Natural Resources Journal

50 Nat Resources J. 3 (*The Water-Energy Conundrum: Water Constraints on New Energy Development in the Southwest*)

Fall 2010

Water for Power Generation: What's the Value

Stacy Tellinghuisen

STACY TELLINGHUISEN*

Water for Power Generation: What's the Value?

ABSTRACT

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.

INTRODUCTION

In the Southwest, water is a limited and valuable natural resource—it is essential for sustaining agriculture, municipalities, industrial operations, and many forms of electricity generation. Yet water has historically been underpriced and undervalued[1] due in large part to the externalities associated with its supply, use, and reallocation. To efficiently allocate water, managers should evaluate the full value of water, including use values, non-use values, and any externalities.[2] Most sur-

---

* Senior Energy/Water Policy Analyst, Western Resource Advocates. Special thanks to Joseph Hoover, Bart Miller, David Berry, Robert Harris, and Jennifer Thorvaldson for their research, thorough reviews, and very helpful suggestions. All figures and tables were created by the author, with data sources noted.

1. Mark W. Rosegrant & Hans P. Binswanger, *Markets in Tradable Water Rights: Potential for Efficiency Gains in Developing Country Water Resource Allocation*, 22 WORLD DEV. 1613 (1994); K. William Easter, Mark W. Rosegrant & Ariel Dinar, *Formal and Informal Markets for Water: Institutions, Performance, and Constraints*, 14 WORLD BANK OBSERVER 99 (1999).

2. AWWA RESEARCH FOUNDATION, THE VALUE OF WATER: CONCEPTS, ESTIMATES, AND APPLICATIONS FOR WATER MANAGERS 41 (2005), http://www.aipa.org/Adobe_Files/Value_of_Water/2005_AWWARF_The_Value_of_Water_Concepts_Estimates_and_Applications_for_Water_Managers.pdf [hereinafter AWWA, VALUE OF WATER].

face and groundwater sources in the West are now fully- or over-allocated, leading scientists to project that climate change will reduce water supplies in the Southwest.[3] As water becomes scarcer, its value will undoubtedly rise.

Although water is a precious commodity, it has seldom limited energy development. Because power plants usually operate for 40 to 50 years, purchased (and transferred) water is not available to meet other demands—urban, environmental, or agricultural. Typically, neither the power-plant developer nor state regulatory agencies consider the other potential uses or the value of that water over the lifetime of the power plant.

Whereas many electric utilities now model a price per ton of carbon emitted in their resource planning, the value of water to electric utilities has evaded quantification. We do not expect to pinpoint a price per acre-foot (AF) of water for use in utility resource planning because water is, by its very nature, a heterogeneous good. Its value varies both geographically and over time, and is influenced by factors such as its quality, relative scarcity, and the value of the activities the water-use supports.[4] In contrast, a ton of CO_2 has the same global warming potential, and the same cost, regardless of the location of the emissions.[5]

Despite the tremendous variation in the value of water, it is not generally zero. In the process of evaluating a power plant, an electric utility typically considers the cost of purchasing a water right in addition to legal or engineering fees. But once the developer obtains water rights, they own that water in perpetuity. In proceedings before public utility

---

3. *See*, *e.g.*, Balaji Rajagopalan, Kenneth Nowak, James Prairie, Martin Hoerling, Benjamin Harding, Joseph Barsugli, Andrea Ray & Bradley Udall, *Water Supply Risk on the Colorado River: Can Management Mitigate?*, 45 WATER RESOURCES RES. W08201 (2009); Martin Hoerling, Dennis Lettenmaier, Dan Cayan & Brad Udall, *Reconciling Projections of Colorado River Streamflow*, 8 SW. HYDROLOGY 20 (2009); Richard Seager, Mingfang Ting, Isaac Held, Yochanan Kushnir, Jian Lu, Gabriel Vecchi, Huei-Ping Huang, Nili Harnik, Ants Leetmaa, Ngar-Cheung Lau, Cuihua Li, Jennifer Velez & Naomi Naik, *Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America*, 316 SCI. EXPRESS 1181 (2007).

4. *See* Jennifer L. Pullen & Bonnie G. Colby, *Influence of Climate Variability on the Market Price of Water in the Gila-San Francisco Basin*, 33 J. AGRIC. & RESOURCE ECON. 473 (2008) [hereinafter Pullen & Colby]; Thomas C. Brown, *Trends in Water Market Activity and Price in the Western United States*, 42 WATER RESOURCES RES. W09402 (2006); AWWA, VALUE OF WATER, *supra* note 2; JOHN LOOMIS, ECONOMIC DEVELOPMENT REPORT NO. 08-02: THE ECONOMIC CONTRIBUTION OF INSTREAM FLOWS IN COLORADO: HOW ANGLING AND RAFTING USE INCREASE WITH INSTREAM FLOWS (2008), http://dare.colostate.edu/pubs/edr08-02.pdf.

5. The location of CO_2 emissions *can* have an important effect on human health and other impacts.

commissions, there is no recognition of the opportunity cost of committing water to a power plant for the lifetime of the plant.

As water scarcity increases, recognizing the long-term value of water will be increasingly important. Southwestern states have seen some of the fastest population growth in the nation and, although growth has slowed in the last two years, most states project it will rebound. In addition, it is projected that climate change will increase average temperatures and evapotranspiration rates, therefore reducing runoff into the Colorado River—a major supply of water for the Southwest. Historically, drought conditions and a growing population have increased the value of water. Accordingly, we would expect the value of water in the Southwest to continue rising in the future.

Importantly, energy efficiency and water-efficient renewable energy sources like wind and solar photovoltaics can provide both direct and indirect long-term water savings. By reducing the demand for electricity generation, energy efficiency measures can reduce water use at existing power plants and delay the need to develop new plants. Even certain energy efficiency measures, like ultra-lowflow showerheads, save water directly. Electric utilities' resource plans should reflect the benefits or costs of energy choices—whether renewables, energy efficiency, or conventional sources of energy—on water.

To better integrate water into utilities' electric resource-planning processes, Western Resource Advocates (WRA)[6] has endeavored to assess the cost and value of water for thermoelectric generation and the value of water for alternative uses. Part I of this article evaluates utilities' strategies to integrate energy and water issues in resource planning and power-plant siting, and summarizes western public-utility commissions' authority to consider water. Parts II, III, and IV present an analysis of the value of water for the three major constituencies that compete with power plants for water: municipalities, agriculture, and instream or environmental needs. Finally, Part V outlines strategies for how both utilities and regulators can improve integration of water in electric resource planning.

The analysis is limited to six states in the Interior West: Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming. A more detailed analysis of the value of water in Colorado is provided throughout this article for several reasons: many of the recent trends in the state are rep-

---

6. WRA is a nonprofit conservation organization dedicated to protecting the land, air, and water of the Interior West. WRA's lawyers, scientists, and economists collaborate with other conservation groups, hunters and fishermen, ranchers, American Indians, and others to ensure a sustainable future for the region. WESTERN RESOURCE ADVOCATES, http://www.westernresourceadvocates.org/about/ (last visited Jan. 17, 2011).

resentative of other western states—rapid municipal population growth, agricultural transfers to urban areas, and a growing recognition of the value of instream flows. In addition, Colorado has the most active, well-functioning water market in the West, as well as more extensive data on the value of water for instream flows.

The methods and terminology used in this analysis are important to define. The "value" of water can be interpreted in many different ways.[7] While the value of water is not confined to its economic value, the economic framework provides a technical basis for valuing water.[8] Under conditions of water scarcity, an economic focus both helps identify efficient water allocations and reduces wasteful practices. This article thus focuses primarily on the monetary value of water, but it is important to note that water provides many intangible, nonmonetized values that are not adequately evaluated here.

The economic value of water is defined as the amount that the user is willing to pay for it.[9] While value is related to cost and price (these three terms are often used interchangeably), they each have very distinct meanings, with important implications for interpreting valuation data.[10] For example, the price users pay will likely differ substantially from the cost of delivering the water for that particular use. Similarly, the price water users actually pay for water use is often less than the maximum amount they would have been willing to pay for water use. Thus, while water costs and prices can provide some useful insight into the value of water, they are not necessarily equivalent to value. When inferring values, water costs and prices must be interpreted in the context of other factors that have an impact on the cost or price of the water. For instance, agricultural subsidies and municipal water-rate distortions complicate the estimation of the value of water for these types of uses.[11]

Under the right conditions, the forces of supply and demand direct market-allocation of a scarce resource, revealing the resource's value and insuring economic efficiency of its use. In the case of water, how-

---

7. The total value of a resource includes its use (either consumptive or nonconsumptive) as well as its non-use (i.e., option, existence, and bequest values).

8. AWWA, VALUE OF WATER, *supra* note 2.

9. Robert A. Young et al., *Economic Value of Water: Concepts and Empirical Estimates, in* REPORT TO THE NATIONAL WATER COMMISSION (Nat'l Technical Info. Serv. No. PB210356, 1972).

10. AWWA, VALUE OF WATER, *supra* note 2.

11. *See, e.g.*, James J. Jacobs & David T. Taylor, *The Increasing Role of States in Water Management: The Wyoming Experience*, 14 W. J. AGRIC. ECON. 261 (1989); STEVEN RENZETTI, THE ECONOMICS OF WATER DEMANDS 53–54 (2002); Noel Gollehon, William Quinby & Marcel Aillery, *Agricultural Resources and Environmental Indicators: Water Use and Pricing in Agriculture, in* AGRIC. RESOURCES & ENVTL. INDICATORS (Econ. Res. Serv. No. AH772, 2002) [hereinafter Gollehon].

ever, the "right conditions" rarely exist due to its public good characteristics, mobility, and uncertainty of supply. The possibility for nonconsumptive and sequential uses of the same water create additional complications, making it often necessary to estimate the economic value of water using non-market techniques.[12] Indeed, contingent valuation methods can serve as a useful tool for measuring customers' willingness to pay for water.[13] In this article, we primarily discuss data generated by market-based techniques, although the results from several existing non-market valuation studies are also discussed.

I. ELECTRIC UTILITIES' VALUATION

The impact of water on electric utilities' resource planning varies tremendously. In Arizona, where drought and water scarcity have a long history, utilities place a strong emphasis on water efficiency. In other parts of the West, water has only emerged as an important consideration in recent years. For most utilities, many other factors—fuel costs, reliability, integration, and CO_2 emissions, to name a few—still dwarf the issues surrounding water.

The following paragraphs describe how most utilities value water today and highlight the differences in its consideration by different utilities. In addition, we review public utility commissions' authority to consider water—along with other environmental factors—in evaluating utilities' resource plans. For most western utilities, water has influenced past decisions about energy generation. This article describes several of these cases, which turn on both economic and noneconomic issues. Many utility representatives have noted that the monetary value of water is implicit in a resource-planning decision; it is incorporated into the capital or operating cost of a power plant. Therefore, data is used in this article on the cost of different cooling technologies to derive an implicit value of water.[14]

---

12. Richard W. Lichty & Curt L. Anderson, *Assessing the Value of Water: Some Alternatives*, 15 J. REGIONAL POL'Y & ANALYSIS 39 (1985); Richard Howitt & Kristiana Hansen, *The Evolving Western Water Markets*, 20 CHOICES 59 (2005) [hereinafter Howitt & Hansen], *available at* http://www.choicesmagazine.org/2005-1/environment/2005-1-12.pdf; Jedidiah Brewer, Robert Glennon, Alan Ker & Gary D. Libecap, *Water Markets in the West: Prices, Trading, and Contractural Forms* (Nat'l Bureau of Econ. Research, Working Paper No. 13002, 2007); AWWA, VALUE OF WATER, *supra* note 2; ROBERT A. YOUNG, DETERMINING THE ECONOMIC VALUE OF WATER: CONCEPTS AND METHODS (2005).

13. Charles W. Howe et al., *The Value of Water Supply Reliability in Urban Water Systems*, 26 J. ENVTL. ECON. & MGMT. 19 (1994).

14. *See infra* Part I.B.

A. Utilities' and Regulators' Integration of Water in Resource Planning

For most western utilities, water is not an economic consideration in the long-range resource-planning process. As utilities move from long-range planning to plant siting, water becomes a bigger consideration. A utility typically evaluates potential locations for building a resource by considering the cost of water, the cost of accessing fuel supplies or transmission, land availability, and air quality issues. Once a utility decides to construct a new generating resource or issues an RFP (request for proposal), water becomes an explicit economic factor. At this point, the cost of water is embedded in the cost of the new resource, including the cost of acquiring or developing water rights, the cost of constructing wells or pipelines, and the operating cost of pumping, treating, and disposing of water throughout the operating life of the plant.

Water is one of several factors—like access to transmission lines and available land—that can impact a project's viability. Adequate water supplies must not only be affordable, but also attainable within a reasonable time frame. Other more subjective questions can also influence the choice of resource and cooling technology. For example, would the public utility commission approve a project using large amounts of freshwater? Does that change if a plant were to use recycled water? Would relying on wet cooling create tremendous opposition to the project? Would developing a plant require the utility to go to water court in order to acquire or change a water right? The relative importance of each of these questions varies from state to state.

Public utility commissions (PUCs) typically have jurisdiction over electric utilities' integrated resource-planning processes and must permit power plants and new transmission lines. In both of these venues, water can influence a PUC's decision. The authority of PUCs to consider water varies considerably. The following subsections outline each PUC's authority and note PUC decisions that have considered—among other factors—water.

1. Arizona

Of all western utility commissions, the Arizona Corporation Commission (ACC) has taken the most assertive approach toward integrating water issues into electric resource planning. The ACC has a history of considering water in its decisions. It denied permits for the proposed Toltec Power Station and Big Sandy power plant—both gas-fired merchant plants—in part due to potential impacts on groundwater.[15] In 2005, as part of a settlement on a rate-making case, the ACC ordered Arizona Public Service (APS) to consider the feasibility of expanding utility-scale solar generation at existing coal-fired power plants. The decision notes that "[g]eneration from a solar electric project will add fuel-free, net-plant energy output resulting in environmental benefits and lower energy specific water usage."[16]

In 2009, the ACC proposed a rule regarding resource planning requiring regulated utilities to consider the cost of externalities—including power-plant water use—among other factors.[17] In addition, the proposed rule would require utilities to report water consumption and water-use rates for both existing facilities and future resource plans. Specifically, the analysis of future resources must include, "[a] plan for reducing environmental impacts related to air emissions, solid waste, and other environmental factors, and a plan for reducing water consumption."[18] Of note, APS, which, when compared to other western utilities has the most advanced approach for integrating water into its resource planning, already reports water consumption for the energy portfolios evaluated.

Water has historically played an important role in APS's resource planning. The utility's Palo Verde nuclear plant relies on treated wastewater from the city of Phoenix; according to APS, when the plant was constructed in 1973, recycled water was the only viable, reliable supply of water for the plant, and APS constructed pipelines to convey water from the treatment plant to Palo Verde. The utility now assumes that a new, combined-cycle gas plant must rely on dry cooling, as the ACC would not approve a wet-cooled gas plant. According to APS, however, the ACC's stance on cooling technologies for new baseload power supplies like coal, nuclear, or solar thermal plants is less clear; as the Arizona Power Plant and Transmission Line Siting Committee[19] has recently ap-

15. Press Release, Ariz. Corp. Comm'n, TOLTEC Power Project Denied (Jan. 31, 2002), *available at* http://www.azcc.gov/divisions/utilities/news/pr01-31-02.htm; Press Release, Ariz. Corp. Comm'n, Big Sandy Doesn't Fly (Nov. 26, 2001), *available at* http://www.azcc.gov/divisions/utilities/news/pr11-26-01.htm.

16. Opinion and Order at 26, *In re* Arizona Pub. Serv., E-01345A-03-0437 (Ariz. Corp. Comm'n, Apr. 7, 2005), *available at* http://www.cc.state.az.us/divisions/utilities/electric/APS-FinalOrder.pdf (Decision No. 67744).

17. Notice of Proposed Rulemaking Regarding Resource Planning, RE-00000A-09-0249, 2009 WL 4898386 (Ariz. Corp. Comm'n, Dec. 15, 2009) (Decision No. 71435).

18. *Id.* at subsec. D, proposed rule R14-2-703—Load-serving entity reporting requirements.

19. The ACC established this committee in 1971. For more information, see http://www.azcc.gov/Divisions/Utilities/Electric/LineSiting-FAQs.asp.

proved Abengoa Solar's plans to construct a wet-cooled solar thermal plant in southwestern Arizona.[20]

Salt River Project (SRP) provides both electricity and water services to the Phoenix metropolitan area. Because SRP supplies both water and energy, water is an inherent component in the utility's electric resource planning. However, SRP's integration of water into its energy planning is more subjective than that of APS. For example, SRP's board approves new resource acquisitions; for any new, water-intensive power plant, the board would question the availability and reliability of the water supplies, but SRP does not explicitly report water consumption for different portfolios.[21] And, like many other electric utilities, SRP considers the cost of acquiring new water supplies in its resource planning and siting processes, but does not factor in an externality value for water-efficient sources of energy.

2. Colorado

In 2004, Colorado voters passed Amendment 37, which declared that "in order to . . . minimize water use for electricity generation . . . and improve the natural environment of the state, it is in the best interests of the citizens of Colorado to develop and utilize renewable energy resources to the maximum practical extent."[22] The Colorado Public Utilities Commission (PUC) may consider the benefits to the state's water resources of the acquisition of renewables, energy efficiency, and new energy technologies.[23] In addition, the Colorado PUC allows utilities to evaluate and rank competitive solicitations for renewable sources of energy, taking into account the cost of energy and other factors that may impact the bidder's ability to fulfill the terms of the bid, including—among other factors—the amount of water used.[24]

As part of Public Service Company of Colorado's (PSCo) Integrated Resource Plan filing in 2007, the Colorado PUC approved PSCo's preferred resource plan, in part because of the benefits to the state's water resources. In addition, the Colorado PUC stated that "Public Service's proposal to address emissions (NOx, SOx, mercury, and particu-

20. Ariz. Corp. Comm'n Decision No. 70638, Docket No. L-00000GG-08-0407-00139 (Dec. 2008). The solar plant will rely on water transferred from agriculture.

21. Telephone interview with Charles B. Duckworth, Manager, Energy Mgmt. & Info., Salt River Project (Jan. 5, 2010).

22. *See* Amendment 37: Regulating Electric Utilities, 4 COLO. CODE REGS. § 723-3, Rule 3651 (2010) (The Colorado PUC incorporated this language from Amendment 37 into its code of regulations.).

23. COLO. REV. STAT. ANN. §§ 40-2-123(3)(b)(III), 40-2-124(1) (West, Westlaw through the end of the Second Regular Session of the 67th General Assembly (2010)).

24. 4 COLO. CODE REGS. § 723-3, Rule 3655(f) (2010).

lates) and water through their costs being embedded in generation resource bids is an appropriate first step in factoring externalities in resource planning."[25] In 2009, PSCo evaluated bids for new resources, and selected a dry-cooled, 280 megawatt (MW) solar thermal plant.[26] The company considered externalities, including water, in evaluating the bids. Although the company did not model a quantified, monetary value of water in its decision, it did perform a qualitative evaluation.[27]

While the Colorado PUC allows consideration of externality benefits in evaluating renewables and emerging technologies, it does not require regulated utilities to report water consumption in their resource plans, with one notable exception: As part of a new resource-planning process, Tri-State Generation & Transmission will report water use for all existing and proposed facilities.[28]

3. Nevada

While the Nevada Public Utilities Commission has the regulatory authority to consider water and other environmental factors in evaluating electric utilities' resource plans, it has not, to date, exercised this authority. The Nevada Administrative Code states that "[t]he environmental costs to the State associated with operating and maintaining a supply plan or demand side plan must be quantified for air emissions, water and land use."[29] The environmental costs of generation outside of the state of Nevada also must be considered in the same manner.[30]

In addition to overseeing resource planning, the Nevada PUC has the authority to grant or deny permits to merchant power plants, through Nevada's Utility Environmental Protection Act (UEPA). Under UEPA, independent power producers must obtain a certificate of public convenience and necessity for proposed merchant power plants. The UEPA statute allows the PUC to consider impacts on environmental resources, including water, when granting a certificate.

---

25. Pub. Serv. Co. of Colo., No. 07A 447E, 2008 WL 4613972, at *29 (Colo. Pub. Util. Comm'n, 2008) (Decision No. C08 0929).

26. PUB. SERV. CO. OF COLORADO, ALL SOURCE SOLICITATION 120 DAY REPORT 13 (2009).

27. Interview with Beth Chacon, Environmental Pol'y Rel. Manager, Xcel, in Denver, Colo. (Jan. 18, 2010).

28. Letter from Kenneth Anderson, Exec. Vice-President/Gen. Manager, Tri-State Generation & Transmission, and John Nielson, Energy Program Director, Western Resource Advocates, to Ron Binz, Chairman, Colorado Pub. Util. Commission (Dec. 8, 2009) (Proposed Settlement at Section 1(3)(k),1(10)), *available at* http://www.dora.state.co.us/puc/DocketsDecisions/decisions/2010/C10-0101A_09I-041E.pdf).

29. NEV. ADMIN. CODE § 704.9359 (2010).

30. NEV. ADMIN. CODE § 704.9063 (2010).

Although the Nevada PUC has not required electric utilities to report water consumption, it did order the creation of a Demand Side Management Collaborative committee in 2009. With representatives from all three utilities (Southern Nevada Water Authority, NV Energy, and Southwest Gas) and other stakeholders, the committee will work to develop a more coordinated, seamless efficiency effort between the utilities in southern Nevada. This inter-utility collaborative effort is, to our knowledge, unique in the West.

NV Energy considers water subjectively in its resource-planning process. Like APS, NV Energy now assumes new combined-cycle gas plants will rely on dry cooling, but new thermoelectric baseload plants could use wet- or hybrid-cooling systems.[31] NV Energy's proposed Ely Energy Center would have employed a hybrid system, in part because the water for a wet-cooled plant was simply not available in rural White Pine County.

In 2009, the state of Nevada created a new position: the Nevada Energy Commissioner, head of the Renewable Energy and Energy Efficiency Authority. The commissioner should consider the impacts of new renewable energy development on water resources and the potential water and energy savings available through certain efficiency measures. This new position represents an important opportunity for better integration of energy and water.

4. New Mexico

New Mexico's Public Regulation Commission (PRC) has focused primarily on the water benefits of energy efficiency programs. Under NMSA 1978, Section 62-17-2 (1972), "The legislature finds that: . . . cost-effective energy efficiency and load management programs undertaken by public utilities can provide significant reductions in greenhouse gas emissions, regulated air emissions, water consumption and natural resource depletion, and can avoid or delay the need for more expensive generation, transmission and distribution infrastructure." The statutory authority is reflected in several rules, which direct utilities to file an annual report that quantifies, to the extent practical, non-energy benefits of the energy efficiency programs,[32] and require utilities to choose energy-efficiency programs based on considerations that include "the existence of substantial non-energy benefits."[33]

31. Telephone interview with John Lescinske, Manager, Generation Engineering, NV Energy (Jan. 18, 2010).
32. 17.7.2.13(C)(7) NMAC (2010).
33. 17.7.2.9(C)(e) NMAC (2010).

Notably, non-energy benefits are defined as "benefits which do not affect the total resource cost of a program, including but not limited to benefits of low-income customer participation in utility programs, and reductions in greenhouse gas emissions, regulated air emissions, water consumption and natural resource depletion."[34]

In addition to these rules, the PRC requires regulated utilities to report freshwater consumption at existing facilities;[35] according to the Public Service Company of New Mexico (PNM), they do not typically report brackish or recycled water consumption.[36] We did not find any cases in which the New Mexico PRC cited water as a factor influencing its decision. In 2000, citizens protesting the proposed Duke Luna Energy Facility, a 600 MW gas plant, cited concerns about water availability and use by the plant. The Luna Facility project manager responded to these concerns by noting that the state engineer—not the PRC—has jurisdiction over water availability at the plant site and whether that water use will be "detrimental to the public welfare of the State."[37] In the final stipulation approved by the PRC, water issues were not mentioned. And, according to PNM, the PRC has not pressured utilities to choose water efficient resources; greenhouse gas emissions and the cost of natural gas remain more pressing issues.[38]

Despite the limited extent to which water has influenced PRC decisions, PNM *has* considered water in its resource planning. For example, in January, 2010, PNM announced a decision to build 80 MW of solar photovoltaic (PV) panels, which use negligible amounts of water. PNM considered both solar thermal and PV technologies, but the PV proposal was cost competitive, and allowed PNM to avoid water disputes.[39]

5. Utah

As part of its integrated resource planning requirements, the Public Service Commission of Utah directs regulated utilities to perform an analysis of environmental risk. The analysis should include the "quantification of actual emissions, as well as a range of dollar values for external

34. 17.7.2.7(W) NMAC (2010).

35. N.M. Code R. § 17.7.3.9.C (12)(c) (2010).

36. Telephone interview with Cindy Bothwell, Manager, Integrated Resources Planning, PNM (Jan. 14, 2010).

37. Letter from Cameron Epard, Project Manager, Duke Energy Luna, LLC, to Peggy McKeown (Oct. 11, 2000) (on file with author).

38. Telephone interview with Cindy Bothwell, Manager, Integrated Resources Planning, PNM (Jan. 14, 2010).

39. *Id.*

costs of each resource acquisition strategy."[40] In the following paragraph of the order, however, the Commission "reject[s] the recommendation to explicitly include external costs into the calculation of least cost and the subsequent acquisition of resources. Nevertheless, the Commission concludes that requiring the Company to conduct an analysis of the risks associated with future internalization of environmental costs is appropriate. . . ."[41]

Rocky Mountain Power (PacifiCorp) considers water in its resource planning process in a very limited manner. In evaluating supply-side resources, the utility considers the cost of acquiring or developing water, the annual operation and maintenance (O&M) costs associated with water (including the cost of treating and disposing of wastewater[42]), and the risk of water not being available. But the utility does not report water consumption in its Integrated Resource Plan (IRP) for existing facilities or proposed new facilities.[43]

Similar to PNM, PacifiCorp has focused more on evaluating the cost of greenhouse gas emissions and other risks. Of note, PacifiCorp serves customers in a seven-state region, and generates a considerable amount of its electricity at hydroelectric facilities in the Pacific Northwest. The utility has worried less about the impacts of its power plants on water resources, and more on the impacts of climate change on water and hydroelectric generation.

6. *Wyoming*

Wyoming does not appear to have any statutes or regulations that directly address water use by electric generation facilities.

B. The Costs of Alternative Cooling Systems

Water availability and cost can influence the type of resource in which an electric utility invests, and most utilities incorporate the cost of water into their decisions about cooling technologies for thermoelectric power plants. Thermoelectric power plants require water to generate steam, which must then be condensed and cooled. Most western thermoelectric plants rely on wet recirculating cooling systems to cool and con-

---

40. Order Adopting Integrated Resource Planning Standards and Guidelines, *In re* PacifiCorp, No. 90-2035-01, 11 (Pub. Serv. Comm'n of Utah, June 18, 1992).

41. *Id.* at 11–12.

42. All of PacifiCorp's plants are zero liquid discharge facilities. Telephone interview with Ian Andrews, Manager, Resource Dev. Generation, PacifiCorp (Jan. 6, 2010).

43. Telephone interview with Pete Warnken, Manager of Integrated Resource Planning, PacifiCorp (Dec. 18, 2009); Telephone interview with Ian Andrews, Manager, Resource Dev. Generation, PacifiCorp (Jan. 6, 2010).

dense the steam. Dry- and hybrid-cooling systems reduce the total consumptive use of water and the costs associated with pumping, treating, and discharging water, but they incur greater capital costs and often generate less electricity during the hottest periods, when electricity demand is highest.

The full cost of water use includes capital costs, O&M costs, opportunity costs (the value that would otherwise be obtained from applying that water to its best alternative use), and externalities.[44] When making water-supply decisions, utilities do not typically take into account the opportunity costs or externalities associated with those decisions. When these costs of providing a resource for a particular use are not accounted for, the resource will be underpriced in that particular use.

The Electric Power Research Institute (EPRI) analyzed the cost of dry- vs. wet-cooling systems in two types of thermoelectric power plants: a 500 MW combined-cycle natural gas plant and a 325 MW coal plant.[45] The report, published in 2004, assessed the capital cost of the different cooling systems, along with the annual costs of operating and maintaining the cooling system and the cost of capacity shortfalls for dry-cooling systems. Table 1 (below) summarizes EPRI's analysis of the costs of cooling systems for a combined-cycle gas plant. Using EPRI's data and assumptions, an implicit value of water is derived for power generation (Table 1, line 9).[46] From the power-plant owner's perspective, the added value of that water is as much as $1,086/AF/year (see Table 1 for details); this value could be considered the economic rent that the water utility (or whoever "owns" the water) could charge the power-plant operators.

In the West, however, most power plants do not buy water from a water utility on an annual basis; rather, they appropriate new water

44. *See generally* PETER ROGERS, RAMESH BHATIA & ANNETTE HUBER, GLOBAL WATER PARTNERSHIP, WATER AS A SOCIAL AND ECONOMIC GOOD: HOW TO PUT THE PRINCIPLE INTO PRACTICE (1998).

45. EPRI, COMPARISON OF ALTERNATE COOLING TECHNOLOGIES FOR U.S. POWER PLANTS: ECONOMIC, ENVIRONMENTAL, AND OTHER TRADEOFFS (2004).

46. EPRI's capital costs are adjusted from 2004 dollars to 2008 dollars using the Bureau of Economic Analysis's (BEA) price index for private fixed investment in electric power structures. Variable costs are escalated using the BEA's gross domestic product deflator. BUREAU OF ECONOMIC ANALYSIS, NATIONAL INCOME AND PRODUCT ACCOUNTS, Table 5.4.4 (2010). We do not escalate the capital cost of water rights for two reasons: (1) in general, water rights are not sold in a well-functioning market, and the cost of a right does not escalate at a predictable rate (e.g., the rate of inflation), and (2) construction costs increased considerably over the period 2004–2008. *Id.* at Table 1.1.9. EPRI assumes a wet-cooled, 500 MW combined-cycle gas plant in the arid Southwest would use almost 2,800 AF/year and would purchase water from a water utility at a rate of $326/AF ($1/1,000 gallons). Annually, a wet-cooled gas plant would cost $3,033,900 less than a dry-cooled gas plant.

rights or purchase existing water rights. Assuming a water right can be amortized in the same manner as other plant capital costs (i.e., using a discount rate of 7 percent and a 30-year period), by WRA's calculations, the "break even" point for adopting a dry-cooled system occurs when the cost of water rights exceeds $17,000/AF.

TABLE 1. Cost analysis of wet- and dry-cooling systems for thermoelectric power plants in hot, arid, southwestern states

Plant	**Gas, CC, 500 MW (water provided by a water utility)**		**Gas, CC, 500 MW (water purchased from willing sellers)**	
1. Cooling System	**Wet**	**Dry**	**Wet**	**Dry**
2. Capital Cost of Cooling Equipment ($)	7,629,421	30,414,637	7,629,421	30,414,637
3. Cost of Water Rights ($/AF)	0	0	1,500	1,500
4. Annualized Capital Cost ($/yr)*	610,354	2,433,171	945,476	2,433,171
5. Annual O&M Costs** (excluding water) ($/yr)	1,493,501	2,704,540	583,501	2,704,540
6. Annual Cost of Water ($/yr)	910,000	–	0	0
7. Total Annual Costs ($/yr)	2,103,855	5,137,711	1,528,977	5,137,711
8. Volume of Water Consumed (AF/yr)	2,793	–	2,793	–
9. Added Value of Water ($/AF/yr)	1,086	–	1,292	–

* Capital costs are annualized using a 7 percent discount rate and 30-year period.
** O&M costs include maintenance costs, fan power costs (for both wet and dry systems), and lost revenues from lost capacity during hot periods (for dry-cooled systems), along with system maintenance costs.

Dry-cooling systems have similar economic impacts on coal, solar thermal, and other thermoelectric power plants. For example, the capital cost of installing dry-cooling technology in solar thermal plants is typically three to five times as expensive as wet-cooling systems. The actual energy and cost penalties for solar thermal plants depend on the location of the plant. For example, the cost of electricity generated at a dry-cooled concentrating solar power plant (CSP) in New Mexico may be 2 percent higher than costs of electricity from a wet-cooled plant, whereas a dry-cooled plant in the Mohave Desert might have average electricity costs 7 to 9 percent higher than a comparable wet-cooled plant.[47]

C. Other Factors

Beyond considering the economics of a new generating resource, utilities must also factor in public or political opposition to a potential project. A utility's decision to use large amounts of water for cooling a power plant can create tremendous public opposition, particularly if the plant will transfer water from other basins, impact rural agricultural communities, require a new diversion, or impact sensitive streams or wetlands. This has been true for both conventional coal plants *and*, more recently, for proposed renewable plants.

Recent news articles have highlighted conflicts surrounding solar thermal power developments and water.[48] Utilities are increasingly choosing to adopt water-efficient cooling technologies in order to avoid impacts on water resources: Since its water use was featured in the *New York Times*, Solar Millennium decided to adopt dry cooling for its proposed plant in Nevada's Amargosa Valley. Though not a direct cost, public opposition often leads to costly legal challenges.

In order to appropriate new water rights or change a water right from an existing use (i.e., agricultural or municipal) to industrial use, an electric utility would—depending on the state—have to file for a change of use in water court or with the state engineer. Hearings in water court or other legal venues can delay or derail a project and drive up costs. In sum, the prospect of water court can, and has, changed the shape of a project.[49] For example, in Colorado, the cost of a large case in water court ranges from a few hundred thousand dollars to as much as several million dollars. Not every proposed power plant would have to acquire

---

47. U.S. DEP'T OF ENERGY, CONCENTRATING SOLAR POWER COMMERCIAL APPLICATION STUDY: REDUCING WATER CONSUMPTION OF CONCENTRATING SOLAR POWER ELECTRICITY GENERATION 5 (2009).

48. *See, e.g.*, Todd Woody, *Alternative Energy Projects Stumble on a Need for Water*, N.Y. TIMES, Sept. 29, 2009, *available at* http://www.nytimes.com/2009/09/30/business/energy-environment/30water.html.

49. The prospect of potential water court proceedings influenced Xcel Energy's decision to rely on municipal water supplies for its Comanche III unit. Interview with Beth Chacon, *supra* note 27.

water rights—many electric utilities already own sufficient water rights in their service areas.[50]

D. Summary

Although electric utilities consider water as a component in their resource planning, most utilities do not yet place a monetary value on water as part of their resource modeling. More importantly, none of the utilities surveyed are modeling the projected future costs, or value of water, despite the fact that most utility staff expect that water issues will increase, causing the water itself to become more valuable. Other costs—particularly the potential cost of CO_2 and fuel costs—still exceed the capital and operating cost of water for electric utilities. Similarly, air permits still pose a bigger challenge than water court.

The different approaches to integrating water reflect the relative scarcity of the resource in different states: APS places the greatest emphasis on water resources in its resource planning, followed by utilities in Nevada and New Mexico. Surprisingly, despite the scarcity of water in Colorado, particularly on the Front Range, Colorado's PUC has not required the state's investor-owned utilities to report water consumption. Finally, representatives of PacifiCorp, a utility with considerable hydroelectric resources, noted that they have greater concerns about the potential effects of climate change on water resources and, in turn, hydroelectric generation, rather than the effect of water availability on thermoelectric electric generation.

II. MUNICIPAL VALUE OF WATER

By far, cities have the highest willingness (and ability) to pay for water. Some proposed new supply projects across the region will cost as much as of $20,000/AF or more in capital expenditures alone.[51] And in 2003, at the height of the drought in Colorado, Colorado cities paid over $30,000/AF for water purchased through transactions.[52] However, the cost of water for municipal use varies tremendously from state to state and even between neighboring cities. Importantly, most households generally do not pay prices that reflect the true value of the water, including externality costs.[53]

---

50. *Id.*; Telephone interview with Cindy Bothwell, Manager, Integrated Resources Planning, PNM (Jan. 14, 2010); Telephone interview with Bob Lotts, Water Resources Manager, APS (Dec. 18, 2009).

51. Both Colorado Springs' Southern Delivery System and Arizona's Big Chino Ranch Water Project have estimated capital costs in excess of $20,000/AF.

52. Value reflects the one-time price paid for water, not an annualized cost.

53. AWWA, VALUE OF WATER, *supra* note 2.

WRA used several market-based metrics to estimate the value of water in western cities: prices paid for permanent water transfers, the cost of new supply projects, and municipal tap fees. For each source of data, the annualized cost of water is calculated as $2008/AF/year. It is assumed that municipalities would fund new supply projects and transfers using municipal bonds; we calculate the annualized value using the current municipal bond rate (4.46 percent) and a 30-year period.[54] Where possible, annual O&M costs are included in total annual costs. Very few studies have examined customers' willingness to pay (WTP), a non-market-based valuation technique, for residential water uses.[55]

A. Water Transfers

Market transactions involving water, while relatively rare and likely imperfect, can nonetheless yield insights into the value of water.[56] Water transfers can take two basic forms: short-term leases or permanent water sales. Only permanent sales were considered in this paper, for a number of reasons: (1) comparing temporary transfers to new supplies proves challenging because temporary leases provide water for a discreet period of time while new supplies provide water in perpetuity; (2) short-term leases (less than five years) may be skewed by unique circumstances and may not accurately reflect the long-term value of water;[57] and (3) permanent sales represent the majority of water transferred (both in terms of the number of transfers and the total volume of water transferred).

We analyzed over 1,300 water transactions recorded by the *Water Strategist* and compiled by researchers at the University of California–Santa Barbara over the period 1987 to 2008.[58] The dataset classifies both the seller and the buyer as urban, agricultural, or environmental entities, and provides information on the volume of water transferred (a single transaction can transfer any volume of water). Of note, the *Water Strategist* data does not include information on the seniority of the water rights. All else equal, water rights of greater seniority will garner greater

---

54. *See* http://www.bloomberg.com/markets/rates/index.html. Most municipal bonds have a 30-year period.

55. AWWA, VALUE OF WATER, *supra* note 2.

56. AWWA, VALUE OF WATER, *supra* note 2.

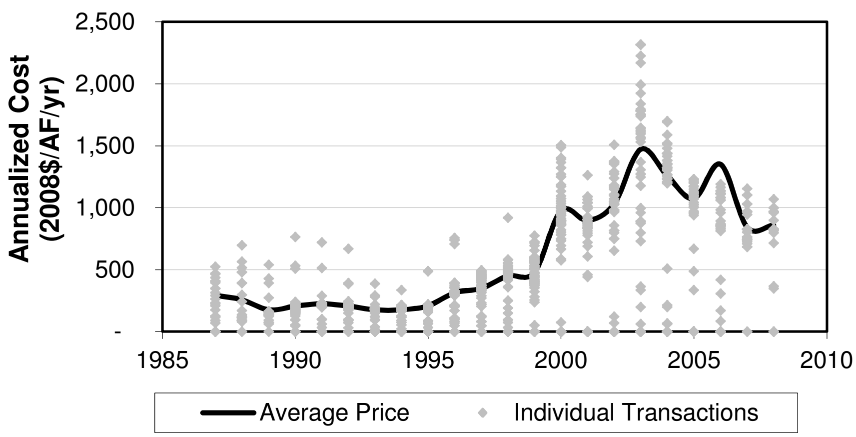
57. For example, cities may have excess water in one year and lease it to farmers or other cities for a very cheap rate. Telephone interview with Patricia Flood, Senior Principal Engineer, Wright Water Engineers (Dec. 21, 2009).

58. Zack Donohew & Gary Libecap, *Water Transfer Level Dataset*, Donald Bren Sch. Envtl. Sci. & Mgmt, U.C. Santa Barbara, http://www.bren.ucsb.edu/news/water_transfers.htm (last visited Jan. 18, 2011).

sale prices, and water rights that are closer to the importing region would presumably garner greater sale prices than those farther away.

Generally, the real price of transferred water is highest in Colorado, but across the region the price of water has risen over the past 21 years. The state of Colorado has the most active water market, and provides a good example of how the value of water has risen since 1987 (Figure 1, below).[59] Prices rose in the late 1990s, a result of population and demand growth along the Front Range, and peaked in 2003, following Colorado's worst drought year on record. This history provides additional insight into how the value of water can be expected to change in the future, as demand rises and/or the supply shrinks.

FIGURE 1. **Water sales to municipalities: Colorado**



B. New Supply Projects

In almost every western state, cities have recently proposed or constructed new municipal water-supply projects. WRA evaluated the projected capital cost and average yields of these projects using data from environmental impact statements, scoping documents, or supporting documents. Including annual O&M costs, the annualized cost of new supplies is as high as $1,829/AF/year.

59. *Id*. The price of water is considerably higher in 2008 than it was in 1987. All values are adjusted to 2008 price using the Consumer Price Index (CPI). Values do not include annual O&M costs like treatment.

C. Municipal Tap Fees

Cities typically levy a "tap fee" on new developments. Tap fees provide a water utility with a stream of revenue to develop new water supplies, treatment facilities, and in some places, wastewater treatment facilities. Some cities levy all of these charges in one all-inclusive tap fee; others split the charges into different fees (e.g., a potable water tap fee, a sewer tap fee, etc). In theory, a tap fee guarantees a household as much water as it needs, but cities generally assume a tap fee provides 0.25–1.0 AF per household per year. While tap fees present a current, readily comparable data point between different cities and states, water values inferred from tap fees may not be directly comparable with values inferred from water transactions or the cost of new supply projects. While tap fees are related to the cost of water, they are also a creature of political decisions; the actual cost of providing water to a new customer may be subsidized by other rate elements.

WRA compiled a dataset of tap fees in 125 cities throughout Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming, relying primarily on city and county planning documents. To determine the volume of water represented by a tap fee, we used city, county, or state planning documents; where planning data were unavailable, we used per capita water-use data. The data is from most medium, large, and fast-growing cities, where demand for water is highest; thus, the values may be not be representative of smaller towns throughout the West.[60]

Tap fees are two to six times higher in Colorado than in other western states. Tap fees vary tremendously within each state, particularly in Colorado and Arizona. This variability can be attributed in large part to resource scarcity.[61] For example, the median price of water in Front Range cities (where demand is high and existing supplies are limited) is $1,550/AF/year. In contrast, the price of a tap fee in slower-growing rural communities on Colorado's eastern plains or western slope is $557/AF/year. Tap fees can vary considerably even between neighboring cities. For example, Broomfield, Colorado, charges over four times as much as its neighbor, Denver (see Figure 2, Part II.D, below). Denver has reliable, diverse, water supplies, whereas Broomfield has ex-

60. David S. Brookshire, Bonnie Colby, Mary Ewers & Philip T. Ganderton, *Market Prices for Water in the Semiarid West of the United States*, 40 WATER RESOURCES RES. W09S04 (2004).

61. *See generally* Edward Ludwig Glaesar & David Christopher Maré, *Cities and Skills*, 19 J. LAB. ECON. 316 (2001); Mark Nord, *Does It Cost Less to Live in Rural Areas? Evidence from New Data on Food Security and Hunger*, 65 RURAL SOC. 104 (2000) (explaining that regional differences in tap fees are also likely to be due in part to the higher home values and higher wages earned typically found in metro areas).

perienced rapid population growth and rising water demands in recent years. In Colorado and Utah, the median cost of tap fees in major population centers[62] is slightly higher than tap fees statewide. The price of tap fees in cities along the Wasatch Front in Utah is $235/AF/year, 26 percent more than the statewide median. And tap fees in Front Range cities are 45 percent higher.

D. Summary

Across the region, the cost of new supplies exceeds the cost of permanent water transfers, suggesting that water transfers represent an economically competitive alternative to developing new water supplies.[63] In general, the cost of a tap fee exceeds the median price of water sold through transactions. But tap fees represent the current price of water,[64] whereas the transactions dataset includes transfers from 1987 to 2008. In Colorado, for example, the cost of water purchased through transactions during recent years (2000–2008) is similar to the cost of a tap in 2009. Comparing the cost of new supplies with tap fees presents mixed results. In some states, the cost of new supplies exceeds the cost of a tap fee, whereas in others, the price of a tap fee is less than the cost of developing a new supply (see Figure 2, below).[65] Where tap fees do not cover the full cost of a new supply project, cities may rely on water bills, municipal general funds, or other funding mechanisms to pay the difference.

Prices paid by municipalities for new water sources represent the upper end of the current value of water. Electric utilities will likely site most new plants in rural areas, remote from cities. But increasingly, cities are also tapping water supplies in rural areas—the Southern Nevada Water Authority has purchased agricultural water in White Pine County,

---

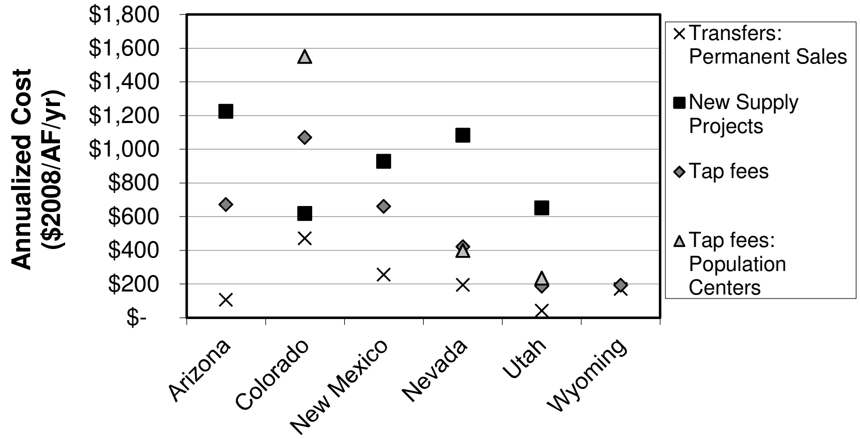
62. "Major population centers" include the Wasatch Front in Utah, the Front Range of Colorado, and the Las Vegas Valley in Nevada.

63. Water transfers hinge on the ability to physically move water from the seller to the buyer. Transfers often take place within the same basin, making infrastructure unnecessary. In transbasin exchanges, cities often rely on infrastructure constructed decades ago; the cost of this infrastructure is a sunk cost, and excluded from our analysis. And, in some cases, new supply projects will facilitate future transfers—Colorado Springs' Southern Delivery System (Colo.) and Aurora's Prairie Waters Project (Colo.) likely will be used to convey agricultural (or other transferred) water in the future.

64. Tap fee data were from 2008 or 2009.

65. For example, in Utah, the Washington County Water Conservancy District has proposed the Lake Powell Pipeline, which will cost substantially more than tap fees in the county; similarly, the cost per AF of SNWA's Groundwater Development Project exceeds the price of tap fees in SNWA's service area. In Arizona, the median price of a tap fee *statewide* is less than the cost of the Big Chino Ranch Water Project, but tap fees in Prescott, the city served by the project, actually exceed the cost of the project.

FIGURE 2. **Municipal value of water**



nearly 300 miles from the Las Vegas Valley; and in 2002/2003, cities on the Front Range of Colorado purchased water in agricultural areas in the Arkansas Valley. Over the short term, using water for electricity generation in rural areas competes directly with agricultural uses. But long term, as urban populations grow and cities continue to tap more remote water supplies, water demand for power plants will increasingly compete with municipal demands.

Across the West, the value of water for municipal use ranges from $41/AF/year for water transferred in Utah to more than $1,800/AF/year for new supply projects on the Front Range of Colorado. The value of water varies considerably between data sources, but the trends are consistent: Coloradans, particularly along the Front Range, have the most expensive water, and residents in Wyoming and Utah—where water is generally less scarce—have the cheapest water. Figure 2 shows the median cost of various sources of municipal water supplies across the Interior West.[66]

III. AGRICULTURAL VALUE OF WATER

Throughout the West, cities and power plants are increasingly turning to the agricultural sector to meet their burgeoning water demands. As with other water uses, the value of agricultural use varies

66. Figure 2 graph compiled by author to illustrate this discussion. See accompanying text. The value of water for municipal use—based on tap fees, permanent transfers, and new supply projects—varies considerably between different states. For Arizona, New Mexico, and Wyoming, we did not disaggregate tap fees in major metropolitan centers from the statewide average tap fee.

tremendously, depending on the scarcity of the resource, the value of the commodity grown, the productivity of the agricultural land, the quality of complementary resources (i.e., irrigation facilities, reservoirs, and other infrastructure), and the cost of using the water—among other factors.[67]

To develop estimates of the value of water for agriculture, we considered several different sources of data, including the price of water rights purchased by farmers through market-based transactions, the price farmers pay for off-farm sources of water, differences in net farm revenues garnered from irrigated crops versus dryland crops, and the difference in land values of irrigated versus dryland farms. Of these, the price paid by farmers for water rights is the metric most directly comparable to the municipal values presented.

Importantly, we focus solely on the monetary value of water for agriculture, and do not include many of the nonmonetary values of agriculture, which are considerably more difficult to measure. These include the value of rural communities and lifestyles, the value of open, undeveloped space, and the value of a local food supply, to name a few. A more thorough analysis of the value of water would include consideration of changes to these nonmonetary values, as well as the indirect effects that agricultural-to-urban water transfers would have on the regional economy.[68]

Colorado has more agricultural land than any other state studied in this report. In addition, the state has seen the most dramatic conversion of water from agricultural uses to municipal uses. Accordingly, a considerable amount of research has focused on the value of water for agriculture and the economic impacts of water transfers. The trends occurring in Colorado, however, are likely to apply to farming communities throughout the region.

---

67. Each of these factors is, in turn, influenced by numerous others. For example, the value of commodities grown is influenced by the cost of fertilizer and pesticides, proximity to marketplaces, and market demand for the commodity. *See generally* Frank A. Ward & Ari Michelsen, *The Economic Value of Water in Agriculture: Concepts and Policy Applications*, 4 WATER POL'Y 423 (2002); Pullen & Colby, *supra* note 4; John Faux & Gregory M. Perry, *Estimating Irrigation Water Value Using a Hedonic Price Analysis: A Case Study in Malheur County, Oregon*, 75 LAND ECON. 440 (1999); Henning Bjornlund & Peter Rossini, An Empirical Analysis of Factors Driving Outcomes in Markets for Permanent Water—An Australian Case Study (Jan. 2006), *available at* http://www.prres.net/papers/Bjornlund_Factors_Driving_outcomes_in_markets_for_permanent_water.pdf.

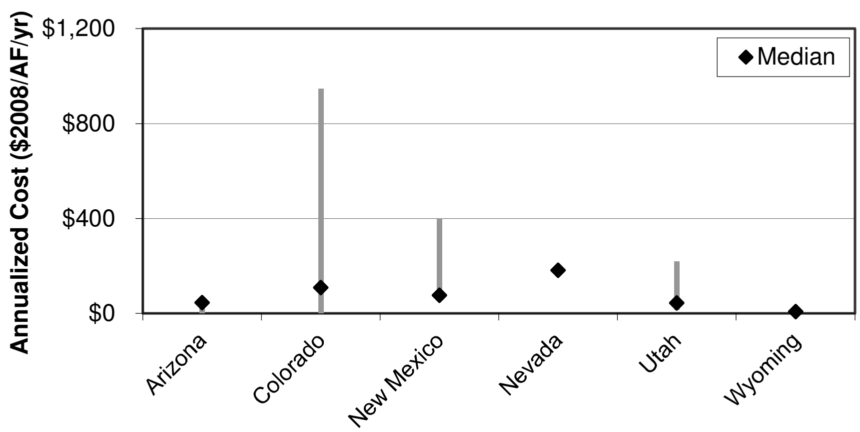
68. *See, e.g.*, Jennifer Thorvaldson & James Pritchett, *Economic Impact Analysis of Reduced Irrigation Acreage in Four River Basins in Colorado* (Colo. State Univ. Dep't of Agric. & Res. Econ., Working Paper No. 207, 2006), *available at* http://limitedirrigation.agsci.colostate.edu/present/economic_activity.pdf.

A. Water Transfers

Between 1987 and 2008, water was transferred to agricultural entities through 475 transactions.[69] As with municipal transfers, the price paid for water acquired through temporary leases can be skewed by a host of different factors, and permanent sales are a better representation of the long-term value of water for agriculture.[70] Therefore, only permanent sales are considered, which represent less than half of the total transactions. The price of sales is annualized using a 30-year period and a discount rate of 4.75 percent, the current interest rate for U.S. Department of Agriculture Farm Service Agency loans.[71]

In almost every transaction (96 percent), water was transferred from an agricultural user to another agricultural user. In addition, almost all of the transactions (92 percent) occurred in Colorado. This is due, in part, to the fact that the Colorado-Big Thompson (C-BT) Project has created a well-functioning market for water transfers. Across the region, the median price paid for water for agriculture is less than $400/AF/year (Figure 3, below)[72]—considerably lower than typical prices paid by mu-

FIGURE 3. **Transfers of water to agriculture: permanent sales**



69. Donohew & Libecap, *supra* note 58.

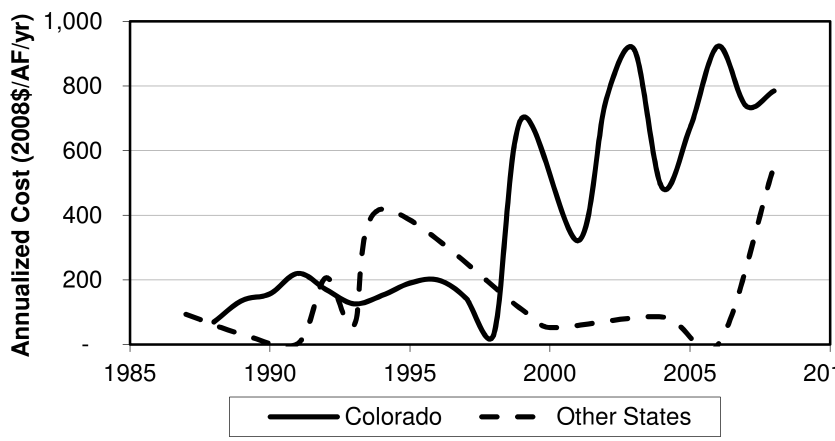
70. YOUNG, *supra* note 12.

71. U.S. Dep't of Agriculture Farm Serv. Agency, Direct Farm Loans Program, http://www.fsa.usda.gov/FSA/webapp?area=home&subject=fmlp&topic=DFl (last visited Jan. 29, 2010).

72. The median price paid for water transferred to agriculture, annualized over a 30-year period at a 4.75 percent discount rate, ranges from $16/AF/year in Wyoming to $153/AF/year in Colorado. Vertical bars reflect the range of values for a particular state. See Donohew & Libecap, *supra* note 58, for Figure 3 data.

nicipalities. In Colorado, the price of water sold to agricultural users increased substantially between 1987 and 2008 (Figure 4, below),[73] likely a result of severe drought in 2002/2003 and increased demands. Of note, market transactions should be interpreted with caution because of the limited market activity and the dependence of water prices on the seniority of the right, among other factors.[74]

FIGURE 4. **Average annual price of water sales to agriculture**



B. Irrigators' Water Costs

The cost of using water for irrigation also includes annual operating and maintenance costs. Irrigation water costs vary widely, reflecting different combinations of water sources, location, suppliers, and distribution systems. In 2008, irrigators in the six-state region reported an average cost of water from off-farm sources of $15.80 per AF delivered (Table 2, below).[75] The price irrigators pay for water is often based on the expense of developing and providing the resource, and may not reflect the full social cost of its use or water's relative scarcity.[76]

---

73. The cost of water sold to agricultural entities rose between 1987 and 2008, particularly in Colorado. See Donohew & Libecap, *supra* note 58, for Figure 4 data.

74. RENZETTI, *supra* note 11.

75. USDA NAT'L AGRIC. STATISTICS SERV., Table 22: *Expenses for Irrigation Water from Off-Farm Suppliers: 2008 and 2003, in* 2008 FARM AND RANCH IRRIGATION SURVEY (2008), *available at* http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/Farm_and_Ranch_Irrigation_Survey/index.asp (reporting 2007 census data).

76. Gollehon, *supra* note 11.

TABLE 2. Cost of irrigation water from off-farm suppliers (2008)

State	Average Cost/AF
Arizona	$28.76
Colorado	$14.29
Nevada	$10.28
New Mexico	$24.76
Utah	$10.88
Wyoming	$5.83

C. Net Revenues and Land Values

In arid and semi-arid regions, most crop production depends heavily on irrigation. Irrigated land generally produces increased crop yields and revenues, but also often entails greater costs. Using the method of net revenue differentials, researchers have calculated the value of water for irrigated (vs. non-irrigated) crop land.[77] In Colorado, for example, an irrigated acre of sunflowers generates $129 in net revenue, while a dry (non-irrigated) acre generates $3.15 in net revenues. Because an acre of sunflower crops consumes approximately 1.34 AF of water per year, the value of water used for irrigation is $99/AF. Table 3 (below) lists the calculations for several other crops in Colorado. Because commodity and input prices fluctuate throughout time and because each individual agricultural producer has slightly different production practices, the values in Table 3 will not hold for every producer, in every river basin, in all time periods.

In addition to the value the water adds to crop production, irrigated land also has a higher land value than non-irrigated agricultural

77. *See, e.g.*, U.S. Water Resources Council, *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (Mar. 10, 1983), ftp://ftp-fc.sc.egov.usda.gov/Economics/priceindexes/Data/PrinciplesAndGuidelinesLocalSite.pdf; RAY SUPALLA, THOMAS V. BUELL & BRIAN MCMULLEN, ECONOMIC AND STATE BUDGET COST OF REDUCING THE CONSUMPTIVE USE OF IRRIGATION WATER IN THE PLATTE AND REPUBLICAN BASINS (2006), http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1042&context=ageconworkpap; R.D. LACEWELL, J.M. SPROTT & B.R. BEATTIE, TEXAS WATER RESOURCES INSTITUTE, VALUE OF IRRIGATION WATER WITH ALTERNATIVE INPUT PRICES, PRODUCT PRICES AND YIELD LEVELS: TEXAS HIGH PLAINS AND LOW RIO GRANDE VALLEY (1974), *available at* http://twri.tamu.edu/reports/1974/tr58.pdf.

Table 3. Net returns/af by crop in Colorado

	Net Revenues After Payments to Capital* ($2008/Acre)**	Average Net Irrigation Requirements (AF/Acre)†	Value of Water for Crop Irrigation‡ ($2008/AF)
Irrigated Sunflower	$129.00	1.34	$98.62
Dryland Sunflower	$(3.15)		
Difference	***$132.15***		
Irrigated Corn Grain (Northeast)	$(56.12)	1.41	$(41.67)
Dryland Corn Grain (Northeast)	$2.63		
Difference	***$(58.75)***		
Irrigated Corn Grain (South, Sprinkler)	$408.20	1.41	$266.06
Dryland Corn Grain (South, No Till)	$33.05		
Difference	***$375.15***		
Irrigated Corn Grain (South, Flood)	$436.05	1.41	$285.82
Dryland Corn Grain (South, No Till)	$33.05		
Difference	***$403.00***		
Irrigated Wheat (Northeast)	$40.16	0.15	$279.80
Dryland Wheat (Northeast, Conventional Till)	$(1.81)		
Difference	***$41.97***		
Irrigated Wheat (Northeast)	$40.16	0.15	$544.73
Dryland Wheat (Northeast, Reduced Till)	$(41.55)		
Difference	***$81.71***		

* Capital costs include capital interest, land rent and interest, and hired labor and management.

** Crop enterprise budgets for Colorado were obtained from Colorado State University's Agriculture and Business Management website (http://www.coopext.colostate.edu/ABM/cropbudgets.htm).

† Net irrigation requirements for Colorado were obtained from A. Frank & D. Carlson, *Colorado's Net Irrigation Requirements for Agriculture, 1995* (1999).

‡ Calculation reflects the difference in net revenues, after payments to capital, adjusted based on the consumptive use of crops (AF/acre).

land.[78] The land-value approach estimates the at-source value of water in agriculture by calculating the difference in land value of farms with irrigated cropland to the land value of farms without irrigated cropland. In Colorado, for example, irrigated land is worth $2,500/acre more than non-irrigated cropland, and provides an additional $91/acre in land-rent value.[79] Adjusting for crop acreages and consumptive water use, these translate into values of $2,080/AF and $76/AF, respectively.[80]

While land-valuation data can provide a first-order approximation of the value of irrigation water, it does not control for other factors that affect agricultural land values, such as soil productivity, average rainfall, access by paved roads, and competing demands for other uses.[81] It nonetheless provides a useful benchmark of the contribution of irrigation water.[82] Research from the 1980s found that the water represented 30–60 percent of the total price paid for irrigated farms sold in five states overlying the Ogallala Aquifer.[83] The value of water is likely to represent an even greater proportion of farm sales today.

D. Summary

As with the value of water in municipal uses, the value of water in agricultural uses varies widely across the six-state region. In 2008, irrigators paid as little as $5.83/AF for off-farm water supplies in Wyoming, to as much as $28.76/AF for off-farm supplies in Arizona. These prices are much lower than those paid by municipalities and urban households. The added value of irrigation water—in terms of net revenues—is also

---

78. L. Allen Torell, James D. Libbin & Michael D. Miller, *The Market Value of Water in the Ogallala Aquifer*, 66 LAND ECON. 163 (1990) [hereinafter Torell, Libbin & Miller]; D.H. SMITH ET AL., AGRICULTURAL WATER CONSERVATION TASK FORCE COMPLETION REPORT NO. 190, IRRIGATION WATER CONSERVATION: OPPORTUNITIES AND LIMITATIONS IN COLORADO—A REPORT OF THE AGRICULTURAL WATER CONSERVATION TASK FORCE, *available at* http://www/cwi.colostate.edu/publications/cr/190.pdf.

79. NAT'L AGRIC. STATISTICS SERV. COLO. FIELD OFFICE, COLO. AGRICULTURAL STATISTICS 2009 (2009), *available at* http://www.cde.state.co.us/artemis/ag/ag13internet/ag132009internet.pdf.

80. *Id*. (acreage and land-value data); ANTONY FRANK & DR. DAVID CARLSON, COLO. DEP'T OF AGRIC., COLORADO'S NET IRRIGATION REQUIREMENTS FOR AGRICULTURE (1995), *available at* http://cospl.coalliance.org/fez/eserv/co:3072/ag92ir71999internet.pdf (net irrigation requirements).

81. *See generally* Leah J. Tsoodle, Bill B. Golden & Allen M. Featherstone, *Factors Influencing Kansas Agricultural Farm Land Values*, 82 LAND ECON. 124 (2006) (land valuation); Cynthia Nickerson, *Land Use, Value, and Management: Agricultural Land Values*, USDA ECON. RES. SERV. (June 28, 2005), http://www.ers.usda.gov/Briefing/landuse/aglandvaluechapter.htm (factors affecting land value).

82. Howitt & Hansen, *supra* note 12.

83. Torell, Libbin & Miller, *supra* note 78.

much higher than prices paid. Irrigation water increases crop revenues by as much as $545/AF in parts of Colorado. The median price paid for water *rights* transferred to agriculture tends to be higher, ranging from $16/AF/year in Wyoming to $153/AF/year in Colorado (annualized costs). The range of transfer prices is large, especially in Colorado, where prices exceeded $1,000/AF/year in several instances.

IV. ENVIRONMENTAL VALUE OF WATER

Leaving water instream provides a host of benefits: it supports recreation, sustains healthy ecosystems, improves water quality, and offers other, aesthetic benefits. While water supplies have traditionally been allocated without regard for instream values, all western states now recognize that instream flows qualify as a beneficial use, and many have an established instream flow program managed by a state agency.[84] As populations and incomes rise, the value of water left instream is expected to continue rising.[85]

Monetizing the value of instream or environmental flows proves more challenging than estimating the value of water for municipal or agricultural needs. Valuing instream flows is a relatively new practice, and estimates of the value of these flows are scarce. Outdoor recreation like fishing and whitewater rafting provide a tremendous (and growing) source of income throughout western states,[86] but attributing that income to a volume of water proves difficult. And many of the benefits of instream flows, e.g., a healthy riverine ecosystem, are not yet adequately measured by economic analyses.

Because of these challenges, much of our analysis of the value of instream flows is qualitative. We rely on several sources of data to estimate the value of water left instream: the water transactions database, prior non-market valuation studies, the value of instream flows to recreation, and the cost of constructing environmental pools in new reservoirs. We calculate the annualized value of a permanent new environmental supply using a 30-year period and a 4.46 percent discount rate.[87]

---

84. DIANA C. GIBBONS, THE ECONOMIC VALUE OF WATER (1986); Lawrence J. MacDonnell, *Environmental Flows in the Rocky Mountain West: A Progress Report*, 9 WYO. L. REV. 335 (2009).

85. GIBBONS, *supra* note 84.

86. *See, e.g.*, COLORADO RIVER OUTFITTING ASS'N , COMMERCIAL RIVER USE IN THE STATE OF COLORADO (Aug. 10, 2009), http://www.croa.org/media/documents/pdf/2009_commercial_rafting_use_report.pdf.

87. This is the current municipal bond rate; we assume that environmental projects (e.g., environmental pools in new reservoirs, the construction of whitewater parks, etc.) would likely be funded with state and local bonds.

A. Market-Based Values

Using the same database of water transactions described in the municipal and agricultural sections, we assess the price paid for temporary and permanent transfers of water from urban and agricultural to environmental uses. From 1987 to 2008, the *Water Strategist* recorded 143 transactions in which agricultural or municipal entities transferred water to environmental purposes; of these, fewer than half were permanent sales. For comparison, over the same time period, water was transferred to urban users in over 1,300 transactions, and nearly all of the transactions were permanent sales.[88] Leases have been more common than permanent sales, likely due to several reasons: temporary leases often face less community resistance than permanent sales; the owner of the water right may garner rent payments from a temporary lease, while retaining the option to use the water again or sell it to a higher bidder in future years; and a temporary lease avoids the water court process, including expensive legal, hydrological, and engineering fees.[89] Because the majority of environmental transactions take the form of temporary leases, these are included in the analysis.

The majority of transfers occurred in Colorado, New Mexico, and Nevada (each with over 30 transactions), with temporary leases dominating in Colorado and New Mexico. Based on the data available, the median and average price for temporary leases was below $65/AF/year. Nevada, where sales dominated, represents the key exception, with an annualized median cost of water transferred of $315/AF (Figure 5, below).[90] Of note, recent studies have found that non-market valuation techniques for recreation are providing estimates fairly close to, and perhaps on the conservative side of, what public agencies are actually paying for instream flows for recreation.[91]

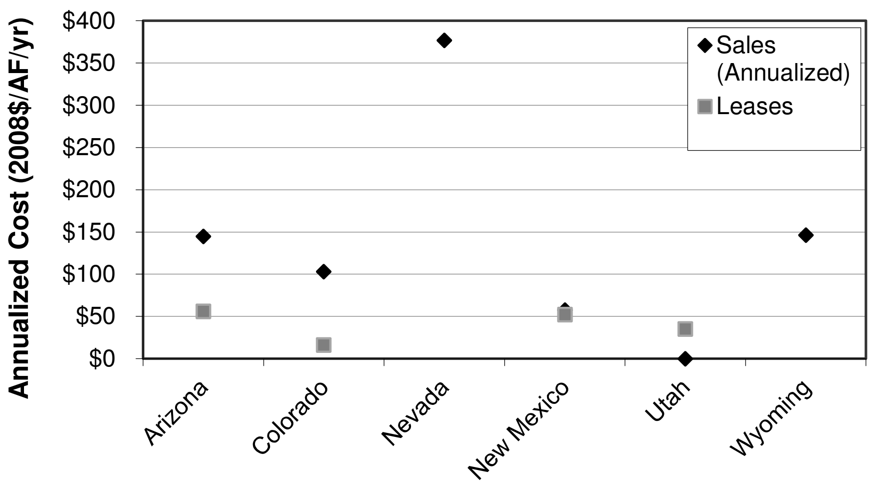
88. Donohew & Libecap, *supra* note 58.

89. Steven Malloch, *Liquid Assets: Protecting and Restoring the West's Rivers and Wetlands through Environmental Water Transactions*, TROUT UNLIMITED INC. (Mar. 2005), http://www.nature.org/initiatives/freshwater/files/liquid_assets.pdf (explaining that many of these reasons may make agriculture-to-urban water leases more common as well; however, environmental water leases may face more notable community resistance in some places).

90. Figures calculated from 23 sales (with price data) to environmental entities. Donohew & Libecap, *supra* note 58.

91. John B. Loomis, Katherine Quattlebaum, Thomas C. Brown & Susan J. Alexander, *Expanding Institutional Arrangements for Acquiring Water for Environmental Purposes: Transactions Evidence for the Western United States*, 19 INT'L J. WATER RES. DEV. 21 (2003).

FIGURE 5. Water transfers to environmental uses[92]



B. Environmental Pools in New Supply Projects

Finally, several of the new water-supply projects recently constructed or proposed include environmental pools. These dedicated pools store water that can be released at a point in time each year to maximize environmental benefits, typically by increasing flows during the peak period of runoff (typically in early summer) or improving base flows during periods with low flow (often late summer). Federal or state government agencies, municipal water utilities, and environmental groups have paid for a portion of the total reservoir costs in exchange for storage of an environmental pool. Because these projects have been funded by state and local governments, we calculate an annualized cost using the municipal bond rate (4.46 percent) and a 30-year period.[93]

In Colorado, several reservoirs have environmental pools dedicated to the recovery of endangered species in the Colorado River. Elkhead Reservoir, expanded at a total cost of $31 million, will store 5,000 AF for environmental releases on the Yampa River. The Upper Colorado River Endangered Fish Recovery Program paid for 43 percent of

92. The price paid for water for the environment is, generally, much lower than the price paid for water for municipalities, but similar to the price paid for agricultural water transfers.

93. BLOOMBERG L.P., *U.S. Government Bonds*, http://www.bloomberg.com/markets/rates/index.html (last visited Oct. 31, 2010).

the reservoir expansion;[94] the annualized cost of this water is $166/AF/year. Ruedi and Granby reservoirs will, combined, store 10,825 AF for environmental releases. Both Front Range and West Slope water providers will permanently supply the water and fund the program, at a projected annualized cost ranging from $72 to $302/AF/year.

Environmental pools have also been created in other states; the state of Wyoming enlarged the Pathfinder Reservoir in order to provide environmental flows for endangered species in the Platte River. The reservoir expansion, which stemmed from the Pathfinder Modification Stipulation[95] cost $10 million; the annualized cost of the environmental pool is approximately $17/AF/year. And, in New Mexico, the city of Albuquerque, the Albuquerque Bernalillo County Water Utility Authority, and environmental groups paid to create 30,000 AF of storage space in the Abiquiu Reservoir.[96] The environmental pool, which has not yet been filled with water, will be used to restore the silvery minnow in the Rio Grande.

In recent years, agencies have re-operated dams to improve environmental flows: Flaming Gorge (Wyoming) was re-operated to improve flows for endangered fish in the Green River; the Aspinal Unit (Colorado) was re-operated to mimic the natural hydrograph in the Gunnison River; and the Bureau of Reclamation has released scouring "pulse flows" from Glen Canyon Dam in order to improve habitat in the Grand Canyon. These re-operations may have embedded costs, like lost revenues from hydroelectric generation, but also often create benefits for multiple constituencies, not just the environment. And, the environmental flows typically vary from year to year. For these reasons, we have not attempted to quantify the environmental cost of reservoir re-operations, but note that it serves as another indicator of the value of environmental flows.

C. Water-Based Recreation: Participation and Expenditures

Although recreational participation and expenditure data do not directly translate into instream flow values, they indicate the magnitude of the industry and its dependence on instream flows. Several measures point to the tremendous value of water for recreation. Rivers like the

---

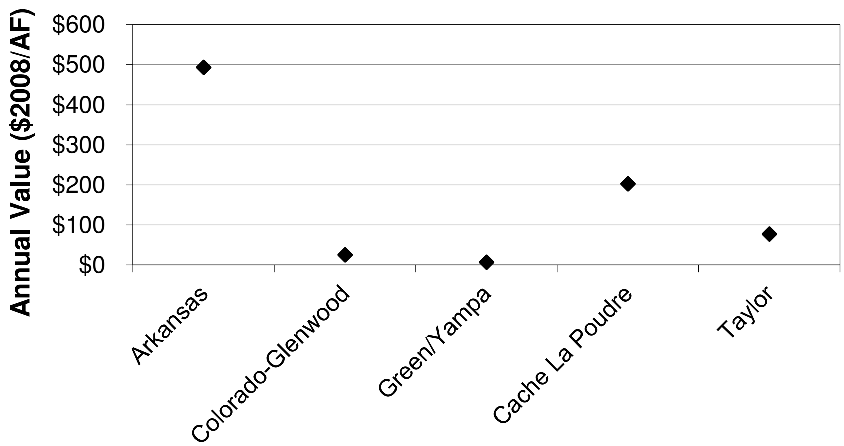
94. *See generally* COLORADO RIVER WATER CONSERVATION DISTRICT, *Elkhead Reservoir Enlargement*, http://www.crwcd.org/media/uploads/Elkhead_fact_sheet_9_06.pdf (last visited Dec. 9, 2010).

95. The stipulation resulted from a settlement in the U.S. Supreme Court case of *Nebraska v. Wyoming*, 325 U.S. 589 (1945), *modified*, 345 U.S. 981 (1953).

96. For a summary of the history of the reservoir and the silvery minnow, see Kara Gillon, *An Environmental Pool for the Rio Grande*, 47 NAT. RESOURCES J. 615 (2007).

Arkansas and Cache la Poudre, located close to major population centers in Colorado, generate the most revenue for commercial rafting operations (Figure 6, below).[97] Importantly, higher flows translate into larger economic benefits for the commercial rafting industry.[98] The value of water for commercial rafting on the Arkansas and the Cache la Poudre is significantly higher than the price paid in environmental transactions.

FIGURE 6. Annual value of water for rafting on Colorado rivers



In general, the economic benefits of fishing correspond directly to the number of user days. In 2006, the six-state study area saw over 20 million "fishing days" and almost $2.9 billion ($2006) in total economic revenues (including trip expenditures and equipment purchases) (Figure 7, below).[99] Although Colorado saw the most fishing days, fishing represents a major source of economic activity in all six states.

In the six southwestern states, an estimated 1.7 million people fished and another 1.1 million people participated in rafting, kayaking, canoeing, or other water-based recreation in 2005.[100] Participation and revenue generated from whitewater sports like rafting and kayaking is

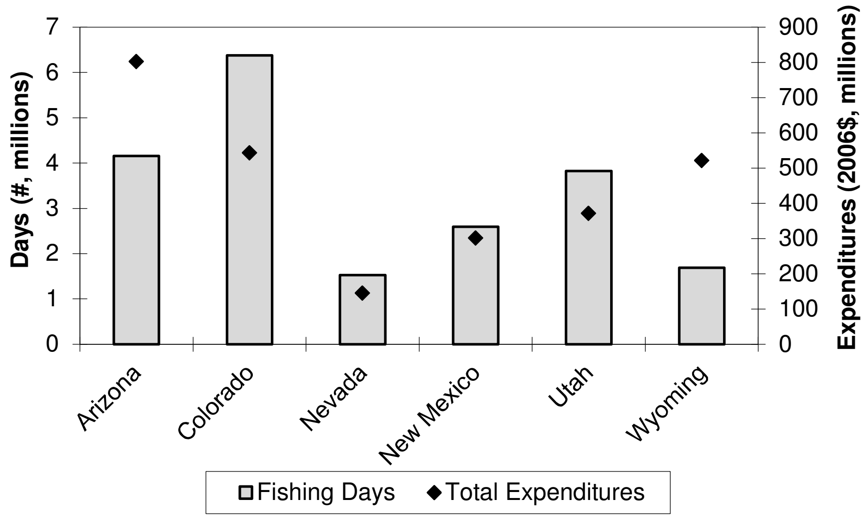
97. LOOMIS, supra note 4.

98. *See* LOOMIS, *supra* note 4 (explaining that optimal flows for fishing are lower than for rafting. For fishing, the optimal flow is approximately 70 percent of bank-full stage. Beyond 70 percent, the value decreases, presumably because at higher flows, rivers become muddy and less ideal for fishing).

99. U.S. FISH & WILDLIFE SERV., 2006 NATIONAL SURVEY OF FISHING, HUNTING AND WILDLIFE-ASSOCIATED RECREATION, http://wsfrprograms.fws.gov/subpages/nationalsurvey/nat_survey2006_final.pdf.

100. OUTDOOR INDUS. ASS'N, STATE OF THE INDUSTRY REPORT 2006, *available at* http://www.docstoc.com/docs/946714/State-of-the-outdoor-industry-report-2006.

FIGURE 7. **Fishing days & expenditures, 2006**



proportional to streamflows: during Colorado's 2002 drought, there were 40 percent fewer commercial rafting user days and a decrease in user expenditures of 39 percent, compared to the previous year.[101] Thus, leaving water instream translates directly into higher revenues for the recreation industry.

Instream flows benefit not just the commercial rafting or fishing industry, but often the local economy as well. Many of Colorado's white-water parks have recreational in-channel diversion (RICD) water rights that provide for flows through the park during certain times of year. The parks provide millions in direct, indirect, and induced benefits. For instance, Steamboat Springs' whitewater park generates an estimated $7.9 million annually and has an associated water right of over 70,000 AF/year. The value of that water right, accordingly, is approximately $115/AF/year (Table 4, below).

101. COLORADO RIVER OUTFITTING ASS'N, COMMERCIAL RIVER USE IN THE STATE OF COLORADO (Aug. 10, 2009), http://www.croa.org/media/documents/pdf/2009_commercial_rafting_use_report.pdf.

TABLE 4. Economic impact of four whitewater parks in Colorado and the value of the associated water

City	Park	Economic Impact ($/yr)*	Water Right (AF/yr)**	Annual Value of Water ($/AF/yr)
Breckenridge[102]	Whitewater Kayak Park	1,364,000	91,061	15
Golden[103]	Clear Creek Whitewater Park	2,535,000	75,701	33
Steamboat Springs[104]	Steamboat Springs Boating Park	7,913,000	71,000	115
Vail[105]	Vail Whitewater Park	850,000	110,162	8

* The economic impact value represents the largest estimated potential annual impact of each whitewater park.

** Based on absolute water-right decree, calculated from flow requirements (in cfs).

† Assuming a 3 percent discount rate and 40-year period.

D. Non-Market Valuation Studies

Instream uses of water are nonconsumptive in nature, often benefiting recreational and environmental users. Because market-based transfers from municipal or agricultural uses to environmental needs are rare, economists have often relied on non-market methods to determine the value of water left instream. As with municipal and agricultural values, the WTP for instream flows is very site-specific. For example, through surveys conducted in 1995 and 1996, Berrens et al. found that residents of New Mexico were willing to pay $75/AF ($2008) to improve flows on the Gila, Pecos, Rio Grande, and San Juan rivers, but just $34/AF ($2008)

102. *See* STRATUS CONSULTING, INC., THE BENEFICIAL VALUE OF WATERS DIVERTED IN THE BLUE RIVER FOR THE BRECKENRIDGE WHITEWATER PARK AND IN GORE CREEK FOR THE VAIL WHITEWATER PARK (2002) [hereinafter BRECKENRIDGE AND VAIL WHITEWATER].

103. *See* STRATUS CONSULTING, INC., PRELIMINARY EVALUATION OF THE BENEFICIAL VALUE OF WATERS DIVERTED IN THE CLEAR CREEK WHITEWATER PARK IN THE CITY OF GOLDEN (2000).

104. *See* STRATUS CONSULTING, INC., THE POTENTIAL BENEFICIAL VALUES OF WATERS DIVERTED IN THE YAMPA RIVER FOR THE STEAMBOAT SPRINGS BOATING PARK (draft 2005) (on file with author).

105. BRECKENRIDGE AND VAIL WHITEWATER, *supra* note 102.

to improve flows on the Middle Rio Grande River.[106] In the state of Colorado, the value of instream flows for fishing or commercial rafting on Colorado's rivers has been estimated at as much as $500/AF/year.[107] We expect the willingness to improve or preserve instream flows in pristine headwaters streams—prized for recreation and other environmental values—to be higher than the WTP for instream flows on remote or degraded stretches.

Non-market valuation studies indicate that the value of water for environmental uses often exceeds the price paid in market transactions. For example, a recent study estimates that residents of Fort Collins, Colorado, were willing to pay, on average, $234 per year to avoid a 50 percent reduction in instream flows in the Cache la Poudre River during April to September. Adjusting for flows, researchers calculated the annual value of water for instream flows in the Cache la Poudre of $171/AF.[108]

E. Summary

Although the value of water left instream is challenging to quantify, it is clearly valuable (Figure 8, below).[109] As with municipal and agricultural uses, the value depends on the location of the stream and a host of other factors; instream flows in pristine headwaters streams with a robust recreational industry will likely have a higher value than flows in degraded streams distant from population centers. In their review of early water quality studies in which both use and non-use values were estimated, Fisher and Raucher found non-use values of surface water resources to be positive and nontrivial, with the existing evidence indicating that non-use values are generally at least half as great as recreational

---

106. R.P. Berrens, A.K. Bohara, C.L. Silva, D. Brookshire & M. McKee, *Contingent Values for New Mexico Instream Flows: With Tests of Scope, Group-Size Reminder and Temporal Reliability*, 58 J. ENVTL. MGMT. 73 (2000).

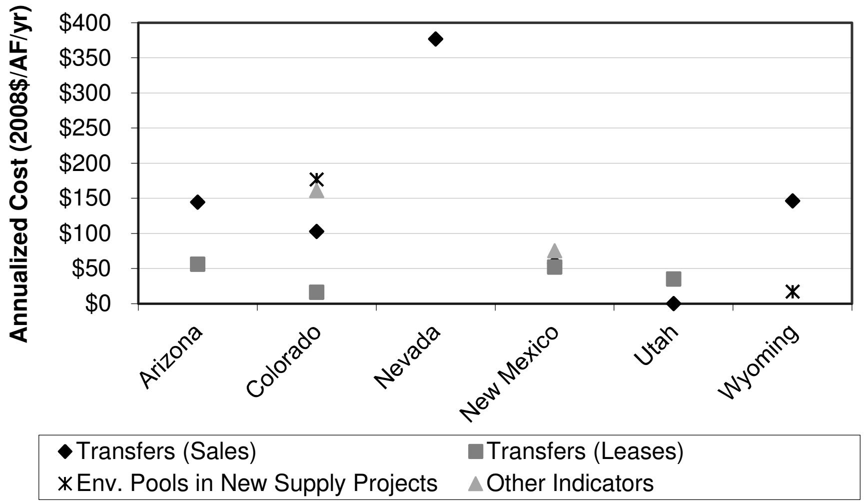
107. Loomis, *supra* note 4. An enormous volume of water flows down rivers like the Colorado each year, making the value of recreation per AF very low. For example, over the period 1967–2009, the USGS's measured average runoff on the Colorado River at the USGS gage below Glenwood Springswas over 2.4 million AF/year). U.S. GEOLOGICAL SURVEY'S NAT'L WATER INFO. SYS., SURFACE-WATER DATA FOR COLORADO, http://waterdata.usgs.gov/co/nwis/sw (last visited Jan. 4, 2010).

108. DR. JOHN LOOMIS, ESTIMATING THE ECONOMIC BENEFITS OF MAINTAINING PEAK INSTREAM FLOWS IN THE POUDRE RIVER THROUGH FORT COLLINS, COLORADO (2008), http://www.fcgov.com/nispreview/pdf/loomis_report.pdf (explaining that the value of commercial rafting varies considerably between different rivers in the state of Colorado).

109. The value of water for instream or environmental flows is somewhat lower than the price paid by municipalities and similar to the price paid for agricultural water transfers. "Other Indicators" include the value of flows for whitewater rafting and whitewater parks in Colorado, and the willingness to pay for instream flows in New Mexico. Figure 8 graph compiled by author to illustrate this discussion. *See* accompanying text.

use values.[110] Importantly, instream flow rights are nonconsumptive, and do not preclude other downstream uses for municipal or agricultural needs.

FIGURE 8. **Environmental value of water**



V. SYNTHESIS AND RECOMMENDATIONS

Throughout the West, water is an increasingly valuable natural resource, whether used in the region's growing cities, to irrigate agricultural lands, or to meet environmental and instream needs. The value varies tremendously, depending on the geographic location, the value of commodities produced, and a host of other factors. The value of water rises 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 is likely to continue rising in the future.

Water use at thermoelectric power plants competes directly with the water demands of cities, agriculture, and environmental needs. Recently, utilities and developers have proposed building *new* thermoelectric power plants in rural locations, distant from municipalities. Many of these rural plants will draw on water supplies that would other-

110. ANN FISHER & ROBERT RAUCHER, INTRINSIC BENEFITS OF IMPROVED WATER QUALITY: CONCEPTUAL AND EMPIRICAL PERSPECTIVES (1983), *available at* http://yosemite.epa.gov/ee/epa/eerm.nsf/AuthorF/62CE5971FFD040FF8525644D0053BDF3.

wise sustain agriculture or environmental needs, and in many cases, the municipal value of water is not directly relevant. In certain cases, however, utilities could retire older thermoelectric power plants in urban areas, potentially freeing up water for municipal use. For example:

> 1. Public Service Company of Colorado's (PSCo) Cherokee Station, located just north of downtown Denver, relies on water from the South Platte River, groundwater wells, and recycled water from Denver Water to meet its cooling needs. In 2007, the coal-fired power plant consumed approximately 7,900 AF of water.[111] PSCo expects to keep the Cherokee Station in operation until 2018 or beyond.[112] The median cost of water from proposed new supply projects that would serve the Denver metropolitan area is $613/AF. If PSCo retired the Cherokee plant in 2013, rather than 2018, the value of the water over that five-year period would total $4,840,000.
>
> 2. Nevada's Reid Gardner Power Plant, owned by NV Energy and the California Department of Water Resources, relies on water from the Muddy River and groundwater wells in southern Nevada and consumes over 4,300 AF/year. The Southern Nevada Water Authority (SNWA) provides water to residents in the Las Vegas Valley, and has recently negotiated agreements to develop water in the Muddy River Valley and deliver it to customers in Las Vegas. In addition, SNWA is pursuing other new water-supply projects, including a Groundwater Development Project in Clark, Lincoln, and White Pine Counties, and augmentation on the Colorado River. Additional water rights in the Muddy River Valley, if available, could (and likely would) be used to meet municipal demands in the Las Vegas Valley.
>
> The annualized cost of SNWA's Groundwater Development Project is approximately $1,169/AF/year. NV Energy expects to retire units 1–3 (300 MW) of the Reid Gardner Plant in 2016, and unit 4 (257 MW) in 2023. The value of water generated by retiring the units five years early (in 2011 and 2018, respectively) would amount to over $5,041,000.
>
> 3. In Arizona and New Mexico, several power plants rely on water from the Colorado River or its tributaries: the Four Corners Power Plant, Navajo Generating Station, and San Juan Generating Station. Both of these states have (or will

111. Response to Discovery Request LWG3-4a, *In re* Pub. Serv. Co. of Colo., No. 07A-447E (Pub. Util. Comm'n Colo., Mar. 21, 2008).

112. PUB. SERV. CO. OF COLO., 2007 COLO. RESOURCE PLAN (Nov. 15, 2007), http://www.xcelenergy.com/Colorado/Company/About_Energy_and_Rates/Resource%20and%20Renewable%20Energy%20Plans/Pages/2007_Colorado_Resource_Plan.aspx.

soon have) the infrastructure to convey Colorado River (or tributary) water to urban areas.[113]

As utilities consider the retirement of older, water-intensive plants, they should consider the economic benefit the water could provide. Water used by electric utilities has value because: (1) it costs money to obtain, deliver, and treat water used to condense steam in thermoelectric power plants; (2) the water may have value in alternative uses; and (3) water in specific locations may be scarce, resulting in an economic rent on water. *Electric utilities and regulators should examine all three aspects of value when assessing additions of new power plants and considering continued operation of existing power plants*. The value of the water for alternative uses will vary, depending on the location and competing demands. For example, in the cases of the Cherokee and Reid Gardner plants described above, the value of using that water to meet municipal needs is high.

Currently, the extent to which the region's electric utilities and regulators consider water varies tremendously. Utilities and regulators in Arizona and Colorado are clear leaders in considering the impacts of electricity generation on water and other environmental resources. *At a minimum, utilities across the region should report water consumption for existing facilities, and projected water consumption for different proposed portfolios as part of their integrated resource plans*. *Finally, in considering new water-intensive power plants, utilities and regulators should assess both the value of water today and the potential value of water in the future*. In areas where water is scarce today, or will likely be scarce in the next 40–50 years (or the lifetime of the proposed power plant), utilities and regulators should assess the opportunity cost of using water for electricity generation. That is, what is the value of the foregone opportunities—continued agricultural production, municipal development, or environmental benefits? Utilities should prepare projections and sensitivity analyses, and incorporate those opportunity costs in their decisions.

113. CENTRAL ARIZONA PROJECT, http://www.cap-az.com/; John W. Leeper, *New Mexico Water Planning 2003*, NEW MEXICO WATER RESOURCES RES. INST. (Nov. 2003), http://wrri.nmsu.edu/publish/watcon/proc48/leeper.pdf (explaining that the Central Arizona Project conveys Colorado River water to Phoenix and Tucson; the proposed Navajo-Gallup pipeline will convey water to Gallup and small towns in eastern Arizona; and the San Juan-Chama Project diverts water from the San Juan River to the Rio Grande and Albuquerque area).