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The California Public Utilities Commission's Pilot Program to Explore the Nexus of Energy Efficiency and Water Conservation

Steven Weissman

University of California at Berkeley Boalt Hall School of Law

Lindsay Miller

University of California, Berkeley

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The California Public Utilities Commission’s Pilot Program to Explore the Nexus of Energy Efficiency and Water Conservation*

Steven Weissman** and Lindsay Miller***

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I. INTRODUCTION

Should electric and natural gas utilities spend money to encourage water conservation? This question, which seemed unlikely just a few years ago, is now a topic of much discussion in California and elsewhere. The context is one in which California's regulated energy utilities are spending hundreds of millions of dollars per year to encourage people to use energy more efficiently.

There is a growing recognition among policy makers that it takes a significant amount of energy to produce, convey, and treat water. This article considers how this relationship should affect public policy related to utility energy efficiency programs. It will discuss how the interdependency between water and energy encourages thinking about water as a manufactured product and the importance of considering the entire life-cycle impact of manufacturing water. Looking at water from a life-cycle perspective is crucial when determining the potential consequences of a new policy. This is especially true with California's State Water Project, a 400-mile series of canals, reservoirs, and pumps that move water north to south. This type of thinking leads to an understanding of the extent to which energy can be saved through traditional energy efficiency measures and through water conservation measures. The question then becomes, to what extent should energy utilities incorporate water conservation into energy efficiency strategies?

This paper will discuss the subtleties of measuring energy savings from water conservation, as well as the uses and limitations of the California Public Utilities Commission's (CPUC) Energy Calculator, which helps the energy utilities design water conservation programs. This paper will then outline the goals, programs, and expected outputs of the pilot program that the CPUC has undertaken to examine the economic feasibility of using investor-owned utility energy efficiency funds on water conservation projects. Finally, the paper offers observations and a discussion of new models for defining and implementing programs to conserve energy through water conservation.

II. ENERGY AND WATER

A. *The Water-Energy Nexus*

In 2001, about nineteen percent of California's electric power was used to produce, convey, distribute, and treat water.^{1,2} At the same time, water is crucial

** Lecturer in Residence, Associate Director for Energy Law & Policy Center for Law, Energy & the Environment at the University of California at Berkeley Boalt Hall School of Law.

*** Candidate, Mechanical Engineering Ph.D. University of California, Berkeley.

1. CAL. ENERGY COMM'N, CEC 700-2005-011-SF, FINAL STAFF REPORT: CALIFORNIA'S WATER-ENERGY RELATIONSHIP PREPARED IN SUPPORT OF THE 2005 INTEGRATED ENERGY POLICY REPORT PROCEEDING 1 (2005) [hereinafter FINAL STAFF REPORT].

for generating power. Reduced freshwater supplies have an impact on the ability of power plants to operate at full capacity. Not only does California depend on hydroelectric power for about 13% of the its electricity, but water is also critical in the operation of other power plants.³ Using coal as an example, water is required during the mining process for cutting the coal, washing it, and controlling dust. Slurry-fed coal plants rely on water to transport pulverized coal from the mine to the power plant, and all coal plants require water for cooling.⁴ In 2003, 39% of freshwater withdrawals and 3% of freshwater consumption in the United States were for cooling in thermoelectric power plants (nuclear, coal, oil, natural gas, or geothermal plants).⁵ Even though the magnitude of water consumed is less than the magnitude of water withdrawn, there is still reason for concern. Power plants require intake cooling water that is sufficiently cold to transfer enough heat away from the plant. Thus, the surface water (usually from a river) must have a flow rate sufficient not only to supply plenty of water, but also to keep the intake water cool by moving the hot output water downstream.

The ill effects of violating this equation were evident during the 2003 heat wave in Europe. France lost seven to fifteen percent of its nuclear power plant generating capacity for five weeks because the rivers used for cooling were too hot and at much lower levels than usual, flowing more slowly, and could not cool the nuclear core when the plants were operating at full capacity.⁶ It also lost twenty percent of its hydroelectric generating capacity because of low reservoir levels. These shortages led France to cut back its power exports to Italy and purchase expensive power on the spot market to make up for the lost generating capacity. Power generation depends on water as much as water production depends on energy.

An exacerbating factor in the energy-water nexus is that California's population is expected to grow from about 36.8 million people⁷ to some 60 million people by 2050.⁸ As the population increases, demand for both water and energy resources will increase. The majority of Californians live in southern California, where water is most scarce and usually must be pumped from

2. *Id.* (additionally, 30% of all natural gas and 88 billion gallons of diesel fuel were used to heat water and for other water-related purposes).

3. FINAL STAFF REPORT, *supra* note 1, at 16. The value of 13% is for the year 2004.

4. Dennen et al, *supra* note 8, at 12.

5. "Water withdrawals" refers to water that is taken from the source, used to cool the power plant, and then returned to the source at a higher temperature than it was taken, whereas "water consumption" refers to the water that is not returned to the source because it has evaporated or been consumed in some other way.

6. James E. McMahon, Presentation to the Council on Competitiveness: The Energy-Water Nexus (June 3, 2008), available at <http://www.compete.org/images/uploads/File/ESIS%20Progressive%20Downloads/McMahon%20-%20ESIS%20Initiative%20Dialogue%20III%20-%20June%202008.pdf>.

7. U.S. Census Bureau, State and County Quickfacts, <http://quickfacts.census.gov/qfd/states/06000.html> (last visited Oct. 24, 2009).

8. STATE OF CAL. DEP'T OF FIN., POPULATION PROJECTIONS BY RACE / ETHNICITY FOR CALIFORNIA AND ITS COUNTIES 2000-2050 (2007), <http://www.dof.ca.gov/research/demographic/reports/projections/p-1/documents/P-1%20Report%20Tables.xls>.

hundreds of miles away. This requires huge sums of energy from a region where the electricity mix relies heavily on coal resources.⁹ This looming demand has generated interest in reducing energy used so that less water is required. It has also generated interest in reducing water use so that less energy is required.

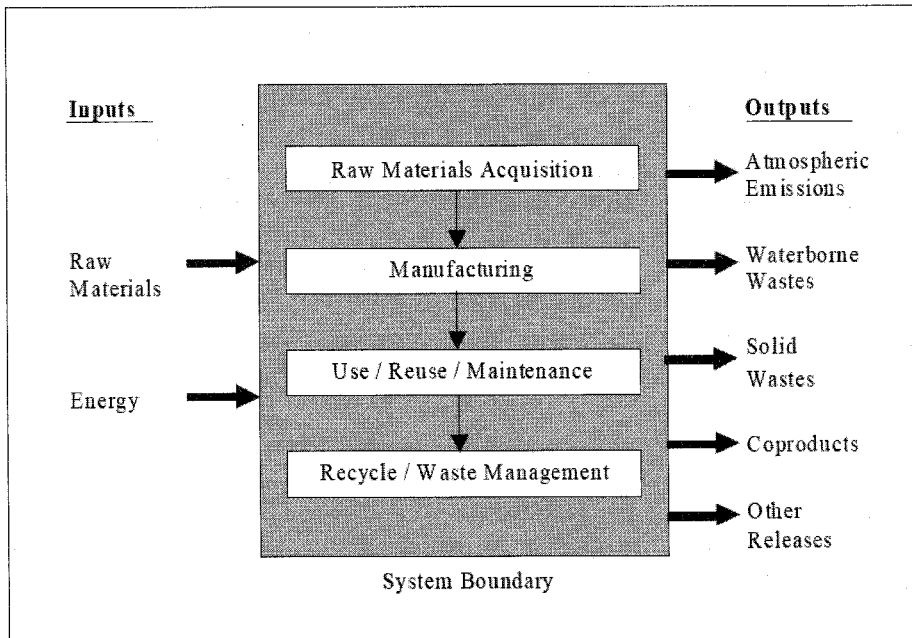
When highly-treated water is delivered directly to our kitchens, miles away from the source, it is no longer a purely natural resource but a manufactured product. This is so because pumping and piping infrastructure systems as well as extensive treatment processes are needed to bring safe, clean water from its source to our faucets. The manufactured nature of water is significant when considering how to reduce energy use associated with delivering water to end-users. This is especially the case in California, because of the need to pump so much water south for hundreds of miles. In order to fully understand the energy and resource intensity of a unit of water, a tool called life cycle assessment is used.

B. Water as a Manufactured Product and Its Lifecycle

Analysts use life-cycle assessment (LCA) to understand the full environmental impacts of a manufactured product. One methodology is called process-based LCA. This approach begins by defining the goal and scope of the study. It then proceeds to an inventory analysis, where the required inputs and the outputs for every step in a product's life cycle are identified. The life cycle phases of a product (illustrated in Figure 1) include mining raw materials, manufacturing, transporting, distributing, using (including operation and maintenance), and handling the end-of-life. Examples of possible inputs are fossil fuels, water, and metals. Examples of outputs include gases, ash, sludge, and scrap metal.

9. Bliss Dennen, Dana Larson, Cheryl Lee, James Lee & Stacy Tellinghuisen, *California's Energy-Water Nexus: Water Use in Electricity Generation 2* (May 7, 2007), (unpublished group project report submitted in pursuance of a M.S. in Environmental Science and Management, University of California, Santa Barbara) (on file with author).

Figure 1. Life Cycle Phases



After identifying all of the inputs and outputs throughout a product's life cycle, the next step in LCA methodology is to perform an "impact analysis." This analysis determines the environmental impacts of resource depletion—to supply the inputs for the process—and of emitted output pollution. Some of the environmental impacts that are often quantified using LCA are water use, energy use, CO₂ emissions, acidification, eutrophication, and human health effects. "Energy use" is defined as the main environmental impact metric of interest in most studies of water's life-cycle assessment, but there are other important impacts on the environment to consider such as pollution from the sludge or brine produced at wastewater treatment plants.

The final step in LCA methodology is "improvement analysis," in which researchers interpret the findings and identify ways to reduce the environmental impact of a product. This can be achieved either by making changes in the supply chain or manufacturing process, or by changing the product's design so that it is used differently. Another approach would be to use more recycled materials rather than raw materials as inputs, or develop ways to prevent toxic outputs from being released into the environment. It is also possible to develop uses for the outputs from manufacturing processes that would otherwise be discarded. An example of this is grinding up discarded toilets to be used as gravel for construction of roads rather than mining gravel as a raw material. Another

example would be using the milk fat skimmed off the top of skim milk as an input to a heavier dairy product.

A second LCA methodology, called EIO-LCA, uses an economic input-output database, combined with environmental consumption and emission data, to quantify the environmental impacts of a product.¹⁰ This methodology has the advantage of being much less data-intensive than process-based LCA. It also uses aggregated data for sectors of the economy, which makes it very accurate for certain sectors but less accurate for others. It is becoming common for researchers to use a hybrid approach, combining process-based LCA and EIO-LCA to take advantage of the strengths of both methodologies. For example, process-based LCA can be used to obtain process-specific or system-specific results, while EIO-LCA provides data on raw material acquisition.¹¹ The hybrid approach significantly reduces the time and money required to complete a life-cycle assessment study, ideally without sacrificing the accuracy of results or the ability to tailor the study to a specific product or process. For a detailed description of both the EIO-LCA process and the hybrid approach, the reader is referred to Hendrickson et al.¹²

Figure 2 provides a basic example to demonstrate process-based LCA in the form of a process flow diagram for a standard porcelain toilet. A process flow diagram is a tool used during the inventory analysis phase of LCA to map the steps involved in a product's life cycle and ensure that all inputs and outputs are accounted for. All stages of the toilet's life cycle are shown: mining of raw materials, manufacturing, use, and end-of-life. The black boxes indicate raw material inputs, the solid lines represent process flows, the dotted lines represent outputs, and the dashed lines signify transportation.

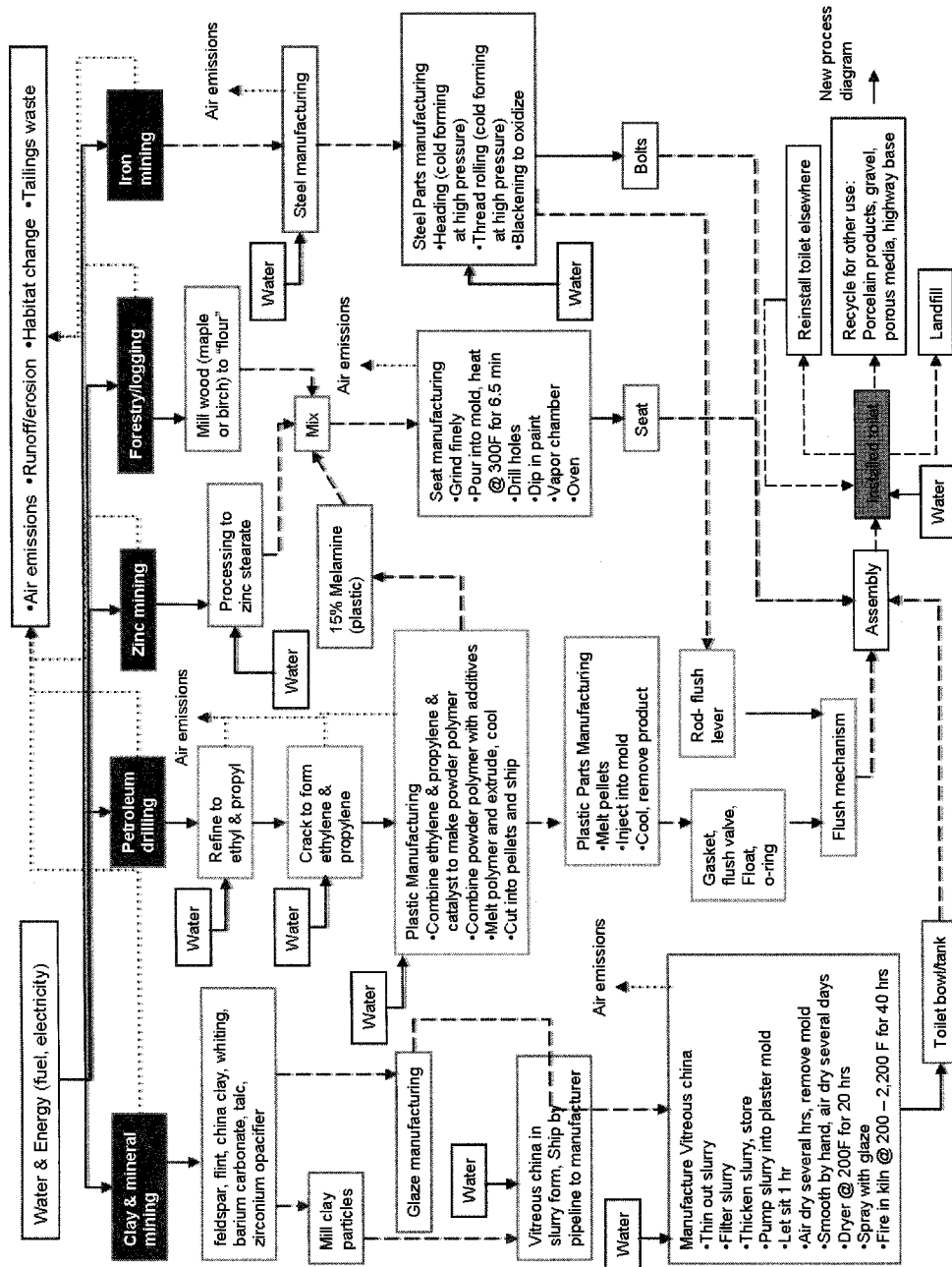
In Figure 2, energy is an input for every process but is not shown on this diagram except during the mining phase. Water is also an input to every process but is only shown on the diagram as an input if that process generally uses water directly. Air emissions are shown as an output if they are directly related to the process. Because each process requires some sort of energy, each process has air emissions associated with it although those indirect emissions are not noted in the diagram (the same is true for water use). Finally, output pollutants other than air emissions are not noted in this diagram because such information is difficult to obtain and is outside the scope of this paper.

10. Chris Hendrickson, Arpad Horvath, Satoshi Joshi & Lester Lave, *Economic Input-Output Models for Environmental Life-Cycle Assessment*, 32 ENVTL. SCI. & TECH. POL'Y ANALYSIS 184A (1998).

11. J. Stokes & Arpad Horvath, *Life Cycle Energy Assessment of Alternative Water Supply Systems*, 11 INT'L J. LIFE CYCLE ASSESSMENT 335, 336-37 (2006) [hereinafter *Alternative Water Supply Systems*].

12. CHRIS T. HENDRICKSON ET AL., ENVIRONMENTAL LIFE CYCLE ASSESSMENT OF GOODS AND SERVICES: AN INPUT-OUTPUT APPROACH (2006).

Figure 2.

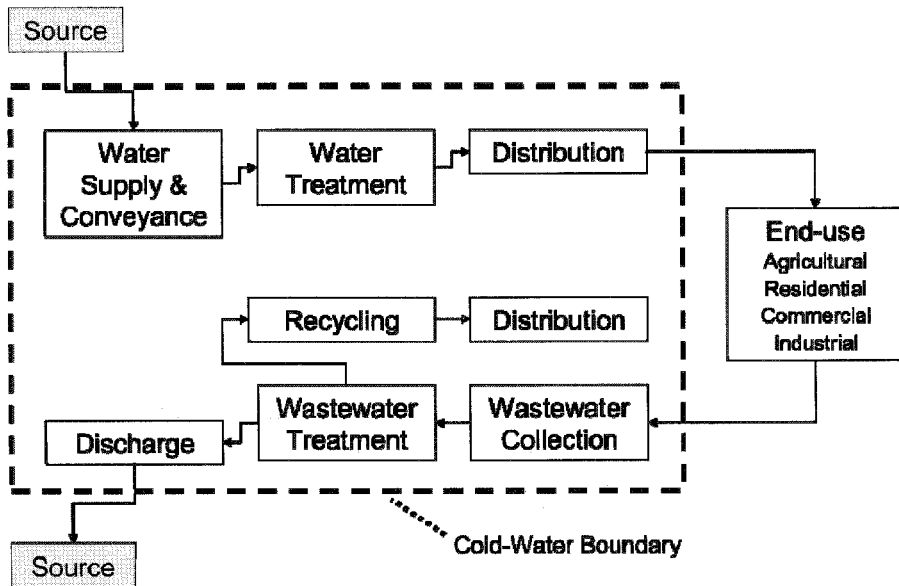


It is pertinent to note that each of the process boxes in Figure 2 could be broken into separate detailed process flow diagrams. For example, “steel manufacturing” is shown simply as a box on the toilet process flow, but steel manufacturing requires an entire process flow diagram of its own. The same is true of oil refining, which is an incredibly complex process that yields many outputs, including ethyl and propyl that are then used to make plastics. With enough time and access to information, one could subdivide every box into a fully detailed process flow, eventually ending when all of the process steps were traced back to their raw material inputs. It is very important in an LCA to clearly define the level of detail one chooses to include and why the boundary was defined as such. Definition of LCA boundaries significantly impacts results of the study and care should be taken when comparing LCA studies to understand how the studies’ boundaries differ.

Understanding the life-cycle energy impacts of water use requires similar analysis. Figure 3 is a process-flow diagram illustrating water’s life cycle impact.¹³ Looking at Figure 1 and Figure 3, it can be seen that the “raw materials acquisition” phase of water’s life cycle involves pumping water from the source and transporting it to the treatment facility. Water treatment is the “manufacturing” phase, after which the water is distributed to the end-user. The end-use of water represents its “use” phase, and the “waste management” or “end-of-life” phase is the collection and treatment of wastewater before it is recycled or discharged to the natural water system.

13. FINAL STAFF REPORT, *supra* note 1, at 7. For an interesting, in-depth LCA study comparing the energy use of imported, desalinated, and recycled water into specific water districts in California, see *Alternative Water Supply Systems*, *supra* note 11, at 339.

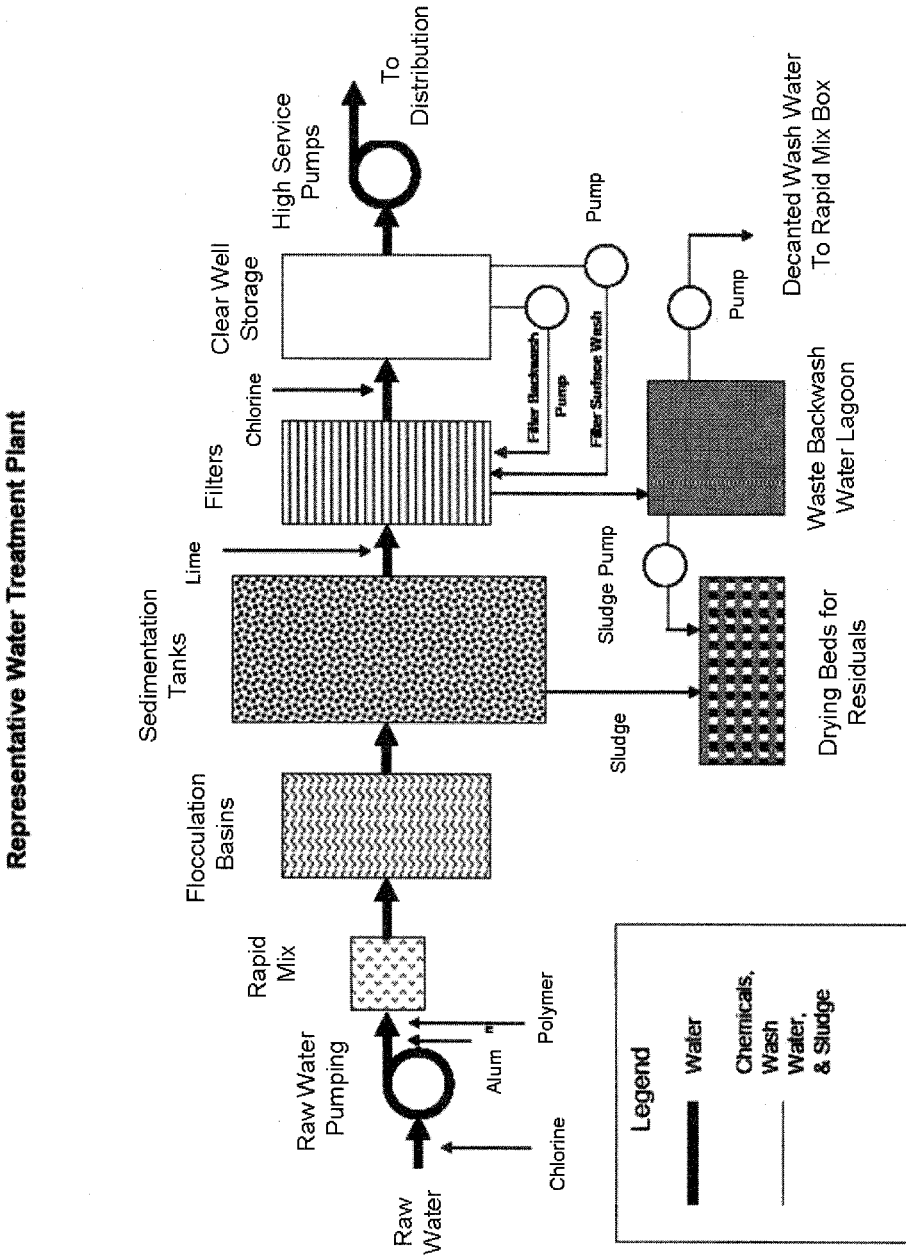
Figure 3. Simple Process-Flow Diagram of Water Supply Phases



Just as each process box in the porcelain toilet diagram could be expanded into its own detailed process, the same is true for Figure 3. This is illustrated by Figure 4, which shows the water treatment process box in a higher level of detail.¹⁴ Similarly, each of the process steps shown in Figure 4 can be broken into raw material inputs. For example, the filters may be fabricated from metal screens, which would require metal ore mining and screen manufacturing. It is evident from these examples that the life cycle of a product, even one as seemingly simple as a porcelain toilet or water, is incredibly complex and nuance.

14. FINAL STAFF REPORT, *supra* note 1, at 34.

Figure 4



Source: Electric Power Research Institute

Consideration of all life cycle phases is important because it is the only way to know how to save the most energy per unit of water conserved—and therefore save the most money per conserved unit.¹⁵ It is critical to realize that the impact of different life-cycle phases for water is highly dependent on the geographic region and water management practices, making it inaccurate to use broad averages or sweeping assumptions about energy needs for manufacturing water. For example, the energy required for withdrawing water depends heavily on whether the water must be pumped up from a well or collected from surface reservoirs. The deeper the well, the more energy is required to extract the water. Similarly, the energy required to transport and distribute water from source to treatment plant to customer increases with the distance the water must travel, as well as elevation gain. The same is true when wastewater is collected and transported from customer to treatment plant. In water treatment, the energy required depends on the initial water quality and the final quality needed, as well as the processes used for treatment at a particular facility. All of the aforementioned factors contribute significantly to energy embedded in water and are specific to a region's water supply, such that using a set of values from one region in another region will likely provide incorrect results.

With this brief background on the interconnectedness of energy and water resources, LCA, and the life cycle phases of water as a manufactured product, we now are ready to discuss the interests of California utilities and policy makers in the energy water nexus and the challenges that arise when formulating policy measures.

III. ENERGY UTILITIES AND WATER CONSERVATION

A. *Why California's Energy Utilities Are Interested in the Energy-Water Nexus*

Regulated energy utilities in California currently receive rewards for energy saved through energy-efficiency programs (they were authorized to spend three billion dollars promoting energy efficiency in the 2010-2012 funding cycle¹⁶). The utilities already have programs in place focused on reducing hot water use because reducing the amount of water for such purposes reduces energy use for heating. In that way, programs encouraging water conservation by using efficient dishwashers, washing machines, and low flow showerheads are considered energy efficiency measures.

15. It is also important to understand life-cycle impacts of water conservation measures before using them under the assumption that they will lead to energy savings. For example, it is not possible to conclude that replacement of a functional toilet with a new water-saving fixture will save energy without knowing how much energy is needed to make, deliver, and install the new toilet.

16. CAL. PUB. UTILS. COMM'N, DECISION APPROVING 2010 TO 2012 ENERGY EFFICIENCY PORTFOLIOS AND BUDGETS, DECISION 09-09-047, at 2 (2009).

Energy utilities are interested in how much energy is embedded in water over its entire lifecycle (rather than only in the heating/use lifecycle phase) because this information could allow them to claim credit for saving energy by saving water in addition to the energy required for direct heating that they already claim. The utilities would like to be able to consider the energy required to withdraw, deliver, and treat water so they could receive even more energy savings credit for water-use reductions that they have already implemented. They would also be interested in adding new water conservation programs as long as the programs prove to be an efficient way to increase earnings. However, before regulators can award such credits to the utilities, they must complete a thorough assessment of the life-cycle energy required to produce a unit of water must be completed.

The question then becomes, if the utilities are going to be awarded credit for the life-cycle energy saved by conserving a unit of water, should they also be awarded (or penalized) for the life-cycle energy savings of compact florescent light (CFL) bulbs, or high-efficiency appliances? If replacing an old refrigerator with a more efficient one used more life-cycle energy than it saved, would the utility be willing to be penalized rather than awarded? Theoretically, it is only fair to demand that utilities be both awarded for life-cycle energy savings and penalized for energy increases. Presently, this is a moot point because it will be a number of years before adequate data exists to accurately calculate the life-cycle energy use for all products on the market.

Still, there is significant interest in identifying the life-cycle energy associated with water in particular, likely because manufacturing water consumes so much of California's electricity (nearly one-fifth), and because water is such essential to survival.

B. Policy Challenges Related to the Water-Energy Nexus

The current manifestation of California regulatory interest in studying the merits of using utility energy efficiency funds and water utility conservation funds to reduce water consumption is a one-year pilot program (described below), originally scheduled to end June 30, 2009. Developing a credible approach to predicting and measuring energy savings resulting from water conservation is crucial to the success of the pilot program. The utilities and regulators are looking for cost-effective ways to invest in water conservation by studying the effectiveness of various program models and measuring the resulting water and energy savings. Since the energy saved by conserving water is dependent on the way water is withdrawn, conveyed, and treated, those savings will likely vary with geography and water provider.

Consideration of the combined benefits of water and energy savings raises interesting public policy challenges. Program designers must view the merits of spending ratepayer dollars exclusively from the ratepayer's perspective. Policy makers must determine a fair means for allocating program costs between the energy customers and the water customers. Regulators in California limit energy

efficiency funding to investments that are cost-effective to the direct beneficiary and to the greater body of ratepayers. Similar constraints often apply to water utility conservation programs.¹⁷ However, when a single program relies on the support of both an energy utility and water utility, flexibility in assessing cost and benefits may be required.

Such combined programs raise jurisdictional challenges as well. In California, the same governmental agency oversees regulated energy utilities and regulated water utilities. That agency could manage joint water conservation programs between regulated entities with relative ease. However, municipal water agencies deliver more than 80% of California's water and are not subject to direct regulation. Joint programs between regulated energy utilities and municipal water agencies may require formal operating agreements and raise different accountability concerns.

IV. PLACING WATER CONSERVATION IN AN ENERGY EFFICIENCY CONTEXT

A. *Traditional Energy Efficiency vs. Saving Energy Through Water Conservation*

Traditional energy efficiency focuses on reducing direct energy consumption in the use phase of a product, whereas nontraditional energy efficiency considers reducing energy consumed over the whole life cycle of a product. For example, one typical energy efficiency tactic is to replace incandescent light bulbs with compact fluorescents (CFL). This reduces the energy consumed directly by the light bulb during its use. The nontraditional way to look at the replacement of the light bulb would be to consider not only the energy saved during the use phase, but also to compare the energy required during raw materials acquisition, manufacturing, use, and end-of-life of both light bulbs in order to determine which bulb is "better". This example can be extended to high-efficiency refrigerators, clothes dryers, air conditioning units, and many other appliances.

Similarly, traditional energy efficiency as it applies to water focuses on reducing hot water use to save energy. For example, a typical energy efficiency measure may be to install low-flow showerheads in order to curtail hot water use, thereby saving energy. This reduces energy consumed directly by heating water—again, in the use phase. The nontraditional approach to energy efficiency applied to water is to also consider the energy required to bring water to the location where it is heated and then to carry the used wastewater away, in addition to simply considering energy to heat the water.

The fact that energy is required to produce and deliver water to the right place, at the right time, and of the right quality means that there is an opportunity to improve energy efficiency by making changes to the manufacturing phase of

17. See Calwater.com, Conservation Recommendations, <http://www.calwater.com/conservation/recommendations.php> (last visited Nov. 10, 2009).

water. There are three general ways to improve the energy efficiency of water use: reduce the amount of water used for a given task, reduce the energy required to manufacture and deliver each unit of water, or increase the amount of work the water does during its life cycle. The first approach is consistent with traditional energy efficiency. The second and third approaches, however, cannot appropriately be considered from the perspective of an energy consumer without examining the entire life cycle of a unit of water. Looking at only one or two phases of the life cycle, as is done in traditional energy efficiency, will not suffice. This is an important distinction.

For traditional energy efficiency, a unit of energy or water saved is simply a unit saved and it does not matter how it was saved. However, the embedded energy in the water used in the San Francisco Bay Area (where water flows largely by the force of gravity from the high Sierras) is very different from water used in many areas of southern California (where huge volumes of water are pumped hundreds of miles and over the Tehachapi Mountains to get to customers). In addition, energy use for water can differ significantly from one community to another, even within the same region. In summary, if one is interested only in water savings, then saving water in any of the life cycle phases without considering the other phases is sufficient. However, if one is interested in energy savings as well as water savings, then all life-cycle phases of water must be considered and one must pay close attention to the role geographic regions play in water's life cycle.

B. Energy Savings from Water Management Strategy

The geographic impact of the water's source, quality, and proximity to its end users are not the only factors that are important in calculating the energy embedded in manufacturing water. A water agency's water management practices can have a big impact on energy use within a region. Water management strategy will determine when an agency pumps its water and where the water goes, as well as how the agency uses available storage capacity. The strategy should also describe what to do in times of drought or surplus to meet demand, how to prepare resources for future shortages, and how to manage wastewater. Furthermore, an effective water management strategy should describe a plan for meeting needs while minimizing costs and environmental impacts.

For example, it might make more sense for an agency to pump water at night during off-peak electricity hours to save money and to avoid using electricity at times of high demand. To do this, the agency would need sufficient water storage capacity. In times of surplus, a water agency may decide to sell extra water to another agency, store it, or recharge groundwater reservoirs with it. During a drought, an agency may tap groundwater reservoirs, import water from other agencies, install desalination plants (if near the ocean or brackish water), or implement conservation measures. The El Dorado Irrigation District offers a good case study of how water management strategy can be used to reduce on-peak

energy use. By adding a five million gallon storage tank to its system and allowing water levels to drop to lower minimum levels, it reduced its on-peak energy use by 60%.¹⁸ Energy savings associated with saving a unit of water will greatly depend on the choices a water agency makes, the water source, its proximity to the source, and other regional factors.

V. THE ENERGY SAVINGS CHALLENGE: DETERMINING WHAT ENERGY IS ACTUALLY SAVED

A. *The California Energy Commission Study—Its Basis and its Limitations*

The California Energy Commission (CEC), one of the two agencies in the state with significant energy regulatory responsibility, changed the policy landscape related to energy embedded in water with the publication of the results of two studies in 2005¹⁹ and 2006.²⁰ In these studies, the CEC attempted to estimate energy savings from water conservation.

The study reports do a good job of describing methodology, compiling general data on energy embedded in water, stating the data source, and discussing the caveats of the data. We note that obtaining the data for these studies is a very complicated task and we commend the CEC. However, there are several conclusions presented in the 2006 report that must be reviewed with caution because of the potential to misinform policy-making.

The CEC reports acknowledge numerous times that the energy required to produce water—especially in the supply and conveyance phases—is highly dependent on geography. Geographical region dictates the topography (i.e. elevation gain), climate, distance to water sources, available water resources, and water quality, all of which impact process design and scale.²¹ Geography even plays a part in how much of the supplied water needs to be potable (versus treated to lower quality standards) and what percentage of water is heated, since regions vary by climate and by land use (industrial, agricultural, urban, etc).

Nonetheless, the CEC continued the practice of other recent studies²² by presenting energy savings estimates as averaged values for northern California and southern California. Tables A and B show the values presented by the 2005 and 2006 CEC reports.

18. FINAL STAFF REPORT, *supra* note 1, at 51.

19. *Id.* at 3.

20. NAVIGANT CONSULTING INC., CAL. ENERGY COMM'N, CEC 500-2006-118, PIER FINAL PROJECT REPORT: REFINING ESTIMATES OF WATER-RELATED USE IN CALIFORNIA 1 (2006) [hereinafter PIER FINAL PROJECT REPORT].

21. *Alternative Water Supply Systems*, *supra* note 11, at 342.

22. FINAL STAFF REPORT, *supra* note 1, at 11; ROBERT C. WILKINSON, METHODOLOGY FOR ANALYSIS OF THE ENERGY INTENSITY OF CALIFORNIA'S WATER SYSTEMS, AND AN ASSESSMENT OF MULTIPLE POTENTIAL BENEFITS THROUGH INTEGRATED WATER-ENERGY EFFICIENCY MEASURES (2000); R. COHEN, B. NELSON & G. WOLFF, ENERGY DOWN THE DRAIN: THE HIDDEN COST OF CALIFORNIA'S WATER SUPPLY 7 (2004).

Table A

	Northern California	Southern California
	kWh/MG	kWh/MG
Water Supply and Conveyance	150	8,900
Water Treatment	100	100
Water Distribution	1,200	1,200
Wastewater Treatment	<u>2,500</u>	<u>2,500</u>
Total	3,950	12,700
Values used in this report	4,000	12,700

Table B

	Indoor Uses		Outdoor Uses	
	Northern California	Southern California	Northern California	Southern California
	kWh/MG	kWh/MG	kWh/MG	kWh/MG
Water Supply and Conveyance	2,117	9,727	2,117	9,727
Water Treatment	111	111	111	111
Water Distribution	1,272	1,272	1,272	1,272
Wastewater Treatment	1,911	1,911	0	0
Regional Total	5,411	13,022	3,500	11,111

The authors of the reports acknowledge that disaggregated values would be more useful, but they cite a lack of available data as the reason for not relying on disaggregated values. However, in the 2006 CEC report, the authors present a matrix of energy intensity data for five different water supply sources, eight regions for conveyance, and two to four values for different types of distribution, wastewater treatment, and wastewater disposal, as shown in Table C (units are kWh/MG). It would be more instructive for policy-makers if the entire matrix was presented as the main result rather than presenting an average of the values in the matrix.

Table C

Supply	Conveyance	Treatment	Distribution	Wastewater Collection	Wastewater Treatment	Wastewater Disposal
Surface Water (0)	SWP-L.A. Basin (8,325)	EPRI Avg. (100)	EPRI Avg. (1,200)	Average of 140 is aggregated within treatment	Trickling Filter (955)	Gravity Discharge (0)
Groundwater (4.45/MG/Foot)	SWP-Bay Area (3,150)		Flat Topography (proposed)		Activated Sludge (1,322)	Pump Discharge (400)
Ocean Desalination (13,800)	SWP-Central Coast (3,150)		Moderate Topography (proposed)		Advanced (1,541)	
Brackish Water Desal (1,240-5,220)	SWP-San Joaquin Valley (1,510)		Hilly Topography (proposed)		Advanced w/Nitrification (1,911)	
Recycled Water (0)	CRA-L.A. Basin (6,140)		Recycled Water (1,200-3,000)			
	Hetch Hetchy-Bay Area (0)					
	Mokelumne Aqueduct (160)					
	Local/Intrabasin (120)					

The data in Table C is still too general, but it more accurately suggests the variability in energy use for water. It can be seen from the numbers in this table that there is a large range of energy intensities for conveyance in northern California, making averaging especially non-representative of reality.

The authors clearly understand the importance of using region-specific data, but they do not make that point clearly enough to be sure that readers will not miss-use the findings in the conclusion. The report states that the averaged numbers are “sufficient for informing policy and prioritization of research and development investments,” but warns that disaggregated data is needed for decisions on where utilities or water agencies should invest.²³ Although reliable disaggregated numbers did not exist, policymakers, utilities, and at least one environmental group responded enthusiastically to the promise of great energy savings suggested by the CEC averages.

23. PIER FINAL PROJECT REPORT, *supra* note 18, at v.

It could be concluded from the averaged values that water supply and conveyance is the most energy-intensive step of water's life cycle, and therefore research and development funds should be invested to reduce that energy intensity. Beyond that statement, however, very few accurate judgments about water's energy intensity for the sake of policy can be made. This is illustrated by the potential scenario of investing in a program to reduce water use in a specific district based on the northern California average energy-intensity value, only to realize later that the energy associated with water in that district is very low. Energy-efficiency dollars might be better spent on conserving water in a district where the water savings would result in larger energy savings. This is not to say that a region with a high energy-intensity value for conveying water would automatically save energy by reducing water use. It is much more complicated than that.

Another misleading conclusion from the 2006 report involves the energy needed to deliver and treat the next unit of water, which comprises the marginal energy requirement. It is reasonable to assume that the marginal energy source embodies the energy savings related to water conservation. The CEC used imports from California's State Water Project (SWP) as the marginal source of water for both northern and southern California in order to reach the energy intensity numbers for conveyance of water.²⁴ It would be incorrect to assume that the SWP is a marginal water source for many water agencies. For instance, the Metropolitan Water District, the largest wholesale water provider in Southern California, considers SWP resources one of two primary sources of water, but considers conservation and local projects and supplies as marginal.²⁵ The purpose of calculating the energy intensities of different phases of water's life cycle is to find the amount of energy that could be saved by reducing the volume of water used. If SWP imports are considered the marginal water source, then it is implied that SWP imports would decrease in a water district if that district conserved water. However, as discussed in the next section, this is not likely to happen.

Despite the many useful contributions of the CEC reports, they present two conclusions that are of questionable value for policymakers. First, it is a misunderstanding to assume that water's energy intensity is well represented by a value for northern California and a value for southern California. Second, the studies' authors should not have assumed that water conservation in southern California will reduce pumping on the SWP. Policy makers should carefully consider the merit of these conclusions before using them in policy decisions.

24. We discuss the SWP in more detail, below.

25. METRO. WATER DIST. OF S. CAL., THE REGIONAL URBAN WATER MANAGEMENT PLAN 160 (2005), available at <http://www.mwdoc.com/documents/2005UWMPFinal-EntireReport.pdf>.

B. The Peculiarities of the California State Water Project

The SWP is the largest water agency in California. It is also the largest single user of electricity, requiring three percent of California's electricity to pump water hundreds of miles around the state and over the Tehachapi Mountains. Pumping water over the Tehachapi Mountains is particularly expensive because it involves an elevation gain of approximately 3000 feet.²⁶ This makes it seem logical to target the SWP for reductions in energy consumption. It has been suggested by previous comments²⁷ and studies²⁸ that the volume of water pumped through the SWP can be reduced by conserving water in districts that import water from the SWP, thereby also reducing energy used. This assumption is questionable,²⁹ because water districts that conserve water are unlikely to turn away their allocated water imports. Because a supply option once lost may never return, water districts are more likely to store the water for future shortages, refill reservoirs, or sell excess water to other districts.

The SWP may be motivated to continue pumping more and more water as far south as possible. The SWP is the largest non-utility power producer in California. Although it uses far more electricity than it generates, the SWP nearly breaks even on costs because it does most of its water pumping at night when electricity is cheap (after storing the water in high-elevation reservoirs in the Tehachapi Mountains). It then produces electricity from hydroelectric plants and can sell it at a high price on the spot-market during times of high demand as it flows down the mountains. The SWP has an economic incentive to pump its water as far south as possible so that it can generate more energy and drop that energy on the spot market at an advantageous time.³⁰ SWP generates the most electricity in its four southernmost delivery zones (Figure 5). The less water it sells to points further south, the less money the SWP makes from electricity sales.

26. NDRC, CEC water energy relationship.

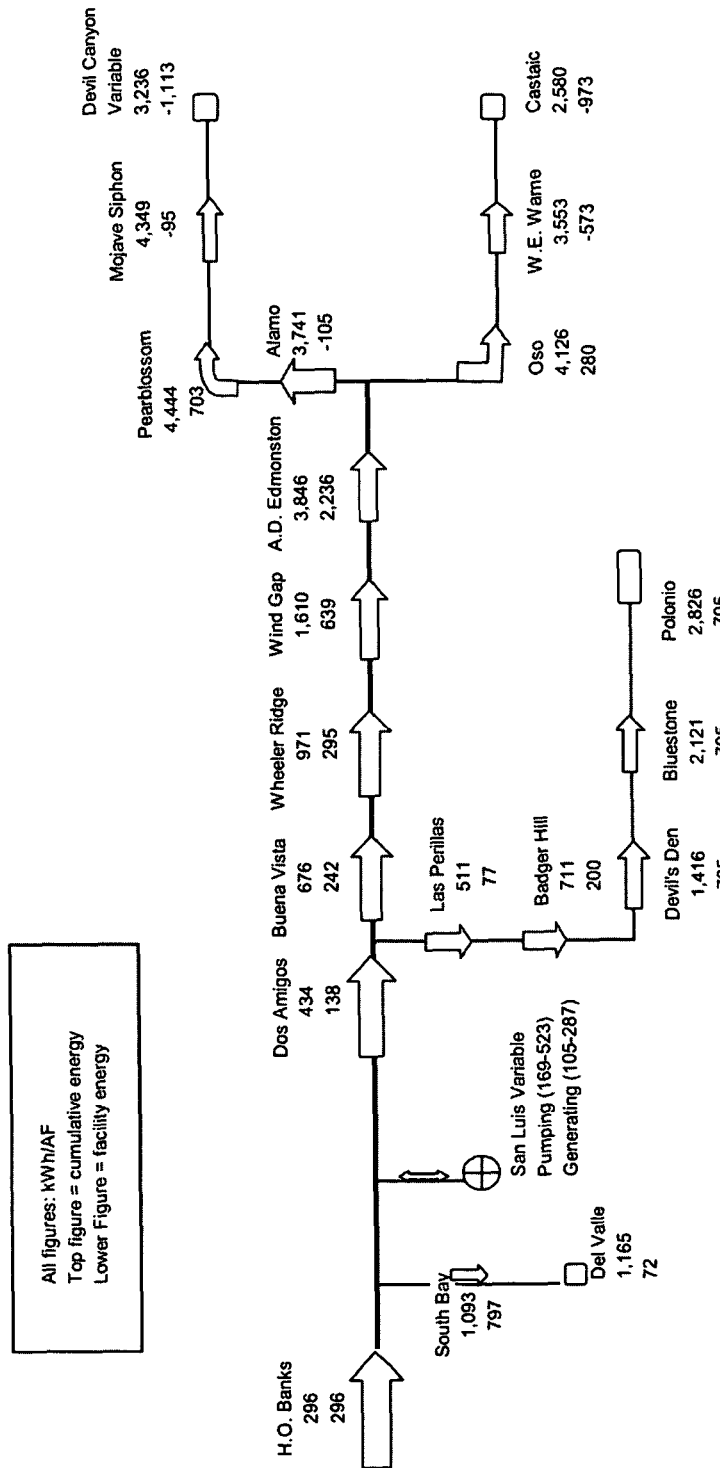
27. CAL. PUB. UTILS. COMM'N, SOUTHERN CALIFORNIA EDISON COMPANY'S RESPONSE TO COMMENTS ON THE UTILITIES' PROPOSED WATER PILOT PROGRAM 2 (2007), available at <http://docs.cpuc.ca.gov/efile/RESP/70592.pdf>.

28. PIER FINAL PROJECT REPORT, *supra* note 18, at 3.

29. *But see* METRO. WATER DIST. OF S. CAL., *supra* note 23, at 172 ("MWDOC is committed to programs that maximize existing water resources and minimize the region's dependency on imported supplies.").

30. CAL. PUB. UTILS. COMM'N, COMMENTS OF THE UTILITY REFORM NETWORK AND THE DIVISION OF RATEPAYER ADVOCATES 12-13 (2007), available at <http://docs.cpuc.ca.gov/efile/CM/70326.pdf>.

Figure 5



Source: Dr. Robert Wilkinson, PhD, University of California, Santa Barbara, based on DWR data.

Another characteristic of the SWP leads to the possibility that conserving water in one area of southern California could actually result in an *increase* in energy use. This is because all available water on the SWP tends to be used (if not consumed, it is stored, used to recharge groundwater, or sold to another entity), and so conservation of water in one area may very well result in the conserved units being shipped further south. This requires even more electricity than what would have been used otherwise. Even though there is some electricity generated by the SWP moving water further south, the transportation requires several times more energy than it produces (again, see Figure 5). Complexities such as this are what make life-cycle assessment a crucial tool in correctly evaluating whether an action results in net energy savings or net energy use in the life cycle phases involving water transportation.

In addition, it is not clear that a water agency that successfully reduces demand would respond by waiving its rights to some increment of supply from the SWP. An agency might choose, instead, to store currently-unneeded water for later use, sell it to another agency, or inject it into an aquifer.

It is important to acknowledge that conserving water likely will lead to some energy savings somewhere, but it is unclear if the energy savings will occur on the SWP. Policy makers have much work to do before the potential savings will be clear in any location. For instance, there may be less desalination in the future if water is presently conserved, stored, or used to replenish groundwater reserves.

VI. THE CALIFORNIA PILOT PROGRAM

A. *Description of the California Pilot Program*

The California Public Utilities Commission (CPUC) approved one-year pilot programs for the largest regulated energy utilities, enabling them to develop partnerships with water agencies, undertake specific water conservation programs, and measure the results. The Commission directed the energy utilities to fund studies necessary to better understand the relationship between water savings and the reduction of energy use, as well as the extent to which those reductions would vary among water agencies.

The goals of these programs are to determine if it is possible to save a measurable amount of energy by saving a measurable amount of water and to determine if water conservation programs are cost-effective investments for the energy utility. An important question is who would pay for these programs—the energy utility customers, the water utility customers, or another entity? Another important question is who would benefit from the monetary savings experienced by the utility. Program costs should be distributed in a manner that is fair for all parties involved. At the same time, all of society benefits if a water crisis can be avoided—from citizens who need clean drinking water to businesses that need water for manufacturing or power production. In addition, the ecosystems people rely on for recreation, inspiration, and livelihood also depend on water resources.

Considering the across-the-board need for water resources, it is especially important to determine a fair way to finance water conservation efforts.

The California Public Utilities Commission, which regulates the investor-owned water and energy utilities in the state, has long promoted energy efficiency programs that are among the most ambitious and far-reaching in the nation. The CPUC also issued a Water Action Plan,³¹ which expresses a commitment to promote water conservation programs as ambitiously as the energy efficiency efforts. The Water Action Plan emphasizes the importance of reducing the energy needed by water utilities for water pumping, purifying, and processes like desalination. The plan supports programs aimed at reducing energy waste by water utilities resulting from system leaks, poorly maintained equipment, defective meters, and improperly operated systems.

The pilot programs and studies were to begin January 1, 2008, run for eighteen months, and consist of three phases. First, the utilities were to design programs while working with the CPUC's Energy Division to retain consultants to conduct evaluations and studies. Second, the consultants were to begin baseline studies and work with the utilities to ensure the pilot programs were likely to produce useful information. Finally, the utilities were to implement the approved pilot programs for one year, beginning July 1, 2008. Because of subsequent delays, regulators now expect the pilot period to end December 31, 2009, with related studies to follow during the next quarter.

Cumulatively, the energy utilities were authorized to spend approximately \$6.4 million on this effort. The hope was that the results of this pilot process would inform later decisions about the incorporation of water conservation efforts in the energy efficiency programs.

The following table sets forth the programs, evaluations, and studies that the CPUC approved in its initial decision:

31. CAL. PUB. UTILS. COMM'N, WATER ACTION PLAN 10 (2005), available at ftp://ftp.cpuc.ca.gov/PUC/hottopics/3water/water_action_plan_final_12_27_05.pdf.

Table D

Adopted Programs, Evaluations and Studies		
Programs		CPUC Adopted \$
SCE	Low Income Direct Install HET (multifamily)	\$200,000
	Express Water Efficiency	\$133,000
	Lake Arrowhead Water Conservation	\$176,500
	Water Leakage	\$300,000
PG&E	Large Commercial Customer	\$700,000
	Low Income Single Family HET Replacement	\$200,000
	Emerging Technologies in Water Utility Efficiency	\$341,000
SDG&E	Managed Landscape	\$250,000
	Large Industrial Customer Audits	\$496,000
	Recycled Water	\$250,000
SCG	CLAWA/EMWD Gas Pump Testing	\$436,407
	LACSD/SCE/SoCal Gas Water Conservation	\$150,000
total		\$3,632,907
Evaluations	Impact Evaluations*	
	Commercial and Industrial Pilot Programs	
	i. Commercial programs (PG&E)	\$123,000
	ii. Industrial Audits/Express Efficiency (SCE)	\$50,000
	iii. Industrial Water Audits (SDG&E)	\$75,000
	HET Replacement Programs (Single and multifamily) (PG&E and SCE)	\$250,000
	Weather-Based Irrigation Controller Programs (SDG&E and SCE)	\$50,000
	Emerging Technologies (PG&E)	\$100,000
	Residential Indoor/Outdoor for Lake Arrowhead (SCE and SCG)	\$91,000
	Leak Detection (SCE)	\$50,000
	Recycled Water (SDG&E)	\$50,000
	Process Evaluations**	\$128,000
total		\$967,000
Studies	Studies	
	Load Profile (all IOUs)	\$475,300
	Toilet Flapper (all IOUs)	\$20,000
	Statewide/Regional Water-Energy Relationship	\$425,000
	Water Agency /Function Component	\$850,000
total		\$1,770,300
Total	total evaluation and studies (EM&V)	\$2,737,300
	Total Pilot (Pilots + Evals + Studies)	\$6,370,207

*Impact evaluations will be conducted by Energy Division.

**Process Evaluations are 2% of total pilot budget and will be overseen by the utilities

In a 2005 decision, which preceded approval of the pilot program, the Commission declared its intention to, “explore the issue of counting embedded energy savings associated with water efficiency by informal or formal procedural vehicles in our rulemaking proceeding”³²

In subsequent comments, parties described two types of energy savings: cold water savings (related to the production, transportation and treatment of water), and hot water savings (those related to reducing the use of energy to heat water for end-use purposes). The pilot program focuses on cold water savings. The commenting parties identified four ways to reduce net energy consumption related to cold water:

1. Conserve water;
2. Use less energy-intensive water (gravity-fed or recycling versus groundwater, aqueducts or desalination);
3. Make delivery and treatment systems more efficient; and
4. Produce more energy through water delivery and treatment.

Most parties asked the Commission to approve a pilot program to explore the potential for future programs to capture water-related embedded energy savings, as the Commission subsequently did.³³ The approved programs include toilet replacements, leakage detection, landscape management, and large customer audits.

B. California’s Energy Calculator—Its Uses and Limitations

The CPUC developed a spreadsheet-style calculator to compute the amount of energy savings for a given unit of water saved. This is an important tool for advancing consideration of embedded energy water conservation programs. Based on user inputs about the water-saving measure and the volume of water saved, the calculator finds the annual energy saved. It does this by implementing a set of measures or an entire program, computing the annual avoided cost and lifetime avoided cost, and determining a ratio of the total resource benefit/cost for a measure or an entire program. The calculator can also produce the total utility program budget, the greenhouse gas emissions for a program, and can compare different utility programs.

32. CAL. PUB. UTILS. COMM’N, INTERIM OPINION: ENERGY EFFICIENCY PORTFOLIO PLANS AND PROGRAM FUNDING LEVELS FOR 2006-2008—PHASE 1 ISSUES, Decision 05-09-043, at 167 (2005), *available at* http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/49859.pdf.

33. CAL. PUB. UTILS. COMM’N OPINION: ORDER APPROVING WATER PILOT CONSERVATION PROGRAMS WITHIN THE ENERGY UTILITIES’ ENERGY EFFICIENCY PROGRAMS, Decision 07-12-050 (2007), *available at* http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/76926.htm.

Like any calculator of this sort, it has several limitations. For instance, the calculator focuses on energy (gas or electric) purchased from the utilities because it is limited to calculating cost-effectiveness for society and the funding utility. It does this despite the fact that some water agencies purchase additional power or generate their own. Further, the designers of the calculator use average values because some data does not exist at a disaggregated level. This causes errors in the results because energy embedded in water is so dependent on location. Water districts that are well-represented by the averaged values may have very small error margins due to the use of aggregated data, but water districts that are far from the average may have huge error margins. Furthermore, those compiling the data often had to collect it from the water agencies themselves. It is not possible to verify the reported data, or know how the data was collected, or even to use some proprietary data.

User errors are another limitation of the calculator. A user might not choose the correct district or region when using the calculator or might not interpret the results from the calculator with an understanding of limitations on the data. These errors could produce faulty conclusions. It is recommended that anyone using the energy calculator to draw conclusions from the CPUC pilot project first become well acquainted with the sources of the data and with the calculator's abilities and limitations. When using the calculator to prepare reports about the pilot project, analysts should carefully explain the sources and limitations of the data used to obtain the results.

C. Expectations—What Might Happen Once the Program Ends

The goal is to enable the large utilities and regulators to identify water conservation strategies that are cost-effective from the standpoint of energy utility customers. Perhaps the pilot program will demonstrate that some of the strategies employed are cost-effective. Regardless, the underlying studies should enable the Commission staff to fine-tune its "calculator" for use in exploring other promising program options. The intent would be for energy utilities to include cost-effective water conservation measures in future energy efficiency programs.

D. Measurement and Evaluation of the CPUC Pilot Programs

Accurate measurement of both the water savings and the related energy savings is critical to an assessment of cost-effectiveness. In describing the pilot program, the Commission describes in detail the methodology it intends to use to measure the water savings achieved by each measure, relying heavily on pre and post retrofit data from both water bills and water meters.³⁴ The CPUC staff

34. CAL. PUB. UTILITIES COMM'N, ORDER APPROVING PILOT WATER CONSERVATION PROGRAMS

intends to determine the energy saved by using the energy calculator that was described previously.

The challenge with accurately measuring water savings is that the measurements need to reflect usage—not just once when the retrofit is first completed, but over the lifetime of the retrofit. Consider, for instance, the replacement of a toilet that is shown to flush the proper amount of water when first installed, but begins to leak over time and five years later it may be shown to use much more than its rated amount of water. If this is not corrected with maintenance, then the toilet's water use over its lifetime will be drastically higher than anticipated. This example demonstrates the need for periodic audits and appropriate maintenance to ensure that the water and energy conserved is actually measurable rather than just predicted.

Consider, for instance, buildings that are LEED-certified (Leadership in Energy and Environmental Design), meaning they have been designed in a manner approved by one independent organization with the intent of delivering exceptional energy savings. As discussed in the paper by Scotfield and the responses to that paper,³⁵ an audit of a LEED-certified building in Oberlin, Ohio two years after completion found the building was using much more energy than was predicted, and it overall had no better efficiency than a non-LEED building. Other studies have shown that LEED buildings save energy on average, but perform sporadically.³⁶ It is very important to anticipate these types of discrepancies between predicted and measured performance for water conservation programs as well, and to do everything possible to bring measured savings closer to predicted savings.

The CPUC should require periodic auditing and maintenance of the approved water-saving measures to ensure that the expected water savings are indeed the savings that are achieved. Without basic maintenance, the pilots may produce fewer savings of water and energy over time. It is recommended that the CPUC include an audit and maintenance plan for each of the measures in the pilot program.

VII. CONCLUSION

A. *What the Pilots Will Show and What They Will Not Show*

As a result of the California pilot program, analysts should come closer to understanding the merits of having the energy utilities develop ongoing water

WITHIN THE ENERGY UTILITIES' ENERGY EFFICIENCY PROGRAMS, Decision 07-12-050, Appendix B at 2 (2007), available at http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/76926.pdf.

35. John H. Scofield, *Early Performance of a Green Academic Building*, 108 ASHRAE TRANSACTIONS 1213, XX (2002).

36. CATHY TURNER & MARK FRANKEL, ENERGY PERFORMANCE OF LEED FOR NEW CONSTRUCTION BUILDINGS 5 (2008), available at http://www.newbuildings.org/downloads/Energy_Performance_of_LEED-NC_Buildings-Final_3-4-08b.pdf.

conservation programs. More will be known about the cost of implementing each water-saving measure and the amount of water used before and after retrofit. However, to know how much water each measure will ultimately save, analysts will have to consider water use over a longer period of time, and adjust the observed usage to account for factors such as weather, occupancy, or building closure. Although more will be known about the amount of energy saved through water conservation in several parts of the state, data collection in the water districts will need to be more extensive to develop a comprehensive picture.

Participants will also learn about the efficacy of water agencies and energy utilities combining forces to reduce water use. From the outset, it was evident that the two types of organizations exist within different cultures. In establishing the pilot, the Commission talked about encouraging productive interaction between the two groups, and sparking creative new programs. Perhaps because of the limited opportunity inherent in a quickly-developed pilot program, the number of new working relationships spawned by this experiment seems limited, and the process has resulted in few new programs. Perhaps, as well, there are institutional and language barriers that these different organizations need to work to overcome.

With the limited number of water conservation options that the participants are exploring through the pilot, policymakers and utilities will not have developed a comprehensive list of cost-effective measures for future implementation. Because of the need to determine location-specific embedded energy values, these same entities will not have a fully developed means of assessing cost-effectiveness in the future. Yet, the societal imperative of conserving water and reducing the use of fossil fuels, and the inherent logic of expecting water conservation to result in reduced energy consumption, ensure that the pilot offerings will be only the beginning. It is the what (which measures) and the how (who will pay and who will manage the programs) that remain to be discovered.

B. New Models That Might Help Make This Work

There are places, such as the City of Los Angeles, where one entity delivers both water and power. In most locations, however, there are two different service providers which do not work together often. Without a significant cultural shift, it might be unduly optimistic to expect that the providers alone will develop optimal strategies for joint water conservation efforts. There is an opportunity to introduce additional participants who could work to develop joint programs for the water and energy providers.

One potential model is that of a “third-party broker,” in which a broker would develop credible embedded energy values for a given location and develop programs to sell to the energy and water providers serving that location. The third-party broker would be the go-between for the energy and water utilities, collecting the necessary data from each utility and completing a cost-benefit

analysis to determine if it makes financial sense to invest in such measures. The broker could also develop a means for allocating program costs between the energy and water providers.

In a variation on this model, the third party broker could sell services, such as installation of retrofits or evaluation/measurement of savings due to retrofits. Here, the broker would manage all of the retrofit installations as well as the evaluation of the performance so that neither the water nor the energy utility would need to develop expertise in this area. A third approach would be to create a new water-conservation and energy-efficiency utility. With this approach, the existing water and energy utilities would contribute ratepayer funds to the new utility, which would design and implement cost-effective water conservation programs to maximize energy savings. Hopefully, policymakers in California and elsewhere will be interested in exploring these and other variations after the completion of the pilot program and related studies.