses State and international boundaries and is ruled by myriad sets of laws and treaties. Impacts of water use are cumulative in nature and impact downstream users. Sharing information across institutional boundaries and agreeing on management impacts is an ongoing challenge in transbundary water management.

Research Initiatives

Critical

- Decision support systems (5 dots), including
  - Spatial optimization of renewable generation sources and with transmission lines, storage, future demand, and other siting constraints
  - Balance storage and intermittency
  - Integrated regional modeling center for energy/water planning
  - Maximize integration of variable resources into hydro system
  - Case study (operational) of integrating wind (etc.) with an existing reservoir (storage) system
  - Energy sustainability analysis (Will there be enough generation to sustain the region?)

  The need for a regional entity that would perform mathematical modeling and integrated data analysis was seen as necessary to approach any of the planning and allocation issues.
- Better understanding of future spatial patterns in energy carbon management (5 dots). Carbon management policies and technologies will have significant effects on energy generation, water use, and water availability in the Pacific Northwest (climate change). Therefore, research on these technologies and policies and, more importantly, their interface with energy production and water use, must be considered. This includes
  - Water and carbon capture sequestration ≈ 2025
  - Carbon storage and sequestration technologies

Important

- Geothermal (2 dots), including
  - Investigation of cost effective geothermal technologies
  - Investigation of technology to increase success rate of finding geothermal resources
- Policy (2 dots)
  - Economic impacts of changing water resources from agriculture to power production (water rights)
- Cooling technology (1 dot), including
  - Air cooling technologies for thermal generation
  - Dry cooling
- Efficiency (1 dot), including
  - Investigation of technologies to improve demand-side management
  - Investigation of heated cooling water for other industrial uses (smart siting) co-location
- Enhanced hydropower (0 dots), including
  - Exploration of options for low-head and other hydro supplies
  - Improved turbine and other efficiency at hydro plants

- Transmission (0 dots), including
  - Analysis of benefits of developing electricity transmission grids from potential resource sites to load
  - Development of non-wire alternatives (“smart grid”) to reduce new transmission needs

Nice to Do

No research initiatives were deemed to be nice to do. Group members felt that none should be delayed.

Water Allocation and Use

Status and Trends

- What will be the dominant water demands in 2030?
- What will be the likely changes in water supply in 2030? Consider spatial, temporal, and compartment aspects (e.g., surface water, ground water, salt water, and brackish water).

Challenges

- Need for flexibility
- Predicting short-term supply
- Reconsideration of how to make basin-wide allocation decisions
- Adapting to changes in water use for crops with different irrigation needs
- Adapting to different values of water assigned by users
  - Consideration of larger economic issues in the community

Research Initiatives

Critical

- Supply forecasting (5 dots), including
  - Forecast improvement (5 dots)
    - Short-term weather
    - Long-term weather
    - Water supply
  - Improved weather forecast modeling, including
    - Weather
    - Hydrologic processes
  - Analysis of hydrologic process to assimilate observed and modeled information
  - Understanding supply variations
- Water use/valuation/planning (5 dots), including
  - Improved population, economic, and water use forecasting
  - Improved planning for changes in water use values
  - Evaluation of conservation versus pricing
  - Understanding societal impacts of water valuation paradigms

- Managing with uncertainty (5 dots), including
  - Research on water management in the face of growing variability
  - Evaluation of increased flexibility of operation
    - Physical flexibility
    - Institutional flexibility
  - Physical risk analysis of flow variability

Important

- Applying other world successes to Northwest for energy and water (4 dots).

Nice to Do

- Improved planning models to evaluate future river flow (1 dot)
- Water use information to aid management of water considering timing, crops, and crop stages (0 dots)

Energy/Water Storage

Status and Trends

- How much energy/water storage will we need in the future and how much is available using our current technologies?
- What existing anthropogenic and natural systems can be expanded and what new or innovative techniques can be developed for storing medium to large quantities of energy and water?
- How will our water and energy storage needs change and what do we believe our status will be in the basin in 2030?

Challenges

- Moving water across boundaries
- Determining what energy source will be used
  - Renewables
  - Storage for renewables
  - Other forms of energy storage
- Balancing instantaneous demand with instant generation
- Decoupling water storage from energy storage
- Using existing pumped storage that isn't being used
- Why wouldn't we want to be all renewable for the incremental part?
- Global climate changes affect the optimizing system
- Aquifer storage
- Coupling water and energy storage in a different way
- Anti-degradation laws
- Achieving sufficient quantities of aquifer storage
- Getting utilities to look at energy storage
- Understanding current system's ability to store energy
- Getting all experts on renewable energy talking to solve energy problems collectively
- Getting policy makers to look long-term in regards to energy/water storage
- Real-time pricing for rate-payers
- Improved forecasting for supply/demand
- Water storage and release needs to be further analyzed
- Water rights issues

- Data and tools to assess feasibility of integrated alternative water/energy storage system
  - Inverse relationship to traditional dams
- Transmission to locate energy storage in optimal place
- Optimizing current system to meet multiple objectives

Research Initiatives

Critical

- Off-Columbia River storage, (4 dots), including
  - Develop storage solutions that do not require use of the Columbia River system (Center for Advanced Energy Studies, flywheels, H_2, biomass, natural gas)
  - Develop/demonstrate alternative wind (and other renewables) energy storage technologies
  - Why energy and water storage should be decoupled
  - Map compressed air energy storage sites (include capacity), mines, and aquifers
- Systems analysis tools (4 dots), including
  - Systems analysis tools
  - Climate impacts on energy needs and system operation
  - Improved forecasting (short- and long-term) for water and energy supply and demand
  - Maximize performance of existing Columbia River energy/water storage system while meeting competing demands
  - Integration of energy sources and water resources across jurisdictions
  - Education and research on uncertainty and risk
- Advanced energy/water storage (4 dots), including
  - Develop tools to assess feasibility of "inverse" energy/water storage
  - Improved understanding of potential for aquifer storage and recovery (water and energy availability)
- Examine what other countries have done.

Important

The group did not define any initiatives as important.

Nice to Do

- Transmission (0 dots), focused on optimizing energy storage/transmission interface and generation locations (which form is transported)

Environmental Considerations

Status and Trends

- What ecosystem components are most affected by water and energy use and generation?
- What will be the status of the existing issues and what new ecosystem issues are likely to appear by 2030, assuming the status quo and assuming projected population, infrastructure, and operational changes?

Challenges

- Global warming. Global warming will affect the hydrologic cycle by altering the spatial and temporal distributions of precipitation, recharge, and runoff, especially snowmelt runoff. In particular, snowmelt may occur earlier than it does now. The Washington and Oregon Cascades are already experiencing this phenomenon. The change in the distribution of streamflow (less in late spring and summer, more in winter and early spring) may adversely affect fisheries – especially anadromous fishes – and aquatic ecosystems in general (environmental flows). More surface storage may needed just for environmental flow maintenance during the summer.

  Concomitant with changes in the streamflow distribution, there may be changes in power generation because the Snake-Columbia Basin relies on hydroelectric power for about 60% of its electricity. Global warming may also increase the demand for electricity in the summer, as the demand for air conditioning may rise. That combination of warmer summers and earlier snowmelt may dictate the need for increased surface storage to generate summer flows for hydroelectricity and/or the construction of non-hydroelectric generating plants. Either one will have negative impacts on the air and water quality and water use. Water quality will be impacted because of increases in stream temperatures, reductions in dissolved oxygen levels, and possible reduction in the dilution ability of streamflow.

  The combination of global warming coupled with hydrologic cycle changes may exacerbate the alien invasive species problem. Such species could be aquatic or terrestrial and can also include diseases such as malaria (recall that in the 1800s, the Willamette Valley had malaria epidemics), West Nile virus, and avian influenza. Human and other populations will be affected.

  Existing species could also face extinction or extirpation if they are unable to migrate or adapt to changing conditions. Habitat fragmentation could be an issue, leading to isolated “pockets” of once-continuous habitats.

  Forest and range fires will likely become more prevalent, leading to increased erosion and stream sediment loads. Because forests produce much of the runoff in the Snake-Columbia Basin, water yields may be affected. Even if surface runoff increases, soil moisture and ground water recharge may decrease.

- Population growth. The Snake-Columbia Basin is perceived by many as a desirable place to live. This may prove even truer now because a common belief, not entirely unfounded, appears to be that the Snake-Columbia Basin will cope with global warming better than a place like the American Southwest because of more water and cooler temperatures. Population growth may occur at an even higher rate because of out-migration from the Southwest, California, or other areas. Major metropolitan areas such as Boise, Portland and the Willamette Valley, and Spokane-Coeur d'Alene, along with smaller ones such as Bend, Idaho Falls, Pocatello, and Twin Falls, are all slated to grow. Although Seattle and Vancouver are outside the Snake-Columbia Basin, their growth will impact the Basin because they use power generated from the Basin's hydroelectric and other plants and food from its land and water resources. Reductions in Snake-Columbia Basin air quality caused by growth outside the basin will be noticeable. Water use will increase, stressing aquatic and riparian ecosystems and threatened and endangered species. More species may become listed. Water quality will be degraded, a consequence of increased growth. Water quality degradation will be caused by a variety of factors: temperature, dissolved oxygen, nutrients, sediment, pharmaceuticals and other organic chemicals, metals, etc. Land degradation will also occur as land is "consumed" by development and more waste disposal sites will be necessary to accommodate the increased population.

- Energy production and related effects. Increased energy production will have environmental consequences. The effects of hydroelectric generation have already been mentioned. Increased burning of fossil fuels will impact air and water quality and will require water. Biofuels production will consume land and water resources. Fertilizer use, if increased, could deleteriously impact surface and ground water quality. Even electricity from wave energy, touted as a "green" energy source, may have as-yet unknown environmental effects. Certainly, the cluttering of the ocean floor with thousands of miles of cables may adversely affect near-shore ecosystems. Geothermal resources will see increased development throughout the Snake-Columbia Basin. The quality-quantity impacts of geothermal fluid production on shallower subsurface and surface water resources will need to be addressed. Land, air, and ecosystems could also be affected. Increased exploration for fossil fuel resources has the potential for degrading water, land, and air resources, and ecosystems.

  The Snake-Columbia Basin is being touted by some as a region for carbon sequestration; the many basalt formations specifically appear to be targeted. What effects will this have on the region's water and other resources?

- Water quantity and use. The effects of global warming and energy production on water quantity and use have been broached above. But there are other impacts as well. Increased agricultural production may dictate increased water withdrawals. Transfer of water rights from agriculture to "higher-valued" uses (e.g., residential development) may become an issue. Water banking, marketing, and trading will become more commonplace; for some regions, the social impacts of these practices may be negative.

  Aquifer storage and recovery will likely become a more common form of water storage so as to offset the negative impacts of dam construction and evaporative water loss. But there are issues with aquifer storage and recovery: water rights, water quality, and aquifer degradation (reduction in storage caused by chemical precipitation).

  Will water reuse become more commonplace, overcoming psychological and other barriers? Will desalination of sea water and/or brackish/saline terrestrial waters be more common? If so, what will be the energy and environmental impacts of these operations?

- Miscellaneous. Governance issues may come to the fore. There may be more desire by local communities (counties, municipalities) to manage their own resources with less interference from state and federal governments. In-migration either from outside or within the Snake-Columbia Basin may lead to a "last immigrant" mentality and a desire to limit growth. Integrated management of land, water quantity, and water quality will be essential.

  Other social issues will arise. As stated above, water marketing, banking, and trading will become more commonplace. Will water therefore "flow uphill to power and money," leaving poorer communities to literally "dry up and blow away"? Water banking and transfer rules need to be developed so that the wealthy communities do not receive all the benefits. The same will be true for water quality, carbon, and environmental trading as well.

Environmental impacts will be felt to varying degrees in different parts of the Snake-Columbia Basin. Some regions may even benefit. Will the costs and benefits be distributed equally? Who or what will determine the sharing mechanisms? Will sharing decrease incentives?

Research Initiatives

Critical

- Ecosystem effects (5 dots), including
  - Effects on the environment of carbon sequestration (risks, costs, benefits)
  - Effects on species of oil and gas exploration (possible extinction)
  - Effects on salmonids (climate change, hydrologic changes)
  - Shifting environmental impacts (i.e., from one region to another)
- Water quality considerations (4 dots)
  - Water quality effects (Total Maximum Daily Loads, etc.)
  - Water quality and emerging contaminants
  - Connectivity between water quantity and water quality
  - Effects of potential ecosystem improvements (integrated management of land, water quantity, and water quality)
  - Water reuse technology and perceptions.

Important

- Water storage considerations (4 dots), including
  - Understand effects of surface storage on environmental, social, economic, and cultural behaviors
  - Feasibility of aquifer storage and recovery for increasing storage (effects on water quality, suitable locations, and water rights issues)
  - Pros and cons of aquifer recharge (unintended consequences)
- Economic and behavioral considerations (2 dots), including
  - What is the best mix of energy from an economic and environmental perspective (including all costs)?
  - What is the "real" cost of water (vs. water delivery only)?
  - What is the cost of preserving (for 100+ years) the environment and ecosystem of the Snake-Columbia Basin?
  - How do we motivate energy/water conservation?
  - How do we change use and consumption behaviors for water and energy?
  - How could water pricing affect environmental conservation?

- Framework (1 dot)
  - What process is best to allow collective decisions (collaboration) to be made in the Snake-Columbia Basin regarding the environment?

Nice to Do

Group members felt that none of these could be delayed.

- Tools to manage (0 dots), including
  - How can we (and how should we) decentralize energy production (develop incentives for more local production)?
  - How should we build and run a (restricted) carbon dioxide and water market?

Social, Economic, Political, & Regulatory Considerations

Status and Trends

- What are the crucial economic, political, and regulatory issues associated with increasing water and energy demands and increasing populations in the Columbia River Basin?
- What are the dominant social and economic changes in the Basin that will promote or impede the development, maintenance, and operations of our energy/water infrastructure and operations?
- What will be the dominant policy and legal conflicts associated with retrofitting 1800s policies and laws to meet current and future energy and water needs?

Challenges

- Transboundary coordination. In many aspects, the Pacific Northwest is very integrated and coordinated and in other cases it is very fragmented. For example, energy production and transmission in the Pacific Northwest is highly coordinated as is (to a large extent) flood control. However, the Basin appears to take an "every man for him self" approach to managing water allocation; every state and province controls water allocation relative to their own needs and desires. It was widely agreed upon that because we share a single basin we can greatly improve the management of our energy and water resources by maintaining a robust dialogue and by developing coordinated solutions between the northwestern states and Canada.
- Communication and coordination.It is often stated that "perception is reality"; however, most people understand that in the absence of appropriate information, perception is often wrong and decision-making based on uninformed perceptions is often wasteful and sometimes very detrimental. There was much discussion by the group on how to better communicate scientific research results and political and regulatory issues and needs to better inform decision makers and the public. The general thought was that by helping the public and decision makers better understand the science and political/regulatory issues and needs, we can better identify institutional and procedural structures that impede rational results and we can gain their support to adjust ("tweak") our existing energy and water institutions to produce more rationale outcomes.
- Better science. The group agreed that it is very important to base our decisions, at least in part, on solid scientific information. However, the issue was raised that we don't always seem to know what science we need to use to make the best decisions. For example, we inherently understand the importance of studying hydrology and physics relative to designing and operating our water and energy systems; however, it is not as clear that we understand the importance and incorporate the contributions other related sciences (e.g., the soft sciences) into the development and management of these systems. The group also discussed the need to develop reliable assessment, prediction, and validation tools to better understand population growth and trends. Without developing a solid understanding of future population growth in the Basin and its impact on our energy and water supplies and demands, we will not be able to properly manage the system.
- Holistic approaches. There was an excellent group discussion relative to the need to develop an integrated scientific/technical foundation for better understanding of the needs and conditions within the Basin and for developing an evolutionary and adaptive regional approach to addressing future changes (e.g., climate change, population shifts, and changes in land use) and addressing future

uncertainties in the Basin. The group also discussed the need for expanding the energy/water nexus framework to include broader participation in the process and a broader consideration of social, economic, and political values. In addition, the group expressed the need for putting more emphasis on the need for energy and water conservation, sustainability, and responsibility within the Basin. A number of members expressed that while these concepts are often discussed, in practice they are often lost in the planning and implementation processes. A critical question along these lines is can we evaluate the principles of conservation, sustainability, and responsibility so we have a better understanding of the goals of these principles so we can establish programs to implement them and metrics to measure our level of success relative to those goals? Finally, the group discussed that broadening the scope of the process and discussions may cause us to “lose the forest for the trees.” Therefore, it is important that we establish solid goals and then prioritize our activities to meet the stated goals.

- Markets. There was a robust discussion by the group relative to the pros and cons of moving away from a regulatory-dominated environment to a market-based environment for managing our energy and water resources. The primary argument for a market-based system is that our existing regulatory-based system doesn’t truly reflect the value of these resources. Because regulations and subsidies artificially inflate or deflate the cost of energy and water to consumers, those consumers don’t understand the true costs of producing energy and water supplies and therefore, they are often not willing to pay the full recover cost to provide those resources. In addition, by artificially adjusting the costs, much of our energy and water supplies are used on “lower value” uses when, from an economic perspective, those supplies could be put to higher uses. There was a robust discussion as to who defines “higher” or “lower” values, the potential societal impacts of going to strictly market-based systems, and issues such as price fixing and various social benefit/social justice issues.
- Public policy. The group discussed the need for developing new or improving existing public policy mechanisms to increase energy and water supplies and to meet established environmental goals. It was pointed out that we need flexible policies that include energy and water conservation but maximize the production and availability of energy and water supplies in a very uncertain environment. These uncertainties include such things as changing climate conditions, large population increases, changing land use and water management practices, changing demands for energy and water and others, including overcoming NIMBY and BANANA paradigms relative to new energy and water development proposals. The “grand challenge” posed by the group was to figure out how to achieve these goals without placing too much of a burden on those paying the bills, including taxpayers, corporations, and families (associated with the values).

Research Initiatives

Critical

- Government decision-structure adequacy (5 dots), including
    - Prospects and problems of increased use of markets to allocate water
    - Alternative institutions and their effect on incentives
    - Obstacles to water markets
    - Measurement/evaluation of effects of management on sustainability
    - Changes required to support water markets by state
    - Urban domestic water use adjudication (advanced research)
    - Facility siting decision processes

- Decision-making processes (4 dots), including
  - Regional and state modeling and planning efforts
  - Integrated regional climate changes scenarios (multi-state coordination)
  - Carbon dioxide alternative impact considerations (choice versus consequences) related to climate change
- Type/use of science in decision-making and public information (3 dots), including
  - Science and technology roadmap for energy and water
  - What works for education and outreach?
  - How much certainty does business need?
  - Determine public attitudes regarding the awareness of climate change
  - Gather public opinion on energy consumption versus cost
  - How good does science need to be?
  - Economic development considerations with regard to energy and water
  - What "science"—political, social, history, religious, moral, environmental?
  - What is damage?

Important

No research initiatives were deemed to be important.

Nice to Do

No research initiatives were deemed to be nice to do.

Focus Group Members

Energy Generation and Use

▪ Bob Neilson, moderator	Idaho National Laboratory
▪ Mike Louis, facilitator	Boise State University
▪ Jeff Beaman	Idaho Power
▪ Andy Ford	Washington State University
▪ Karen Humes	University of Idaho
▪ Andrea McNemar	DOE National Energy Technology Laboratory
▪ Ken Miller	Snake River Alliance
▪ Paul Wichlacz	Idaho National Laboratory

Water Allocation and Use

▪ Gary Johnson, moderator	Idaho Water Resources Research Institute
▪ Helen Harrington, facilitator	Idaho Department of Water Resources
▪ Steve Billingsly	Inland Northwest Research Alliance
▪ Jeanne Knight	Idaho National Laboratory
▪ Patrick MacQallin	Oregon State University
▪ Bob McLaughlin	Idaho Department of Water Resources
▪ Howard Neiblin	University of Idaho
▪ Tim Newton	Columbia Basin Trust
▪ Pamela Pace	Idaho Power
▪ Kathy Peter	U.S. Geological Survey
▪ Steve Porter	University of Idaho

Energy/Water Storage

▪ Michael Barber, moderator	State of Washington Water Research Center
▪ Alison Conner, facilitator	Idaho National Laboratory
▪ Gerald Fleischman	Idaho Energy Division
▪ Todd Haynes	Boise State University
▪ Richard Skaggs	Pacific Northwest National Laboratory

Environmental Considerations

▪ Michael Campana, moderator	Institute for Water and Watersheds, Oregon State University
▪ Carole Nimnich, facilitator	Boise State University
▪ Maxine Dakins	University of Idaho
▪ Patrick MacQuarrie	Oregon State University
▪ Sondra Miller	Boise State University
▪ Peggy Scherbinske	Idaho National Laboratory

Social, Economic, Political, & Regulatory Considerations

▪ Gerald Sehlke, moderator	Idaho National Laboratory
▪ Bryan Parker, facilitator	Idaho National Laboratory
▪ Maureen Finnerty	Idaho National Laboratory
▪ Stephen Gajewski	Pacific Northwest National Laboratory
▪ Joel Hamilton	University of Idaho (retired)
▪ Todd Jarvis	Oregon State University
▪ Jim Kempton	North West Power and Conservation Council
▪ Dennis Lopez	Idaho Power
▪ Gerry O'Keefe	State of Washington
▪ Richard Slaughter	University of Washington
▪ Marilyn Whitney	Idaho National Laboratory

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