Regional Research Institute

Resource Document Series

WATER VALUATION RESEARCH

ANNOTATED BIBLIOGRAPHY

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RRI Resource Doc 2014-01

Date submitted: August 20, 2014
Date revised:
Key words/Codes: Water resources, ecological economics, environment and development; Q32, Q56, Q57

WATER VALUATION RESEARCH

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1.6 Alphabetical Listing of Sources and Abstracts

California Drought 2014: Farm and Food Impacts.” USDA Economic Research Service 2014. Web.
The ongoing drought in California–with the driest year on record for the State following several prior years of drought–is likely to have a major impact on the State's agricultural production in 2014. Despite a relatively recent series of major storms, long-term moisture deficits across most of the State remain at near-record levels. Because California is a major producer in the fruit, vegetable, tree nut, and dairy sectors, the drought has potential implications for U.S. supplies and prices of affected products in 2014 and beyond.-Web Page

"Climate Impacts on Energy.” United States Environmental Protection Agency 2014. Web.
Changes in temperature, precipitation, sea level, and the frequency and severity of extreme events will likely affect how much energy is produced, delivered, and consumed in the United States. Energy plays an important role in many aspects of our lives. For example, we use electricity for lighting and cooling. We use fuel for transportation, heating, and cooking. Our energy production and use is interconnected with many other aspects of modern life, such as water consumption, use of goods and services, transportation, economic growth, land use, and population growth. Our production and use of energy (most of which comes from fossil fuels) also contributes to climate change, accounting for more than 80% of U.S. greenhouse gas emissions.-Web Page

“Coping with Water Scarcity.” Food and Agriculture Organization of the United Nations: Agriculture and Consumer Protection Department 2007. Web.
Each year around 3 830 cubic km - that's 3.8 billion tonnes - of freshwater is withdrawn for human use. The lion's share is taken by the agriculture sector, which accounts globally for about 70 percent of all water withdrawals. “Agriculture has been highly successful in capturing the bulk of the world's freshwater resources,” says an

FAO report to COAG, "but with little accountability." That is changing rapidly, in the face of demographic growth and economic development that has placed unprecedented pressure on water supplies, particularly in arid regions.

Energy Demands on Water Resources: Report to Congress2006. Print
"a report to Congress on the interdependency of energy and water focusing on threats to national energy production resulting from limited water supplies, utilizing where possible the multi-laboratory Energy-Water Nexus Committee." The report presents background information on the connections between energy and water, identifies concerns regarding water demands of energy production, and discusses science and technologies to address water use and management in the context of energy production and use.

Overview of the Water-Energy Nexus in the United States: NCSL: National Conference of State Legislatures, 2014. Print.
State legislatures and natural resource managers have traditionally addressed water and energy as two separate issues. However, water and energy are deeply connected and sustainable management of either resource requires consideration of the other. Thus, resource managers and lawmakers across the country are beginning to take a comprehensive and interdisciplinary approach to the management of water and energy. This report provides overview information about the nexus between water and energy and provides a summary of state legislation addressing this issue. Total water withdrawals from all sources in the United States in 2011: 405,868 gallons per person (World Bank, 2011 and United States Census Bureau, 2011)Electric power consumption in the United States in 2011: 13,246 kWh per person (World Bank, 2011)

The Importance of Water to the U.S. Economy: Synthesis Report: United States Environmental Protection Agency: Office of Water, 2013. Print.
Water is essential to life, making its total economic value immeasurable. At the same time water is a finite resource, and one for which competition is likely to increase as the U.S. economy grows. Driven by this heightened competition, the economic value of water will rise, and decision-makers in both the private and the public sectors will need information that can help them maximize the benefits derived from its use.
This report is an initial step toward (1) raising awareness of water's importance to our national economic welfare, and (2) assembling information that is critical to sustainably managing the nation's water resources. It highlights the U.S. Environmental Protection Agency's (EPA) review of the literature and practice on the importance of water to the U.S. economy, identifies key data gaps, and describes the implications of the study's

findings for future research.

"The Value of Water." Nexus of Water and Energy 2014. Web.
Water rights and use has been a central issue for political tensions and military conflicts for millennia and is why the United Nations proposes monitoring worldwide reserves for drinking water and establishing agreements for the use of water.
Water rights and use has been a central issue for political tensions and military conflicts for millennia and is why the United Nations proposes monitoring worldwide reserves of drinking water and establishing agreements for the use of water. - See more at: http://nexuswaterenergy.com/how-energy-impacts-water/value- water

U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather: U.S. Department of Energy, 2013. Print.
This report–part of the Administration's efforts to support national climate change adaptation planning through the Interagency Climate Change Adaptation Task Force and Strategic Sustainability Planning process established under Executive Order 13514 and to advance the U.S. Department of Energy's goal of promoting energy security–examines current and potential future impacts of these climate trends on the U.S. energy sector. Report updated July 16, 2013.

"Water and Climate Change." The World Bank 2014. Web.
For poor countries that have always faced hydrologic variability, climate change will make water security even more difficult and costly to achieve. Climate change may also reintroduce water security challenges in countries that for a hundred years have enjoyed reliable water supplies and few, if any, water shocks. Much of the developing world will have to cope with droughts and/or the growing risk of flooding. Currently, 1.6 billion people live in countries and regions with absolute water scarcity and the number is expected to rise to 2.8 billion people by 2025.

Water for Energy: Is Energy Becoming a Thirstier Resource?: International Energy Agency, 2012. Print.
Energy and water are valuable resources that underpin human prosperity and are, to a large extent, interdependent. Water is ubiquitous in energy production: in power generation; in the extraction, transport and processing of fossil fuels; and, increasingly, in irrigation to grow feedstock crops used to produce biofuels. Similairly, energy is vital to the provision of water, needed to power systems that collect, transport, distribute and treat it (Box 17.1). Each faces rising demands and constraints in many regions as a consequence of economic and population growth and climate change, which amplify the mutual vulnerability of energy and water. For the energy sector, constraints on

water can challenge the reliability of existing operations and the viability of proposed projects, imposing additional costs for necessary adaptive measures. This chapter addresses water for energy in the context of the WEO-2012 energy scenarios.

"Water Resource Valuation and Partial Client List." WaterBank 2005. Web. 6/17/2014.
WaterBank performs valuations of water supplies worldwide. The valuation of water resources is quite complex and requires multidisciplinary capabilities. The valuation of a water resource involves some or all of the following steps. Hydrological determination of the sustainable quantity and quality of the water. This is highly technical and may involve carrying out hydrogeological studies or surface water flow probability studies. Demand analysis may be required to evaluate whether future needs can be met. Water resources must be legally available before the water can be captured by wells or surface water diversion works. Historical analysis of past water use must be carried out in areas where the doctrine of prior appropriation is the legal basis for water right ownership. This activity can involve review of very old documents including deeds, maps, survey records, oral history records, aerial photography. Functional analysis is carried out to value the water based on a variety of uses. Political analysis is carried out gage the political wind for acceptance or rejection of specific possible uses. The political climate plays a major role in valuing water resources. Comparable sales information is examined where available. The valuation is based on the multiple concerns examined above.

"Water, Energy and Climate Change." World Business Council for Sustainable Development-WBCSD, 2009. Print.
Water, energy and climate change are inextricably linked. If we truly want to find sustainable solutions, we must ensure that we address all three in a holistic way. They are pieces of the same puzzle and therefore it is not practical to look at them in isolation. This paper is only a first step in fitting some of the pieces of that puzzle together. The search for solutions is complicated because water, energy and climate change are each complex. Examining their interrelationship further complicates the discussion but we must if we are to take the next step toward a sustainable society. They also touch all parts of our culture and are interconnected with other issues, such as our values, ecosystems and livelihoods.
To make meaningful progress, we must acknowledge this complexity and use it to our advantage. When you have an energy problem, you most certainly have a water problem. It works the other way, too. And if you are concerned about climate change, you are actually concerned about both energy and water - whether you know it or not.
Just as the issues are interconnected, so too are the solutions. For example, we know that municipal wastewater is not waste at all. The water can be reused, and the solid

waste can be used as a source of energy and fertilizer. By taking a holistic view of the situation, we can find solutions that address both water and energy concerns.

"What's Water Worth?" Food and Agriculture Organization of the United Nations: Agriculture and Consumer Protection Department 2006. Web.
Purely economic valuation of water often overlooks two important dimensions: environmental values, such as the role of water flows in maintaining ecosystem integrity, and social values - such as using water to grow food to eat... This article examines these issues.

"World Water Assessment Programme (Wwap)." United Nations Educational, Scientific and Cultural Organization 2009. Web.
The subject of valuing water is highly controversial, thus its discussion must account for people's cultural traditions and world perception as well as economic considerations of full-cost recovery.
The most important role of water valuation is in demand management and better allocation among its various uses. Improved water resource management requires decisions based on economic efficiency, social equity, and ecological sustainability. Ultimately the value of water does not depend solely on its quantity but on at least four other factors – quality, location, reliability of access, and time of availability.
Because of water's unique characteristics and socio-cultural importance, attempts to monetarily value water services is both difficult and, according to some, altogether inappropriate. Nevertheless, economic valuation – the process of attaching a monetary metric to water services – is an increasingly important tool for policy-makers and planners faced with difficult decisions regarding the allocation and development of freshwater resources. With market prices unable to capture the full spectrum of their costs and benefits, economists have developed special techniques to estimate water's non-market values. Two important occasions when these tools are employed are during tariff-setting and assessments of alternative government strategies.
Understanding the value of water is essential if this ever more scarce resource is to be more effectively and efficiently utilized to meet societal needs.

Aubuchon, Craig P., and Kevin M. Morley. "The Economic Value of Water: Providing Confidence and Context to Fema's Methodology." Journal of Homeland Security & Emergency Management 10.1 (2013): 1-21. Print.

As municipalities, utilities and communities place more emphasis on security, resilience and disaster planning, it is increasingly more important to have an accurate dollar value to assess the economic importance of water for a community. This allows community

level decision makers to accurately plan and implement pre-disaster mitigation strategies and effectively allocate resources post-disaster. This decision-making is based in part on a benefit cost analysis framework established by FEMA that establishes several per capita, per day (pcpd) dollar values that capture the total economic impact of the loss of potable water service. A primary motivation of this work is to acknowledge some of the uncertainties and data parameters in the FEMA model so that water utilities can downscale loss projections to the appropriate level of analysis. This study recommends using population weighted state level data and finds an estimated range of economic losses per capita per day between $67 and $457. This research allows utilities to better understand and estimate supply disruption valuations for their own service areas and choose the appropriate risk level for their benefit-cost decisions with regards to security preparedness infrastructure improvements. [ABSTRACT FROM AUTHOR]

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Averyt, K., et al. "Water Use for Electricity in the United States: An Analysis of Reported and Calculated Water Use Information for 2008." Environmental Research Letters 8.1 (2013): 015001-01. Print.

Water use by the electricity sector represents a significant portion of the United States water budget (41% of total freshwater withdrawals; 3% consumed). Sustainable management of water resources necessitates an accurate accounting of all water demands, including water use for generation of electricity. Since 1985, the Department of Energy (DOE) Energy Information Administration (EIA) has collected self-reported data on water consumption and withdrawals from individual power generators. These data represent the only annual collection of water consumption and withdrawals by the electricity sector. Here, we compile publically available information into a comprehensive database and then calculate water withdrawals and consumptive use for power plants in the US. In effect, we evaluate the quality of water use data reported by EIA for the year 2008. Significant differences between reported and calculated water data are evident, yet no consistent reason for the discrepancies emerges.

—. “Sectoral Contributions to Surface Water Stress in the Coterminous United States.” Environmental Research Letters 8.3 (2013): 035046-46. Print.

Here, we assess current stress in the freshwater system based on the best available data in order to understand possible risks and vulnerabilities to regional water resources and the sectors dependent on freshwater. We present watershed-scale measures of surface water supply stress for the coterminous United States (US) using the water supply stress index (WaSSI) model which considers regional trends in both water supply and demand. A snapshot of contemporary annual water demand is compared against different water supply regimes, including current average supplies, current extreme-year supplies, and projected future average surface water flows under a changing climate. In addition, we investigate the contributions of different water demand sectors to current water stress. On average, water supplies are stressed, meaning that demands for water outstrip natural supplies in over 9% of the 2103 watersheds examined. These watersheds rely on reservoir storage, conveyance systems, and groundwater to meet current water demands. Overall, agriculture is the major demand-side driver of water stress in the US, whereas municipal stress is isolated to southern California. Water stress introduced by cooling water demands for power plants is punctuated across the US, indicating that a single power plant has the potential to stress water supplies at the watershed scale. On the supply side, watersheds in the western US are particularly sensitive to low flow events and projected long-term shifts in flow driven by climate change. The WaSSI results imply that not only are water resources in the southwest in particular at risk, but that there are also potential vulnerabilities to specific sectors, even in the ’water-rich’ southeast.

Averyt, Kristen. “Freshwater Use by U.S. Power Plants: Initial Insights into the Energy-Water Nexus.” (2012). Web.

Every minute, all the power plants in the United States take in about three times as much water as flows over Niagara Falls. The nation’s thermoelectric power plants– which boil water to create steam, which in turn drives turbines to produce electricity– withdraw as much water as farms, and more than four times as much as all U.S. residents. That means lighting rooms, powering computers and TVs, and running appliances requires the withdrawal of more water, on average, than the total amount we use in our homes– washing dishes and clothes, showering, flushing toilets, and watering lawns and gardens. Simply, generating electricity requires a lot of water.

Averyt, Kristen, et al. Freshwater Use by U.S. Power Plants: Electricity’s Thirst for a

Precious Resource. Union of Concerned Scientists 2011. Print.

Take the average amount of water flowing over Niagara Falls in a minute. Now triple it. That's almost how much water power plants in the United States take in for cooling each minute, on average. In 2005, the nation's thermoelectric power plants which boil water to create steam, which in turn drives turbines to produce electricity - withdrew as much water as farms did, and more than four times as much as all U.S. residents. That means lighting rooms, powering computers and TVs, and running appliances requires much more water on average than the total amount we use in our homes - washing dishes and clothes, showering, flushing toilets, and watering lawns and gardens. This tremendous volume of water has to come from somewhere. Across the country, water demand from power plants is combining with pressure from growing populations and other needs and straining water resources-especially during heat waves.

Badr, Lamya, Gregory Boardman, and John Bigger. "Review of Water Use in U.S. Thermoelectric Power Plants." Journal of Energy Engineering 138.4 (2012): 246-57. Print.

The importance of water use in thermoelectric power plants is increasing across the nation. For example, power plants in New York and California are forced to deal with cooling systems that pose threats to ecosystems and water availability. The purpose of this paper is to summarize, compare, and contrast previous studies in this subject area using journal articles and government/laboratory reports. This literature review presents a myriad of results obtained from previously conducted research pertaining to (1) power generation in the United States, (2) water use in power plants, (3) power plant cooling technologies, (4) comparisons of cooling technologies (including cost), (5) impact of drought on power generation, and (6) projections of power generation and water use. Among the findings of this study is that whereas water usage data for once-through and wet-recirculating cooling systems are well developed, dry and hybrid cooling system data are not as complete. This review, therefore, serves as an assimilation of existing information and points out gaps in our knowledge base of the systems. [ABSTRACT FROM AUTHOR]

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the original published version of the material for the full abstract. (Copyright applies to all Abstracts.)

Barrett, Kelli. "The Water-Energy-Food Nexus: Interlinked Solutions for Interlinked Challenges." Ecosystem Marketplace: A Forest Trends Initiative 2014. Web.

We can't prevent global shortages of drinking water while providing enough food and energy to meet the needs of a growing population in a climate-constrained world if we don't understand the linkages between water, energy and food security. Here's a look at how our demands for energy, food and water all drive each other, and how we can prevent them from driving in the wrong direction.

Beckman, Jayson, Allison Borchers, and Carol Jones. Agriculture's Supply and Demand for Energy and Energy Products: USDA Economic Research Service, 2013. Print. This report examines both sector and farm-level responses to changing market and policy drivers–such as the increased production of biofuel crops and higher energy prices–together with changes in production practices to economize on energy-based inputs like fertilizer.

Borisova, Tatiana, et al. "A Benefit-Cost Analysis of Total Maximum Daily Load Implementation." Journal of the American Water Resources Association 44.4 (2008): 1009-23. Print.
Total Maximum Daily Load (TMDL) implementation generates benefits and costs from water quality improvements, which are rarely quantified. This analysis examines a TMDL written to address bacteria and aquatic-life-use impairments on Abrams and Opequon Creeks in Virginia. Benefits were estimated using a contingent valuation survey of local residents. Costs were based on the number and type of best management practices (BMPs) necessary to achieve TMDL pollution reduction goals. BMPs were quantified using watershed-scale water quality simulation models (Generalized Watershed Loading Function and Hydrological Simulation Program-FORTRAN). Based on our projections, the costs to achieve TMDL induced pollution reduction goals outweigh the estimated benefits. Benefit-cost ratios ranged between 0.1 and 0.3. [ABSTRACT FROM AUTHOR] Copyright of Journal of the American Water Resources Association is the property of Wiley-Blackwell and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use. This abstract may be abridged. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material for the full abstract. (Copyright applies to all Abstracts.)

Brown, T. C., R. Foti, and J. A. Ramirez. "Projected Freshwater Withdrawals in the United States under a Changing Climate." Water Resources Research 49.3 (2013): 1259-76. Print.

Relying on the U.S. Geological Survey water use data for the period 1960-2005, this paper summarizes past water use and then projects future water use based on the trends in water use efficiency and major drivers of water use. Water use efficiency has improved in most sectors. Over the past 45 years, withdrawals in industry and at thermoelectric plants have steadily dropped per unit of output. In addition, domestic and public withdrawals per capita, and irrigation withdrawals per unit area in most regions of the west, have recently begun to decrease. If these efficiency trends continue and trends in water use drivers proceed as expected, in the absence of additional climate change the desired withdrawals in the United States over the next 50 years are projected to stay within 3% of the 2005 level despite an expected 51% increase in population. However, including the effects of future climate change substantially increases this projection. The climate-based increase in the projected water use is attributable mainly to increases in agricultural and landscape irrigation in response to rising potential evapotranspiration, and to a much lesser extent to water use in electricity production in response to increased space cooling needs as temperatures rise. The increases in projected withdrawal vary greatly across the 98 basins examined, with some showing decreases and others showing very large increases, and are sensitive to the emission scenario and global climate model employed. The increases were also found to be larger if potential evapotranspiration is estimated using a temperature-based method as opposed to a physically based method accounting for energy, humidity, and wind speed.

Byers, E. A., J. W. Hall, and J. M. Amezaga. "Electricity Generation and Cooling Water Use: Uk Pathways to 2050." Global Environmental Change 25 (2014): 16-30. Print.

Thermoelectric generation contributes to 80% of global electricity production. Cooling of thermoelectric plants is often achieved by water abstractions from the natural environment. In England and Wales, the electricity sector is responsible for approximately half of all water abstractions and 40% of non-tidal surface water abstractions. We present a model that quantifies current water use of the UK electricity sector and use it to test six decarbonisation pathways to 2050. The pathways consist of a variety of generation technologies, with associated cooling methods, water use factors and cooling water sources. We find that up to 2030, water use across the six pathways is fairly consistent and all achieve significant reductions in both carbon and water intensity,

based upon a transition to closed loop and hybrid cooling systems. From 2030 to 2050 our results diverge. Pathways with high levels of carbon capture and storage result in freshwater consumption that exceeds current levels (37-107%), and a consumptive intensity that is 30-69% higher. Risks to the aquatic environment will be intensified if generation with carbon capture and storage is clustered. Pathways of high nuclear capacity result in tidal and coastal abstraction that exceed current levels by 148-399%. Whilst reducing freshwater abstractions, the marine environment will be impacted if a shortage of coastal sites leads to clustering of nuclear reactors and concentration of heated water discharges. The pathway with the highest level of renewables has both lowest abstraction and consumption of water. Freshwater consumption can also be minimised through use of hybrid cooling, which despite marginally higher costs and emissions, would reduce dependence on scarce water resources thus increase security of supply.

Carter, Nicole. Energy's Water Demand: Trends, Vulnerabilities, and Management: Congressional Research Service, 2011. Print.
The energy choices before Congress represent vastly different demands on domestic freshwater because water is used in varying amounts in most aspects of the energy sector. Transitions in the energy sector, such as the pursuit of greater energy independence and security, produce changes in how much and where the energy sector uses water. The energy sector is the fastest-growing water consumer in the United States, in part because of energy policies. Whether the federal government addresses the energy sector's rising water demand, and if so how, is one of the many energy decisions that may be considered by the 112th Congress.

—. "Energy-Water Nexus: The Energy Sector's Water Use." Prepared for Members and Committees of Congress: Congressional Research Service, 2013. Print.
Water and energy are critical resources that are reciprocally linked; this interdependence is often described as the water-energy nexus. Meeting energy-sector water needs, which are often large, depends upon the local availability of water for fuel production, hydropower generation, and thermoelectric power plant cooling. The U.S. energy sector's use of water is significant in terms of water withdrawals and water consumption. In 2005, thermoelectric cooling represented 41% of water withdrawn nationally, and 6% of water consumed nationally. The majority of the anticipated increase in water consumption by 2030 is attributed to domestic biofuel and oil and gas production. Policy makers at the federal, state, and local levels are faced with deciding whether to respond to the growing water needs of the energy sector, and if so, which policy levers to use (e.g., tax incentives, loan guarantees, permits, regulations, planning, or education). Many U.S. energy sector water decisions are made by private entities, and

state entities have the majority of the authority over water use and allocation policies and decisions.

"Water for Energy and Energy for Water: Challenges and Opportunities for Utilities." Publisher, 2014. Web.
Energy and water are interdependent. Water scarcity, variability, and uncertainty are becoming more prominent. This is leading to vulnerabilities of the U.S. energy system. We cannot assume the future is like the past in terms of climate, technology, and the evolving decision landscape. Aging infrastructure brings an opportunity to make some changes. Water-Energy has geopolitical significance. DOE has strong expertise in technology, modeling, analysis, and data and can contribute to understanding the issues and pursuing solutions across the entire nexus.

Cooperman, Alissa, John Dieckmann, and James Brodrick. "Power Plant Water Use." ASHRAE Journal 54.1 (2012): 65-68. Print.

The article discuses electric energy costs versus water costs at power plants. Topics covered include power generation by power plants in the U.S., water use at power plants, and the water consumption of cooling technologies. It is noted that the water which is consumed for evaporative cooling by power plants does not offset water consumption savings.

Copeland, Claudia. "Energy-Water Nexus: The Water Sector's Energy Use." Prepared for Members and Committees of Congress: Congressional Research Service, 2014. Print.
Water and energy are resources that are reciprocally and mutually linked, because meeting energy needs requires water, often in large quantities, for mining, fuel production, hydropower, and power plant cooling, and energy is needed for pumping, treatment, and distribution of water and for collection, treatment, and discharge of wastewater. This interrelationship is often referred to as the energy-water nexus, or the water-energy nexus. There is growing recognition that "saving water saves energy." Energy efficiency initiatives offer opportunities for delivering significant water savings, and likewise, water efficiency initiatives offer opportunities for delivering significant energy savings. In addition, saving water also reduces carbon emissions by saving energy otherwise generated to move and treat water. This report provides background on energy for facilities that treat and deliver water to end users and also dispose of and discharge wastewater. Energy use for water is a function of many variables, including water source (surface water pumping typically requires less energy than groundwater pumping), treatment (high ambient quality raw water requires less treatment than

brackish or seawater), intended end-use, distribution (water pumped long distances requires more energy), amount of water loss in the system through leakage and evaporation, and level of wastewater treatment (stringency of water quality regulations to meet discharge standards). Likewise, the intensity of energy use of water, which is the relative amount of energy needed for a task such as pumping water, varies depending on characteristics such as topography (affecting groundwater recharge), climate, seasonal temperature, and rainfall. Most of the energy used for water-related purposes is in the form of electricity. Estimates of water-related energy use range from 4% to perhaps 13% of the nation's electricity generation, but regional differences can be significant. In California, for example, as much as 19% of the state's electricity consumption is for pumping, treating, collecting and discharging water and wastewater.

Dalhuisen, Jasper M., et al. "Price and Income Elasticities of Residential Water Demand: A Meta-Analysis." Land Economics 79.2 (2003): 292. Print.
This article presents a meta-analysis of variations in price and income elasticities of residential water demand. Meta-analysis constitutes an adequate tool to synthesize research results by means of an analysis of the variation in empirical estimates reported in the literature. We link the variation in estimated elasticities to differences in theoretical microeconomic choice approaches, differences in spatial and temporal dynamics, as well as differences in research design of the underlying studies. The occurrence of increasing or decreasing block rate systems turns out to be important. With respect to price elasticities, the use of the discrete-continuous choice approach is relevant in explaining observed differences. [ABSTRACT FROM AUTHOR] Copyright of Land Economics is the property of University of Wisconsin Press and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use. This abstract may be abridged. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material for the full abstract. (Copyright applies to all Abstracts.)

Egan, Kevin J., et al. "Valuing Water Quality as a Function of Water Quality Measures." American Journal of Agricultural Economics 91.1 (2009): 106-23. Print.
Employing a unique and rich data set of water quality attributes in conjunction with detailed household characteristics and trip information, we develop a mixed logit model of recreational lake usage and undertake thorough model specification and fitting procedures to identify the best set of explanatory variables, and their functional form for the estimated model. Our empirical analysis shows that individuals are responsive to the full set of water quality measures used by biologists to identify the impaired status of lakes. Thus, changes in these quality measures are not simply a scientific exercise,

but they also translate into changes in the recreational usage patterns and well-being of individual households. Willingness-to-pay (WTP) estimates are reported based on improvements in these physical measures. [ABSTRACT FROM AUTHOR]
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"The Energy-Water Nexus: State and Local Roles in Efficiency & Water and Wastewater Treatment Plants." DOE's State and Local Technical Assistance Program. Publisher, 2013. Web.

This series of slides provides an overview of the DOE's State and Local Technical Assistance Program and the Energy-Water Nexus.

Feeley, Thomas, et al. "Department of Energy/Office of Fossil Energy's Power Plant Water Management R&D Program." United States Department of Energy. Office of Fossil Energy, 2005. Print.

Coal-fired power plants utilize significant quantities of both coal and water for generating electrical energy. For example, a 500 MW power plant burns approximately 250 tons per hour of coal while using over 12 million gallons per hour of water for cooling and other process requirements. The United States Geological Survey (USGS) estimates that thermoelectric generation accounts for approximately 136,000 million gallons per day (MGD) of freshwater withdrawals, ranking only slightly behind agricultural irrigation as the largest source of freshwater withdrawals in the United States.1 As U.S. population and associated economic development continues to expand, the demand for electricity will increase. The Energy Information Administration's (EIA) latest forecast estimates U.S. coal-fired generating capacity will grow from approximately 305 GW in 2003 to 389 GW in 2025.2 As such, coal-fired power plants may increasingly compete for freshwater with other sectors such as domestic, commercial, agricultural, industrial, and in-stream use – particularly in regions of the country with limited freshwater supplies. In addition, current and future water-related environmental regulations and requirements will also challenge the operation of existing power plants and the permitting of new thermoelectric generation projects.

In response to these challenges to national energy sustainability and security, the Department of Energy/Office of Fossil Energy's National Energy Technology Laboratory (DOE/NETL) has initiated an integrated research and development (R&D) effort under its Innovations for Existing Plants (IEP) program directed at technologies and concepts to reduce the amount of freshwater used by power plants and to minimize any potential impacts of plant operations on water quality. This paper provides background information on the relationship between water and thermoelectric power generation and describes the R&D activities currently being sponsored by DOE/NETL's IEP program to address current and future water-energy issues.

Gerrity, Daniel, and Shane Snyder. "The Economic Value of Water in Metropolitan Areas of the United States." Water Policy 13.4 (2011): 443-558. Print.
Water has been a passionately contested issue in the United States (US) over the past century. Some argue for growth restrictions in drought-susceptible regions, but based on economic production, it may be worthwhile implementing creative measures to ensure continued and sustainable growth. The following economic analysis correlates water withdrawals in the 32 most populous metropolitan areas in the US with several economic indicators, including gross metropolitan product (GMP), income, and employment. The ratio of GMP to water withdrawals (GMP/H2O) ranged from (US)$58,788 per million gallons in Tampa to $939,555 per million gallons in San Jose ($15,532 to $248,231 per megaliter, respectively). Some drought-susceptible areas (e.g., Atlanta, Denver, Los Angeles, and Las Vegas) had relatively high GMP/H2O values, while others (e.g., Phoenix and San Diego) had relatively low GMP/H2O values. From a regional perspective, the Northwest had the strongest economy relative to its water withdrawals, and the Midwest had the weakest. These data indicate that the GMP/H2O metric can be used to justify water use in certain metropolitan areas but that the metric is less applicable to regional analyses due to unique aspects of local economies and water resource portfolios. [ABSTRACT FROM AUTHOR]

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Hanemann, Michael. "The Value of Water." University of California, Berkeley, 2005.

Print.
There is a widespread perception among water professionals today of a crisis in water resources management. Water resources are poorly managed in many parts of the world, and many people – especially the poor – lack access to adequate water supply and sanitation. Moreover, this is not a new problem – it has been recognized for a long time, yet the efforts to solve it over the past three or four decades have been disappointing, accomplishing far less than had been expected. In addition, in some circles there is a feeling that economics may be part of the problem. There is a sense that economic concepts are inadequate to the task at hand, a feeling that water has value in ways that economics fails to account for, and a concern that this could impede the formulation of effective approaches for solving the water crisis.

My own personal assessment is that the situation is somewhat more complex than critics suggest. On the one hand, as environmental economics has evolved over the past forty years, it has developed a conceptual toolkit that I think is well suited for dealing with many of the issues of water supply and water resource management. On the other had, economists sometimes slip into older ways of thinking and characterize economic value in terms that are inadequate or misleading. Moreover, even among economists there is an inadequate appreciation of the complexities of water as an economic commodity; these render it distinctive from other commodities and they contribute to the explanation of the current crisis in water.

This paper examines the economic concept of value and some related notions as they apply to water, at least partly in light of these concerns. It consists of two main sections. Section 2 reviews the economic concept of value, explains how it is measured, and discusses how this has been applied to water in various ways. Section 3 takes on the debate regarding whether or not water can or should be treated as an economic commodity, and discusses the ways in which water is the same or different as other commodities. The paper ends with a few concluding observations in Section 4.

Hurd, B., and M. Rouhi-Rad. "Estimating Economic Effects of Changes in Climate and Water Availability." Climatic Change 117.3 (2013): 575-84. Print.

Social, economic, and environmental systems can be vulnerable to disruptions in water supplies that are likely to accompany future climate changes. Coupled with the challenges of tightening environmental regulations, population growth, economic development and fiscal constraints water supply systems are being pushed beyond the limits of their design and capacity for maintenance. In this paper we briefly review key

economic concepts, various economic measures and metrics, and methods to estimate the economic effects on water resources from water supply changes that could accompany climate change. We survey some of the recent empirical literature that focuses on estimates developed for U.S. watersheds at both national and regional scales. Reported estimates of potential damage and loss associated with climate and water supply changes that we observe are significant, though often the metrics vary and make valid and consistent direct cross-comparisons difficult. Whether in terms of changes in GDP or in terms of estimated changes in economic welfare based on associated changes in economic costs and benefits, both national and regional estimates suggest that governments and organizations incorporate prudent steps to assess vulnerabilities to plausible future water supply and demand scenarios and develop responsive adaptation strategies.

Kuwayama, Yusuke. "Groundwater Markets: Managing a Critical, Hidden Resource." Resources for the Future. Print.

Nearly all our usable freshwater comes from groundwater, so why is it mostly unregulated in the United States? Yusuke Kuwayama describes a market-based solution to better manage our nation's depleted aquifers.

Kuwayama, Yusuke, Sheila Olmstead, and Alan Krupnick. "Water Resources and Unconventional Fossil Fuel Development." DP 13-34 ed: Resources for the Future, 2013. Print.

The production of crude oil and natural gas from unconventional reservoirs has become a growth sector within the North American energy industry, and current projections indicate that the production of some of these unconventional fossil fuels will continue accelerating in the foreseeable future. This shift in the energy industry has been accompanied by rising concerns over potential impacts on water resources because producing these fuels is thought to require more water per unit of energy produced than conventional sources and may lead to greater degradation of water quality. In this paper, we address these emerging environmental issues by (a) providing a comprehensive overview of the existing literature on the water quantity and quality implications of producing the main unconventional fossil fuels in North America and (b) characterizing the differences in social costs that arise from the extraction and production of these fuels versus those from conventional fossil fuel production.

Langášek, Petr, and Ebo Tawiah Quartey. "Economic Tools for Managing Environmental Aspects of Water Use in Power Plants." Scientific Papers of the University of

Pardubice. Series D, Faculty of Economics & Administration 16.21 (2011): 110-18. Print.

Water use in a power station is an irreplaceable resource due to its physical and chemical properties, good availability and abundance. That is why it is used in large volumes for many purposes. Despite the simplicity of water, it is very comprehensive in energy chemistry. Hence if you evaluate the variables in power plants, the second highest variable cost is water. All other types of variable costs are negligible against water. The largest portion of water in power plants is used for refilling cooling circuits. However the largest portion of water added to the cooling circuits (approximately two thirds) is lost to evaporation and is carried over in cooling towers. There is a concentration of water (evaporation) and carry over (drift of small droplets of cooling water in a stream of cooling air). The concentration of water leads to increased concentrations of impurities in the water. Effect of thickening and loss of water is one of the aspects that are discussed in this work. [ABSTRACT FROM AUTHOR]

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MacKnick, J., et al. "Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies: A Review of Existing Literature." Environmental Research Letters 7.4 (2012): 045802-02. Print.

This report provides estimates of operational water withdrawal and water consumption factors for electricity generating technologies in the United States. Estimates of water factors were collected from published primary literature and were not modified except for unit conversions. The water factors presented may be useful in modeling and policy analyses where reliable power plant level data are not available. Major findings of the report include: water withdrawal and consumption factors vary greatly across and within fuel technologies, and water factors show greater agreement when organized according to cooling technologies as opposed to fuel technologies; a transition to a less carbon- intensive electricity sector could result in either an increase or a

decrease in water use, depending on the choice of technologies and cooling systems employed; concentrating solar power technologies and coal facilities with carbon capture and sequestration capabilities have the highest water consumption values when using a recirculating cooling system; and non-thermal renewables, such as photovoltaics and wind, have the lowest water consumption factors. Improved power plant data and further studies into the water requirements of energy technologies in different climatic regions would facilitate greater resolution in analyses of water impacts of future energy and economic scenarios. This report provides the foundation for conducting water use impact assessments of the power sector while also identifying gaps in data that could guide future research.

Macknick, J., et al. "The Water Implications of Generating Electricity: Water Use across the United States Based on Different Electricity Pathways through 2050." Environmental Research Letters 7.4 (2012): 045803-03. Print.

The power sector withdraws more freshwater annually than any other sector in the US. The current portfolio of electricity generating technologies in the US has highly regionalized and technology-specific requirements for water. Water availability differs widely throughout the nation. As a result, assessments of water impacts from the power sector must have a high geographic resolution and consider regional, basin-level differences. The US electricity portfolio is expected to evolve in coming years, shaped by various policy and economic drivers on the international, national and regional level; that evolution will impact power sector water demands. Analysis of future electricity scenarios that incorporate technology options and constraints can provide useful insights about water impacts related to changes to the technology mix. Utilizing outputs from the regional energy deployment system (ReEDS) model, a national electricity sector capacity expansion model with high geographical resolution, we explore potential changes in water use by the US electric sector over the next four decades under various low carbon energy scenarios, nationally and regionally.

Mansur, Erin T., and Sheila M. Olmstead. "The Value of Scarce Water: Measuring the Inefficiency of Municipal Regulations." Journal of Urban Economics 71.3 (2012): 332-46. Print.

Rather than allowing urban water prices to reflect scarcity rents during periods of drought-induced excess demand, policy makers have mandated command-and-control approaches, primarily rationing the use of water outdoors. While such policies are ubiquitous and likely inefficient, economists have not had access to sufficient data to

estimate their economic impact. Using unique panel data on residential end-uses of water in 11 North American cities, we examine the welfare implications of urban water rationing in response to drought. Using estimates of expected marginal prices that vary both across and within markets, we estimate price elasticities specific to indoor and outdoor water use. Our results suggest that current policies do target water uses that households, themselves, are most willing to forgo. Nevertheless, we find that rationing outdoor water in cities has costly welfare implications, primarily due to household heterogeneity in willingness-to-pay for scarce water. We find that replacing rationing policies with a market-clearing "drought price" would result in welfare gains of more than 29% of what households in the sample spend each year on water.

Matthews, Olen Paul, David Brookshire, and Michael Campana. "The Economic Value of Water: Results of a Workshop in Caracas, Venezuela." (2000). Web.

In November 2000 a small workshop of 14 people met in Caracas, Venezuela, to discuss the "value" of water.1 The meeting was sponsored by the International Water Resources Network (IWRN),2 the Organization of American States (OAS), The Nature Conservancy, the University of New Mexico, and the National Oceanic and Atmospheric Administration (NOAA). The meeting was hosted by Jose Ochoa-Iturbe, Director of the School of Civil Engineering at the Universidad Catolica Andres Bello. The participants represented a mix of academics, water administrators, government officials and NGOs (non-governmental organizations) from around the Americas.3 Although many of the participants are economists, multiple disciplines and perspectives were represented. The meeting occurred as part of a process for stimulating discussion about water issues in the Americas. During and after IWRN's Dialog III in Panama, the participants at a session on water valuation discussed the need for an intermediate meeting that would keep the discussion moving forward. The feeling was that the time interval between Dialogs was too long and significant time was spent at each Dialog repeating conversations that had occurred before. An intermediate conference was organized in Caracas to fill that need. This document was produced as a result of the Caracas meeting and is meant to serve as an input to IWRN's Dialog IV in Brazil. The document should not be looked on as the final word but as an intermediate step meant to stimulate additional discussion.

Meldrum, J., et al. "Life Cycle Water Use for Electricity Generation: A Review and Harmonization of Literature Estimates." Environmental Research Letters 8.1 (2013): 015031-31. Print.

This article provides consolidated estimates of water withdrawal and water consumption for the full life cycle of selected electricity generating technologies, which includes component manufacturing, fuel acquisition, processing, and transport, and power plant operation and decommissioning. Estimates were gathered through a broad search of publicly available sources, screened for quality and relevance, and harmonized for methodological differences. Published estimates vary substantially, due in part to differences in production pathways, in defined boundaries, and in performance parameters. Despite limitations to available data, we find that: water used for cooling of thermoelectric power plants dominates the life cycle water use in most cases; the coal, natural gas, and nuclear fuel cycles require substantial water per megawatt-hour in most cases; and, a substantial proportion of life cycle water use per megawatt-hour is required for the manufacturing and construction of concentrating solar, geothermal, photovoltaic, and wind power facilities. On the basis of the best available evidence for the evaluated technologies, total life cycle water use appears lowest for electricity generated by photovoltaics and wind, and highest for thermoelectric generation technologies. This report provides the foundation for conducting water use impact assessments of the power sector while also identifying gaps in data that could guide future research.

Mittal, Anu, and Franklin Rusco. Energy-Water Nexus: Coordinated Federal Approach Needed to Better Manage Energy and Water Tradeoffs: U.S. Government Accountability Office, 2012. Print.

Water and energy are inextricably linked and mutually dependent, with each affecting the other's availability. Since 2009, GAO has issued five reports on the interdependencies between energy and water. These reports have shown that a considerable amount of water is used to cool thermoelectric power plants, grow feedstocks and produce biofuels, and extract oil and natural gas. Some of these sources of energy may also negatively affect water quality. In addition, developing oil and gas resources can produce wastewater– known as "produced water"–that must be managed or treated. Conversely, significant amounts of energy are needed to extract, transport, treat, and use water in urban areas. GAO was asked to identify key energy-water nexus issues that Congress and federal agencies need to consider when developing and implementing national policies for energy and water resources. To conduct this work, GAO systematically reviewed its five reports to identify key nexus issues. GAO also used a content analysis of related literature and interviews with specialists to validate these themes.

Mittal, AnuGaffigan Mark. "Improvements to Federal Water Use Data Would Increase Understanding of Trends in Power Plant Water Use." GAO Reports (2009): 1. Print.

The article focuses on the study by the U.S. Government Accountability Office (GAO) on technologies and approaches to lessen freshwater use by power plants. The study evaluates the usefulness of water data to experts and state regulators. The Energy Information Administration (EIA) is recommended to collect and report data on the use of these power plants of advancing cooling technologies and alternative water sources.

Moreau, D. H. "Relative Value of Water for Hydropower and Municipal Supply in Southeastern Reservoirs." Journal of the American Water Resources Association 50.1 (2014): 196-204. Print.

Population growth in the Southeast has driven withdrawals for municipal water beyond the limits of local supplies. With few options left for development of virgin sources, a number of urban areas are looking toward demand management and additional supplies by reallocating storage in reservoirs that were built primarily or in part for hydropower. Hydropower has become a lesser part of the mix of energy sources, and the question arises as to value of water for that purpose relative to its value for municipal use. Three cases are used to examine the issue. Effects of withdrawal for municipal water supply on output of electric energy are estimated. Benefits of foregone energy are evaluated using the least cost alternative for replacement, and benefits for municipal water are estimated using costs for development of new sources. Benefits for use as municipal water are found to be considerably higher than benefits for hydroelectric energy at existing prices, even higher than the least cost alternative for replacement. Given the spatial distribution of the cases, that finding would appear to hold in general across the region.

National Research, Council. Valuing Ground Water : Economic Concepts and Approaches. Washington, D.C.: National Academy Press, 1997. Print.

Ground water in the United States is usually considered as either an invaluable good or as a 'free' good. At one extreme, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) implies a very high value for ground water by requiring restoration of contaminated water sources to drinking water quality. Billions of dollars have been spent to clean up contaminated ground water with little comparison of costs or technological difficulty to future benefits. At sites where cleanup is technically infeasible, the Superfund law essentially assigns an infinite value to the resource.

Petrie, Ragan A., and Laura O. Taylor. "Estimating the Value of Water Use Permits: A Hedonic Approach Applied to Farmland in the Southeastern United States." Land Economics 83.3 (2007): 302-18. Print.

Agricultural irrigation permits in the Flint River Basin in Georgia had been routinely granted until a moratorium was placed on permit issuance in 1999. This research exploits this policy change within a hedonic-pricing framework to estimate the value of irrigation rights in the southeastern United States. While the value of irrigation rights has been studied extensively in the western United States, differences in property rights and legal regimes, as well as a lack of established water-rights markets in the eastern United States, leave us with little information regarding the value of irrigation rights in this setting. [ABSTRACT FROM AUTHOR]

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Sanders, Kelly, and Michael Webber. "Evaluating the Energy Consumed for Water Use in the United States." Environmental Research Letters.7 (2012). Web.

This letter consists of a first-order analysis of the primary energy embedded in water in the United States. Using a combination of top-down sectoral assessments of energy use together with a bottom-up allocation of energy-for-water on a component wise and service-specific level, our analysis concludes that energy use in the residential, commercial, industrial and power sectors for direct water and steam services was approximately 12.3 +/− 0.3 quadrillion BTUs or 12.6% of the 2010 annual primary energy consumption in the United States. Additional energy was used to generate steam for indirect process heating, space heating and electricity generation.

Schmid, A. Allan. "Nonmarket Values and Efficiency of Public Investments in Water Resources." American Economic Review 57.2 (1967): 158. Print.

The task is to form questions directed to predicting the performance of the economy with reference to the production and distribution of certain water derived goods which are often alleged to be inappropriate for market exchange. These include reduction

of threats to human life, health, scenic beauty, and preservation of historic sites. In popular usage intangibility is sometimes used to mean that a good has nearly infinite value. A good is walled off from its alternatives and no further analysis is needed, since no matter what is foregone the commodity is assumed to have a higher price. The possibility of such evaluation cannot be theoretically denied, but one can observe that there seem to be limits in past choices, and that some risk to life, etc. is tolerated in order to gain other useful goods. It is confusing to talk of a change in the characteristics of water commodities as changes in product quality. It might be more useful just to consider water with different chemical and biological content as different products, like steel, stainless steel, and aluminum are different products and not changes in the quality of metals. Each water product then has a different cost and demand schedule and the interactions such as crosselasticities can be analyzed.

Skaggs, R., et al. Climate and Energy-Water-Land System Interactions: U.S. Department of Energy: Office of Science, 2012. Print.

This technical input report on climate and energy-water-land (EWL) system interactions has been prepared for the U.S. Department of Energy in support of the U.S. National Climate Assessment (NCA). Prepared on an accelerated schedule to fit the NCA's timeline, it provides a summary of existing information and understanding of this broad topic.

Stillwell, A. S., et al. "The Energy-Water Nexus in Texas." Ecology and Society 16.1 (2011): art2-art2. Print.

Understanding the nexus between energy and water - water used for energy and energy used for water - has become increasing important in a changing world. As growing populations demand more energy supplies and water resources, research aims to analyze the interconnectedness of these two resources. Our study sought to quantify the energy-water relationship in Texas, specifically the relationship between electricity generation and water resources as it pertains to policy and society. We examined the water requirements for various types of electricity generating facilities, for typical systems both nationwide and in Texas. We also addressed the energy requirements of water supply and wastewater treatment systems, comparing national averages with Texas-specific values. Analysis of available data for Texas reveals that approximately 595,000 megaliters of water annually - enough water for over three million people for a year - are consumed by cooling the state's thermoelectric power plants while generating approximately 400 terawatt-hours of electricity. At the same time, each year Texas

uses an estimated 2.1 to 2.7 terawatt-hours of electricity for water systems and 1.8 to 2.0 terawatt-hours for wastewater systems - enough electricity for about 100,000 people for a year. In preparing our analysis, it became clear that substantially more site-specific data are necessary for a full understanding of the nature of the energy-water nexus and the sustainability of economic growth in Texas. We recommend that Texas increase efforts to collect accurate data on the withdrawal and consumption of cooling and process water at power plants, as well as data on electricity consumption for public water supply and wastewater treatment plants and distribution systems. The overarching conclusion of our work is that increased efficiency advances the sustainable use of both energy and water. Improving water efficiency will reduce power demand, and improving energy efficiency will reduce water demand. Greater efficiency in usage of either energy or water will help stretch our finite supplies of both, as well as reduce costs to water and power consumers.

Tellinghuisen, Stacy. Every Drop Counts: Valuing the Water Used to Generate Electricity: Western Resource Advocates, 2011. Print.

Water has tremendous value – people, crops, industry, and the environment all rely on this limited resource. In the arid and semi-arid West, the value of water is even more pronounced, rising precipitously in times of drought and scarcity. Climate change models project increased rates of evapotranspiration throughout the West, more severe droughts, and reduced runoff in the Colorado River. Accordingly, the value of water in the Southwest will continue to rise. In 2005, power plants in six states – Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming – consumed an estimated 395,000 acre-feet (AF) of water. These plants impact our region's rivers and aquifers, and tie up water that could meet growing urban, agricultural, or environmental needs.

—. "Water for Power Generation: What's the Value?" Natural Resources Journal 50.3 (2010): 683-720. Print.

In the arid Interior West, water is a valuable, but limited natural resource. Yet today, most electric utilities and regulators do not adequately integrate water into electric resource planning. In this article, we present western utilities' and regulators' current strategies for integrating the value of water into electric resource planning and outline important policy changes that would improve integration. To develop a range of values for use in electric resource planning, we present data on the value of water for the three constituencies that compete with power plants for limited water supplies: municipalities, the agricultural sector, and the environment. Across the region, the value

of water varies tremendously, depending on the location, type of use, and scarcity of the resource, among other factors. As urban populations continue to grow and climate change reduces available supplies, the scarcity and value of water will undoubtedly increase. When developing and evaluating electric resource plans, utilities and regulators should consider the cost of committing water to power generation over the lifetime of the power plant.

Tidwell, Vincent C., et al. "Exploring the Water-Thermoelectric Power Nexus." Journal of Water Resources Planning & Management 138.5 (2012): 491-501. Print.

In 2005, thermoelectric power accounted for 41% of all freshwater withdrawals and roughly 3% of all consumptive use in the United States. With the demand for electricity projected to increase by 24% by 2035 concerns have been raised as to the availability of water for this growing industry; particularly, as the siting of several new thermoelectric facilities have been challenged on the basis of water supply. To address this concern we estimate the potential impact of water availability on future expansion of the thermoelectric power industry. Specifically, both the extent and location of thermoelectric developments at risk due to limited fresh water supply is estimated for a variety of alternative energy futures that differ according to the assumed mix of fuels utilized in new plant construction. According to the analyzed scenarios water consumption for thermoelectric power generation is projected to increase by 36-43% between 1995 and 2035, with much of this development expected to occur in basins with rapidly growing demands in the nonthermoelectric sectors. To identify where this thermoelectric development might be problematic, projected future thermoelectric production has been mapped onto basins subject to limited water availability. For the purposes of this study, water availability is defined as a local ratio of water demand to physical water supply. Results suggest that 10-19% of all new thermoelectric power production is likely to be sited in watersheds with limited surface and/or groundwater availability. These problematic watersheds are largely located in the West. [ABSTRACT FROM AUTHOR]

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(Copyright applies to all Abstracts.)

Van Der Zaag, P., and H.H.G. Savenije. Water as an Economic Good: The Value of Pricing and the Failure of Markets: UNESCO-IHE: Institute for Water Education, 2006. Print.

The concept of water as an economic good came up during the preparatory meetings for the Earth Summit in Rio de Janeiro of 1992. It was brought forward and discussed extensively during the Dublin conference on Water and the Environment (ICWE, 1992), and became one of the four Dublin Principles (see Box 1.1). The first principle says that water is essential and finite, requiring an integrated approach to water resources management. The fourth principle says that water is an economic good. However, since Dublin considerable misunderstanding remained about what the concept of water as an economic good really implies. Box 1.1: The Four Dublin Principles (ICWE, 1992) 1. Water is a finite, vulnerable and essential resource which should be managed in an integrated manner. 2. Water resources development and management should be based on a participatory approach, involving all relevant stakeholders. 3. Women play a central role in the provision, management and safeguarding of water. 4. Water has an economic value and should be recognised as an economic good, taking into account affordability and equity criteria. The interpretation of the concept "water as an economic good" causes confusion. Two schools of thought may be distinguished. The first school, here called the market proponents, maintains that water should be priced through the market. Its economic value would arise spontaneously from the actions of willing buyers and willing sellers. This would ensure that the water is allocated to uses that are valued highest. The second school interprets 'water as an economic good' to mean the process of integrated decision making on the allocation of scarce resources, which does not necessarily involve financial transactions (e.g. McNeill, 1998; Perry et al., 1997).

Watson, Philip S., and Stephen Davies. "Modeling the Effects of Population Growth on Water Resources: A CGE Analysis of the South Platte River Basin in Colorado." Annals of Regional Science 46.2 (2011): 331-48. Print.

This research examines the general equilibrium implications of economic and population growth on a fixed (or exogenously determined) total supply of available water in the South Platte River Basin in Colorado. Instead of looking at the effects of increased

demand for water on a fixed allocation regime, we allow for transfers of water between agricultural and municipal water users based on the respective factor demand for water across the economy. The study utilizes an 18-sector computable general equilibrium (CGE) model, where water is incorporated as a primary factor of production for agricultural operations and for a municipal water supply sector, but as an intermediate input for all other sectors. It is determined that, by allowing for water transfers with a fixed supply of water, the projected 50% increase in population from 2002 to 2030 will result in a 5.7% shift in water allocation from agriculture to other sectors. However, the total real value of agricultural sales is expected to increase slightly over this same period. The price of municipal water is expected to increase by 8.4% and the price of agricultural water is expected to increase by 10.4%. This result is contrasted to a scenario where significant barriers to water transfers are enacted. In this case the price of municipal water increases by 25% and agricultural water prices remain constant.

Webber, Michael. "Drought Impacts on Electricity Generation in Texas: Challenges and Opportunities." 2012. Print.

Droughts and other water extremes expose important vulnerabilities in the Texas power sector. However, by switching the fuel mix and implementing advanced cooling technologies, these vulnerabilities can be eliminated or mitigated. Furthermore, these investments will yield significant air quality benefits.

Weiwei, Mo, Wang Ranran, and Julie B. Zimmerman. "Energy-Water Nexus Analysis of Enhanced Water Supply Scenarios: A Regional Comparison of Tampa Bay, Florida, and San Diego, California." Environmental Science & Technology 48.10 (2014): 5883-91. Print.

Droughts and other water extremes expose important vulnerabilities in the Texas power sector. However, by switching the fuel mix and implementing advanced cooling technologies, these vulnerabilities can be eliminated or mitigated. Furthermore, these investments will yield significant air quality benefits.

Worthington, Andrew C., and Mark Hoffman. "An Empirical Survey of Residential Water Demand Modelling." Journal of Economic Surveys 22.5 (2008): 842-71. Print.

The increased reliance on demand-side management policies as an urban water consumption management tool has stimulated considerable debate among economists, water utility managers, regulators, consumer interest groups and policymakers. In turn, this has fostered an increasing volume of literature aimed at providing best-practice estimates of price and income elasticities, quantifying the impact of non-price water restrictions and gauging the impact of non-discretionary environmental factors affecting residential water demand. This paper provides a synoptic survey of empirical residential water demand analyses conducted in the last 25 years. Both model specification and estimation and the outcomes of the analyses are discussed. [ABSTRACT FROM AUTHOR]

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Xiaoying, Yang, and Benedykt Dziegielewski. "Water Use by Thermoelectric Power Plants in the United States." Journal of the American Water Resources Association 43.1 (2007): 160-69. Print.

Thermoelectric power generation is responsible for the largest annual volume of water withdrawals in the United States although it is only a distant third after irrigation and industrial sectors in consumptive use. The substantial water withdrawals by thermoelectric power plants can have significant impacts on local surface and ground water sources, especially in arid regions. However, there are few studies of the determinants of water use in thermoelectric generation. Analysis of thermoelectric water use data in existing steam thermo-electric power plants shows that there is wide variability in unitary thermoelectric water use (in cubic decimeters per 1 kWh) within and among different types of cooling systems. Multiple-regression models of unit thermoelectric water use were developed to identify significant determinants of unit thermoelectric water use. The high variability of unit usage rates indicates that there is a significant potential for water conservation in existing thermoelectric power plants. [ABSTRACT FROM AUTHOR]

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Yates, D., et al. "A Water Resources Model to Explore the Implications of Energy Alternatives in the Southwestern Us." Environmental Research Letters 8 (2013). Print.

This letter documents the development and validation of a climate-driven, southwestern-US-wide water resources planning model that is being used to explore the implications ofextended drought and climate warming on the allocation of water among competing uses. These model uses include a separate accounting for irrigated agriculture; municipal indoor use based on local population and per-capita consumption; climate-driven municipal outdoor turf and amenity watering; and thermoelectric cooling. The model simulates the natural and managed flows of rivers throughout the southwest, including the South Platte, the Arkansas, the Colorado, the Green, the Salt, the Sacramento, the San Joaquin, the Owens, and more than 50 others. Calibration was performed on parameters of land cover, snow accumulation and melt, and water capacity and hydraulic conductivity of soil horizons. Goodness of fit statistics and other measures of performance are shown for a select number of locations and are used to summarize the model's ability to represent monthly streamflow, reservoir storage, surface and ground water deliveries, etc. under 1980-2010 levels of sectoral water use.

Yates, D., J. Meldrum, and K. Averyt. "The Influence of Future Electricity Mix Alternatives on Southwestern Us Water Resources." Environmental Research Letters 8 (2013). Print.

A climate driven, water resource systems model of the southwestern US was used to explore the implications of growth, extended drought, and climate warming on the allocation of water among competing uses. The analysis focused on the water benefits from alternative thermoelectric generation mixes, but included other uses, namely irrigated agriculture, municipal indoor and outdoor use, and environmental and interstate compact requirements. The model, referred to as WEAP-SW, was developed on the Water Evaluation and Planning (WEAP) platform, and is scenario-based and for-

ward projecting from 2008 to 2050. the scenario includes a southwest population that grows from about 55 million to more than 100 million, a prolonged dry period, and a long-term warming trend of 2 degrees C by mid-century.

2 Methodology

2.1 General Econometric

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WaSSI, Spatial analysis

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Meldrum, J., et al. "Life Cycle Water Use for Electricity Generation: A Review and Harmonization of Literature Estimates." Environmental Research Letters 8.1 (2013): 015031-31. Print.
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General econometric, Projections

Weiwei, Mo, Wang Ranran, and Julie B. Zimmerman. "Energy-Water Nexus Analysis of Enhanced Water Supply Scenarios: A Regional Comparison of Tampa Bay, Florida, and San Diego, California." Environmental Science & Technology 48.10 (2014): 5883-91. Print.
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Xiaoying, Yang, and Benedykt Dziegielewski. "Water Use by Thermoelectric Power Plants in the United States." Journal of the American Water Resources Association 43.1 (2007): 160-69. Print.
Regression analysis, general econometric

Yates, D., et al. "A Water Resources Model to Explore the Implications of Energy Alternatives in the Southwestern Us." Environmental Research Letters 8 (2013). Print.
General econometric

Yates, D., J. Meldrum, and K. Averyt. "The Influence of Future Electricity Mix Alternatives on Southwestern Us Water Resources." Environmental Research Letters 8 (2013). Print.
General econometric

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Resilience, Cost-benefit,

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Total Maximum Daily Load (TMDL), cost-benefit, simulation

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Compilation, Overview

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