WATER DEMAND AND ENERGY PRODUCTION IN A TIME OF CLIMATE CHANGE

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I. INTRODUCTION: WATER AND FUTURE ENERGY PRODUCTION

Water availability has long been an integral component of all phases of energy production, but it has not constrained supplies. Today, the question is, does the past predict the future? For some, the answer is a clear no. There is growing literature which argues that water availability will be a serious constraint on future energy production as more new large-scale conventional and solar power plants are built in water stressed areas, biofuel production is increased, and hydroelectric energy production is ramped up at the same time that the projected adverse impacts of global climate change for water resources begin to manifest themselves. For example, water constraints on new thermoelectric plants have already been identified in all parts of the country. A possible indicator of future legal conflicts is the Supreme Court’s decision to hear an interstate dispute between

1. See notes 48 to 66.
3. Benjamin K. Sovacool, Running on Empty: The Electric-Water Nexus and the U.S. Electric Sector, 30 Energy L.J. 11 (2009) (examining water constraints in eight metropolitan areas from Atlanta to San Francisco and recommending that utilities adopt a moratorium on new plant construction assuming the accuracy of electricity demand projections). Similar concerns that western rivers would be sucked dry were expressed in the 1970’s after a Federal Power Commission report projected a steeply rising demand curve for electricity. FED. POWER COMM’N, THE 1970 NATIONAL POWER SURVEY, pt. 1 (1971). However, this did not happen in large part because of falling demand in the 1980s. These scenarios also failed to take in account the ability of water markets to supply the necessary water.
South Carolina and North Carolina where the primary issue is the necessary minimum flows for downstream hydroelectric generation.\footnote{South Carolina v. North Carolina, 128 S.Ct. 349 (2007) (memorandum opinion granting South Carolina leave to file complaint to object to upstream transfers authorized under N.C. GEN. STAT. ANN. § 143-215.22G(1)(b) (1993) as South Carolina alleges that it needs a minimum of 1,100 cfs to satisfy its uses and that North Carolina has authorized interbasin transfers which will make it impossible to meet this target during the severe droughts that the region has experienced, most recently between 1998-2002). In 2010, the Court ruled that a North Carolina public utility and water supplier, but not the City of Charlotte, could intervene. South Carolina v. North Carolina, 130 S.Ct. 854 (2010). The decision expands the rights of non-sovereign parties to intervene in equitable apportionments and, over a strong dissent by Chief Justice Roberts, appears to give electric utilities special intervention status. Justice Alito reaffirmed the intervention standard announced in New Jersey v. New York, 345 U.S. 369 (1953), which requires a compelling showing that the intervener has an interest apart from that of all the state’s citizens who are represented by state parens patriae. The utility met the standard because any apportionment would have to take into account its uses and it “has a unique and compelling interesting in protecting the terms of its existing FERC license.” 130 S.Ct. at 866. The dissenting opinion characterized the utility’s interest in protecting the terms of its FERC license as an “intramural dispute” and also noted that the United States had not supported the utility’s motion. 130 S.Ct. at 870.}{\footnotemark}

At the present time, the primary drivers for investment in renewable energy are state portfolio standards which require utilities to provide a certain percentage of energy from renewable sources. Many states have such portfolio standards.\footnote{See Pew Center on Global Climate Change, U.S. States & Regions, http://www.pewclimate.org/states-regions (last visited August 24, 2010). See also Shelly Welton, From the States Up: Building A National Renewable Energy Policy, 17 N.Y.U. ENVTL. L. J. 987 (2008) (discussing a history of legislative efforts to mandate federal portfolio standards and arguing federal standards are needed to prevent states which do not have standards from free riding off those who do).}{\footnotemark}

Congress appeared to be on the verge of adopting federal standards in 2009, but as of mid-2010, the prospect of this had dimmed. The Obama Administration initially set a national target of generating twenty-five percent of all electricity from renewable sources by 2025.\footnote{H.R. Con. Res. 25, 110th Cong. (2007); S. Con. Res. 3, 110th Cong. (2007). See generally Lincoln L. Davies, Power Forward: The Case for a National RPS, 42 CONN. L. REV.1339 (2010).}{\footnotemark}

But, the House version of the American Clean Energy Security and Security Act of 2009 (H.R. 2454), which passed the House of Representatives but stalled in the Senate, scaled back the target to twenty percent by 2020 and held it constant to 2039.\footnote{American Clean Energy and Security Act of 2009, H.R. 2454, 111th Cong. § 101(d)(2) (2009). The 20 percent target was extended only to 2031 in the original House bill. H.R. 2454, 111th Cong. § 610(d)(2) (Proposed Bill 2009). This paper was started when H.R. 2454 was under active consideration in Congress. Dead legislation is dead, but the scope of the American Clean Energy and Security Act of 2009 is much broader than the Discussion Draft of the Clean Energy and American Power Act, S. 1733, 111th Cong. (2010), and may serve as the template for future legislation. The draft American Power Act, for example, contains no national portfolio standards.}{\footnotemark}
Should federal standards be adopted, the most water-impacted portfolio source will be hydroelectric generation. H.R. 2454 classified hydro power as a renewable energy source, but credit was limited to "qualified hydro power." This was defined as either energy efficiency or capacity additions to pre-1992 hydroelectric facilities which were placed in service after January 1, 1992. This was done to create incentives to add new or additional hydro generation capacity to existing dams and reservoirs or to upgrade existing facilities. It also recognized existing, recent upgrades as qualified hydro power, including post-January 1, 1992 efficiency and capacity additions to any multiple purpose dams which were not generating electricity on that date.

Portfolio standards are part of a larger effort to switch from unstable carbon-based sources of energy to renewable fuels, many of which raise additional questions about possible water supply constraints on energy production. In 2009, the Obama Administration announced that the United States would make a second run at a measure of energy independence or at least decreased reliance on imported oil. All moves in this direction require a substantial switch from nonrenewable hydrocarbons to renewable energy sources as well as the eternal dream of clean coal and the currently "dirty" biofuels.

This article explores how federal and state water allocation institutions might respond to the twin challenges of

8. American Clean Energy and Security Act of 2009, H.R. 2454, 111th Cong. § 101(a)(17)(G) (2009). The purpose is to insure that most existing hydro power, which constitutes about seventy percent of renewable electricity generation, does not count toward the portfolio standard. The object of the legislation is to move the current 2.4% of non-hydropower sources toward 20%.


11. Current United States energy policy, as is the case with all energy policy, is always a partial case of déjà vu all over again. Our first try at energy independence between 1973–1980 proved more difficult than anticipated and was ultimately unsuccessful. See generally DONALD E. KASH & ROBERT W. RYCOFT, U.S. ENERGY POLICY: CRISIS AND COMPLACENCY (1984) (tracing the rise of serious federal efforts to achieve energy independence in the 1970’s and the rejection of these efforts in the 1980’s, as world oil prices fell, a trend which continued through the Bush I, Clinton and Bush II administrations; the mix of energy sources and the balance between domestic and imported supplies have remained relatively constant over the decades since the first OPEC oil embargo, but the United States has succeeded in increasing Western coal use and in shifting oil imports from the Middle East to Africa, South America and Canada).
increased demand for water energy production and our evolving understanding of the water related impacts of global climate change. It focuses on two broad water availability and global climate change-energy links that could constrain production. The first is the lack of adequate supplies for the generation of electricity from fossil fuel, nuclear and hydroelectric plants. The second is the increased demand for water for alternative energy resources, primarily biofuel production, oil shale production and solar energy, although this list of possible energy-water links is far from exhaustive.

The article poses two primary questions: (1) will global climate change increase the competition for water for energy over and above the foreseeable conventional water stresses on these energy sources; and (2) how well is water law, broadly defined, suited to adapt to this projected increased competition? These are not easy questions to answer. Energy issues are always a moving target because of the changing mix of political and economic factors and the uncertainties of the geographical impacts of global climate change. The failure of the Copenhagen climate change conference in 2009 to agree on an effective mitigation regime and the consequent death of the federal greenhouse gas emissions reduction legislation in 2009 are cases in point as is the catastrophic Gulf of Mexico oil spill. Thus, definitive answers to these questions are not possible at this time.

We do know that global climate change will alter many of the fundamental hydrologic assumptions upon which water allocation, water pollution control and aquatic ecosystem conservation are premised. We know that water law has some capacity to adapt to global climate change, but it also has major structural elements which inhibit adaptation. Thus, we know that we need to revisit the water-energy link in light of global climate change, although, again, any effort to address the water-energy link is inherently speculative because much of the concern about future water availability is based on scientific assumptions that are subject to change. At this time, we simply

13. Any doubts about the total failure of the world’s nations to reach a meaningful mitigation agreement at the 2009 Copenhagen Summit are dispelled by Tobias Rapp, Christian Schaeferl and Gerald Traufetter. Tobias Rapp, Christian Schäferl & Gerald Traufetter, How China and India Sabotaged the UN Climate Summit, DER SPIEGEL, May 5, 2010 (translated from German by Christopher Sultan), available at http://www.spiegel.de/international/world/0,1518,692861,00.html.
do not know how much global climate change will increase the competition for water for energy over existing water stresses to make firm policy recommendations.\textsuperscript{16}

To further complicate matters, federal policy shifts and energy market volatility can radically change the picture. For example, if we had a coherent and integrated federal energy and food security policy, corn-based biofuels might be taken off the table. Thus, there would be less need to be concerned about state water law and its ability to cope with stresses. If the country had the political will (when pigs begin to fly) to address issues such as crop subsides, we would have a better idea of how much water should be devoted to irrigated agriculture for human consumption rather than biofuel use, given competing urban and environmental demands. For example, crop subsidy withdrawal and less emphasis on beef production could free up water for other uses from environmental restoration to energy production and would promote global climate change adaptation. In short, the absence of a coherent federal energy and food security policy makes speculation very difficult. Nonetheless, the article assumes that there will be some increase in the demand for water-based renewable and nonrenewable energy and that climate change will have adverse impacts on existing energy production, especially from hydroelectric and nuclear sources.

The uncertainty surrounding energy and global climate change adaptation policy is reflected in three different, reoccurring, competing stories which are told about water and nonrenewable natural resources. The most gripping is the crisis story. The country will either run out of nonrenewable resources or overwhelm the capacity of rivers and aquifers to supply exploration and production demands.\textsuperscript{17} Economists and engineers often tell the oppositive story of institutional and technological optimism. Either markets or new technology will step in to address any scarcity problems.\textsuperscript{18} Lawyers and policy wonks often tell a third story. Problems such as water availability for renewable energy are serious, but the real problem is the lack of adequate planning and management

\textsuperscript{16} Nat’l Research Council, Toward A Sustainable and Secure Water Future: A Leadership Role for the U.S. Geological Survey 49 (2009) (acknowledging that “[f]uture water needs cannot be precisely known” and attempting to identify the “predictable surprises” that future holds).


\textsuperscript{18} The leading exponent of this position was the late economist Julian Simon. See generally Julian L. Simon, The Ultimate Resource (1981).
institutions including functioning markets.\textsuperscript{19} This article reflects all three stories, but on balance, it most reflects the lack of planning and management.

The article’s primary, if unsatisfactory, conclusion is that water use will continue to be important as the United States tries to chart a new, global climate change adaptive, and a less hydrocarbon-dependent energy future, but lack of availability will not be central component of this project. A nonrenewable future is a distant aspiration, and a significant increase in hydroelectric power is not a part of this future. Instead, the law should concentrate on two long, unfulfilled objectives: (1) the full internalization of the water-related social or external costs of energy generation; and (2) the integration of the risks of reduced hydroelectric generation capacity into global climate change river management adaptation plans.

II. THE POTENTIAL STRESSES OF GLOBAL CLIMATE CHANGE

Global climate change will impact energy production in two ways: (1) it will control the amount of water available for this use; and (2) it will influence energy demand. Around the world, arid and semiarid areas will face the more severe water-related stresses from global climate change. In the United States, there is a relatively firm consensus that arid and semiarid regions in the West will face a net loss of stream run off as snow packs diminish due to the rising elevation of the snow line and increased evaporation. The projections for California are the range of a twenty-five percent snow pack reduction and thirty-three percent overall decrease in Spring runoff.\textsuperscript{20} We do not,

\textsuperscript{19} This view is well articulated by Daniel Botkin. Daniel Botkin, \textit{Powering the Future: A Scientist’s Guide to Energy Independence} (2010). \textit{See also} James L. Huffman, \textit{The Federal Role in Water Resource Management}, 17 N.Y.U. ENVTL L.J. 669, 671 (2008). In 2009, the third story received judicial sanction. In a case holding that the U.S. Army Corps of Engineers lacked the authority to increase withdrawals to supply drought-stricken Atlanta, a federal district court observed in dicta that “only by cooperating, planning, and conserving can we avoid the situation that give rise to this litigation.” \textit{In re Tri-State Water Rights Litig.}, 639 F.Supp.2d 1308, 1355 (2009).

\textsuperscript{20} “The estimated average reduction in Sacramento River region April through July runoff was projected to be forty-three percent, leaving fifty-seven percent of current runoff. The southern Sierra impact was less with twenty-three percent reduction overall. The total runoff reduction for all watersheds was thirty-three percent. These results were crude and preliminary, but have been roughly confirmed by more recent work by Scripps [Institution of Oceanography & U.S. Geological Survey] and others. A Knowles and Cayan study [Scripps, 2001] included a 2090 projection from the Parallel Climate Model with 2.1 degrees C (3.8 F) of warming to come up with a fifty percent reduction in April snow water content and a 4.5 million acre-foot reduction in April through July runoff.” Maurice Roos, \textit{California Water Plan Update 2005}, 4 ACCT. FOR CLIMATE CHANGE 611, 617
however, know the scale and timing of these impacts,\textsuperscript{21} and it is still hard to tease out “normal” climate cycles from global climate change impacts.\textsuperscript{22} Predictions are cloudier and mixed for more humid areas.\textsuperscript{23} Many areas may experience intense bursts of increased runoff which may cause severe flood events at the same time that these areas experience lower summer water flows in major, heavily used rivers impacting both thermal and hydroelectric power plants.\textsuperscript{24}

Decreased river flows will be a major problem if the impact of projected temperature increases boosts energy demand at the same time that lowered flows result in a decrease in hydroelectric generation capacity and available cooling water. The likelihood of this depends on the rate of temperature increase, the impact of these increases on energy demand, and the cooling technology used.\textsuperscript{25} A report published at the end of the Bush II administration synthesized the existing water-energy studies and concluded that there may be slight net decreases in energy demand for winter heating but substantial increases in

\begin{itemize}
  \item[(2005).] The National Research Council confirms that more precipitation in the West falls as rain rather than snow. NAT'L RESEARCH COUNCIL, ADAPTING TO THE IMPACTS OF CLIMATE CHANGE 34–35 (2010).
  \item[21.] Miller, supra note 12.
  \item[22.] For example, researchers at Columbia University have concluded that the 2005-2007 drought in the Southeast which stressed Atlanta’s water supply and destroyed billions of dollars of crops was the product of regional population growth and bad planning, not GCC. Richard Seagar, Alexandrina Tzanova & Jennifer Nakamura, Drought in the Southeastern United States: Causes, Variability over the Last Millennium, and the Potential for Future for Hydroclimate Change, 22 J. OF CLIMATE 5021, 5042 (2009).
  \item[23.] Noah D. Hall, Interstate Water Compacts and Climate Change Adaptation, 5 ENVTL. & ENERGY L. & POL'Y J. 237 (2010).
  \item[25.] Thermoelectric plants initially used once through cooling, but Clean Water Act requires the use of the best available technology for cooling intake systems, 33 U.S.C. § 1326 (2006), and this has resulted in a preference for closed loop cooling systems which substantially reduce the amount of cooling water withdrawn. Robert H. Abrams & Noah D. Hall, Framing Water Policy in a Carbon Affected and Carbon Constrained Environment, 49 NAT. RESOURCES J. (forthcoming 2010), available at http://works.bepress.com/cgi/viewcontent.cgi?article=1010&context=noahhall. The authors cite a National Energy Technology Laboratory (“NETL”) report which estimates that even with an increase in new plant construction withdrawals will decrease from 0.5 to 30.5 percent. Thomas J. Feeley III et al., Water: A Critical Resource in the Thermoelectric Power Industry, 33 ENERGY 1, 4 (2008), available at http://www.netl.dot.gov/technologies/coalpower/ewr/pubs/net%20water%20estimate%20article%20Elsevier%20201107.pdf. Consumptive use will increase from 27.4 to 48.4%.
\end{itemize}
the demand for summer cooling. Therefore, in northern latitudes there may be a net decrease in electricity demand, but in southern latitudes, which have experienced the greatest population growth, there may be a substantial jump in summer demand. Reduced flows will be a very serious problem in the American West because variable stream flows and increased reservoir evaporation will mean less net water available for hydroelectric generation. Less water may also be available for thermal cooling during period of intense droughts.

III. THREE EXAMPLES OF POTENTIAL BUT UNCERTAIN WATER STRESS

A. Biofuels

The United States has aggressively pursued a strategy, beloved by the Midwestern states, to substitute renewable biofuels, primarily ethanol, for conventional gasoline. The Energy Independence and Security Act of 2007 mandated progressively higher percentages of corn ethanol in gasoline, reaching a fifteen percent plateau in 2015 and set a target of twenty-two billion barrels of ethanol and advanced biofuels by 2022. In that year, the act mandates steeply rising cellulosic percentages reflecting the unresolved environmental and technical problems with non-corn sources. Thus, our current policy encourages intensive water use for irrigation or supplemental irrigation without a systematic evaluation of the net energy and climate change benefits of this fuel.

Most currently refined ethanol is largely derived from corn which is produced primarily in the six West North Central states which straddle both sides of the 100th meridian. These states rely heavily on groundwater to irrigate this crop. Some estimates of the water demand for biofuels project that water...

28. Id. at 20.
consumption will increase 2.5 times over 2005 levels by 2030. Reliance on groundwater is a matter of concern because aquifers could be mined as a result. However, the energy irrationality of this strategy may cure any future water crunch. The future is said to rely in more abundant, more water efficient cellulosic wood products and other non-corn wastes and non-food plants. At the present time, the existing fermentation process for cellulosic ethanol is costly and dangerous, but new technologies may be on the horizon.

The Obama administration is pursuing a “clean” ethanol policy which places greater emphasis on cellulosic sources, subjects refining plants to tougher emission limitations, and requires life cycle greenhouse gas reduction standards. This may result in marginally less corn being devoted to ethanol. Switchgrass, touted by President Obama during the 2008 presidential election campaign, may be a less water demanding alternative along with forest waste and sugar cane. These plants might benefit from higher temperatures, are more efficient water users compared to corn, and they provide ecosystem services such as pollution filtering and carbon dioxide.

32. The major issue in biofuels is whether the hydrocarbon consumption saved by biofuels exceeds the conventional energy sources needed to produce the ethanol. For a clear no answer see David Pimentel & Tad Patzek, Ethanol Production Using Corn, Soybeans, Switchgrass and Wood; Biodiesel Production Using Soybean and Sunflower, in BIOFUELS, SOLAR AND WIND AS RENEWABLE ENERGY SYSTEMS: BENEFITS AND RISKS 373 (David Pimentel ed., 2008).
33. The fermentation process, however, will be the same as the one currently used for corn so “at the transformation phase, second generation biofuels are unlikely to use less water than current technologies.” WORLD ECON. FORUM, ENERGY VISION UPDATE 2009 THIRSTY ENERGY: WATER AND ENERGY IN THE 21ST CENTURY 20 (2008), available at http://www2.cera.com/docs/WEF_Fall2008_CERA.pdf.
38. Id. at 43.
recycling. British Petroleum is investing in projects in Brazil and the United States which will develop techniques using sugarcane and related grasses. However, non-climate change water problems do exist, and the environmental, land use, and climatic impacts from boosting production of this fuel source are not well understood.

B. Oil Shale

In the 1970’s and early 1980’s, increased coal production and the development of oil shale primarily in Utah and Colorado were integral components of efforts to achieve energy independence. This strategy failed because of a number of structural barriers which gave coal, oil and gas, and nuclear power substantial competitive political advantages over oil shale. For a start, oil shale required massive government subsidies, but these were withdrawn in the Reagan administration.

Water availability for oil shale is a particular problem because the deposits are located in the stressed, arid Colorado River basin where demand may be exceeding supply, a condition that climate change will only make worse. Any evaluation of water availability must deal with both hydrological and institutional uncertainties. Not surprisingly, there are a range of projections ranging from faith-based to cautious. The United States Department of Energy (“DOE”) website for oil shale is an example of the former. It states that oil shale retorting will require “significant quantities of water” and optimistically and unrealistically suggests that the water will come from the Colorado River, from the water contained in the shale, or “possible” transfers from the Upper Missouri. This last alternative is a highly unrealistic possibility as major interregional water transfers have been off the political agenda since 1968, although engineers in the United States still dream of doing what China is in fact doing. The DOE signs off on the

40. GERMAN ADVISORY COUNCIL ON GLOBAL CHANGE, WORLD IN TRANSITION: FUTURE BIOENERGY AND SUSTAINABLE LAND USE (2009).
42. See JAMES T. BARTS ET AL., OIL SHALE DEVELOPMENT IN THE UNITED STATES: PROSPECTS AND POLICY ISSUES (2005).
43. Id. at 50.
44. In energy, one can never say never. Robert W. Adler, Climate Change and the Hegemony of State Water Law, 29 STAN. ENVTL. L.J. 1, 40–41 (2010) (suggesting that GCC will increase and revive pressure for large-scale interbasin transfers).
issue of availability with the blithe assertion that “[w]ater in the West is treated much the same as other commodities- it can be bought and sold in a competitive market.” This true, but as Part V of this article illustrates, transfers will be harder to arrange compared to biofuels. As the Rand Corporation dryly observed in 2005, “[e]arlier analyses of water availability . . . need to be updated based on current and expected demands for water from the Colorado River basin.”

C. Solar Power

Large-scale solar power plants raise isolated water availability issues. Thermal solar plants are steam generation plants powered by multiple rows of solar panels rather than by burning coal, oil, natural gas or nuclear fission. Of necessity, these plants are generally located in arid, sunny areas where available water supplies are often fully allocated. Water constraints have popped up in California and Nevada. Water use is a function of technology. Wet-cooled plants use much more water than do dry cooled plants, but dry-cooled plants use more energy and thus are less efficient. At this point it is too early to know whether this is a genuine policy problem or simply a case where power plant operators will have to assemble a water rights package at market rates.

IV. WATER AND ENERGY DATA

This section asks how much we know about water demands and the availability of reliable supplies for these uses. The answer is not nearly as much as we want and need to know.

45. See BARTIS ET AL., supra note 43.
47. A large solar park may be constructed in the Westlands Irrigation District on the west side of San Joaquin Valley of California. Westlands owns 100,000 acres of land with attached water rights. The land was purchased to move the water to more productive lands in the District but droughts and federal laws have reduced water deliveries to these lands so there are substantial incentives to follow land, thus freeing up water for the solar park. Jason Dearen & Tracie Cone, New Light for Westlands?, HANFORD SENTINEL, Mar. 23, 2010, available at http://hanfordsentinel.com/articles/2010/03/24/news/doc4ba910d351536661102825.txt.
A. What Does History Teach?

Water availability has not historically been a major constraint on energy extraction and production for two reasons. First, consumptive uses of water for both extraction and production have been relatively modest. Withdrawals of water for energy production are largely non-consumptive. Second, since these demands can be met with minimum impacts on other users, energy producers have acquired the necessary water through state water law procedures for new water rights applications, transfers of existing rights, or contractual purchases from public and private water suppliers. When the law appears to constrain water availability, courts or legislatures have adapted state laws to the special needs of energy claimants.48

For decades, the primary water-energy issue has not been supply availability but the incomplete regulation of adverse environmental impacts of production. For example, water pollution remains a serious concern because it has not been effectively addressed by the Clean Water Act.49 Dams and power plants have major environmental impacts such as reduced downstream fish runs, species entrainment, and altered water quality from thermal discharges. Unfortunately, dam discharges are not classified as point source pollution,50 and power plant...
intakes are also under-regulated. New energy facilities such as desalinization plants also present environmental impacts.

The question is will the past hold for the future in light of efforts to mitigate global climate change. From a global perspective, as discussed earlier, many predict a perfect energy supply and demand storm. First, there will be a general worldwide decline in energy supply, including hydroelectric generation, as we reach the point where half of the world’s recoverable oil reserves have been exploited. Second, there will be an increase in demand and increased competition for diminishing supplies by nations such as China and India as these nations increase their consumption. Even without factoring in the possible adverse impacts of global climate change, this will severely stress developing nations and pose new forms of national security risks for the United States and other large energy using countries:

How many ways are there to say the world is heading for hard times? Losing most of our oil is bad enough, and losing most of our gas as well borders on the catastrophic. Combining these losses with the exponential growth of those nations that can least afford it is nothing short of catastrophic. The ramifications spread out like ripples on a pond. There will be seven billion people who will need fertilizer and irrigation water to survive, but would be too poor to buy it even at today’s prices. Given the probable escalation in the costs of fertilizer and the diesel fuel or electricity for their water pumps, it isn’t hard to understand why the spread of famine in energy-poor regions of the world seems virtually inevitable.

The perfect storm trend of rising demand and decreasing supplies seems well established, but still a note of caution must be sounded. The current energy source mix is likely to prevail for


53. PAUL CHEFURKA, WORLD ENERGY AND POPULATION TRENDS TO 2010 (2007), http://www.paulchefurka.ca/WEAP/WEAP.html (projecting that hydro capacity will double by 2060 and then drop back to current levels by 2100 as all the world’s high value sites are developed and GCC-induced flows begin to manifest themselves).

54. DANIEL BOTKIN, POWERING THE FUTURE: A SCIENTIST’S GUIDE TO ENERGY INDEPENDENCE (2010) (summarizing the disputes about where this will occur in 50 or 100 years).

the near future and perhaps beyond. Therefore, water needs are likely to remain a relatively small component of United States policy, such as it is, for the foreseeable future. This condition may hold for the longer term as well, even with efforts to make the transition to a more sustainable one. The most realistic future energy scenario suggests that if we do in fact make the transition from carbon sources, it will be primarily through the hope of the 1950's nuclear energy, natural gas, increased solar power, and technological fixes such as carbon sequestration. If this is the case, the major water-energy availability problem will likely be selected instances of local cooling water deficits, although the switch to closed cycle cooling spurred by the Clean Water Act has reduced the predictions about water shortages for thermal power plants.

B. What Do the Data Show?

The first step to good policy formulation is information. Better water use data is essential for any new water-energy policy because we do not have a full picture of the amount of water used for energy production from extraction to generation. However, critical data are often nonexistent, too unrefined, wildly speculative, or just plain misleading. The problem starts with the major United States water data collection agency, the United States Geological Survey (“USGS”). The USGS issues five year water use surveys, which are widely seen as the most

56. NAT'L ACADEMY OF SCIENCES, NAT'L ACADEMY OF ENGINEERING & NAT'L RESEARCH COUNCIL, AMERICA'S ENERGY FUTURE: TECHNOLOGY AND TRANSFORMATION 49-60 (2009) summarizes the projected mix of conventional and renewable sources and technological improvements in conventional sources. It also notes that a more sustainable energy future will come with higher energy costs.

57. A June 2009 report estimates that United States natural gas reserves are thirty-four percent higher than previously estimated. The conclusion is based on new technologies to tap deep shale beds. Substantial problems must be addressed including the risk of water pollution and the extensive use of water to fracture shale rocks and, as always, the decision to extract is a function of price. Jad Mouawad, Estimate Places Natural Gas Reserves 35% Higher, N.Y. TIMES, June 18, 2009, at B1.


accurate snapshot of the country’s water use, but energy use is not a discrete category in the survey. Thermoelectric power is the only express energy category. Otherwise, energy use data is folded into other, more inclusive categories. The industrial and mining category mentions energy extraction and production, but water use for this purpose is lumped in with all non-energy related uses. Surface and ground water irrigation withdrawals are neither crop-specific nor do they specify the crop’s end use so there is no way to distinguish water withdrawn for crops for human consumption and feed stocks versus crops grown to produce biofuels.

Power generation is divided into thermoelectric and hydroelectric power. The former is a quasi-consumptive use. It accounts for forty percent of all freshwater withdrawals nationwide, and sixty-four percent in the East.\footnote{62} Once-through cooling, which is only allowed in older plants, returns eighty-eight percent of the withdrawals to the stream and consumes the rest.\footnote{63} In the West, this use accounts for only eleven percent of the withdrawals.\footnote{64} Data on hydroelectric power is harder to extrapolate because this use is an instream, almost totally a non-consumptive use. For this reason, USGS does not even track water used to generate hydroelectric power. However, the carry-over storage reservoirs behind many hydroelectric facilities consume water. Reservoirs contribute to global climate change because they increase evaporation rates over those of the natural river and evaporate an average of 9,063 million gallons of water per day.\footnote{65}

The net result is that energy water use data must be assembled from a variety of sources not just the USGS surveys. Two of the best energy sources are studies of individual sources and the climate change literature, but at this point these studies basically recycle the incomplete USGS data and therefore can only highlight issues rather than provide more reliable estimates about future use rates and impacts. For example, in 2008, the National Academy of Sciences held a colloquium on water use and biofuels. The colloquium report could only conclude that the amounts of water are still small compared to total agricultural

\footnote{62} HUTSON ET AL., supra note 62, at 35.  
\footnote{64} Id.  
water use but that increased irrigation withdrawals in corn growing regions will stress already mined aquifers.\textsuperscript{66}

Future demands for other sources such as oil shale retorting are even harder to pin down because it is mostly a series of changing estimates and unrealistic assumptions.\textsuperscript{67} Some 1.8 trillion barrels of recoverable oil shale sits in the most water stressed area of the United States, the Colorado River Basin.\textsuperscript{68} Estimates of water need have dropped from the 2.1 to 5.2 barrels per barrel of oil to between 1 and 3, but the amount of new water required remains substantial.\textsuperscript{69} The question is how much, and no one yet knows the answer. Solar power demands are even harder to pin down because there are no good studies of the water demand and availability in dry, sunny areas for large-scale solar plants.\textsuperscript{70}

Previous efforts to address this problem have not yielded very helpful results. A 2006 Congressionally-mandated Department of Energy survey of water demand and energy production and use concluded “[i]t is difficult to accurately predict future electricity generation supply and water demand” and then proceeded to list the various reasons.\textsuperscript{71} To address the data gaps or chasm, in 2009, the “Energy and Water Integration Act” was introduced in the United States Senate and, as of mid-2010, is still pending.\textsuperscript{72} The proposed legislation takes the usual first steps and mandates, \textit{inter alia}, that the Department of Energy prepare a “Energy-Water Research and Development Roadmap” to address the water-related challenges to energy development, the best available technologies to maximize water-efficient energy production, and also mandates the now-almost-obligatory National Academy of Sciences study in the hope that a group of experts can say something useful. The study would involve a life cycle assessment of the amounts of water consumed in all phases of energy feedstocks, the generation and transmission of electricity, and oil shale and tar sands. The proposed legislation also calls for an evaluation of the water used by different generation technologies.\textsuperscript{73} Although the legislation...

\begin{itemize}
  \item \textsuperscript{66} NAT’L RESEARCH COUNCIL, WATER IMPLICATIONS FOR BIOFUELS PRODUCTION IN THE UNITED STATES 6 (2008).
  \item \textsuperscript{67} BARTIS ET AL., supra note 42, at 33.
  \item \textsuperscript{68} \textit{Id}. at 6.
  \item \textsuperscript{69} \textit{Id}. at 50.
  \item \textsuperscript{70} See Woody, supra note 46.
  \item \textsuperscript{71} U.S. DEP’T OF ENERGY, ENERGY DEMANDS ON WATER RESOURCES 69 (2006).
  \item \textsuperscript{72} S. 531, 111th Cong. (2009).
  \item \textsuperscript{73} This tracks a suggestion made by the former Solicitor of the Department of the Interior during the Clinton Administration. John Leshy, \textit{Notes on a Progressive National Water Policy}, 3 HARV. L & POL’Y REV. 133, 134 (2009). The Bureau of Reclamation would
\end{itemize}
does not call for this exercise, all existing data need to be “corrected” to factor in global climate change.

Some of the data gaps in the West and other regions may soon be closed by legislation passed in 2009. Congress authorized a selective water, energy, and climate change data collection and adaptation program for the Bureau of Reclamation in 2009. The Bureau must assess the projected climate change impacts on eight BuRec functions in eight major river basins in which the Bureau operates. The availability of water for hydroelectric generation is one of the functions, and the Act mandates a special study for federal hydroelectric projects. By 2011, the Bureau must describe the risks on its water delivery and management functions posed by global climate change, and by 2012, it must submit a comprehensive national water availability assessment report to Congress. The United States Geological Survey must implement an enhanced stream flow measurement system incorporating the suggestions of a 2004 National Research Council White Paper.

V. System and Market Adaptation

A. Are Water Rights Global Climate Change Adaptive?

Water availability for energy exploration and production has not been a major constraint because water rights for energy uses can be acquired under state law or through transfers at a reasonable cost. Energy producers have used their considerable financial resources to compete with other users successfully for the necessary water and are well positioned to continue to do so. To take a celebrated example, Delta, the Intermountain West Power Plant was built in the western Utah Desert. Despite the fact the area averages less than nine inches of rain per year, the company was able to acquire the necessary water for cooling by negotiating dry leases from farmers. Global climate change may not change water from running uphill to money; one

be mandated to identify its projects which consume the most energy and conservation opportunities.

75. 16 U.S.C. § 9503.
76. 16 U.S.C. § 9505.
77. 16 U.S.C. § 9508.
79. However, plans to expand the plant ended when its largest customer, the City of Los Angeles, decided to end the purchases of energy from coal-fired plants. Robin Bravender, Los Angeles’ ‘Coal Free’ Vow Scuttles Utah Power-Plant Expansion, N.Y. TIMES, July 9, 2009.
adaptation strategy for biofuels, oil shale, solar energy, and other energy producers would be to continue to rely on state water law and the markets that they induce to meet their water needs for energy extraction and production from these sources. The reason is that the law of water rights is, at least in theory, a risk-based system and, thus, has some capacity to adapt to global climate change.80

Water right holders face a variety of risks from “natural climate” variability to challenges to the level of their use by the state.81 Therefore, it is reasonable and foreseeable that they must factor additional risks into the use and enjoyment of their rights. If they need additional water, the market is available to correct existing inefficiencies. However, ramping up hydroelectric production is harder and is discussed separately in the next section.

The major barrier to the use of water rights to adjust to climate rights is that correlative nature of all rights. Both appropriative and riparian water rights are property rights, but the acquisition and transfer rules are different for both compared to other commodities. The essence of a property right is the power to exclude others and by this standard, water rights have always been incomplete rather than complete property rights.82 Water is both a shared and communal resource. Both appropriative and riparian rights are correlative; one person’s right to use is subject to the rights of other similarly situated users. In addition, water is unique and necessary for human and ecosystem survival.83 Therefore, the state has great discretion to establish the ground rules for the acquisition, exercise, and transfer of water rights and to subordinate them to public rights and public interest limitations. Thus, the unique nature of water increases the risks of enjoyment and the transaction costs of transfer. The questions are: (1) are there significant prohibitions against the acquisition of new rights and transfers for energy extraction and production; and (2) are the transaction costs of

80. This is an example of the beneficiary pays principle which suggests that “the responsibility for adaptation [should be placed] at the lowest possible government level.” Daniel A. Farber, Climate Adaptation and Federalism: Mapping the Issues, 1 SAN DIEGO J. OF CLIMATE & ENERGY LAW 259, 270 (2009).
83. DAVID LEWIS FELDMAN, WATER POLICY FOR SUSTAINABLE DEVELOPMENT 1 (2007).
transfers excessive given the importance of water for energy exploration and production?

B. The Common Law of Riparian Rights

The common law of riparian rights, which prevails in the east and in California and Nebraska, is a classic correlative rights system. All rights are subject to being “re-balanced” at any point in time, and therefore, it is difficult to acquire a secure, exclusive right to a fixed quantity of water. All land owners along a stream have an equal right to use the water, and rights are defined post-hoc by open-ended standards that can only be firmed up by a judicial action.

The Restatement (Second) of Torts section 850 uses an eight-factor balancing test. The factors are: (1) the purpose of the use, (2) its suitability to the waterbody, (3) its economic value, (4) its social value, (5) the harm that it causes, (6) the potential to avoid harms through the adjustment of other uses, (7) the protection of existing uses, and (8) the justice of requiring the existing user causing harm to bear the loss. In theory, the multi-factor reasonableness analysis deters new uses but a user cannot predict the quantity of water to which it will be entitled over time as subsequent claims arise or when proportionate sharing burdens are imposed on all users on a stream in periods of scarcity. In practice, courts give considerable, but not decisive weight, to prior uses, and the risk of substantial interference is often relatively low.

The first six factors reflect that courts have long articulated, although seldom actually applied because of their incoherence. The sixth and the eighth incorporate the principle that a riparian right may be claimed at any time and that the high economic value of the use is a relevant factor to consider in displacing existing uses. Thus, they permit some adaptation to global climate change because they theoretically permit a new, more efficient uses to displace an existing, less efficient one. In contrast, the seventh factor introduces the notion of priority, in theory the antithesis of riparianism, on the ground that courts in

84. E.g., Turner v. James Canal Co., 99 P. 520 (Cal. 1909) (stating that landowner whose land occasionally lapped river had seasonable riparian rights).
fact give considerable weight to the factor. There is a considerable, but not uniform, case support for this position. Protection of priority places the burden of compensating injured users on new users such as energy production users. It also makes a riparian system more like prior appropriation and thus allows new users to identify the likely objectors to the planned use and encourages the use of the market to minimize the risks of future supply disruption.

Riparian rights are not well-suited to facilitate market correction. They are difficult to transfer. The early common law functioned to foster the development of water mills and small-scale agriculture, and the assumption was that users should be limited to those owning land along a stream to ensure that a constant flow was available to all these users. Thus, rights could not be used on non-riparian land and outside the watershed of origin. These per se restrictions have been gradually replaced with compensation rules which allow these uses if no riparian is injured. Today, both consumptive and non-consumptive riparian rights may be severed and separately conveyed. For example, a leading Georgia case holds that severed riparian rights may be used on non-riparian land if there is no injury to other riparians.

Many states allow transbasin diversions subject to environmental review. This said, the risks of relying on a transfer of riparian rights are much higher compared to appropriative rights because of the inherent uncertainty of common law.

A conveyance by a riparian only binds the riparian transferor. Other, non-joining riparians remain free to assert their right to make a reasonable use at any time. Transfers to non-riparian land or out of the watershed are especially problematic. It is not clear if a court would apply the riparian-nonriparian distinction, the watershed rule or a reasonableness test. Commentators have suggested that a conveyance of riparian rights apart from the land is nothing more than a grantor-grantee contract not to interfere with the exercise of the granted

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89. The history of factor seven and the debate over the weight, if any, that should be given to priority in the common law is set out in A. Dan Tarlock et al., Water Resource Management: A Casebook in Law and Public Policy 132-37 (2009).

90. Id. at 145–147.


94. Restatement (Second) of Torts § 856(2) (1979) (imposes liability on a riparian who makes an unreasonable use that harms a non-riparian grantee who is making a reasonable use of water).
right.\textsuperscript{95} There is even precedent which allows the grantor to make a concurrent, but non-injurious use, despite the conveyance.\textsuperscript{96}

\section*{C. Prior Appropriation}

1. Is it a Complete Risk Allocation System?

The correlative aspects of prior appropriation are harder to discern but exist to constrain global climate change adaptation. Prior appropriation should function as a complete global climate change risk allocation system because it allocates water in times of shortage by a simple, elegant principle: strict enforcement priority schedules. There is no \textit{pro rata} sharing. The rationale for the banishment of any idea of equity among users is that the system provides fair notice to junior users of their potential risks and thus they should plan and adapt accordingly. However, there are indirect elements designed to promote sharing with other users which poses a risk for all users including energy users if shortages intensify. An appropriative right depends on the continuous application of water to beneficial use. Thus, rights can be trimmed or terminated for wasteful use as well as for non-use over a period of years.\textsuperscript{97} In practice, the first is a mild, seldom-applied restriction while termination for non-use is more frequent. In addition, in some states, junior appropriators can condemn senior water rights if they have a higher preference, and irrigation always trumps power generation.\textsuperscript{98}

The biggest risks that new energy users face are: (1) a higher global climate change-enhanced risk that water to supply junior rights will not be available during droughts and that a market correction may not be possible for legal or economic reason, and (2) the prohibition against speculation. The high costs and market uncertainties of alternative energy projects often require that rights be held for a long period of time, and court may cancel the application because it was held for speculative purposes.\textsuperscript{99} In practice, these risks are not severe,
and, thus, there is a high expectation of non-enforcement of priorities. Strict prior enforcement is generally confined to small systems, and western state water administrators have worked hard to make sure that there are few calls. In addition, if there is a large disparity between the efficiency of senior and junior uses, states and junior users will aggressively seek to avoid a call.

State efforts have been further backstopped by federal water policy during the first seven decades of the 20th century. The thrust of federal and state water policy from the conservation era to the 1970’s has been to minimize the risks of shortages by carry-over storage. However, the federal government has never exercised its constitutional commerce power to preempt state allocation of water and, thus, lacks direct control over state water allocation. Federal preemption of state water law has been suggested as an adaptation strategy, but any substantial hint of federal displacement of state control is a political third rail.

Shale Oil Co., 986 P.2d 918, 922 (Colo. 1999) (1.5 million in expenditures over six years sufficient to show due diligence to inspecting rights for an oil shale project that might not be feasible for 50-85 years).

100. State ex. rel. Cary v. Cochran, 292 N.W. 239, 246 (Neb. 1940). Senior users may issue a “call” requiring junior users to cease use if the senior user’s rights are being adversely affected by the junior’s use.

101. American Falls Reservoir Dist. v. Idaho Dep’t of Water Res., 154 P.3d 433, 451 (Idaho 2007) is an instructive case of junior appropriator “push back.” Starting in 1993, senior appropriators have made calls on junior pumpers in the Snake River Plain. The Idaho Department of Water Resources eventually threatened to shut pumps for 33,000 acres and several towns and industries in the Magic Valley, but to avoid this drastic remedy, the state adopted Rules for the Conjunctive Management of Surface and Ground Water Resources which allow the Director of the Idaho Department of Water Resources to apply a combination of the traditional futile call doctrine and the doctrine, developed in the Snake River Plain, that a senior’s use must be reasonable before a call will be honored. A district court held that the Rules violated the constitutional right to divert because they do not permit the timely administration of water rights and failed to include a presumption that any junior withdrawal in times of shortage is a per se interference with senior surface rights, but the Supreme Court reversed. The Court first observed that “[w]hile the Constitution, statutes and case law in Idaho set forth principles of the prior appropriation doctrine, these principles are more easily stated than applied. These principles become especially more difficult, and harsh, in their application in times of drought.” The need for a presumption of interference was rejected because Director of the Department of Water Resources, the state engineer of old, needed the discretion to decide when to honor a call and thus the rules contained sufficient standards and did not constitute a readjudication of decreed water rights. It also held that a contrary ruling would ignore “the constitutional requirement that priority over water be extended only to those using water.” The Court ultimately concluded that it more important to have an administrative agency charged with allocating this public resource Department make a scientifically-informed decision about the extent of injury to a senior than to make a speedy delivery based on the reflexive enforcement of priorities.

102. Farber, supra note 80, at 274.

2. The Problems of Market Correction to Adapt to Global Climate Change Risks

Proponents of global climate change adaptation have long argued that any risk that energy users face under prior appropriation could be corrected by the market. Water marketing can cure the junior priority problem, but it is less able to cure the risk of holding water for speculative purposes. Prior appropriation rights were never tied to riparian land or subject to any watershed limitations. However, some states made appropriative water rights appurtenant to the land on which the water was initially put to beneficial use to enshrine the vision of a permanent, Jeffersonian agrarian society into law. However, since the 1960’s, economists and many western water critics have criticized western water law because it ignores higher, alternative values of water. They assert that too much water is used to grow surplus or low-valued crops and too much water is used in a wasteful manner.\(^{104}\) The remedy is the greater use of water markets and water banks to make permanent and short term transfers. Today, the barriers to water transfers are primarily political rather than legal.

Considerable amounts of water in states such as Colorado have moved from agricultural to urban uses, but water marketing exposes two basic problems with the proposed transfer remedy. The first question is an institutional one: will water users respond sufficiently to market incentives? The second is a political one: are the redistributions commanded by the market fair and socially beneficial in both the short and long run? Transfers can dewater communities\(^{105}\) and aquatic ecosystems causing a range of unaddressed economic, social and environmental problems.

The first problem stems from the potentially high transaction costs associated with transfers. The doctrine of prior appropriation protects junior right holders who may be injured by a transfer.\(^{106}\) An appropriative water right cannot be transferred unless there is no injury to junior water right

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\(^{105}\) For an argument that transfers from the Imperial irrigation District to urban San Diego violate the trust duties that IID owes to its members, see Shannon Baker-Branstetter, The Last Stand of the Wild West: Twenty-First Century Water Wars in Southern California, 38 Envtl. L. Reporter 10726, 10727 (2008).

holders. This long-entrenched rule could be a major barrier to energy transfers because the range of affected water right holders, the amount of water actually used by the transferor, and the amount of water that junior water right holders are using must be identified and adverse effects mitigated. In addition, the interest of non-right holders who assert "community welfare" claims or environmental interests are a factor in transfers. Water law provides no direct protection for these interests, but these claims are increasingly being asserted both through litigation and the political process.

Groundwater transfers may be more of a problem because the common law sought to protect agricultural pumpers by allowing them exclusive access to aquifers beneath their land. Water would only be used on land overlying an aquifer. This rule was never strictly applied, except in Arizona, because the courts replaced the absolute ownership rule with the reasonable use rule which allowed cities to sink well fields in rural areas and transport the water to the city subject to a duty to compensate farmers for some of damages caused by the pumping. Still, transfer to non-overlying land could be problem in corn growing states such as Illinois which follow the common law. It is not a problem in the corn producing state of Nebraska because, in 1978, the legislature allowed transfers for agricultural use on non-overlying land subject to the rights of third party objectors which now include surface right holders.

To counter the potential "chilling effect" of third-party protection rules, three water transfer reforms have been proposed to: (1) transaction cost reduction, (2) water conservation and incentives, and (3) water banking. Water marketing advocates argue that reduced transactions costs will promote more transfers. Proposals to reduce the transactions costs of transfers include streamlining existing processes and creating...
incentives to conserve water and to transfer the saved water. While such reforms are desirable, they will not alone "unblock" large quantities of water. A major study of water transfers in six states concludes that, with the exception of lawyer-dominated Colorado, the current transaction costs of water transfers are not excessive. The real barriers are political not legal.

Water banking is another route to tapping under-used water rights, but it has been used primarily to reallocate water to municipalities and to support aquatic ecosystems. The basic theory is that any given year a senior agricultural water right holder may have excess water available for other uses due to market demands for its crops or decisions to fallow. Historically, the rule that an appropriated right may be abandoned or forfeited created perverse incentives to waste water by applying it to use regardless of the economically of the use. Water banking seeks to counter the "use it or lose it" rule by allowing irregular transfers which do not impair the underlying right. Water banking was pioneered in Idaho on the Snake River and adopted by California during the drought of the late 1980’s and early 1990’s. In early 1991, California was facing the fifth consecutive year of drought; major reservoir storage was fifty-four percent of average. To meet the gap between available supplies and demand, the state created a Drought Water Bank. Emergency legislation was enacted to allow water suppliers the authority to enter into contracts with the Bank and to provide that any temporary transfer would not effect the supplier's water rights.

V. THE PROBLEMS OF RAMPING UP HYDRO

This section deals with the special case of hydropower. Water power is the only conventional renewable resource in the current energy mix. Thus, increased hydroelectric generation
Water demand and energy production could be an important adaptation strategy or an additional source of clean, green energy. However, this section explains why this is unlikely to happen unless we reverse the policies put in place in the last fifty years to conserve and restore the hydrographs of managed rivers.

A. The Limited Promise of Hydro

Hydroelectric energy is a relatively climate friendly source and could become more important in the future. For example, increased generation has been identified as a source of emission credits for coal emissions because it does not produce significant greenhouse gases. But, hydro is not completely clean and is in a “steady-state.”\footnote{This conclusion was recently reaffirmed by a recent survey of future energy production options. The Nat’l Academies, Electricity From Renewable Resources: Status, Prospects, and Impediments 56 (2010).} Hydroelectric generation causes other forms of major environmental damage, primarily to fish runs and aquatic ecosystems.\footnote{Kim Murphy, Boom in Hydropower Pits Fish Against Climate, L.A. Times, July 27, 2009.} Moreover, hydropower reservoirs, especially in the tropics, are large methane emitters.\footnote{United Nations Env’tl. Programme, Climate Change and Dams: An Analysis of the Linkages Between the UNFCCC Legal Regime and Dams 4 (2000) (calls for further study because international climate change regime makes no provision for exploring the relationship between dams and climate change).} The primary problem is the reality that hydro’s day is past in the United States and, as a result, any effort to ramp up production will face substantial constraints.\footnote{E.g., Christopher G. Pernin et al., Generating Electric Power in the Pacific Northwest: Implications of Alternative Technologies 8 (2002) (“Current projections show that, in the future, the majority of all new electricity generation in the Northwest--in fact in the entire West--will come from natural-gas-fired plants.”).}

Additional hydroelectric capacity could either come from the construction of new dams and reservoirs or by increasing the generating capacity of existing facilities. Turbines could be added to dams built without them, existing ones could be upgraded or more water could be put through existing ones.\footnote{See Dep’t of Interior, Potential Hydroelectric Development at Existing Federal Facilities For Section 1834 of the Energy Policy Act of 2005 (2007). Electricity From Renewable Resources, supra note 121, at 56–57, estimates that new capacity could add 10 GW of power; 2.3 GW would come from upgrading existing facilities, 2.7 GW from small and low head, and 5.6 GW would come from adding hydro capacity to existing “non-powered” dams. Tidal, river, and ocean currents are additional sources of hydrokinetic power but are beyond the scope of this paper. Id. at 99–100.} The Department of Energy estimates that up to 30,000 megawatts of
electricity could be generated from undeveloped sites. The Energy Information Administration puts that total potential increase in hydroelectricity for new and upgraded plants at forty terawatts.

Efforts to ramp up hydropower to promote secure, renewable energy trace back to the country’s first run at energy independence from 1973 to 1980. In 1978, legislation was enacted to increase hydroelectric generation by bringing smaller, low head plants on line, but the increased generation produced by the legislation is well below the initial expectations. Today, three interrelated institutional problems make it hard to substantially increase hydroelectric generation: (1) the low, but still unrealistic aspirations for hydroelectric energy, (2) the end of the “Big Dam Era,” and (3) the outdated, dysfunctional federal water planning and regulatory structure. The legal legacy of the environmental era, which partially supplanted the “Big Dam Era,” is an accumulation of unintegrated and fragmented statutes which can be used to restore hydrographs on an ad hoc and incomplete basis. As a 2010 National Academies study concluded, “[t]he future of hydropower will play out in the public policy debate, where the benefits of the electric power are weighed against its effects on the ecosystem.” Hanging over all of these is the fear that global climate change may contribute to a decrease in river flows during times of high demand.

B. Federal Policy Shifts from Building to Removing Dams

The roots of hydropower’s inability to expand easily can be traced to the mid-20th century reaction to the water policies of the Progressive Conservation Era (1890-1920). In the name of science and efficiency, engineers and others posited a vision of efficient water management which mandated that river basins be

128. Section 210(b) of The Public Utility Regulatory Policies Act of 1978 (PURPA), 16 U.S.C.A. § 824a-3, mandated that public utilities purchase power from qualifying facilities, such as small, independent hydropower facilities. FERC interpreted the mandate as not requiring utilities to pay more than their avoided costs. 16 C.F.R. § 292.304(b) (1987). This interpretation was upheld by the Supreme Court. Am. Paper Inst., Inc. v. Am. Elec. Power Serv. Corp., 461 U.S. 402 (1983).
129. STEVEN FERRAY, LAW OF INDEPENDENT POWER § 3:4 (2010).
131. See Craig, supra note 49.
132. ELECTRICITY FROM RENEWABLE RESOURCES, supra note 121, at 99.
developed to harness rivers fully. Rivers were to be transformed from imperfect nature to “working rivers.” The most controversial issue was public versus private development, not development versus non-development. In 1920, Congress resolved the debate and enacted the Federal Water Power Act, which opted for private over public hydroelectric power development. During the first half of the 20th century, private and later public power providers developed most of the best high dam sites in the American West and elsewhere. Hydroelectric generation was an integral part of many of the large publically-financed multiple purpose dams built from the New Deal to the 1960’s because power revenues helped to finance subsidized irrigation and free flood control. Ironically, the preference for private power created a legacy of dams which are increasingly seen as obsolete and candidates for removal or modification.

When the Federal Water Power Act was enacted, the United States generated forty percent of its electricity from hydropower. Today, the figure hovers around seven percent and long-term projections hold it constant. Hydroelectric generation peaked in the mid-twentieth century because for every action, there is a reaction. Starting in the 1950’s, the preservation movement, the precursor to the modern environmental movement, mounted political campaigns against new proposed dams in scenic canyons. Eventually, the movement tapped into fiscal pressures on the federal government


135. “[T]he drive to economical use of capital investment has placed growing emphasis upon power as the principal and often feasible means of recovering project costs.” 3 WATER RESOURCES POLICY COMM’N, THE REPORT OF THE WATER RESOURCES POLICY COMMISSION: WATER RESOURCES LAW 259 (1950), available at http://www.westernwater.org/ index.php/browse/bySet/10. However, the Obama Administration is trying to induce greater production. In March, 2010, the Departments of Energy and Interior and the U.S. Army Corps of Engineers signed a Memorandum of Understanding to explore ways to increase hydropower production. Sonya Baskerville and Charles R. Sensiba, Hydropower: A Renewable We Can Believe In, Vol. 41, No. 6 Trends 5 (ABA Section of Environment, Energy, and Resources Newsletter, July/August 2010).


138. Initially, the promise of federal scientific management of natural resources united the utilitarian and spiritual wings of the conservation movement, but the movement split into the rational exploitation, conservation, and preservation movements after the federal government allowed Hetch Hetchy Valley, next to Yosemite National Park, to be flooded for a reservoir to supply San Francisco. See RICHARD WHITE, “It’s YOUR MISFORTUNE AND NONE OF MY OWN:” A NEW HISTORY OF THE AMERICAN WEST 412-414 (1991).
and a growing Congressional disinterest in promoting regional development in the South and West through subsidized water development. This effort produced the 1968 Wild and Scenic Rivers Act which protects most of the major undeveloped sites on free-flowing rivers from hydroelectric dams. State wild and scenic river programs protect other rivers. Jimmy’s Carter’s infamous “hit list” of water resources projects in 1977 administered the “coup de grace” and convinced the Western states that the federal money spigot would be substantially reduced. Since that time, federal budget dollars devoted to water are increasingly being spent on aquatic ecosystem restoration rather than dam construction.

C. Working Rivers Become Rivers that Work - For Themselves and Us

The idea that most of our remaining high quality “natural” rivers should run wild eventually evolved into the broader idea that reservoir operations, including full hydroelectric generation capacity, should be subordinated to the protection of endangered fish and the promotion of white water rafting. Today, the conservation era vision of hard working rivers, with the stewardship-based idea of a river that works for a wider variety of uses, includes aquatic ecosystem protection. There are several strands of resource stewardship.

One strand posits that rivers should be managed and “restored” to maximize the maintenance of the ecosystem “services” that they provide such as biodiversity, pollution filtering and flood retention.” A more radical version argues that a river’s natural hydrograph should be restored, within the bounds of reason, to support the stream’s ecological functions regardless of whether these functions can be quantified as sustainable, non-wasteful levels of consumptive use and non-consumptive uses such as hydroelectric power generation and aquatic ecosystem conservation and service production.

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140. FELDMAN, supra note 83, at 50-51. Feldman explains why President Carter tried to curb the power of Congress to distribute federal "pork" through inefficient water projects. The political firestorm that resulted is told in MARC REISNER, CADILLAC DESERT: THE AMERICAN WEST AND ITS DISAPPEARING WATER 306–331 (1993).
141. The distinction between a working river, which is dammed and managed for flood control, irrigation, hydroelectric generation and municipal water supply, and a river that works by providing a wide range of services and functions is made in MARC REISNER, CADILLAC DESERT: THE AMERICAN WEST AND ITS DISAPPEARING WATER 306–331 (1993). Rivers that work can accommodate sustainable, non-wasteful levels of consumptive use and non-consumptive uses such as hydroelectric power generation and aquatic ecosystem conservation and service production. Id. at 3-2 to 3-3.
ecological services which benefit human users of the ecosystem. Both theories have been synthesized in the concept of the “normative river.” This synthetic construct recognizes that we can seldom, if ever, return to pre-development (dam) conditions on large, regulated rivers. Instead, the goal is to create a new managed hydrograph that performs a reasonable range of the historic functions altered by the dam within the constraints such as existing water rights and the legislative mandates which control reservoir operation.

The normative river is no longer an abstract idea, although the name is seldom used, as numerous ad hoc experiments are trying to implement it. The most ambitious is the Comprehensive Everglade’s Restoration Plan, enacted as part of the omnibus Water Resources Development Act of 2000, which seeks to recreate a normative river of grass in the Everglades after decades of human alteration. The ecosystem depends on seasonal sheet flows of water from Kissimmee River in central Florida and Lake Okeechobee. To make South Beach and Miami hip, these flows were substantially diverted for agricultural and urban development and flood control. The objective of the legislation is no less than to replumb the Everglades to restore some measure of pre-diversion flows. Any effort to add more hydroelectric capacity to existing facilities or squeeze more out of current projects faces two major constraints: (1) legal restrictions on new hydroelectric flow regimes, and (2) the lack of a coherent federal water policy to change the status quo.
Dam re-operation currently flows in the opposite direction. Over the past three decades, we have engaged in piecemeal experiments to restore or stabilize rivers by minimum flow regimes. Many restoration experiments require releases from relicensed FERC hydropower projects. The Federal Water Power Act of 1920 authorized 50-year renewable licenses. As the original licenses reached their golden anniversary, Congress amended the Act with the Electric Consumers Protection Act of 1986, which requires that FERC give equal weight to the benefits of relicensing the project and to “the protection, mitigation of damage to, and enhancement of, fish and wildlife (including related spawning grounds and habitat) . . . ”. Hydropower-rich states such as Oregon have a similar rigorous review process for new and re-licensed non-FERC facilities.

FERC’s discretion has been further limited by environmental laws. Until the Clean Water Act, it had the exclusive authority to regulate the operation of its licensed facilities. Section 401 of the Clean Water Act requires that federal licenses obtain a state certification that the operation of the project will not violate state water quality standards. PUD No. 1 of Jefferson County v. Washington Department of Ecology held that Section 401 includes state imposed minimum flows for fish protection and aesthetic enhancement. Section 401 certification applies to both public utilities and state-operated hydroelectric facilities, and FERC must accept the 401 conditions imposed by the state. Thus, the section provides an opportunity for environmental NGOs to impose minimum flow or environmental flow release conditions on FERC licensees.

management structure. This conclusion was first reached in NAT’L WATER COMM’N, WATER POLICIES FOR THE FUTURE: FINAL REPORT TO THE PRESIDENT AND TO THE CONGRESS OF THE UNITED STATES (1973), and echoed in study after study. See e.g., U.S. ARMY CORPS OF ENG’R, WATER RESOURCES PLANNING: A NEW OPPORTUNITY FOR SERVICE 46 (2004).

150. Federal Power Act, 16 U.S.C.A. § 797(e) (2005). The first case to construe the amendment, National Wildlife Fed’n v. F.E.R.C., 801 F.2d 1505 (9th Cir. 1986), held that FERC must either prepare a comprehensive plan for the river or require permittees to evaluate the cumulative adverse environment impacts of the project.
156. E.g., In the Matter of Petitions for Water Quality Certification for the Re-Operation of Pyramid Dam for the California Aqueduct Hydroelectric Project Federal
The Endangered Species Act is another source of flow conditions for at risk species. Finally, Indian water rights settlements are another source of minimum flows. In 2004, the state of Idaho, the federal government and the Nez Perce tribe entered into a creative settlement that provides for a more stable flow regime on Lower Snake River which can benefit both salmon restoration efforts and hydropower generation. Global climate change adaptation may impose additional operating constraints of FERC licensees. Subtitle E of Clean Energy and Security Act of 2009 mandated a hyper-rational national and state adaptation planning process to ensure the resiliency of aquatic ecosystems. Water scarcity and the risks of prolonged droughts were among the adverse impacts which must be factored into adaptation plans.

D. The Ultimate Extension: Dam Removal

Some environmental groups have taken the normative river concept to its ultimate conclusion and argue that many dams, including those that generate hydroelectricity, should be removed. Many targeted dams are small and have exceeded their planned useful life or no longer perform their intended functions. Some of these small, marginal hydroelectric dams have been

Energy regulatory Commission Project No. 2426, State of California, California Environmental Protection Agency, State Water Resources Control Board, Order WQ 2009-0007 (License requires state to operate project to stimulate natural flow conditions “to the extent operationally feasible” to protect the federally listed arroyo toad but rejected NGO petition to increase summer minimum flows).

160. American Clean Energy and Security Act of 2009, H.R. 2454, 111th Cong. §§ 451-482 (2009). For finance planning, each state will be given allowances to sell, and the proceeds must be used to prepare a state adaptation plan. Each state plan must prioritize the particular risks that the state faces and detail a list of cost-effective projects and strategies to “to assist fish, wildlife, plant populations, habitats, ecosystems, and associated ecological processes in becoming more resilient, adapting to, and better withstanding” the impacts of GCC. H.R. 2454 § 479(c)(1)(C).
removed in Maine, and a dam removal program on the Elwha River in Washington State is going forward with “all deliberate speed.” FERC has the authority to deny a license renewal application and order that a dam be decommissioned if it has become uneconomic. More ambitious dam removal proposals include breaching four dams on the Upper Snake River to support salmon runs in the Columbia River basin, removing O'Shaughnessy Dam north of Yosemite National Park, and even the mighty Glen Canyon Dam on the Colorado. Should

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161. A Maine conservation organization, the Penobscot River Restoration Trust, raised $25 million to supplement a $15 million federal grant to purchase and remove two hydroelectric dams at the lower end of the river and to build a fish run around a third. The hope is that fish will return to the watershed. The river was a major source of economic development as logs were floated from the headwater forests to downstream paper mills but much of the resulting pollution has now been cleaned up. Katie Zezima, Maine Conservationists Reach Milestone in Plan to Buy Three Dams, N.Y. Times, Aug. 22, 2008, at A16.

162. The efforts to remove the dam were triggered by a major Supreme Court decision, Washington v. Washington State Commercial Passenger Fishing Vessel Ass’n, 443 U.S. 658 (1979), which recognized on and off reservation tribal fishing rights for several reservations in Washington state, including one downstream from two dams on the salmon-rich Elwha River, Glines Canyon and Elwha Dams mounted. In 1992, Congress authorized their removal. Elwha River Ecosystem and Fisheries Restoration Act, Pub. L. No. 102-443, § 3, 106 Stat. 3173 (1992). The two dams were purchased by the federal government in 2000 and removal is slated to start in 2012. The removal will be the largest removal to date, and environmentalists are setting their sights on some of the nation’s biggest dams.

163. City of Tacoma, Washington v. F.E.R.C., 460 F.3d 53 (D.C. Cir. 2006). See also Jackson County, North Carolina v. F.E.R.C., 589 F.3d 1284 (D.C. Cir. 2009) (FERC reasonably accepted surrender of license and plan to remove dam and powerhouse and had no power to compel transfer of license to county).

164. The efforts to restore salmon runs on the Columbia River and its tributaries is an epic tale, and it illustrates the role that dam removal can play in the future resolution of such conflicts. After a court suggested that the federal government study removing 11 dams on the Columbia and the Snake Rivers, the Clinton Administration (1992-2000) began a study to assess the consequences of breaching four major dams on the Snake River. However, the Bush II Administration rejected the idea. A 2002 Rand Corporation Report found that four Lower Snake River could be removed with no disruption to the regional economy. PERNIN ET AL., supra note 124, at 27–32.

165. O'Shaughnessy Dam in the Hetch Hetchy Valley in Yosemite National Park supplies the city of San Francisco with water and power. The decision to build the dam was one of the great natural resource fights of the Conservation Era and played a major role in splitting the movement into the utilitarian, multi-use and preservation wings and still resonates in California. See WHITE, supra note 138, at 413. California environmentalists have long dreamed on restoring the valley to John Muir’s vision of it as the “flow of nature.” MICHAEL P. COHEN, THE PATHLESS WAY: JOHN MUIR AND THE AMERICAN WILDERNESS 330 (1984). See SPRECK ROSEKRANS ET AL., PARADISE Regained: SOLUTIONS FOR RESTORING YOSEMITE’S HETCH HETCHY VALLEY (2004) for a comprehensive effort to simulate a removal debate. In 1987, President Reagan’s Secretary of the Interior, Donald Hodel, was the first high ranking official to suggest removal. Environmentalists viewed the suggestion as a ploy to split green northern California. In 2007, the Bush II Administration proposed a $7,000,000.00 removal feasibility study but Senator Diane Feinstein, the former mayor of San Francisco and Hetch Hetchy defender was not amused.

166. Scott K. Miller, Undamming Glen Canyon: Lunacy, Rationality, or Prophecy?, 19 STAN. ENVTL. L.J. 121 (2000). Miller reviews proposals to take down Glen Canyon
this happen, hydropower loses could be substantial and would have to be made up largely by new nuclear, natural gas, or coal plants.

The opposite could also happen. Like a meandering river, water policy is always evolving and changing course; a new era of reservoir construction could be on the horizon. Global climate change adaptation could produce a counter scenario that would support increased hydroelectric generation by subordinating environmental protection to power. Increased run off capture is on the adaptation agenda, and this includes the revival of building new carry-over storage. In May of 2007, Governor Arnold Schwarzenegger called for the construction of two new hydroelectric dams to help meet the state’s ambitious greenhouse gas emission targets. However, many new storage facilities may be off-stream and small, so the capacity of these for substantial increased hydroelectric generation is unknown.

VI. POSSIBLE WATER-ENERGY INTEGRATION STRATEGIES

A. Three Easy Steps

The first option is to do nothing. The status quo is a rationale interim integration strategy and is our current water-energy policy. Water rights for energy use have long been acquired under state law or through transfers. State water law and the markets that they induce seem capable of meeting our current water needs for energy extraction and production at least until there is more compelling evidence that water availability is constraining sustaining energy development. The next modest strategy is to collect better data to make decisions about energy-water needs. The 2009 “Energy and Water Integration Act” is a positive step in this direction.

The third and more complicated step would be the development of a coherent federal food security policy. It is difficult to decide which existing water institutions should be

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Dam. The issues raised by dam removal are beyond the subject of this paper. See DAM REMOVAL RESEARCH: STATUS AND PROSPECTS (William H. Graf ed. 2002); David D. Hart et al., Dam Removal: Challenges and Opportunities for Ecological Research and River Restoration, 52 BIO SCIENCE 669 (2002).

167. To overcome public opposition to new high voltage power lines, many lines are being planned under rivers and bays. As a president of an offshore cable company noted, “The fish don’t vote.” Matthew L. Wald, Underwater Cable an Alternative to Electrical Towers, N.Y. TIMES, Mar. 16, 2010.


changed to promote energy development in the absence of a coherent federal food security policy. For example, if we took corn-based biofuels off the table, there would be less need to be concerned about state water law and its ability to cope with stresses. Were the federal government to address issues such as crop subsidies, we would have a better idea of how much water should be devoted to irrigated agriculture for human consumption compared to biofuel use, given competing urban and environmental demands. A “food security” policy would also inform us whether there is a case for new agricultural land allocation. Similarly, crop subsidy withdrawal and less emphasis on beef production could free up water for other uses from environmental restoration to energy production.

B. A Harder Step: Embrace the Normative River

The most productive major reform would be integrating hydroelectric production into a broader global climate change adaptation strategy. Some version of the normative river is central to any adaptation strategy because aquatic ecosystem conservation will (or should) be an integral part of any adaptation. Subtitle E of Clean Energy and Security Act of 2009 required state plans which “prioritized” the particular risks that the state faces and detailed a list of cost-effective projects and strategies to “to assist fish, wildlife, plant populations, habitats, ecosystems, and associated ecological processes in becoming more resilient, adapting to, and better withstanding” the impacts of global climate change. A new National Academy of Sciences study calls for a new adaptation paradigm.

Global climate change presents an opportunity to “adapt” the conservation era dream of the rational development of all major river basins through large and small projects so that not a drop would be wasted. The United States must learn to adapt its legacy infrastructure and water expertise to a wider variety of demands which were either not anticipated or marginalized when the infrastructure and allocations it permitted, which partially realized this dream, were built. Modern watershed planning must start from the idea of the normative river and its role in the river basin landscape, discussed earlier, and ask what magnitude of functions, from power generation to ecosystem

protection, can a river that “works” be legitimately asked to perform as we adapt to global climate change.

The normative river is compatible with hydroelectric generation, although it may require that some production be foregone at certain times of the year, especially as river managers begin to adapt to global climate change. A global climate change adaptation strategy could ultimately benefit hydroelectric generators in two ways. First, it would make it easier for private and public hydroelectric generators to assess the longer-term risks of altered flows for a variety of reasons from global climate change to aquatic ecosystem restoration. Both right holders and stakeholders would have clearer notice of the potential impact of adaptation measures on existing political and legal entitlements. The determination of the necessary seasonable flow regime for the normative river could start as planning exercise to give ample time for operators and stakeholders to look for common ground before hard choices have to be made. The second benefit is that it would lead to the greater use of adaptive management.

Adaptive management was developed in the late 1970’s as a criticism of static or deterministic environmental assessment using decision tree analysis. It proceeds from the premise that “fixed review of an independently designed policy” is inconsistent with the reality that most resource management decisions must be made under conditions of uncertainty and with what has come to be called non-equilibrium ecology. In brief, the later posits that ecosystems are dynamic rather than stable systems, and, thus, any management decision must be constantly evaluated and changed when new information so counsels.

“True” adaptive management is a rigorous, continuous process of acquiring and evaluating scientific information which requires the practice of regulatory science and a necessary component of any successful restoration program. Regulatory


173. See notes 147 to 149.

174. HOWARD RAIFFA, DECISION ANALYSIS: INTRODUCTORY LECTURES ON CHOICES UNDER UNCERTAINTY (1968).

175. INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS, ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT (C.S. Holling ed. 1978).


science is science designed to answer, to the best extent possible, causal questions about management choices, such as the minimal viable population of an at risk species that regulatory programs pose. Regulatory science requires that scientists contribute to the establishment of standards that have both a normative and scientific component and then to devise ways to measure whether these standards are being met over time. Modern regulatory programs required mixed scientific-value choices. For example, any effort to create past conditions requires baselines and performance targets. These are not strictly scientific questions because they require normative judgments about the value of the past and the extent to which we wish to try and recreate, but these decisions must be informed by science.\(^{178}\) The hope is that adaptive management will permit decision makers to avoid the current paralysis that scientific uncertainty creates. Adaptive management experiments are intended to reduce progressively the initial scientific uncertainty over time.

Unfortunately, to date the experience suggests that adaptive management is seldom actually used or is simply relabeled mitigation and monitoring.\(^{179}\) Adaptive management has been enthusiastically endorsed by many agencies and stakeholders because it allows decision makers to call for monitoring, hold out the premise of the modification of a regulatory or operating regime, and push a problem far into the future. When it has been applied to hydroelectric generation, it has been used to develop reservoir release patterns that improve the downstream environment.\(^{180}\) Thus, adaptive management remains part theology and part science. Perhaps this is all that we can expect because, as an early proponent observed, with perspicacity, “[a]daptive management is not really much more than common sense. But common sense is not always in common use.”\(^{181}\)


180. For a thorough articulation and analysis of this thesis see Daniel Pollack, Adaptive Management in Hydropower Regulation, 39 ENVTL. L. REP. 10979, 10993 (2009).

181. INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS, supra note 176, at 136. See also PANARCHY: UNDERSTANDING HUMAN TRANSFORMATIONS IN HUMAN AND NATURAL SYSTEMS (Lance H. Gunderson & C.S. Holling eds. 2002); CARL WALTERS, ADAPTIVE MANAGEMENT OF RENEWABLE RESOURCES (1986).
A new strategy which alters existing flow regimes will initially be perceived as radical and destabilizing. A major problem with adaptive management is that it decreases scientific uncertainty but increases regulatory uncertainty. Any departure from clear historic river operations plans, which have generated high expectations of the maintenance of the status quo, will be resisted as the efforts to push the Corps to vary flow release patterns on the Missouri River illustrates. The elimination of historic legal or political entitlements will raise substantial takings issues under the 5th and 14th Amendments to the U.S. Constitution. However, the idea of the normative river is not as radical as it seems. First, it reflects what is going on with many rivers. Second, although, the establishment of a new river regime will increase the risks to existing users, there are ways of minimizing these risks. Flow regime change need not be an all or nothing proposition, and thus it need not result, and adaptive management regimes could include limited compensation for substantial foregone uses. Third, the proposal is consistent with global climate change adaptation strategies.

VII. CONCLUSION

Any energy policy is always a moving target because of the changing mix of political and economic factors. Our current water-energy policy is reliance on the status quo. This is not a static policy. It relies on existing water rights and environmental regulatory regimes, and it relies on the market to supply the necessary water and to correct for the social costs of the use for energy development. This has much to recommend to it until there is more compelling evidence that water availability is constraining sustainability-based energy development.

182. See Pollack, supra note 181, at 10986–10992.