Greenhouse Gas Emissions from Water Supply Operations: Current Inventory and Potential Reductions

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1 EXECUTIVE SUMMARY

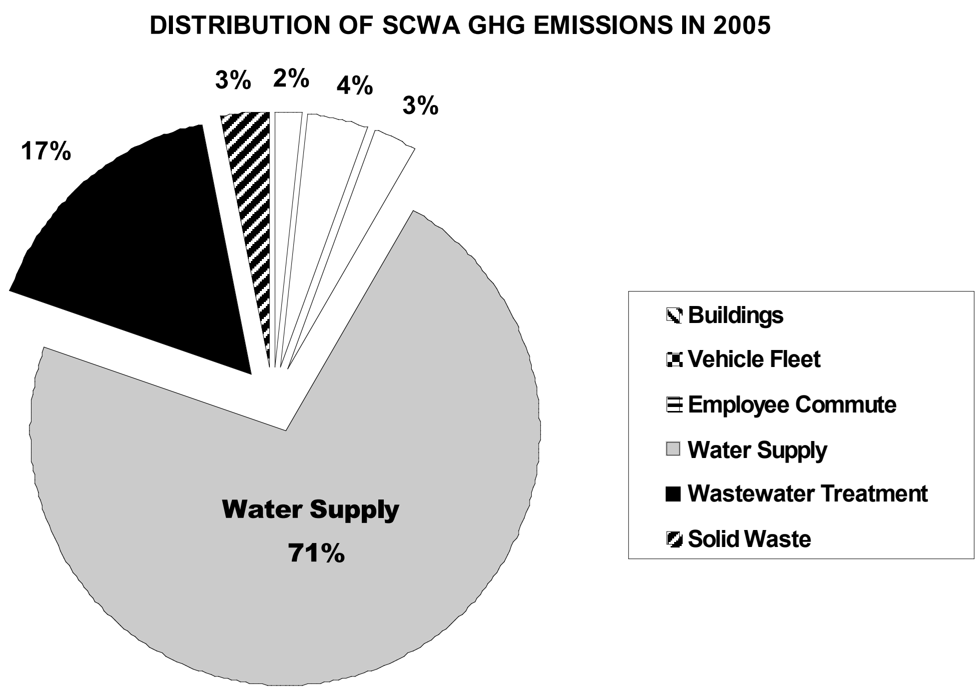
SCWA delivers water to urban water agencies in Sonoma and Marin counties from the Russian and Eel rivers. SCWA's maximum demand from its customers is 68,200 acre-feet per year (AF/yr) while current average demand is 65,200 AF/yr. Since a 2 percent annual population growth is predicted in the service area, SCWA has initiated the Water Supply, Transmission, and Reliability Project (Water Project) to satisfy a maximum demand of 94,100 AF/yr by 2020.

In 2005, the SCWA Directors resolved to reduce greenhouse gas (GHG) emissions from SCWA operations. This report is part of the initial task of quantifying the current inventory of emissions and recommending a feasible target for GHG reductions by 2020.

This report examines a number of cost-effective opportunities for GHG reductions that, when implemented, would make SCWA a leader in regional climate protection efforts by combining distribution system efficiencies with reductions in water demand. Additional opportunities to include in future evaluations would be the expanded use of GHG-free renewable energy resources and the displacement of potable water with reclaimed wastewater.

The report focuses on emissions from electricity used to pump water across SCWA's service area. Fig. ES-1 shows that water supply pumping represented 71 percent of SCWA's total GHG emissions in 2005.

FIG. ES-1



The baseline for the evaluation was derived from 2004 and 2005 annual water supply, electricity use, electricity cost, and GHG emissions (based on the fuel mix used to generate the electricity supplied to SCWA in 2005). These baseline numbers are shown in Table ES-1, along with the unit values.

TABLE ES-1
2005 Baseline Values for the Evaluation

TOTAL WATER MG/yr	TOTAL ENERGY MWhr/yr	TOTAL COST $/yr	TOTAL GHG Ton-CO2/yr	ELECTRICTY RATE $/MWhr	UNIT ENERGY MWhr/MG	UNIT COST $/MG	UNIT GHG Ton-CO2/MG
21,200	56,800	$4,390,000	10,600	$77	2.7	$207	0.5

The potential for reducing GHG emissions by 2020 was evaluated by estimating reductions in energy use from:

- Improving equipment and aqueduct
- Optimizing pump/storage operations for peak power reductions
- Improving water efficiency throughout the service area to reduce the need for pumping

This report compares three scenarios for 2020 with the 2005 baseline. The three scenarios are:

- **Standard Efficiency** is based on SCWA's current conservation target of 9,200 AF/yr (9.8 percent of the 2020 supply that would have been required without efficiency measures), including all the California Urban Water Conservation Council's Best Management Practices (BMPs).
- **Available Efficiency** is based on the Pacific Institute's 2003 report *Waste Not, Want Not: The Potential for Urban Water Conservation*. These available efficiencies include off-the-shelf equipment and controls, proven designs, and readily available services up to a cumulative $600/AF life-cycle cost (set to be less than the lowest reported cost of new water supply in California). The average reduction from efficiency measures across SCWA's service area and all user sectors would be 38 percent of the 2020 supply that would have been required without efficiency measures.
- **GHG Target Efficiency** would reduce GHG emissions by at least 70 percent.[1] The average reduction required from efficiency measures across SCWA's service area and all user sectors would be 51 percent of the 2020 supply that would have been required without efficiency measures. Since the reduction is so large, feasibility must be confirmed with demand-side analyses, which is the intent of a companion report for the City of Santa Rosa.

Electrical power reductions of 12 percent from pump/drive efficiency improvements, optimization of operations to reduce peaks, and transmission system improvements are included in all the scenarios.

Fig. ES-2 summarizes the changes in water demand, electricity use, electricity costs, and GHG emissions for the three scenarios. All four parameters increase for the Standard Efficiency scenario, while all except cost decrease for the Available and GHG Target Efficiency scenarios. It must be noted that without the water use and energy efficiency measures that are included in

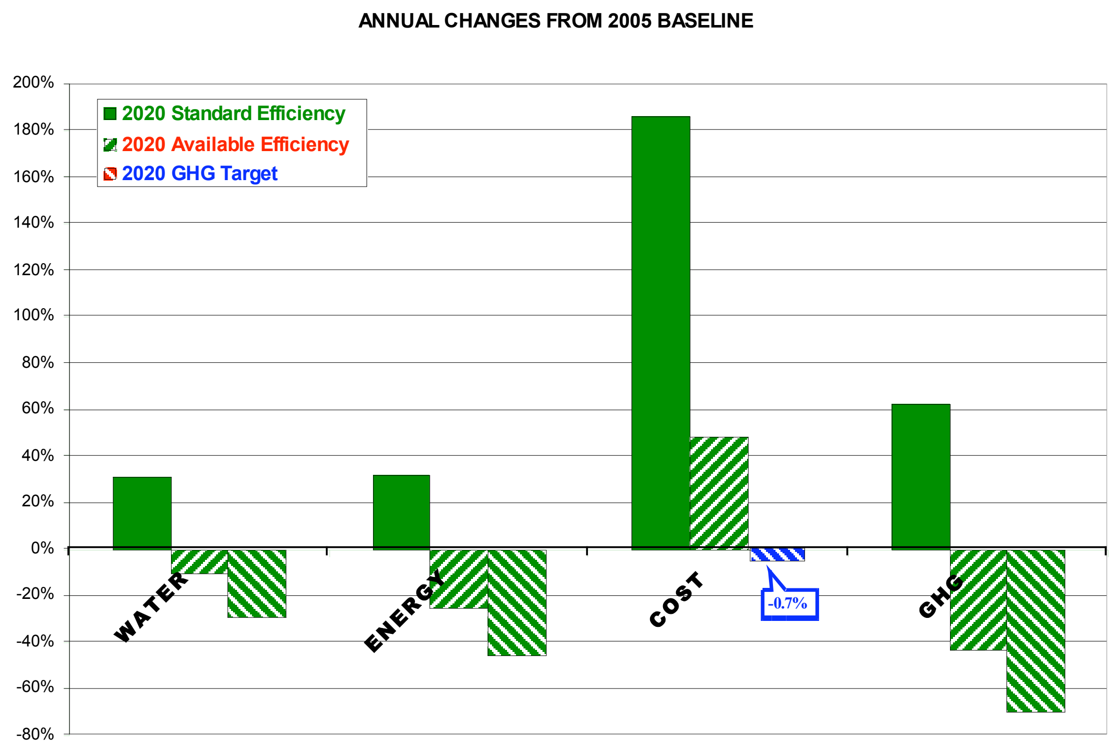
[1] The Intergovernmental Panel on Climate Change (IPCC) has determined that a 70 percent reduction from 1990 GHG emissions was imperative from a scientific perspective – widely referred to as the "Scientific Imperative." This report examines a 70 percent reduction from 2005 GHG emissions.

Standard Efficiency scenario, the energy demand increases would have been much larger: 45 percent for water; 77 percent for energy; 296 percent for cost; and 151 percent for GHG emissions.

The main points summarized in Fig. ES-2 are:

- Current water supply plans will lead to a 62 percent increase in GHG emissions by 2020, while additional water efficiency could decrease GHG emissions 43-70 percent
- Current water supply plans will be accompanied by a nearly three-fold increase in energy costs by 2020, while additional demand-side water efficiency could stabilize energy costs at 2005 levels (the 48 percent cost increase for the Available Efficiency scenario would still save $6 million per year compared to the current plan, and cost stabilization under the GHG Target Efficiency scenario would save $8.2 million per year)

FIG. ES-2

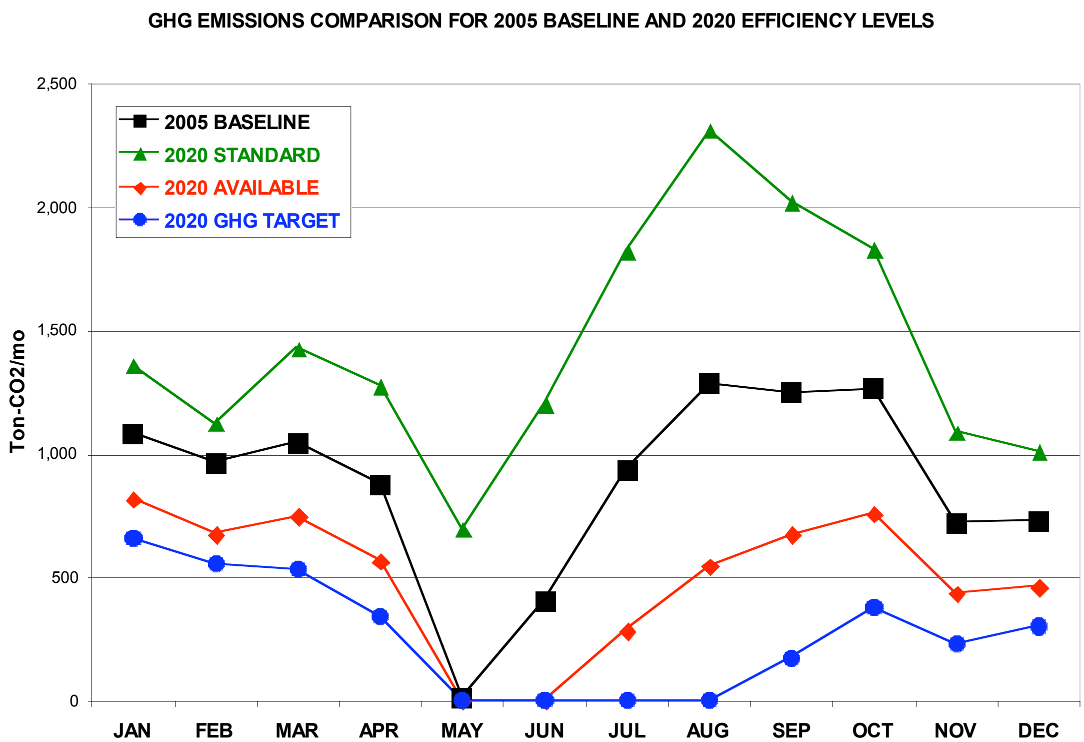


It is important to note that the Available and GHG Target efficiency scenarios examined in this report are not the only means for reducing GHG emissions and costs. Other methods include additional energy efficiencies beyond the 12 percent derived from pumping system upgrades (which can be confirmed by examining 2004–2006 Supervisory Control and Data Acquisition [SCADA] data and in cooperation with SCWA's contractors), displacement of potable water with reclaimed wastewater, and procurement of additional electricity from renewable resources. The broader objective of this report is to demonstrate that GHG emissions resulting from future water supply activities can be reduced — and that finding cost-effective combinations of methods to do so should be part of the Water Project design.

SCWA's GHG emissions are very sensitive to the availability of hydropower from the Western Area Power Agency (WAPA). The impact of the "run-of-the-river" availability of WAPA hydropower is clearly reflected in the shape of the baseline curve in Fig. ES-3. Maximum hydropower is available in May with zero GHG emissions; then hydropower falls off during subsequent summer months and GHG emissions increase — just as SCWA's energy demands for water pumping increase. The very large reduction in water demand for the GHG Target Efficiency scenario allows SCWA to get by with only hydropower from May through August, with zero GHG emissions and no need to purchase fossil-fueled market power.

In 2005, very little WAPA hydropower was available in January, February, and March, which required the SCWA to rely on fossil-fuel energy sources that caused relatively high GHG emissions. It is possible that by 2020, more hydropower will be available in these months to significantly reduce annual GHG emissions.

FIG. ES-3



Given the sensitivity of SCWA's GHG emissions to the availability of WAPA hydropower, the details of the electricity pool-purchasing contract with the Power and Water Resources Pooling Authority (PWRPA) are almost as important as water efficiency. The combination of water use and energy efficiency measures with other renewable energy sources besides WAPA hydropower could result in significantly lower GHG emissions, and lower costs, by 2020. It is also important to note that large-scale hydropower such as WAPA's is not eligible for renewable resource funding from the State of California. Eligible renewables could be developed locally by SCWA, including wind, methane/cogen from dairy manure, landfill biogas, and photovoltaics.

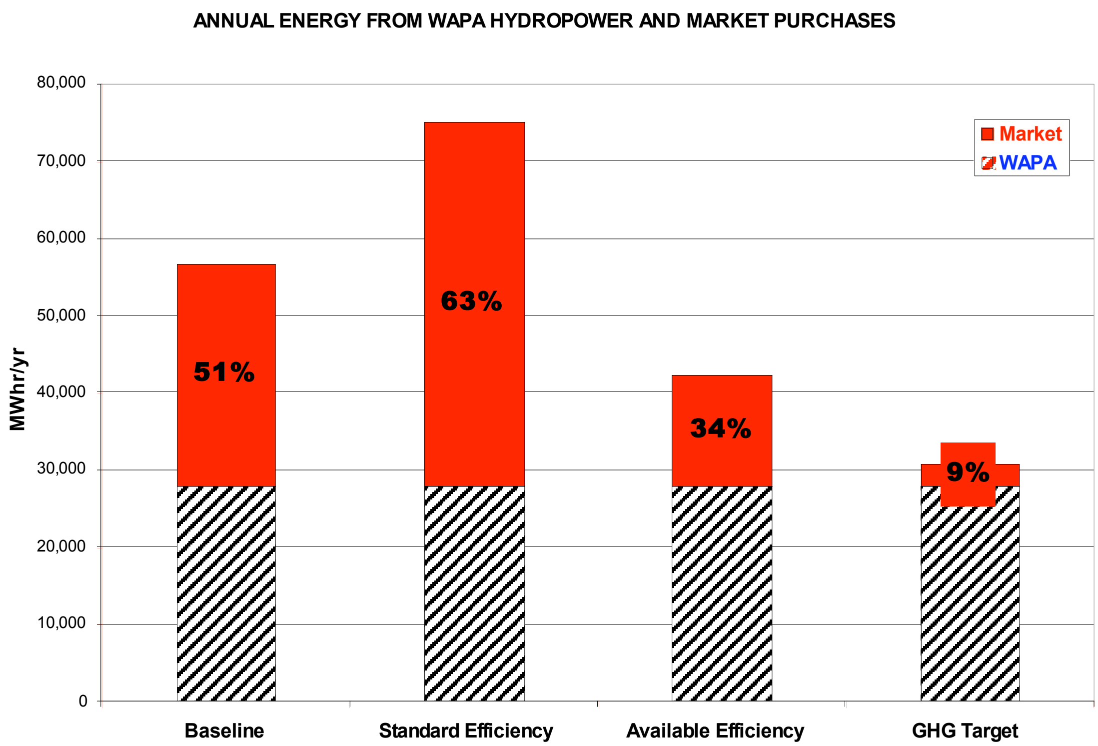
Fig. ES-4 shows the breakdown between hydropower and market power for each of the efficiency scenarios, based on the assumption that WAPA hydropower energy supplied to

SCWA in each month will remain the same as in 2005. This might not be the case, especially in drought years, so creating a portfolio of additional renewable resources would not only replace market power, but also provide a safeguard against climate impacts on hydropower.

Feasible implementation of ambitious water efficiency programs, such the Available and GHG Target Efficiency scenarios, requires long-term planning that can be included Water Project. Even the feasibility of the Standard Efficiency scenario, already included in the Water Project, is uncertain because of shortfalls in water rights, multi-year droughts, and climate change. Shortfall agreements have been added to future supply contracts, but additional efficiency beyond the Standard Efficiency scenario could help avoid potential conflicts. The key elements for successful planning and implementation are:

- Maximizing water use and energy reductions rather than meeting prescriptive regulatory targets
- Capitalizing on water use and energy efficiency measures within infrastructure projects
- Integrating water use and energy efficiency, renewable energy generation, and GHG reduction
- Developing technical, financial, and administrative services to support large programs and obtain high customer participation

FIG. ES-4



Much of the potential feasibility of water and energy efficiency measures can be evaluated by examining SCWA's existing operational data for 2004, 2005, and 2006, with a few additional measurements, in particular:

- Energy-flow relationships and trends for the future
- Pump/drive efficiency improvements
- Optimization of pump/storage operations for peak load reduction
- Time-of-use fuel mix and GHG emissions
- Transmission system improvements

Although it is beyond the scope of this report, we expect far lower life-cycle costs, and even net savings, when regional end-use energy savings and wastewater energy savings are included in the calculations. We will demonstrate this in a companion study for the City of Santa Rosa that will include customer end-use and wastewater savings, and the displacement of potable water with reclaimed wastewater.

2 INTRODUCTION

Sonoma County Water Agency (SCWA) delivers water to urban water agencies in Sonoma and Marin counties from the Russian and Eel rivers. SCWA's maximum demand from its customers is 68,200 acre-feet per year (AF/yr)[2] while current average demand is 65,200 AF/yr.[3] Since a 2 percent annual population growth is predicted in the service area, SCWA has initiated the Water Supply, Transmission, and Reliability Project (Water Project) to satisfy a maximum demand of 94,100 AF/yr by 2020.[4] This represents a 44 percent increase over SCWA's 2005 water deliveries.

In 2005, the SCWA Directors[5] resolved to find ways to reduce greenhouse gas (GHG) emissions from SCWA operations.[6] This report is part of the initial task of quantifying the inventory of emissions and recommending a feasible target for GHG reductions. More specifically, the report will focus on emissions resulting from electricity used to pump water across SCWA's service area, and the feasibility of reductions for (1) current operations and (2) the 44 percent increase in water demand by 2020.

This report's main objective is to identify the most promising GHG-reduction approaches to include in SCWA's infrastructure planning efforts, rather than to provide a list of specific implementation measures.

To provide a demand-side perspective for this supply-side report, a companion report is also being prepared regarding GHG reductions for the City of Santa Rosa's water and wastewater operations (Santa Rosa uses 36 percent of SCWA's annual supply[7]). The overall intent of both reports is to consider the feasibility of GHG reductions throughout the entire water cycle from river extraction through customer use to wastewater treatment, discharge, and reclamation. This allows consideration across jurisdictional boundaries, and the combination of private and public costs and benefits. For example, customer energy reductions and cost savings resulting from water efficiency improvements are several times larger than from water supply pumping,[8] and since most of the customer GHG emissions come from gas-fueled water heaters, the GHG reduction potential is even larger. Thus customer participation in GHG reduction greatly multiplies regional GHG reductions from local governments' water efficiency efforts.

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[2] This is the total current Reasonable Annual Need defined in *Description of Model that Calculates the Allocation of Water Available to Sonoma County Water Agency for Its Customers During a Water Supply Deficiency Taking Demand Hardening into Account*, April 4, 2006, by John Olaf Nelson Water Resources Management for the 11th Restructured Water Supply Agreement (JONWRM Model).
[3] Average annual deliveries for 2004 and 2005, from SCWA records.
[4] This is the total future Reasonable Annual Need defined in the JONWRM Model.
[5] Sonoma County Board of Supervisors.
[6] Water Agency Board resolution authorizing the Agency's participation in the Cities for Climate Protection Program, Aug. 23, 2005.
[7] Based on monthly data from January 2004 to February 2006.
[8] Details provided in section Potential Reduction in GHG Emissions.

For SCWA, this report focuses on energy reductions from:

1. Pump efficiency improvements
2. Optimization of pump/storage operations for peak power reductions
3. Aqueduct improvements
4. Improvements in water efficiency throughout the service area to reduce the need for pumping

3 EVALUATION OF CURRENT SCWA PUMPING OPERATIONS

3.1 Russian River (Wohler and Mirabel) Pumps

The 10 main supply pumps are rated at 1,000 horsepower (HP) (Wohler) and 1,250 HP (Mirabel), resulting in system power demands ranging from 1.5 to 8.3 megawatts (MW) (4 to 8 MW in dry months). On an annual basis, these pumps represent 75 percent of electricity use in the water supply system,[9] and trigger an overwhelming portion of peak demands.

3.1.1 Operating Schedule and the Potential for Load Shifting

The first level of evaluation was to determine whether load management can reduce energy use and costs by reducing the maximum number of active pumps at any given time, especially during peak summer hours, and allowing storage tank levels to fluctuate. Although a previous evaluation in 2003[10] concluded that load shifting was physically feasible and could pay for itself in less than a year, SCWA staff determined, at that time, that successful implementation would be hindered by other factors:

1. The need for similar management systems for all contractors to create predictable demands
2. Impending changes in SCWA's electricity supply and rate structure that would reduce average prices and almost eliminate peak pricing
3. Construction of aqueduct intertie pipelines to remove bottlenecks that severely limited flow rates and created very large friction losses
4. To a lesser extent, the need to:
   a. Complete upgrades of the Supervisory Control and Data Acquisition (SCADA) system
   b. Create new storage/emergency procedures with fire-prevention agencies

Revisiting load management in 2006 for this study is premised on several factors:

1. Construction of interties have eliminated some hydraulic bottlenecks
2. The SCADA system has been upgraded
3. As water demands increase over time and additional ~1 MW pumps are installed,[11] higher flow rates will require higher power demands
4. It might be profitable to reduce peak period demands in return for future incentives that could be developed within SCWA's new electricity purchasing contract with Power and Water Resources Pooling Authority (PWRPA)[12]
5. Cooperative demand management might now be very attractive to SCWA contractors as their peak PG&E rates soar.[13] This will be reinforced as the California Public Utilities Commission (CPUC) and California Energy Commission (CEC) develop new financial

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[9] The other 25 percent is used by booster pumps across the service area, and will be analyzed in the next section.
[10] *Energy Efficiency Study of the Sonoma County Water Agency's Russian River Pumping System*, Provimetrics, Corp., April 2003.
[11] Caisson 6 with two 1,250 HP pumps is already scheduled to come on line in August 2006.
[12] PWRPA is the purchasing pool for several large water agencies and has successfully avoided peak power surcharges for SCWA. Demand-reduction programs could reduce the entire pool's exposure to peak prices.
[13] To avoid construction of very costly "peaker" plants in California, the CPUC is developing high surcharges for electric utilities to pass on to all their customers, and various incentive programs for load shifting. PG&E's Critical Peak Pricing program more than doubles energy charges (not only demand charges) during peak periods, and offers some incentives to customers seeking to avoid triggering large surcharges.

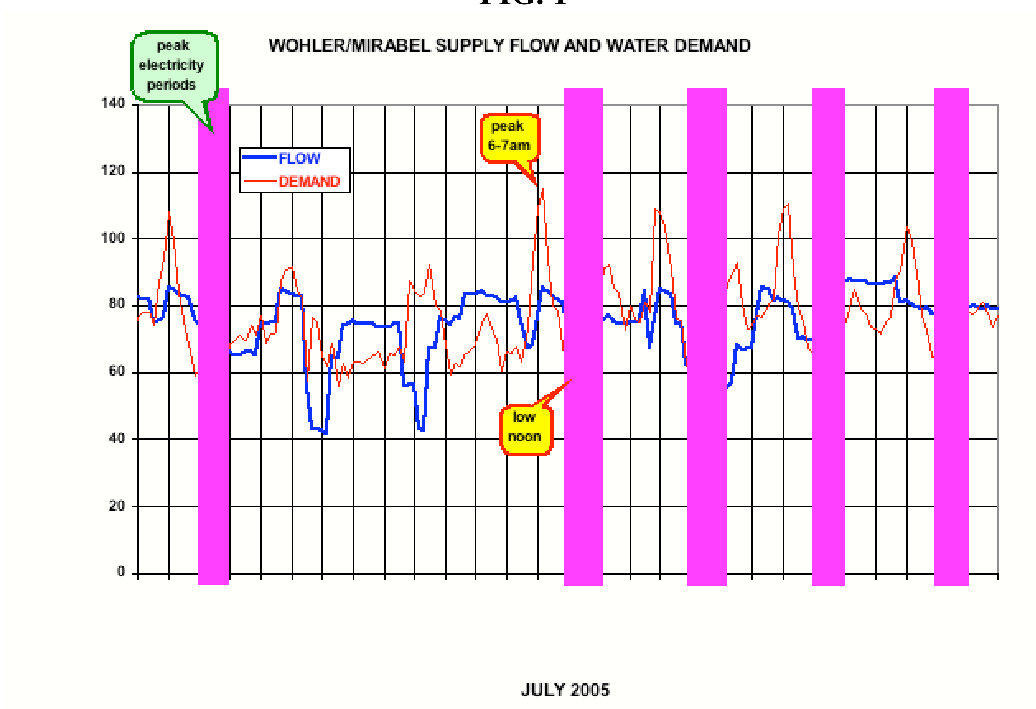
incentives for water and wastewater agencies to reduce peak power demands as part of the Integrated Energy Policy Proceedings[14]

6. A large fraction of peak period power is generated from natural gas turbines that are "dirtier" than Northern California's baseline, which includes a large fraction of renewable energy

In accordance with the budgeted scope of work for this evaluation, we examined one-hour data increments[15] from SCWA's SCADA system for July 2005 to evaluate the potential impact of load management. Fig. 1 shows the combined flow of water from the Wohler/Mirabel pumps[16] and aggregate water demand across the service area[17] in the second week of July 2005. The main conclusions from similar graphs for all four weeks are:

1. Peak water demand occurs between 6:00 and 7:00 A.M. on weekdays. This pattern is directly influenced by customer demand
2. Lowest water demand begins at noon and does not increase until the end of the peak electricity periods. This pattern is mainly influenced by the desire of SCWA's contractors to avoid PG&E peak demand surcharges, and is possible because midday demand by residential customers is very low.

FIG. 1



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[14] *California's Water-Energy Relationship: Final Staff Report*, CEC-700-2005-011-SF, November 2005. The report used the Skymetrics report on GHG emissions from Sonoma County water and wastewater operations, and CEC staff is eager to review this follow-up.

[15] This involved downloading 744 time periods with 119 operational parameters (the 2003 Provimetrics evaluation examined 15 months of 30-minute data for 100 parameters).

[16] Because of SCADA data limitations, it was not possible to disaggregate power use by each pump nor validate whether their flow was directed to the Cotati or Santa Rosa aqueducts.

[17] Only monthly water use by each contractor was available, so the one-hour aggregate water demand was calculated from the difference between flow from Mirabel/Wohler and the cumulative increase/decrease of water levels in storage tanks. Thus the demand shown in Fig. 1 is not individual customer usage, but withdrawals by SCWA's contractors — and this is what SCWA operators actually respond to.

Fig. 2 shows the electrical power required by the Wohler/Mirabel pumps, the aggregate water demand, and the cumulative increase/decrease in storage across the service area (for the second week in July 2005). The main conclusion is that tanks are often being filled during peak electrical periods (77 percent of the 120 hours for all four weeks), with moderate to high power demands (91 percent between 6 to 8 MW). Conversely, low power demands occur very infrequently during peak electricity periods (e.g., 4.8 MW on July 12).

Fig. 3 shows the July 2005 distribution of electrical power demands for Wohler/Mirabel/ pumps for peak electrical periods and the combined balance of partial and off-peak periods.[18] Load management would attempt to move the peak demands to the left (i.e., reducing the fraction of power demand in the 6 to 8 MW range while increasing the fraction in the 3 to 5 MW range). This would probably also require a small redistribution of the off- and partial-peak power demands. While the main question is whether the overall change will significantly reduce GHG emissions and/or operating costs, it is worthwhile to understand the operational conditions driving the current distribution.

Fig. 4 shows the water levels in the Ralphine and Cotati storage tanks[19] for the second week of July 2005. Without a detailed analysis of weather patterns, maintenance records, and at least daily details of customer water use, it is difficult to explain why tank levels decreased continuously from Monday (7/11) noon to Wednesday (7/13) at 9:00 A.M. The outcome from an energy perspective is clear: all pumps were turned on to prevent the tank contents from falling below acceptable levels.[20] Although this was a prudent operating decision given the information available at the time, it triggered maximum power in the middle of the Wednesday peak electricity period. In hindsight, Fig. 4 also shows that the tank levels began to increase even before turning on all the pumps, so the decision could have been delayed. It would also have been better to keep all pumps on until noon on Thursday (7/14) in order to reach higher water levels in the Cotati tanks.

The main point of the discussion about Fig. 4 is to illuminate the potential to shift loads away from peak electricity periods. It also shows the need to incorporate demand patterns, weather information, and maintenance restrictions into load management decisions.[21] Such decisions would not be automated, but presented as alternatives for the SCWA operators to consider before turning pumps on or off.

[18] Total monthly peak period duration was 120 hours, and the balance was 624 hours.
[19] The Cotati and Ralphine tanks represent 70 percent of the storage volume in SCWA's service area.
[20] In 2003, the lowest acceptable level in the Ralphine and Cotati tanks was ~2 feet below the top (i.e., no less than 95 percent full). In the cooler summer of 2005, and after construction of the interties relieved major flow bottlenecks, the acceptable level was dropped to 6 to 8 feet below the top (80–85 percent full). With more than a day's supply reserve in the tanks, water levels are allowed to drop below the acceptable range during very hot spells.
[21] Modern control software can include heuristic self-learning probability estimates to accommodate variabilities inherent in demand and weather patterns.

FIG. 2

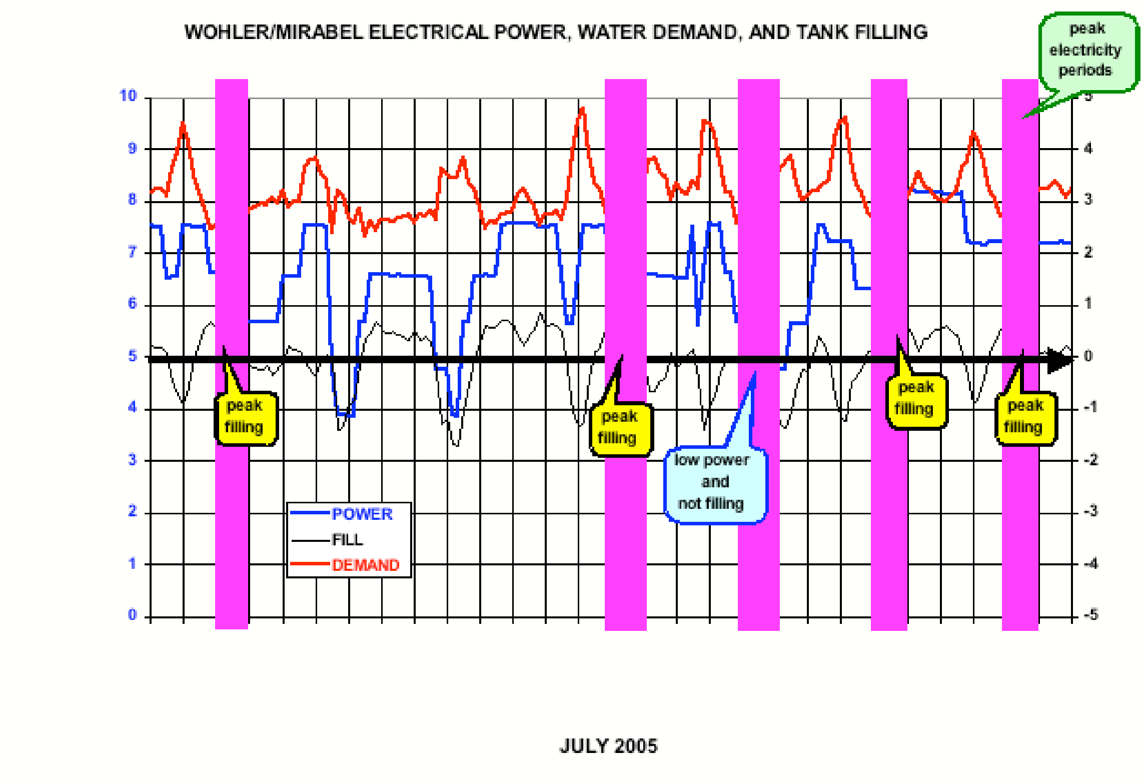

WOHLER/MIRABEL ELECTRICAL POWER, WATER DEMAND, AND TANK FILLING
peak electricity periods
peak filling
peak filling
low power and not filling
peak filling
peak filling
POWER
FILL
DEMAND
JULY 2005

FIG. 3

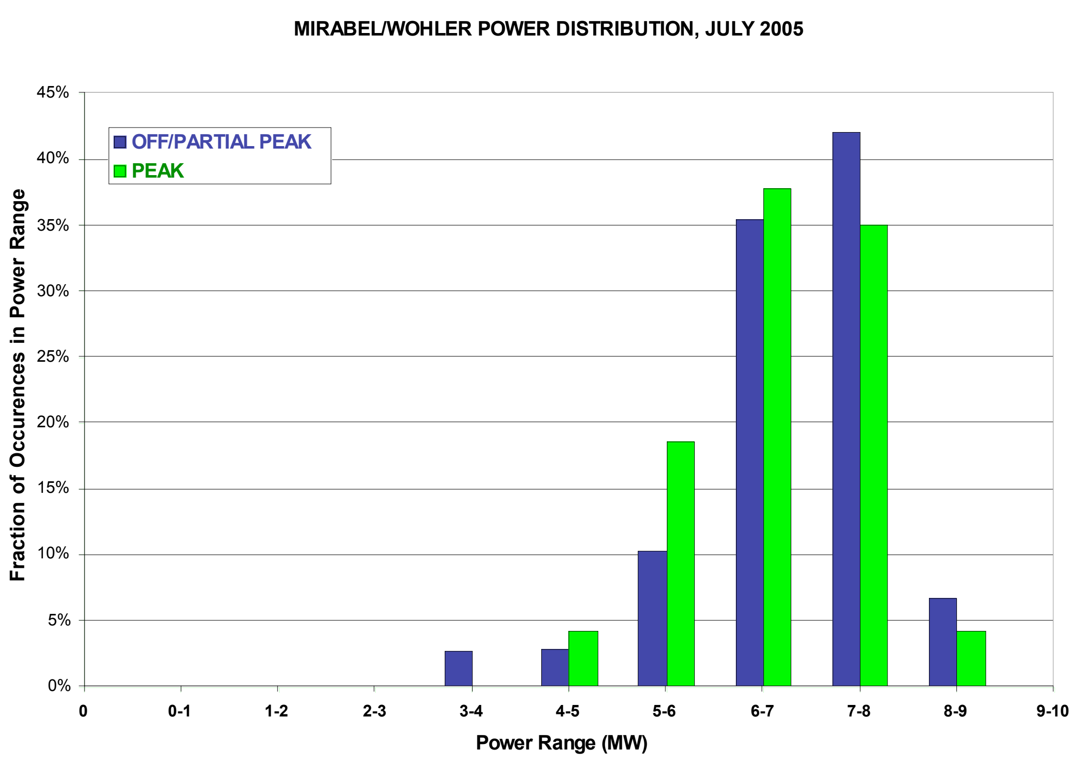
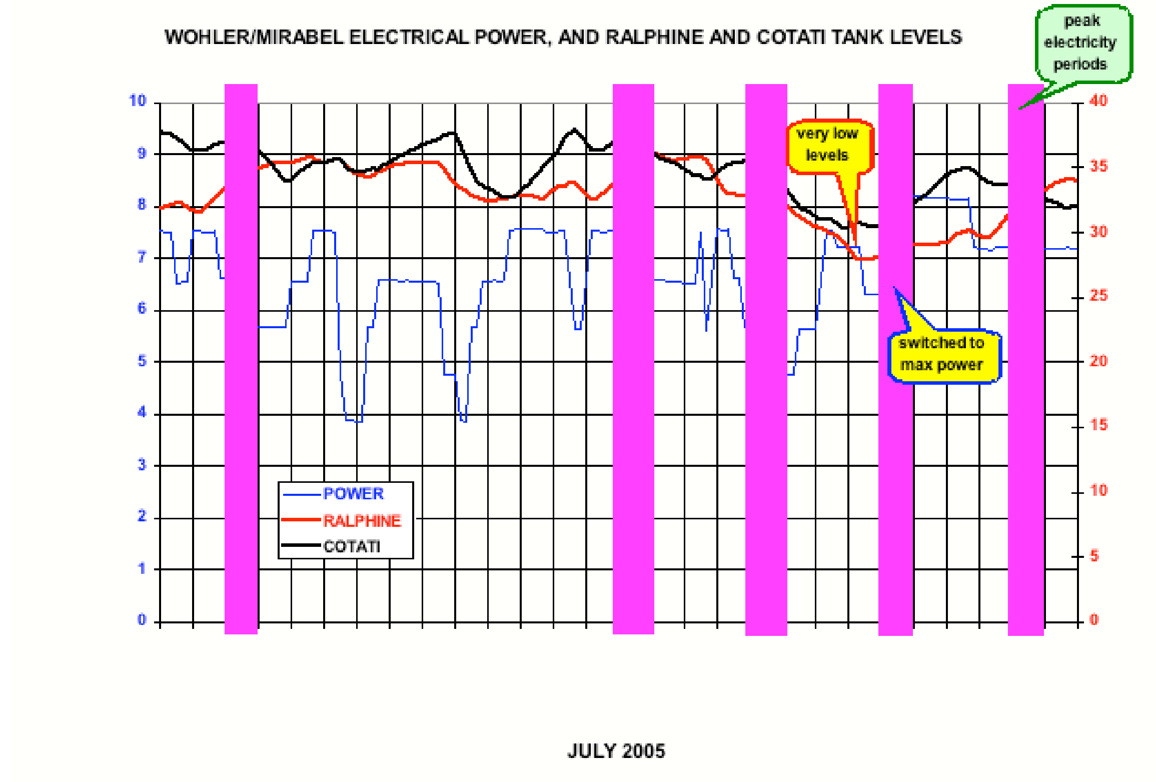

MIRABEL/WOHLER POWER DISTRIBUTION, JULY 2005
OFF/PARTIAL PEAK
PEAK
Fraction of Occurences in Power Range
Power Range (MW)
0
0-1
1-2
2-3
3-4
4-5
5-6
6-7
7-8
8-9
9-10

FIG. 4



3.1.2 Power-Flow Rate Relationship and the Potential to Reduce Energy Use

The next step in the analysis is to quantify the potential GHG reductions from load management. Fig. 5 shows that system power demand and head pressure[22] are clearly grouped according to specific combinations of pumps in operation.[23] The head pressure groupings imply variability in conveyance system friction from a combination of changing aqueduct flow patterns, changing caisson water levels, and changing storage tank levels.[24] The main energy conclusion from Fig. 5 is that power demand remains constant for each grouping, and that power demand changes only when groupings are changed as pumps are turned on/off.

[22] Since SCADA data was unavailable for all pumps in all periods, and no data was available for caisson levels/pump inlet, the head pressure was calculated from the available average outlet pressure, with 30 feet added for average below-ground caisson water level.
[23] This was confirmed from the larger data set available for the 2003 Provimetrics report.
[24] The 20-foot level difference in tanks implies a 7 pound-force per square inch gauge (psig) difference, and caisson water level differences might add another 10 psig. Combined, they can make up most of the head variation in Fig. 5.

FIG. 5

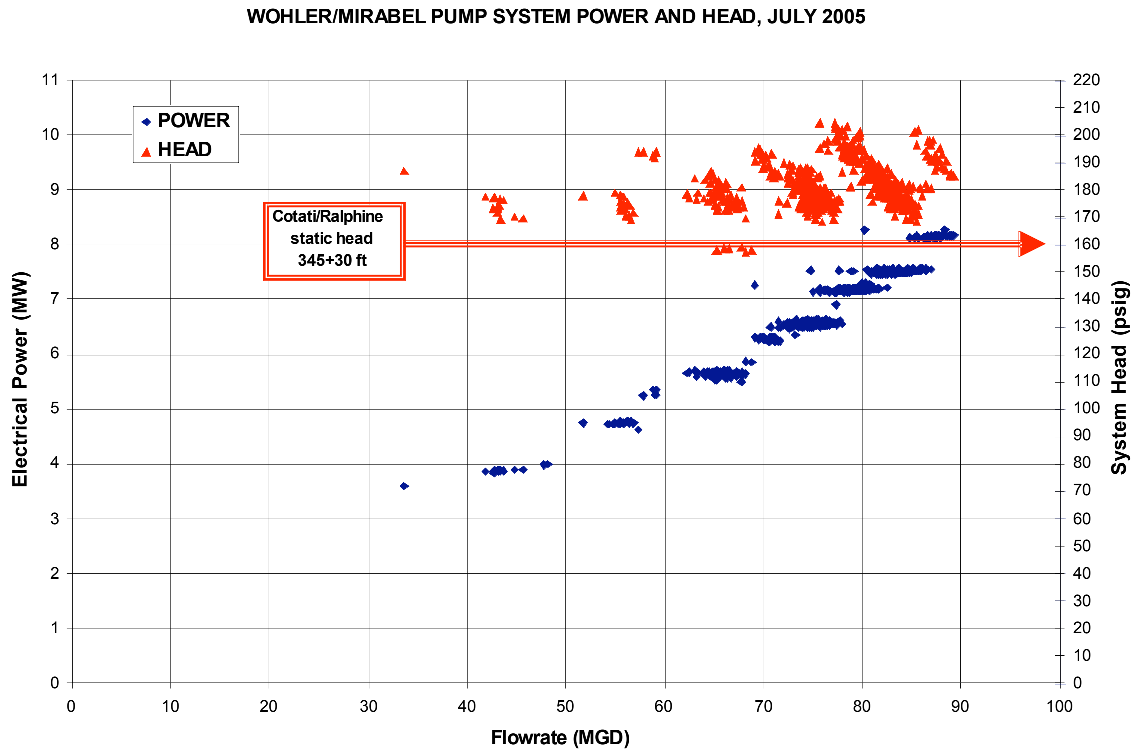


Fig. 6 shows that system wire-to-water efficiency[25] is reasonably high, averaging 62 percent for all flow rates. Although most efficiency points range between 52 to72 percent, there is no correlation to flow rate and it was not possible to define which particular pump/system combinations have high or low efficiencies. A more detailed evaluation with more data points could identify potential improvements to individual pumps,[26] piping constraints, and booster pumping schedules that could increase average wire-to-water efficiency. For example, increasing average efficiency to 70 percent could reduce electricity use by 12 percent. The maximum improvement would be 38 percent from attaining 72 percent efficiency at all operating points; a more practical estimate of the maximum would be 26 percent.[27] GHG emissions will also be reduced, but they also depend on the fuel mix for electricity generation, as will be discussed in the next section.

Fig. 6 also shows that unit power (kilowatts per million gallons [kW/MG]) within each pump combination or pump station improves (decreases) as head pressure is reduced and flow increases. Although it is not clearly defined, it seems that average unit power across combinations degrades (increases) for flow rates larger than 60 million gallons per day (MGD).[28] Again, a more detailed evaluation, especially with more data at lower flows, could quantify potential reductions in energy use and GHG emissions from scheduling operations to avoid high flow rates.

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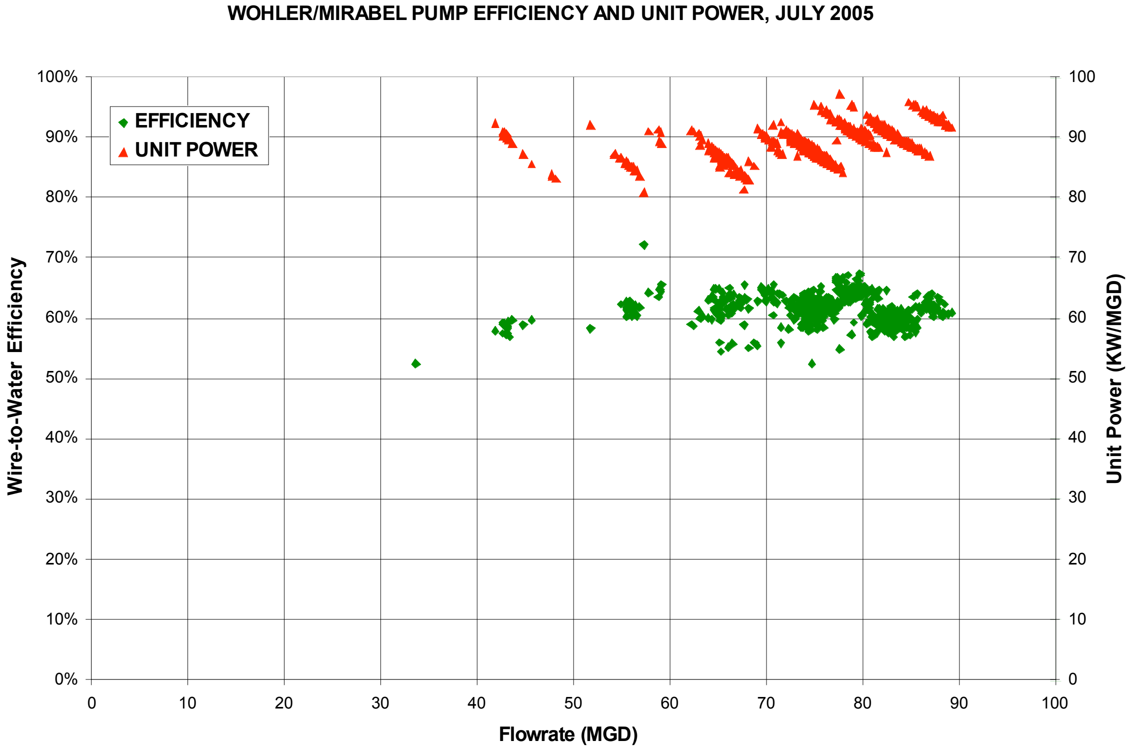
[25] Wire-to-water efficiency is the hydraulic power (head times flow rate) divided by the electrical power input.
[26] The 2003 Provimetrics report defined individual pump efficiencies, and prioritized an improvement schedule.
[27] Half way between 12 percent and 38 percent (with some rounding from the actual data).
[28] There are too few data points lower than 60 MGD in July 2005 to reach any valid conclusions.

FIG. 6



To reinforce the potential benefits of a more detailed analysis, Fig. 7 shows possible trends in power and unit power as future water demand increases. The trends are plotted from averages for each combination of pumps, with far more certainty in the correlation for power ($R^2 = 0.99$) than for unit power ($R^2 = 0.66$).[29] The trend line indicates that if the maximum flow rate increases 22 percent, power will increase 33 percent (to 12 MW); if the maximum flow rate increases 29 percent, power will increase 99 percent (to 18 MW).[30] The parallel increases in unit power will be significant but less dramatic (15 percent and 54 percent correspondingly), but this will change when a more certain correlation is established with additional data. The main conclusion from Fig. 7 is that as increasing water demand requires higher flow rates, there will be much larger increases in power demand.[31] Load management to reduce maximum flow rates will lead to overall energy savings and lower GHG emissions.

The potential impact of managing maximum flow rates is already implicit in the monthly data for the Wohler/Mirabel system. Fig. 8 shows the monthly water and energy data for the Wohler/Mirabel system, revealing a general increase in average unit energy (kilowatt hours per million gallons [kWhr/MG] per pump station) use in summer when water demand is highest. At the same time, unit energy use in summer fluctuates quite widely demonstrating that even under current conditions, there is a large potential to reduce energy use (with optimization of tank

[29] The relative uncertainty for unit power is mainly because head pressure variations are not included, and a lack of data under 60 MGD (R^2 is known as the "correlation coefficient" and is a measurement of "goodness of fit" of a trend line).
[30] The 22 percent increase in maximum flow rate is half the projected 44 percent increase in annual water demand by 2020; 29 percent is two-thirds of the projected increase.
[31] Eliminating hydraulic bottlenecks will reduce friction and future power demand, but the quadratic nature of the flow-power relationship will remain.

levels and pump operating schedules, based on caisson water levels, and probabilistic demand and weather patterns).

FIG. 7

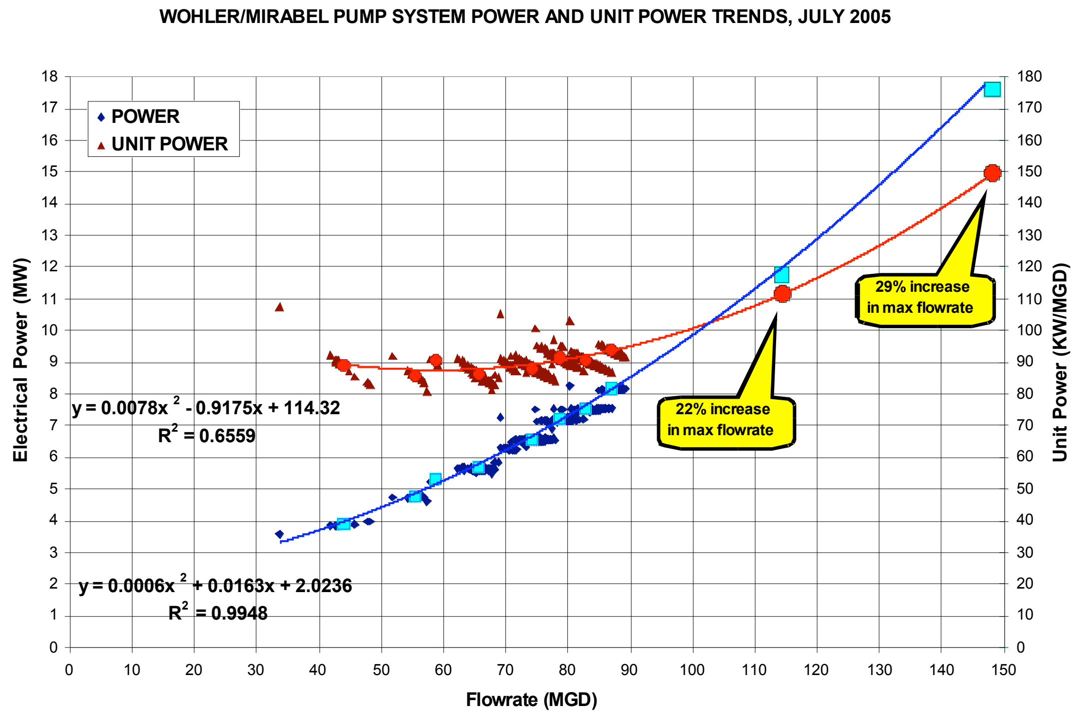


FIG. 8

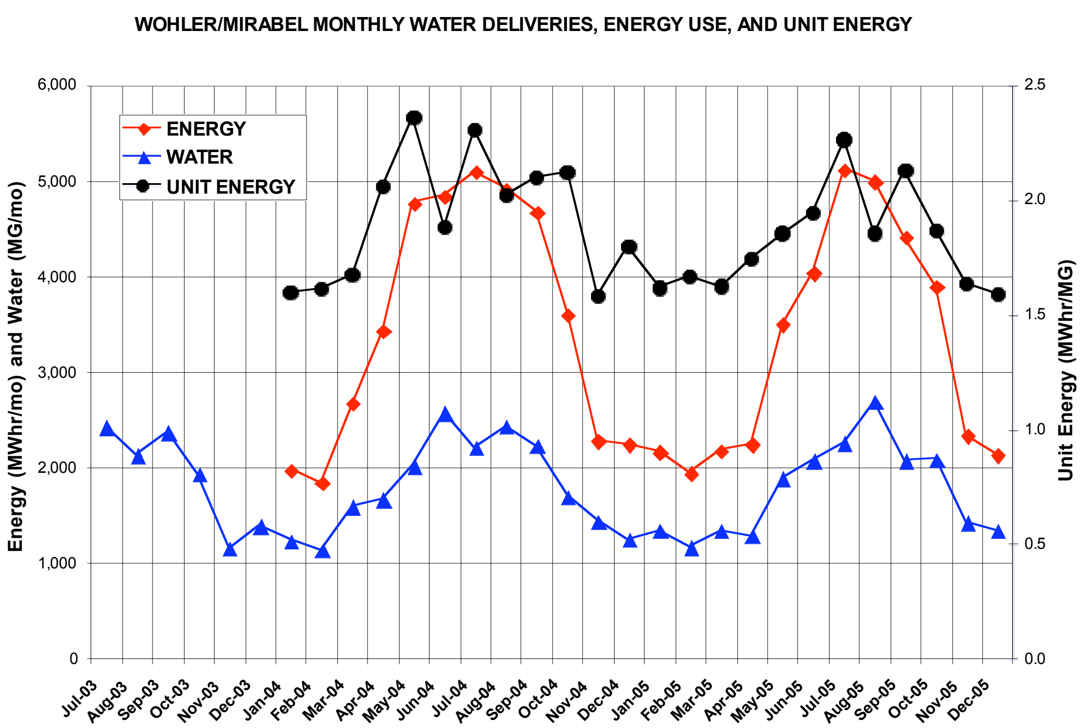
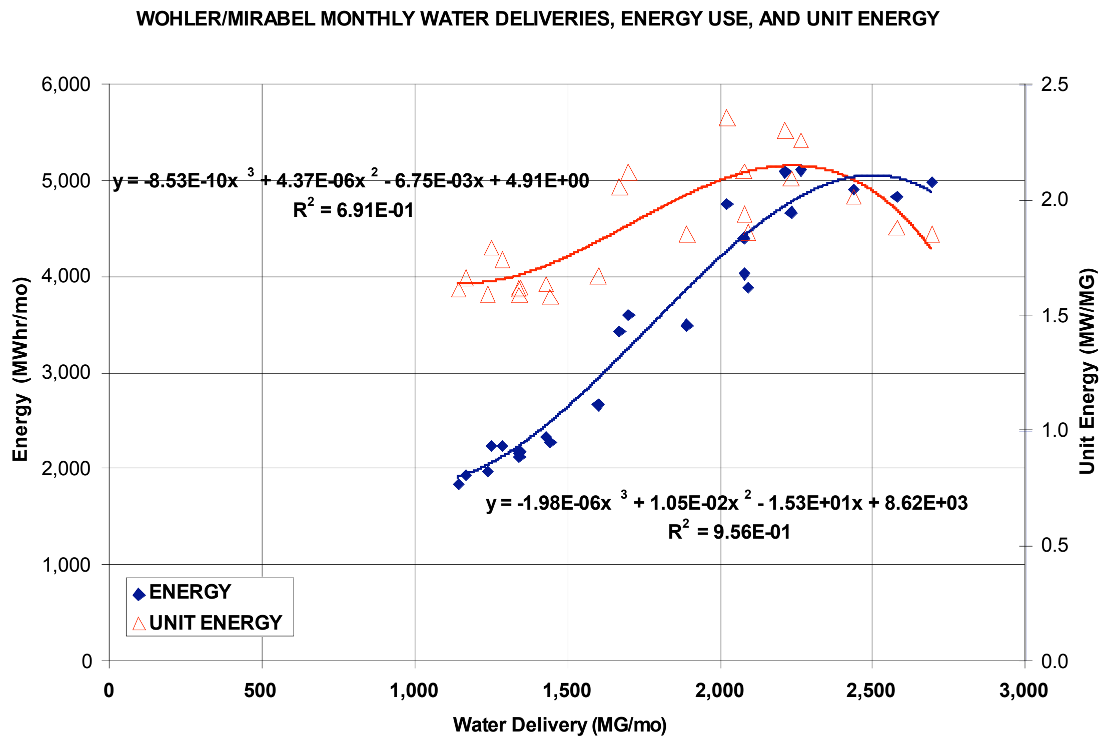


Fig. 9 shows that unit energy is much higher for summer flows (more than 2,000 million gallons [MG]/month) than for winter flows (less than 1,600 MG/month), and fluctuates less. Summer unit energy fluctuates 26 percent, from 1.9 megawatt hours per million gallons (MWhr/MG) to 2.4 MWhr/MG, while the fluctuation for winter flows is only 12 percent, from 1.6 MWhr/MG to 1.8 MWhr/MG. Although the details could not be analyzed within the scope and budget for this evaluation, it is clear that the "flattening" of monthly energy use at 5,200 MWhr is due to practical limitations on the operation of existing pumps[32] — rather than concluding that efficiency improves beyond 2,200 million gallons per month (MG/month).

FIG. 9

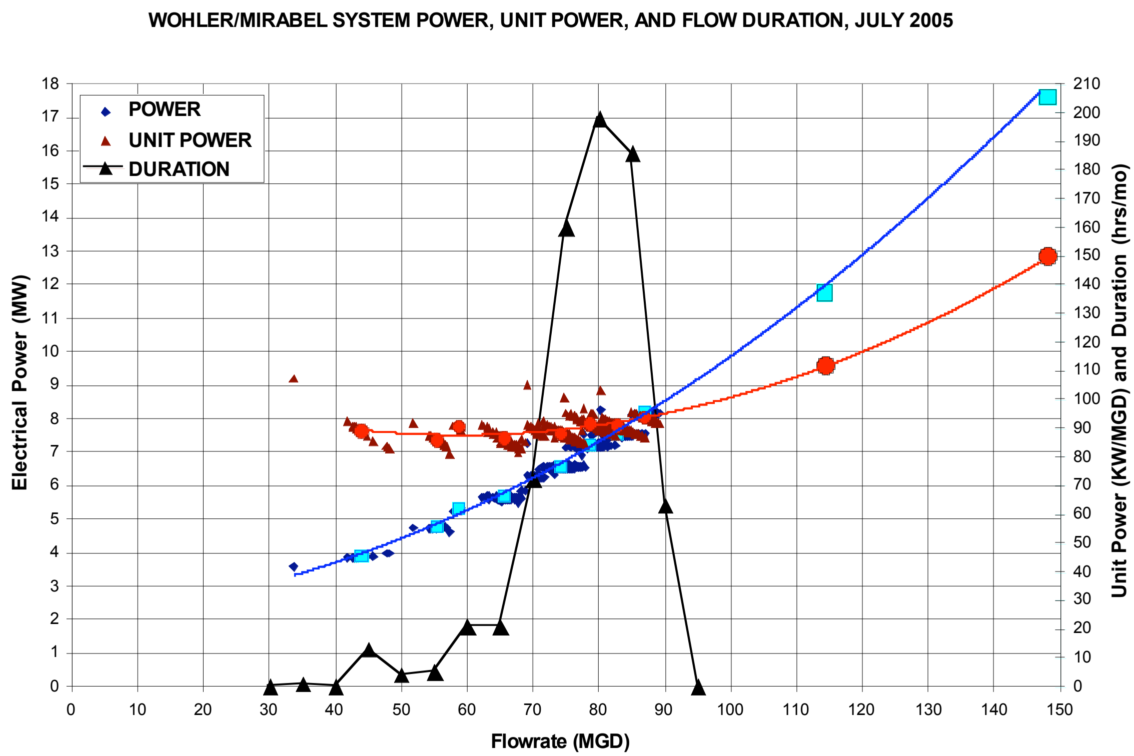


The potential for reductions in energy use and GHG emissions could be quantified by evaluating the one-hour SCADA data for months with flows larger than 2,000 MG/month using more than 4,000 MWhr/month (e.g., June through October 2005). Fig. 10 provides an example of the quantification methodology by adding duration data to Fig. 7 to show how flow and power were distributed for July 2005. For this distribution, 76 percent of the monthly energy was used for flows of 70 to 85 MGD with a power demand of 6.6 to 7.5 MW. The question is whether it would have been possible to reduce monthly energy demand by shifting the distribution to the left (e.g., operating at flows of 60 to 75 MGD for more hours, but with power demands of only 4.9 to 6.6 MW). Answering this question requires far more data points at lower flows, and verification against monthly energy billings.

[32] Even with all 10 existing pumps on all the time, maximum energy use would be 5,900 MWhr/month, but such operation can only be sustained for a few hours a week. Groundwater hydraulics are the main limitation — operating too many pumps quickly draws down all the water in the casissons.

Fig. 10 (and Fig. 7) shows that it is far more likely that redistribution will result in significant energy savings as annual water demand increases as the slopes of the power and unit power curves get steeper. Quantification of the energy savings will require construction of future demand distributions, which is time-consuming but not difficult.

FIG. 10



3.1.3 Conclusions from the Operational Data Analysis

The overall conclusions from the Wohler/Mirabel SCADA data analysis are:

1. A more detailed analysis of pump/system combinations, with all available SCADA data from 2004, 2005, and 2006, could identify pump and system improvements to reduce electricity use by:
   a. 12 to 26 percent in summer months
   b. Somewhat less than 12 percent in winter months
2. Load management could reduce energy use and GHG emissions, although further analysis, especially at flows below 60 MGD, is needed[33]
3. As water demand increases in the future, load management to avoid maximum flow rates could significantly reduce energy use and GHG emissions, but it is not prudent to assume more than the minimum 12 percent estimate without a more detailed SCADA data analysis
4. Load management can reduce power demand during peak electricity periods. Even though SCWA's current rate structure does not have direct surcharges for peak power, and no savings are currently possible, there will most certainly be opportunities in the future:

---

[33] SCWA is developing a hydraulic model of the supply system, which might help complete such an analysis.

a. The PWRPA pool integrates the price of peak purchases and reserves into the average rate, and as market prices and pool members' power demands increase, so will PWRPA's rates
b. The PWRPA contract already credits members for using less than their full Western Area Power Agency (WAPA) allocation. It would be worthwhile renegotiating this clause to explicitly reward load shifting, especially since implementation costs should be relatively low[34] compared to the cost of contracts for additional peak power.
c. Load shifting in water and wastewater facilities is emerging as a specific target for new State incentives in the CEC's Integrated Energy Policy Proceedings

Although much of the data is already stored in the SCADA system, some additional data must be gathered:

1. Work-arounds for missing parameters and data
2. Power and head measurements for each pump
3. Time-of-use power and fuel mix records from PWRPA
4. SCWA's contractors' pumping schedules, customer demand curves, and storage tank operating criteria
5. Fire department criteria for emergency storage and flow rates

3.2 Laguna Production Wells

SCWA operates three wells in the Laguna de Santa Rosa:

- Occidental Road
- Sebastopol Road
- Todd Road

All three discharge into the Cotati Aqueduct after chlorination. Fig. 11 shows that the relative annual contribution from the wells is small, but increasing over time.

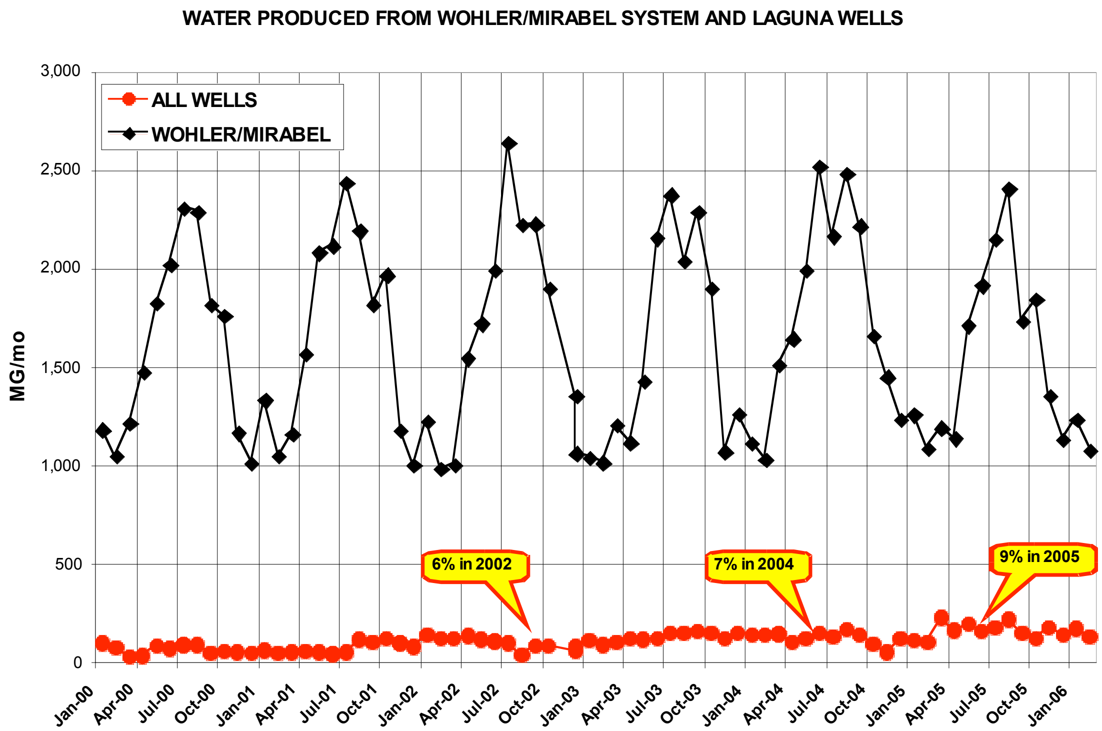
Fig. 12 shows water supply and energy use at the Occidental Road well, and that a significant improvement was made to unit energy use when the pumps were upgraded at the beginning of 2005. Fig 13 shows water supply and energy use at the Sebastopol Road well, and that there has been a 13 percent deterioration in unit energy in 2005. Fig. 14 shows water supply and energy use at the Todd Road well, and that there has been a 15 percent deterioration in unit energy in 2005.[35]

Even though energy use is very small compared to the Wohler/Mirabel system, well pump upgrades will almost certainly reduce energy use and GHG emissions. The first step would be to conduct pump tests to validate the potential for improvements.[36]

---

[34] The $100,000 to $200,000 cost would be mainly to add SCADA screens showing tank level trends, pump power, and electricity costs from operating different combinations of available pumps.
[35] The "outlier" in November 2005 might have been caused by a mistake in the water meter recording (e.g., 39 MG rather than 19 MG), but even without this data point, the deterioration is 12 percent.
[36] Pump tests are funded by the CPUC and administered by PG&E, but only to customers paying charges for Public Purpose Programs. PWRPA is not currently paying these "Public Goods" charges.

FIG. 11


WATER PRODUCED FROM WOHLER/MIRABEL SYSTEM AND LAGUNA WELLS
ALL WELLS
WOHLER/MIRABEL
MG/mo
3,000
2,500
2,000
1,500
1,000
500
0
6% in 2002
7% in 2004
9% in 2005
Jan-00
Apr-00
Jul-00
Oct-00
Jan-01
Apr-01
Jul-01
Oct-01
Jan-02
Apr-02
Jul-02
Oct-02
Jan-03
Apr-03
Jul-03
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Apr-04
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Oct-05
Jan-06

FIG. 12

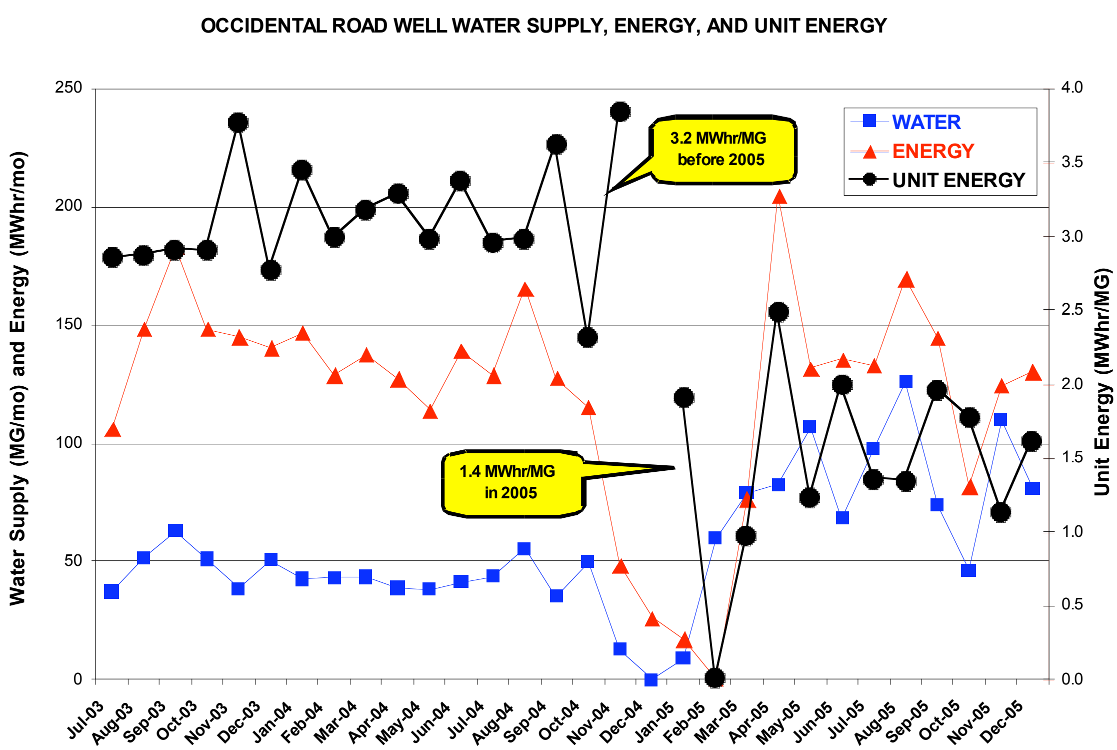

OCCIDENTAL ROAD WELL WATER SUPPLY, ENERGY, AND UNIT ENERGY
WATER
ENERGY
UNIT ENERGY
Water Supply (MG/mo) and Energy (MWhr/mo)
Unit Energy (MWhr/MG)
3.2 MWhr/MG before 2005
1.4 MWhr/MG in 2005
250
200
150
100
50
0
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04
Oct-04
Nov-04
Dec-04
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Jun-05
Jul-05
Aug-05
Sep-05
Oct-05
Nov-05
Dec-05

FIG. 13

SEBASTOPOL ROAD WELL WATER SUPPLY, ENERGY, AND UNIT ENERGY

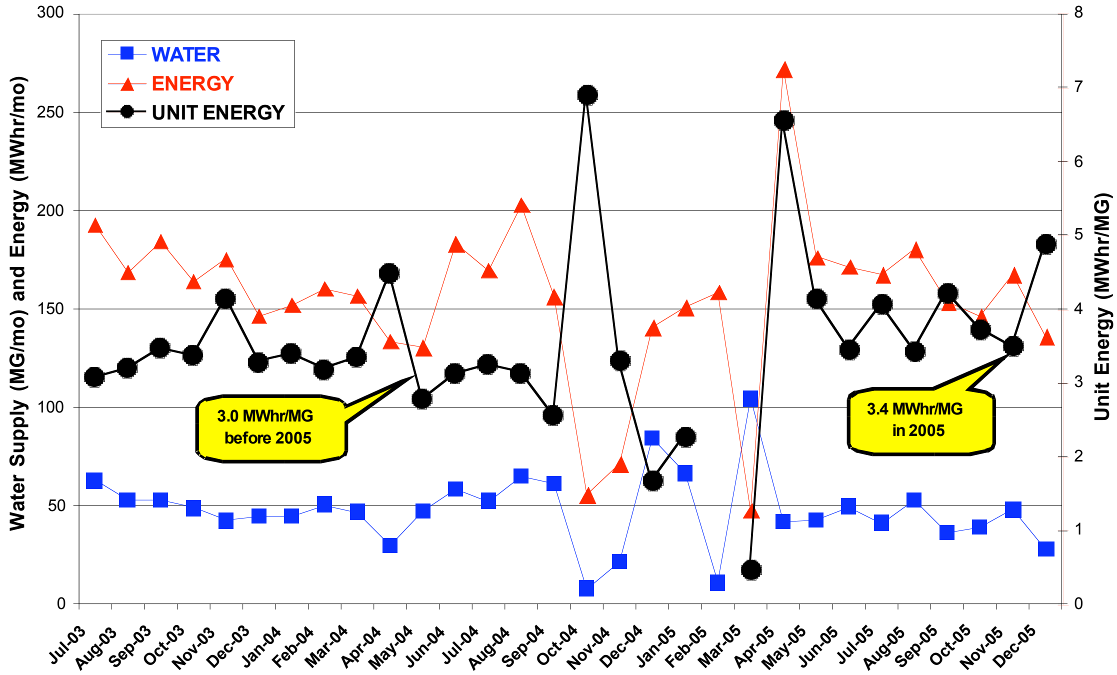
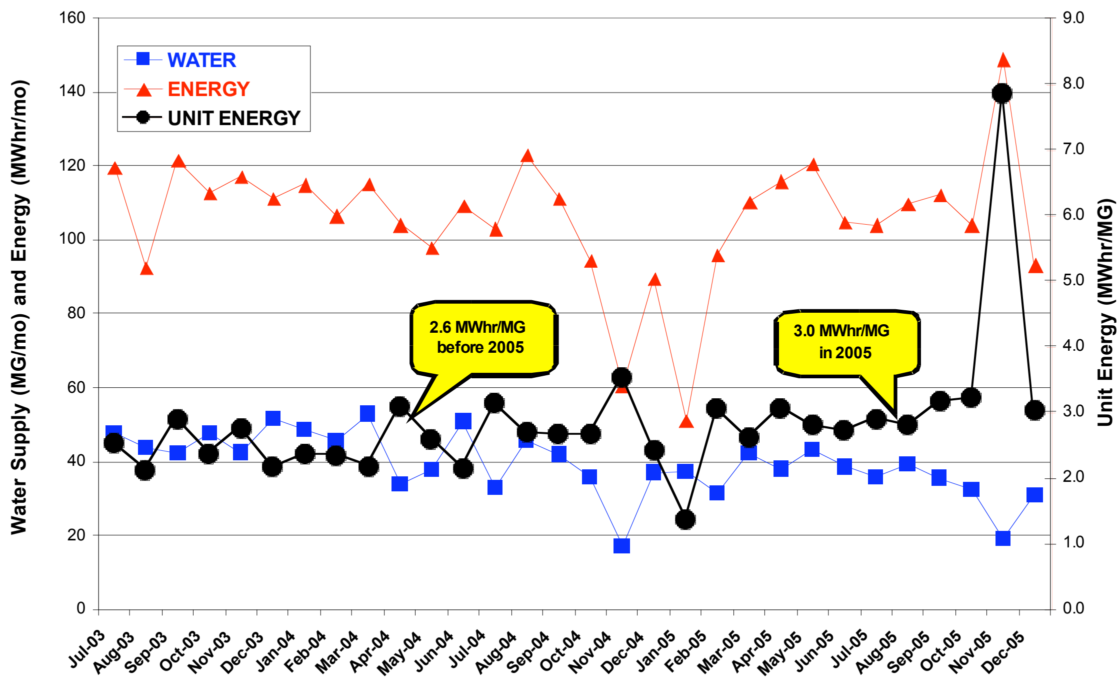


FIG. 14

TODD ROAD WELL WATER SUPPLY, ENERGY, AND UNIT ENERGY



3.3 Booster Pumps

3.3.1 Allocation of Energy Use by Zone

The SCADA system only records whether booster pumps are operating, without power demand or flow rate data. Monthly electricity billings are available for each booster pump station, but monthly water deliveries are available only by contractor, and most booster pumps support several contractors. For this reason, evaluation of the booster pumps was made by zone, to allow derivation of unit energy and unit costs. The three zones are shown in Table 1, along with the volume of water supplied by SCWA in 2005.

TABLE 1
Water Supply Zones and 2005 Volumes

LAGUNA DE SANTA ROSA		
	MG/yr	**% SCWA**
Santa Rosa	7,460	36%
Rohnert Park	1,620	8%
Cotati	349	2%
Windsor	192	0.9%
Forrestville	139	0.7%
Larkfield	169	0.8%
Ag/Golf/Business	51	0.2%
TOTAL	**9,980**	**48%**
SONOMA/EAST		
	MG/yr	**% SCWA**
Sonoma	751	4%
Valley of the Moon	974	5%
Kenwood	2	0.01%
Lawndale	20	0.10%
TOTAL	**1,747**	**8%**
PETALUMA/SOUTH		
	MG/yr	**% SCWA**
Petaluma	3,280	16%
North Marin Water District	3,400	16%
Marin Municipal Water District	2,370	11%
Penngrove	70	0.3%
TOTAL	**9,120**	**44%**

Table 2 shows the booster pump stations in each zone, along with the annual energy used in 2005. It is immediately obvious that unit energy use (MWhr/MG) is highest for Sonoma/East.[37] Since the booster pumps in the Laguna also support deliveries to the other two zones, part of their energy use (and costs) should be apportioned between the zones. The most logical

[37] With 5.5 times less water than the other zones, but only 1.5 times less energy.

allocation is according to water deliveries, and this was done according to the fraction of total SCWA deliveries for each zone, in each month.

TABLE 2
Booster and Well Pumps in each Zone and 2005 Energy Use

LAGUNA DE SANTA ROSA		
48% annual SCWA deliveries	**MWhr/yr**	**% All Boosters**
Occidental Well	1,350	9%
Sebastopol Well	1,930	13%
Todd Well	1,270	9%
Kawana	842	6%
Wilfred	246	2%
Forrestville B1/B2	38	0.3%
TOTAL	**5,677**	**39%**
SONOMA/EAST		
8% annual SCWA deliveries	**MWhr/yr**	**% All Boosters**
Eldridge	70	0.5%
Sonoma B1/B2	3,560	25%
TOTAL	**3,630**	**25%**
PETALUMA/SOUTH		
44% annual SCWA deliveries	**MWhr/yr**	**% All Boosters**
Ely	2,950	20%
Kastania	2,150	15%
TOTAL	**5,100**	**35%**

3.3.2 Monthly Energy Use

Fig. 15 shows monthly electricity use by each booster pump from July 2003 to December 2005. As can be expected, energy use is highest in summer. The largest users are: Ely, which moves water to Petaluma; Kastania, which moves water over a ridge from Petaluma to North Marin Water District (NMWD) and Marin Municipal Water District (MMWD); and Sonoma, which delivers water to several ridge top tanks. The spike in usage for Kastania in November 2005 was to deliver water to MMWD, most probably to reservoirs.[38] The spikes in usage for the Sonoma booster pump in January and February 2005 occurred at the lowest water deliveries to the zone, and cannot be explained.

[38] MMWD received most water deliveries in wet months when customer demand is low; the Kastania summer peak is mostly (70 to 85 percent) for deliveries to NMWD.

Fig. 16 shows the monthly cost of electricity for the booster pumps and reveals a significant drop in costs in 2005. This coincides with the transfer of all SCWA accounts to the PWRPA pool, which resulted in lower average rates and eliminated peak demand surcharges.

3.3.3 Conclusions

The first step toward operational conclusions for the booster pumps would be to conduct pump tests.[39] In the long term, to help coordinate load management, it would be prudent to install flowmeters and power meters and link them to SCWA's SCADA system. It would also be worthwhile linking to level gauges in the contractors' storage tanks to enable effective coordination of demands.

3.4 Energy and GHG Intensity of Water Deliveries

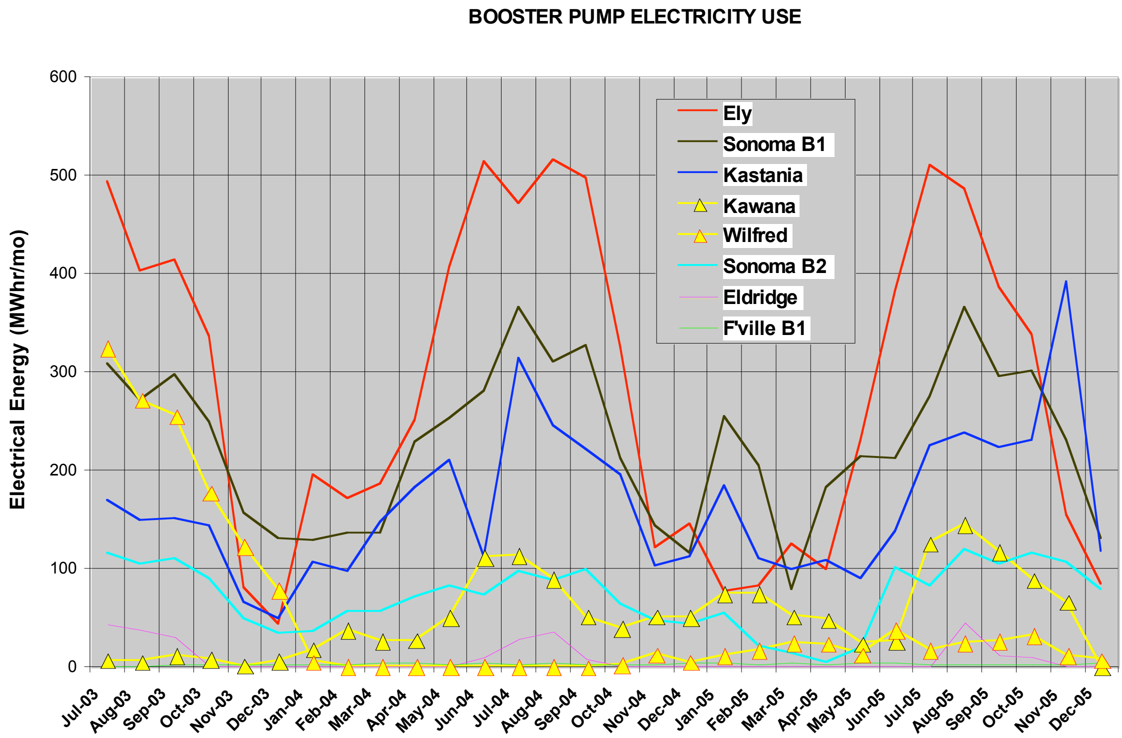
3.4.1 Overall Energy Use and Costs

To allow incorporation of booster pump stations, the evaluation of energy intensity is performed by delivery zone. Monthly water use in each zone provides the basis for allocating the energy use and costs of the Wohler/Mirabel system and the Laguna boosters and wells, across all the zones they support. Fig. 17 shows the monthly water use in each zone, revealing that there was a very small 2 percent reduction in total water delivered in 2005 (driven by a relatively cool summer).

Fig. 18 shows that three times as much energy is used by the Wohler/Mirabel system than by the booster pumps/wells. Fig. 19 compares the costs, and reveals that although costs for the booster pumps decreased 29 percent after SCWA joined the PWRPA, costs for the Wohler/Mirabel system increased 8 percent. Fortunately, Table 3 shows that the very large reductions in costs for the booster pumps created a 7 percent net reduction of SCWA's total costs.

[39] Pump tests are funded by the CPUC and administered by PG&E, but only to customers paying charges for Public Purpose Programs. PWRPA is not currently paying these "Public Goods" charges.

FIG. 15


BOOSTER PUMP ELECTRICITY USE
Electrical Energy (MWhr/mo)
600
500
400
300
200
100
0
Ely
Sonoma B1
Kastania
Kawana
Wilfred
Sonoma B2
Eldridge
F'ville B1
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04
Oct-04
Nov-04
Dec-04
Jan-05
Feb-05
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Sep-05
Oct-05
Nov-05
Dec-05

FIG. 16

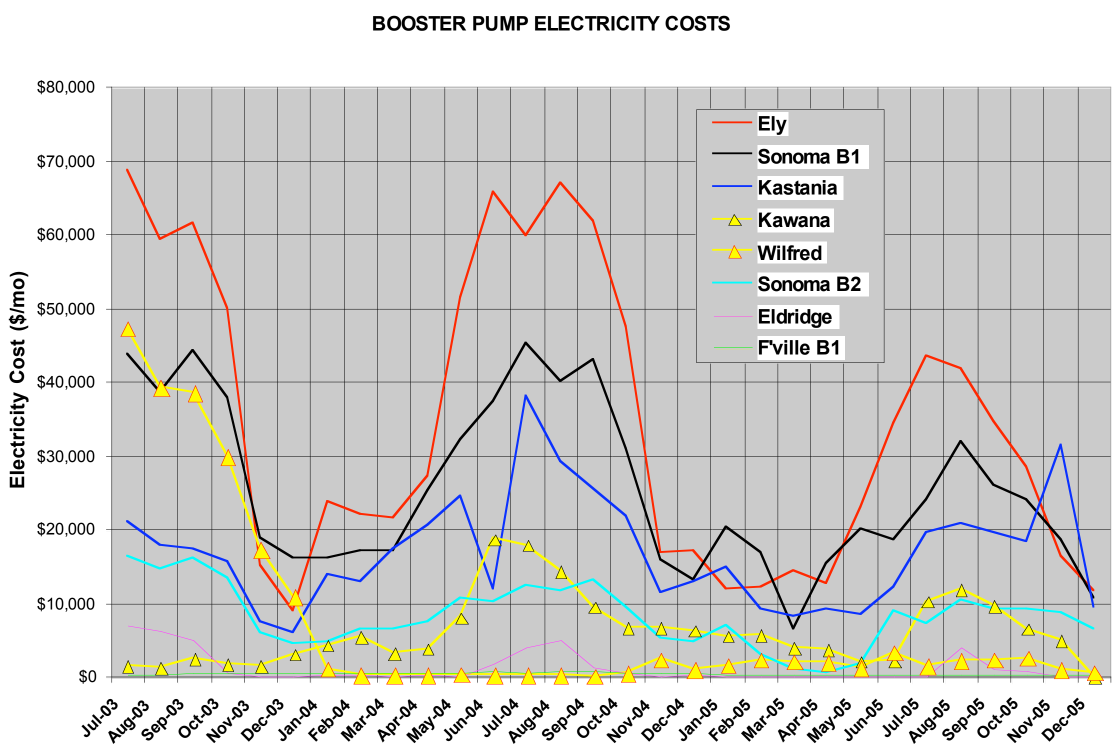
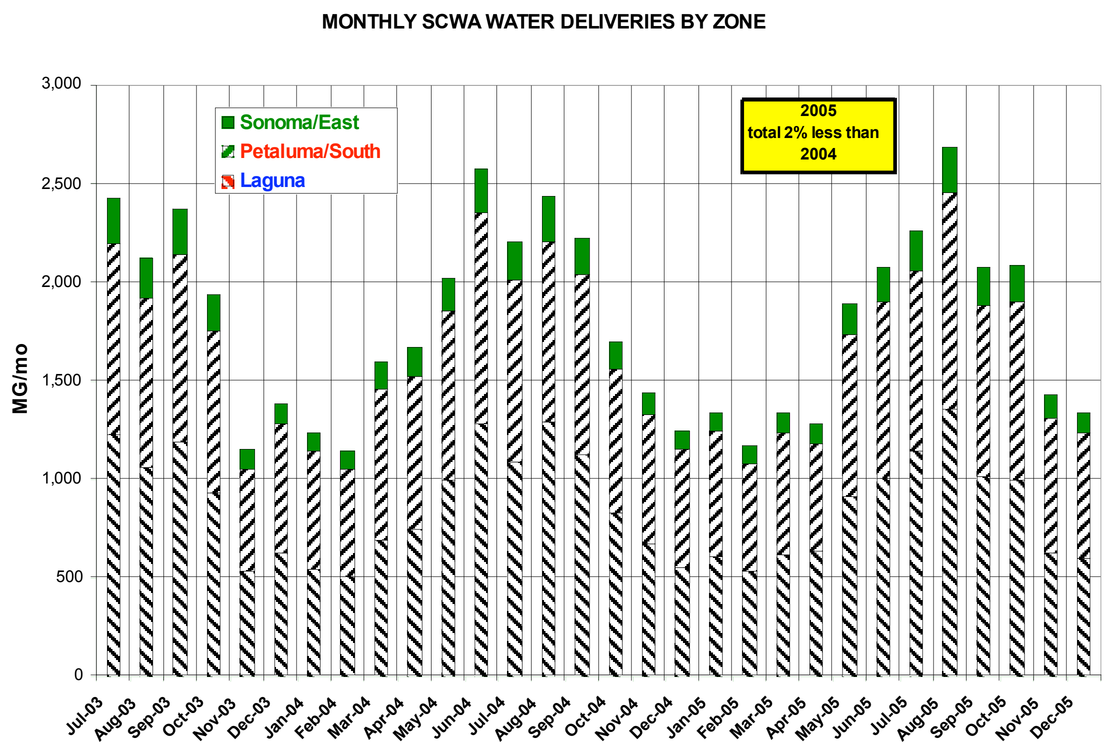
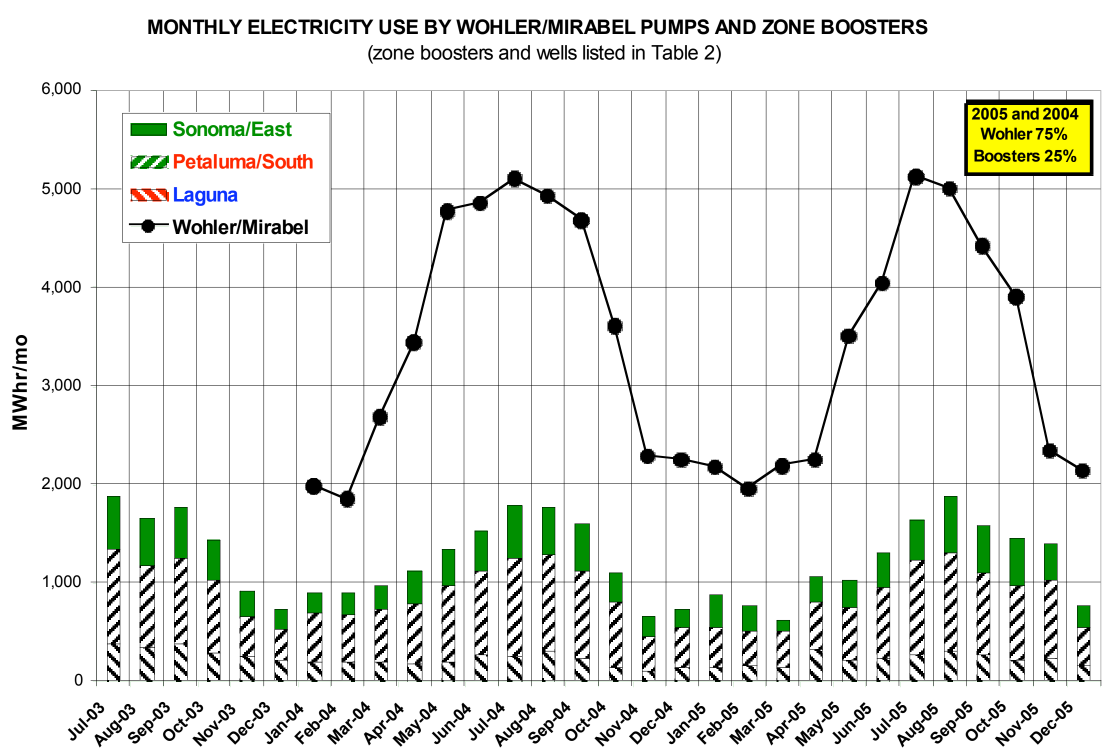

BOOSTER PUMP ELECTRICITY COSTS
Electricity Cost ($/mo)
$80,000
$70,000
$60,000
$50,000
$40,000
$30,000
$20,000
$10,000
$0
Ely
Sonoma B1
Kastania
Kawana
Wilfred
Sonoma B2
Eldridge
F'ville B1
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04
Oct-04
Nov-04
Dec-04
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Jun-05
Jul-05
Aug-05
Sep-05
Oct-05
Nov-05
Dec-05

FIG. 17



MONTHLY SCWA WATER DELIVERIES BY ZONE
MG/mo
Sonoma/East
Petaluma/South
Laguna
2005 total 2% less than 2004
3,000
2,500
2,000
1,500
1,000
500
0
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04
Oct-04
Nov-04
Dec-04
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Jun-05
Jul-05
Aug-05
Sep-05
Oct-05
Nov-05
Dec-05

FIG. 18



MONTHLY ELECTRICITY USE BY WOHLER/MIRABEL PUMPS AND ZONE BOOSTERS
(zone boosters and wells listed in Table 2)
MWhr/mo
Sonoma/East
Petaluma/South
Laguna
Wohler/Mirabel
2005 and 2004 Wohler 75% Boosters 25%
6,000
5,000
4,000
3,000
2,000
1,000
0
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04
Oct-04
Nov-04
Dec-04
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Jun-05
Jul-05
Aug-05
Sep-05
Oct-05
Nov-05
Dec-05

FIG. 19

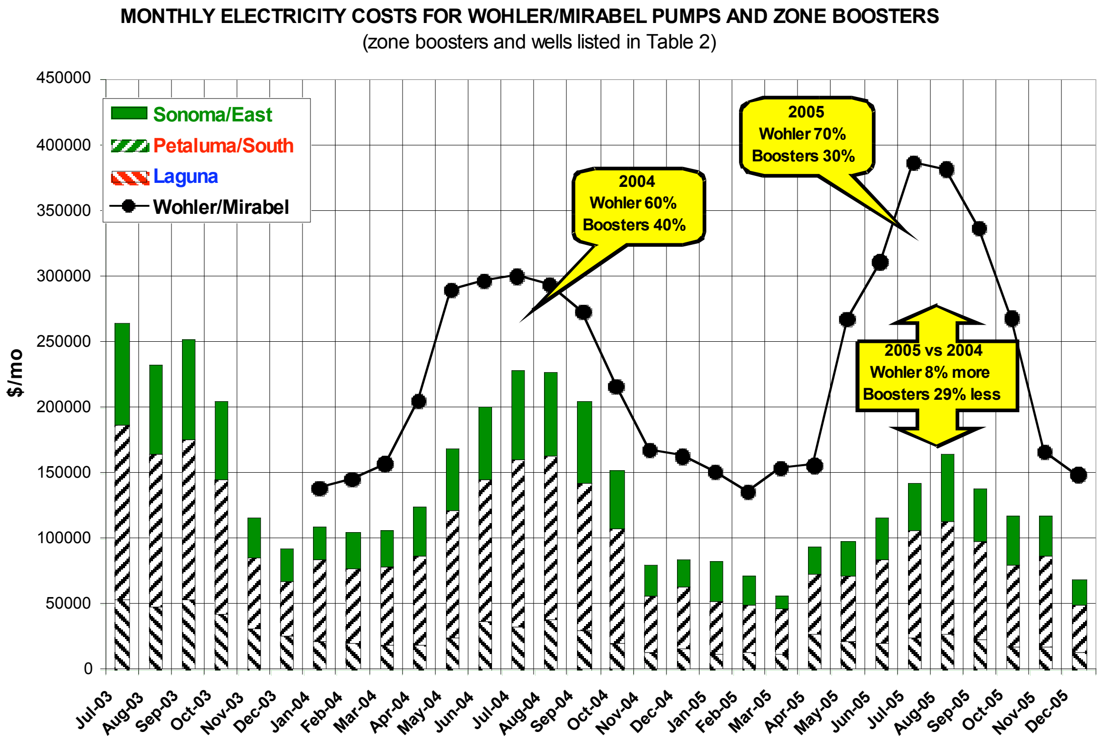


TABLE 3
Annual Water Deliveries, Energy Use, and Costs for 2004 and 2005

	WATER DELIVERED			ELECTRICAL ENERGY			ELECTRICITY COST		
	2004	2005		2004	2005		2004	2005	
	MG/yr	MG/yr	% change	MWhr/yr	MWhr/yr	% change	$/yr	$/yr	% change
Wohler/Mirabel	21,000	18,900	-10%	42,400	39,000	-8%	$2,640,000	$2,850,000	8%
Laguna	10,300	10,000	-3%	5,090	5,680	12%	$619,000	$486,000	-21%
Sonoma/East	1,810	1,760	-3%	3,530	3,630	3%	$452,000	$314,000	-31%
Petaluma/South	9,400	9,200	-2%	5,840	5,100	-13%	$722,000	$467,000	-35%
TOTAL	**21,500**	**21,000**	**-2%**	**56,860**	**53,410**	**-6%**	**$4,430,000**	**$4,120,000**	**-7%**
	Total water includes Laguna wells: 1,500 MG in 2004, and 1,900 MG in 2005.								

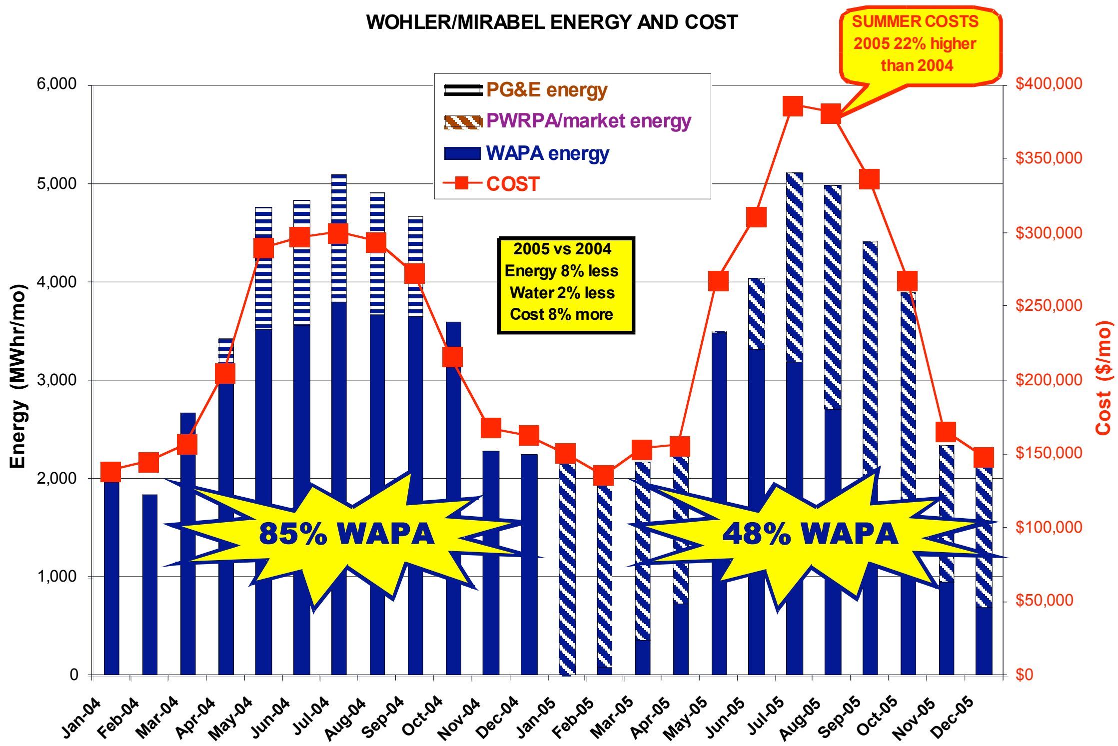
3.4.2 The Relationship between Electricity Purchasing Contracts, Rates, and GHG Emissions

The delicate net balance of costs between the Wohler/Mirabel system and the booster pumps is worth illuminating in more detail since short-term cash flow priorities can often deter long-term energy and GHG strategies. These details are also important because GHG emissions are very dependent on the mix of low-cost hydropower, which has no GHG emissions, and high-cost "market" power, generated mostly with fossil-fuels.

3.4.2.1 WOHLER/MIRABEL

Fig. 20 shows the cost elements for the Wohler/Mirabel system in 2004 and 2005. The difference between 85 percent WAPA hydropower in 2004 and only 48 percent in 2005 is the main reason that costs increased 8 percent even as energy use decreased 8 percent. In 2004, SCWA was using short-term access to a much larger allocation of low-cost WAPA hydropower,[40] and was able to sharply reduce purchases from PG&E under a contract that was heavily weighted toward peak power prices.[41] Before 2004, hydropower was available for only 25 percent[42] of annual energy required by the Wohler/Mirabel system. The increase to 85 percent hydropower in 2004 allowed the annual average cost of electricity to fall 25 percent from $82/mega watt hour (MWhr)[43] to $62/MWhr in 2004 (summer rates were reduced 35 percent from $91/MWhr[44] to $59/MWhr[45]).

FIG. 20



The federal government auctioned all WAPA contracts in 2005, and SCWA joined the PWRPA pool in bidding for the new allocations. Table 4, based on PWRPA billing records, shows that SCWA's annual hydropower allocation in 2005 (across all SCWA facilities, not only water pumping) was 47 percent, and the remaining 53 percent were "market" purchases. The PWRPA/market energy fraction in Fig. 20 was calculated from the monthly fraction of "market" purchases in Table 4.

A major change in new WAPA contracts is that only "run-of-the-river" power is sold, without the previous pool purchases that allowed WAPA to continue providing low-cost power throughout the dry season; long after most water was released from the dams. This is reflected in Fig. 20 by the rapid reduction in WAPA hydropower after July 2005. These additional

[40] SCWA purchased a portion of the City of Palo Alto's WAPA allocation.
[41] The details of the PG&E contract and cost implications are analyzed in the 2003 Provimetrics report.
[42] 2003 Provimetrics report.
[43] 2003 Provimetrics report.
[44] 2003 Provimetrics report.
[45] The billing data reveals that rates in January, February, November, and December 2004 were $70 to $78/MWhr while June, July, August, and September were $58 to $61/MWhr.

purchases were actually mostly from Federally subsidized nuclear power plants and long-term contracts with coal-fired western utilities. Therefore the GHG emissions of WAPA's late summer deliveries were not really zero.[46]

TABLE 4
WAPA and Market Purchases by PWRPA for SCWA in 2005

	WAPA MWhr/mo	MARKET MWhr/mo	TOTAL MWhr/mo	%WAPA
Jan-05	0	3,090	3,090	0%
Feb-05	110	2,630	2,740	4%
Mar-05	550	2,700	3,250	17%
Apr-05	1,090	2,250	3,340	33%
May-05	4,610	30	4,640	99%
Jun-05	4,500	980	5,480	82%
Jul-05	4,270	2,560	6,830	63%
Aug-05	3,620	3,040	6,660	54%
Sep-05	2,580	3,280	5,860	44%
Oct-05	1,700	3,500	5,200	33%
Nov-05	1,380	2,000	3,380	41%
Dec-05	1,030	2,070	3,100	33%
ANNUAL	**25,400**	**28,100**	**53,600**	**47%**

Fig. 21 shows first that monthly electricity rates for Wohler/Mirabel pumps increased 28 percent between summer 2004 and summer 2005. For this reason, unit costs ($/MG) in summer 2005 are much higher than summer 2004. PWRPA has been successful in dampening the sharp increases in summer rates compared to winter by (1) correctly forecasting high market purchase costs and distributing them across the whole year, and (2) sharing WAPA allocations between members and crediting pool members for any unused portion of their allocation. The resulting annual increase in rates from 2004 to 2005 was 18 percent.

Fig. 21 also shows that unit energy (MWhr/MG) is significantly higher in summer than in winter, again reinforcing the case for load management (i.e., to avoid higher energy use for larger flow rates).

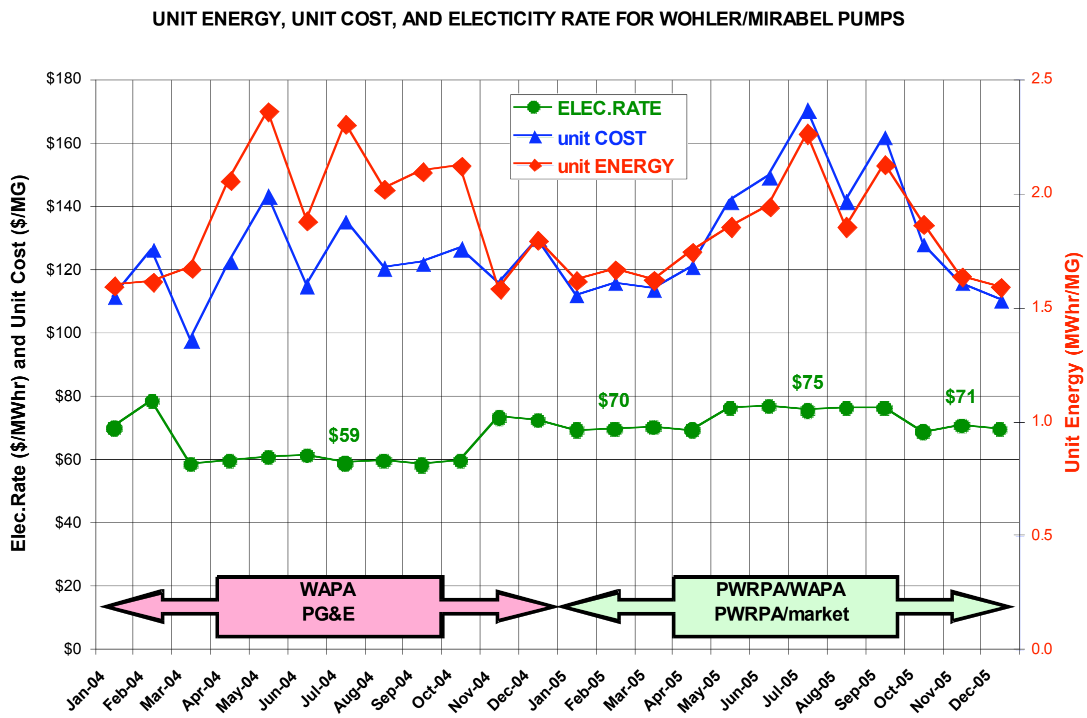
Energy use does not translate directly into GHG emissions, because of the need to separate out the contribution of hydropower. It is assumed that market power has a GHG emissions factor of 0.73 pounds per CO_2 kilo watt hour (lb-CO_2/KWhr),[47] which is applied to PG&E in 2004 and

[46] Besides pricing, City of Palo Alto energy planners decided to withdraw from WAPA to contract with more reliable and sustainable sources of renewable energy for summer peaks. Palo Alto is municipal utility with more options than SCWA to engage in such contracting, and also has a large and firm access to California hydropower projects.

[47] This is the coefficient for California and Nevada used by the Western Systems Coordinating Council, which is the value used by most State agencies. Another approach might be to apply the 1.34 lbs eCO_2/kWhr coefficient developed by Northern California Power Agency (NCPA) (wholesaler to the City of Healdsburg Utility Dept) for

PWRPA/market in 2005. Fig. 22 compares monthly energy use and GHG emissions, revealing that with the transition to the new WAPA allocations, GHG emissions increased 212 percent in 2005 compared to 2004. It is important to recognize the unique access SCWA had to WAPA hydropower in 2004, and that GHG emissions before 2003 averaged 11,000 Tons-CO_2/yr.[48]

FIG. 21



3.4.2.2 BOOSTER PUMPS

As shown in Fig. 19, booster energy costs were reduced 29 percent in 2005 with the transfer from PG&E to PWRPA. Based on Table 4, low-cost hydropower replaced 46 percent of the PG&E market-priced power. Fig. 23 shows the dramatic reduction in electricity rates, and the attenuation of summer peaks in all three zones. The key point is that the initial rates for the booster pumps were much higher than for Wohler/Mirabel pumps, decreasing from an annual average of $124/MWhr in 2004 to $87/MWhr in 2005 (which is still 16 percent higher than the $75/MWhr for Wohler/Mirabel).

FIG. 22

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their "California Mix" of non-hydro power, based on the following mix of sources: 45.2 percent natural gas; 29.0 percent coal; 22.6 percent eligible renewable; 3.2 percent nuclear; and <1 percent other. To avoid overestimating GHG emissions while PWRPA establishes a long-term average for its market power, and to provide an "apples-to-apples" comparison for future discussions with State agencies, we have chosen to retain the 0.73 lbs eCO_2/kWhr coefficient.

[48] The 2003 Provimetrics report shows that 2002 electricity purchases from PG&E for Wohler/Mirabel were 29,438 MWhr, resulting in GHG emissions of 10,712 Tons-CO_2/yr. The 2002 Skymetrics report estimated that average emissions for all SCWA facilities were 14,000 Tons-CO_2/yr in 2001 and 2002.

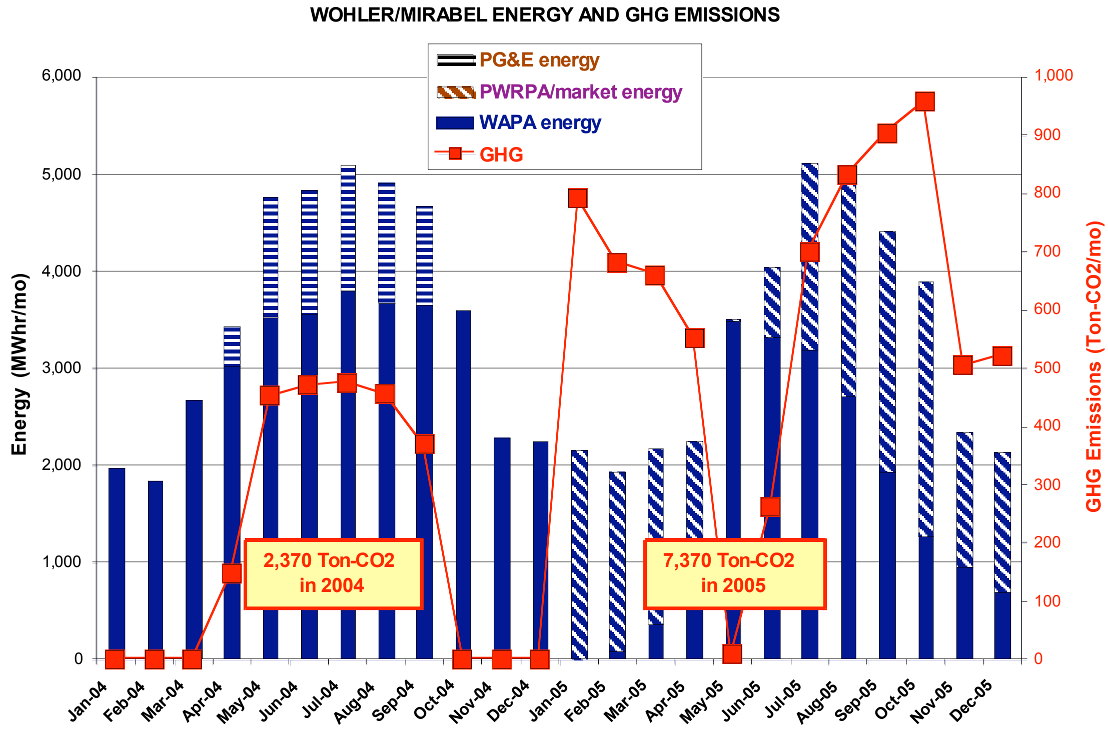


FIG. 23

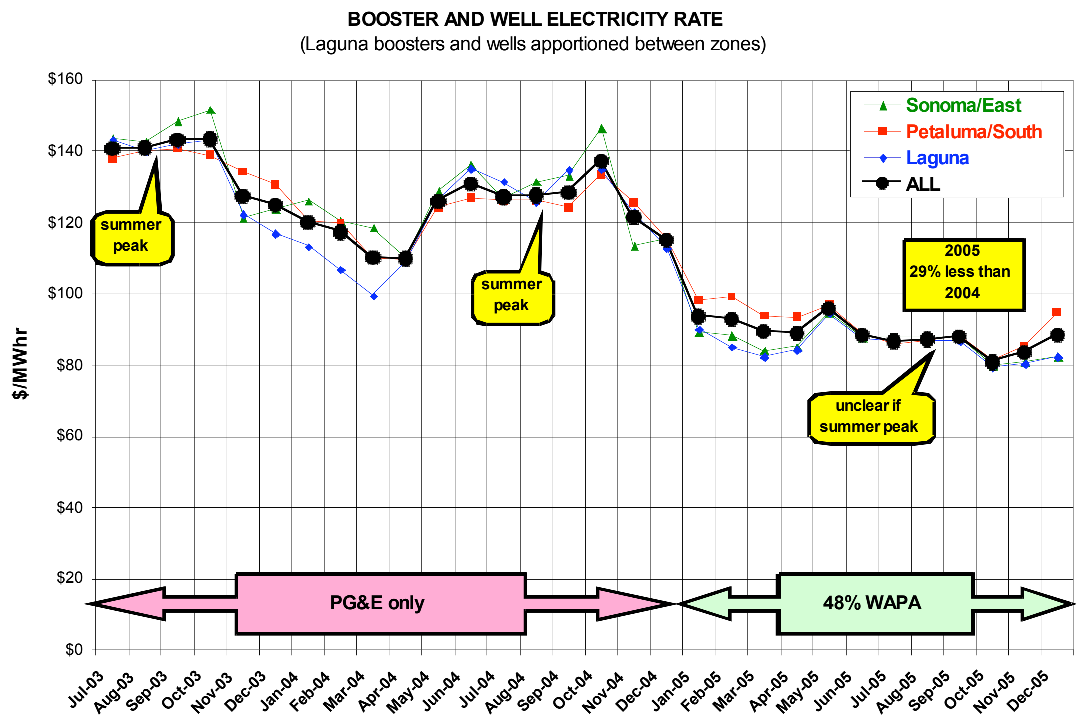


Fig. 24 shows the relative energy intensity for each of the three zones and the combination of all zones. Unit energy use for Sonoma/East is much higher than the others and does not exhibit any performance pattern. At least two high outliers in wet months of 2005 indicate that there might be other loads connected to the meter. The large fluctuations for Sonoma/East and Petaluma/South[49] imply that pump testing might reveal potential improvements (i.e., constant operation at the lower values).

FIG. 24

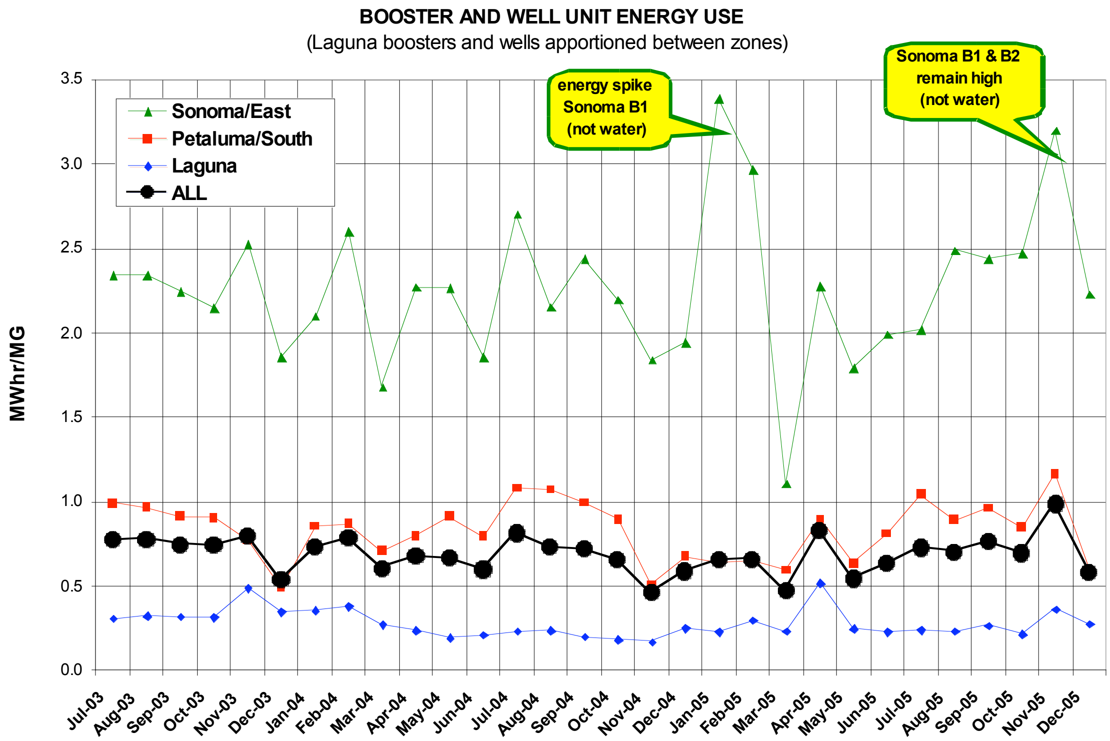


Fig. 25 shows the combined electricity rate, unit energy (MWhr/MG) and unit cost ($/MG) for boosters in all three zones. Unit costs are reduced in direct relationship to the 29 percent reduction in rates, and are generally much lower than for Wohler/Mirabel ($60/MG annual average for 2005 vs. $136/MG for Wohler/Mirabel). Unit energy has very large fluctuations, reflecting the need for individual analysis of each pump station, but in general are much lower than for Wohler/Mirabel (1.9 MWhr/MG annual average for 2005 vs. 0.7 MWhr/MG for Wohler/Mirabel).

The unit energy in Fig. 24 does not translate directly into GHG emissions, because of the need to separate out the contribution of hydropower. It is assumed that market power has a GHG emissions factor of 0.73 lbs-CO_2/KWhr,[50] which is applied to all electricity in 2004 (purchased

[49] The scale required to include Sonoma/South, slightly obscures the 110 percent fluctuation between 0.5 MWhr/MG and 1.0 MWhr/MG for Petaluma/South.

[50] This is the coefficient for California and Nevada used by the Western Systems Coordinating Council, which is the value used by most State agencies. Another approach might be to apply the 1.34 lbs eCO_2/kWhr coefficient developed by NCPA (wholesaler to the City of Healdsburg Utility Dept) for their "California Mix" of non-hydro power, based on the following mix of sources: 45.2 percent natural gas; 29.0 percent coal; 22.6 percent eligible renewable; 3.2 percent nuclear; and <1 percent other. To avoid overestimating GHG emissions while PWRPA establishes a long-term average for its market power, and to provide an "apples-to-apples" comparison for future discussions with State agencies, we have chosen to retain the 0.73 lbs eCO_2/kWhr coefficient.

from PG&E) and to PWRPA/market electricity in 2005 (derived from the percentage of WAPA in Table 4).

Fig. 26 compares monthly energy use and GHG emissions for all the boosters in all three zones, revealing that with the transition to the new WAPA allocations, GHG emissions decreased 46 percent in 2005 compared to 2004.

The 2,440 Ton-CO_2 reduction from the boosters is smaller than the 5,000 Ton-CO_2 increase from the Wohler/Mirabel pumps, increasing overall GHG emissions by SCWA's water delivery system from 7,640 Tons-CO_2 in 2004 to 10,210 Tons-CO_2 in 2005 (34 percent).

3.4.3 Conclusions

The main conclusions from analyzing the details of SCWA's electricity purchasing contracts are:

1. WAPA's January 2005 switch to "run-of-the-river" hydropower allocations has drastically reduced SCWA's access to low-cost, zero-emissions electricity
2. SCWA's electricity-purchasing contract with the PWRPA pool has resulted in the following changes from 2004 to 2005:
   a. Wohler/Mirabel system:
      - Increased electricity rates by 18 percent
      - Increased GHG emissions by 212 percent
   b. Booster Pumps and Laguna wells:
      - Reduced electricity rates by 29 percent
      - Reduced GHG emissions by 46 percent
   c. Overall SCWA water supply system (with a negligible 2 percent reduction in water supply):
      - A 7 percent reduction in electricity costs
      - A 34 percent increase in GHG emissions

4 BASELINE

4.1 Assumptions for Establishing a Baseline

The detailed evaluation in the previous sections reveals that there is a wide variability in unit energy, unit costs, and unit greenhouse gas (GHG) emissions, depending on several interrelated factors. To simplify the calculations for establishing a representative baseline and estimating potential improvements in the future, we made the following simplifying assumptions.

4.1.1 Fixed Water Demand Distribution between Zones and between Months

Total annual water delivery is set as the average from 2004 and 2005, 21,240 million gallons per year (MG/yr) (65,200 acre-feet per year [AF/yr]).

The fraction delivered in each month is set as the average for the same months in 2004 and 2005, and then adjusted by a common factor to obtain a sum of 100 percent for all 12 months.

The relative distribution of water demand between zones is set as the annual average for 2005 shown in Table 1, and assumed constant for all months and over time.

FIG. 25

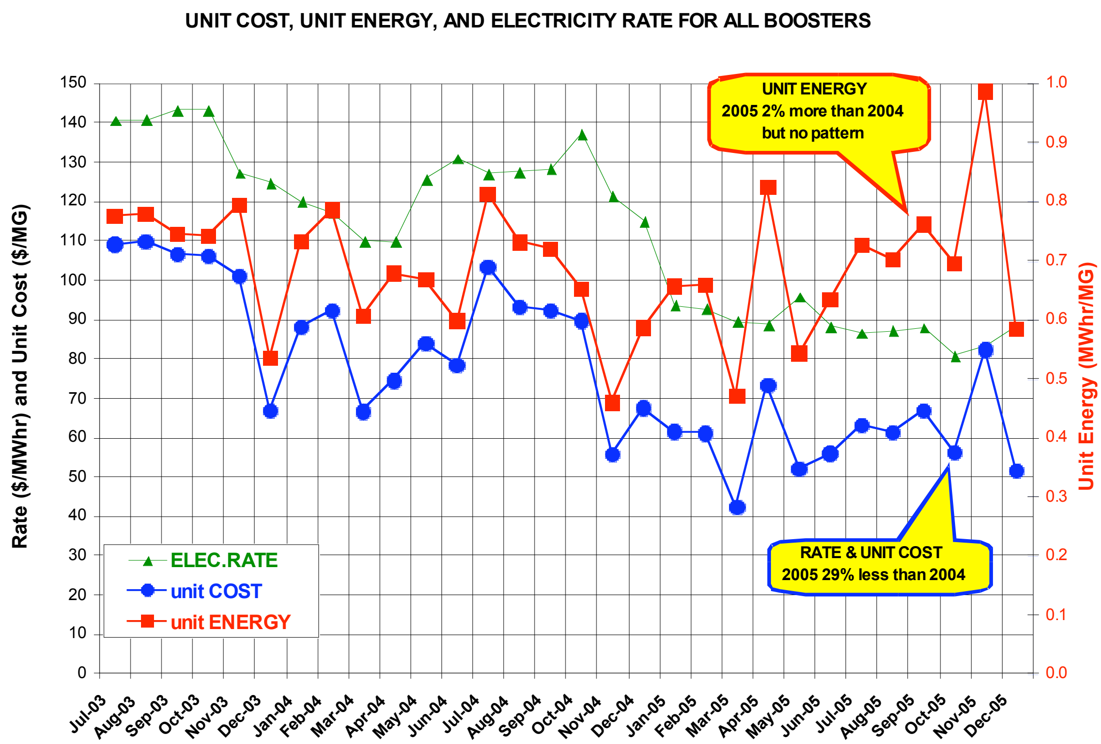
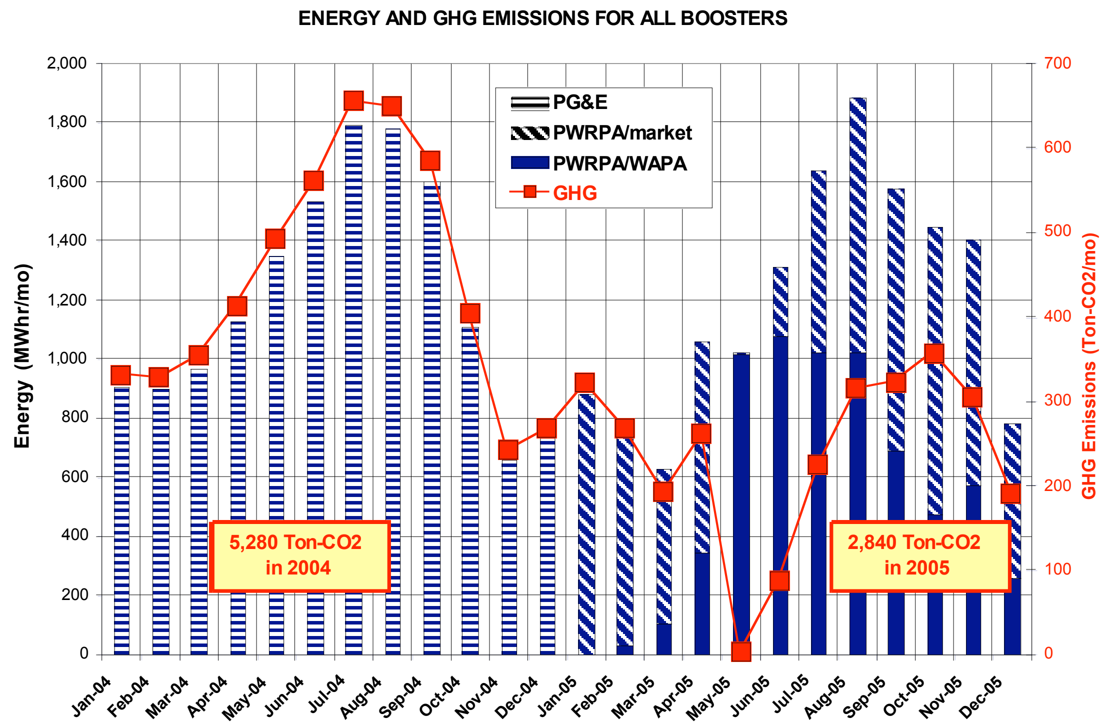


FIG. 26

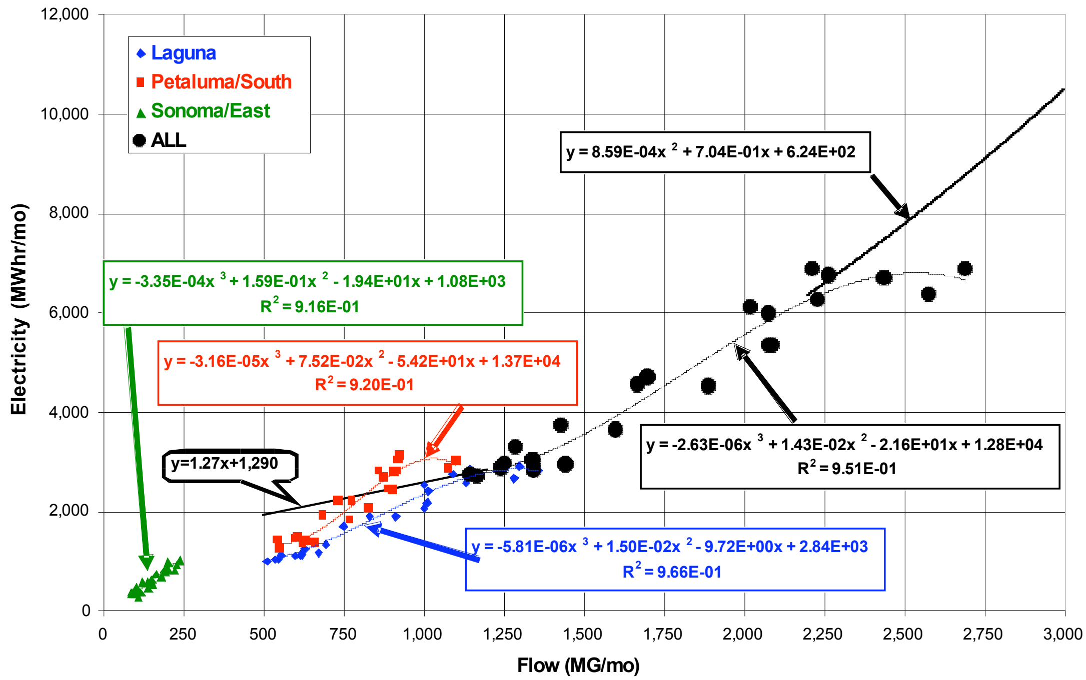


4.1.2 Energy-Flow Relationship

Fig . 27 shows the existing correlations between monthly water deliveries and monthly energy use in each zone, and the aggregate correlation for total delivery. The energy for each zone includes the flow-apportioned fraction of Wohler/Mirabel pumps and Laguna boosters/wells. The cubic relationship used for total monthly delivery is between 1,200 MG/month and 2,200 MG/month within the range of available data. The linear relationship extends the range below 1,200 MG/month total monthly deliveries, and the quadratic relationship extends the range beyond 2,200 MG/month (as discussed for Figs. 7, 9, and10).

FIG. 27

EXISTING ENERGY-FLOW CORRELATIONS

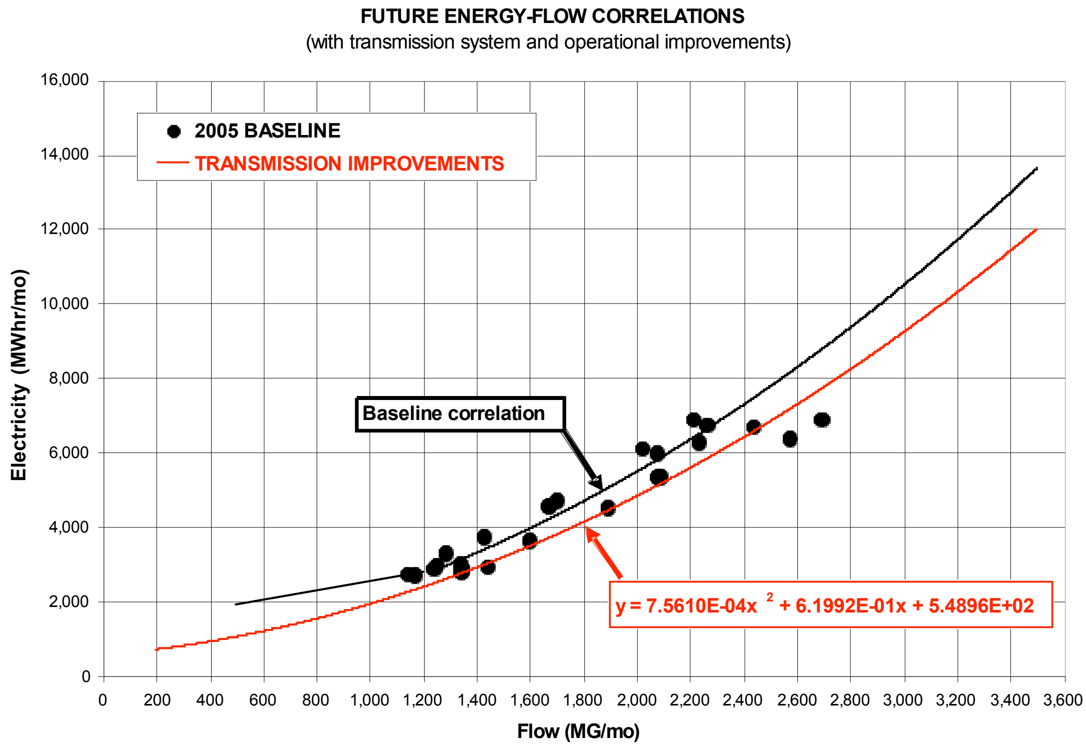


Similar correlation extensions for each zone can easily be developed, but are not needed for this initial evaluation (and need some pump tests to validate the relationship, similar to the application of one-hour Supervisory Control and Data Acquisition (SCADA) data for the Wohler/Mirabel system).

The shape of the curves in Fig. 27 is critical for projecting energy demand as water demand increases, and estimating savings from implementing energy and water efficiency measures. To account for scheduled improvements to the transmission system, including construction of parallel piping and replacement bottleneck sections with larger diameter piping, we assumed a minimum 12 percent reduction in monthly energy use. This is shown in Fig. 27(b) compared to the 2005 baseline. Statistical validation of the correlations is a primary justification for a more detailed analysis of operating data in the SCADA system, and for booster/well pump testing.[51]

[51] A more accurate curve could be derived from the hydraulic model currently being developed for SCWA.

FIG. 27(b)



4.1.3 Electricity Rates

The baseline rate is calculated from the sum of all electricity costs divided by the total electricity used in each month of 2005. This provides a weighted average of the significant difference between Wohler/Mirabel and the three zones. Table 5 lists the monthly rates used in the baseline.

TABLE 5
Baseline Electricity Rates

	$/MWhr
JAN	$76
FEB	$76
MAR	$74
APR	$75
MAY	$81
JUN	$80
JUL	$78
AUG	$79
SEP	$79
OCT	$72
NOV	$75
DEC	$74

Given utility/CPUC plans to sharply surcharge peak period electricity, and to provide targeted incentives for peak load reductions, it is important to understand the impact of peak periods on the average Power and Water Resources Pooling Authority (PWRPA) rates in Table 5. A more detailed analysis of operating data in the SCADA system will reveal how the Sonoma County Water Agency (SCWA) can capture benefits from load shifting (the benefits include direct savings, financial incentives from the PG&E, and credits from the PWRPA pool).

The assumed escalation for the electricity rates were:

- Market power (PG&E) assumed 6 percent per year used for SCWA's for solar photovoltaic projects[52]
- Western Area Power Agency (WAPA) hydropower was assumed to grow only 66 percent as fast as market power (i.e., 4 percent per year)
- The combined cost escalation was calculated as a weighted average, using the fraction of market and WAPA power for each of the scenarios for 2020[53]

4.1.4 Substitution of WAPA Hydropower for Market Power

If energy use can be reduced for the water distribution system, GHG emissions will be reduced only if market power is displaced. This requires an agreement within the PWRPA pool that SCWA will be allowed to retain a fixed WAPA allocation while improving energy efficiency. Assuming that such an agreement is possible, at least in the near future, monthly WAPA usage in 2005 will be fixed as listed in Table 4, even though it is unclear that January, February, and March will always have such small allocations.

Some of the PWRPA charges are fixed, and will be retained even if SCWA reduces energy use. On the other hand, the contract can credit SCWA for unused energy if another pool member needs it. To accommodate the fixed portion, we assume that the fixed charge is $100,000/month. If potential savings are shown to approach the fixed limit, it might be worthwhile negotiating an agreement that will be beneficial to all members of the pool.

4.1.5 Indoor and Outdoor Use

To reasonably forecast future water demand, it is important to differentiate between indoor and outdoor uses. For simplification, it is assumed that the month with the lowest water demand represents indoor use, and anything in access of this value represents outdoor demand. This is a common assumption[54], and is generally accurate.[55]

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[52] Discussion with Jim Flessner and Cordel Stillman, October 31, 2006.

[53] Based on the assumptions, market rates will increase 140 percent by 2020, and WAPA rates will increase 79 percent. For a scenario using 20 percent market and 80 percent WAPA, the combined escalation in costs by 2020 would be 91 percent.

[54] Several examples from SCWA's planning documents are mentioned in the JONWRM Model.

[55] For Petaluma/South there will be an overestimation of indoor use because deliveries to MMWD peak in winter when customers' demands are low. In 2004 and 2005, 55 percent of MMWD deliveries occurred in winter, representing 15 percent of the annual total for Petaluma/South.

4.2 Baseline Values

TABLE 6
Electricity Cost and GHG Emissions Components for the Baseline (2005)

	ELEC.RATE	FIX.CHARGE	WAPA ALLOCATION	
	$/MWhr	$/mo	MWhr/mo	% total
JAN	$76	$100,000	0	0%
FEB	$76	$100,000	110	4%
MAR	$74	$100,000	590	17%
APR	$75	$100,000	1,170	33%
MAY	$81	$100,000	5,750	99%
JUN	$80	$100,000	5,080	82%
JUL	$78	$100,000	4,280	63%
AUG	$79	$100,000	4,200	54%
SEP	$79	$100,000	2,680	44%
OCT	$72	$100,000	1,680	33%
NOV	$75	$100,000	1,370	41%
DEC	$74	$100,000	990	33%
ANNUAL	**$77**	**$1,200,000**	**27,900**	**49%**

GHG coefficient
Ton-CO2/KWhr
0.73

TABLE 7
2005 Baseline Monthly Water Supply, Electricity Use and Costs, and GHG Emissions

	WATER DELIVERIES			ELECTRICITY USE			ELECTRICITY COST			GHG EMISSIONS		
	INDOOR	OUTSIDE	ALL	INDOOR	OUTSIDE	ALL	INDOOR	OUTSIDE	ALL	INDOOR	OUTSIDE	ALL
	MG/mo	MG/mo	MG/mo	MWhr/mo	MWhr/mo	MWhr/mo	$/mo	$/mo	$/mo	Ton-CO2/mo	Ton-CO2/mo	Ton-CO2/mo
JAN	1,160	130	1,290	2,660	310	2,970	$202,300	$23,600	$226,000	970	110	1,080
FEB	1,160	0	1,160	2,760	0	2,760	$209,800	$0	$209,800	970	0	970
MAR	1,160	310	1,470	2,710	740	3,450	$202,200	$54,900	$257,100	820	220	1,050
APR	1,160	350	1,500	2,740	830	3,570	$206,800	$62,300	$269,100	670	200	880
MAY	1,160	910	2,060	3,240	2,540	5,790	$261,800	$205,100	$466,900	10	10	10
JUN	1,160	1,020	2,170	3,280	2,890	6,180	$261,300	$230,400	$491,700	210	190	400
JUL	1,160	1,160	2,310	3,420	3,430	6,850	$267,200	$267,600	$534,800	470	470	940
AUG	1,160	1,340	2,490	3,580	4,140	7,720	$283,600	$328,300	$612,000	600	690	1,290
SEP	1,160	1,000	2,150	3,280	2,830	6,110	$259,800	$224,100	$483,800	670	580	1,250
OCT	1,160	740	1,900	3,130	2,010	5,140	$225,200	$144,400	$369,600	770	490	1,260
NOV	1,160	280	1,430	2,690	650	3,340	$203,000	$49,100	$252,100	580	140	720
DEC	1,160	140	1,300	2,650	320	2,980	$197,500	$24,100	$221,600	650	80	730
ANNUAL	**13,900**	**7,400**	**21,200**	**36,100**	**20,700**	**56,900**	**$2,781,000**	**$1,614,000**	**$4,395,000**	**7,400**	**3,200**	**10,600**
% ALL	**66%**	**34%**		**63%**	**37%**		**63%**	**37%**		**70%**	**30%**	
		AF/yr	**65,056**	**Unit Energy (MWhr/MG)**		**2.7**		**Unit Cost ($/MG)**	**$207**	**Unit GHG (Ton-CO2/MG)**		**0.5**
								Elec Rate ($/MWhr)	$77			

5 POTENTIAL REDUCTIONS IN GHG EMISSIONS

5.1 Operational Improvements

As discussed in the evaluation of current operations, a more detailed analysis of Supervisory Control and Data Acquisition (SCADA) data and the Power and Water Resources Pooling Authority (PWRPA) rate structure is required to determine whether reductions in energy use and costs are feasible. The data required for Wohler/Mirabel pumps is already available, but pump tests are required for the Laguna wells and all the booster pumps. The range of potential energy reductions could be as high as 12 to 26 percent, but a valid estimate could not be derived from the July 2005 data alone.

Given the relatively high wire-to-water efficiencies of the Wohler/Mirabel pump combinations shown in Fig. 6, it is more likely that reductions will come from load management rather than pump/motor improvements. Load management means optimization of pumping schedules and storage tank levels to:

1. Reduce maximum flow rates and power demands
2. Redistribute flow rates so that the most frequent power demands are lower (e.g., shift the distribution shown in Fig. 10 for July 2005 to the left)
3. Reduce power demand during peak electricity periods, if the PWRPA rate structure and/or State incentives provide economic benefit to Sonoma County Water Agency (SCWA)

On top of improvements in pump operations, several transmission system projects are scheduled to reduce hydraulic friction by adding parallel pipelines and removing bottlenecks. This will also improve the potential to reduce power demand by matching the combination of operating pumps to aqueduct back-pressure conditions.

Applying a minimum monthly energy reduction of 12 percent is probably a reasonable assumption for all the above operational improvements combined. The impact of transmission system improvements and operational improvements will be calculated from the system curve shown in Fig. 27(b).

5.2 Integrating GHG Reductions into the Water Project

5.2.1 Framework

Besides the transmission system improvements that are already part of the Water Project, and load management that could be implemented with the existing SCADA system, large and economically viable reductions could be captured by implementing very high levels of water efficiency as part of the Water Project. Since the project is still in planning, it is feasible to consider the following elements.

5.2.1.1 INTEGRATION OF WATER EFFICIENCY WITH ENERGY EFFICIENCY AND GHG REDUCTIONS

Besides reducing pumping costs, water use efficiency can generate much larger energy reductions (and other savings) for end-users, and considerable energy reductions in wastewater treatment. This greatly multiplies regional GHG reductions from water efficiency efforts. Table

8 shows an example of energy use intensity (mega watt hours per million gallons [MWhr/MG]) for the water/wastewater cycles in San Diego County[56] and Sonoma County.[57]

TABLE 8
Energy Use Intensity for Urban Water/Wastewater Cycles

	SAN DIEGO COUNTY WATER AUTHORITY		SCWA AND SANTA ROSA	
	MWhr/MG	% TOTAL	MWhr/MG	% TOTAL
Wholesale Water Conveyance	6.3	30%	2.7	17%
Water Treatment	0.2	1%	0.2	1%
Water Distribution	1.0	5%	1.0	6%
Wastewater Treatment	1.7	8%	4.0	25%
Customer Use	**12.0**	**57%**	**7.9**	**50%**
TOTAL	**21.2**		**15.7**	

Table 8 shows that water efficiency programs initiated by SCWA will enable very large energy and subsequent GHG reductions for end-use customers — several times larger than possible in SCWA's water delivery system. Beyond the energy intensity shown in Table 8, the overwhelming use of natural gas for hot water heating makes it very likely that there will be an even larger difference in the intensity of GHG emissions from customer use than all other water and wastewater related emissions.[58]

5.2.1.2 Maximization of Reductions Rather than Meeting Prescriptive Regulatory Targets

Maximizing multiple resource benefits allows "tunneling through" of cost barriers common to single-purpose programs with low prescriptive targets. Tunneling through is a concept developed in *Natural Capitalism: Creating the Next Industrial Revolution*, by Amory Lovins, Hunter Lovins, and Paul Hawken. As described by the authors and reinforced with many engineering examples, there are two main methods of tunneling through:

1. Careful planning to create a package of efficiency measures that all have multiple benefits that simultaneously reduce both capital and operating costs
2. Piggybacking efficiency measures into projects already underway for other reasons

[56] Figure 4 on page 32 in R. Cohen, B. Nelson, and G. Wolff, *Energy Down the Drain: The Hidden Costs of California's Water Supply*, August 2004, National Resources Defense Council (NRDC) and Pacific Institute.
[57] Conveyance energy intensity was taken from Table 7 in this study. Wastewater energy intensity was taken from a 2004 GHG inventory evaluation of the Laguna Sub-Regional Water Pollution Control Plant by Provimetrics Corp. for Skymetrics (based on electricity purchased in 2001 and 2002 for treatment and reclamation). Since Sonoma County has less far less industry than San Diego, we assumed only 66 percent of San Diego's customer use energy intensity; water treatment and distribution assumed similar to San Diego.
[58] Table 1-1 of *California's Water-Energy Relationship: Final Staff Report*, CEC-700-2005-011-SF, November 2005 shows that across the State, customers' water-related electricity use is 2.9 times the total for water supply and wastewater treatment; for natural gas, the ratio is 91.7. Site specific details will be examined in the GHG evaluation for the City of Santa Rosa.

Both methods are applicable to the Water Project. For example, water efficiency could reduce the size/cost of peak flow facilities (pump stations and pipelines). Beyond the Water Project itself, Table 8 shows the potential for regional benefits of water use efficiency, especially on the customer side of water meters. At the institutional level, we believe there are large mutual benefits to be reaped from coordinated water use efficiency planning in SCWA's Water Project and the City of Santa Rosa's Incremental Recycled Water Project (IRWP). This will be pursued further in the companion report for Santa Rosa.

5.2.1.3 TECHNICAL, FINANCIAL, AND ADMINISTRATIVE SERVICES TO OBTAIN HIGH CUSTOMER PARTICIPATION

High customer participation is the key to the success of any water use efficiency program. The impact of large efficiency improvements will be negligible[59] unless a coordinated and adequately funded effort is made to ensure widespread implementation. This requires far more than waiting for customers to respond to rebate offers. Technical and financial services must be provided to address site- and customer-specific conditions; delivery and performance must be monitored, and corrective action taken if needed.

Focusing only on water use efficiency will not attract much attention from customers since water itself is still "cheap." A comprehensive service to support energy and water use efficiency (and GHG reductions) will attract participation, and avoid the inherent obstacles of trying to navigate between a multitude of single-purpose programs.[60]

This implies developing SCWA's role in providing water services, rather than only delivering the resource. Numerous utilities and resource companies such as PG&E, Shell, and BP are transforming themselves to capture service opportunities — partially to mitigate the effects of climate change on the future of their business.

5.2.1.4 INVESTMENT IN EFFICIENCY MEASURES AS PART OF INFRASTRUCTURE PROJECTS

The main advantage of including efficiency investments in infrastructure funding is to establish least-cost implementation priorities without *a priori* budget limitations for efficiency measures. This implies long-term capital funding for efficiency rather than a fraction of each year's operating costs. In particular, it is important to calculate the life-cycle costs of efficiency to include in the rate impact assessment for the Water Project. The Pacific Institute's report *Waste Not, Want Not: The Potential for Urban Water Conservation* of November 2003 demonstrates the advantages and the methodology, including analysis of revenue impacts.

5.2.2 Water Supply Projections

SCWA is currently preparing detailed projections of future water demand for the Water Project Environmental Impact Report (EIR), for the Urban Water Management Plan (UWMP), and for

[59] The common assumption is that very few customers will achieve large reductions, while many more will achieve small reductions (and mainly during new construction/remodeling). For example, 2 percent of customers achieving 50 percent reductions results in an overall reduction of 1 percent, while 80 percent of customers making easy 10 percent reductions provides an 8 percent reduction.

[60] For example, the differentiation between "new" and "existing" facilities/buildings, between types of end-uses, and between purchasing contracts increases the effort needed to apply for incentives that might not even cover the cost of the application.

allocations during supply deficiencies.[61] The UWMP was not yet available to include in this report, and the Water Project EIR is still under revision, so we relied on the water supply projection contained in the JONWRM report on deficiency planning. The report states that maximum demand is currently 68,188 acre-feet per year (AF/yr) and will be expanded to 94,093 AF/yr by 2020. This implies a 38 percent increase in capacity, and a 44 percent potential increase in deliveries compared to the 2005 baseline shown in Table 7.

5.2.3 Scenarios for Water Use Efficiency Projections

5.2.3.1 Context

To provide an initial evaluation of the potential for water use efficiency improvements in SCWA's service area, we compared average 2005 residential water use to the definitive 1999 American Water Works Association (AWWA) study of 1,188 homes in 12 cities.[62] The AWWA study set a 69.3 gallons per capita per day (gpcd) baseline for water use before any particular efficiency measures. The JONWRM model[63] documents that average water use for all sectors across SCWA's service area was 94 gpcd, and that residential fraction was 73 percent. This implies 68.8 gpcd for residential uses, which is almost the same as the AWWA baseline. There are several studies of high-performance residential water efficiency retrofits; a 1999 study from Seattle,[64] which begins at 63.6 gpcd, is closest to conditions found in SCWA's service area. The average reduction in 37 homes was 37 percent, which implies potential reductions of 37 to 42 percent in water demand in SCWA's service area.

Besides water use efficiency, wastewater reclamation displaces potable water deliveries. However, from a GHG perspective, reclaimed wastewater requires energy for advanced treatment, pumping to storage, and pumping to the point of use, that greatly reduce, if not actually increase, net GHG emissions. This requires examining the entire water supply, wastewater collection/treatment, and reclamation cycle, which can be done in conjunction with the companion report for the City of Santa Rosa. This report will evaluate only the impact of water use efficiency, to provide the basis for subsequent addition of reclamation.

5.2.3.2 Standard Water Efficiency

SCWA will include all the California Urban Water Conservation Council's (CUWCC) Best Management Practices (BMPs) required for State funding of water supply projects.[65] Based on presentations made to the SCWA Board of Directors, future water conservation will be in the 6,600-9,200 AF/yr range.[66] Using the upper limit produces a water efficiency target of 9.8 percent of the 2020 supply that would have been required without efficiency measures. This level of efficiency will be labeled "Standard."

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[61] Two types are deficiencies are addressed: (1) droughts, and (2) water demand growing faster than supply capacity.
[62] Mayer, DeOreo, Opitz, Kiefer, Davis, Dziegliewski, and Nelson, *Residential End Uses of Water*, American Water Works Association (AWWA) Research Foundation, 1999.
[63] *Description of Model that Calculates the Allocation of Water Available to Sonoma County Water Agency for Its Customers During a Water Supply Deficiency Taking Demand Hardening into Account*, April 4, 2006, by John Olaf Nelson Water Resources Management for the 11th Restructured Water Supply Agreement.
[64] http://www.aquacraft.com/Publications/seattle.htm
[65] SCWA will expand some of the BMPs such as leak prevention.
[66] The Water Policy Policy Statement of 2002 uses the lower limit (SCWA website displays the *Revised Draft Sonoma County Water Agency Water Policy Policy*, December 2002).

5.2.3.3 *Available Water Efficiency*

To evaluate the benefits to SCWA of proceeding to higher levels of water efficiency, we used values contained in the Pacific Institute's report *Waste Not, Want Not: The Potential for Urban Water Conservation* of November 2003. The report evaluated the life-cycle cost-effectiveness of off-the-shelf equipment and controls, proven designs, and readily available services. Cost-effectiveness included capital and operating costs of water and wastewater systems related to specific water end uses, and quantifiable end-use energy demands. Efficiency measures were considered feasible if their combined life0cycle cost was less than the $600/AF average life-cycle cost for new water supply systems in California (in 2003). These efficiency measures could reduce water demands by 38 percent of the 2020 supply that would have been required without efficiency measures. This level of water efficiency is labeled "Available."

5.2.3.4 *GHG Target for Water Use Efficiency*

A third level of reduction was included in our evaluation, based on a desired target for GHG reductions by 2020. Recommending a feasible target for SCWA is the overall objective of Climate Protection Campaign's effort, which includes more than the water supply system evaluated in this report. To initiate consideration of feasibility, we set a target of 70 percent reduction from 2005 GHG emissions by 2020, which is considered imperative by the scientific community.[67] The average reduction required from efficiency measures across SCWA's service area would be 51 percent of the 2020 supply that would have been required without efficiency measures. Since the reduction is so large, feasibility must be confirmed with demand-side analyses, which is the intent of a companion report for the City of Santa Rosa. This level of water efficiency is labeled "GHG Target."

5.2.3.5 *Summary of Water Use Efficiency Scenarios*

Table 9
Range of Water Use Efficiency Improvements

	INDOOR (67%) EFFICIENCY REDUCTIONS			OUTSIDE (33%) EFFICIENCY REDUCTIONS		
	Standard	Available	GHG Target	Standard	Available	GHG Target
RESIDENTIAL (73%)	9.8%	39.0%	48.7%	9.8%	32.5%	48.7%
CII (27%)	9.8%	39.0%	48.7%	9.8%	50.0%	74.9%
COMBINED	**9.8%**	**39.0%**	**48.7%**	**9.8%**	**37.2%**	**55.7%**

1. Standard reductions obtained from *Revised Draft Sonoma County Water Agency Water Policy Policy*, December 2002
2. Available reductions obtained from Table ES-1 in *Waste Not, Want Not: The Potential for Urban Water Conservation*, Pacific Institute, 2003.
   (a) Outside Residential is the average of 25-40%.
   (b) Outside CII obtained from p.91.
3. GHG Target derived to reduce 2005 GHG emissions 70% by 2020 (the scientific imperative).
   (a) Outside CII adjusted according to ratio of CII /Residential for Available Efficiency, and implies on-site reuse.

OVERALL REDUCTIONS FROM DEMAND w/o EFFICIENCY		
Standard	**Available**	**GHG Target**
9.8%	**38%**	**51%**

1. Based on 2004/2005 average distribution of 67% indoor and 33% outside across all sectors.

[67] The Intergovernmental Panel on Climate Change (IPCC) has determined that a 70 percent reduction from 1990 GHG emissions was imperative from a scientific perspective — widely referred to as the "Scientific Imperative."

6 RESULTS

6.1 Water Demand, Energy Use and Costs, and GHG Emissions

Table 10 summarizes the average annual water deliveries, energy use, and GHG emissions, and their unit values. The 2020 values without transmission system improvements (i.e., energy efficiency) or increased water use efficiency provide a basis for calculating the marginal benefits of measures considered for the Water Project.

TABLE 10

	TOTAL WATER MG/yr	TOTAL ENERGY MWhr/yr	UNIT ENERGY MWhr/MG	AVG.ELEC RATE $/MWhr	TOTAL COST $/yr	UNIT COST $/MG	TOTAL GHG Ton-CO2/yr	UNIT GHG Ton-CO2/MG
2005 Baseline	**21,200**	**56,800**	**2.7**	**$77**	**$4,390,000**	**$207**	**10,600**	**0.50**
2020 w/o Energy or Water Efficiency	**30,700**	**100,800**	**3.3**	**$172**	**$17,370,000**	**$566**	**26,600**	**0.87**
2020 with Energy but no Water Efficiency	**30,700**	**88,500**	**2.9**	**$171**	**$15,090,000**	**$492**	**22,100**	**0.72**
2020 Standard Efficiency	27,700	75,000	2.7	$168	$12,570,000	$454	17,200	0.62
2020 Available Efficiency	18,900	42,300	2.2	$154	$6,500,000	$344	6,000	0.32
2020 GHG Target	15,000	30,800	2.1	$142	$4,360,000	$291	3,200	0.21

Fig. 28 shows the changes, from the 2005 baseline, in water deliveries, energy use, and GHG emissions for the 2020 Standard Efficiency, and what they would have been without the energy and water use efficiency measures already included in the Water Project. The point is that even though there will be significant increases in all parameters by 2020, they would have been much higher without including efficiency measures. For example, there would have been a 151 percent increase in GHG emissions rather that the expected 62 percent increase under the Standard Efficiency scenario. Electricity costs would have quadrupled rather than tripled.

Fig. 29 summarizes the changes in water demand, electricity use, electricity costs, and GHG emissions for the three scenarios for 2020. All parameters increase for the Standard Efficiency scenario, while all except costs are reduced for the two other scenarios.

As shown in Table 8, the energy and GHG emissions related to water use by Sonoma County Water Agency's (SCWA) contractors and their end-use customers are several times larger than in SCWA's water delivery system. This implies that on a regional basis, the increases in GHG emissions for the Standard Efficiency scenario will be very much larger than indicated in Table 10. On the other hand, water use efficiency programs initiated by SCWA for the Available and GHG Target efficiency scenarios will enable much larger reductions in regional GHG emissions than indicated in Fig. 29. This could turn SCWA into a regional climate stabilization leader by expanding its water efficiency programs.

Fig. 30 compares monthly water deliveries in 2020 to the 2005 baseline. Both the Available and GHG Target efficiency levels reduce water deliveries below the baseline, and even though water deliveries are 32 percent larger for the Standard Efficiency option, Fig. 28 shows that they would have been 45 percent higher without efficiency measures.

FIG. 28

ANNUAL CHANGES FROM 2005 BASELINE

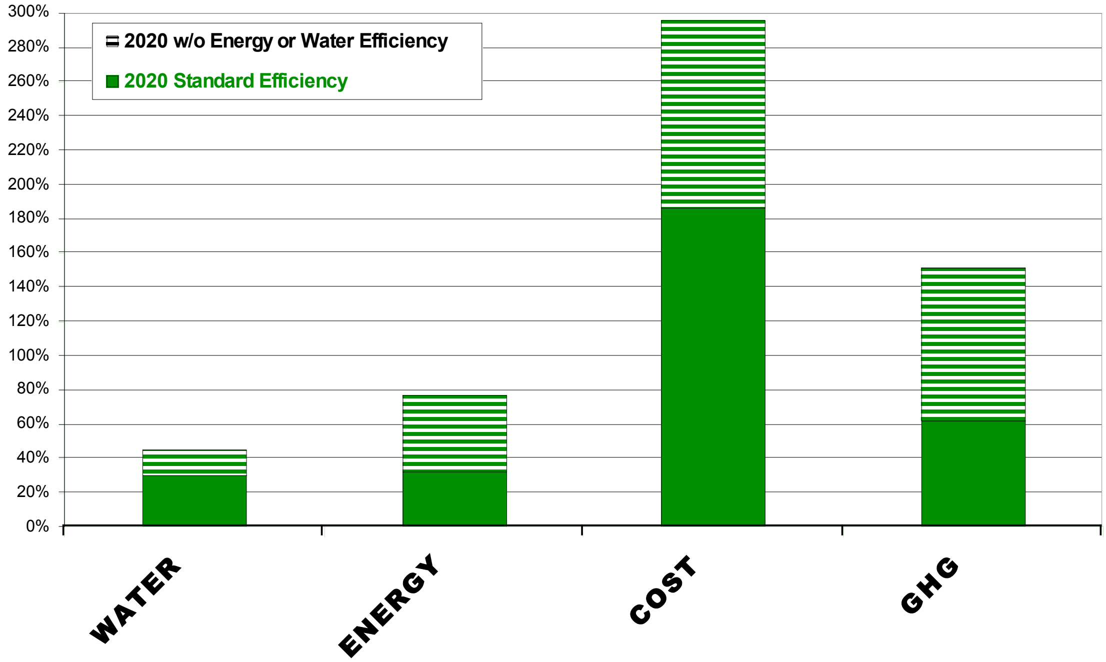


FIG. 29

ANNUAL CHANGES FROM 2005 BASELINE

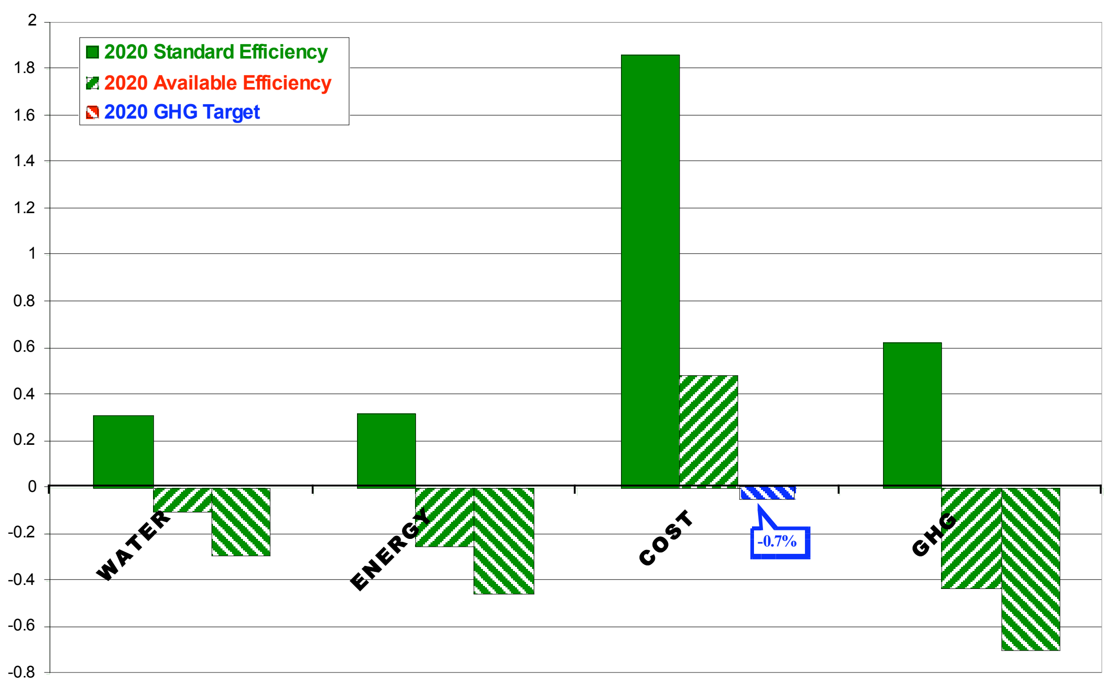


FIG. 30

WATER DELIVERY COMPARISON FOR 2005 BASELINE AND 2020 EFFICIENCY LEVELS

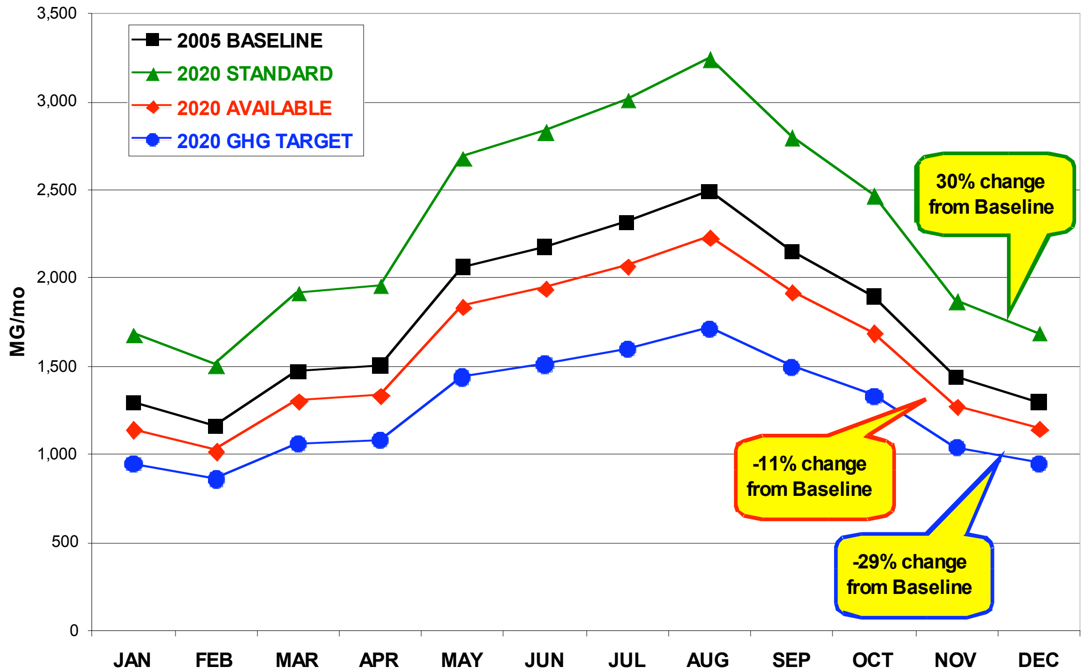


Fig. 31 compares monthly energy demand in 2020 to the 2005 baseline. Both the Available and GHG Target efficiency levels reduce annual energy demand below the baseline.[68] The 32 percent increase in annual energy use for the Standard Efficiency option is larger than the increase in water deliveries, but Fig. 28 shows that energy use would have been 77 percent higher without water efficiency.

Fig. 32 compares monthly energy costs in 2020 to the 2005 baseline. The Standard Efficiency scenario will be accompanied by almost triple the energy costs by 2020, but costs would have quadrupled without the energy and water efficiency measures already included in the Water Project. The 48 percent increase for the Available Efficiency scenario will still save $6 million per year compared to the Standard Efficiency scenario. Cost stabilization (i.e., the 0.7 percent reduction) under the GHG Target Efficiency scenario will save $8.2 million per year compared to the Standard Efficiency scenario.

Fig. 33 compares monthly GHG emissions in 2020 to the 2005 baseline. Both the Available and GHG Target efficiency levels reduce GHG emissions significantly below the baseline. The 62 percent increase in GHG emissions for the Standard Efficiency is still significantly below the 151 percent increase shown in Fig. 28 that would have occurred without water efficiency.

The impact of the "run-of-the-river" availability of Western Area Power Agency (WAPA) hydropower is clearly reflected in the shape of the curve in Fig. 33. Maximum hydropower is

[68] The energy reductions in winter months are very small, reflecting the "flattening" of the energy-flow correlation in Fig. 27.

available in May with zero GHG emissions; then hydropower falls off during subsequent summer months, and GHG emissions increase — just as SCWA's energy demand increases. The very large reduction in water demand for the GHG Target Efficiency scenario allows SCWA to get by with only hydropower from May through August, with zero GHG emissions and no need to purchase fossil-fueled market power.

In 2005, very little WAPA hydropower was available in January, February, and March, causing relatively high GHG emissions. In typical years, more hydropower will be available in these months to significantly reduce annual GHG emissions. However, because of projected climate-induced changes in hydrology, there will be reductions in overall hydropower supply.

Given the sensitivity of SCWA's GHG emissions to the availability of WAPA hydropower, the details of the Power and Water Resources Pooling Authority (PWRPA) contract are almost as important as water efficiency. The combination of water use and energy efficiency measures with several renewable energy sources besides WAPA hydropower could result in very much lower GHG emissions, and lower costs, by 2020. It is important to note that large-scale hydropower such as WAPA's is not eligible for renewable resource funding from the State of California. Eligible renewables could be developed locally by SCWA, including wind, methane/cogen from dairy manure, landfill biogas, and photovoltaics.

Fig. 34 shows the breakdown between hydropower and market power for each of the efficiency scenarios, based on the assumption that WAPA hydropower energy supplied to SCWA in each month will remain the same as in 2005. This might not be the case, especially in drought years, so creating a portfolio of additional renewable resources will not only replace market power, but will also provide a safeguard against climate impacts on hydropower.

FIG. 31

ENERGY DEMAND COMPARISON FOR 2005 BASELINE AND 2020 EFFICIENCY LEVELS

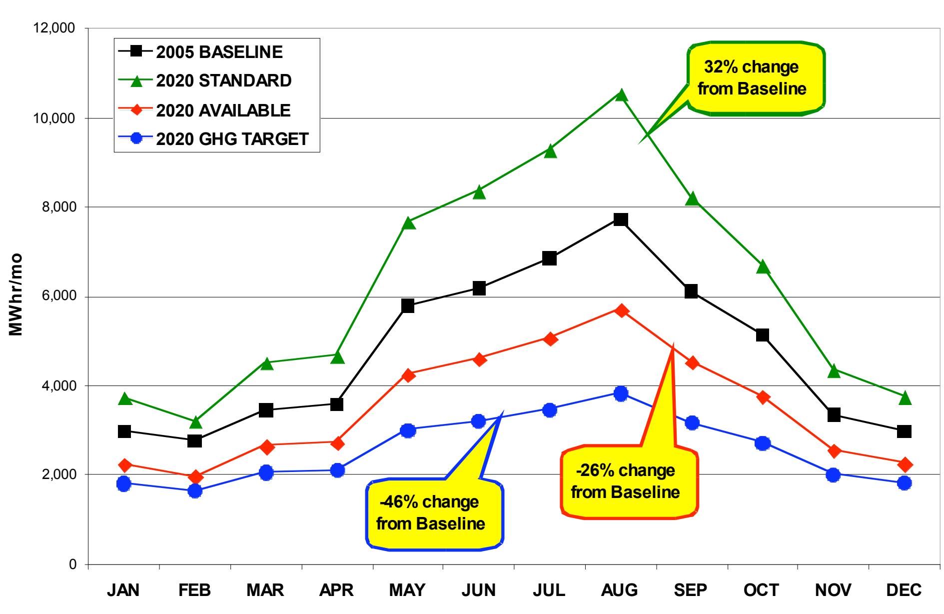


FIG. 32

ENERGY COST COMPARISON FOR 2005 BASELINE AND 2020 EFFICIENCY LEVELS

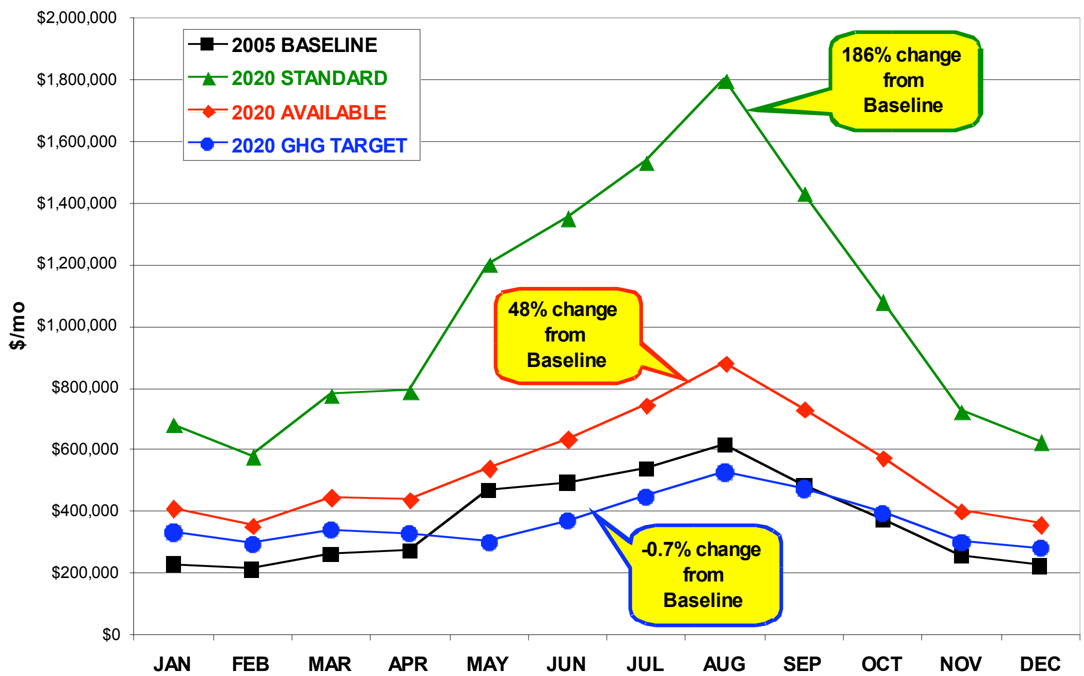


FIG. 33

GHG EMISSIONS COMPARISON FOR 2005 BASELINE AND 2020 EFFICIENCY LEVELS

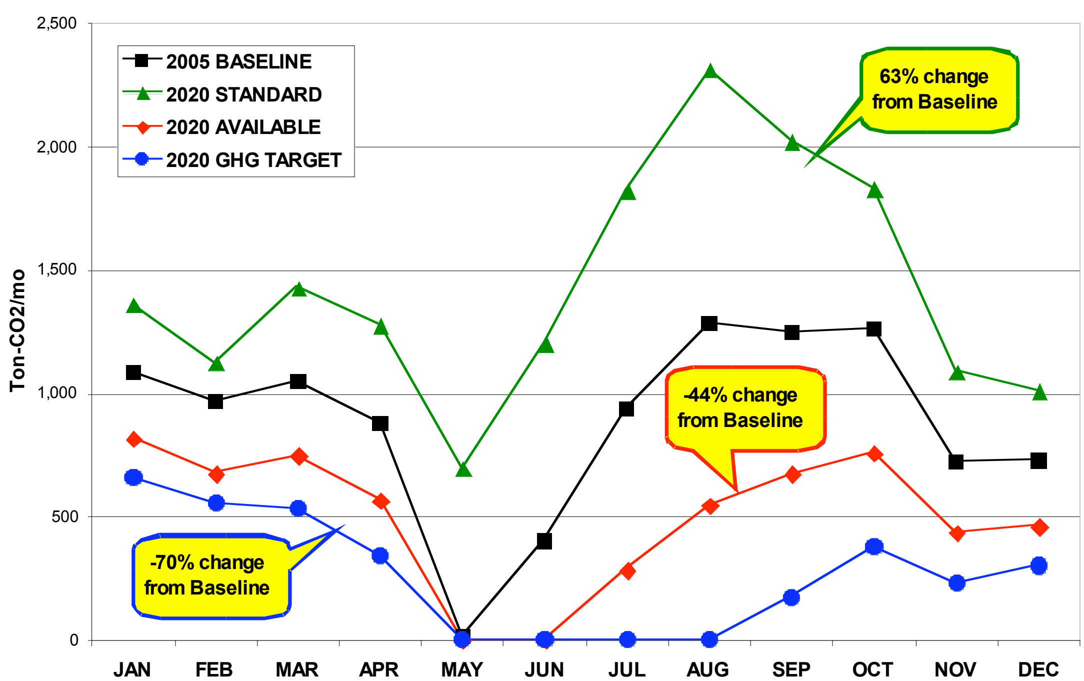
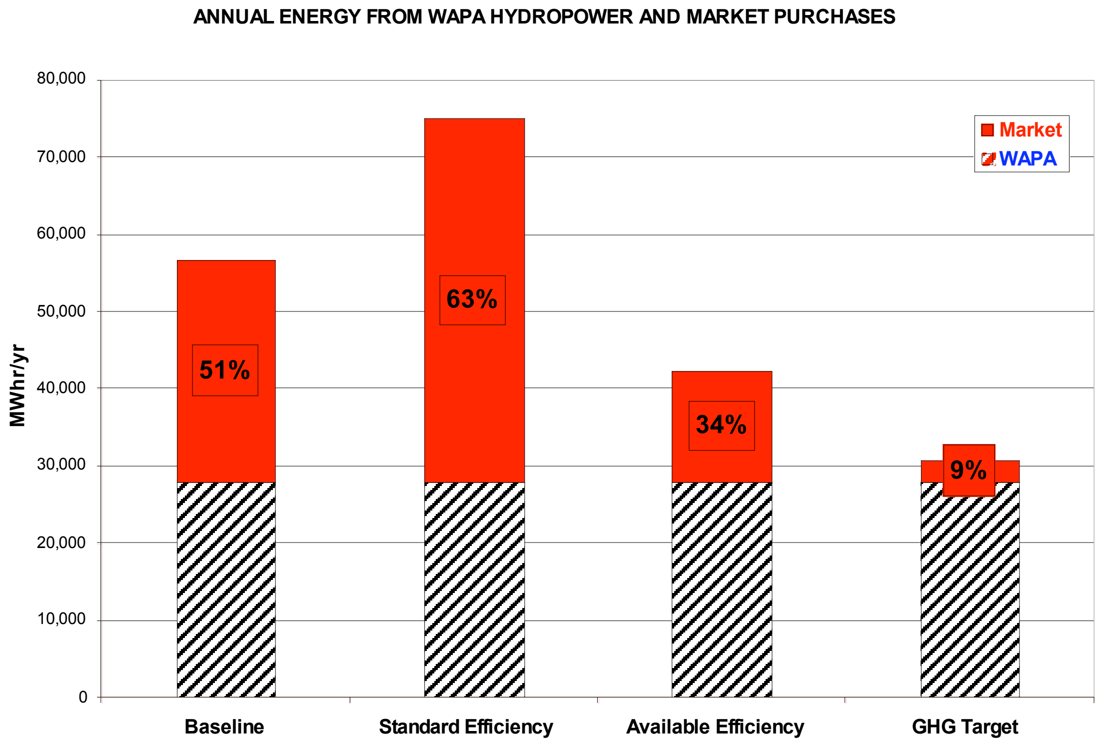


FIG. 34



6.2 Evaluating Technical and Economic Feasibility

Feasible implementation of ambitious water efficiency programs, such the Available and GHG Target Efficiency scenarios, requires long-term planning that can be included Water Project. Even the feasibility of the Standard Efficiency scenario, already included in the Water Project, is uncertain because of potential shortfalls in water rights, multi-year droughts, and climate change. Shortfall agreements have been added to future supply contracts, but additional efficiency beyond the Standard Efficiency scenario could help avoid impending conflicts. The key elements for successful planning and implementation are:

- Maximizing water use and energy reductions rather than meeting prescriptive regulatory targets
- Capitalizing on water use and energy efficiency measures within infrastructure projects
- Integrating of water use and energy efficiency, renewable energy generation, and GHG reduction
- Developing technical, financial, and administrative services to support large programs and obtain high customer participation

Much of the potential feasibility of water use and energy efficiency measures can be evaluated by examining SCWA's existing operational data for 2004, 2005, and 2006, with a few additional measurements, in particular:

- Energy-flow relationships and trends for the future

- Pump/drive efficiency improvements
- Optimization of pump/storage operations for peak load reduction
- Time-of-use fuel mix and GHG emissions
- Transmission system improvements

It is important to note that the additional water use efficiency scenarios examined in this report are not the only means to reducing GHG emissions and costs. Other methods include additional energy efficiency beyond 12 percent (which can be confirmed by examining 2004–2006 SCADA data and in cooperation with SCWA's contractors), displacement of potable water with reclaimed wastewater, and procurement of additional electricity from renewable resources. The broader objective of the report is to demonstrate that the GHG emissions generated by future water supply can be reduced — and that finding cost-effective combinations of methods to do so should be part of the Water Project design.

Although it is beyond the scope of this report, we expect far lower life-cycle costs, and even net savings, when regional end-use energy savings resulting from reduced water demand and wastewater energy savings are included in the calculations. We will demonstrate this in a companion study for the City of Santa Rosa, which will estimate implementation costs and performance for the efficiency measures, with their end-use and wastewater savings, and displacement of potable water with reclaimed wastewater. Life cycle cost-effectiveness will require the following information:

- Total cost for the Water Project, including Caisson 6 and transmission system improvements already underway
- Construction projects required to increase reliability even if peak supply capacity is reduced
- A projection of future electricity procurement contracts, including rates, hydropower availability, and credits for lower demands
- SCWA's operating budget for water efficiency
- Bond terms and possible State financial incentives