The Critical Role of Water and Wastewater Agencies in Meeting California's Future Energy Needs

Martha Davis, Inland Empire Utilities Agency
Laurie Park, Navigant Consulting, Inc.

ABSTRACT

The 2005 Integrated Energy Policy Report prepared by the California Energy Commission (CEC) evaluated the relationship between energy and water resources in California "to better understand this link and determine what, if any, mutually beneficial strategies can be developed to improve both the water and energy sectors." (CEC 2005) The CEC's conclusion was that much can be done to improve both water and energy systems to reduce energy demand and to create new renewable energy supplies for the State.

However, relatively little information is available about actions taken by the water industries in California to address these issues. The Inland Empire Utilities Agency (IEUA) is a municipal water and wastewater agency that serves about 800,000 residents within the west end of San Bernardino County. This paper describes the goals and strategies being implemented by IEUA to enhance the energy efficiency of its operations and of the water supplies used within its service area, as well as to generate new renewable supplies of power.

The direct benefits of IEUA's programs include improved access to more reliable and cost effective sources of energy, and a reduced need for power from the State's overburdened grid. Additionally, by reducing the "energy intensity" of its water supplies, IEUA is indirectly helping California reduce statewide energy demand, particularly during critical peak times. IEUA's success in implementing these projects underscores the importance of the CEC's focus on the water-energy nexus and the potential for water industries to play a significant role in reducing predicted energy supply shortfalls.

Introduction

The 2005 Integrated Energy Policy Report (IEPR), published by the California Energy Commission (CEC), indicates that California could face severe electricity shortages in the next few years due to the expected growth in the State's population and its related energy demand. (CEC 2005)

One of the critical areas identified by the CEC in addressing this challenge is the relationship between water and energy. The CEC estimates that water related energy use for the entire State currently consumes about 19% of the State's electricity. In its report, the CEC states that "(i)f not coordinated and properly managed on a statewide basis, the water-related electricity demand could ultimately affect the reliability of the electric system during peak load periods" when reserve margins are low. (CEC 2005)

The provision of water and wastewater services is, by its very nature, energy intensive. Collecting water, moving it to storage reservoirs, treating the water to make it potable, distributing the water and then recollecting it for wastewater treatment, processing the water within the facilities, and then disposing of the treated solids and re-distributing recycled water

requires the operation of many pumps, compressors and associated purification equipment. (Wilkinson 2000)

The amount of energy needed to deliver water to its end use varies with the location, source and use of the water within the state. The "energy intensity" of water supplies is used to describe the total amount of energy, calculated on a whole-system basis, required for the use of a given amount of water in a specific location.[1] This concept is particularly helpful in understanding the impact that the production and delivery of water has on the state's energy system, as most water agencies obtain their supplies from multiple sources and the energy costs are melded into the price of the water.

The CEC recognizes that improving energy efficiency is the most effective way to reduce the State's energy costs, bolster California's economy and lower the likelihood of future supply shortages that can cause expensive price spikes and affect the grid's reliability. In its 2005 IEPR, the Commission urges local water agencies, along with others, to pursue cost-effective water efficiency opportunities that would save energy and decrease the energy intensity in the water sector. (CEC 2005)

The CEC also recognizes that the state's water industry has promising opportunities to increase its generation of electricity from renewable resources, including in-conduit hydropower and the use of anaerobic digesters, which could further reduce the water sector's impact on the state's power grid. The 2005 IEPR recommends an array of policies to facilitate the ability of utilities to self-generate, including expediting and reducing the cost of utility interconnection, eliminating economic penalties such as standby charges, removing size limitations for net metering and allowing water and wastewater utilities to wheel power within their own systems.

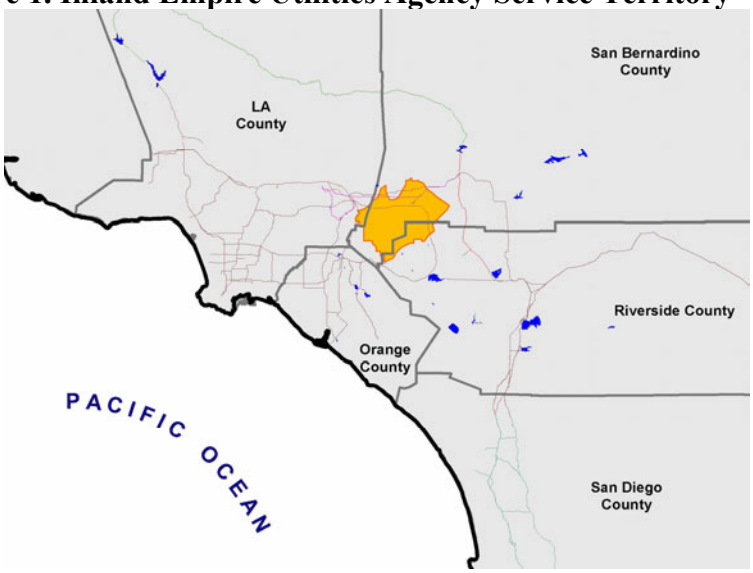
The CEC's recommendations provide an important road map for the state's water and wastewater industry to ensure that the future needs of their customers are met reliably and cost-effectively at the same time that the overall reliability of the state's energy system is enhanced. However, there is not a great deal of information on the actions that have been taken by this industry to-date to reduce its impact on the power grid and to develop renewable primary fuels such as biogas. The purpose of this paper is to present a case study of the goals and strategies being implemented by the Inland Empire Utilities Agency, a municipal water and wastewater utility located in Southern California, to enhance the energy efficiency of its operations and of the water supplies used within its service area, as well as to generate new renewable supplies of power.

Background

The Inland Empire Utilities Agency (IEUA) is a California municipal water and wastewater utility. The Agency is a wholesale distributor of imported water and recycled water, provides regional wastewater treatment services, and produces renewable energy and high quality compost products. Located in the west end of San Bernardino County in Southern California, IEUA serves about 800,000 residents within the cities of Chino, Chino Hills, Fontana, Montclair, Ontario, Rancho Cucamonga and Upland. Figure 1 shows IEUA's service area.

[1] The concept of "energy intensity of water" was developed by Dr. Robert Wilkinson, U.C. Santa Barbara, Bren School of Environmental Science and Management, as a means of comparing the relative energy needed to collect, transport, treat, use, treat wastewater, and dispose of a unit of water from different sources of supplies and for different uses. See Wilkinson 2000.

Figure 1. Inland Empire Utilities Agency Service Territory



IEUA's 242-square mile service area is located in one of the fastest growing regions in California, and it is facing the multiple water and energy challenges described in the 2005 IEPR. Population growth is expected to almost double within the next twenty years, reaching an expected 1.1 million by 2025. The retail water needed to serve this growing population is expected to increase over 70%, from 214,000 acre-feet per year to 365,000 acre-feet per year by 2025. Similarly, wastewater treatment needs are expected to almost double from the current level of 60 million gallons per day to over 110 million gallons per day.

The energy needed to meet the current wastewater treatment and water supply demands within IEUA's service area is significant. On the wastewater side, the Agency collects industrial and municipal wastewater through a network of regional wastewater sewer interceptors and two non-reclaimable wastewater sewer pipeline systems. Sewage treatment is provided by five regional plants. Recycled water is produced through tertiary treatment by all but one of the plants, which only processes solids. IEUA is also building the state's largest enclosed composting facility which is expected to begin operations in the fall of 2006. On the water side, IEUA distributes imported and recycled water and operates the Chino groundwater desalter. The current combined energy requirements for all of IEUA's facilities average 7 megawatts, with peak demand of 9 MW, as shown in Table 1.

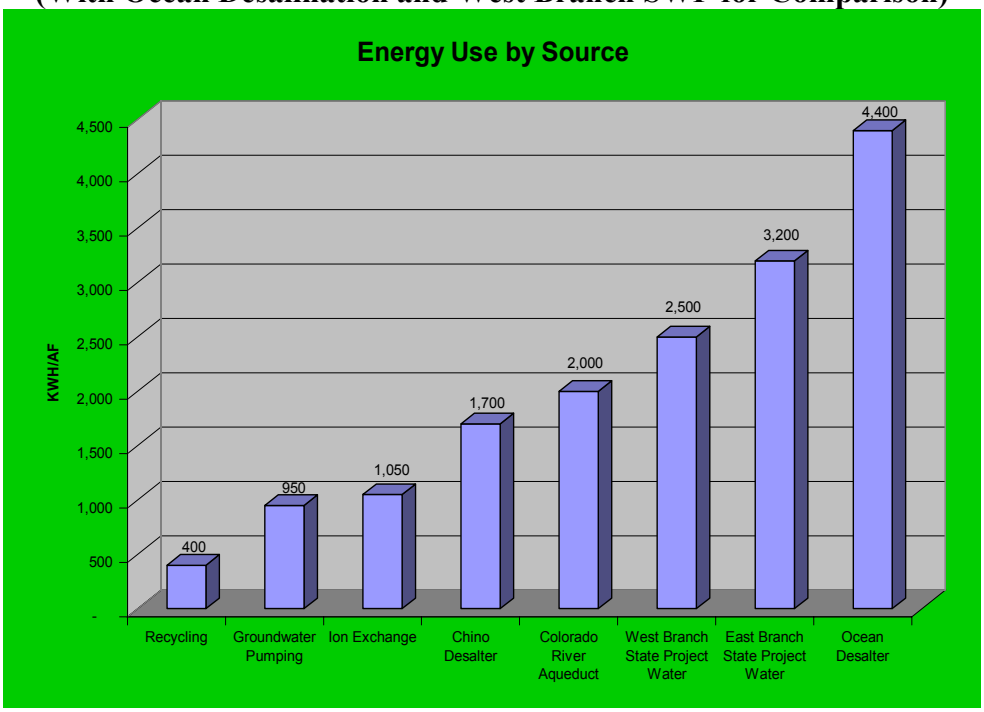
Table 1. IEUA Electric Demand

IEUA Electric Demand	Current (2006)	Projected (2010)
Average Electric Demand	7 MW	15 MW
Peak Electric Demand	9 MW	19 MW

Currently, 30% of the water used in IEUA's service area is imported from northern California through the energy intensive State Water Project, and 70% comes from local sources including groundwater, groundwater desalination, and recycled water. The energy intensity of these water supplies is estimated to range from 400 kWh/acre foot for recycled water (the additional energy needed to pump and distribute recycled water) to 3,200 kWh/acre foot for

imported water that is supplied through the East Branch of the State Water Project, as shown in Figure 2.

Figure 2. Energy Intensity of Water Supplies Within IEUA's Service Area (With Ocean Desalination and West Branch SWP for Comparison)



Source: Robert Wilkinson, University of California, Santa Barbara, based on data from IEUA, DWR, and desalination estimates.

IEUA estimates that the current amount of energy needed to meet the total water demand within its service area, based upon the energy intensity of these water supplies is about 241 million kWh/year, as shown in Table 2.

Table 2. The Energy Intensity of IEUA's Water Supply Portfolio

Year		1995		2005		2025	
Population		637,000		800,000		1,100,000	
Water Demand	AF	208,000		220,000		334,400	
Conservation	AF	-		8,600		33,400	
Supplies	kWh/AF	AF	MWh	AF	MWh	AF	MWh
Groundwater	950	145,500	138,225	152,300	144,685	198,700	188,765
Desalted Water[2]	1,700	-	0	3,900	6,630	14,200	24,140
Imported Water[3]	3,200	43,800	140,160	60,200	192,640	82,500	264,000
Surface Water	-	17,600	0	18,000	0	18,700	0
Recycled Water	400	4,700	1,880	7,000	2,800	104,000	41,600
Total Water Supplies		211,600	280,265	241,400	346,755	418,100	518,505
Average kWh/AF			755		696		806

AF = acre-feet
kWh = kilowatt hours
MWh = one megawatt hour, or 1,000 kilowatt hours

Looking to the future, with the expected population growth, the Agency's energy needs are anticipated to rise dramatically. By 2010, IEUA projects its electric load to growth by 115%, to 15 megawatts average demand and a peak of 19 megawatts. Similarly, the amount of energy needed to supply water to meet the region's growing retail needs is expected to increase significantly. Until recently, the core assumption in regional plans to meet future water needs was to increase the use of imported water. As shown above, this is the most energy intensive source of water supply available to IEUA's service area.

IEUA's Seven Point Energy Action Plan

In 2000-2001, California's energy crisis caused power costs to rise abruptly, creating an unprecedented impact on IEUA and its service area. For the first time in its fifty year history, the Agency experienced unreliable energy supplies. In one month alone (January 2001), the IEUA had over 20 days of interrupted service. Price spikes caused IEUA to spend large amounts of cash reserves on emergency back up generation to ensure that the wastewater treatment operations would not experience further interruptions.

IEUA's Board responded to the energy crisis by adopting a Seven Point Energy Action Plan in 2002. This plan has guided IEUA's energy policy over the past four years. The goals of IEUA's Action Plan are to:

1. Maximize the efficiency of office and plant operations;
2. Minimize external energy, natural gas and other fuel costs;
3. Maximize operational flexibility of plants to "roll off" the electric grid and natural gas sources, particularly during peak power use periods;
4. Maximize "self-sufficient" operations;

[2] Chino Desalter (brackish water).
[3] East Branch, State Water Project.

5. Generate new local sources of energy for plant operations and related facilities (e.g., Chino Basin Desalter), with excess generation available for sale to the grid;
6. Promote regional energy and water conservation programs; and
7. Promote development of local water supply options (that would reduce the energy intensity of water used within the Agency's service area).

IEUA's Direct Energy Actions: Energy Efficiency and Renewable Generation

During the energy crisis, IEUA evaluated its office and plant operations for conservation opportunities that could be implemented immediately. In addition, the staff took advantage of the pipeline interconnections among the wastewater treatment plants to detain wastewater flows and shift operations so that the use of power during critical peak periods could be minimized.[4]

Prior to the energy crisis, IEUA had installed and operated anaerobic digesters for processing of biosolids but had only used a small amount of the methane gas for energy generation. As a result of the energy crisis, the Agency reviewed the opportunity to increase methane gas production and embarked on an aggressive program to develop additional digester capacity and to optimize the generation of this renewable source of energy. IEUA partnered with the California Energy Commission, U.S. Natural Resources Conservation Service and the Milk Producers Council to construct a centralized anaerobic digester (plug flow system) to process dairy manure. This facility began operations in 2003, generating 750 kW of power to serve the Chino Desalter. As part of the project, IEUA tested the use of biogas in microturbines that were contributed by the South Coast Air Quality Management District.

The digester is currently being expanded to generate 1.5 megawatts, and a second anaerobic digester using a European complete mix design will be constructed in 2006 that will generate an additional 1.5 megawatts. In addition, IEUA participated in the CEC's Public Interest Energy Research Program to evaluate opportunities for optimizing the production of biogas from a variety of feedstock, including biosolids, dairy manure and food waste. (CEC, 2006)

IEUA also initiated the Renewable Energy Efficiency Project (REEP) in partnership with the U.S. Department of Energy to develop more efficient combinations of energy generation equipment and the use of waste heat. The goal of the REEP project is to achieve a minimum generation efficiency of 65%, combining innovative processes including the use of a Stirling Engine, an Organic Rankine Cycle unit, thermal energy storage and a fuel cell. The REEP project is being located in an "energy campus" at the Agency's state-of-the-art recycled water treatment facility, No. 5. One of IEUA's goals is to continue to develop more efficient processes for energy generation.

Table 3 shows a complete list of the renewable energy (biogas) generation projects that IEUA is currently implementing and the increased renewable energy (measured in therms) that IEUA expects to produce. The resource value of the estimated incremental biogas production from all of these projects is nearly $39 million over a 10-20 year lifecycle. Given recent increases in the cost of electricity and natural gas, these projects provide an important alternative source of energy that, based upon individual project review, are proving cost-effective for IEUA

[4] IEUA's wastewater treatment system is designed to be flexible and permit water flows to be diverted or detained. As a result, one of its treatment plants has the ability to turn off all treatment for up to six hours each day.

to implement. Within two years, the Agency expects to meet 60% of its energy needs through self-generation using methane gas.

Table 3. IEUA's Biogas Innovation Program

Project Name	Project Description	Est. Life (years)	Est. In-Svc	Increased Annual Therms	Increased Lifetime Therms
1. Three-Phase Thermophilic Digestion	Incremental biogas with production of Class A biosolids	20	2/2006 & 2/2007	+659,102	+13,182,040
2. Food Waste Additions	Innovative biofeedstock reduces waste streams while increasing biogas	20	6/2007 & 1/2008	+1,938,860	+38,777,200
3. Manure Digester Modifications	Full mix manure digesters using European technology increase biogas production	20	3/2007	+2,155,814	+43,116,280
4. Flared Biogas Recovery (Fuel Cells)	Innovative digester gas cleaning system allows biogas to be used to produce zero emission electricity	10	1/2008	+535,521	+2,677,605
5. Gassifier with or without production of liquefied biofuel	Commercialization of new, more efficient digestion process	15	1/2008	+1,139,698	+17,095,470
6. Digester Optimization	Installation of centralized control systems to optimize processes	15	2/2007	Included in above #s	Included in above #s
			Total Biogas Portfolio	**6,428,995**	**114,848,595**

The resource value of the estimated incremental biogas production from all of the above projects is approximately $38.7 million on a life cycle benefit basis.[5]

The Agency will continue to test and evaluate additional waste conversion technologies such as gasification as these projects provide the additional benefit of local management and use of organic materials, including biosolids, food wastes, dairy manure, and municipal green waste. IEUA developed an Organics Management Program in 2002 that addresses the need to create value added products, such has high quality soil amendment and renewable energy, from these organics. This program has proven visionary given the recent conflicts over hauling and spreading of biosolids in California's central valley. Through IEUA's organics management program, the Agency can handle all of the municipal wastes locally and is helping the local dairies and cities to process their organic material locally as well.

As part of Agency's response to the energy crisis, IEUA made energy and water efficiency a primary goal for the construction of its new 66,000 square foot office headquarters. Completed in 2003, IEUA became the first public agency to achieve the LEED Platinum Standard in the nation. The headquarters features a 60 kW rooftop photovoltaic system. Currently the facilities use the same amount of energy as two average residences. The Agency will install a cogeneration system (as part of the REEP project) that will enable the facility to operate 100% off the grid and become a Zero Energy LEED Platinum facility.

[5] Based on the California Public Utilities Commission's adopted avoided cost methodology and model developed by its consultant, E3, for estimating total resource cost of energy efficiency programs.

IEUA continues to seek additional opportunities for improving energy efficiency and the production of renewable energy in its operations. Last year, the Agency participated in the California Local Energy Efficiency Program (CALeep) Pilot Project in order to evaluate additional programs it could implement to achieve energy savings. This project evaluated 5 different areas for improvements: (1) wastewater treatment plant energy efficiency actions; (2) wastewater treatment facility lighting; (3) use of geothermal cooling for new buildings; (4) energy efficiency for recycled water pipeline projects; and (5) in-conduit hydropower. As shown in Table 4, the CALeep analysis identified additional opportunities for reducing IEUA's energy needs by over 29,000,000 kilowatt-hours at an estimated value of $4.5 million annually.

IEUA has already implemented a light switch replacement project at its headquarters, and will fund installation of energy efficient lighting for its wastewater treatment plants in the coming year. The CALeep study also resulted in additional value engineering on the recycled water pipelines to ensure that all opportunities for energy efficiency were included in these designs. One of the important outcomes of the CALeep project was the development of Energy Efficiency Design Criteria for IEUA's entire capital program. The Agency intends to include these design criteria into every proposed bid.

In-Direct Energy Actions: Local Water Supply Development

As a wholesale municipal water supplier, IEUA does not directly provide water at the retail level, but has worked closely with the retail agencies within its service area to develop local water supply options to meet the future water needs of this rapidly growing region. As described in the background section of this paper, IEUA's service area currently obtains about 30% of its water from local sources, including groundwater, desalted groundwater, recycled water, and surface flows. Based on 2005 energy prices, the value of the energy needed to deliver this water to IEUA's service ranges from $16 million to as high as $127 million, depending on the types and the quantity of water served.

Given the continuing conflicts over the State Water Project, the uncertainty over whether additional water supplies from this source will be available in the future and the increasing costs of these supplies, water supply planning within IEUA's service area has focused on the development of local water supplies and the reduction of the need for additional imported water. As outlined in its adopted 2005 Urban Water Management Plan, IEUA plans to meet future demands through increases in (1) water conservation (10% of its demand), (2) use of recycled water (95,000 acre-feet/year), (3) groundwater production (165,000 acre-feet/year), and (4) desalted groundwater (27,000 acre/feet per year). As a result, IEUA expects that the total amount of local water supplies will increase over current water production levels by more than 130,000 acre-feet per year, while projected full service imported water supplies will increase by a small amount - about 10,000 acre-feet over current levels. By 2025, IEUA expects that it will be able to meet 80% its water needs through local sources.

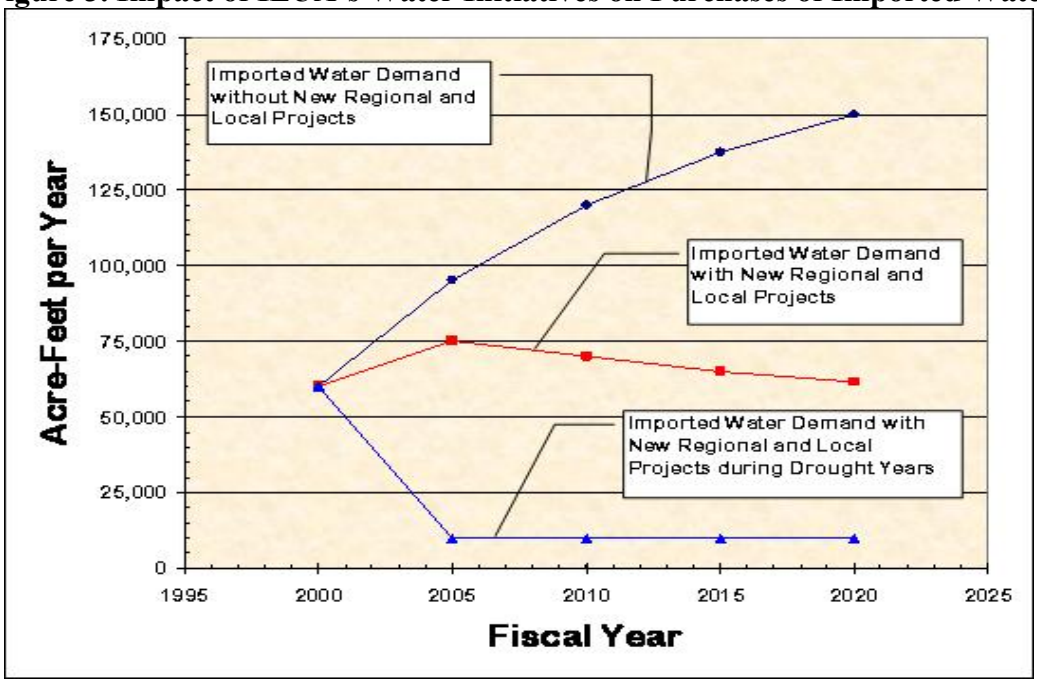
As illustrated in Table 2, these local water production strategies are expected to reduce the energy intensity of the water supply portfolio for IEUA's service area over the next twenty years. The state will realize a significant indirect benefit through reduction of the overall energy required to deliver this water to the end users.

Table 4. Energy Efficiency Opportunities Identified Through CALeep

Pilot Evaluation	Identified Opportunities	Energy Savings (kWh/year)	Current Status
Waste Water Treatment Plant Energy Efficiency/Production	Reduction in energy use and/or increase in biogas production through: • Wastewater Equalization • Activated Sludge System Optimization • Digester Gas Production Optimization	13,000,000	IEUA is commencing an R&D partnership with its electric and gas utilities to test and implement these concepts
Waste Water Treatment Plant Facility Lighting	• Replace exterior lighting with lower lumens and higher efficiency lighting options • Change lighting control strategies for all projects	1,136,000	These recommendations are being implemented.
Geothermal Building Cooling	• Consider use of utility water heating/cooling for new or existing buildings and other facilities (e.g., pump stations)	226,000	IEUA is incorporating a requirement to evaluate the costs vs. benefits of geothermal cooling in its future projects.
Recycled Water Energy Efficiency	• Increase diameter of recycled water pipelines to reduce friction and pumping energy	12,546,000[6]	IEUA is applying for incentives from its electric utility to help offset the incremental capital costs of implementing this recommendation.
In-Conduit Hydropower	• Install hydro-turbines in recycled water pipelines instead of pressure reducing valves in locations where power can be utilized	1,625,500	Since these sites are typically not adjacent to IEUA loads, the output cannot be used to offset IEUA's energy requirements. IEUA has proposed legislation that will allow it to sell the output from these types of facilities to its electric utility on an "as-delivered, must-take" basis.

[6] This represents the difference between the 2001 Recycled Water Master Plan and 2005 Recycled Water Master Plan which incorporated the CALeep energy efficiency design criteria.

Figure 3. Impact of IEUA's Water Initiatives on Purchases of Imported Water



Summary and Conclusions

The 2005 IEPR recommended that the state encourage water and wastewater utilities to become energy self-sufficient in order to alleviate stress on the state's energy resources and infrastructure. As illustrated in Table 5, IEUA's programs to promote energy efficiency and to attain energy "self-sufficiency" provide an outstanding example of how the CEC's recommendations can be implemented by the state's water industry.

Table 5. IEUA's Best Energy Management Practices

IEPR Goals	IEUA Best Practices
Increase water-related energy production	1 – Biogas Innovation Portfolio, converting complex biofeedstocks to energy through conventional (internal combustion engines) and emerging (gasification) technologies 2 – In-Conduit Hydropower Investigations 3 – Development of Dual-Fuel Combined Heat & Power Systems
Reduce water-related energy end-use	1 – Energy Policy adopted 2001 2 – Energy efficiency design guidelines & specifications for capital program 3 - Partnering with electric & gas utilities to increase efficiency of wastewater treatment systems and processes, and increase biogas production
Increase energy benefits from water storage	1 – Some treatment plants connected via pipelines to increase operating flexibility, allowing deferral of treatment to non-peak hours 2 – Investigating over-sizing of reservoirs and pipelines to further increase operating flexibility
Save energy by saving water	1 – Working with regional partners to reduce dependence on water imports, reducing the energy intensity of the region's water supplies 2 – Demonstrating opportunity for schools to integrate water and energy planning to achieve savings

The direct benefits of IEUA's programs include improved access to more reliable and cost-effective sources of energy, and a reduced need for power from the State's overburdened grid. Additionally, by reducing the "energy intensity" of its water supplies, IEUA is indirectly helping California to reduce statewide energy demands, particularly during critical peak times.

IEUA's energy achievements over the past four years are evidence that the water-energy goals identified in the 2005 IEPR are attainable. The energy projects being implemented by IEUA underscore the potential for water industries to play a significant role in reducing the state's forecasted energy shortfalls. Future work by the CEC should evaluate the potential net resource, economic and societal benefits attainable by implementing similar water and wastewater programs statewide.

References

(CEC 2005) California Energy Commission, 2005, "*Integrated Energy Policy Report*" and "*California's Water-Energy Relationship*".

California Energy Commission, 2006. "*Making Renewables Part of an Affordable and Diverse Electricity System in California"*, Public Interest Energy Research Program Area, Program Renewables and Research and Development, Contract No. 500-00-36 (prepared in partnership with Commonwealth Energy Corporation, Regional Economic Research, CH2M Hill, Endecon Engineering, The Renewable Energy Development Institute, and Zaininger Engineering Company).

Inland Empire Utilities Agency, 2005. "*Regional Urban Water Management Plan*".

Inland Empire Utilities Agency, 2005. "*Urban Water Management Plan, Chino Basin Desalter Authority*".

Inland Empire Utilities Agency, 2005. "*Urban Water Management Plan, Water Facilities Authority*".

MWH Americas, Inc., 2005. "*Recycled Water Implementation Plan*" (prepared for Inland Empire Utilities Agency).

Parsons, 2002. "*Wastewater Facilities Master Plan, Volume I and II*" (prepared for Inland Empire Utilities Agency).

Wilkinson 2000) Dr. Robert 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*", Exploratory Research Project, Ernest Orlando Lawrence Berkeley Laboratory, California Institute for Energy Efficiency, 2000.